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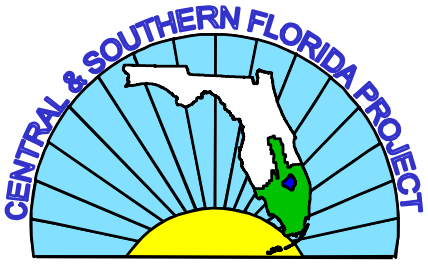
CENTRAL AND SOUTHERN FLORIDA PROJECT

COMPREHENSIVE EVERGLADES RESTORATION PLAN



COMPREHENSIVE EVERGLADES
RESTORATION PLAN

GEOTECHNICAL TECHNICAL MEMORANDUM

LAKE OKEECHOBEE WATERSHED PROJECT

U.S. Army Corps of Engineers
Jacksonville District

South Florida
Water Management District

Assisted By:

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This document was prepared by the Lake Okeechobee Watershed Project Delivery Team, with assistance from HDR Engineering, Inc. The final document will be one component of the Lake Okeechobee Watershed Assessment Report. Sections of this document are numbered according to the proposed outline for the Watershed Assessment Report.

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1.0 Project Information

1.1 Introduction

The Comprehensive Everglades Restoration Plan (CERP) was developed by the U.S. Army Corps of Engineers (USACE) and South Florida Water Management District (SFWMD), in cooperation with other Federal, Tribal, state and local agencies. The overall objective of the Plan is the restoration, preservation, and protection of the south Florida ecosystem while providing for other water related needs for the region.

Lake Okeechobee and its watershed are key components of south Florida's Kissimmee-Okeechobee-Everglades Ecosystem, which extends from the headwaters of the Kissimmee River in the north to Florida Bay in the south. The Lake Okeechobee Watershed (LOW) Project is one component of CERP. Its objective is to protect and enhance the resources of Lake Okeechobee and its surrounding watershed through planning, regulation and engineering activities. Four separate elements of CERP are located within the Lake Okeechobee Watershed:

- North of Lake Okeechobee Storage Reservoir
- Taylor Creek/Nubbin Slough Storage and Treatment Area
- Lake Okeechobee Watershed Water Quality Treatment Facilities
- Lake Okeechobee Tributary Sediment Dredging

These components were combined into the Lake Okeechobee Watershed Project to generate a more efficient design of each component and to address the interdependencies and tradeoffs between the different components.

The components of the Lake Okeechobee Watershed Project, as presented in CERP, are conceptual and additional planning is required prior to design. Currently, plan formulation for these components is underway. Alternatives resulting from this process will be evaluated using both existing baseline conditions and future project conditions that have been established for the Lake Okeechobee Watershed. One criterion that will be used in both the development and evaluation of alternatives is geotechnical or soils information.

Geotechnical information will be used during both plan formulation and evaluation by providing information about soil characteristics, engineering design requirements, and constructability.

1.2 Purpose

This Technical Memorandum (TM) is intended to assess the existing geotechnical data, where it is located, and its potential usefulness with regards to this project. The information in this report is provided as part of Task 1.12 – Initial Geotechnical Data. During this stage of the project, geotechnical information has been reviewed and assembled. Some of this information includes existing borehole logs, geophysical logs, existing public reports, academic studies, and several other sources. There are no plans to conduct any soil borings during the information gathering stage of the project. More information including field explorations and soil borings will be conducted, as needed, at later stages of this continuing project.

Williams Earth Sciences, Inc. has been tasked to first determine the sources of the existing geotechnical data and what types of data exist that may be useful for this project. Williams has reviewed numerous resources and contacted various governmental agencies, departments, and others which possess a variety of geotechnical information including soil borings, wells, other drilling information, as well as geologic and lithographic information from sites within the area under the study. Other items of interest include information concerning burrow pits where materials like aggregates and sands may be obtained or used once actual construction begins.

1.3 Scope of Technical Memorandum

The watershed area (see Figure 1.1) is extensive and covers portions of five counties, Highlands, Glades, Okeechobee, and the western tips of Martin and St. Lucie Counties. It should be noted that at the time that this report is being assembled, planning area alternatives are being identified and more specific areas of study will be the focus of future geotechnical submittals. Therefore, future submittals will be able to focus on more specific details about the soils conditions and geological formations at particular areas of interest.

As such, collection of existing data and evaluating this geotechnical information with regards to its potential usefulness for the LOW Project are considered to be of great importance to the project objectives. Another important requirement is to determine whether data can be utilized in terms of availability, accessibility, cost, compatibility, and age for the purpose of assessing design alternatives. At this stage of the process, the purpose, as referenced earlier in this report, is to determine the best sources for geotechnical information and to begin to evaluate its potential usefulness for the LOW Project. Future submittals will deepen the evaluations of the existing geotechnical information discovered during this phase.

During this phase of the data collection processes there was significant time spent attempting to locate the sources of the existing geotechnical information. This included some site reconnaissance, internet searches, review of USGS Soil Conservation Maps, and visits to the various agencies including the individual counties, SFWMD, FDOT district offices in charge of the counties, and some other agencies in an attempt to determine where the existing geotechnical data could best be located and to begin the data gathering process.

It should be noted that it became somewhat obvious that much of the data that is believed to be currently in existence will likely not be extremely useful for the design and implementation of the structures that will be the results of the LOW Project. This is mostly due to age of the equipment and techniques used to obtain the majority of the geotechnical data that has been reviewed to date. This issue will be further discussed in later submittals, which will focus more on the evaluations of the existing information. However, because lithologies do not typically change dramatically within the relatively short time frames, such as the past 40 or 50 years, the existing information may be useful in the determination of which general areas will be most efficient for the proposed improvements based upon soil types present in general areas within the LOW Project boundaries.

Geotechnical and soils data are not like well monitoring or the measurement of contaminants, which varies periodically in terms of length of time, seasons, etc. Soils data varies mainly in terms of location and depth, but not with the time of year or season, except for the surface layer that may vary due to erosion and deposition by the elements of the weather over the years. However, the groundwater and aquifer conditions tend to be dependent on the seasons. In the situation where old boring logs are obtained, ground water conditions may not be reliable, but the soil strata may remain the same.

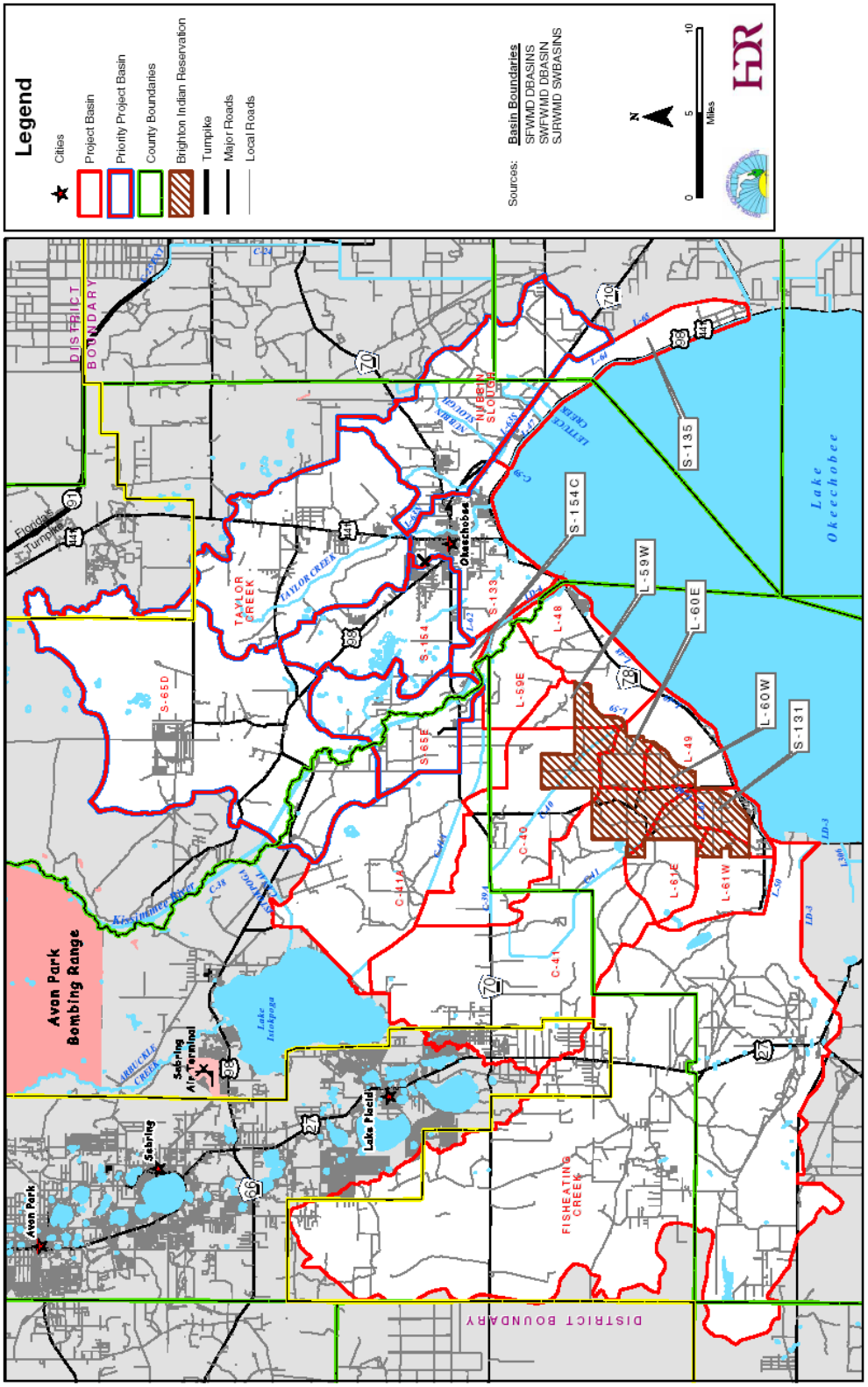

Figure 1.1 Project Area

2.0 Data Collection

In accordance with the aforementioned scope, Williams has documented many sources with available geotechnical and soils data that will be evaluated for the project and its relationship to CERP data management guidelines.

Several different types of data are available and will potentially be useful in the future for evaluating locations, performing design, and during construction of the multitude of features of the LOW Project. Generally the most likely use for the existing information is to aid in the assessment of the geologic formations that are expected at specific locations, and then subsequent fieldwork will be required to verify geologic conditions and to evaluate the subsurface soils' compatibility for the intended purpose(s).

At this time, it is not known exactly which structures will be required or their locations. Some of the proposed improvements for the LOW Project are likely to include Stormwater Treatment Areas (STAs), pump stations, ponds, and other typical water management structures. It is proposed that by studying the existing geotechnical data at the early stages of this project that the general geology of an area can be obtained in advance and subsequently utilized to suggest locations that may be best suited for specific structure types. It will also provide some insight as to which foundation alternative that may provide the most economical structure. Also, the existing information may alert the management team to certain concerns such as presence of limestone, sinkholes, muck layers, etc., at the early stages of the project and therefore perhaps suggest certain areas that should be avoided. Basically, it will assist the team to best determine the potential suitability, or non-suitability, of any particular location with regards to the proposed improvement.

Some of the more commonly used sources for such geotechnical information include the U.S. Army Corps of Engineers, South Florida Water Management District, U.S. Geological Survey, USDA, Soil Water Conservations Department of the various counties, and the Florida Dept. of Transportation. These sources are known to perform such investigations regularly.

In addition to the above sources, Williams' staff contacted several other potential sources including each of the counties and several of the incorporated cities within the project study limits. Phone calls were made to all County offices, and some cities, in the project area to determine if they had a collection of reports or soils data that we could obtain and include as part of the evaluation processes. The response, however, was not

encouraging. Basically, each agency beyond those referenced in the above paragraph suggested that contact be made with County Soil and Water Conservation Departments, the FDOT, or SFWMD. The implication of these findings was that the individual county and local agencies may do some geotechnical work, but that they basically do not keep track of the work that has been done and do not have an efficient manner to determine the location of the geotechnical work that has already been accomplished. Therefore, future efforts will focus on the available information from the more common sources.

USDA Soil Survey reports for the five counties within the project study limits are currently available and were obtained and reviewed. Some of this information is discussed later in this report.

The South Florida Water Management District (SFWMD) has perhaps the most significant amount of geotechnical data within the project area. Much of this data may be with regard to relevant structures. It should also be noted that the SFWMD has much of the geotechnical data that was collected by the U.S. Army Corps of Engineers. It has been learned that the geotechnical data is available, and has been made available to Williams during this study. The Map Room at SFWMD has numerous geotechnical boring logs and identifies locations at which the data was obtained. However, this data is limited and not well organized for a study such as this one.

Apparently, the SFWMD does not have a system by which geotechnical reports are maintained for already completed projects. Although the map room has a relatively significant amount of boring logs, most of which are relatively old, there is little in the way of determining the methods used for the data collection, or any other potentially useful information, that may have been detailed in the full geotechnical reports. However, boring logs were obtained that were performed by the U.S. Corps of Engineers during the 1950s and 1960s and additional research may yield some more information regarding the specific locations once they are determined. Williams was also made aware that they had photographic maps and USGS quadrangle maps of this region available for purchase.

The FDOT has a fairly well kept documentation center with geotechnical reports and boring logs for basically all old FDOT structures that may be near the locations of a proposed structure for this project. Sources at the FDOT have indicated that they will assist the finding of these old documents at the time they are desired. Depending upon future planned locations of the improvements for this project, the FDOT may also prove to be a valuable resource for geotechnical information.

With all of this available information, it should be noted that virtually all of it will not conform to the requirements set forth for this project. That is to say that the sample intervals will not conform, or the equipment used to collect the data is out of date, or the soils information collected will not be compatible with CERP conventions. Obviously, future soils information that will be gathered in the field will be collected with the CERP conventions in mind and will comply with the appropriate requirements.

3.0 Evaluation of Existing Geotechnical Information

3.1 Data Availability and Compatibility

As discussed in the Scope and Purpose of this Technical Memorandum, Williams has located, and obtained much, available geotechnical and soils information that will be utilized as this project progresses. Some consideration has been made regarding how this information may be obtained, in what format it is available, and its relationship to CERP data management guidelines. The actual information gathered from some of the various agencies is briefly discussed in this chapter. More detailed discussions of the available geotechnical data may be necessary, and will be incorporated into future submittals, at particular areas of interest once they have been determined.

3.2 U.S. Army Corps of Engineers' Data

The U.S. Army Corps of Engineers (COE) performed some drilling in the project area, therefore the COE was contacted and it was indicated that information including some boring logs and geotechnical reports for specific structures would be provided. It was expected that Williams would obtain maps and borings that were performed by the COE during the design phases for some of the SFWMD pump stations and other structures, which have been constructed within the project limits. However, at the date of this report the COE information has not been obtained. Because the request was made with regards to specific existing structures, which may be irrelevant, as the area of interest for this project is getting smaller, the request for geotechnical information will be revised and resubmitted at a later date, as necessary.

3.3 Countywide USDA Geotechnical Data

Soil survey reports by USDA were obtained from the five counties within the project limits. These surveys have been reviewed and are briefly summarized in this chapter. Again, this information is readily available and will be analyzed for specific areas of interest in later submittals. These reports are

useful as sources of information regarding the general geology of regions, as well as, the general soil profile of the county. However, this information is limited to upper layers of the subsurface soils. Generally these documents detail the typical soil conditions only in the upper 6 to 7 feet of the subsurface soil profile. While limited, this information could prove useful in making preliminary evaluations of soils and ground conditions that will be best suited for structures and in planning more detailed surveys in the future. This information will also be potentially useful to assist in the location of possible resources for construction materials such as sand, gravel, and aggregates suitable for use in construction.

Soils descriptions obtained in these documents include grain size distributions, Atterberg limits, moisture density relationships, and classifications according to AASHTO and USCS for the various soils within the each county. Also, the USDA Soil Conservation Service books for each county identify expected seasonal high groundwater tables for the numerous soils within each county. It should be noted that the seasonal high groundwater tables are typically within the upper 2 to 4 feet of the soil horizon within the project area.

Using the AASHTO classification, most of these soils fall in the A-2 and A-3 categories. These are equivalent to SP, SP-SM, SC-SM, and SC according to the Unified Soil Classification System. These are mostly poorly graded and Non-plastic. However, soil types vary from location to location and within the project limits there have been potentially significant areas of muck and organic soils encountered at or near the ground surface.

Another potentially useful parameter that the USDA Soil Surveys attempt to quantify is the permeability. Permeability ranges from 6 to 20 in/hr were noted during our review of the most typical soil types found in the area of this project. Please note, that these permeability rates should serve as a guide, but like most of the available information, should be verified by field-testing at the specific areas of interest during later phases of this project.

3.4 Review of USGS Maps

USGS maps, which are now available on the Internet, were reviewed and are discussed briefly in this section. Use of the USGS Maps can provide some general indication of what soil types should be expected at general locations. This information is general, but can be relatively accurate at relatively significant depths. These maps use lithographic units and include the Quaternary System and Tertiary/Quaternary System, to help in predicting the soil structure that may be expected in deeper depths within a particular area. The following is illustrated as an example of the type of information

that is available by review of the USGS Maps. As shown in Figure 3.4 and Table 3.1, the shallower soils in the southern peninsular Florida (which are the area of interest for this submittal) consist of Holocene and Pleistocene lithostratigraphic units comprising Quaternary and Tertiary/Quaternary systems. The soil profile is revealed by section B-B in Figures 3.5 and 3.6.

The following information was obtained from a publication by the Florida Geological Survey; Open file report 80, Text to Accompany the Geologic Map of Florida, By Thomas M. Scott, P.G. #99. By using this information and a general understanding of some of the Quaternary Sediments, Tertiary-Quaternary Sediments, and lithostratigraphic units can assist in the prediction of soil types that should be expected at depth in general areas.

This information also may prove useful in prediction of foundation types for any proposed structures and where they may be best located within the boundaries of the LOW Project. Also, because this information can assist in preparation of a vague anticipated depth for certain foundation types, which could be utilized for cost comparison purposes during the early evaluation stages of structure development and can therefore also focus the geotechnical field exploration efforts.

Table 3.1a Tertiary/Quaternary Units

TERTIARY/QUATERNARY Unit		Lithologies
	Pliocene	
Tt	Tamiami Formation	limestone, sand, clay
Tjb	Jackson Bluff Formation	clay, sand
Tic	Intracoastal Formation	limestone, sand, clay
Tmc	Miccosukee Formation	sand, clay
Tci	Citronelle Formation	sand, clay
Tc	Cypresshead Formation	sand, clay
TQuc	Reworked Cypresshead Formation	sand, clay
TQd	Dunes	sand
TQu	Undifferentiated sediments	sand, clay
TQsu	Shell-bearing sediments	shells, sand, clay
	QUATERNARY	
	Pleistocene	
Qtr	Trail Ridge sands	sand, heavy minerals
Qm	Miami Limestone	limestone, sand
Qk	Key Largo Limestone	limestone
Qa	Anastasia Formation	limestone, coquina, sand
	Pleistocene/Holocene	
Qu	Undifferentiated	sand, clay, organics
Qbd	Beach Ridge and Dune	sand
Qal	Alluvium	sand, clay, organics
	Holocene	
Qh	Holocene sediments	

(Source: Florida Geological Survey, Open File Report 80, Text to Accompany the Geological Map of Florida, by Thomas M. Scott, P.G. #99, 2001)

Table 3.1b Tertiary/Quaternary Units (Continued)

TERTIARY/QUATERNARY		
	Unit	Lithologies
	Pliocene	
Tt	Tamiami Formation	limestone, sand, clay
Tjb	Jackson Bluff Formation	clay, sand
Tic	Intracoastal Formation	limestone, sand, clay
Tmc	Miccosukee Formation	sand, clay
Tci	Citronelle Formation	sand, clay
Tc	Cypresshead Formation	sand, clay
TQuc	Reworked Cypresshead Formation	sand, clay
TQd	Dunes	sand
TQu	Undifferentiated sediments	sand, clay
TQsu	Shell-bearing sediments	shells, sand, clay
	QUATERNARY	
	Pleistocene	
Qtr	Trail Ridge sands	sand, heavy minerals
Qm	Miami Limestone	limestone, sand
Qk	Key Largo Limestone	limestone
Qa	Anastasia Formation	limestone, coquina, sand
	Pleistocene/Holocene	
Qu	Undifferentiated	sand, clay, organics
Qbd	Beach Ridge and Dune	sand
Qal	Alluvium	sand, clay, organics
	Holocene	
Qh	Holocene sediments	

(Source: see Table 3.1a)

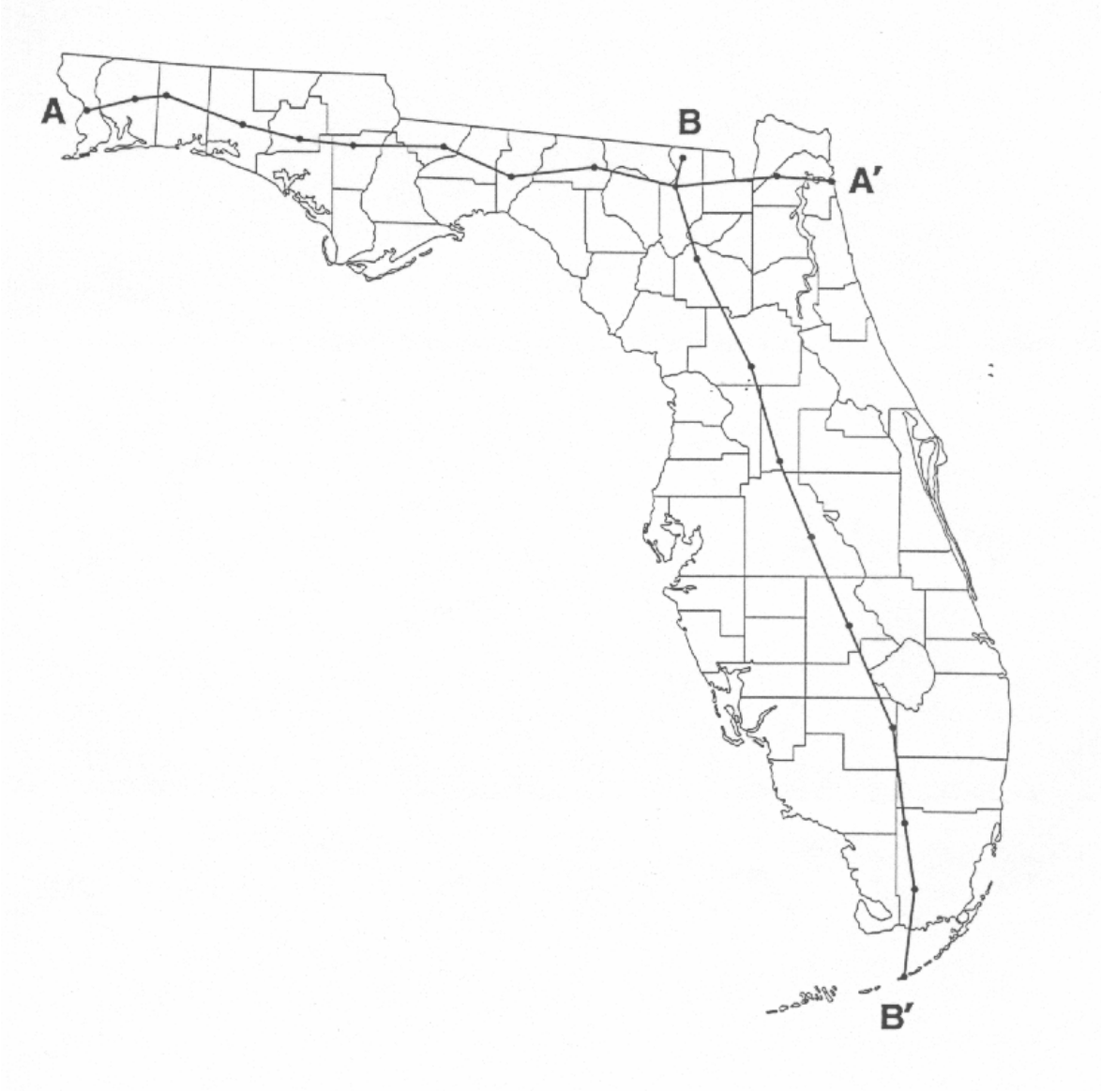

Figure 3.5 Geological Cross-section locations (Source: see source, table 3.1)

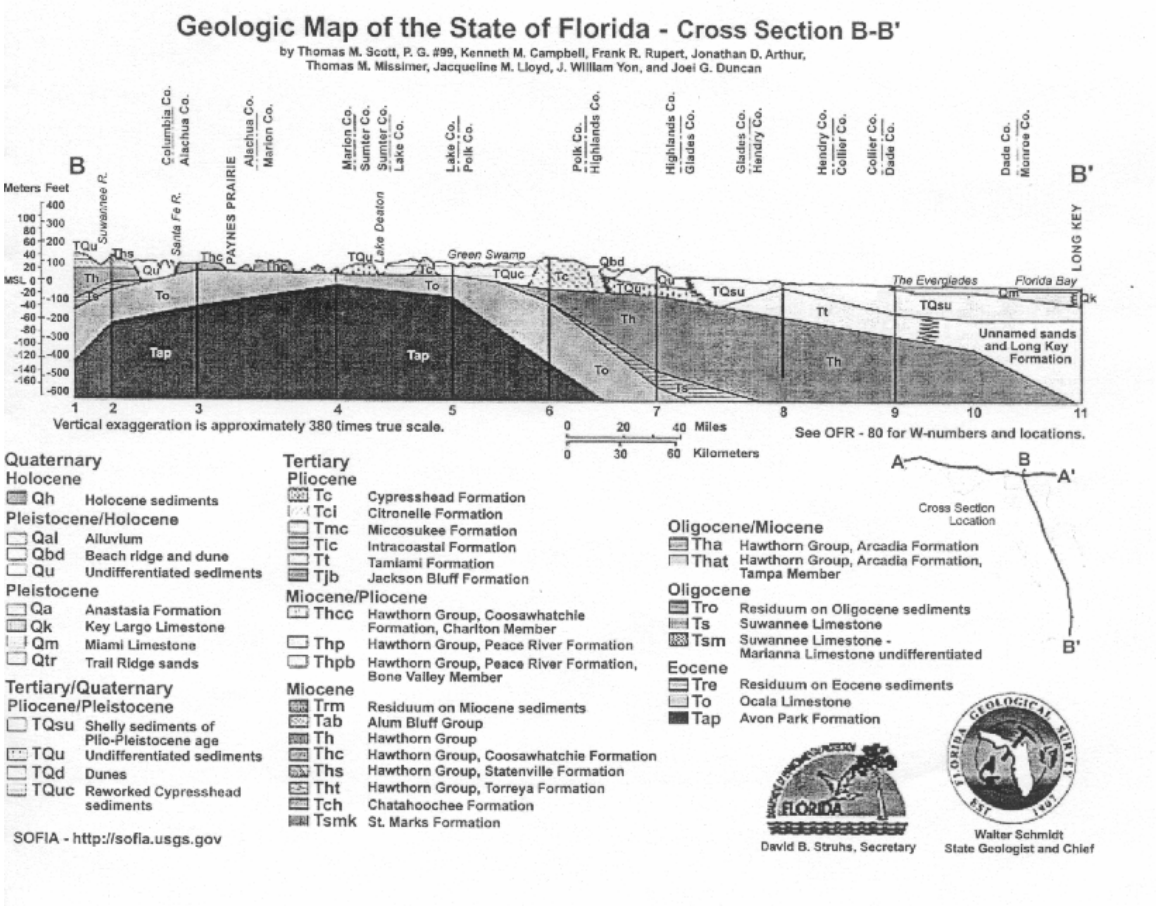

Figure 3.6 Geological Cross-section B-B (Source: see source, Table 1)
Note: Area of interest for LOW Project is between Sections 7 and 8, above.

3.5 Review of SFWMD Maps

As discussed earlier the SFWMD map room provides many things, including boring logs as far back as the 1940's and 1950's. Also, of note is that some of these soil-boring logs are actually old COE borings. Of the many boring logs available in the SFWMD map room, it was noted that there is some boring information specific to structures within the project limits, as referenced earlier in this report, were available for review. Many of these borings were obtained for several of these structures. These structures include the following Pump Stations: S-75, S-135, S-70, S-68, S-83, S-84, S -82, and S-191. The locations of these structures have been provided in Figure 3.7.

However, some of these structures will likely fall outside of the smaller project area that will be the focus of future submittals. These borings will likely be significantly useful in the planning stages of structures specific to the proposed improvements that will result from the LOW Project. This information will be reviewed regarding the planned structure locations once they are determined. It should be noted that here again, this information is relatively old and appears to have been collected utilizing out of date geotechnical practices and will require field verifications. But, it does serve as useful information at the early stages of the improvement considerations for this project.

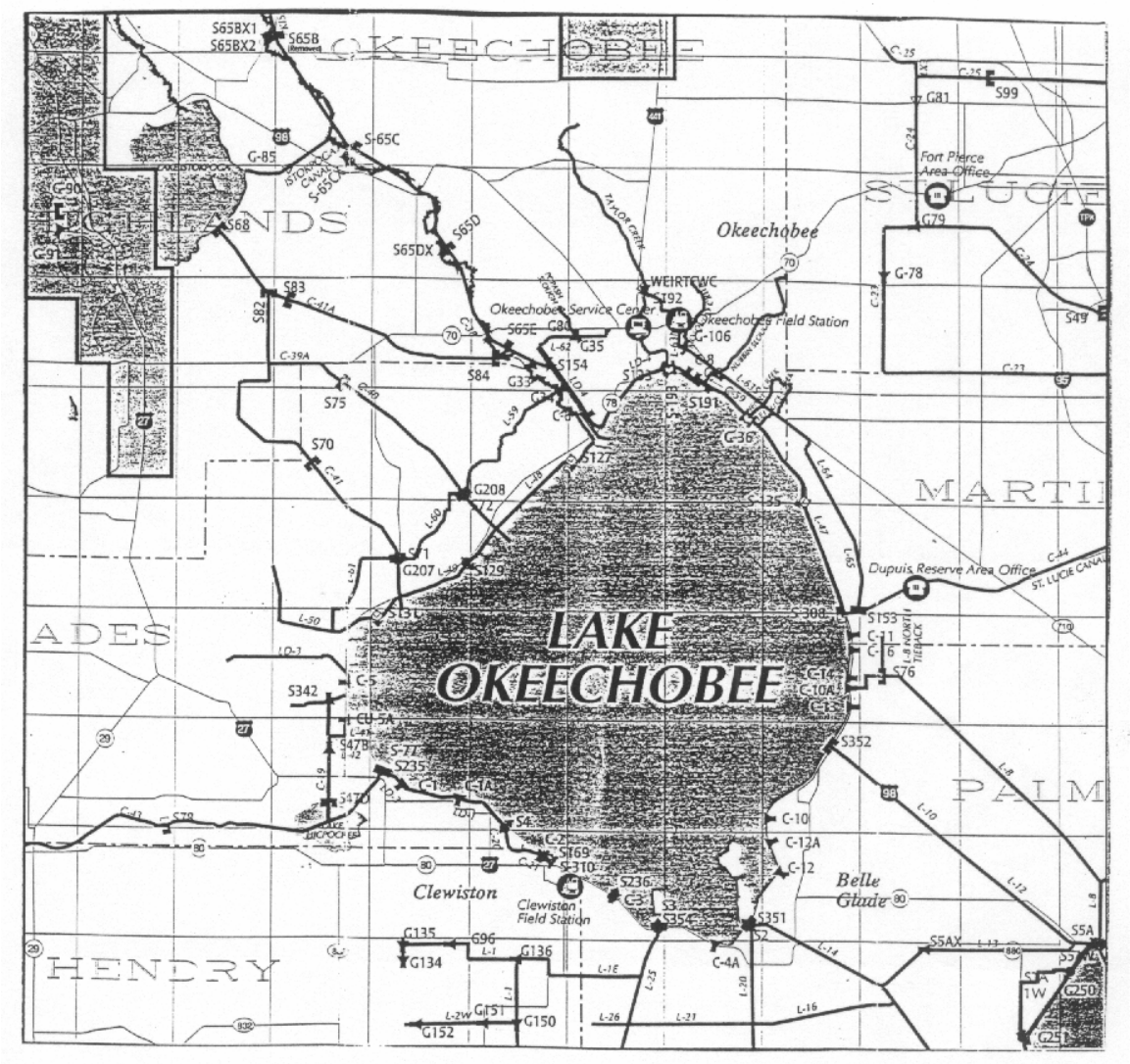

Figure 3.7 Locations of Structures and Boring Logs

3.6 Software Programs from Internet Websites

The Florida Geological Survey websites have data and map databases for use by anyone. Most of these services are free and can be downloaded for use. Most of the stored data comes from the various Water Management Districts of the State of Florida.

The website listed below which contains FGSLOGS Lithologic Database Program has boring data for wells that were built for the districts to depths from as low as 45 feet to as deep as 1500 feet below ground surface. Samples of this software are available for use, if it should become desired. This website provides a useful source of information in that well boring locations can be plotted on the map to develop density maps for the project area. This could provide site-specific soil boring information for future use for the proposed structures during the design and construction phases of the LOW project.

The URL web page is shown below:
http://www.dep.state.fl.us/geology/gisdatamaps/litholog.htm#TipsnTricks

4.0 Other Sources of Information

4.1 Introduction

There are numerous other possible sources of geotechnical and geological information available. The following sources of note are mentioned herein for the purpose of illustrating that they have not been thoroughly reviewed at the time of this submittal, but may be useful during subsequent phases of the LOW Project.

4.2 USGS Quadrangle Maps

USGS quadrangle maps and geological maps for the area can be reviewed in order to get some insight into ground surface elevations and evaluate possible patterns associated with apparent sinkhole formations and other features pertinent to the project. These maps can be obtained from SFWMD, as well as several other sources for a fee. However, they are most useful with regards to specific site locations and for field reconnaissance. Therefore, the USGS Quadrangle maps may be utilized at later stages of this project development.

4.3 SFWMD Aerial Contour Maps

SFWMD has aerial maps that can be utilized. Again, review of these maps would be most useful with regards to field reconnaissance and at specific site locations will be considered for use at subsequent phases of this project. These aerial contour maps can illustrate one-foot contour intervals.

5.0 Discussion

5.1 Assessment of Existing Data:

USDA data was successfully obtained from each of the five counties, Okeechobee, Martin, St. Lucie, Highlands, and Glades. This data provides general, near surface, soil profiles for the LOW project area. However, there are detailed maps for every locality, i.e., the county is divided into approximately 70 sections and each section has a separate map that provides details of the soils expected to be encountered in the area. The depths covered in the survey reports are shallow, i.e. up to approximately seven feet deep. Therefore the data is not suitable for estimating soils deeper than seven feet. Also, because the USDA information focuses on the upper soil layers, it is typical that development or farming efforts can alter the upper soils making this information inaccurate.

However, there are several sources, which can provide some insight in the soils beyond the upper regions to help in the evaluation. These include, but are not limited to, the use of the data available from the web page of the Florida Geological Survey where one can obtain wells information and soil data at much deeper locations, use of the USGS maps, review of individual boring logs, etc., as discussed.

At this time, it is not known exactly which structures will be required or their locations. It is anticipated that there will be several structures proposed and constructed within LOW Project area. However, existing information is limited to specific areas and much of the data is out of date. But by looking at aerial photographs and the geology of the area, suggestions with regard to structure locations and foundation types could be made with some insight based upon the existing information that has been located during this phase of the project. Information including anticipated depths of a limestone layer, possible sinkhole considerations, the existence of muck layers, etc., may all help in the determination of the suitability, or non–suitability, of a specific location.

More information on the suitability of soil types for use in construction can be obtained from the Florida Department of Transportation's Standard Specification for Road and Bridge Construction. This is useful when selecting locations for structures and obtaining materials for construction.

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