MC Squared, Inc.

Preliminary Geotechnical Engineering Services Report

Bull Barn Trail over Devil's Creek Bridge Replacement
Sumter County, Florida

Prepared for: ***Greenman-Pedersen, Inc.***
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Project No. T041705.067
October 2017

MC^2
GEOTECHNICAL • ENVIRONMENTAL
MATERIALS TESTING

October 2, 2017

Mr. Roger Menendez, A.I.C.P., C.E.
Greenman-Pedersen, Inc.
1000 North Ashley Drive, Suite 100
Tampa, Florida 33602

Subject: Preliminary Geotechnical Engineering Services Report
Bull Barn Trail over Devil's Creek Bridge Replacement
Sumter County, Florida
MC^2 Project Number T041705.067

Dear Mr. Menendez:

MC Squared, Inc. (MC^2) has completed our Preliminary Geotechnical Engineering Services Report (Report) for the proposed Bull Barn Trail over Devil's Creek Bridge Replacement in Sumter County, Florida. These services included both a subsurface exploration and laboratory testing, and the results, together with our recommendations, are included in the accompanying Report. The project and Report were performed in general accordance with Florida Department of Transportation (FDOT) guidelines.

We trust that this report will assist you in further design development and construction of the proposed project. We appreciate the opportunity to be of service on this project. Should you have any questions, please do not hesitate to contact us.

Respectfully submitted,
MC^2

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APPENDIX

1 PROJECT INFORMATION

MC^2 has completed our preliminary geotechnical engineering services for the proposed Bull Barn Trail over Devil's Creek Bridge Replacement in Sumter County, Florida. Included in this Report are the results of the subsurface exploration and laboratory testing performed, as well as our recommendations regarding pile foundations for the bridge and shallow foundation considerations for box culvert or ConSpan design alternatives.

1.1 Project Authorization

Our services have been performed in general accordance with **MC^2** Proposal T041705.067 dated May 19, 2017 and the Sub-Consultant Agreement for Design Services with **Greenman-Pedersen, Inc. (GPI)** dated July 10, 2017.

1.2 Project Location and Description

The existing bridge on Bull Barn Trail is across Devil's Creek in the Green Swamp in Sumter County, Florida. Project information has been provided by Mr. Roger Menendez of **GPI** and Mr. Jeffrey Hagberg of **Southwest Florida Water Management District (SWFWMD)**, through verbal and email communications including partial copies of a previous Bridge Inspection Report. The bridge is currently closed to public vehicles and is load-restricted with a posted weight limit of 13 tons to authorized vehicles and personnel only. We understand that the existing bridge was constructed around 1959 and consists of eight, 10-foot spans of steel stringers (railroad and crane rails) supported by timber piles and caps.

Our geotechnical services are required to provide foundation recommendations to support the proposed bridge. No design information for the new bridge has been provided at this time. Estimated depths for round timber piles and square prestressed concrete piles (14, 16 and 18-in.) have been requested. The design team is also considering shallow foundations in case a box culvert or ConSpan option might be viable. Recommendations for a box culvert option have been evaluated for this Report.

If any of the noted information presented is incorrect or has changed, please inform **MC^2** so that we may amend the recommendations presented in this Report, if appropriate or necessary.

2 PURPOSE AND SCOPE OF SERVICES

The purpose of this scope of services was to obtain information on the general subsurface conditions at the proposed project site. The subsurface materials encountered were then evaluated with respect to the available project characteristics. In this regard, engineering assessments of the following items have been formulated:

1. Deep pile foundation system, evaluations and analyses. The analyses included design dimensions and estimated axial capacities.

2. Box culvert considerations related to the anticipated subsurface conditions.

3. Soil subgrade preparation, including stripping, grubbing and compaction. Engineering criteria for placement and compaction of approved structural fill materials.

4. Suitability of on-site soils for use as structural fill for the bridge or box culvert structure.

5. General location and description of potentially deleterious materials encountered in the borings, which may interfere with construction progress or structure performance, including existing fills or organics.

6. Identification of some critical design or construction details, including groundwater levels (seasonal fluctuations).

The following services were provided in order to achieve the preceding objectives:

1. Reviewed readily available soils information titled "Soil Survey of Sumter County, Florida" published by the United States Department of Agriculture (USDA) Soil Conservation Service (SCS).

2. Executed a program of subsurface exploration consisting of subsurface sampling and field testing. As requested by the client, a total of two (2) Standard Penetration Test (SPT) borings, extending to depths of 40 and 45 feet below the existing ground surface (bgs) were performed at the bridge approaches near the proposed end bent areas.

3. Visually classified representative soil samples in the laboratory using the Unified Soil Classification System. Conducted a laboratory testing program consisting of percent passing the No. 200 sieve, Atterberg limits, organic content and natural moisture content tests. Identified soil conditions at each boring location and formed an opinion of the soil stratigraphy.

4. Collected soil samples for corrosion series testing consisting of: pH, sulfate, chloride and resistivity. The results are used for the environmental classification of the substructure.
5. Collected groundwater level measurements and estimated seasonal high groundwater levels.

6. Summarized the results of the subsurface exploration and laboratory testing, and preliminary geotechnical engineering recommendations that are presented herein.

The locations of the SPT borings performed, including the soil profiles, are presented on **Sheet 2** in the **Appendix.**

The scope of our services did not include an environmental assessment for determining the presence or absence of wetlands or hazardous or toxic materials in the soil, bedrock, groundwater, or air, on or below or around the project site. Any statements in this Report or on the boring profiles regarding odors, colors, unusual or suspicious items or conditions are strictly for the information of our client. In addition, our scope of services did not include an evaluation of sinkholes or sinkhole activity and none were performed.

3 SITE AND SUBSURFACE CONDITIONS

3.1 Site Conditions

The existing bridge structure is located along Bull Barn Trail over Devil's Creek, about 1 mile west of Tanic Grade Road in the Green Swamp in Sumter County, Florida. The bridge consists of eight, 10-foot spans of steel stringers (railroad and crane rails) supported by timber piles and caps. Each timber cap appears to be a railroad cross tie that is supported by three (3) round timber piles. In the last bridge inspection report dated January 13, 2016, no erosion of the slopes and no deficiencies of a critical nature were noted.

3.2 General Geology

The geology of Sumter County can briefly be described as surficial sands and clays, sandy clays and clayey sands overlying Limestone.

3.3 Sumter County Soil Survey

Based on a review of the Sumter County Soil Survey, for near-surface soils (ground surface to 80 inches below ground surface) it appears that there are two (2) primary soil mapping units noted within the vicinity of the existing bridge: Paisley fine sand, boulder subsurface (Map Unit 9) and Nittaw muck, frequently flooded (Map Unit 29).

Paisley find sand, bouldery subsurface (9) has a parent material of clayey marine deposits and a typical profile of sand from 0 to 16 inches bgs followed by sandy clay from 16 to 80 inches bgs. The material is somewhat poorly drained and has a moderately low to high capacity to transmit water. The depth to water table is about 6 inches.

Nittaw muck, frequently flooded (29) has a parent material of clayey marine deposits and a typical profile of muck from 0 to 5 inches bgs, loamy fine sand from 5 to 12 inches bgs, followed by sandy clay from 12 to 65 inches bgs, and loamy fine sand from 65-80 inches bgs. The material is very poorly drained and has a moderately low to moderately high capacity to transmit water. The depth to water table is about 0 to 12 inches.

This information was published in a report titled *The Soil Survey of Sumter County, Florida* using Version 15, dated September 28, 2016. The aerial images were photographed from February 2, 2015 to March 18, 2017.

The USDA Soil Survey is not necessarily an exact representation of the soils on the site. The mapping is based on interpretation of aerial maps with scattered shallow borings for confirmation. Accordingly, borders between mapping units are approximate and the change may be transitional. Differences may also occur from the typical stratigraphy, and small areas of other similar and dissimilar soils may occur within the soil-mapping unit. As such, there may be differences in the mapped description and the boring descriptions obtained for this report. The survey may, however, serve as a good basis for evaluating the shallow soil conditions of the area.

3.4 Standard Penetration Test (SPT) Borings

A total of two (2) SPT borings were drilled to depths of 40 and 45 feet bgs at the approximate locations shown on the **Report of Borings** (**Sheet 2)** in the **Appendix**. The SPT boring procedure was conducted in general accordance with the ASTM test designation D-1586. Closely spaced samples using a 2-inch OD split-barrel sampler were collected in the upper 4 to 10 feet with 5-foot sample intervals used thereafter. After initial penetration of 6-inches of the split-barrel sampler into the soil, the number of successive blows from the same 140-lb. hammer operating freely over a 30-in. drop required to drive the sampler a further 12 inches into the soil constitutes the test result commonly referred to as the “N” value. The “N” value has been empirically correlated with various soil properties and is considered to be indicative of the soil density of cohesionless soils and the consistency of cohesive soils. The recovered split-barrel samples were visually classified in the field with representative portions of the samples placed in airtight jars and transported to our Tampa office for review by a geotechnical engineer and confirmation of the field classifications. Rock coring was not a part of the scope of services and was not performed.

3.5 Generalized Subsurface Conditions

The following subsurface description is of a generalized nature, provided to highlight the major soil strata encountered. The boring logs/soil profiles, included in the **Report of Borings, Sheet 2** in the **Appendix**, should be reviewed for specific information at individual test locations. The stratifications shown on the boring profiles represent the conditions only at the actual test locations. Variations may occur and should be expected between test locations. The stratifications represent the approximate boundary between and among subsurface materials; however, the transition may be gradual.

The soils encountered in the soil borings are generally consistent across the site. The upper soils from the ground surface to 2 to 4 feet bgs are fine SAND and slightly silty fine SAND (SP, SP-SM). A very loose silty SAND layer was penetrated from 4 to 7 feet bgs in boring SPT-02 before encountering a loose to medium dense clayey SAND layer to 28.5 feet bgs. A similar loose to medium dense clayey SAND layer was observed from 2 to 18.5 feet bgs in boring SPT-01. The clayey SAND stratum is underlain by weathered limestone at 18.5 and 28.5 feet bgs to the boring termination depths of 40 and 45 feet bgs at SPT-01 and SPT-02, respectively. The weathered limestone varies in hardness and contains layers of calcareous clay with limestone fragments.

3.6 Groundwater Information

Groundwater measurements ranged from 4.5 to 5 feet bgs in the boreholes at the time of drilling. Groundwater levels will vary with seasonal conditions, such as the frequency and magnitude of rainfall patterns, as well as man-made influences including existing water management canals, swales, drainage ponds, underdrains and areas of covered soils such as paved parking lots.

Based on the borings performed, the estimated seasonal high ground water table (SHWT) levels in the vicinity of the bridge are estimated to be at 1 to 2 feet bgs at the boring locations. These estimates are based on soil stratigraphy, measured groundwater levels from the borings, the Sumter County, Florida USDA Soil Survey information and the water levels in the creek. Flood stage water levels and creek water levels are different from the SHWT.

The groundwater levels encountered at the time of our drilling are shown on the soil profiles in the **Appendix**. We recommend that the contractor determine the actual groundwater levels at the time of construction to determine groundwater impact on the construction procedures. According to the Sumter County Soil Survey, a SHWT ranging from 0 to 1 foot bgs can be anticipated along the banks of the waterway. As previously mentioned, stratigraphy differences can occur within soil mapping unit information. Therefore, it is our opinion that the SHWT will be at 1 to 2 feet bgs at the boring locations.

4 LABORATORY TESTING

4.1 General

A representative set of soil samples was tested in the laboratory to assist in the classification and determination of engineering characteristics of the soils based on their mechanical and physical behavior. Laboratory testing was accomplished in general accordance with applicable ASTM standards. Laboratory tests completed on soil samples retrieved for this project and summarized in Table 1 below, include:

- nine (9) moisture content determinations,
- nine (9) percent passing the No. 200 US standard sieve tests,
- seven (7) Atterberg limit determination tests [five (5) samples were determined to be non-plastic (N.P.)], and
- visual classification in general accordance with applicable procedures.

Results for each of these laboratory tests are summarized in the following table and are also presented on the individual **Soil Profile** logs provided in the **Appendix.**

Table 1: Summary of Laboratory Testing

Boring No. (Depth) (ft.)	Moisture Content (%)	Sieve Analysis (% Passing)							Liquid Limit	Plastic Limit	Plastic Index	USCS
		#10	#20	#40	#60	#100	#140	#200				
SPT-01 (4-6)	24.0	-	-	-	-	-	-	25.6	27	17	10	SC
SPT-01 (6-8)	20.0	100	99.8	94.8	68.4	39.9	25.6	20.9	-	-	N.P.	SC
SPT-01 (8-10)	20.1	100	99.3	93.4	66.1	40.1	28.0	23.8	-	-	N.P.	SC
SPT-01 (13.5-15)	23.0	-	-	-	-	-	-	40.4	46	16	30	SC
SPT-02 (4-6)	57.1	100	98.7	93.9	73.1	44.1	27.3	20.6	-	-	-	SM
SPT-02 (6-7)	21.3	-	-	-	-	-	-	22.2	-	-	N.P.	SC
SPT-02 (7-8)	22.5	-	-	-	-	-	-	20.7	-	-	N.P.	SC
SPT-02 (8-10)	18.2	-	-	-	-	-	-	22.8	-	-	N.P.	SC
SPT-02 (13.5-15)	14.8	100	99.1	89.0	49.7	24.4	19.0	18.2	-	-	-	SC

In addition to the above laboratory testing, environmental corrosion tests were conducted in accordance with the FDOT test designations FM 5-550, FM 5-551, FM 5-552 and FM 5-553. These tests were performed on recovered soil samples obtained from soil borings performed at the site. Environmental corrosion tests measure parameters such as pH, resistivity, sulfate content and chloride content. Test results obtained are presented in Table 2 on the following page. Based on the laboratory test results and the FDOT Structures Design Guidelines, Jan 2017, the subsurface soil conditions should be classified as moderately aggressive for both steel and concrete. This classification was based on Section 1.3.2 and 1.3.3 of the Structures Design Guidelines. We recommend using the applicable provisions in the FDOT Structures Design Guidelines and FDOT Standard Specifications for corrosion protection.

Table 2: Summary of Environmental Corrosion Test Results

Sample No.	Sample Depth (ft)	USCS	pH	Resistivity (ohms-cm)	Sulfates (ppm)	Chlorides (ppm)	Individual Environmental Classification *	
							Steel	Concrete
1	14	SC	8.62	2677	3.0	2.4	Moderately Aggressive	Moderately Aggressive
2	24	SC	7.53	2142	3.9	3.4	Moderately Aggressive	Moderately Aggressive
Sample 1 – west end of bridge abutment (SPT-01) approx. 13.5-15' below grade.								
Sample 2 – east end of bridge abutment (SPT-02) approx. 23.5-25' below grade.								
Notes:	*As per FDOT Structures Design Guidelines (Version 2017) Section 1.3.2, Table 1.3.2-1							
	Section 1.3.3, Figure 1.3.3-1 Superstructure is classified as Slightly Aggressive Table 1.3.2-1 Substructure classified as Moderately Aggressive for both Steel and Concrete							
pH (FM-5-550); Resistivity (FM-5-551); Sulfates (FM-5-553); Chlorides (FM-5-552)								

5 EVALUATION AND RECOMMENDATIONS

The following preliminary recommendations have been developed on the basis of the previously described project characteristics and subsurface conditions encountered. If there are any changes in the project characteristics, including project location on the site, a review must be made by **MC^2** to determine if any modifications in the recommendations would be required.

5.1 Foundation Alternatives

Precast Pre-stressed Square Concrete (PSC) Piles (14, 16 and 18-inch)

Precast pre-stressed concrete piles are a feasible foundation alternative for the project. They are a widely used and a proven foundation system in West Central Florida. Precast pre-stressed square concrete piles are readily available and generally have a lower cost per ton of capacity than other pile types. The minimum size of prestressed concrete piles used by FDOT on a vehicular bridge is 18-in. square, as referenced in the Structures Design Guidelines (625-020-018). Depending on the applied loads, it may be possible to use 14-in. or 16-in. square PSC piles for this rural bridge. A disadvantage of the precast pre-stressed concrete piles is the potential impact the driving operation may have on existing nearby structures. However, at this site there are no nearby structures that would be impacted by driving vibrations.

Round Timber Piles (12 and 14-inch)

Round timber piles are typically used by the FDOT for temporary bridges and pedestrian bridges; however, if acceptable, they are also an alternative for this project and are an economical foundation system. Southern Yellow Pine, size 12 and 14-inch treated, round timber piles were analyzed for pile capacity.

5.2 Pile Design Criteria

- Precast Pre-stressed Square Concrete (PSC) Piles or Round Timber Piles
- End bents and surrounding embankments will be protected with rubble riprap or fabriform type erosion protection, making the abutment scour negligible.
- The top of pile for the end bents is assumed to be at the ground surface elevation of our test boring locations. For the intermediate bents, we assumed that the scour depth is 8 feet below our test boring elevation.
- Significant fill is not anticipated at the end bents; therefore, downdrag loads are not anticipated or are negligible.
- Pile driving analyzer (PDA) is recommended by **MC^2** for quality assurance/quality control. Therefore, a resistance factor (ϕ) of 0.65 may be used to calculate the **Nominal Bearing Resistance (NBR), which has to be equal or higher than the factored load divided by 0.65 plus side resistance for the scour zone. Downdrag has been assumed to be negligible.**

1. Axial Capacity

Axial capacities (estimated Davisson capacities) were computed for the PSC piles using the FDOT program "SPT 97", and to calculate the estimated ultimate capacity for the timber piles we used "A-Pile" by Ensoft, Inc. The capacities were calculated anticipating both end bearing and skin friction for the piling. For the PSC piles, a summary of the results of these analyses for 14, 16 and 18-in. piles are presented in the graphs of Pile Depth (feet) vs. Estimated Davisson Capacity (tons) for each boring for both the end bent and intermediate bents. For the timber piles, graphs showing Pile Depth (feet) vs Estimated Ultimate Capacity (tons) are provided for 12 and 14-inch round piles for each boring for both the end bent and intermediate bents. The capacity curves are shown in the **Appendix.**

2. Lateral Load Analyses

Detailed lateral load analyses of the piles were not performed by **MC^2**. If lateral load analysis is required, we can be retained to provide this service.

3. Downdrag (Negative Skin Friction)

The value of the unit friction or adhesion force developed between the pile and its surrounding soil depends upon the nature and strength of the soils, the nature and method of the pile installation, and the relative displacement between the soil and the pile. When the foundation soil is in equilibrium (not settling) and the pile settles under the action of external loads, friction and/or adhesion is mobilized on the contact surface in a positive sense, that is, opposite to the sense of the external load. However, if a portion of the foundation soil settles relative to the pile, the same friction and/or adhesion is mobilized in this portion of the pile but in the opposite direction to that in the previous case i.e., in a negative sense. The total value of this mobilized force is called negative skin friction (NSF). The following situations can produce continuing settlements of certain portions of the foundation soils after piles have been installed:

1. The foundation soils may be under-consolidated under existing natural overburden.
2. Foundation strata of compressible soils may be consolidating under the load of recently placed fills.
3. Foundation strata of compressible soils may start consolidating under the load of new fills necessary to achieve certain grade elevations. However, minimal fills are anticipated.
4. Consolidation of compressible soils can be induced by lowering of the water table e.g., due to pumping in the vicinity.
5. Consolidation of soft compressible soils can be induced by the remolding effects due to the soils displacement in sites where large numbers of piles are driven.

Significant down drag loads are not anticipated for this project.

4. Anticipated Driving Conditions

Based on the information provided from the boring logs, there does not appear to be a very hard soil or rock layer, therefore, pre-drilling does not appear to be necessary. However, care should be taken not to overstress the pile during driving.

While a slight variation in the bearing stratum surface throughout the project site was encountered during the subsurface investigation, we caution the users of this report that, **somewhat smaller or larger variances in the pile tip elevations may be realized and should be anticipated.**

For structures that are below grade, the piles may have to be installed prior to or after the excavation. The excavated holes may be backfilled, after the piles are installed. Pile top elevations can also be temporarily extended to near grade and then cut-off to final grade after excavation is complete and the pile is exposed.

5. Vibration Considerations

We are not aware of any nearby structures located in relatively close proximity to the proposed bridge structure.

6. Test Pile Program

We preliminarily recommend performing dynamic pile testing (PDA) during pile driving on a minimum of one (1) pile per end bent and (1) pile per every other intermediate bent to confirm the required pile capacity is achieved and to establish driving criteria for the remaining production piles. Once the bridge layout is determined, the recommendations for PDA testing can be re-addressed. Results of the PDA testing will be summarized and used to assess the pile bearing capacity, hammer performance and driving stresses.

The PDA monitoring should conform to FDOT Specifications 455.3.14 and Standard Test Method for High-Strain Dynamic Testing of Piles (ASTM-D4945).

7. Pile Foundations Constructability

The FDOT Standard Specifications 455 shall be used as a guideline for structure foundations and pile driving requirements. Once pile type is selected, we can provide recommendations that the structural engineer may need to consider in preparing the construction plans.

5.3 Box Culvert Option

A box culvert is being considered as an option to replace the existing bridge. Box culvert construction at this site will be difficult. The stream sediment is very soft and extends to more than 5 feet below the water/sediment line. The culvert design option should take into consideration the required dewatering and removal of the soft sediments down to stable soils. The resulting excavations can be stabilized using a geotextile wrapped washed 57 stone blanket. For estimating purposes, we recommend including 5 feet of compacted 57 stone beneath the box culvert and extending at least 5 feet beyond the horizontal limits of the box culvert and wingwall foundations. The 57 stone blanket should also extend below and beyond the footings for the box culvert wingwalls.

Below grade walls restrained at the top should be designed for "at rest" earth pressure conditions. Retaining walls that are free to deflect should be designed for "active" earth pressure conditions. The "passive" earth pressure state should be used for soils supporting the retaining structure, such as toe backfill.

Table 3 on the following page presents recommended values of earth pressure coefficients based on our experience with soils in the area. Equivalent fluid pressures are also provided for conditions above and below the groundwater table.

These design recommendations have assumed that the wall has horizontal backfill and no surcharge loads, using soils with an approximate angle of internal friction of 28 degrees, no cohesion, a total unit weight of 120 pcf, no factor of safety. Since a permanent drainage system behind the below grade walls of the structure will not be practical, the design needs to include hydrostatic pressures also. For analysis of sliding resistance of the base of the retaining walls, the ultimate coefficient of friction may be taken as 0.34 between concrete and soil. If the walls are designed using earth pressure coefficients, the hydrostatic pressure due to groundwater must be included.

Table 3: Summary of Earth Pressure Coefficients

Earth Pressure State	Earth Pressure Coefficient	Equivalent Fluid Pressure(pcf)	
		Above Water	Below Water
At-Rest	0.53	64	93
Active	0.36	43	83
Passive	2.75	--	--

The design bearing capacity for the box culvert and wingwalls supported by the geotextile wrapped 57 stone should not exceed 3,000 pounds per square foot which includes a factor of safety of 3. The below grade wall equivalent fluid horizontal design pressure criteria previously presented can be used for the box culvert design. Backfill and compaction of soils around the box culvert and wingwalls should be in general accordance with the FDOT and Sumter County specifications.

Groundwater may be a significant concern for construction of a box culvert depending on final grades, the time of year construction is performed and water level in the creek. For limited, relatively shallow excavations below the groundwater level, pumping from the excavation or sumps should be sufficient to control groundwater seepage. If deeper and larger excavations are needed, it will require more sophisticated dewatering measures such as well points or cut-off walls, which might be difficult, but possible, if needed. We strongly recommend that an experienced dewatering specialist contractor be sub-contracted for any dewatering required on the project.

6 REPORT LIMITATIONS

The recommendations submitted are based on the available soil information obtained by **MC^2** and information provided by **GPI** for the proposed project. If there are any revisions to the plans for this project or if deviations from the subsurface conditions noted in this Report are encountered during construction, **MC^2** should be notified immediately to determine if changes in the recommendations are required. If **MC^2** is not retained to perform these functions, **MC^2** cannot be responsible for the impact of those conditions on the performance of the project.

The geotechnical engineer warrants that the findings, recommendations, specifications, or professional advice contained herein have been made in accordance with generally accepted professional geotechnical engineering practices in the local area. No other warranties are implied or expressed.

After the plans and specifications are more complete, the geotechnical engineer should be provided the opportunity to review them to assess that our engineering recommendations have been properly incorporated into the design documents. At that time, it may be necessary to submit supplementary recommendations. This Report has been prepared for the exclusive use of **GPI and their Client** for the specific application to the proposed Bull Barn Trail over Devil's Creek Bridge Replacement in Sumter County, Florida.

APPENDIX

Source: Google Earth
Image Date: 3/17/17

DATE	NAME	REVISION	APPROVED BY:

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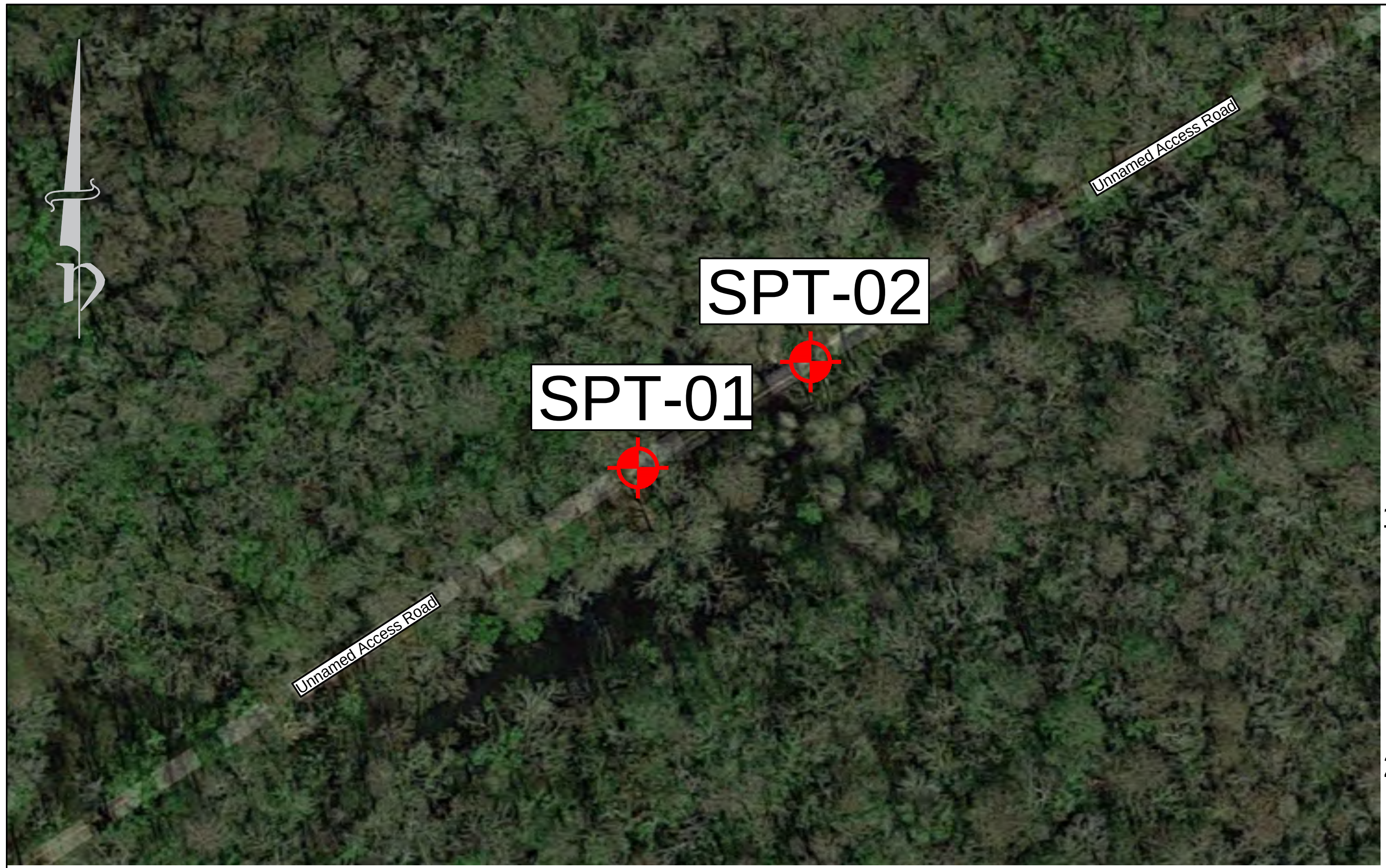
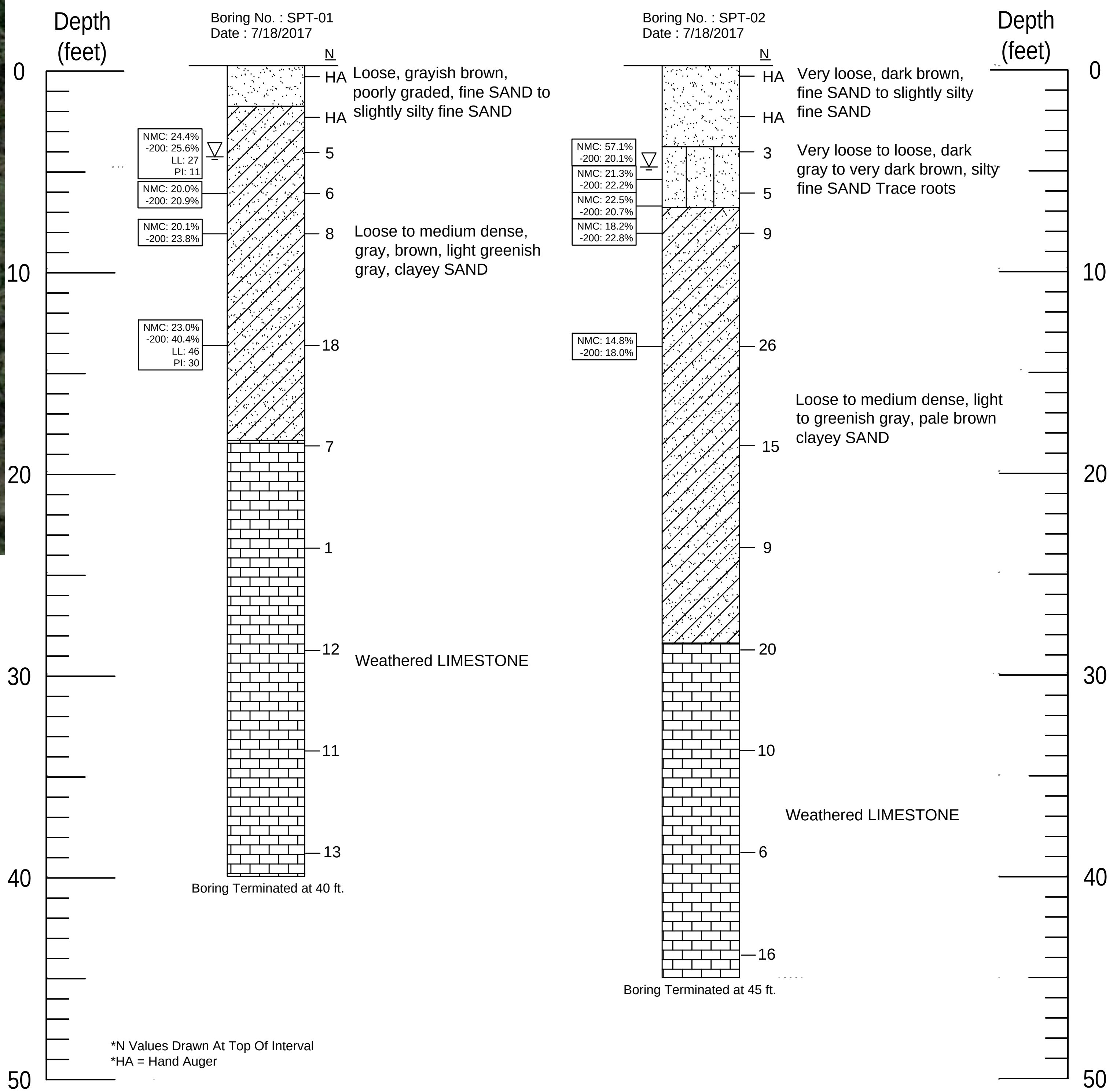
	NAME	DATE
DESIGNED BY:	TC	07/31/2017
DRAWN BY:	TC	07/31/2017
CHECKED BY:	JJ	08/02/2017
SUPERVISED BY:	JH	

Project Location Map

Bull Barn Trail over Devil's Creek Bridge Replacement
Sumter County, Florida

MC^2 PROJ. NO.	SHEET NO.
T041705.067	1





*N Values Drawn At Top Of Interval
*HA = Hand Auger

LEGEND

▨	(SP/SP-SM) Pale Brown, Brown or Gray, Fine Sand to Slightly Silty Fine Sand
▨	(SC) Gray Clayey Fine Sand
▨	(SM) Dark Gray to Very Dark Brown, Silty Fine SAND
▦	Pale Brown to Gray Weathered Limestone with Calcareous Clay

NOTES:

∇	WATER TABLE
N	SPT N-VALUE
HA	HAND AUGER
NMC	NATURAL MOISTURE CONTENT (%)
-200	FINES PASSING A NO. 200 SIEVE (%)
⌖	APPROXIMATE SPT BORING LOCATION
●	APPROXIMATE HAND AURGER LOCATION
◉	APPROXIMATE PAVEMENT CORING LOCATION

LL	LIQUID LIMIT (%)
PI	PLASTICITY INDEX (%)
OC	ORGANIC CONTENT (%)
GNE	GROUNDWATER NOT ENCOUNTERED WITHIN THE DEPTH EXPLORED

GRANULAR MATERIALS- RELATIVE DENSITY	SPT (BLOWS/FT)
VERY LOOSE	LESS THAN 4
LOOSE	4-10
MEDIUM	10-30
DENSE	30-50
VERY DENSE	GREATER THAN 50
SILTS AND CLAYS CONSISTENCY	**SPT (BLOWS/FT)**
VERY SOFT	LESS THAN 2
SOFT	2-4
FIRM	4-8
STIFF	8-15
VERY STIFF	15-30
HARD	GREATER THAN 30
VERY HARD	

DATE	NAME	REVISION	APPROVED BY:

MC²
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MATERIALS TESTING

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	NAME	DATE
DESIGNED BY:	TC	07/31/2017
DRAWN BY:	TC	07/31/2017
CHECKED BY:	JJ	08/02/2017
SUPERVISED BY:	JH	

Report of Borings

Bull Barn Trail over Devil's Creek Bridge Replacement
Sumter County, Florida

MC² PROJ. NO.	SHEET NO.
T041705.067	2

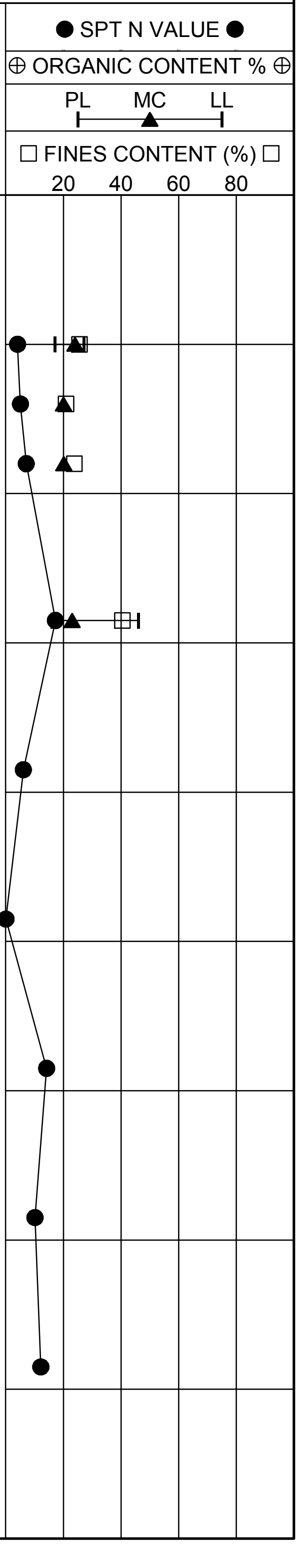
MC²
Geotechnical • Environmental
Materials Testing

Soil Profile

BORING ID: SPT-01

CLIENT Greenman-Pedersen, Inc.
PROJECT NAME Bull Barn Trail over Devil's Creek Bridge Replacement
PROJECT NUMBER T041705.067
PROJECT LOCATION Sumter County, Florida
DATE STARTED 7/18/17 **COMPLETED** 7/18/17
GROUND ELEVATION ______ **HOLE SIZE** 4 inches
DRILLING CONTRACTOR Standard Drilling
GROUND WATER LEVELS:
DRILLING METHOD Mud Rotary - Rig Type: BR 2500
▽ **AT TIME OF DRILLING** 4.5 ft
LOGGED BY AW **CHECKED BY** JH
AT END OF DRILLING ---
NOTES ______
AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	USCS Group Symbol	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	RECOVERY % (RQD)
0		SP, SP-SM	Grayish brown, poorly graded, fine SAND to slightly silty fine SAND	HA 1		
		SC	Loose to medium dense, gray, brown, light greenish gray, clayey SAND	HA 2		
5			▽	SS 3	3-2-3-3 (5)	
				SS 4	3-3-3-4 (6)	
10				SS 5	5-4-4-5 (8)	
15				SS 6	5-9-9 (18)	
20		WLS	Very pale brown, weathered LIMESTONE with calcareous clay seams	SS 7	3-3-4 (7)	
25				SS 8	3-1-0 (1)	
30				SS 9	6-6-9 (15)	
35				SS 10	5-6-5 (11)	
40				SS 11	5-7-6 (13)	
			Bottom of hole at 40.0 feet.			



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Soil Profile

BORING ID: SPT-02

CLIENT Greenman-Pedersen, Inc.

PROJECT NAME Bull Barn Trail over Devil's Creek Bridge Replacement

PROJECT NUMBER T041705.067

PROJECT LOCATION Sumter County, Florida

DATE STARTED 7/18/17 **COMPLETED** 7/18/17

GROUND ELEVATION ____ **HOLE SIZE** 4 inches

DRILLING CONTRACTOR Standard Drilling

GROUND WATER LEVELS:

DRILLING METHOD Mud Rotary - Rig Type: BR 2500

∇ **AT TIME OF DRILLING** 5.0 ft

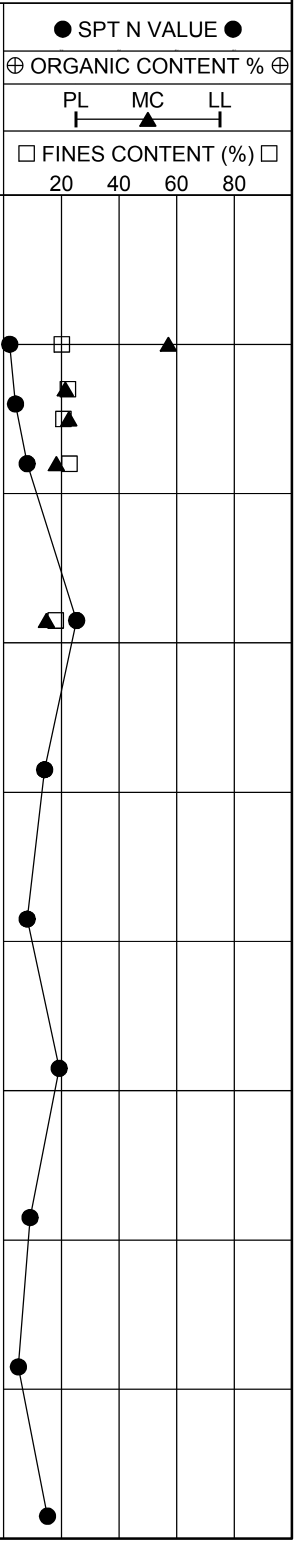
LOGGED BY AW **CHECKED BY** JH

AT END OF DRILLING ---

NOTES ____

AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	USCS Group Symbol	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	RECOVERY % (RQD)
0		SP, SP-SM	Very loose, dark brown, fine SAND to slightly silty fine SAND	HA 1		
				HA 2		
5		SM	∇ Very loose to loose, dark gray to very dark brown, silty, fine SAND	SS 3	1-2-1-1 (3)	
			Trace roots at 6 feet.	SS 4	2-3-2-3 (5)	
		SC	Loose to medium dense, light to greenish gray, pale brown, clayey SAND	SS 5	4-4-5-7 (9)	
10						
15				SS 6	11-12-14 (26)	
20				SS 7	6-7-8 (15)	
25				SS 8	4-4-5 (9)	
30		WLS	Very pale brown, weathered LIMESTONE with calcareous clay seams	SS 9	7-7-13 (20)	
35				SS 10	7-5-5 (10)	
40				SS 11	6-4-2 (6)	
45				SS 12	10-8-8 (16)	



Bottom of hole at 45.0 feet.

GRAIN SIZE DISTRIBUTION TEST REPORT

MC SQUARED, INC.

Project No T17-067 Date: 7/27/2017

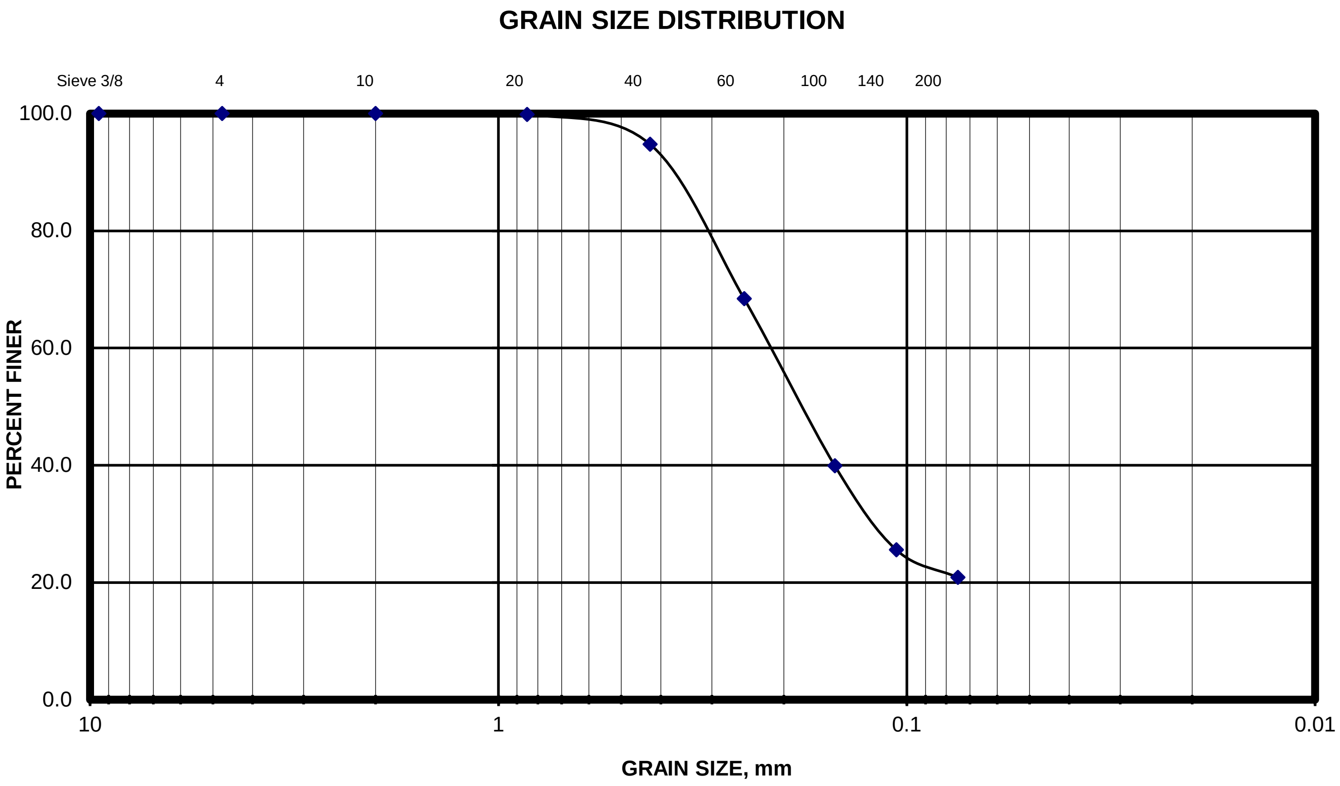
Project: Devil's Creek

Sample Location: B-1 @ 6-8

Soil Description: light brown clayey sand

Soil Classification: SC LL NP PI NP

NMC % 20.0



% Gravel	% Sand	%-200
0.0	79.1	20.9

D60	D30	D10	CC	CU

GRAIN SIZE DISTRIBUTION TEST REPORT

MC SQUARED, INC.

Project No T17-067

Date: 7/27/2017

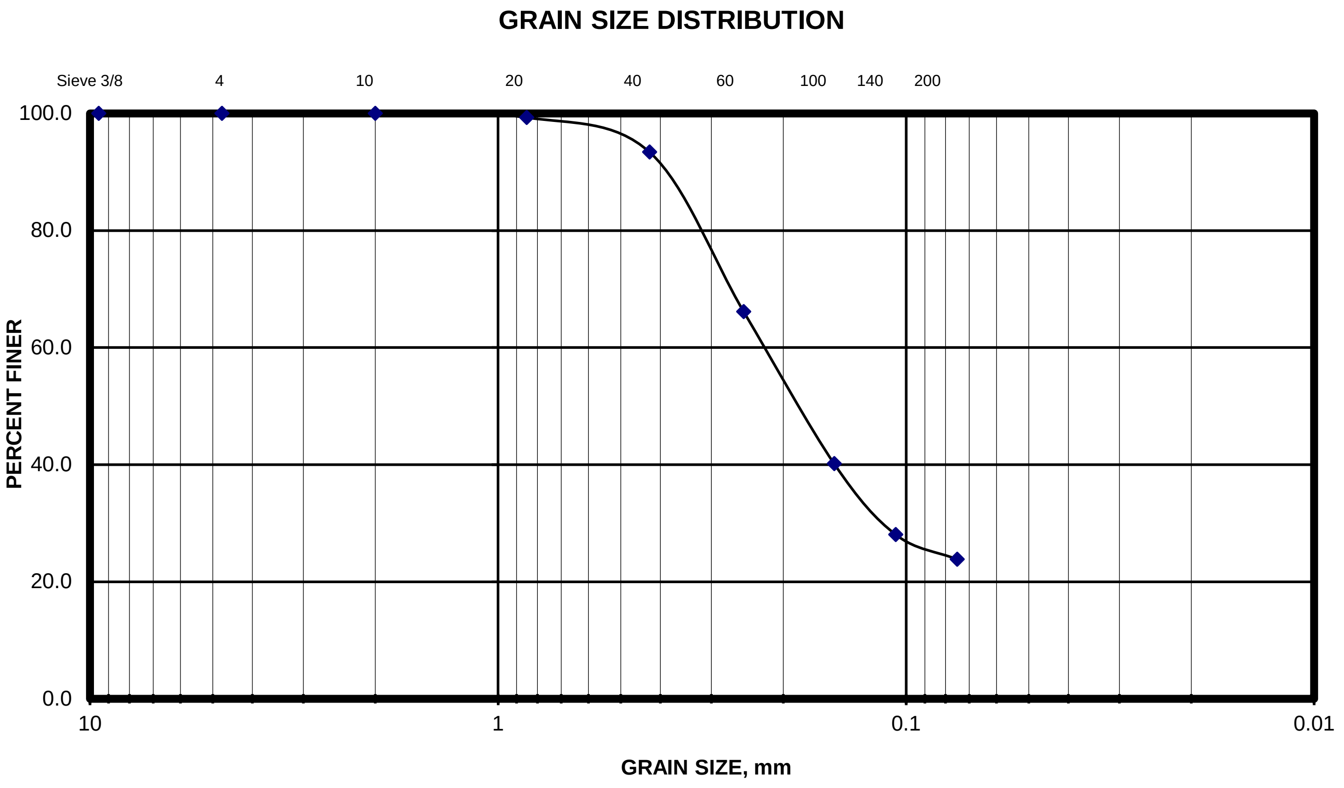
Project: Devil's Creek

Sample Location: B-1 @ 8-10

Soil Description: light gray clayey sand

Soil Classification: SC LL NP PI NP

NMC % 20.1



% Gravel		% Sand		%-200
0.0		76.2		23.8
D60	D30	D10	CC	CU

GRAIN SIZE DISTRIBUTION TEST REPORT

MC SQUARED, INC.

Project No T17-067 Date: 7/27/2017

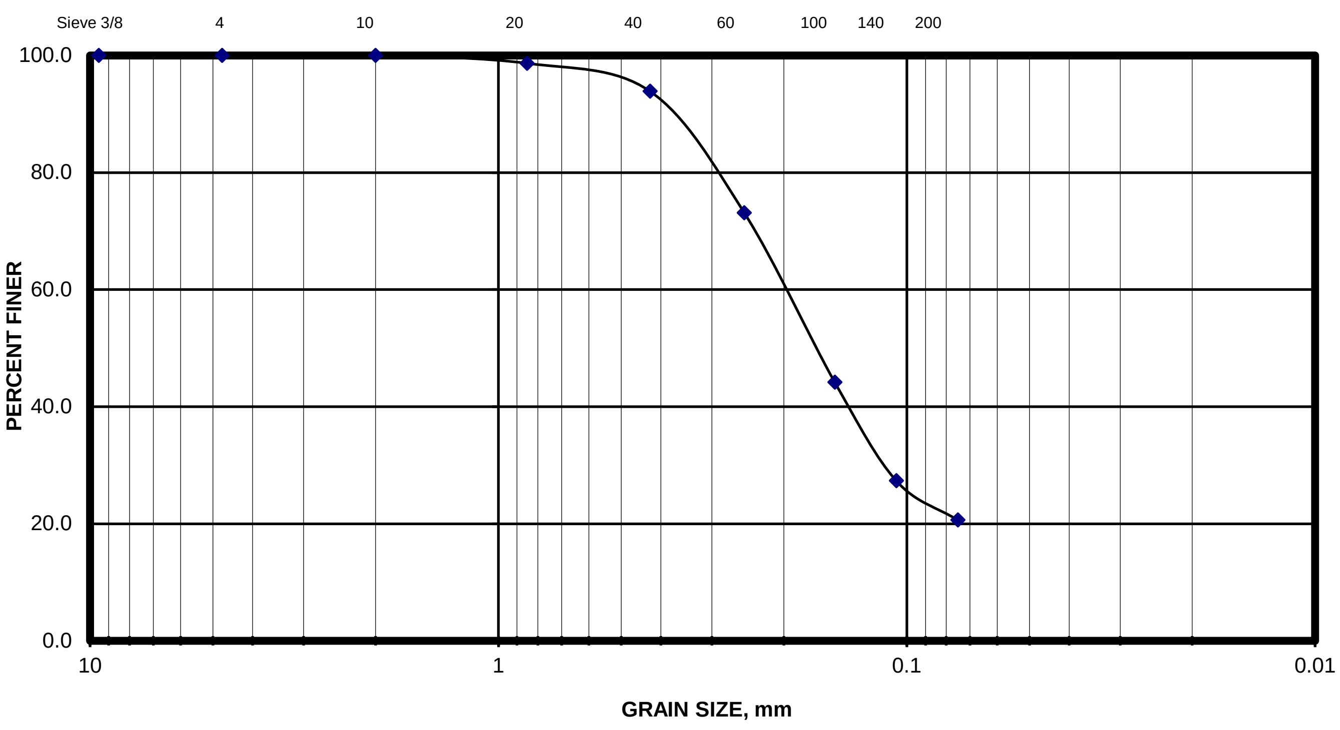
Project: Devil's Creek

Sample Location: B-2 @ 4-6

Soil Description: dark grayish brown silty sand

Soil Classification: SM LL ______ PI ______

NMC % 57.1



GRAIN SIZE DISTRIBUTION

% Gravel	% Sand	%-200
0.0	79.4	20.6

D60	D30	D10	CC	CU

GRAIN SIZE DISTRIBUTION TEST REPORT

MC SQUARED, INC.

Project No T17-067

Date: 7/27/2017

Project: Devil's Creek

Sample Location: B-2 @ 13.5-15

Soil Description: gray clayey sand

Soil Classification: SC LL PI

NMC % 14.8

% Gravel	% Sand	%-200
0.0	81.8	18.2

D60	D30	D10	CC	CU

Figure 1

Pre-Stressed Concrete Square Piles - Estimated Davisson Capacity

Bull Barn Trail over Devil's Creek Bridge Replacement
Sumter County, Florida
MC^2 Project Number T041705.067
SPT-01 End Bent

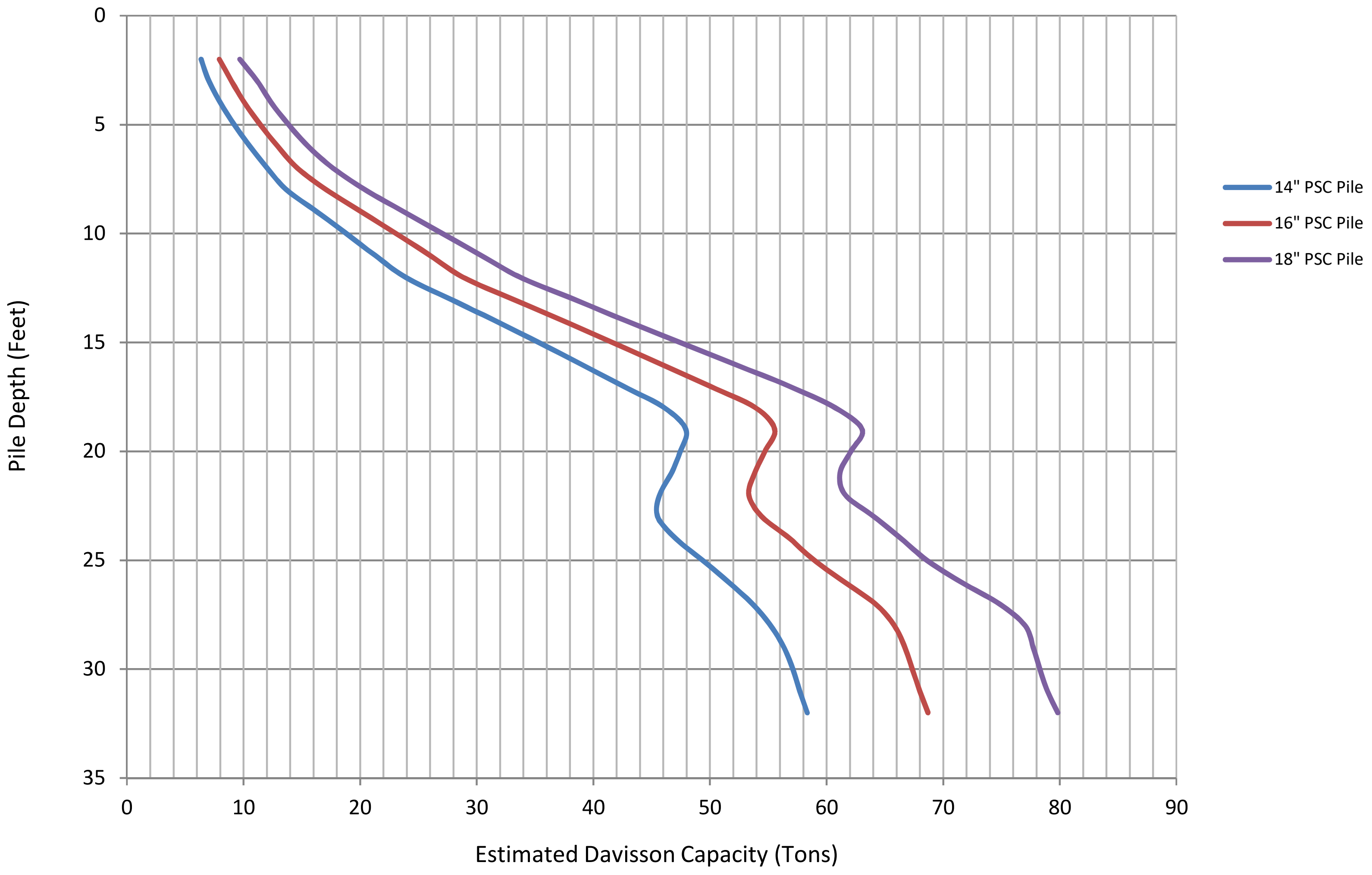


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Figure 2

Pre-Stressed Concrete Square Piles - Estimated Davisson Capacity

Bull Barn Trail over Devil's Creek Bridge Replacement
Sumter County, Florida
MC^2 Project Number T041705.067
SPT-01 Intermediate Bent

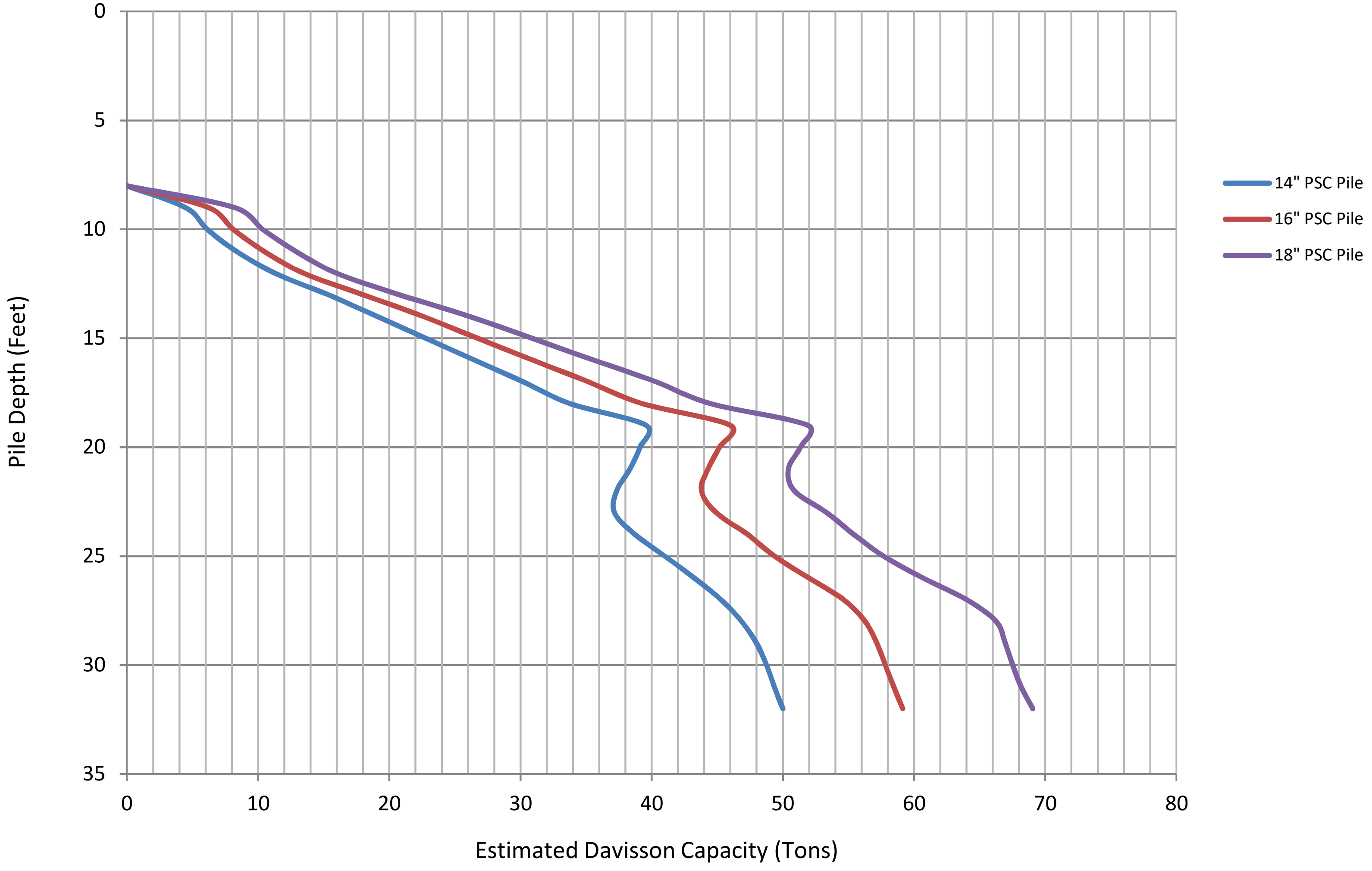


Figure 3

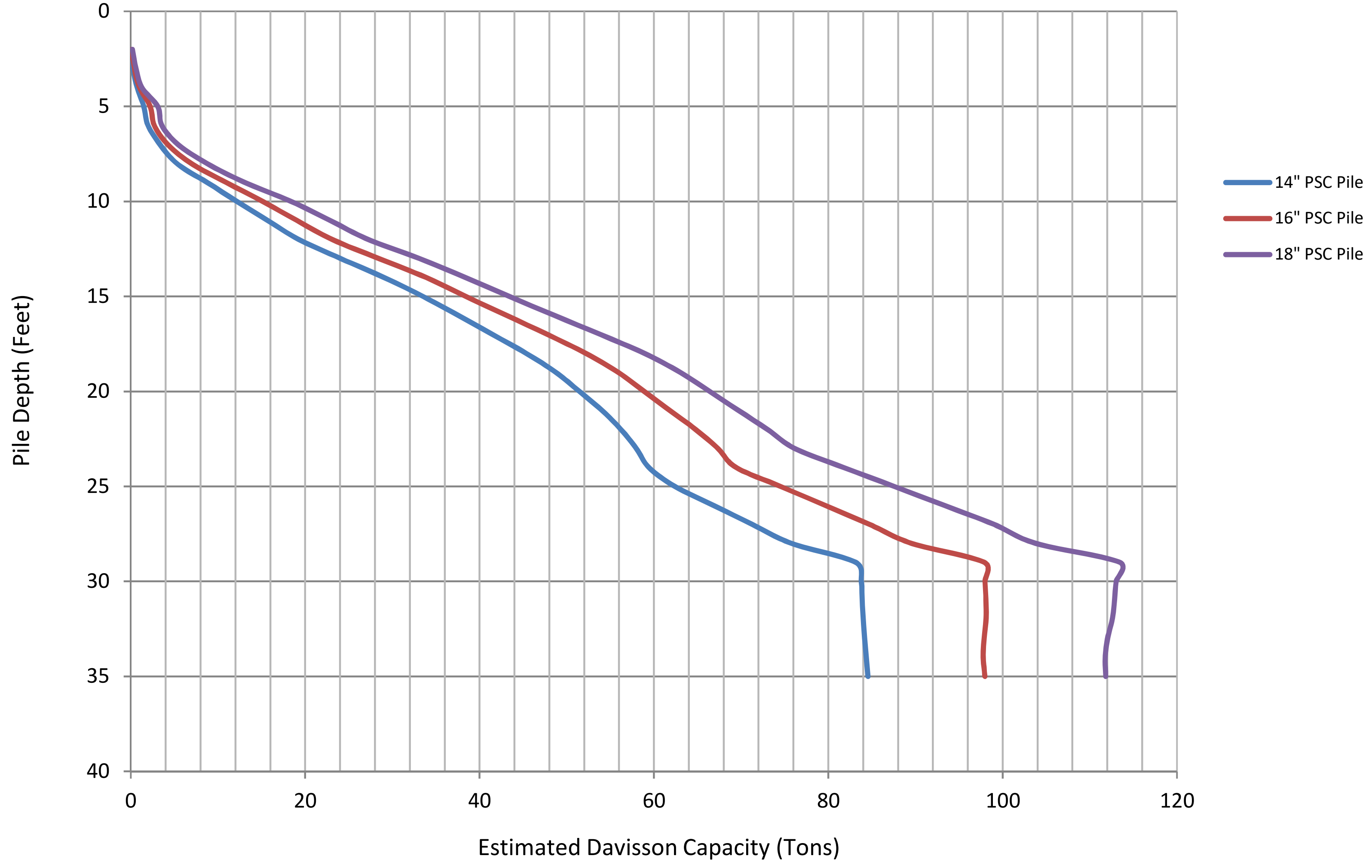
Pre-Stressed Concrete Square Piles - Estimated Davisson Capacity

Bull Barn Trail over Devil's Creek Bridge Replacement

Sumter County, Florida

MC² Project Number T041705.067

SPT-02 End Bent



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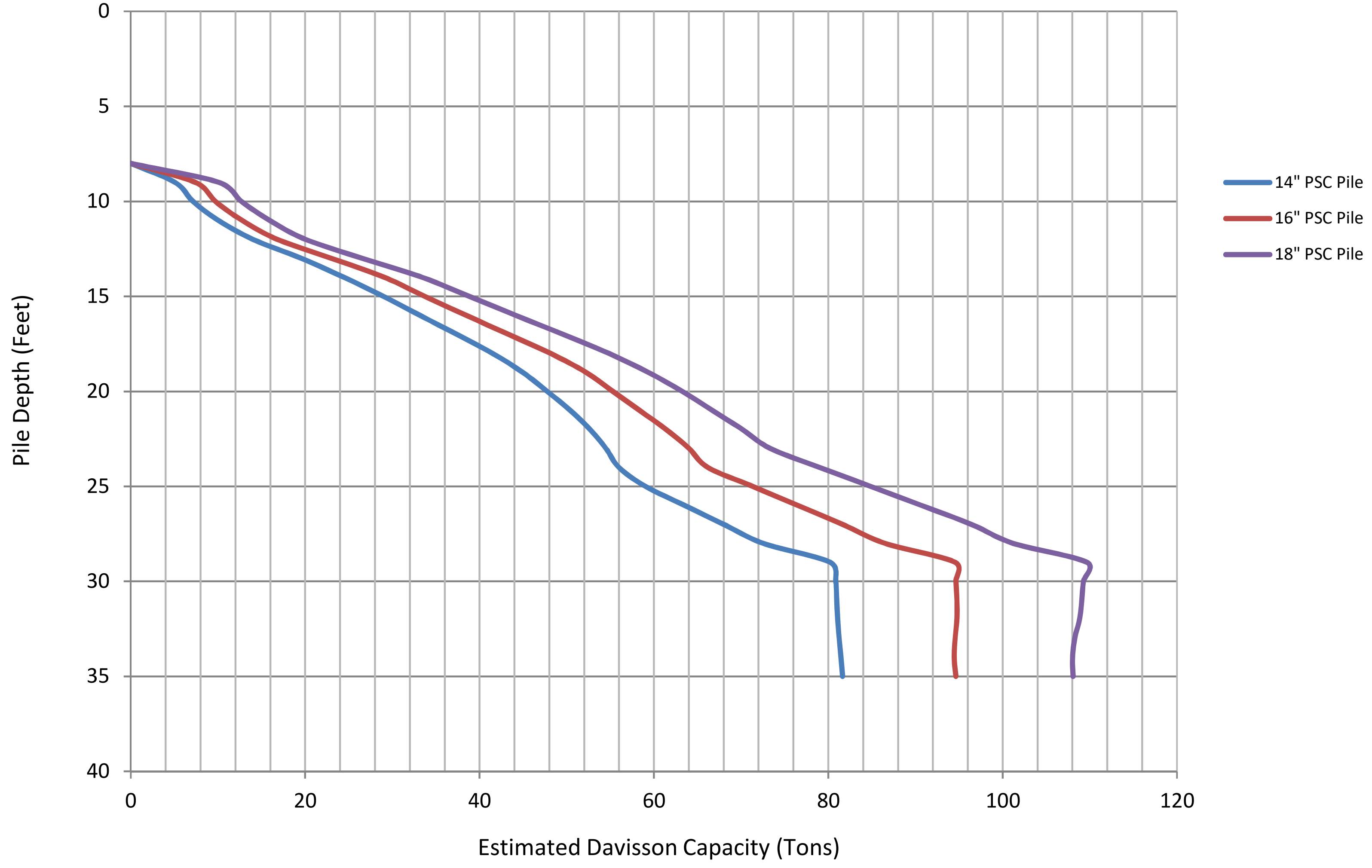
MATERIALS TESTING

Figure 4

Pre-Stressed Concrete Square Piles - Estimated Davisson Capacity

Bull Barn Trail over Devil's Creek Bridge Replacement
Sumter County, Florida
MC² Project Number T041705.067
SPT-02 Intermediate Bent



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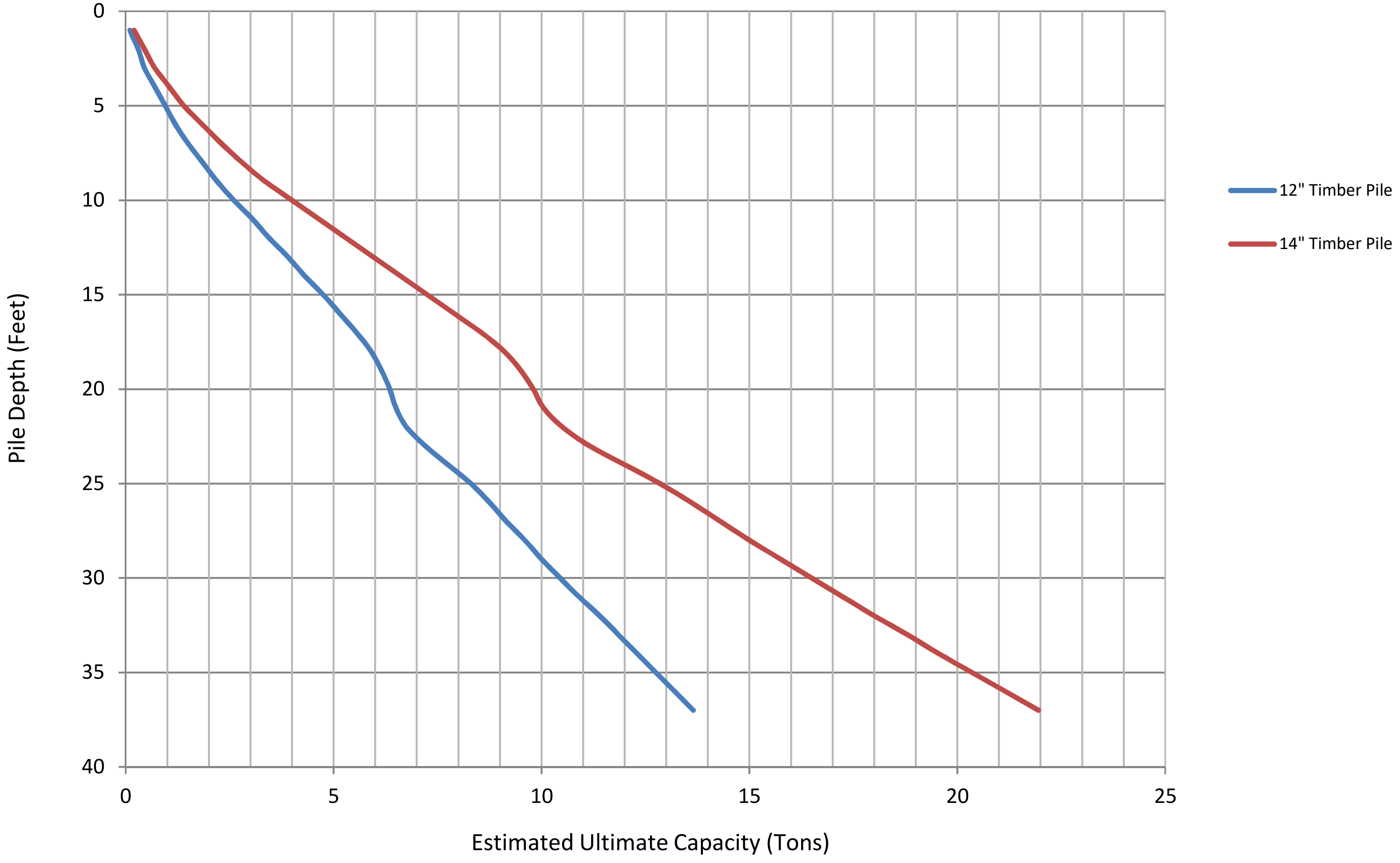
MATERIALS TESTING

Figure 5
Round Timber Piles - Estimated Ultimate Capacity
Bull Barn Trail over Devil's Creek Bridge Replacement
Sumter County, Florida
MC² Project Number T041705.067
SPT-01 End Bent



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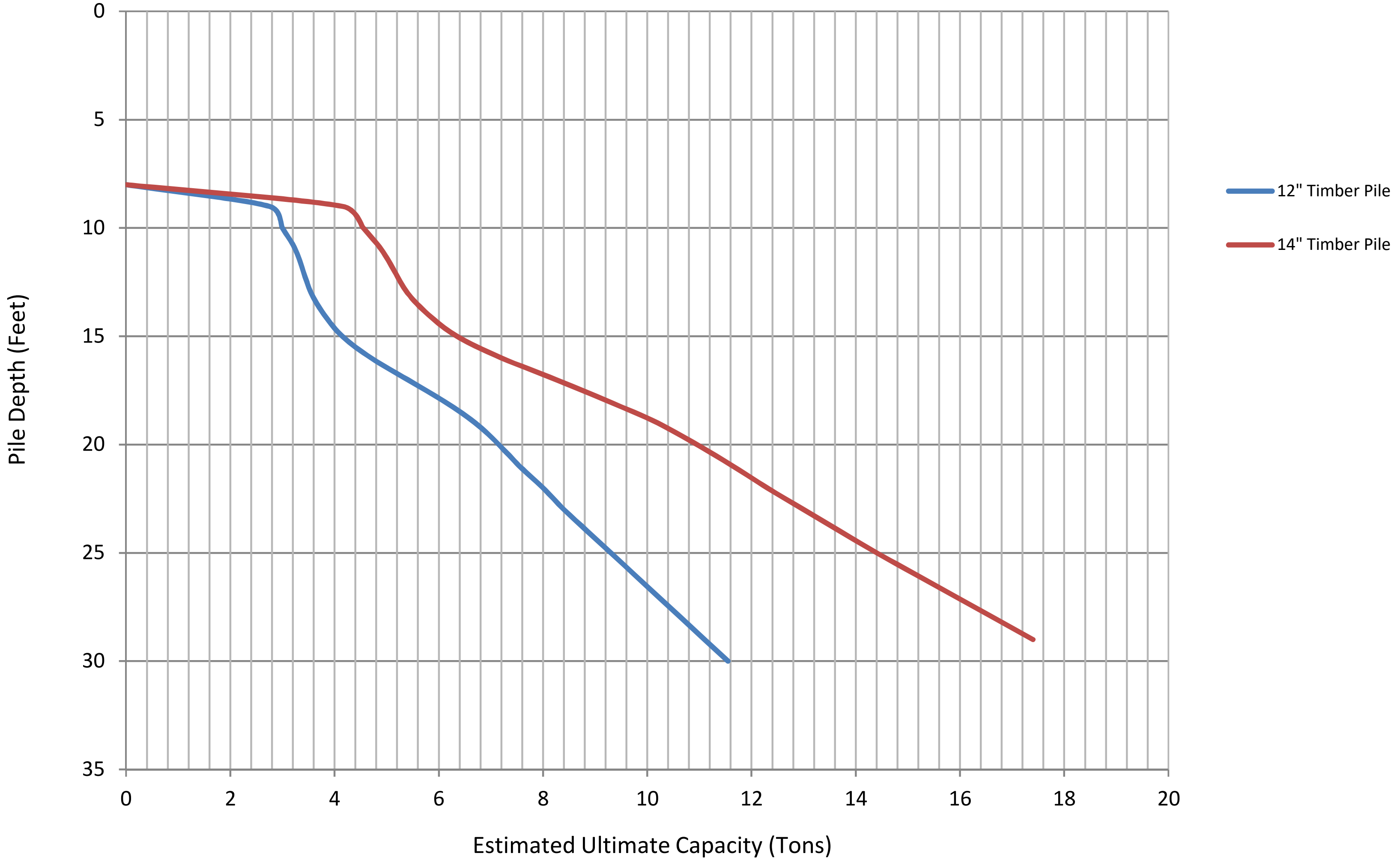
MATERIALS TESTING

Figure 6
Round Timber Piles - Estimated Ultimate Capacity
Bull Barn Trail over Devil's Creek Bridge Replacement
Sumter County, Florida
MC^2 Project Number T041705.067
SPT-01 Intermediate Bent



MC^2
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MATERIALS TESTING

Figure 7

Round Timber Piles - Estimated Ultimate Capacity

Bull Barn Trail over Devil's Creek Bridge Replacement
Sumter County, Florida
MC^2 Project Number T041705.067
SPT-02 End Bent

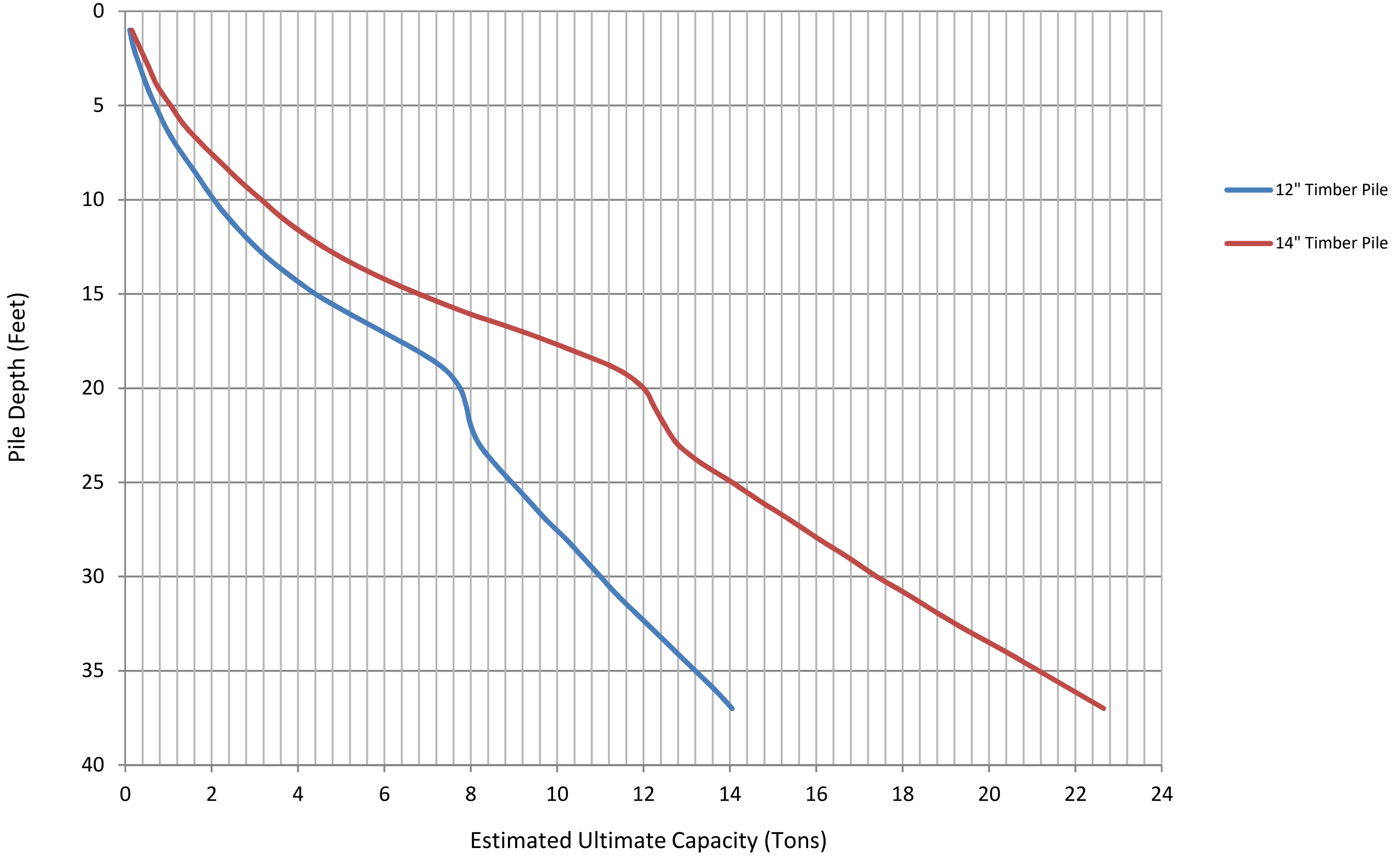
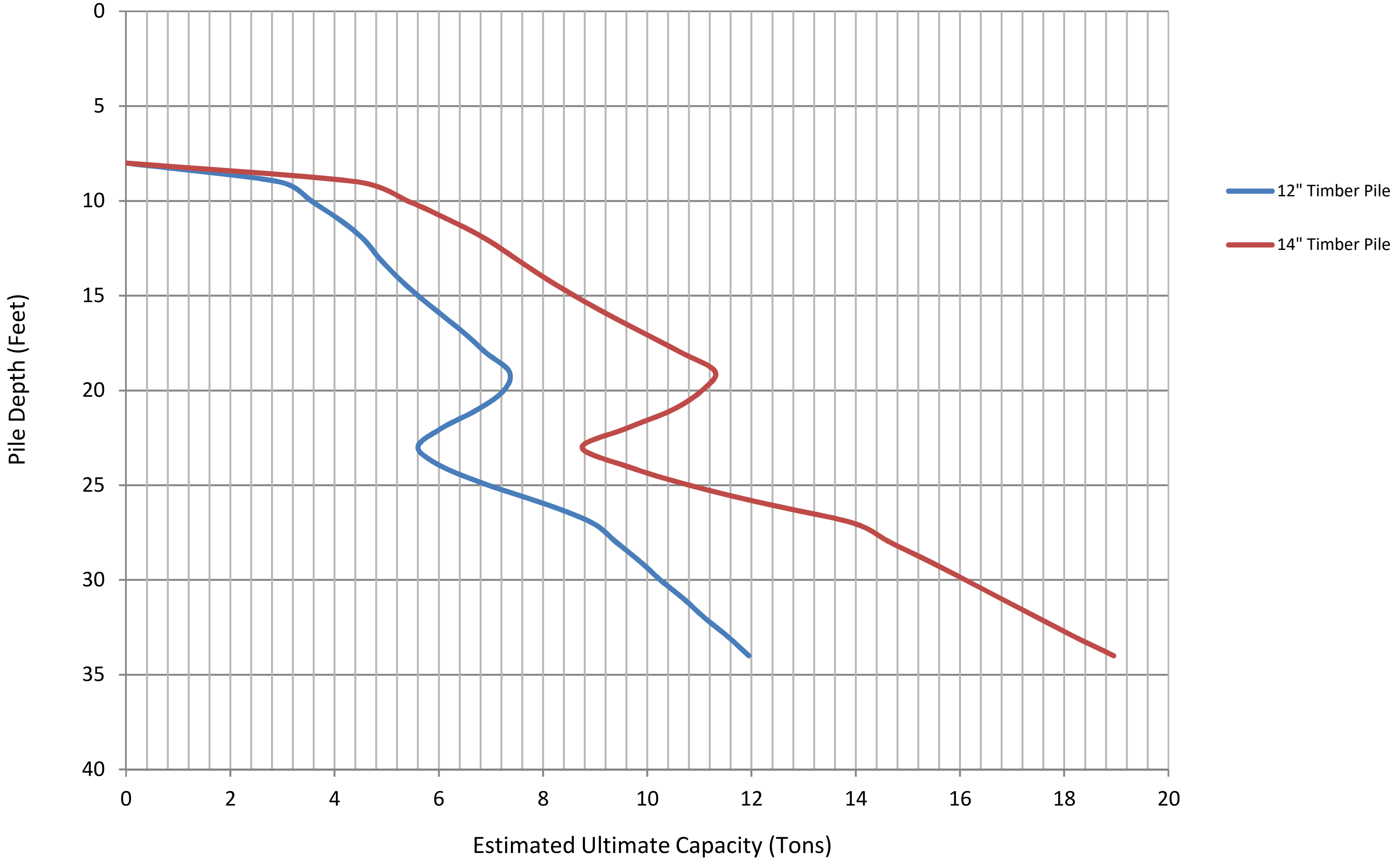


Figure 8

Round Timber Piles - Estimated Ultimate Capacity

Bull Barn Trail over Devil's Creek Bridge Replacement
Sumter County, Florida
MC² Project Number T041705.067
SPT-02 Intermediate Bent



TEST PROCEDURES

The general field procedures employed by MC Squared, Inc. (**MC²**) are summarized in the American Society for Testing and Materials (ASTM) Standard D420 which is entitled "Investigating and Sampling Soil and Rock". This recommended practice lists recognized methods for determining soil and rock distribution and groundwater conditions. These methods include geophysical and in-situ methods as well as boring.

Standard Drilling Techniques

To obtain subsurface samples, boring are drilled using one of several alternate techniques depending upon the subsurface conditions. Some of these techniques are:

In Soils:

a) Continuous hollow stem augers.
b) Rotary boring using roller cone bits or drag bits, and water or drilling mud to flush the hole.
c) "Hand" augers.

In Rock:

a) Core drilling with diamond-faced, double or triple tube core barrels.
b) Core boring with roller cone bits.

Hollow Stem Augering: A hollow stem auger consists of a hollow steel tube with a continuous exterior spiral flange termed a flight. The auger is turned into the ground, returning the cuttings along the flights. The hollow center permits a variety of sampling and testing tools to be used without removing the auger.

Mud Rotary: In situations where unconsolidated materials are anticipated, the direct-rotary or “mud” rotary method may be used as a more effective method for obtaining soil samples. The fluid used, which is typically stored in an aluminum tub (also known as a “mudtub”), is a mix of water and bentonite, also known as a bentonite slurry or “mud”. This fluid circulates into the borehole and then returns to the mudtub using a pump system. A loss of circulation, partially or otherwise, may signify a void at that sample depth. The key advantage of using this drilling method is that it stabilizes the borehole wall while drilling in unconsolidated formations, due to the buildup of a filter cake on the wall.

Core Drilling: Soil drilling methods are not normally capable of penetrating through hard cemented soil, weathered rock, coarse gravel or boulders, thin rock seams, or the upper surface of sound, continuous rock. Material which cannot be penetrated by auger or rotary soil-drilling methods at a reasonable rate is designated as “refusal material”. Core drilling procedures are required to penetrate and sample refusal materials.

Prior to coring, casing may be set in the drilled hole through the overburden soils, to keep the hole from caving and to prevent excessive water loss. The refusal materials are then cored according to ASTM D-2113 using a diamond-studded bit fastened to the end of a hollow, double or triple tube core barrel. This device is rotated at high speeds, and the cuttings are brought to the surface by circulating water. Core samples of the material penetrated are protected and retained in the swivel-mounted inner tube. Upon completion of each drill run, the core barrel is brought to the surface, the core recovery is measured, and the core is placed, in sequence, in boxes for storage and transported to our laboratory.

Sampling and Testing in Boreholes

Several techniques are used to obtain samples and data in soils in the field; however the most common methods in this area are:

a) Standard Penetrating Testing
b) Undisturbed Sampling
c) Dynamic Cone Penetrometer Testing
d) Water Level Readings

The procedures utilized for this project are presented below.

Standard Penetration Testing: At regular intervals, the drilling tools are removed and soil samples obtained with a standard 2-inch diameter split tube sampler connected to an A or N-size rod. The sampler is first seated 6 inches to penetrate any loose cuttings, and then driven an additional 12 inches with blows of a 140-pound safety hammer falling 30 inches. Generally, the number of hammer blows required to drive the sampler the final 12 inches is designated the "penetration resistance" or "N" value, in blows per foot (bpf). The split barrel sampler is designed to retain the soil penetrated, so that it may be returned to the surface for observation. Representative portions of the soil samples obtained from each split barrel sample are placed in jars, sealed and transported to our laboratory.

The standard penetration test, when properly evaluated, provides an indication of the soil strength and compressibility. The tests are conducted according to ASTM Standard D1586. The depths and N-values of standard penetration tests are shown on the Boring Logs. Split barrel samples are suitable for visual observation and classification tests but are not sufficiently intact for quantitative laboratory testing.

Water Level Readings: Water level readings are normally taken in the boring and are recorded on the Boring Records. In sandy soils, these readings indicate the approximate location of the hydrostatic water level at the time of our field exploration. In clayey soils, the rate of water seepage into the boring is low and it is generally not possible to establish the location of the hydrostatic water level through short-term water level readings. Also, fluctuation in the water level should be expected with variations in precipitation, surface run-off, evaporation, and other factors. For long-term monitoring of water levels, it is necessary to install piezometers.

The water levels reported on the Boring Logs are determined by field crews immediately after the drilling tools are removed, and several hours after the boring are completed, if possible. The time lag is intended to permit stabilization of the groundwater level that may have been disrupted by the drilling operation.

Occasionally the boring will cave-in, preventing water level readings from being obtained or trapping drilling water above the cave-in zone.

BORING LOGS

The subsurface conditions encountered during drilling are reported on a field boring log prepared by the Driller. The log contains information concerning the boring method, samples attempted and recovered, indications of the presence of coarse gravel, cobbles, etc., and observations of groundwater. It also contains the driller's interpretation of the soil conditions between samples. Therefore, these boring records contain both factual and interpretive information. The field boring records are kept on file in our office.

After the drilling is completed a geotechnical professional classifies the soil samples and prepares the final Boring Logs, which are the basis for our evaluations and recommendations.

SOIL CLASSIFICATION

Soil classifications provide a general guide to the engineering properties of various soil types and enable the engineer to apply his past experience to current problems. In our investigations, samples obtained during drilling operations are examined in our laboratory and visually classified by an engineer. The soils are classified according to consistency (based on number of blows from standard penetration tests), color and texture. These classification descriptions are included on our Boring Logs.

The classification system discussed above is primarily qualitative and for detailed soil classification two laboratory tests are necessary; grain size tests and plasticity tests. Using these test results the soil can be classified according to the AASHTO or Unified Classification Systems (ASTM D-2487). Each of these classification systems and the in-place physical soil properties provides an index for estimating the soil's behavior. The soil classification and physical properties are presented in this report.

The following table presents criteria that are typically utilized in the classification and description of soil and rock samples for preparation of the Boring Logs.

Relative Density of Cohesionless Soils From Standard Penetration Test

Very Loose	≤ 4 bpf
Loose	5 - 10 bpf
Medium Dense	11 - 30 bpf
Dense	31 - 50 bpf
Very Dense	> 50 bpf

(bpf = blows per foot, ASTM D 1586)

Consistency of Cohesive Soils

Very Soft	≤ 2 bpf
Soft	3 - 4 bpf
Firm	5 - 8 bpf
Stiff	9 - 15 bpf
Very Stiff	16 - 30 bpf
Hard	30 – 50 bpf
Very Hard	> 50 bpf

Relative Hardness of Rock

Very Soft	Very soft rock disintegrates or easily compresses to touch; can be hard to very hard soil.
Soft	May be broken with fingers.
Moderately Soft	May be scratched with a nail, corners and edges may be broken with fingers.
Moderately Hard	Light blow of hammer required to break samples.
Hard	Hard blow of hammer required to break sample.

Particle Size Identification

Boulders	Larger than 12"
Cobbles	3" - 12"
Gravel	
Coarse	3/4" - 3"
Fine	4.76mm - 3/4"
Sand	
Coarse	2.0 - 4.76 mm
Medium	0.42 - 2.00 mm
Fine	0.42 - 0.074 mm
Fines (Silt or Clay)	Smaller than 0.074 mm

Rock Continuity

RECOVERY = $\frac{\text{Total Length of Core}}{\text{Length of Core Run}} \times 100\ \%$

Description	Core Recovery %
Incompetent	Less than 40
Competent	40 - 70
Fairly Continuous	71 - 90
Continuous	91 - 100

Relative Quality of Rocks

RQD = $\frac{\text{Total core, counting only pieces > 4" long}}{\text{Length of Core Run}} \times 100\ \%$

Description	RQD %
Very Poor	0 - 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %