Eustis Engineering Services, L.L.C.
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20 March 2014

Professional Engineering Consultants Corporation
7600 GSRI Avenue
Baton Rouge, Louisiana 70820

Attention Mr. Gerald W. Babin, Jr., P.E.

Gentlemen:

Geotechnical Exploration - Final Report
False River Ecosystem Restoration
Phase I
South Flats
Pointe Coupee Parish, Louisiana
Eustis Engineering Project No. 22348

Transmitted is one bound copy of our engineering report covering a geotechnical exploration for the subject project. An electronic copy is also being provided to you.

Thank you for asking us to perform these services.

Yours very truly,

EUSTIS ENGINEERING SERVICES, L.L.C.

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PROFESSIONAL ENGINEER

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JJH:nfr/aln

GEOTECHNICAL EXPLORATION - FINAL REPORT

FALSE RIVER ECOSYSTEM RESTORATION

PHASE I

SOUTH FLATS

POINTE COUPEE PARISH, LOUISIANA

EUSTIS ENGINEERING PROJECT NO. 22348

FOR
PROFESSIONAL ENGINEERING CONSULTANTS CORPORATION
BATON ROUGE, LOUISIANA

By
Eustis Engineering Services, L.L.C.
Metairie, Louisiana

20 MARCH 2014

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INTRODUCTION

1. This report contains the results of a geotechnical exploration performed for the proposed ecosystem restoration project to be located in False River in Pointe Coupee Parish, Louisiana. Refer to Figure 1 for a site vicinity map. The exploration was performed in general accordance with Eustis Engineering Services, L.L.C.'s proposal dated 18 September 2013. The project was authorized on 11 October 2013 by Mr. Gerald Babin Jr., P.E., Vice President of Professional Engineering Consultants, Corporation (PEC), the engineer for the project. A proposal for supplemental geotechnical services dated 23 December 2013, was authorized by Mr. Babin on 30 December 2013.

BACKGROUND

2. We published a preliminary geotechnical report dated 9 December 2013 for this project. A meeting was held at the State of Louisiana, Department of Natural Resources's (LaDNR) office on 12 December 2013 with representatives of Eustis Engineering, PEC, and the DNR. The group evaluated the pros and cons of the earthen island terrace option for the purpose of facilitating spawning of fish in the south flats of False River. Constructibility was a concern.

3. An alternative to the option defined in the preliminary geotechnical report dated 9 December 2013, and the plans presented at the meeting, was to create a line of earthen containment dikes using adjacent dredged material as borrow for the dike construction. The dikes would be constructed to form an island that could be filled with hydraulically dredged and pumped sediment. After dike construction was complete, additional material from the hydraulic dredging operations, occurring on the western side of the dike system that is required for creating a spawning environment for fish, would then be pumped within the dike system. This ecosystem restoration project is at the southern terminus of the oxbow that is False River.

SCOPE

4. Initial Study. The exploration included the drilling of nine soil test borings to determine subsoil stratification and to obtain samples of the subsoils. Soil mechanics laboratory tests, performed on samples obtained from the borings, were used to evaluate the physical properties of the various substrata. Engineering analyses were performed using available soil boring and laboratory test data.

5. Slope stability and settlement analyses were performed for the design of proposed earthen terraces that will create an environment for the spawning of fish. Eustis Engineering evaluated slope stability to verify the required terrace side slope geometry and underlying dredged slope geometry that would produce adequate factors of safety. Stability analyses considered various widths of the berm. Settlement analyses were performed to estimate the long term settlement and corresponding overbuild required for the proposed island terraces. Analyses were also performed to provide shrinkage estimates for the fill used to construct the terraces and to determine borrow to fill ratios. Recommendations are included in this report regarding site preparation and island terrace construction procedures.

These procedures also apply to earthen containment berms as discussed in the following paragraph.

6. Supplemental Study. A bulk grab sample was obtained in a second field exploration program. The new alternative previously described required additional laboratory testing to help define how the dredged sediments would settle out in suspension after they would be placed in the standing water on the retained side of the dike. This testing involved a self-weight consolidation test and a settling column test.

7. Material required for these two tests was obtained by Eustis Engineering using a crew boat. Slope stability was reevaluated for the containment dike, and settlements would be estimated considering the advanced laboratory testing. Results of the advanced testing are included in this final report. Although not originally requested in our supplemental scope of services from December 2013, we considered a sheetpile alternative for the purpose of cost estimating in comparison to the containment dike alternative at the request of the Engineer. These results are included in this final report.

FIELD EXPLORATION

Initial Exploration

8. Nine soil test borings were made on 21 through 30 October 2013 at the locations shown on Figure 2. Borings designated as B-1, B-3, B-5, B-6, and B-9 were each made to a depth of 60 feet below the mudline. These borings were performed with a drill rig on pontoons and a support air boat. Borings designated as B-2, B-4, B-7, and B-8 were each made to a depth of 15 feet below the mudline and were obtained using a vibracore with a support crew boat. The vibracore enabled continuous sampling for these borings that were intended to characterize the proposed dredged sediments. Upon completion of drilling operations, the borings were backfilled in

accordance with the laws of the State of Louisiana. Detailed descriptive logs of the borings are shown in both tabular and graphical form in Appendix I.

9. <u>Standard Soil Sampling.</u> For Borings B-1, B-3, B-5, B-6, and B-9, undisturbed samples of cohesive or semi-cohesive subsoils were obtained at close intervals or changes in stratum using a 3-in. diameter thinwall Shelby tube sampling barrel. The samples were transported to our laboratory and were then extruded from the sampling barrel, inspected, and visually classified by Eustis Engineering's soil technician. Pocket penetrometer tests were performed on the soil samples to give a general indication of their shear strength or consistency. The results of these tests are shown on the logs of the borings under the column heading "PP." Representative portions were then promptly placed in moisture proof containers and sealed for preservation of their natural moisture content.

10. For Borings B-1, B-3, B-5, B-6, and B-9, samples of cohesionless and semi-cohesive materials were obtained during the performance of in situ Standard Penetration Tests. This test consists of driving a 2-in. diameter sampler 1 foot into the soil after first seating it 6 inches. A 140-lb weight dropped 30 inches is used to advance the sampler. The number of blows required to drive the sampler is indicative of the relative density of cohesionless soils and the consistency of cohesive soils. The samples were retained in moisture proof containers for preservation of their natural moisture content. The results of the Standard Penetration Tests are shown on the boring logs under the column heading "SPT."

11. <u>Vibracore Sampling</u>. The vibracores for Borings B-2, B-4, B-7 and B-8 were sampled with a handheld Wink Vibracore which uses vibration to advance a sampler into the subsurface. A small motor controls the amount of vibration transmitted through a hydraulic hose into the drill header. Using the weight of the drill head and sampling rods, the vibratory hammer imparts energy at a frequency that liquifies the soil adjacent to the cutting shoe and advances the sample through the

subsoils. Sampler soil liners were inserted within the sampler to enable unit weight determination and other subsequent laboratory testing. The subsoils were obtained continuously to the 15-ft depth below the mudline using 2.25-in. diameter by 5-ft long soil liners inside of the 2.75-in. diameter drill pipe. The soil liners were immediately taken out of the drill pipe, inspected, and visually classified by Eustis Engineering's soil technician. The samples were capped and sealed with plastic caps to preserve their natural moisture content.

Supplemental Exploration

12. Approximately five, 5-gallon buckets of near surface soil and five, 5-gallon buckets of site water were obtained by Eustis Engineering personnel using a crew boat on 10 January 2014 for the settling column test. A portion of the soil was also used to perform the self weight consolidation testing. Both of these tests were performed in house by Eustis Engineering.

LABORATORY TESTS

13. Soil mechanics laboratory tests generally consisted of classification tests including natural water content, unit weight, and either unconfined compressive shear (UC) or one-point unconsolidated undrained triaxial compression shear (OB) on undisturbed samples obtained from the borings. In addition, Atterberg limits and determination of percent (by weight) of soil passing the No. 200 sieve (-#200) were performed on samples in the proposed dredging areas to provide additional soil classification information. The results of the laboratory tests are tabulated on the borings logs in Appendix I.

14. Self Weight Consolidation. We performed one self weight consolidation test on material obtained from the bulk grab sample. The test was performed as specified in the U. S. Army Corps of Engineers's Engineering Manual EM 1110-2-5207. The

results of this test are provided in Appendix II. The self weight consolidation results were evaluated and incorporated into the settlement analyses to determine the amount of marsh fill required to be pumped into the marsh creation area to meet final elevation criterion.

15. Settling Column. We performed a settling column test on a bulk grab sample in an 8-in. diameter by 8-ft high column using the test procedure provided in Appendix III. An average initial concentration of approximately 106.5 grams/liter was determined prior to pumping the slurry into the column. An average initial concentration of 185 grams/liter was determined from the eight ports within the column. Ports were located at the 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, and 6.0-ft heights within the column. Samples were tested to determine the total suspended solids (TSS) in the slurry at 1, 2, 4, 6, and 12 hours and at 1, 2, 4, 7, 11, and 15 days. In addition, a particle size distribution curve was obtained from the composite sample used for the settling column test. The results of the test on this composite sample are provided in Appendix III. A plot of the TSS concentration for the eight ports sampled at various times is also provided in Appendix III.

DESCRIPTION OF SUBSOIL CONDITIONS

Stratigraphy

16. Reference to the boring logs indicates extremely soft to very soft gray and tan clay with silt pockets and lenses, decayed wood, silty sand pockets and lenses, organic matter, and shell fragments was encountered to a depth of approximately 25 to 30 feet below the mudline. Borings B-2, B-4, B-7, and B-8 were terminated within these soils at the 15-ft depth. Beneath these soils in Borings B-1, B-3, B-5, B-6, and B-9, deposits of medium dense to very dense gray silty sand, clayey sand, and fine sand with clay pockets, organic matter, decayed wood, and gravel continue to the terminal boring depth of 60 feet. A subsoil profile is shown on Figure 3.

Water Depths

17. Standing water was encountered at all boring locations. The water depths measured at the time of our field exploration generally ranged between 1 and 3.5 feet. The water depth will vary with climatic conditions, drainage improvements, and other factors. The water level and site conditions should be investigated by those persons responsible for construction immediately prior to beginning work.

FOUNDATION ANALYSES

Furnished Information

18. We understand the purpose of this project is to create an environment to facilitate spawning of fish. This is needed because the southern portion of the False River has water depths that are too shallow for spawning (i.e., less than 3 feet deep). To create this environment, sediments will be dredged and side cast to form an earthen containment dike as shown on Figure 2. Construction is intended to be "in the dry" where the water will be drawn down 2 feet. This drawdown stage is also shown on Figure 2. After construction of the dikes, the water stage will be returned to the normal pool elevation. We understand the drawdown stage will be limited to an approximate six-month duration (Fall 2014 to Spring 2015).

19. We understand a normal pool elevation in False River is at approximate el 16 (False River datum) or el 14.8 (NAVD 88) and the existing mudline is at approximate el 13.5 to el 15.0 (False River) or el 12.3 to 13.8 (NAVD 88) in the areas of the proposed dikes.

20. Initially, the crowns of the terrace islands were desired to be at 2 to 2.5 feet above the normal pool elevation, approximately five to ten years after construction. A furnished cross-section showed 6 horizontal to 1 vertical (6H:1V) side slopes for the

constructed terraces, and dredging would extend along this same slope down to a few feet below the existing mudline. A 25-ft wide "aquatic bench" was shown at el 11 (False River) or el 9.8 (NAVD 88), and the dredging template continued at a 3H:1V slope down to a depth that would be a function of how much dredge material will be needed to construct the terraces.

21. After the meeting held at the DNR's office on 12 December 2013, discussions in January and February with PEC resulted in a line of earthen containment dikes oriented in an oval shape to form an island. This solution is preferable to the Owner in comparison to constructing a cluster of island terraces. As shown on Figure 2, the dikes create a containment fill area of approximately 16.5 acres. The proposed bottom dredge elevation is the same as the initial study (el 9.8 NAVD 88) and dredging is planned predominantly to the west of the island as shown on Figure 2.

<u>General Recommendations</u>

22. We recommend staged construction be performed for the earthen containment dikes (similar to the island terraces). Staged construction will allow for an initiation of the consolidation process. Consolidation will affect a gain in foundation shear strength and reduce the potential for lateral plastic deformation ("lateral spread") and containment dike settlement. Recommendations regarding containment dike construction are given subsequently in this report. We recommend side slopes of 5H:1V be established for the containment dike, and geotextile reinforcement be placed on natural grades prior to dike construction. The geotextile reinforcement will also reduce the amount of lateral spread. The excavated slopes below natural grades should be at a 3H:1V inclination in order to maintain adequate stability. This recommendation considers a final dike crown elevation at 2 feet above the normal pool elevation or at 18.0 (False River) or el 16.8 (NAVD 88), initial construction to el 19.7 (False River) or el 18.5 (NAVD 88), and existing grade at el 14.7 (False River) or el 13.5 (NAVD 88). Details of these recommendations follow in this report.

Stability Analyses

23. Methodology - Slope Stability. Stability analyses of the earthen containment dikes and a sheetpile alternative were performed using the Geo-Slope International, Ltd.'s SLOPE/W, Version 7.20, slope stability program. This program generally utilizes circular and non-circular slip surfaces to define the soil failure planes. These surfaces are divided into vertical slices and the factor of safety is computed by summing forces, summing moments, or both. Interslice forces are considered for these analyses. We recommend a minimum acceptable factor of safety equal to approximately 1.1 (containment dikes) and 1.3 (sheetpile). We recommend a slightly higher factor of safety for sheetpiles, considering sheetpiles are structural elements rather than simply earthwork. Factors of safety presented in this report are based on Spencer's method which assumes horizontal interslice forces.

24. Methodology - Wall Stability. Eustis Engineering utilized the U.S. Army Corps of Engineers' computer program entitled "CWALSHT" for evaluation of the proposed sheetpile wall alternative. This program considers conventional earth pressure theory. We evaluated a top of wall at el 19.7 (i.e., same elevation as the containment dike alternative). We also considered a 5-ft excavation depth on the outside of the containment area in the area of the hydraulic dredging, and a containment fill elevation of el 18.7 (same as the containment dike alternative). We evaluated a required sheetpile tip elevation and bending moment capacity using a factor of safety of 1.3 applied to the soil shear strengths.

25. Soil Design Parameters. Soil design parameters were developed for Borings B-1, B-3, B-5, B-6, and B-9. In addition, for the containment dike, fill materials obtained from the single handling, side-cast dredging operations, Eustis Engineering assumed a wet unit weight of 100 pcf and a cohesion (i.e., undrained shear strength) of 200 psf. These parameters consider fill to be placed by uncompacted methods as discussed in the "Construction Recommendations" section of this

report. We understand the dredged fill material will be excavated, transported, and placed onto the retained side of the dike using hydraulic methods. This hydraulically dredged and pumped fill material will have a total unit weight on the order of 75 pcf, and we estimated an undrained shear strength of 75 psf after initial self weight consolidation has occurred.

26. <u>Water Levels.</u> The stability analyses presented are based on the furnished mean low water level. Extreme low or high water levels due to a storm event were not evaluated. Water levels above or below that analyzed may result in localized sloughing or failure of the recommended section. Long term maintenance should consider this potential. Otherwise, Eustis Engineering should be consulted to evaluate alternate water levels.

27. <u>Results from our December 2013 Report - Island Terraces.</u> We have included the results of our stability analyses of the island terrace option that was considered in our preliminary report in this final report. These results are included in Appendix IV of this final report. We evaluated island terrace and dredging template configurations that yielded minimum computed factors of safety of approximately 1.0 and 1.1. Island terrace side slopes of 6H:1V with dredged side slopes of 3H:1V were required under low water conditions during construction at el 14. We do not recommend the configuration shown on Figure 5 because the island terrace is at incipient failure (factor of safety of 1.0). The analysis shown on Figure 6 reveals that a 43-ft wide berm at el 14 is required to achieve a factor of safety of 1.1. This factor of safety ensures that the island terraces will not fail immediately after construction is completed when water levels are in a drawdown state (el 14). The factors of safety will increase when the water levels are restored to their natural levels of approximately el 16 (False River) or el 14.8 (NAVD 88).

28. <u>Results - Containment Dike Alternative.</u> We reconsidered the analyses of our prior report in an effort to reduce the containment dike cross-section and make this

project more economical. To reduce the risk of lateral spread during dike construction and provide more resistance to slope instability, we included geosynthetic reinforcement at the existing mudline. This reinforcement will extend the entire width of the containment dikes which is 55 feet as shown on Figures 5 and 6. The reinforcement should have a minimum tensile strength of 14,000 lbs/ft at 5% strain.

29. Figure 5 presents the "during construction" case when the water level is drawn down to el 14.0 (False River) or el 12.8 (NAVD 88). The dredged excavation on the inside of the dike (i.e., within the footprint of the island) is approximately 10.7 feet deep. Figure 6 presents the "after construction" case when the water level is restored to its natural level at el 16.0 (False River) or el 14.8 (NAVD 88). This condition exists when the island is filled with dredged and pumped sediment to el 18.7 (False River) or el 17.5 (NAVD 88). The dredged excavation on the outside of the dike where the fish will spawn is approximately 10.7 feet deep. We understand this depth is not required for the fish to spawn (only a 5-ft depth is required), yet we considered this depth in our analysis in the event more fill material is required for dike construction. Detailed results of slope stability analysis are provided in Appendix V.

30. <u>Results - Sheetpile Alternative.</u> As previously mentioned, we considered a sheetpile alternative for the purpose of cost estimating in comparison to the containment dike alternative. The "after construction" ground surface conditions for the sheetpile alternative are the same as for the containment dike alternative shown on Figure 6. Our results of stability analysis of the sheetpile alternative are shown on Figure 7. The required sheetpile tip elevation is governed by local wall stability rather than global slope stability. Global slope stability analysis using SLOPE/W resulted in a required tip of el 0 (False River) or el -1.2 (NAVD 88) which is a 19.7-ft long sheetpile. However, the wall stability analysis using CWALSHT yielded a required sheetpile tip at el -15.0 (False River) or el -13.8 (NAVD 88) which is a 34.7-ft long sheetpile. The maximum bending moment for this sheeting is 15 kip-ft.

Settlement Analyses

31. General. Settlement of the proposed containment dikes for this project will occur over time due to consolidation of the foundation soils. Because the predominant soil deposit at this site is clay, the consolidation of the foundation soils occurs over long periods of time and at a diminishing rate. This settlement has been considered in the design of the proposed containment dikes.

32. Estimated Settlement and Shrinkage of Containment Dikes. For the sections shown on Figures 5 and 6, consolidation settlement will occur within the foundation soils that underlie the proposed island terraces constructed to el 19.7. These estimates were made assuming an existing grade at el 14.7. Staged construction will reduce the amount of lateral spread and post construction settlement of the levee section.

33. Shrinkage in the fill used for the containment dikes will also occur as sediments dry out and consolidate under their own weight. Volume change due to shrinkage is more pronounced in clayey soils than sandy soils. We estimate approximately 18 inches of settlement and shrinkage will occur over a two-year period after construction. Therefore, we estimate a grade of approximately el 18.0 (False River) or el 16.8 (NAVD 88) approximately two years after initial construction of the dikes to el 19.7 (False River) or el 18.5 (NAVD 88).

34. In addition, the amount of crust that will form due to drying out of near surface soils is a function of the decanting process. We estimate marsh fill soils will be submerged (or nearly submerged) for a majority of the time due to large scale consolidation settlement. Assuming a crust of approximately 1 foot thick, based on a target terrace elevation of 18.0 (False River) or el 16.8 (NAVD 88), and a mean low water level of el 16.0 (False River) or el 14.8 (NAVD 88), we estimate an additional ½ to 1 inch of settlement will occur.

35. Areal Subsidence. Our estimates of settlement do not include the effect of areal subsidence over the design life of the project. Areal subsidence is a result of filling and lowering of the ground water level over large areas. Areal subsidence is generally considered a background condition over which man has no control and should be relatively uniform in the project area. Sufficient information is not available in the geotechnical exploration to make accurate estimates of areal subsidence in the project area. However, some additional settlement should be anticipated. Subsidence may also occur during construction as a result of the proposed drawdown. The magnitude and extent will depend on the duration of the drawdown operations.

Borrow to Fill Ratio

36. Estimates of the amount of borrow required to construct the proposed island terraces were obtained from the USACE based on data compiled on similar projects. Based on the available data, a typical borrow to fill ratio is 3:1 for natural moisture contents in excess of 50%, considering the soils encountered in Borings B-2, B-4, B-7, and B-8 exhibited high contents of silt and organic material. These borrow to fill ratios do not include the volume of fill required due to settlement and shrinkage, which should be added to the theoretical volume prior to estimating the borrow required.

Construction Recommendations

37. Constructibility. The organic and soft clay materials encountered near the proposed subgrade of the containment dikes may be displaced during fill placement and dredging operations. Construction techniques are critical to the constructibility and ultimate stability of the dike sections. Our analyses assume the dike fills are placed as recommended and outlined subsequently in this report. The stability of the dikes

constructed of in situ materials will be dependent on the borrow materials used and the rate at which the dredged fill is placed.

38. Water Levels. Water levels along the project are subject to seasonal fluctuations. Site conditions should be investigated immediately prior to initiating construction to confirm the limits of the proposed drawdown stage.

39. Containment Dikes. The containment dikes will be constructed of in situ materials. According to the boring logs, this material will generally be fat clay (CH material as defined by the Unified Soil Classification System). Large roots and organic matter should not be placed within the dike sections. Based on the boring logs, existing near surface materials appear to be suitable as island terrace fill. Visual inspection of the uncompacted fill is sufficient to ensure the borrow materials meet the requirements.

40. Geosynthetic Reinforcement. Geosynthetic reinforcement was implemented in our designs shown on Figures 5 and 6. The geotextile fabric properties shown in Table 1 were utilized within the SLOPE/W analyses to obtain the desired target factor of safety for slope stability. The geotextile was placed the full length and width of the proposed design sections.

41. The fabric should be placed in accordance with the manufacturer's recommendations and project specifications. Submittals regarding fabric characteristics and placement should be reviewed by the geotechnical engineer of record. The requirements for the geotextile fabric used for shoreline protection are also presented in Table 1. The geotextile chosen for the project should meet or exceed these requirements.

TABLE 1:
REQUIRED GEOTEXTILE PROPERTIES FOR
EARTHEN CONTAINMENT DIKES

PROPERTY	TEST PROCEDURE	MINIMUM AVERAGE ROLL VALUES
Tensile Strength[1]	ASTM D 4632	350 pounds in any principal direction
Tensile Strength at 5% Strain	ASTM D 4595	1,167 lbs/in. (14,000 lbs/ft)
Tensile Strength at Ultimate	ASTM D 4595	1,800 lbs/in. (21,600 lbs/ft)
Seam Strength[2]	ASTM D 4884	100 lbs/in. minimum
Elongation at Break	ASTM D 4632	15% minimum in any principal direction
Apparent Opening Size (AOS)	ASTM D 4751	No finer than the U.S. Standard Sieve No. 70 and no coarser than the U.S. Standard Sieve No. 30
Permittivity	ASTM D 4491	0.35 per second minimum

(1) Value represents minimum average roll value of new geotextile received from the manufacturer or distributor.

(2) All of the samples shall yield test values that are greater than the minimum value that is specified.

42. <u>Placement of Uncompacted Fill.</u> The borrow material will be placed by uncompacted methods for construction of the containment dikes. Our stability analyses assume these materials will be excavated and placed by mechanical methods using a dragline, clamshell or conventional bucket, or similar mechanical equipment. Eustis Engineering should be contacted to reevaluate our recommendations provided herein if the containment dike fill material will be placed by hydraulic methods. Uncompacted levee fill should be placed in lifts of no more than 3 feet. Depending on the depth of standing water and moisture content of the borrow materials, consideration should be given to placing an initial fill lift for the entire length of each island terrace before proceeding to the next lifts to mitigate the potential for "mud waves". This method will initiate consolidation of foundation soils as well as provide a means for the uncompacted fill to provide a sufficient wearing surface. This will decrease the potential for lateral spread and slope failure within the fill as the containment dikes are constructed.

43. Consideration of Mud Waves. The contractor should expect the creation of a "mud wave" during construction due to the low shear strength and unit weights of the surficial material. Plans and specifications should alert the contractor to anticipate this phenomenon. Two options exist for handling these mud waves. Option 1 is to place the uncompacted fill from the centerline of the design section outward to the toes and parallel to the centerline to "push" the mud wave toward the outside of the dike section. This option is good because the magnitude of the mud wave will be smaller than working the mud wave from the edge of the design section to the other edge (Option 2). Option 2 is to place the uncompacted fill from the outside edge of the design section and push it inward toward the inside toe. Option 2 requires working parallel to the centerline to "push" the mud wave toward the inside (i.e., containment fill side) of the dike section. Mud waves created while placing the dike fill toward the section's edge may require removal to eliminate the potential to trap the very soft surficial material within the fabric. Option 2 would likely yield larger mud waves because the lateral distance the mud wave is pushed is longer than Option 1. Ultimately, consideration of mud waves is a means and methods issue that is the responsibility of the construction contractor. The contractor must monitor the condition and location of the geotextile during construction to ensure it remains flat and taut during fill placement.

44. Staged Containment Dike Construction. We recommend construction of the containment dikes be performed in stages. Staged construction will allow consolidation of the subsoils to begin and affect a gain-in-strength in the rapidly consolidating swamp/marsh deposits. This will minimize the potential for lateral plastic deformation of these soils. Staged construction will also minimize localized failures within the uncompacted fill as described above, particularly when these materials remain saturated during initial lift placement.

45. Maintenance. Our stability analyses consider a 1.7-ft overbuild (to el 19.7) to maintain the proposed crown elevation for the proposed containment dikes (el

18.0). Long term maintenance will still be required to accommodate the estimated ongoing settlements and areal subsidence.

46. Monitoring. Consideration should be given to the use of settlement plates or other surveying methods to monitor the actual rates of settlement for the project. In addition, vibrating wire settlement gauges are a recent technology in the filed of geotechnical instrumentation. Eustis Engineering should be contacted to discuss the long term benefits of this technology to the project. Natural variations in the materials placed as well as the desiccation and biodegradation of these deposits may affect our estimates. If long term performance of the fill placement is to be evaluated, the monitoring should be performed at regular intervals to provide sufficient data.

LIMITATIONS

47. This report has been prepared in accordance with generally accepted geotechnical engineering practice for the exclusive use of PEC for specific application to the subject site. In the event of any changes in the nature, design, or location of the proposed terraces or containment dikes, aquatic bench, and in-filled marsh, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and the conclusions of this report are modified and verified in writing. Should these data be used by anyone other than PEC, they should contact Eustis Engineering for interpretation of data and to secure any other information pertinent to this project.

48. The analyses and recommendations contained in this report are based in part on data obtained from the soil borings and a bulk grab sample. The nature and extent of variations in subsoil conditions between and away from the boring locations and bulk grab sample may not become evident until construction. If variations then

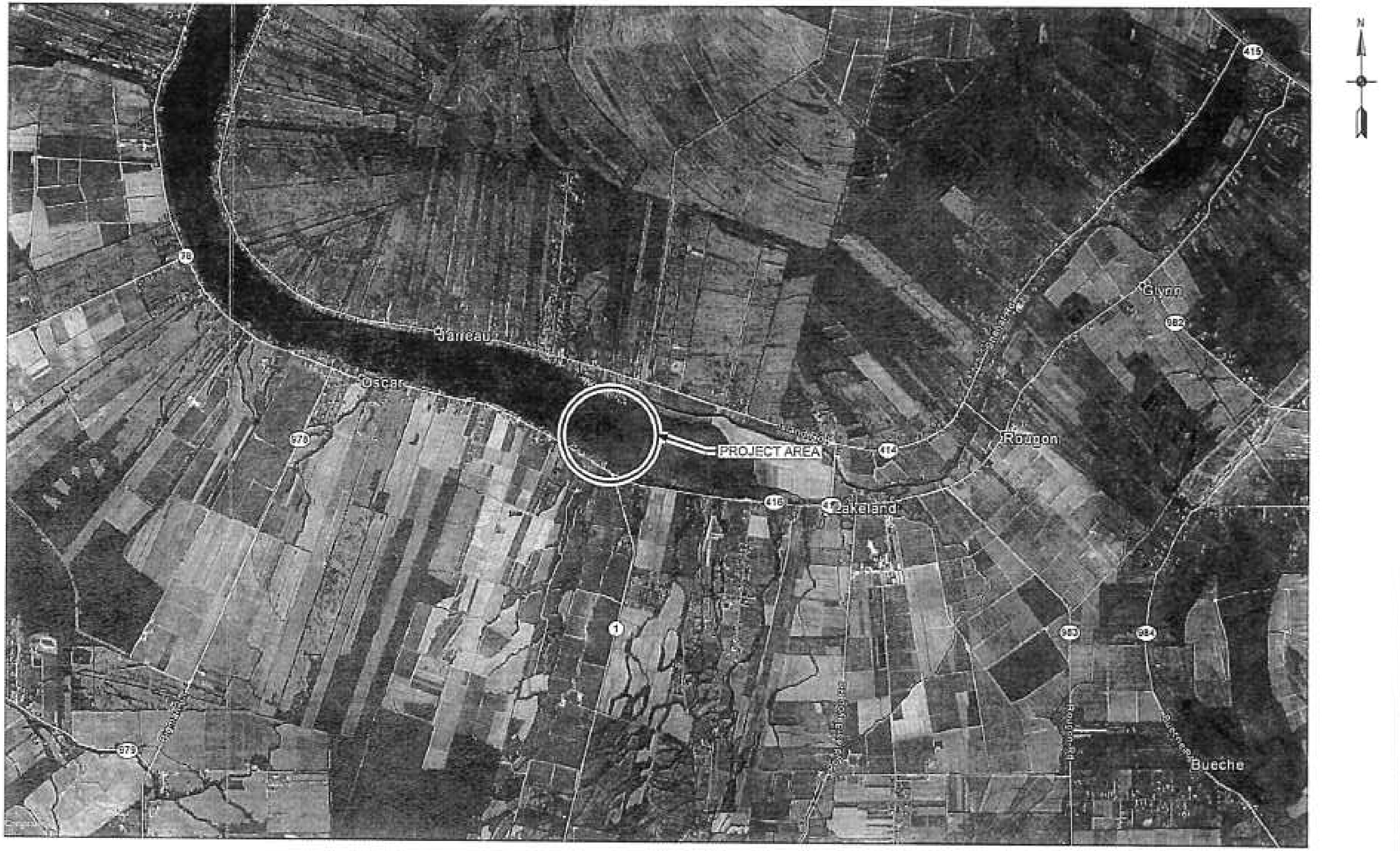
appear, it will be necessary to reevaluate the recommendations contained in this report.

49. Recommendations and conclusions contained in this report are to some degree subjective and should be used only for planning or design purposes. This report should not be included in the contract plans and specifications. However, the results of the soil borings and laboratory tests contained in Appendices I and II of this report may be included in the plans and specifications.

50. This report is issued with the understanding that the owner or the owner's representative has the responsibility to bring the information and recommendations contained herein to the attention of the scientists and engineers for the project so that they are incorporated into the plans and specifications for the project. The owner or owner's representative also has the responsibility to take the necessary steps to see that the general contractor and all subcontractors follow such recommendations. It is further understood the owner or owner's representative is responsible for submittal of this report to the appropriate governing agencies.

51. As the geotechnical engineer of record for this project, Eustis Engineering has striven to provide our services in accordance with generally accepted geotechnical engineering practices in this locality at this time. No warranty or guarantee is expressed or implied.

52. Eustis Engineering should be provided the opportunity for a general review of the final design and specifications in order that earthwork and foundation recommendations may be properly interpreted and implemented in the design and specifications. If Eustis Engineering is not accorded the privilege of making this recommended review, we can assume no responsibility for misinterpretation of our recommendations.



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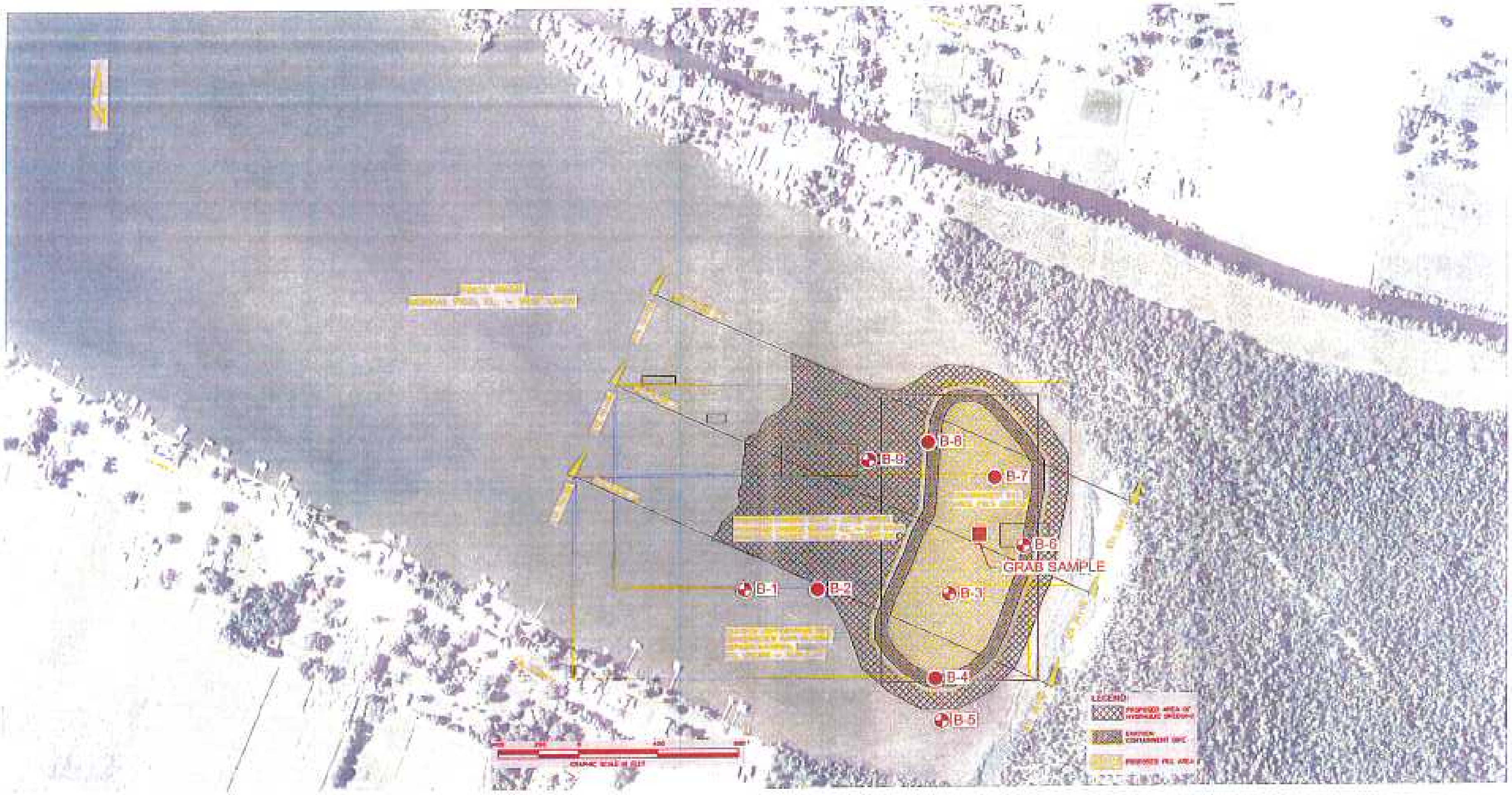
LAFAYETTE • BATON ROUGE • NEW ORLEANS • GULFPORT

SITE VICINITY MAP

FALSE RIVER ECOSYSTEM RESTORATION
PHASE I, SOUTH FLATS
POINTE COLPEE PARISH, LOUISIANA

DRAWN BY: J.L.S.	PLOT DATE: 5 DEC 13	CADD FILE: SITE VICINITY.DGN
CHECKED BY: J.T.H.	JOB NO.: 22348	FIGURE 1



DENOTES APPROXIMATE LOCATION OF UNDISTURBED SOIL BORINGS DRILLED: 28 THROUGH 30 OCTOBER 2013

DENOTES APPROXIMATE LOCATION OF VIBRACORE SAMPLES OBTAINED: 21 AND 22 OCTOBER 2013

DENOTES APPROXIMATE LOCATION OF GRAB SAMPLE OBTAINED ON 10 JANUARY 2014
FOR PERFORMING SELF-WEIGHT CONSOLIDATION TESTING AND SETTLING COLUMN TESTING

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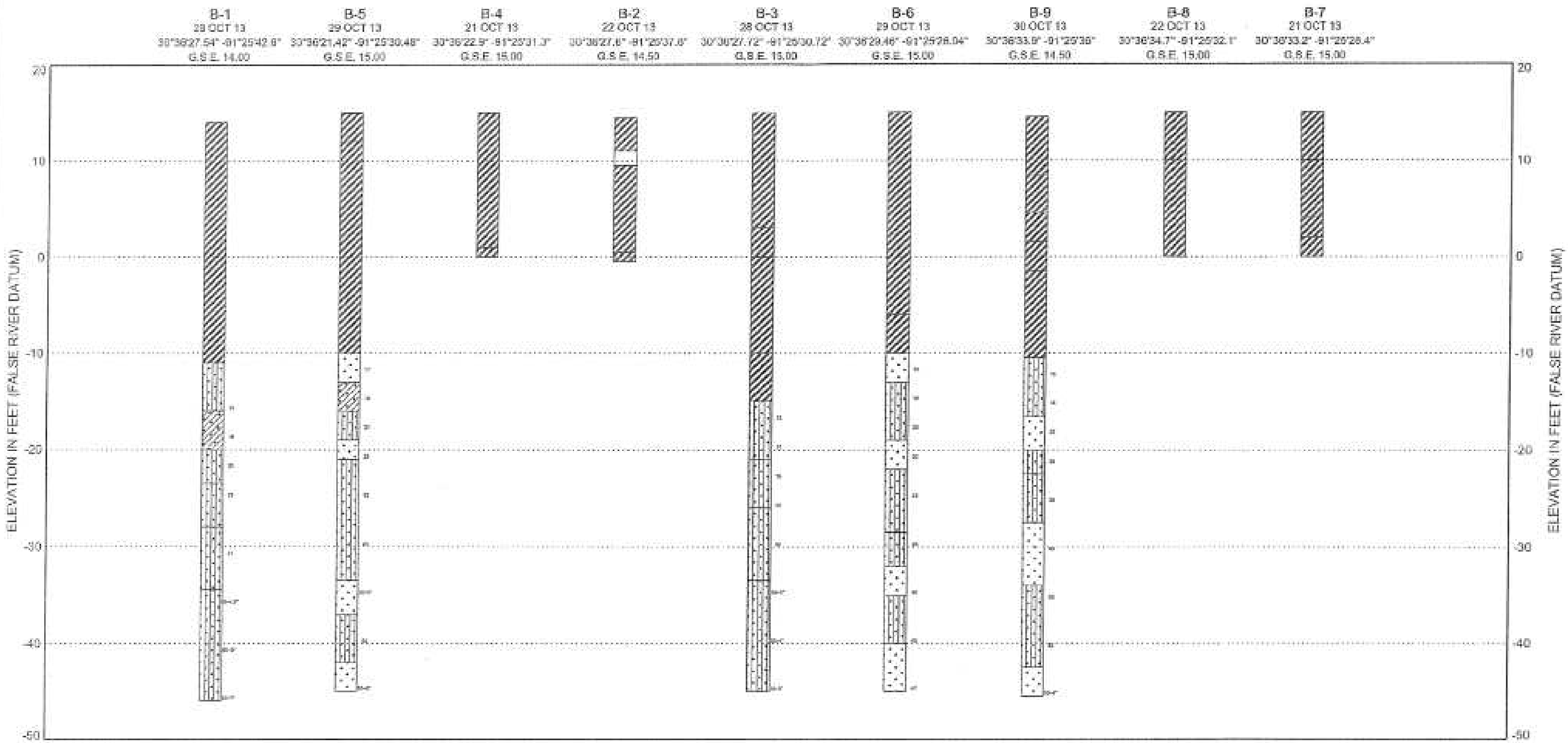
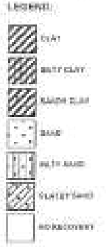
BORING LOCATION PLAN

FALSE RIVER ECOSYSTEM RESTORATION
PHASE I, SOUTH FLATS
POINTE COUPEE PARISH, LOUISIANA

DRAWN BY: J.L.S.	PLOT DATE: 14 MAR 14	CADD FILE
CHECKED BY: K.R.D.	JOB NO.: 22348	FIGURE 2



LEGEND:



NOTE:

1. NUMBERS TO THE RIGHT OF THE BORING LOG REPRESENT RESULTS OF STANDARD PENETRATION TESTS (SPT).

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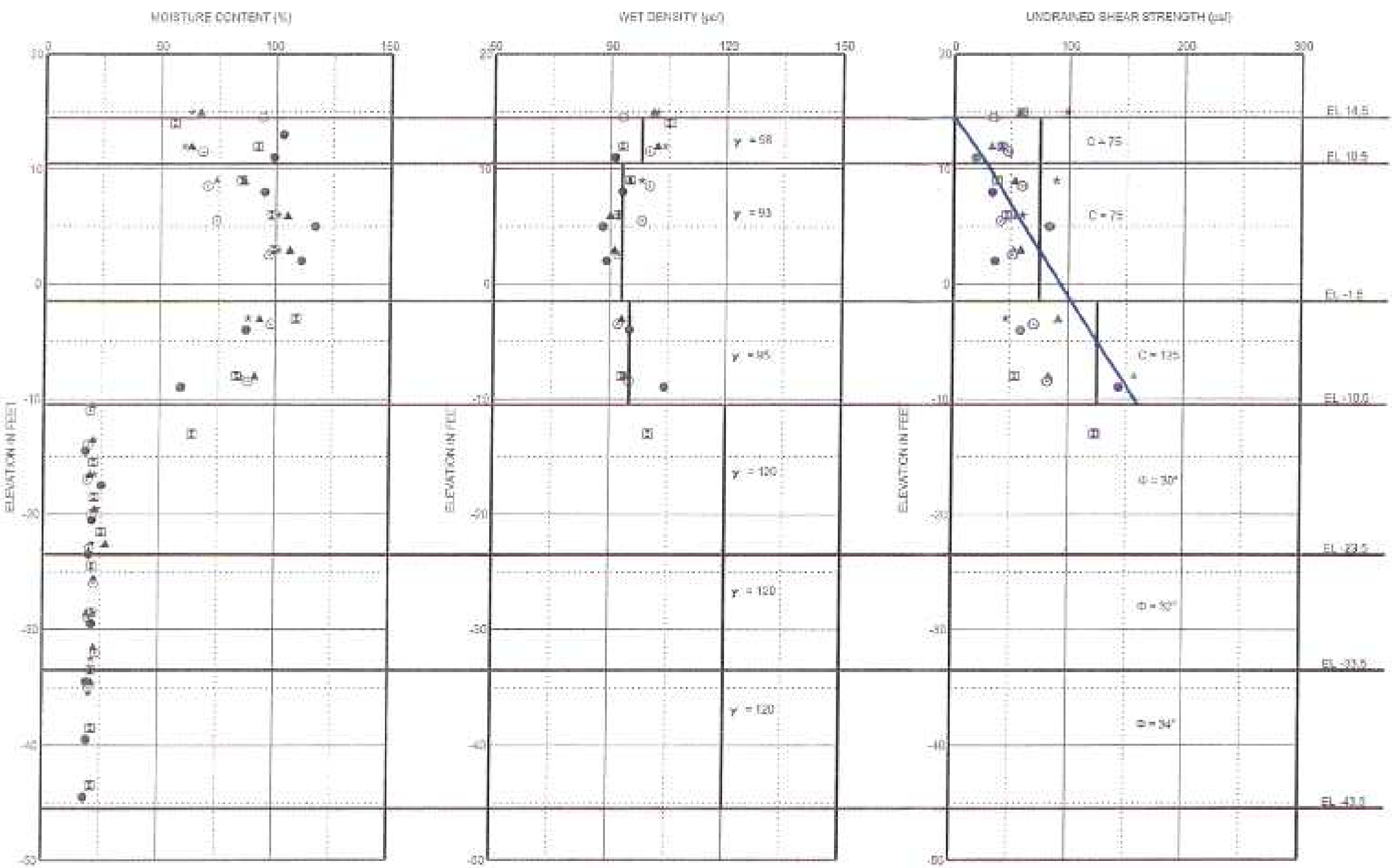
SUBSOIL PROFILE

FALSE RIVER ECOSYSTEM RESTORATION
PHASE I, SOUTH FLATS
POINTE COUPEE PARISH, LOUISIANA

DRAWN BY: J.L.B.	PLOT DATE: 5 DEC 13	CADD FILE: PROFILE.DGN
CHECKED BY: J.T.H.	JOB NO.: 22346	FIGURE 3



Boring No.
- ● B-1
- ⊡ B-3
- ▲ B-5
- ★ B-6
- ⊙ B-9

UC TESTS ARE BLUE
UU TESTS ARE GREEN
DESIGN LINE IS BLACK
0.20 C/P LINE IS LIGHT BLUE

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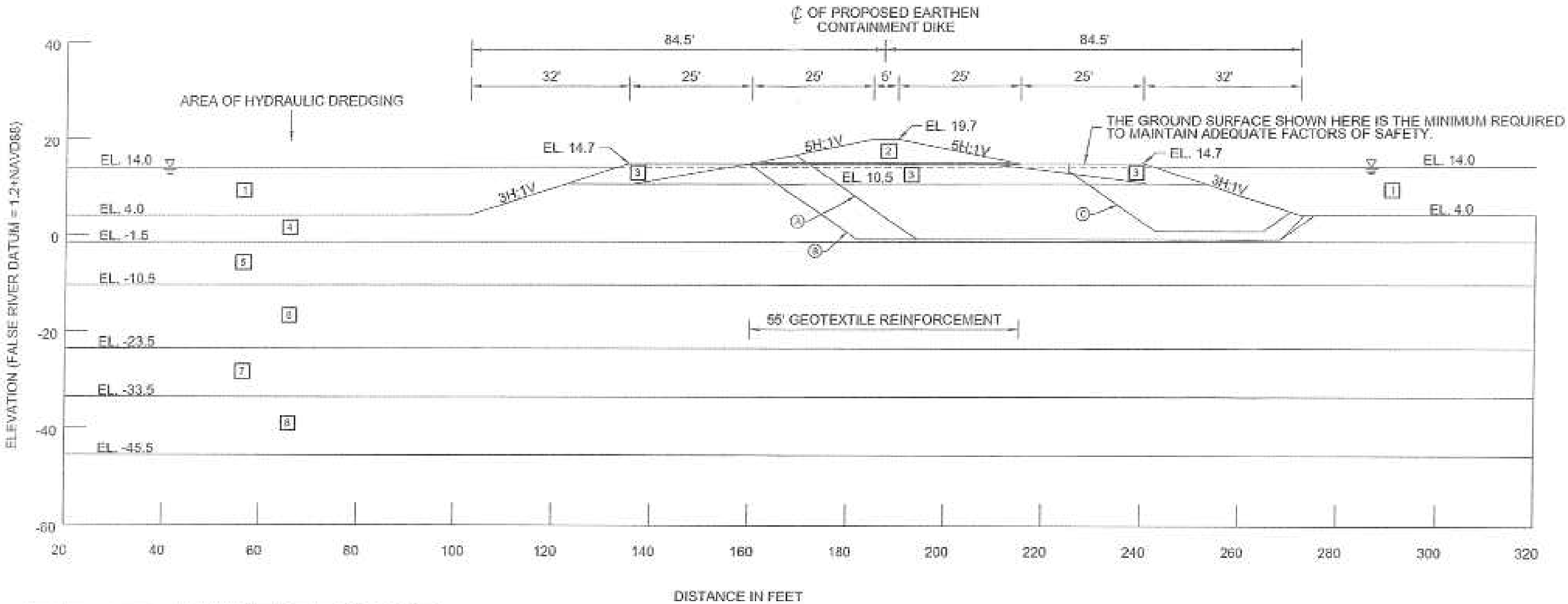
SOIL PARAMETERS

FALSE RIVER ECOSYSTEM RESTORATION
PHASE I, SOUTH FLATS
POINTE COUPEE PARISH, LOUISIANA

DRAWN BY: J.L.S.	PLOT DATE: 6 DEC 13	CADD FILE:
CHECKED BY: J.T.H.	JOB NO.: 21843	FIGURE 4



SOIL NO.	DESCRIPTION	FRICTION ANGLE IN DEGREES	UNIT WEIGHT IN PCF	COHESION IN PSF	
				AVG.	BASE
1	WATER	0	62.4	0	0
2	EARTHEN CONTAINMENT DIKE	0	100	200	200
3	CLAY	0	98	76	73
4	CLAY	0	93	75	77
5	CLAY	0	95	125	125
6	SAND	30	120	0	0
7	SAND	32	120	0	0
8	SAND	34	120	0	0

SLIP SURFACE DESIGNATION	TYPE OF SEARCH	FACTOR OF SAFETY	FILE NAME	MINIMUM REQUIRED FACTOR OF SAFETY
A	BLOCK SPECIFIED	1.17	FALSE RIVER ANALYSIS WITH BERM AND BENCH REVISED EL 19.7_GT_B_EL 11 NC REV (BS 14 LT TO RT THRU).GSZ	1.10
B	BLOCK SPECIFIED	1.36	FALSE RIVER ANALYSIS WITH BERM AND BENCH REVISED EL 19.7_GT_B_EL 11 NC REV (BS 14 LT TO RT AROUND).GSZ	
C	BLOCK SPECIFIED	1.43	FALSE RIVER ANALYSIS WITH BERM AND BENCH REVISED EL 19.7_GT_B_EL 11 NC REV (BS 14 LT TO RT LOCAL).GSZ	

NOTES:

1. SLOPE STABILITY ANALYSES WERE PERFORMED BY SPENCER'S METHOD USING SLOPE/W SOFTWARE, VERSION 7.23.
2. GEOTEXTILE STRENGTH USED IN ANALYSES EQUALS 14,000 LBS/FT AT 5% STRAIN.
3. BECAUSE BOTH SIDES OF THE CONTAINMENT DIKE ARE SYMMETRICAL, ANALYSIS WAS PERFORMED ON ONE SIDE. EUSTIS ENGINEERING SHOULD BE CONTACTED IF THIS ASSUMPTION IS INVALID.

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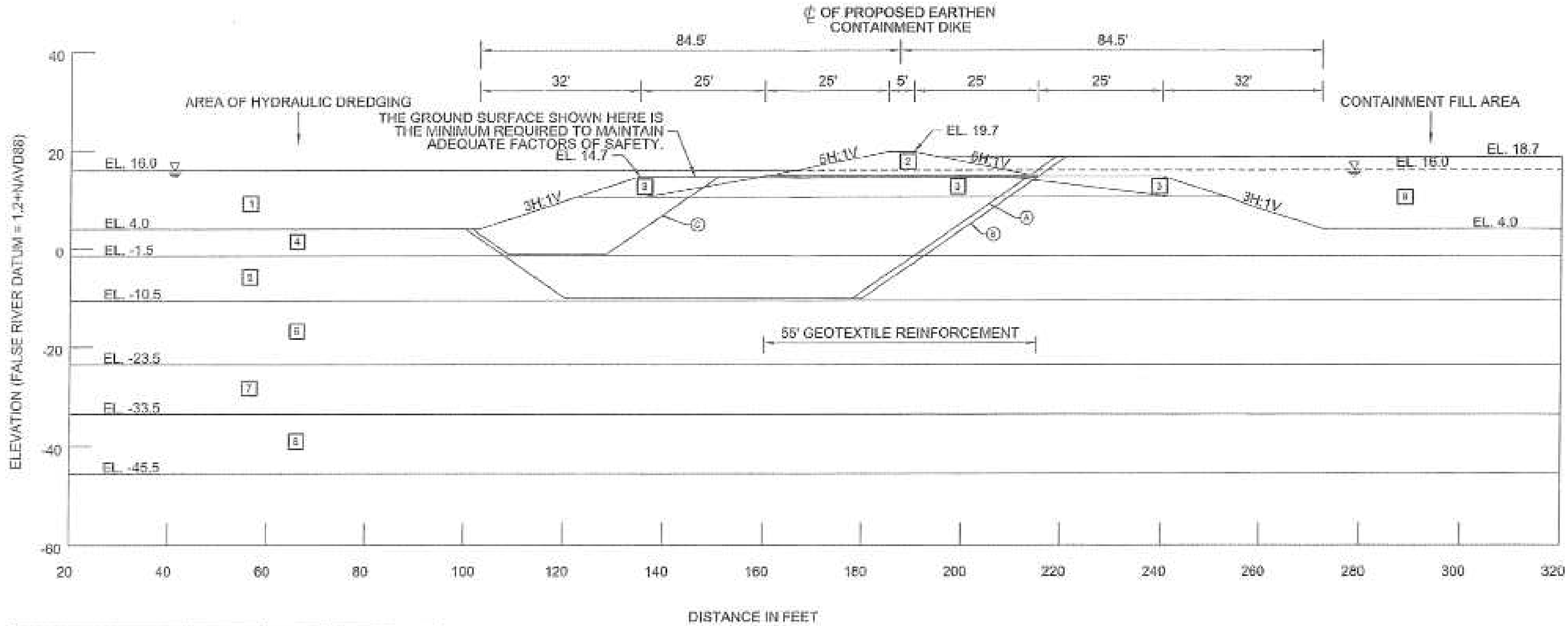
SLOPE STABILITY ANALYSES - EARTHEN CONTAINMENT DIKE ALTERNATIVE DURING CONSTRUCTION

FALSE RIVER ECOSYSTEM RESTORATION
PHASE I, SOUTH FLATS
POINTE COUPEE PARISH, LOUISIANA

DRAWN BY: J.L.S.	PLOT DATE: 14 MAR 14	CADD FILE:
CHECKED BY: K.R.D.	JOB NO.: 22348	FIGURE 5



SOIL NO.	DESCRIPTION	FRICTION ANGLE IN DEGREES	UNIT WEIGHT IN PCF	COHESION IN PSF	
				AVG.	BASE
1	WATER	0	62.4	0	0
2	EARTHEN CONTAINMENT DIKE	0	100	200	200
3	CLAY	0	98	75	75
4	CLAY	0	93	75	75
5	CLAY	0	96	125	125
6	SAND	30	120	0	0
7	SAND	32	120	0	0
8	SAND	34	120	0	0
9	HYDRAULICALLY DREDGED/ PUMPED SLURRY	0	75	75	75

SLIP SURFACE DESIGNATION	TYPE OF SEARCH	FACTOR OF SAFETY	FILE NAME	MINIMUM REQUIRED FACTOR OF SAFETY
(A)	BLOCK SPECIFIED	1.20	22348 FALSE RIVER EL 19.7_GT, BENCH WITH HP SLURRY (BS 18 RT TO LT THRU).GSZ	1.10
(B)	BLOCK SPECIFIED	1.27	22348 FALSE RIVER EL 19.7_GT, BENCH WITH HP SLURRY (BS 18 RT TO LT AROUND).GSZ	
(C)	BLOCK SPECIFIED	1.53	22348 FALSE RIVER EL 19.7_GT BENCH WITH HP SLURRY (BS 18 RT TO LT LOCAL).GSZ	

NOTES:

1. SLOPE STABILITY ANALYSES WERE PERFORMED BY SPENCER'S METHOD USING SLOPE/W SOFTWARE, VERSION 7.23.
2. GEOTEXTILE STRENGTH USED IN ANALYSES EQUALS 14,000 LBS/FT AT 5% STRAIN.

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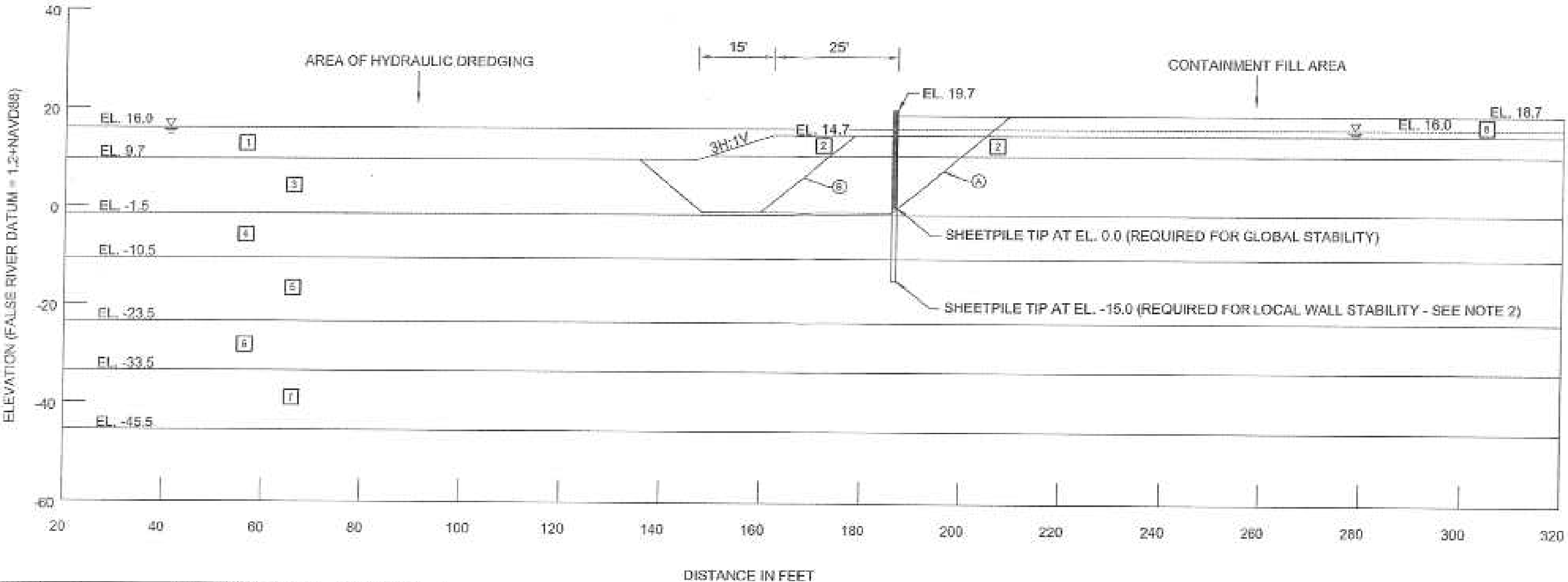
SLOPE STABILITY ANALYSES - EARTHEN CONTAINMENT DIKE ALTERNATIVE
FINAL CONSTRUCTION

FALSE RIVER ECOSYSTEM RESTORATION
PHASE I, SOUTH FLATS
POINTE COUPEE PARISH, LOUISIANA

DRAWN BY: J.L.S.	PLOT DATE: 14 MAR 14	CADD FILE:
CHECKED BY: K.R.D.	JOB NO.: 22348	FIGURE 6



SOIL NO.	DESCRIPTION	FRICTION ANGLE IN DEGREES	UNIT WEIGHT IN PCF	COHESION IN PSF	
				AVG.	BASE
1	WATER	0	62.4	0	0
2	CLAY	0	98	75	75
3	CLAY	0	93	75	75
4	CLAY	0	95	125	125
5	SAND	30	120	0	0
6	SAND	32	120	0	0
7	SAND	34	120	0	0
8	HYDRAULICALLY DREDGED/ PUMPED SLURRY	0	75	75	75

SLIP SURFACE DESIGNATION	TYPE OF SEARCH	FACTOR OF SAFETY	FILE NAME	MINIMUM REQUIRED FACTOR OF SAFETY
(A)	BLOCK SPECIFIED	1.30	22348 FALSE RIVER EL 19.7_GT, BENCH WITH HP SLURRY_SHEETPILE (BS 16 RT TO LT BS).GSZ	1.30
(B)	BLOCK SPECIFIED	2.37	22348 FALSE RIVER EL 19.7_GT BENCH WITH HP SLURRY_SHEETPILE (BS 16 RT TO LT BS LOCAL).GSZ	

NOTES:

1. SLOPE STABILITY ANALYSES WERE PERFORMED BY SPENCER'S METHOD USING SLOPE/W SOFTWARE, VERSION 7.23.
2. SHEETPILE TIP DETERMINED BASED ON GLOBAL SLOPE STABILITY IS PRESENTED HERE. THE INTERNAL STABILITY (I.E., LOCAL, WALL STABILITY) GOVERNS THE SHEETPILE DESIGN, AND A TIP AT EL. -15 IS RECOMMENDED. THIS IS A 35.7-FT SHEETPILE. WE DETERMINED THIS TIP ELEVATION USING THE CWALSHT PROGRAM, CONVENTIONAL EARTHEN PRESSURE THEORY, AND A FACTOR OF SAFETY OF 1.30 APPLIED TO THE SOIL STRENGTHS. THIS ALSO RESULTS IN A MAXIMUM BENDING MOMENT OF 15 KIP-FT.

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SLOPE STABILITY ANALYSES - SHEETPILE ALTERNATIVE FINAL CONSTRUCTION

FALSE RIVER ECOSYSTEM RESTORATION
PHASE I, SOUTH FLATS
POINTE COUPEE PARISH, LOUISIANA

DRAWN BY: J.L.S.	PLOT DATE: 14 MAR 14	CADD FILE: WALLGSH
CHECKED BY: K.R.D.	JOB NO.: 22348	FIGURE 7