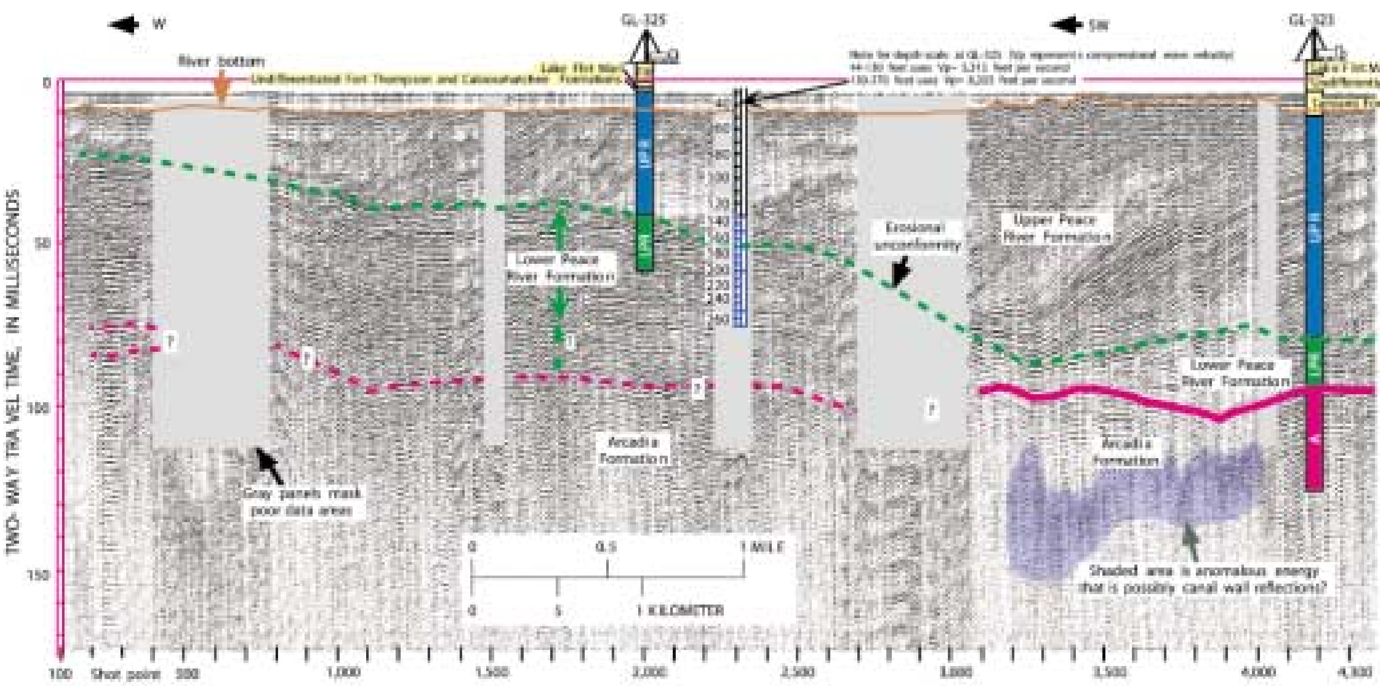
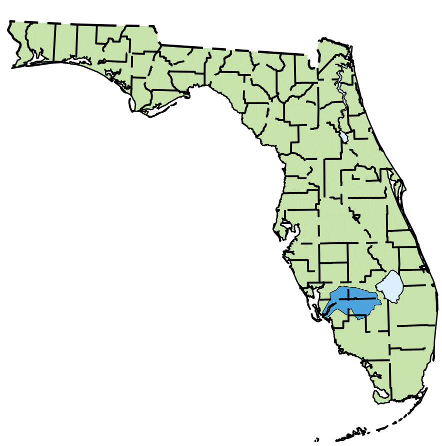
Surface-Geophysical Characterization of Ground-Water Systems of the Caloosahatchee River Basin, Southern Florida





U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 01-4084

Prepared in cooperation with the

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

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By Kevin J. Cunningham, Stanley D. Locker, Albert C. Hine,
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Tallahassee, Florida
2001

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Conversion Factors, Acronyms, and Abbreviations

Multiply	By	To obtain
inch (in.)	25.4	centimeter (cm)
foot (ft)	0.3048	meter (m)
foot per second (ft/s)	0.3048	meter per second (m/s)
foot per day (ft/d)	0.3048	meter per day (m/d)
foot per nannosecond (ft/ns)	0.3048	meter per nannosecond (m/ns)
mile (mi)	1.609	kilometer (km)
mile per hour (mi/hr)	1.609	kilometer per hour (km/hr)
square mile (mi^2)	2.590	square kilometer (km^2)

Acronyms	
FGS	Florida Geological Survey
GPR	Ground-penetrating radar
SFWMD	South Florida Water Management District
SRM	Standard reference material
USGS	U.S. Geological Survey
Abbreviations	
Hz	Hertz
J	Joule
Ma	Million years
MHz	Megahertz
ms	Millisecond
ns	Nannosecond
Vp	Compressional wave velocity

Surface-Geophysical Characterization of Ground-Water Systems of the Caloosahatchee River Basin, Southern Florida

By Kevin J. Cunningham[1], Stanley D. Locker[2], Albert C. Hine[2], David Bukry[3], John A. Barron[3], *and* Laura A. Guertin[4]

Abstract

The Caloosahatchee River Basin, located in southwestern Florida, includes about 1,200 square miles of land. The Caloosahatchee River receives water from Lake Okeechobee, runoff from the watershed, and seepage from the underlying ground-water systems; the river loses water through drainage to the Gulf of Mexico and withdrawals for public-water supply and agricultural and natural needs. Water-use demands in the Caloosahatchee River Basin have increased dramatically, and the Caloosahatchee could be further stressed if river water is used to accommodate restoration of the Everglades. Water managers and planners need to know how much water will be used within the river basin and how much water is contributed by Lake Okeechobee, runoff, and ground water.

In this study, marine seismic-reflection and ground-penetrating radar techniques were used as a means to evaluate the potential for flow between the river and ground-water systems. Seven test coreholes were drilled to calibrate lithostratigraphic units, their stratal geometries, and estimated hydraulic conductivities to surface-geophysical profiles.

A continuous marine seismic-reflection survey was conducted over the entire length of the Caloosahatchee River and extending into San Carlos Bay. Lithostratigraphic units that intersect the river bottom and their characteristic stratal geometries were identified. Results show that subhorizontal reflections assigned to the Tamiami Formation intersect the river bottom between Moore Haven and about 9 miles westward. Oblique and sigmoidal progradational reflections assigned to the upper Peace River Formation probably crop out at the floor of the river in the Ortona area between the western side of Lake Hicpochee and La Belle. These reflections image a regional-scale progradational deltaic depositional system containing quartz sands with low to moderate estimated hydraulic conductivities. In an approximate 6-mile length of the river between La Belle and Franklin Lock, deeper karstic collapse structures are postulated. These structures influence the geometries of parallel reflections that intersect the river channel. Here, reflections assigned to the Buckingham Limestone Member of the Tamiami Formation (a confining unit) and reflections assigned to the clastic zone of the sandstone aquifer likely crop out at the river bottom. Beneath these shallow reflections, relatively higher amplitude parallel reflections of the carbonate zone of the sandstone aquifer are well displayed in the seismic-reflection profiles. In San Carlos Bay, oblique progradational reflections assigned to the upper Peace River Formation are shown beneath the bay. Almost everywhere beneath the river, a diffuse ground-water flow system is in contact with the channel bottom.

Ground-penetrating radar profiles of an area about 2 miles north of the depositional axis of the deltaic depositional system in the Ortona area show that progradational clinoforms imaged on seismic reflection profiles in the Caloosahatchee River are present within about 17 feet of the ground surface.

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Ground-penetrating radar profiles show southward dipping, oblique progradational reflections assigned to the upper Peace River Formation that are terminated at their tops by a toplapping or erosional discontinuity. These clinoformal reflections image clean quartz sand that is probably characterized by moderate hydraulic conductivity. This sand could be mapped using ground-penetrating radar methods.

INTRODUCTION

The Caloosahatchee River Basin is located in southwestern Florida and includes approximately 1,200 mi^2 of land (LaRose and McPherson, 1980). The Caloosahatchee River receives water from Lake Okeechobee, runoff from the watershed, and seepage from the surficial aquifer system. The river empties into the Gulf of Mexico behind Sanibel and Pine Islands near Fort Myers (fig. 1), and supplies water for public, agricultural, and natural needs. Water-use demands in the Caloosahatchee River Basin have increased dramatically and could be further stressed if used to accommodate restoration of the Everglades (Dabbs, 1998). To determine how much water, if any, can be diverted for restoration, water managers and planners need to know how much water will be used within the river basin, and how much water is contributed to the river by Lake Okeechobee, runoff, and ground water. An integrated surface-water/ground-water model is being used by the South Florida Water Management District (SFWMD) to develop a water budget for the Caloosahatchee River Basin based on current usage in order to predict the effects of water-management alternatives (Dabbs, 1998). To better assess the hydraulic connection between the Caloosahatchee River and the underlying aquifer systems used in the model, the U.S. Geological Survey (USGS), in cooperation with the SFWMD, initiated a study to provide a high-resolution geophysical and hydrogeologic framework for the aquifer systems underlying the Caloosahatchee River Basin.

Purpose and Scope

The purpose of this report is to characterize the hydrogeologic framework of ground-water systems that are being simulated by the integrated ground-water/surface-water model for the Caloosahatchee River Basin. This is accomplished through the interpretation of geophysical, lithologic, micropaleontological, and strontium-isotope data.

Depth to geologic contacts and hydrogeologic units, orientation of bedding, lithologic types and thickness, and sequence stratigraphy are interpreted from seismic-reflection and ground-penetrating radar (GPR) profiles. Lithologic descriptions of seven test coreholes are linked to the geophysical interpretations to provide an accurate hydrogeologic framework. Micropaleontologic and strontium-isotope data provide temporal constraints that guide correlation of reflections on seismic profiles and of lithologic units in cores.

Previous Studies

Few surface-geophysical surveys have been collected in the area of the Caloosahatchee River Basin. Missimer and Gardner (1976) demonstrated the benefits of linking the hydrology of Lee County, Fla., to subsurface geologic features on seismic profiles, including lithostratigraphic boundaries, bedding orientation, paleochannel-fills, and lithology. Wolansky and others (1983) correlated seismic-stratigraphic units to the hydrologic units of the surficial and intermediate aquifer systems in an area including Charlotte Harbor and Venice in southwestern Florida. Lewelling and others (1998) showed how seismic-reflection data can contribute to the identification of geologic features that could act as potential conduits for the exchange of surface water in the Peace River and underlying aquifers in west-central Florida. About 8 mi of single-channel and multichannel airgun data have been collected on the inland river section of the Caloosahatchee River and about 5.5 mi in the Caloosahatchee River estuary and San Carlos Bay (Scholz and Cunningham, 1997). Specific hydrogeologic features that can be inferred from GPR profiles include sediment types and thickness (Beres and Haeni, 1991), karst features (Barr, 1993; McMechan and others, 1998), subaerial-exposure surfaces (Kruse and others, 2000), depth to water table and clay beds (Johnson, 1992; Barr, 1993), and soil types and soil conditions (Freeland and others, 1998). Finally, van Overmeeren (1998) showed the application of linking radar stratigraphy to hydrogeological characteristics of the shallow subsurface.

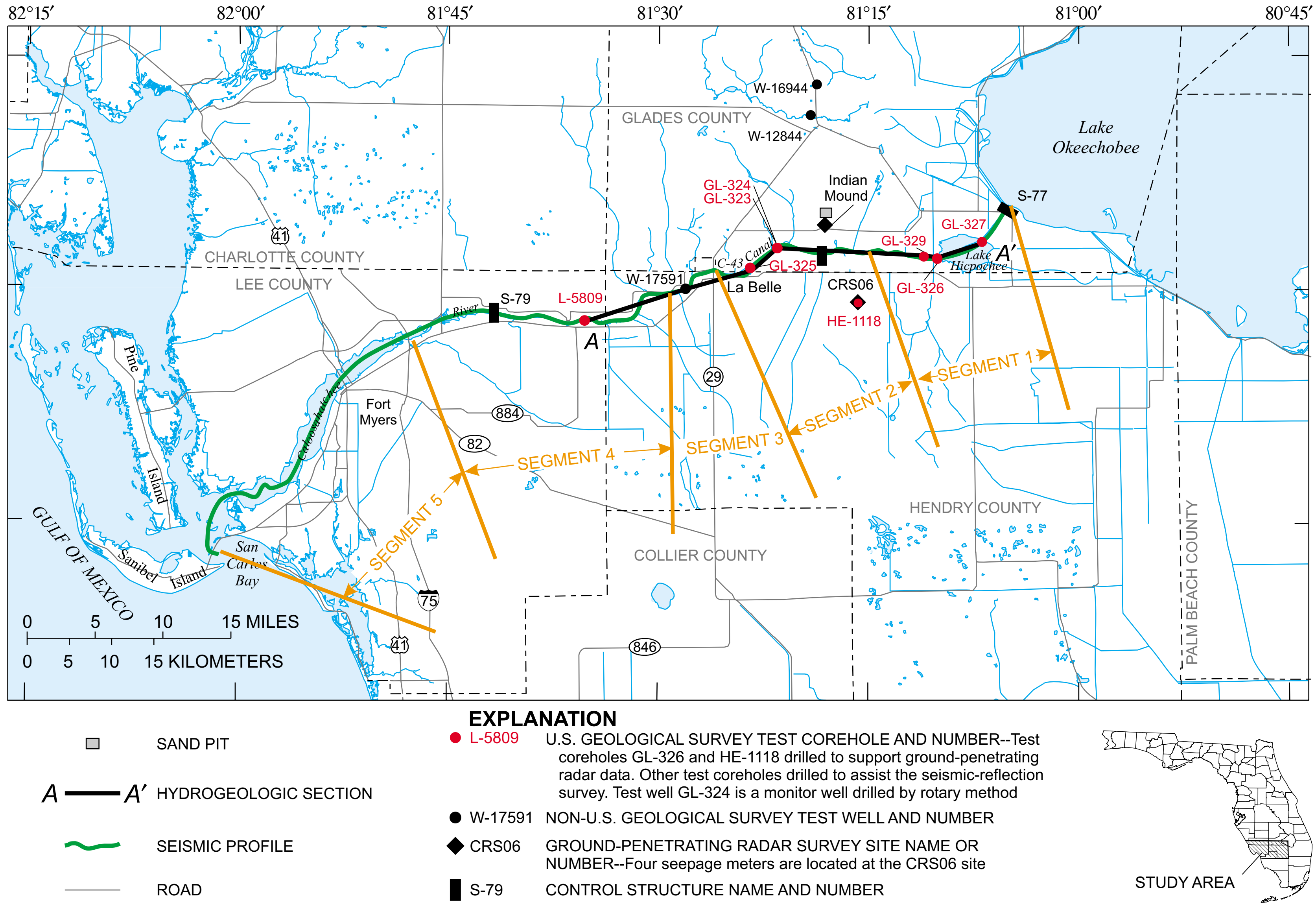

Figure 1. The Caloosahatchee River Basin study area showing locations of seismic illustrations, test coreholes drilled for this study, seepage meter sites, ground-penetrating radar sites, and established test wells. Continuous seismic surveys were run from S-77 at Lake Okeechobee to the bridge crossing the entrance to San Carlos Bay at the Gulf of Mexico. Segments 1-5 are areas on seismic profiles exhibiting different seismic stratigraphic characteristics.

Acknowledgments

Pamela Telis of the USGS is acknowledged for providing technical support for this investigation. Jim Trindell of the Florida Geological Survey (FGS) drilled seven test coreholes. Tom Scott (FGS) contributed to the organization of the drilling program. Anthony Brown and Steven Memberg (USGS) provided assistance in geophysical logging of wells. Marc Buursink (USGS) gave long-distance assistance with the GPR instrumentation. The x-ray diffraction determinations were conducted by Donald McNeill (University of Miami).

METHODS

A multidisciplinary approach was taken to produce an accurate high-resolution hydrogeologic framework of the ground-water systems underlying the Caloosahatchee River Basin. This approach included the integration of marine seismic-reflection techniques, GPR methods, core analyses, micropaleontology, and strontium-isotope stratigraphy.

Seismic-Reflection Survey

About 180 mi of digital, single-channel, marine seismic-reflection data were collected along much of the Caloosahatchee River and part of San Carlos Bay (fig. 1). Good seismic penetration was achieved to more than 250 ms or about 800 ft during the survey. Problems with intense acoustic reverberations generated at the river floor prevented meaningful imaging in parts of the seismic survey. Muddy sediments or gas, especially in freshwater environments, can contribute to reverberations (Snyder and others, 1989; Evans and others, 1994). The obscured penetration was localized and sometimes not present across the full width of the river. For the section of river between structures S-79 and S-77 (fig. 1), lines were run on opposite sides of the river during traverses upstream and downstream so that the double coverage could avoid some of the localized problems caused at the river bottom.

The seismic-reflection survey was collected using an Elics Delph2 digital acquisition and processing system. A Huntec electrodynamic “boomer” plate attached to a catamaran sled was used to generate the underwater acoustical pulse. This acquisition unit was powered by an Applied Acoustics CSP-1000 power supply at a setting of 700 or 1,000 J. The shot rate was 1 second with a sampling rate of 8,000 Hz. An Innovative Transducer ST-5 10-channel hydrophone array was used to detect the return pulse. The range of the recording window was from 0 to 300 ms. Real-time navigational positions were obtained using Trimble digital global positioning system equipment. Post-cruise data processing included bandpass filtering, automatic gain control, and trace summing.

For seismic data at and close to test coreholes GL-323, GL-325, GL-327, GL-329, and L-5809 (fig. 1), approximate depth scales for seismic profiles were calculated from two-way traveltimes using velocities of 5,315 ft/s above the top of the lower Peace River Formation (fig. 2) and 8,203 ft/s below the top of the lower Peace River Formation. These velocities are based on correlation of test-corehole data to seismic profiles. The velocities above the top of the lower Peace River Formation are lower than velocities reported for similar facies (quartz sand) by Anselmetti and others (1997). For seismic profile illustrations herein that do not include test coreholes, approximate depth scales were calculated using a Vp of 5,578 ft/s above the top of the lower Peace River Formation and 7,218 ft/s below the top of the lower Peace River Formation. These velocities are more consistent with the laboratory measurement of Anselmetti and others (1997). Description and interpretation of seismic-reflection configuration patterns are based on comparison to examples in Mitchum and others (1977).

Ground-Penetrating Radar

The surface-geophysical method of GPR was used to obtain continuous images of geologic and hydrogeologic units at two sites in the Caloosahatchee River Basin. The Indian Mound and CRS06 sites were chosen for detailed interpretation, owing to the superior quality of the GPR profiles (fig. 1).

All GPR data were collected using a SIR System-10A+ with a dual 100-MHz antenna array manufactured by Geophysical Survey Systems, Inc. The profiles were collected by towing the antennas 55 ft behind a truck with a connecting rope and cable at a rate of about 0.5 mi/hr. The separation between the center point of the antennas was 35 in. Interpretations were made using RADAN for WinNT software and the RADAN-to-bitmap conversion utility.

At the Indian Mound site, approximate depth scales for radar profiles were calculated from two-way

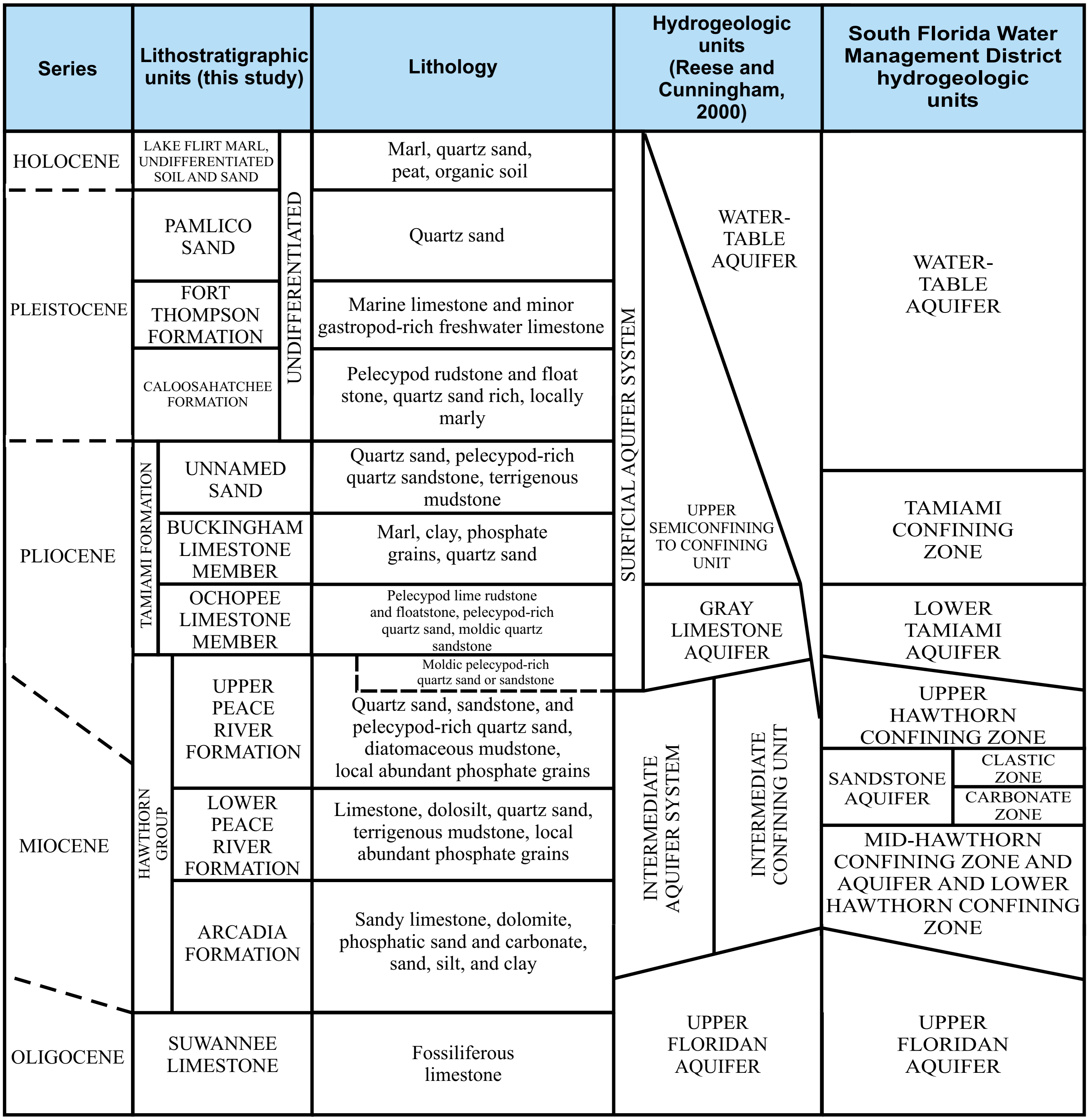

Figure 2. Lithostratigraphic units recognized in the study area, their generalized geology, and relation with hydrogeologic units. Modified from Olsson and Petit (1964), Hunter (1968), Wedderburn and others (1982), Miller (1986), Smith and Adams (1988), Missimer (1992), Brewster-Wingard and others (1997), Missimer (1997; 1999), Weedman and others (1999), and Reese and Cunningham (2000).

traveltimes employing velocities of 0.49 ft/ns for unsaturated sand and 0.20 ft/ns for saturated sand (Davis and Annan, 1989). At the CRS06 site, velocities were calculated using depths to reflections that could be determined from positive correlations with a buried culvert, depth to water table, and test-corehole lithologies. The velocity of unsaturated sand was calculated at 0.39 ft/ns using a traveltime from ground level to the measured depth of an exposed metal culvert. The velocity of saturated sand was calculated at 0.24 ft/ns, the traveltime between the measured top of the water table and the measured depth to the top of limestones of the Caloosahatchee Formation (fig. 2). A velocity of 0.18 ft/ns was used for saturated limestone. This value was obtained from Kruse and others (2000) for saturated near-surface limestones in southern Florida.

Drilling, Well Completion, Geophysical Logging, and Core Analysis

Seven continuous test coreholes (fig. 1) were drilled to groundtruth seismic-reflection and GPR surveys. The test coreholes were drilled by the FGS using a Failing 1500 drilling rig that employs a wireline coring method. Five of the test coreholes are located in Glades County (GL-323, GL-325, GL-326, GL-327, and GL-329), one in Lee County (L-5809), and one in Hendry County (HE-1118) as shown in figure 1. The GL-326 and HE-1118 test coreholes were drilled to support the GPR data, whereas the other coreholes were drilled to support interpretation of the seismic-reflection survey. Three test coreholes (GL-325, GL-327, and L-5809) were constructed as monitoring wells using 2-in. diameter slotted, polyvinyl-chloride casing. An additional monitoring well (GL-324) was drilled by normal rotary method at a distance of 10 ft from test corehole GL-323 (fig. 1). Descriptions of the test coreholes and a normal-rotary well drilled for this study are given in table 1.

Borehole-geophysical logs collected by the USGS for six of the test coreholes drilled during this study include induction resistivity, natural gamma ray, spontaneous potential, and single-point resistance. The induction-resistivity log was not collected at well GL-323 because of operational problems with the borehole-geophysical tool, and no logs were run in well GL-329 because of the shallow collapse of the wellbore. Borehole-geophysical tools were run in holes filled with drilling mud and cased with 6-in. diameter steel surface casing set to a depth between 10 and 25 ft below ground level. The data were collected in digital format and are archived at the USGS office in Miami, Fla.

Table 1. Description of wells drilled during this study

[Well locations are shown in figure 1. USGS, U.S. Geological Survey; FGS, Florida Geological Survey; MW, monitoring well; WLC, wireline core; NA, not applicable; NR, normal rotary; PVC, polyvinyl chloride; TW, test well]

Well identifier		Well type	Drilling method	Land net location	Latitude[1]	Longitude[1]	Altitude of measuring point[2] (feet)	Total depth drilled (feet)	Well construction material	Screen interval		
USGS local well number	FGS									Depth at top (feet)	Depth at bottom (feet)	Sand pack
GL-323	W-18069	TW	WLC	SE SEC25 T42S R29E	264738	0812142	21	401	NA	NA	NA	NA
GL-324	NA	MW	NR	SE SEC25 T24S R29E	264738	0812142	21	38	2-inch PVC	20	37	6/20
GL-325	W-18070	TW, MW	WLC	NW SE SEC35 T42S R29E	264622	0812338	25.5	200.75	2-inch PVC	25	55	6/20
GL-326	W-18073	TW	WLC	SW SW SEC30 T42S R32E	264659	0811017	16	39.5	NA	NA	NA	NA
GL-327	W-18074	TW, MW	WLC	SW SEC22 T42S R32E	264803	0810705	14	454	2-inch PVC	40	100	20/30
GL-329	W-18075	TW	WLC	SW SW SEC25 T42S R31E	264707	0811114	34	431	NA	NA	NA	NA
HE-1118	W-18072	TW	WLC	NE SEC19 T43S R31E	264408	0811555	22	26.75	NA	NA	NA	NA
L-5809	W-18071	TW, MW	WLC	NE SEC26 T43S R27E	264257	0813527	8	100	2-inch PVC	41	61	6/20

[1]North American Datum of 1983.
[2]Ground level.

Core samples were described in the laboratory using a 10-power hand lens and binocular microscope to determine vertical patterns of microfacies, sedimentary structures, lithostratigraphic boundaries and to estimate hydraulic conductivity. Core-sample descriptions are presented in the appendix. Limestones were classified by combining the schemes of Dunham (1962), Embry and Klovan (1971), and Lucia (1995). Rock colors were recorded by comparing dry samples to a rock-color chart containing Munsell color chips (Geological Society of America, 1991). Hydraulic conductivity of cores was visually estimated using a classification scheme based on local lithologies and physical properties of sediments developed by Fish (1988, table 7). This scheme distinguishes five categories of hydraulic conductivity for lithologies within the surficial aquifer system in Broward County: very high is greater than 1,000 ft/d, high ranges from 100 to 1,000 ft/d, moderate ranges from 10 to 100 ft/d, low ranges from 0.1 to 10 ft/d, and very low to nearly impermeable is less than 0.1 ft/d.

Micropaleontology

Coccoliths and diatoms were prepared and identified using standard methods at the USGS Micropaleontology Laboratory in Menlo Park, Calif. Coccolith floras were assigned to the biostratigraphic zones of Okada and Bukry (1980) with normalized additions of Subzones CN12aA, aB, and aC from Bukry (1991). Diatom floras were dated using the correlations of Barron (1992). Ages are reported in accordance with the integrated magnetobiochronologic Cenozoic time scale of Berggren and others (1995).

Information contained in Bock and others (1971), Poag (1981), and Jones (1994) was used to help identify benthic foraminifera at the genus level. Paleoenvironmental interpretations are based on Murray's (1991) grouping of individual benthic foraminiferal associations and species into broad depth categories of inner and outer shelf, which are defined as mean sea level to approximate water depths of 330 ft and 330 to 660 ft, respectively.

Strontium-Isotope Stratigraphy

Thirteen pelecypod shells and one echinoderm shell that appeared to be unaltered, based on examination with a binocular microscope, were collected from test coreholes GL-323, GL-325, and L-5809 for strontium-isotope analysis. Five samples were collected from the Arcadia Formation, six samples from the Peace River Formation, and three samples from the Tamiami Formation. Chemical separations and isotopic analyses were conducted by the Thermal Ionization Mass Spectrometry Laboratory at the University of Florida in Gainesville. The x-ray diffraction analyses showed that all samples were composed of low-magnesium calcite. The within-run precision for single analyses ranged from 10 to 21 x 10^{-6} (2σ standard error from the mean). All strontium-isotopic ratios were normalized to $^{86}Sr/^{88}Sr = 0.1194$ and to SRM-987 = 0.710249 with a 2σ error of 23 x 10^{-6}. Conversion of $^{87}Sr/^{86}Sr$ values to ages was derived from "Look-up Table Version 3:10/99" of Howarth and McArthur (1997). A value of 1 x 10^{-6} was subtracted from all $^{87}Sr/^{86}Sr$ values to correct for an interlaboratory bias between the University of Florida values and data presented in the "Look-up Table" of Howarth and McArthur (1997). The ages are used in accordance with the integrated magnetobiochronologic Cenozoic time scale of Berggren and others (1995).

HYDROGEOLOGIC FRAMEWORK

This study focused on the surficial aquifer system and the intermediate aquifer system or intermediate confining unit (fig. 2) underlying the study area. The surficial aquifer system consists of the water-table aquifer and hydraulically connected units above the first occurrence of laterally extensive beds of much lower permeability. The surficial aquifer system is composed mainly of sediments and rocks of Pliocene age (Tamiami Formation) and of Pleistocene and Holocene ages (fig. 2). The surficial aquifer system is divided into two aquifers: the water-table aquifer and the gray limestone aquifer, also called the lower Tamiami aquifer (Smith and Adams, 1988; Reese and Cunningham, 2000). The Ochopee Limestone is included in the gray limestone aquifer of southern Florida; this major aquifer was defined by Fish (1988) and investigated over a broad area by Reese and Cunningham (2000). The water-table aquifer and the gray limestone aquifer are either separated by a semiconfining to confining unit or coincide where confinement is absent (Knapp and others, 1984; Smith and Adams, 1988; Reese and Cunningham, 2000).

The intermediate aquifer system includes permeable rock and sediment that lie between the surficial aquifer system and the Floridan aquifer system; however, the intermediate aquifer system acts as a confining unit to the Floridan aquifer system in the study area. The intermediate aquifer system occurs within the Hawthorn Group and is composed mostly of a heterogeneous mixture of low-permeability clay, sandy clay, and dolosilt. Zones of permeable limestone, dolostone, sandstone, sand, and gravel also occur in this aquifer system. The intermediate aquifer system has been divided by the SFWMD into the sandstone aquifer, which lies between the upper Hawthorn confining zone and the mid- and lower Hawthorn confining zones; the sandstone aquifer is composed of a clastic and carbonate zone (Smith and Adams, 1988).

The Hawthorn Group is composed of the Peace River Formation and the Arcadia Formation (fig. 2). As defined by Missimer (1999), the Peace River Formation contains an informal upper and lower member. These are referred to herein as the upper Peace River Formation and the lower Peace River Formation, respectively (fig. 2). The upper Peace River Formation is primarily composed of siliciclastic strata. The lower Peace River Formation is similar to the underlying Arcadia Formation; both are composed of limestone as well as dolosilt, sand, and clay.

The Upper Floridan aquifer is composed of permeable portions of the lower Arcadia Formation, the Suwannee Limestone, the Ocala Limestone, and the Avon Park Formation. None of the test coreholes drilled for this study penetrate rocks of the Upper Floridan aquifer; however, the seismic-reflection survey probably contains reflections from strata of the upper portion of the Upper Floridan aquifer.

GEOPHYSICAL CHARACTERIZATION OF GROUND-WATER SYSTEMS OF THE CALOOSAHATCHEE RIVER BASIN

Seismic-reflection and GPR profiles, when combined with geologic and hydrologic data, can contribute substantially to the characterization of hydrogeologic properties of shallow aquifers and confining units. A marine seismic-reflection survey and several GPR surveys were used to characterize the hydrogeologic framework of the ground-water systems of the Caloosahatchee River Basin. Seven test coreholes were drilled to link subsurface hydrogeologic features to the geophysical profiles. Age constraints determined by micropaleontologic and strontium-isotope data were used to correlate reflections on seismic profiles with lithologic units in cores. Interpretations of some depositional environments were strengthened by including micropaleontologic data.

Marine Seismic-Reflection Survey

The seismic-reflection survey spanned the Caloosahatchee River and part of San Carlos Bay (Locker and Hine, 1999). The primary survey area extends more than 38.5 mi from Moore Haven Lock (S-77) to the Franklin Lock (S-79) as shown in figure 1. An additional seismic profile from Franklin Lock to San Carlos Bay (fig. 1) was made, in part, for comparison with previous seismic profiles made in San Carlos Bay by Missimer and Gardner (1976) and Scholz and Cunningham (1997).

The seismic survey from Moore Haven to San Carlos Bay has been divided into five seismic-reflection survey segments as shown in figure 1. The division is based on similarity of seismic-reflection configurations and continuity along discrete lengths of the survey. An interpretive line drawing of survey segments 1 to 3 and the eastern part of segment 4, between Moore Haven and Franklin Lock, is shown in figure 3.

Survey Segment 1

Survey segment 1 contains imaging of the Tamiami Formation, Peace River Formation, Arcadia Formation, surficial aquifer system, and intermediate confining unit (fig. 4). Seismic reflections within the Tamiami Formation are discontinuous with parallel, subparallel, and wavy parallel configurations (fig. 4). Seismic reflections assigned to the Tamiami Formation drape over the paleotopography of a truncation surface at the top of the upper Peace River Formation (fig. 4). Missimer (1999) reported a 0.2-Ma hiatus at this discontinuity between the Tamiami Formation and upper Peace River Formation in southwestern Florida.

The presence of the silicoflagellates *Dictyocha ornata africana*, *D. ornata ornata*, and *D. ornata tamarae* from mudstones in the middle part of the Tamiami Formation in test corehole GL-329 and the lower Tamiami Formation in test corehole GL-327 indicates assignment of these reflections to the late Pliocene (table 2 and fig. 5). The late Pliocene age for

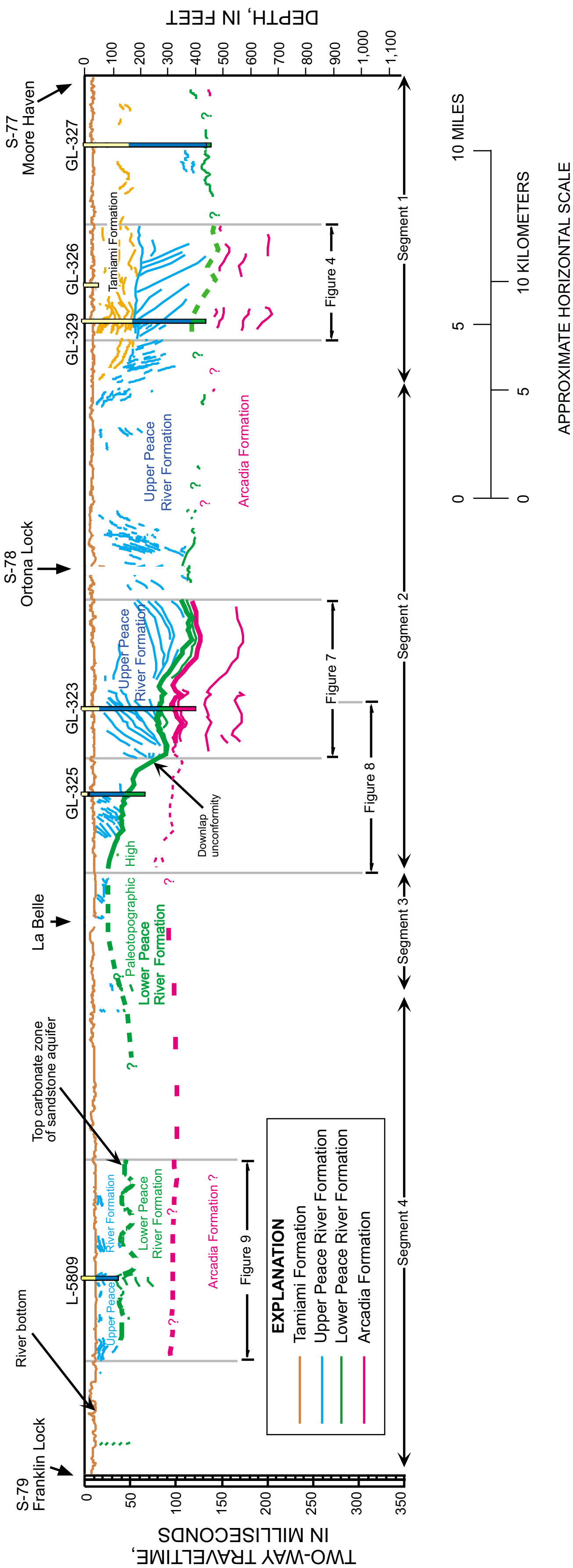

Figure 3. Interpretive line drawing based on marine seismic-reflection profiles along the Caloosahatchee River from structures S-77 to S-79. Oblique and sigmoidal progradational reflections indicate the presence of a regional-scale deltaic depositional system within the upper Peace River Formation approximately between La Belle and test corehole GL-326.

the lower Tamiami Formation is corroborated by two ages (2.15 and 1.91 Ma) derived from strontium isotopes (table 3). Coccoliths from the base of the Tamiami Formation in test corehole GL-329 suggest probable correlation of basal Tamiami reflections to Subzone CN12aA or to the late-early Pliocene based on the presence of rare *Discoaster surculus* and *Sphenolithus* sp. but without *Reticulofenestra pseudoumbilca* (table 4 and figs. 5 and 6).

Correlation of the survey segment 1 seismic-reflection profile to the GL-326 and GL-329 test coreholes suggests that sediments of the Tamiami Formation probably crop out along the river bottom (about 45 ft below land surface) at these test corehole locations. Sand and shells of moderate to high hydraulic conductivity that overlie clay (at 37 ft below land surface) of very low hydraulic conductivity are included in the Tamiami Formation at the GL-326 test corehole (see appendix). Sand of moderate hydraulic conductivity is included in the upper Tamiami at the GL-329 test corehole (see appendix). These coreholes suggest that both the water-table aquifer and the Tamiami confining zone (fig. 2) of Smith and Adams (1988) may crop out along the Caloosahatchee River bottom in the western part of the survey segment, and perhaps elsewhere.

In the western part of survey segment 1, seismic reflections assigned to the upper Peace River Formation are discontinuous, oblique, and progradational. These reflections are truncated updip by a prominent seismic-sequence boundary (fig. 4). The progradational seismic-reflection patterns of the upper Peace River Formation likely represent the eastern flank of a deltaic depositional system. The patterns are similar to prograding deltaic clinoforms identified in the Fort Myers area by previous investigators (Missimer and Gardner, 1976; Evans and Hine, 1991; Scholz and Cunningham, 1997). Closer to Moore Haven, the reflections within the upper Peace River Formation more closely approach a horizontal and wavy configuration (fig. 4, easternmost area), but are widely interrupted by areas of chaotic reflections that cannot be reliably interpreted.

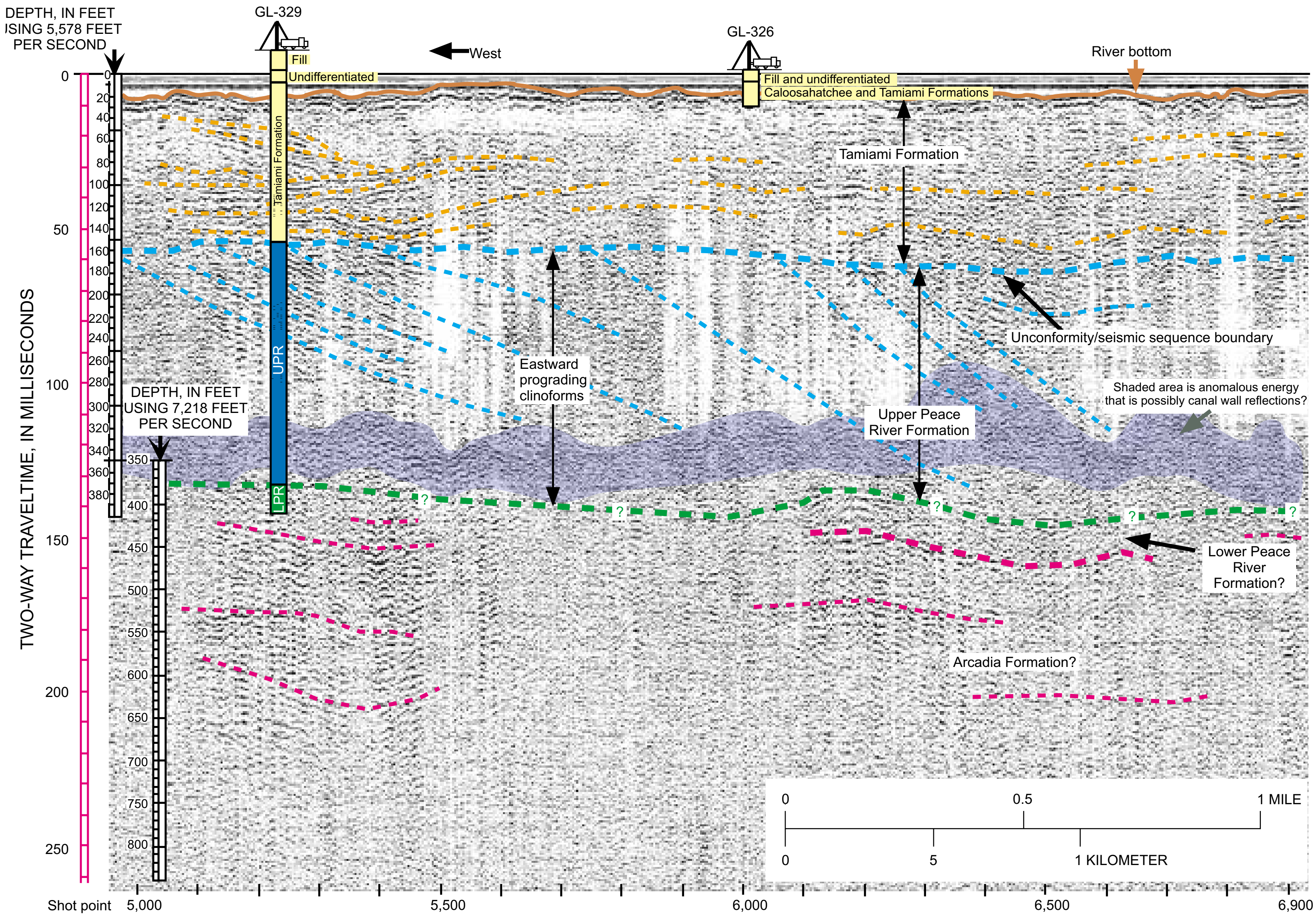

Figure 4. Seismic-reflection profile between Ortona Lock and Moore Haven (location in fig. 3). The thick section of oblique, progradational reflections is assigned to the upper Peace River Formation (UPR), and the overlying subhorizontal reflections are assigned to the Tamiami Formation. LPR represents the lower Peace River Formation.

Table 2. Occurrence of stratigraphically important silicoflagellate taxa in test coreholes GL-327 and GL-329

[UPR, upper Peace River Formation; LPR, lower Peace River Formation; +, present; -, not present; --, not determined]

Sample depth (feet)[1]	Silicoflagellates (barren or present)	Stratigraphic unit	Subepoch[2]	Silicoflagellate taxa[3]		
				Dictyocha ornata africanus	*Dictyocha ornata ornata*	*Dictyocha ornata tamarae*
GL-327						
102.5	Present	Tamiami	Late Pliocene	+	+	+
108.0	Present	Tamiami	Late Pliocene	+	+	+
109.7	Present	Tamiami	Late Pliocene	+	+	+
113.4	Present	Tamiami	Late Pliocene	+	+	+
116.1	Present	Tamiami	Late Pliocene	+	+	+
120.0	Present	Tamiami	Late Pliocene	+	+	+
121.2	Present	Tamiami	Late Pliocene	+	+	+
124.9	Present	Tamiami	Late Pliocene	+	+	+
130.4	Barren	Tamiami	--	-	-	-
208.5	Barren	UPR	--	-	-	-
251.5	Barren	UPR	--	-	-	-
302.6	Barren	UPR	--	-	-	-
319.0	Barren	UPR	--	-	-	-
326.9	Barren	UPR	--	-	-	-
337.5	Barren	UPR	--	-	-	-
352.5	Barren	UPR	--	-	-	-
361.2	Barren	UPR	--	-	-	-
371.5	Barren	UPR	--	-	-	-
383.1	Barren	UPR	--	-	-	-
429.0	Barren	UPR	--	-	-	-
445.2	Barren	UPR	--	-	-	-
449.2	Barren	LPR?	--	-	-	-
453.1	Barren	LPR?	--	-	-	-

Table 2. Occurrence of stratigraphically important silicoflagellate taxa in test coreholes GL-327 and GL-329 (Continued)

[UPR, upper Peace River Formation; LPR, lower Peace River Formation; +, present; -, not present; --, not determined]

Sample depth (feet)[1]	Silicoflagellates (barren or present)	Stratigraphic unit	Subepoch[2]	Silicoflagellate taxa[3]		
				Dictyocha ornata africanus	*Dictyocha ornata ornata*	*Dictyocha ornata tamarae*
GL-329						
72.9	Present	Tamiami	Late Pliocene	+	+	-
74.5	Present	Tamiami	Late Pliocene	+	-	-
76.7	Present	Tamiami	Late Pliocene	+	-	+
77.9	Present	Tamiami	Late Pliocene	+	-	-
226.0	Barren	UPR	--	-	-	-
243.1	Barren	UPR	--	-	-	-
270.0	Barren	UPR	--	-	-	-
282.8	Barren	UPR	--	-	-	-
311.8	Barren	UPR	--	-	-	-
312.1	Barren	UPR	--	-	-	-
334.5	Barren	UPR	--	-	-	-
335.5	Barren	UPR	--	-	-	-
344.5	Barren	UPR	--	-	-	-
366.5	Barren	UPR	--	-	-	-
367.5	Barren	UPR	--	-	-	-
382.0	Barren	UPR	--	-	-	-
398.0	Barren	LPR?	--	-	-	-
398.3	Barren	LPR?	--	-	-	-
411.0	Barren	LPR?	--	-	-	-
417.5	Barren	LPR?	--	-	-	-

[1]Below ground surface.
[2]Subepoch names reported in accordance with integrated magnetobiochronologic time scale of Berggren and others (1995).
[3]Identification by David Bukry, U.S. Geological Survey, Menlo Park, Calif.

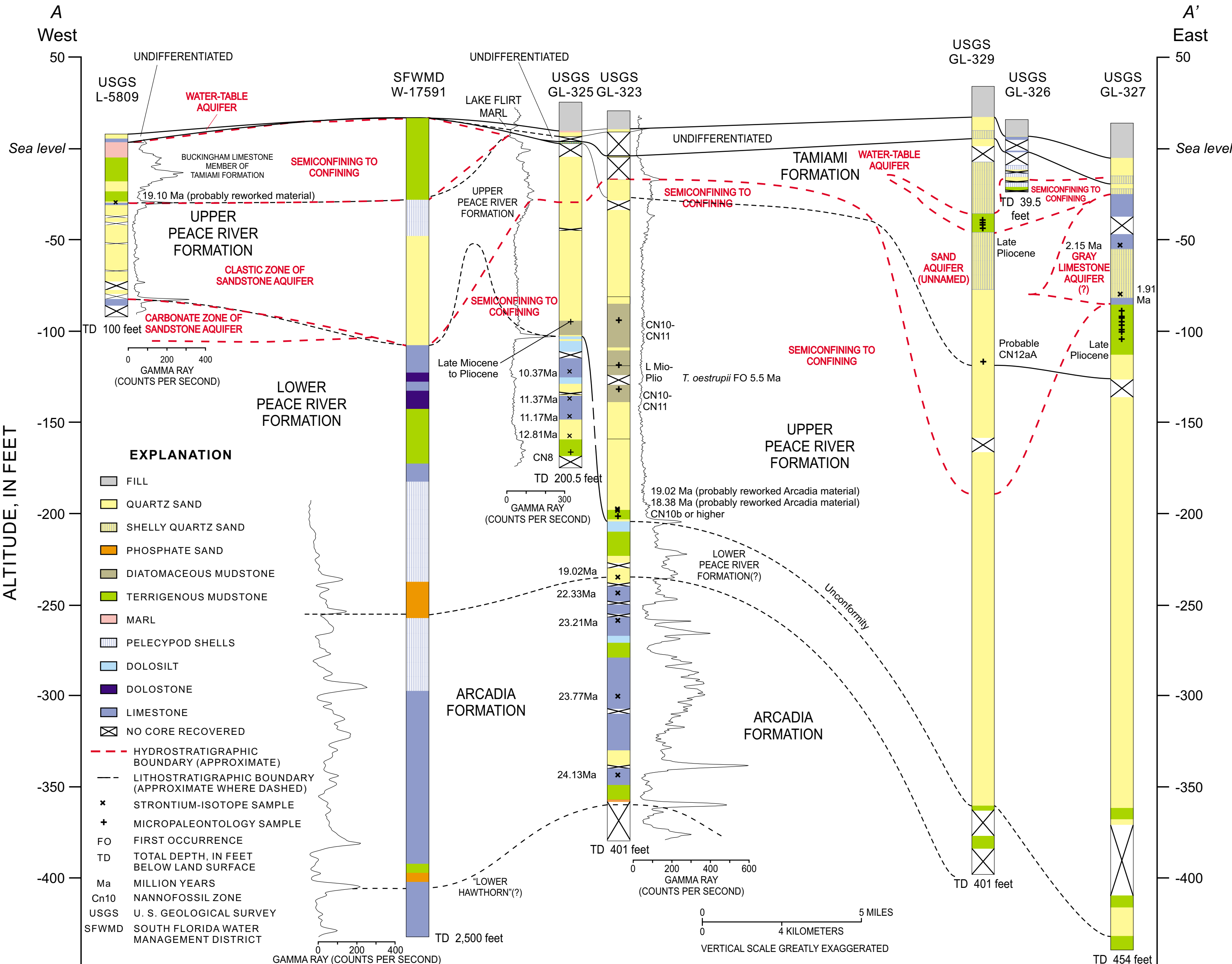

Figure 5. Hydrogeologic section A-A′ showing test coreholes drilled for this study near the Caloosahatchee River. Site locations shown in figure 1. Some gamma-ray logs used to correlate between wells are shown.

Table 3. Strontium-isotope data and ages from shell material collected from test coreholes GL-323, GL-325, GL-327, and L-5809

[All shell material collected has low-magnesium calcite mineralogy determined from x-ray diffractometer records. Ma, million years]

Local well identifier	Depth (feet)[1]	Stratigraphic position	$^{87}Sr/^{86}Sr$[2]	Estimated age (Ma)[3]
GL-323	217.6	Upper Peace River	0.708518	19.02[4]
	218.0	Upper Peace River	.708564	18.38[4]
	255.5	Arcadia	.708518	19.02
	265.2	Arcadia	.708333	22.33
	279.2	Arcadia	.708299	23.21
	322.0	Arcadia	.708270	23.77
	364.6	Arcadia	.708249	24.13
GL-325	147.6	Lower Peace River	.708879	10.37
	162.7	Lower Peace River	.708849	11.37
	172.8	Lower Peace River	.708855	11.17
	183.5	Lower Peace River	.708821	12.81
GL-327	67.2	Tamiami	.709081	2.15
	94.3	Tamiami	.709088	1.91
L-5809	37.5	Tamiami	.708513	19.10[4]

[1]Below ground level.

[2]Measured at the University of Florida Thermal Ionization Mass Spectrometry Laboratory, normalized to $^{86}Sr/^{88}Sr = 0.1194$, and corrected to a mean value of SRM-987 = 0.710249 ($\pm$0.000023). A value of 1×10^{-6} was subtracted from all $^{87}Sr/^{86}Sr$ values to correct for an interlaboratory bias between the University of Florida values and data presented in the "Look-up Table Version 3:10/99" of Howarth and McArthur (1997).

[3]Ages derived from "Look-Up Table Version 3:10/99" of Howarth and McArthur (1997), and used in accordance with time scale of Berggren and others (1995).

[4]Probable reworked material from Arcadia Formation.

The lower terminations of the clinoforms assigned to the upper Peace River Formation are masked by chaotic seismic reflections (fig. 4) possibly created by anomalous energy reflected off steeply inclined areas of the river bottom. Presumably the lower clinoforms downlap onto subhorizontal, slightly wavy, parallel seismic reflections assigned to the lower Peace River Formation below the zone of chaotic reflections (fig. 4). The subhorizontal reflections of the lower Peace River Formation are interpreted to grade downward into reflections with a similar reflection configuration assigned to the Arcadia Formation and possibly the upper part of the Suwannee Limestone (fig. 4).

Survey Segment 2

Survey segment 2 includes seismic representation of the same formations and aquifers as shown in survey segment 1. Seismic reflections assigned to the Tamiami Formation are represented by only a thin zone of poorly defined reflections beneath the river bottom in an area near test corehole GL-323 (fig. 7). These seismic reflections are within a zone of poor data quality, and their geometry is obscured by water-bottom reflections. Quartz sands of the Tamiami Formation crop out at the floor of the Caloosahatchee River at the GL-323 location, based on correlation of the GL-323 test corehole data to survey segment 2 (fig. 7). Visual estimates of the hydraulic conductivity

Table 4. Occurrence of stratigraphically important coccolith taxa in test coreholes GL-323, GL-325, GL-327, and GL-329

[Identification of coccoliths by David Bukry, U.S. Geological Survey, Menlo Park, Calif. UPR, upper Peace River Formation; LPR, lower Peace River Formation; --, not determined]

Well identification	Sample depth[1] (feet)	Stratigraphic position	Coccoliths barren or present	Nannofossil zone[2]
GL-323	109.2	UPR	Barren	--
	115.9	UPR	Present	CN10c-11
	134.2	UPR	Barren	--
	140.5	UPR	Barren	--
	153.8	UPR	Present	CN10-11
	223.4	UPR	Present	CN10c-11
	230.5	LPR	Barren	--
	292.7	Arcadia	Barren	--
GL-325	121.0	UPR	Present	Miocene to Pliocene
	130.0	LPR	Barren	--
	192.7	LPR	Present	CN8
GL-327	100.2	Tamiami	Barren	--
	102.5	Tamiami	Barren	--
	108.0	Tamiami	Barren	--
	109.7	Tamiami	Barren	--
	113.4	Tamiami	Barren	--
	116.1	Tamiami	Barren	--
	120.0	Tamiami	Barren	--
	121.2	Tamiami	Barren	--
	124.9	Tamiami	Barren	--
	126.3	Tamiami	Barren	--
	130.4	Tamiami	Barren	--
	208.5	UPR	Barren	--
	251.5	UPR	Barren	--
	302.6	UPR	Barren	--
	319.0	UPR	Barren	--
	326.9	UPR	Barren	--
	337.5	UPR	Barren	--
	352.5	UPR	Barren	--
	361.2	UPR	Barren	--
	371.5	UPR	Barren	--
	383.1	UPR	Barren	--

Table 4. Occurrence of stratigraphically important coccolith taxa in test coreholes GL-323, GL-325, GL-327, and GL-329 (Continued)

[Identification of coccoliths by David Bukry, U.S. Geological Survey, Menlo Park, Calif. UPR, upper Peace River Formation; LPR, lower Peace River Formation; --, not determined]

Well identification	Sample depth[1] (feet)	Stratigraphic position	Coccoliths barren or present	Nannofossil zone[2]
GL-327	429.0	UPR	Barren	--
	445.2	UPR	Barren	--
	449.2	LPR?	Barren	--
	453.1	LPR?	Barren	--
GL-329	72.9	Tamiami	Barren	--
	74.5	Tamiami	Barren	--
	76.7	Tamiami	Barren	--
	77.9	Tamiami	Barren	--
	153.2	Tamiami	Present	Probable CN12aA
	226.0	UPR	Barren	--
	243.1	UPR	Barren	--
	270.0	UPR	Barren	--
	282.8	UPR	Barren	--
	311.8	UPR	Barren	--
	312.1	UPR	Barren	--
	334.5	UPR	Barren	--
	335.5	UPR	Barren	--
	344.5	UPR	Barren	--
	366.5	UPR	Barren	--
	367.5	UPR	Barren	--
	382.0	UPR	Barren	--
	398.0	LPR	Barren	--
	398.3	LPR	Barren	--
	411.0	LPR	Barren	--
	417.0	LPR	Barren	--

[1]Depth reported below ground level.

[2]Coccolith floras assigned to the biostratigraphic zones of Okada and Bukry (1980) and reported in accordance with integrated magnetobiochronologic time scale of Berggren and others (1995).

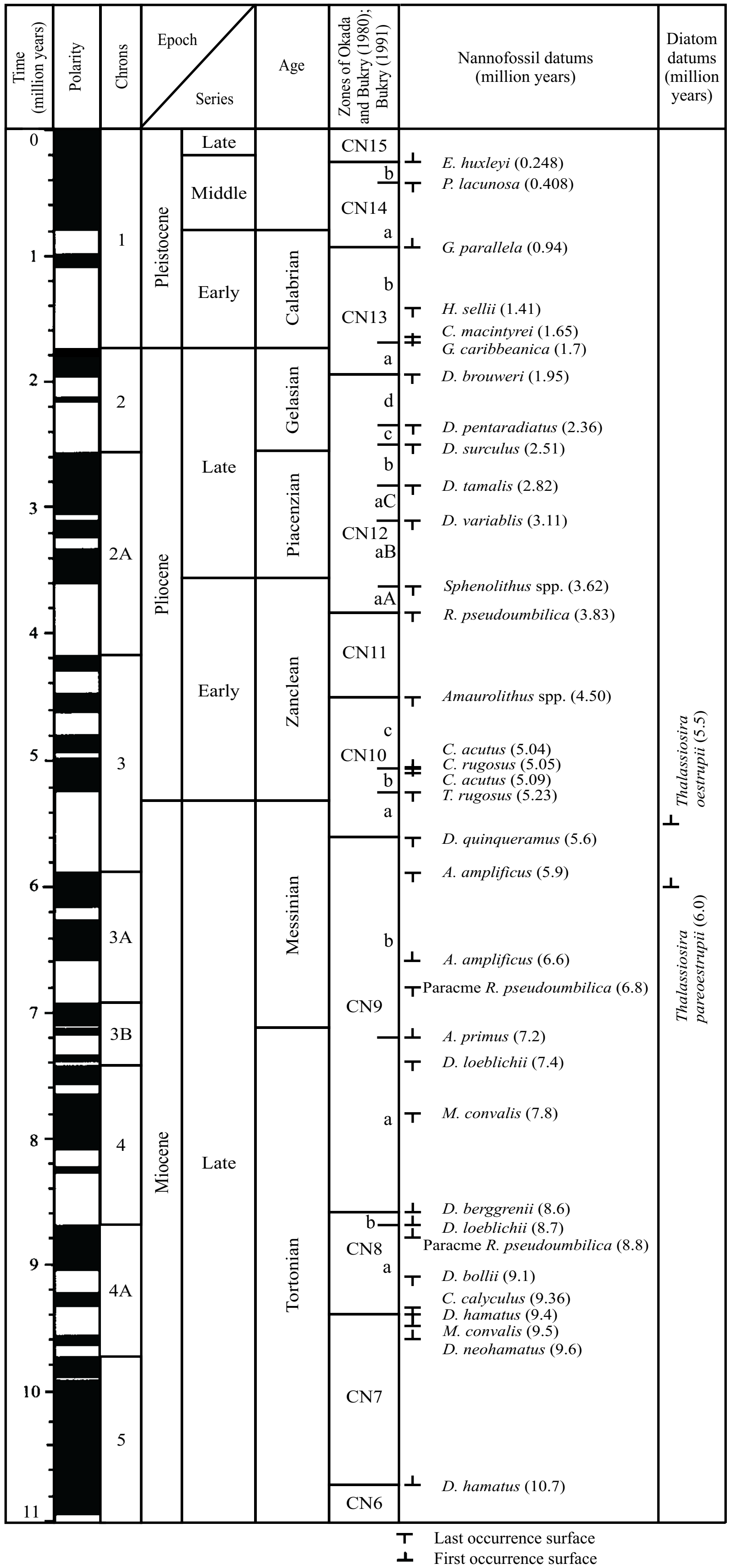

Figure 6. Correlation of the chronostratigraphy of part of the late Tertiary geomagnetic polarity time scale (Berggren and others, 1995). Coccolith zonation from Ocean Drilling Project Leg 171B at the Blake Nose east of the Florida Peninsula (Shipboard Scientific Party, 1998) with normalized additions of subzones CN12aA, aB, and aC from Bukry (1991) and diatom datums from offshore California.

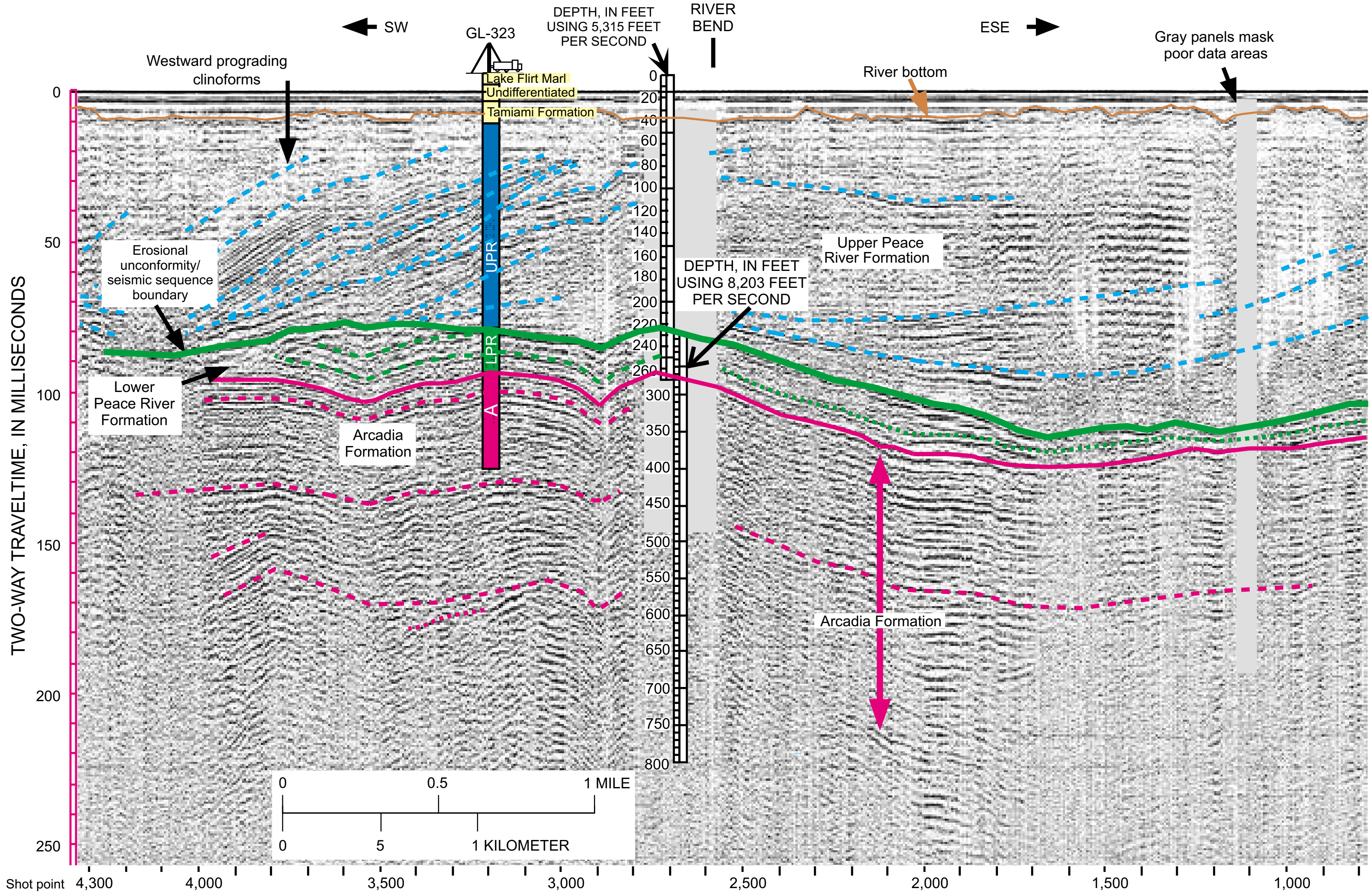

Figure 7. Seismic-reflection profile between La Belle and Ortona Lock showing strata drilled at the GL-323 test corehole (location in fig. 3). Sigmoidal and oblique progradational reflections, identified as siliciclastics and assigned to the upper Peace River Formation (UPR), downlap onto a major seismic sequence boundary that displays local erosional truncation. Parallel reflections below the seismic sequence boundary are assigned to the lower Peace River Formation (LPR) and Arcadia Formation (A). At the GL-323 test corehole, the unnamed sand of the Tamiami Formation may be exposed by dredging at the floor of the canal.

of the quartz sand of the Tamiami Formation in the GL-323 test corehole suggest that sand of low to moderate hydraulic conductivity (see appendix) crop out at the bottom of the Caloosahatchee River at this location, possibly providing the potential for direct exchange between the river and aquifer.

Throughout most of the western half of survey segment 2, seismic reflections assigned to the upper Peace River Formation have either a sigmoid or oblique progradational configuration (figs. 7 and 8). Where visible, the upper parts of the oblique progradational reflections are terminated by an irregular, subhorizontal reflection representing the dredged floor of the Caloosahatchee River (fig. 8, shot points 1,000-2,000) and probably crop out at the river floor in the Ortona area between the western side of Lake Hicpochee and La Belle (fig. 1). Micropaleontologic results support the assignment of the progradational reflections to the upper Peace River Formation (tables 4 and 5). Samples from the GL-323 and GL-325 test coreholes suggest an early Pliocene age for these progradational strata based on diatom taxonomy (table 5 and fig. 6) and assignment to Zones CN10c to CN11 (fig. 6) based on coccolith taxonomy (table 4). The progradational seismic-reflection patterns of the upper Peace River Formation likely represent the western flank of a deltaic depositional system that is similar to prograding deltaic clinoforms identified in the Fort Myers area by previous investigators (Missimer and Gardner, 1976; Evans and Hine, 1991; Scholz and Cunningham, 1997). This environmental interpretation is consistent with ecological data for benthic-foraminiferal genera identifications for samples from test coreholes GL-323 and GL-325 (tables 6 and 7) that suggest deposition in a shallow-marine shelf environment. The depositional axis of the deltaic depositional system is shown in figure 3.

The upper Peace River Formation crops out along the floor of the Caloosahatchee River at test corehole GL-325, based on correlation of test corehole GL-323 to survey segment 2 (fig. 8). Visual estimates of the hydraulic conductivity of the upper Peace River Formation in test corehole GL-325 suggest that quartz sand of moderate hydraulic conductivity (see appendix) crops out at the bottom of the Caloosahatchee River at this location, and thus, the potential exists for direct exchange between the water-table aquifer and the river.

A major seismic-sequence boundary separates the upper Peace River Formation from the lower Peace River Formation (fig. 7). This seismic-sequence boundary approaches to within tens of feet of the river bottom at La Belle, which contrasts with its approximate 350 ft depth between Ortona Lock and Moore Haven (fig. 3). Westward dipping, progradational reflections of the upper Peace River Formation downlap onto much of this unconformity. The erosion of strata beneath the unconformity is represented by local termination of underlying reflections (figs. 7 and 8). This boundary is also indicated by a major shift in lithofacies and a sharp increase in gamma-ray activity in test coreholes GL-323 and GL-325 (fig. 5). In these coreholes, quartz sand or quartz conglomerate containing pebble-sized phosphorite grains of the upper Peace River Formation overlie dolosilt of the lower Peace River Formation (fig. 5 and appendix).

The seismic reflections assigned to the lower Peace River Formation have a subhorizontal, parallel configuration that has a broad, wavy configuration pattern (figs. 7 and 8). Coccoliths from a depth of 192.7 ft in the GL-325 test corehole (fig. 5 and table 5) indicate assignment to Zone CN8 or early-late Miocene (fig. 6). Data derived from strontium isotopes suggest an age between 12.81 and 10.37 Ma for the lower Peace River Formation in test corehole GL-325 (table 3 and fig. 5). Both coccolith and strontium isotope ages indicate these parallel reflections are equivalent to the lower Peace River Formation of Missimer (1999), which ranges in age from 11 to 8.5 Ma.

Concordant seismic reflections delineate the boundary between the lower Peace River Formation and underlying Arcadia Formation (figs. 7 and 8). The formation contact between the Peace River Formation and the Arcadia Formation is an abrupt contact and possible erosional discontinuity in test corehole GL-323 (see appendix). This contact has been defined as a major depositional sequence boundary by Missimer (1997) and Guertin and others (2000) in southwestern Florida. Data derived from strontium isotopes suggest an age between 24.13 to 19.02 Ma for the Arcadia Formation in test corehole GL-323 (table 3 and fig. 5).

Survey Segment 3

Survey segment 3 contains seismic images of the Peace River Formation, possibly the Arcadia Formation, the surficial aquifer system, and intermediate confining unit (figs. 1-3). Seismic-reflection profiles indicate that the base of the upper Peace River Formation is shallower in this segment than in others (fig. 3).

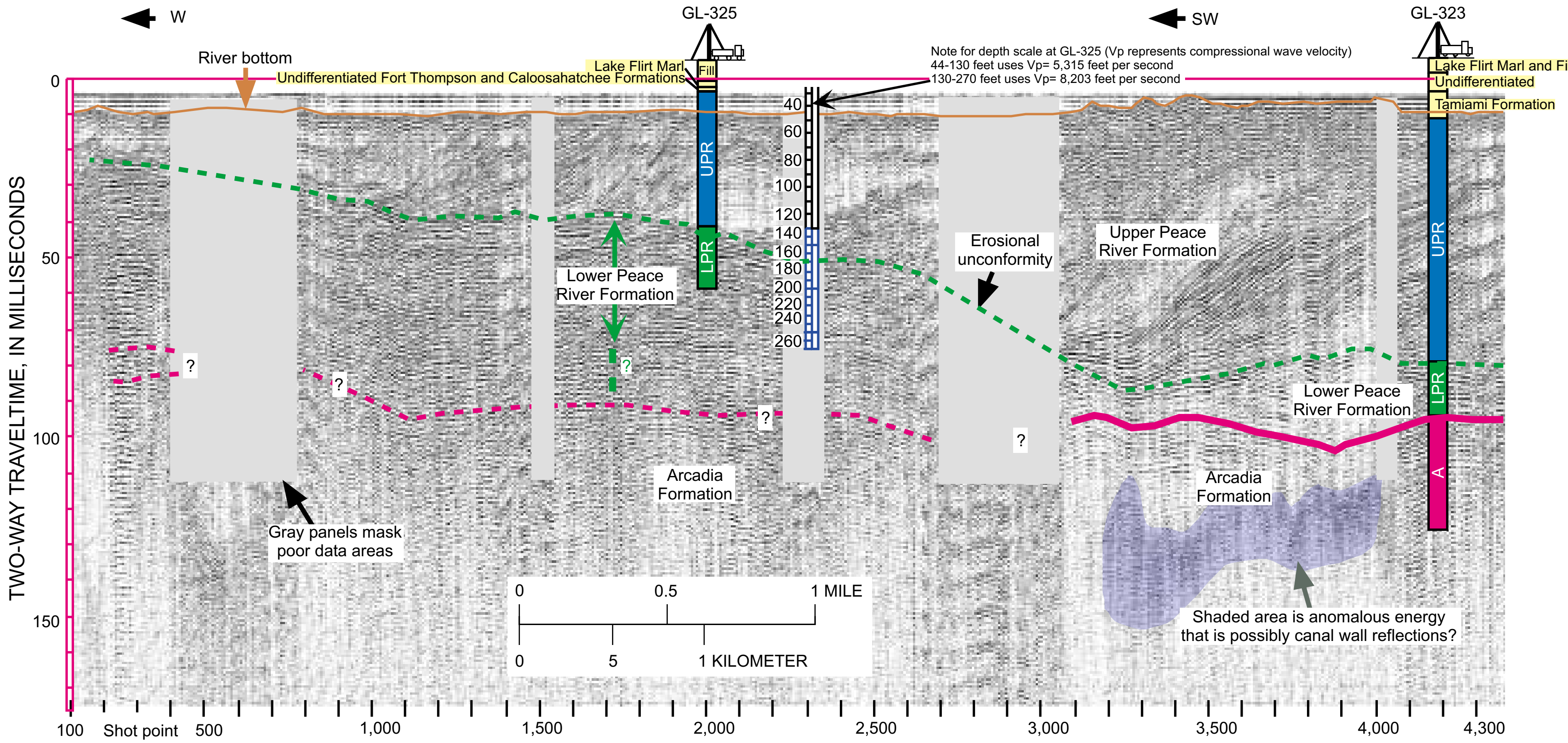

Figure 8. Seismic-reflection profile between La Belle and the GL-323 test corehole (location in fig. 3). The section of oblique prograding reflections assigned to the upper Peace River Formation (UPR) downlaps onto a major seismic sequence boundary that displays local erosional truncation. The parallel reflections below the unconformity are assigned to the lower Peace River Formation (LPR) based on drilling results. Near the GL-325 test corehole, clinoformal beds of the upper Peace River Formation probably crop out at the river bottom. Parallel reflections of the lower Peace River Formation are underlain by parallel reflections of the Arcadia Formation (A).

Table 5. Occurrence of stratigraphically important diatom taxa in test coreholes GL-323, GL-325, GL-327, and GL-329

[Diatom identification by J.A. Barron, U.S. Geological Survey, Menlo Park, Calif. UPR, upper Peace River Formation; LPR, lower Peace River Formation; Ma, million years; <, less than the value; --, not determined; ?, unknown]

Well identification	Sample depth[1] (feet)	Diatoms barren or present	Stratigraphic unit	Subepoch[2]	Estimated age[2] (Ma)	Taxa present
GL-323	109.2	Present	UPR	Early Pliocene	<5.5	*Hemidiscus ovalis, Koizumia tatsunoku-chiensis, Thalassiosira eccentrica, T. leptopus, T. oestrupii*
	140.5	Present	UPR	Early Pliocene	<5.5	*Hemidiscus ovalis, Thalassiosira eccentrica, T. oestrupii*
	223.4	Barren	UPR	--	--	--
	230.5	Barren	LPR	--	--	--
	292.7	Barren	Arcadia	--	--	--
	373	Barren	Arcadia	--	--	--
GL-325	121	Present	UPR	Late Miocene to early Pliocene	<6.0	*Azpeitia vetustissimus, Koizumia adaroi, Koizumia tasunoku-chiensis, Thalassiosira eccentrica, T. leptopus, T. Praeoestrupii*
	130	Barren	LPR	--	--	--
	192.7	Barren	LPR	--	--	--
GL-327	102.5	Present	Tamiami	Late Miocene to Holocene	<11.2	*Hyalodiscus spp. Paralia sulcata*
	108.0	Present	Tamiami	Pliocene	<5.5	*Hemidiscus ovalis, Nitzshcia granulata*
	120.0	Present	Tamiami	?	?	*Actinocyclus divisus Actinocyclus octonarius Actinoptychus sp. Azpeitia nodulifer Hyalodiscus sp. Navicula sp. Paralia sulcata Thalassiosira eccentrica*
	130.4	Barren	Tamiami	--	--	--
	208.5	Barren	UPR	--	--	--
	251.5	Barren	UPR	--	--	--
	302.6	Barren	UPR	--	--	--
	319.0	Barren	UPR	--	--	--
	326.9	Barren	UPR	--	--	--
	337.5	Barren	UPR	--	--	--
	352.5	Barren	UPR	--	--	--
	361.2	Barren	UPR	--	--	--
	371.5	Barren	UPR	--	--	--

Table 5. Occurrence of stratigraphically important diatom taxa in test coreholes GL-323, GL-325, GL-327, and GL-329 (Continued)

[Diatom identification by J.A. Barron, U.S. Geological Survey, Menlo Park, Calif. UPR, upper Peace River Formation; LPR, lower Peace River

Well identification	Sample depth[1] (feet)	Diatoms barren or present	Stratigraphic unit	Subepoch[2]	Estimated age[2] (Ma)	Taxa present
GL-327	383.1	Barren	UPR	--	--	--
	429.0	Barren	UPR	--	--	--
	445.2	Barren	UPR	--	--	--
	449.2	Barren	LPR?	--	--	--
	453.1	Barren	LPR?	--	--	--
GL-329	226.0	Barren	UPR	--	--	--
	243.1	Barren	UPR	--	--	--
	270.0	Barren	UPR	--	--	--
	282.8	Barren	UPR	--	--	--
	311.8	Barren	UPR	--	--	--
	312.1	Barren	UPR	--	--	--
	334.5	Barren	UPR	--	--	--
	335.5	Barren	UPR	--	--	--
	344.5	Barren	UPR	--	--	--
	366.5	Barren	UPR	--	--	--
	367.5	Barren	UPR	--	--	--

[1]Depth reported below ground level.

[2]Diatom floras dated using the correlations of Barron (1992) and reported in accordance with integrated magnetobiochronologic time scale of Berggren and others (1995).

Seismic reflections throughout much of survey segment 3 cannot be reliably interpreted because they have a chaotic reflection configuration or are overprinted by multiples. Oblique progradational configurations present in the eastern part of survey segment 3 are assigned to the upper Peace River Formation. The uppermost reflections are terminated by an irregular, subhorizontal reflection representing the dredged floor of the Caloosahatchee River. The progradational seismic-reflection patterns of the upper Peace River Formation are the westward extension of the deltaic depositional system imaged in survey segments 1 and 2 (figs. 4, 7, and 8). In the upper Peace River Formation, progradational seismic reflections downlap onto subhorizontal, parallel seismic reflections assigned to the lower Peace River Formation (fig. 3). The subhorizontal reflections of the lower Peace River Formation may grade downward into reflections with a similar reflection configuration assigned to the Arcadia Formation.

Survey Segment 4

Survey segment 4 contains imaging of the Tamiami Formation, Peace River Formation, possibly the Arcadia Formation, the surficial aquifer system, and the intermediate aquifer system (figs. 1-3 and 9). The continuity in seismic data is poorest along this section of the river, with short areas of reliable data broken intermittently by data of poor quality. Much of the seismic data in survey segment 4 cannot be interpreted because of a chaotic reflection configuration or overprinting by multiples. To aid in visualizing survey segments of reliable seismic data, the portions of poor quality are not shown in figure 9. Lithostratigraphic results from test corehole L-5809 (fig. 9 and appendix) were used to assign groups of seismic reflections to established lithostratigraphic and hydrogeologic units (fig. 2).

Table 6. Benthic foraminiferal genera listed alphabetically and their distribution with depth in test coreholes GL-323, GL-325, GL-327, GL-329, and L-5809

[References to Bock and others (1971), Poag (1981) and Jones (1994) assisted L.A. Guertin in identification of benthic foraminifers. B, Buckingham Limestone member of the Tamiami Formation; LPR, lower Peace River Formation; US, unnamed sand of the Tamiami Formation; UPR, upper Peace River Formation; --, not determined. Rare indicates less than 15 specimen per sample, common indicates 15 to 45 specimen per sample, abundant indicates greater than 45 specimen per sample]

Well identification	Sample depth[1] (feet)	Benthic forams barren or present	Stratigraphic position	Genera present
GL-323	45.0	Barren	US	--
	54.5	Barren	UPR	--
	59.0	Barren	UPR	--
	68.0	Barren	UPR	--
	76.1	Barren	UPR	--
	81.6	Barren	UPR	--
	89.1	Barren	UPR	--
	96.5	Barren	UPR	--
	100.4	Barren	UPR	--
	103.75	Barren	UPR	--
	114.3	Barren	UPR	--
	120.0	Barren	UPR	--
	127.0	Present	UPR	Common *Bulimina*, *Buliminella*, *Cancris*, *Cibicides*, *Elphidium*, *Hanzawaia*, and *Nonion*
	130.9	Present	UPR	Rare *Buliminella* and *Elphidium.*
	132.4	Present	UPR	Abundant *Buliminella* and *Elphidium.*
	135.5	Present	UPR	Common *Buliminella* and *Elphidium.*
	143.7	Present	UPR	Rare *Buliminella, Elphidium* and *Hanzawaia.*
	153.3	Present	UPR	Common *Buliminella, Elphidium* and *Hanzawaia*; rare *Nonion* and *Rosalina.*
	157.8	Present	UPR	Rare *Buliminella* and *Elphidium.*
	163.4	Present	UPR	Rare *Buliminella, Elphidium* and *Hanzawaia.*
	172.1	Present	UPR	Common *Buliminella, Cancris, Cibicides, Discorbis, Elphidium, Hanzawaia, Nonion* and *Rosalina.*
	179.6	Present	UPR	Rare *Buliminella, Elphidium, Hanzawaia, Nonion* and *Rosalina.*
	185.3	Present	UPR	Rare *Buliminella, Elphidium, Hanzawaia* and *Rosalina.*
	199.8	Present	UPR	Rare *Elphidium.*
	203.4	Present	UPR	Common *Elphidium*; rare *Buliminella, Discorbis and Planulina.*
	207.0	Present	UPR	Rare *Elphidium.*
	212.5	Present	UPR	Rare *Elphidium.*
	221.75	Present	UPR	Rare *Elphidium.*
	223.9	Barren	UPR	--
GL-325	32.0	Barren	UPR	--
	42.5	Barren	UPR	--
	54.5	Barren	UPR	--
	65.0	Barren	UPR	--
	74.5	Barren	UPR	--
	83.2	Barren	UPR	--

Table 6. Benthic foraminiferal genera listed alphabetically and their distribution with depth in test coreholes GL-323, GL-325, GL-327, GL-329, and L-5809 (Continued)

[References to Bock and others (1971), Poag (1981) and Jones (1994) assisted L.A. Guertin in identification of benthic foraminifers. B, Buckingham Limestone member of the Tamiami Formation; LPR, lower Peace River Formation; US, unnamed sand of the Tamiami Formation; UPR, upper Peace River Formation; --, not determined. Rare indicates less than 15 specimen per sample, common indicates 15 to 45 specimen per sample, abundant indicates greater than 45 specimen per sample]

Well identification	Sample depth[1] (feet)	Benthic forams barren or present	Stratigraphic position	Genera present
GL-325	93.0	Barren	UPR	--
	109.2	Barren	UPR	--
	121.0	Barren	UPR	--
	123.5	Present	UPR	Common *Elphidium*; rare *Amphistegina*, *Buliminella*, *Cibicides*, *Fursenkonina*, *Hanzawaia*, and *Nonion*.
	126.2	Barren	UPR	--
	127.9	Barren	UPR	--
GL-327	20.7	Barren	Undifferentiated	--
	28.7	Barren	Undifferentiated	--
	38.5	Barren	Tamiami	--
	66.7	Present	Tamiami	Rare *Nonion*, *Quinqueloculina*, and *Triloculina*
	84.7	Present	Tamiami	Rare *Quinqueloculina*, and *Triloculina*
	100.2	Present	Tamiami	Rare *Ammonia*, *Homotrema*, and *Nonion*
	102.5	Present	Tamiami	Rare *Ammonia* and *Homotrema*
	108.0	Barren	Tamiami	--
	109.7	Present	Tamiami	Rare *Ammonia*, *Homotrema*, and *Nonion*
	113.4	Present	Tamiami	Rare *Ammonia*
	116.1	Barren	Tamiami	--
	120.0	Barren	Tamiami	--
	121.2	Barren	Tamiami	--
	124.9	Barren	Tamiami	--
	126.3	Present	Tamiami	--
	130.4	Barren	Tamiami	Rare *Nonion*
	156.5	Barren	UPR	--
	178.7	Barren	UPR	--
	208.5	Barren	UPR	--
	223.7	Barren	UPR	--
	251.5	Barren	UPR	--
	255.6	Barren	UPR	--
	278.0	Barren	UPR	--
	302.6	Barren	UPR	--
	319.0	Barren	UPR	--
	326.9	Barren	UPR	--
	337.2	Barren	UPR	--
	352.5	Barren	UPR	--

Table 6. Benthic foraminiferal genera listed alphabetically and their distribution with depth in test coreholes GL-323, GL-325, GL-327, GL-329, and L-5809 (Continued)

[References to Bock and others (1971), Poag (1981) and Jones (1994) assisted L.A. Guertin in identification of benthic foraminifers. B, Buckingham Limestone member of the Tamiami Formation; LPR, lower Peace River Formation; US, unnamed sand of the Tamiami Formation; UPR, upper Peace River Formation; --, not determined. Rare indicates less than 15 specimen per sample, common indicates 15 to 45 specimen per sample, abundant indicates greater than 45 specimen per sample]

Well identification	Sample depth[1] (feet)	Benthic forams barren or present	Stratigraphic position	Genera present
GL-327	361.2	Barren	UPR	--
	371.5	Barren	UPR	--
	383.1	Barren	UPR	--
	429.0	Barren	UPR	--
	445.8	Barren	UPR	--
	449.2	Barren	LPR?	--
	453.1	Barren	LPR?	--
GL-329	69.9	Present	Tamiami	Rare *Nonion*, *Spirolina*, *Spiroloculina*, and *Triloculina*
	71.8	Present	Tamiami	Rare *Quinqueloculina*
	77.8	Present	Tamiami	Rare *Ammonia*, *Nonion*, and *Quinqueloculina*
	153.2	Present	Tamiami	Rare *Ammonia*, *Cancris*, *Hanzawaia* and *Nonion*
L-5809	5.8	?	B	--
	9.1	Present	B	Rare *Cibicides* and *Elphidium*
	14.9	Present	B	Common *Ammonia* and *Rosalina*
	20.3	Present	B	Abundant *Ammonia;* common *Cibicidoides, Elphidium,* and *Rosalina*
	23.8	Present	B	Abundant *Cibicidoides* and *Elphidium;* common *Buliminella, Cancris, Fursenkoinam,* and *Nonion*
	25.0	Present	B	Common *Cibicidoides, Elphidium, Fursenkoina,* and *Nonion;* rare *Buliminella* and *Cancris*
	28.3	Present	B	Common *Cibicidoides* and *Elphidium;* rare *Buliminella* and *Cancris,*
	29.9	Present	B	Rare *Cancris, Cibicides, Cibicidoides, Elphidium, Fursenkoina, and Rosalina*
	33.9	Barren	B	--
	35.0	Present	B	Common *Bigenerina, Buliminella, Cancris, Cibicidoides, Elphidium, Fursenkina, Nonion*, and *Rosalina*
	36.3	Barren	B	--
	40.5	Barren	UPR	--
	47.4	Present[2]	UPR	--
	55.1	Barren	UPR	--
	60.8	Barren	UPR	--
	67.7	Barren	UPR	--
	71.8	Barren	UPR	--
	74.1	Barren	UPR	--
	77.5	Barren	UPR	--
	79.1	Barren	UPR	--
	86.7	Barren	UPR	--

[1]Depth reported below ground level.

[2]Present but no identification due to recrystallization.

Table 7. Ecological data for benthic foraminiferal genera identified in test coreholes GL-323, GL-325, GL-327, GL-329, and L-5809

[Depth and environment information according to Murray (1991). Depth values originally published in meters; >, greater than the value]

Genus	Approximate water depth (feet)	Environment
Ammonia	0-160	Brackish and hypersaline lagoons, inner shelf
Amphistegina	0-430	Coral reefs, lagoons
Bigenerina		Shelf
Bulimina		Inner shelf to bathyal
Buliminella		Mainly shelf, but also lagoons and upper bathyal
Cancris	160-490	Inner shelf
Cibicides	0->6,600	Lagoons to bathyal
Cibicidoides		Shelf to bathyal
Discorbis	0-160	Shelf
Elphidium[1]	0-160	Brackish to hypersaline marshes, lagoons, inner shelf
Fursenkoina	0-3,900	Lagoons to upper bathyal
Hanzawaia		Inner shelf
Homotrema		Marine, inner shelf
Nonion	0-590	Shelf
Planulina		Shelf, bathyal
Quinqueloculina		Hypersaline lagoons, marine shelf
Rosalina	0-330	Lagoon, inner shelf
Spirolina	0-200	Lagoons and nearshore
Spiroloculina	0-130	Lagoons, inner shelf
Triloculina		Mainly hypersaline lagoons or marine inner shelf

[1]Poag (1981) states that *Elphidium* is abundant and widespread in coastal lagoons, bays, and estuaries.

Seismic reflections assigned to the Buckingham Limestone Member of the Tamiami Formation (fig. 2) are represented by only a thin zone of poorly defined reflections beneath the river bottom in an area near test corehole L-5809 and beyond in structural lows (fig. 9). These seismic reflections are within a zone of poor data quality, and their geometry is obscured by reflections at the river bottom. Where structural lows are present along survey segment 4, the Buckingham Limestone Member possibly crops out at the river bottom based on correlation of the L-5809 test corehole to survey segment 4 images (fig. 9 and appendix). Visual estimates in test corehole L-5809 indicate that marl, terrigenous mudstone, quartz and phosphatic sand, and dolosilt of the Buckingham Limestone Member mostly have very low to low hydraulic conductivity (see appendix). This suggests confinement between the surface water of the Caloosahatchee River and the ground-water system at structural lows.

A structural template, probably related to karstic collapse of deeper limestone that could be contained in the Floridan aquifer system, is responsible for a wavy,

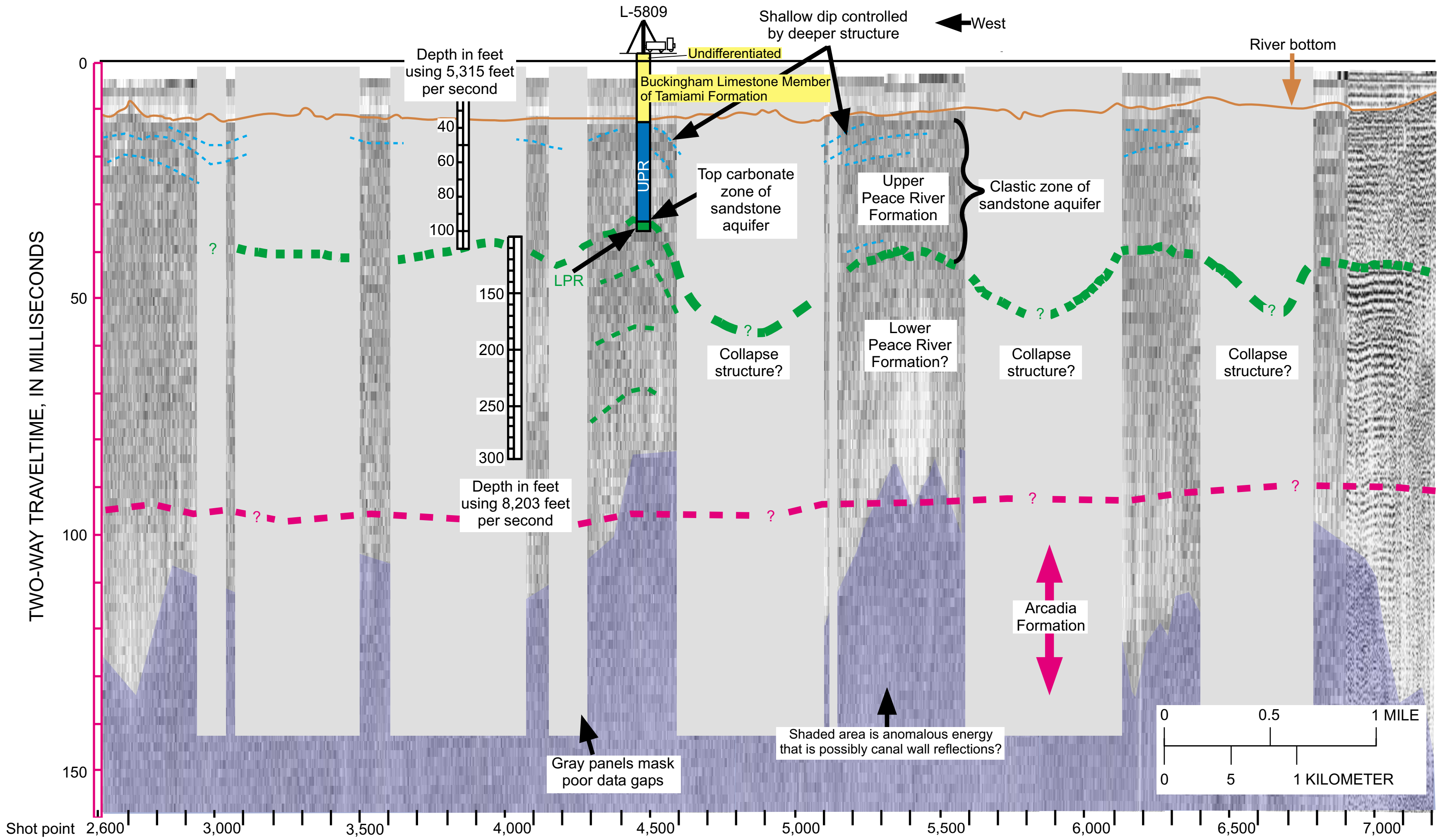

Figure 9. Seismic-reflection profile between La Belle and S-79 (Franklin Lock). Location shown in figure 3. Test corehole L-5809 was sited to reach a relatively high amplitude reflection at about 35 milliseconds depth. This reflection is assigned to the top of the carbonate zone of the sandstone aquifer (fig. 2) and is overlain by reflections imaging siliciclastics of the upper Peace River Formation (UPR) and the clastic zone of the sandstone aquifer (fig. 2). Possible collapse structures may be related to karstification of deeper limestone strata. LPR represents the lower Peace River Formation.

parallel configuration pattern of the seismic reflections assigned to the upper Peace River Formation (fig. 9). The lower bounding seismic reflections of the upper Peace River Formation are concordant with seismic reflections assigned to the lower Peace River Formation below (fig. 9). The upper Peace River Formation possibly crops out at the floor of the Caloosahatchee River along structurally high areas east of test corehole L-5809, based on correlation of the corehole to survey segment 4 (fig. 9 and appendix). Visual estimates of hydraulic conductivity for the upper Peace River Formation in test corehole L-5809 suggest that quartz sand of moderate hydraulic conductivity (see appendix) may crop out along the bottom of the Caloosahatchee River in structurally high areas. This would potentially allow direct water exchange between the river and the clastic zone of the sandstone aquifer. Thus, a potential connection exists between the intermediate aquifer system and the Caloosahatchee River at structural highs (fig. 9).

The seismic reflections assigned to the lower Peace River Formation, as was the case with the upper Peace River Formation, have a wavy, parallel configuration pattern (fig. 9) that is also controlled by local structural deformation. The uppermost seismic reflections of the lower Peace River Formation have a stronger or higher amplitude than the reflections of the upper Peace River Formation. This change in amplitude is associated with the density change (in the sandstone aquifer) of the clastic-zone quartz sand and carbonate-zone limestone. The strong seismic reflections bounding the top of the carbonate zone of the sandstone aquifer can be traced for several miles in the seismic profile, indicating that the aquifer can be mapped, at least locally, with seismic-reflection methods. The parallel reflections of the lower Peace River Formation may grade downward into reflections with a similar reflection configuration assigned to the Arcadia Formation (fig. 9).

Survey Segment 5

Survey segment 5 contains imaging of the Tamiami, Peace River, and Arcadia Formations (figs. 1, 2, and 10), and the surficial and intermediate aquifer systems. In the Fort Myers area, survey segment 5 seismic reflections assigned to the upper Peace River Formation (Missimer and Gardner, 1976; Missimer, 1999) have either a sigmoid or oblique progradational configuration or subhorizontal, parallel configuration (fig. 10). The progradational seismic-reflection patterns of the upper Peace River Formation likely represent a deltaic depositional system as suggested by Missimer and Gardner (1976) and Missimer (1999). East of the delta, where the seismic reflections are subhorizontal, they drape over a seismic discontinuity separating the upper and lower Peace River Formations as shown by Missimer and Gardner (1976) and Missimer (1999). The progradational reflections of the upper Peace River Formation downlap onto this discontinuity (fig. 10). Seismic reflections below the discontinuity have a parallel configuration. These reflections assigned to the lower Peace River Formation are subhorizontal and locally have a broad, wavy configuration. The subhorizontal reflections of the lower Peace River Formation grade downward into reflections with a configuration similar to those assigned to the Arcadia Formation. Missimer (1999) shows that discontinuity between reflections of the lower Peace River Formation and the Arcadia Formation includes erosional truncation of uppermost seismic reflections of the Arcadia Formation. The wavy configuration pattern of limestone of the Hawthorn Group shown in figure 10 is probably related to karstic collapse of deeper limestone that could be contained in the Floridan aquifer system, similar to the structures observed in survey segment 4 (fig. 9).

Ground-Penetrating Radar

Interpretations of GPR profiles are presented for two rural sites in the coastal lowlands that include the Caloosahatchee River Basin. The Indian Mound site (fig. 1) is located at the abandoned Florida Rock Industries sand pit and adjacent Indian Mound Park in Glades County. Data were collected on barren, sandy terrain and gravel roads. The CRS06 monitoring well site (fig. 1) in Hendry County includes a GPR traverse that runs parallel to the C-3 canal and includes four seepage meters. No substantial change in land-surface altitude was observed along the GPR traverses except for artificial levees adjacent to canals.

Indian Mound Site

The GPR survey at the Indian Mound site contains imaging of surficial quartz sands, possibly quartz sands of the Tamiami Formation, and quartz

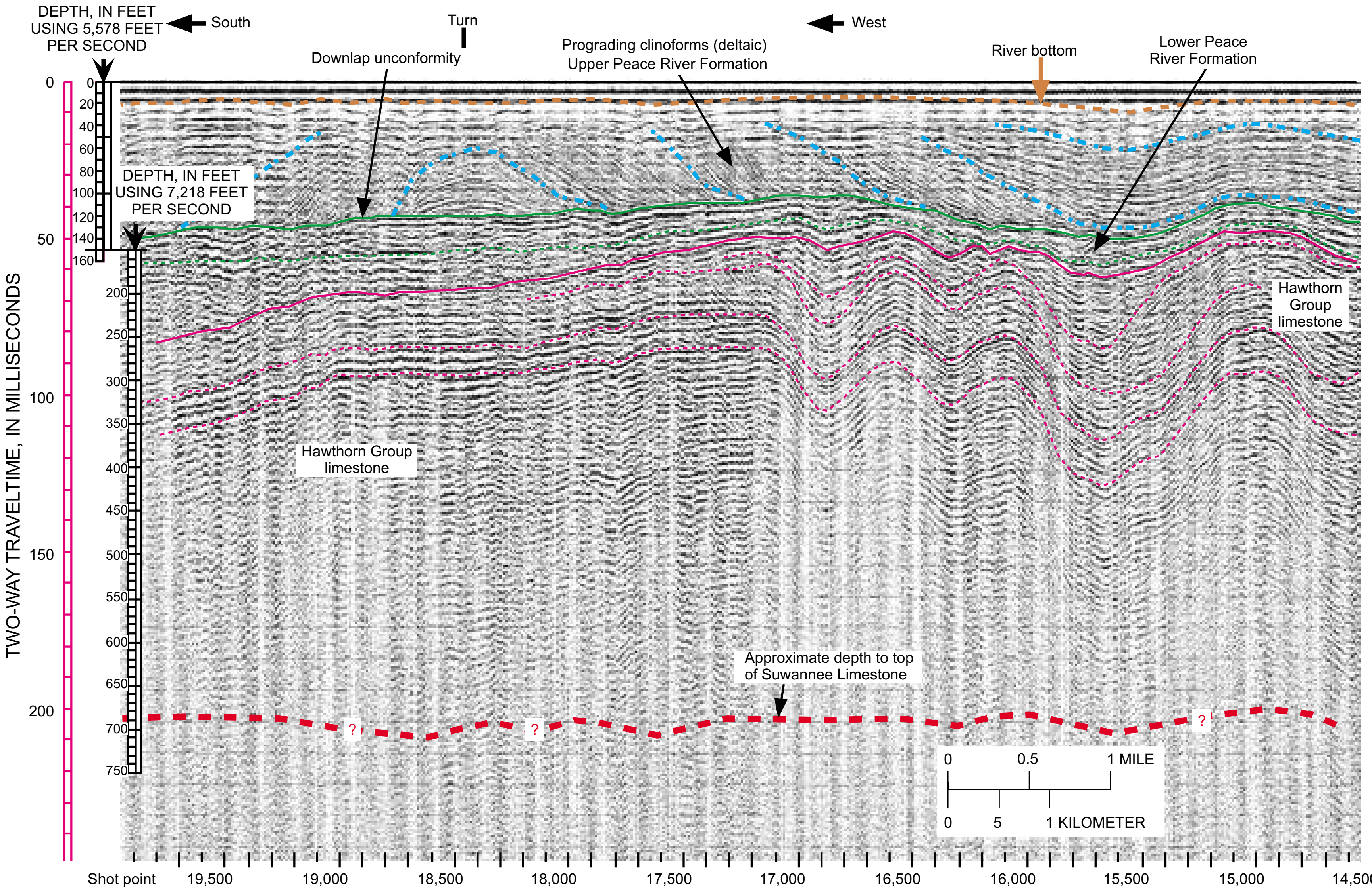

Figure 10. Seismic-reflection profile in San Carlos Bay (location shown in fig. 1). The same section of prograding clinoformal reflection has been documented in other studies by Missimer and Gardner (1976), Scholz and Cunningham (1997), and assigned to the upper Peace River Formation by Missimer (1999). These clinoformal reflections likely represent a southward prograding deltaic depositional system as suggested by Missimer (1999). Underlying the major downlap surface are parallel reflections assigned to the lower Peace River Formation.

sands of the upper Peace River Formation (fig. 11) and the surficial aquifer system. Radar reflections assigned to the upper Peace River Formation have a parallel, oblique progradational configuration (fig. 11). The uppermost inclined radar reflections assigned to the upper Peace River Formation form a toplapping or erosional discordance with overlying horizontal parallel radar reflections tentatively assigned to the Tamiami Formation (fig. 11). Verification of assignment of the inclined reflections to the upper Peace River Formation is based on correlation of the GPR profile to the Caloosahatchee River seismic survey and nearby lithologic logs obtained from test wells W-12844 and W-16944 (fig. 1). The inclined radar facies present within the upper Peace River Formation (fig. 11) is probably indicative of moderate hydraulic conductivities for quartz sands (Fish, 1988, table 7), because samples from spoil banks around the sand pit suggest this facies lacks any significant clay matrix and is friable. The apparent angle on the south dipping seismic reflections is about 7 degrees. The parallel, oblique progradational pattern of radar reflections (fig. 11) may be images of the tops of progradational seismic-reflection configurations that dip as much as 5 degrees in the easternmost part of survey segment 2 (fig. 3). Thus, GPR has potential to image the shallow part of the subsurface above the river bottom not imaged in the marine seismic-reflection profiles collected along the Caloosahatchee River. The reflection geometries displayed in the GPR profile (fig. 11) are interpreted to be low-angle, accretionary foreset beds associated with the depositional axis of the deltaic depositional system imaged in seismic-reflection profiles to the south along the Caloosahatchee River (fig. 3).

Abundant discoid pebbles have been recovered from the spoil banks surrounding the sand pit and have been excavated possibly from equivalent strata. The possible presence of discoid pebbles within the southward dipping beds of the upper Peace River Formation (fig. 11) are consistent with deposition in foreshore, shoreface and offshore marine or channel-spit environments. Dobkins and Folk (1970) showed that the presence of discoid pebbles can be used as evidence of beach environments.

CRS06 Site

A test corehole (HE-1118) was drilled to a depth of 22 ft at the CRS06 site (figs. 1 and 12) to obtain lithostratigraphic and hydraulic information about the shallow rock units of the surficial aquifer system. Horizontal, parallel radar reflections assigned to a surficial quartz sand onlap onto the sides of the lows on an undulatory radar reflection assigned to the top of the Caloosahatchee Formation (fig. 12). The radar facies of the Caloosahatchee Formation has a wavy, parallel to semiparallel, configuration with radar reflections of relatively moderate to high amplitude compared to overlying reflections of the surficial sand.

The depth and continuity of the Caloosahatchee Formation is of hydrologic interest because these properties may influence drainage. At the CR06 site, four seepage meters were installed by Belanger (1999) to measure rates of exchange between canal water and ground water. The estimated stratigraphic positions of the basal contacts of seepage meters 1 and 2 with canal-bottom outcrops are correlated to intervals of no recovery in test corehole HE-1118 (fig. 12). Very high seepage rates are reported for seepage meter 2 (fig. 13). Since correlation of the estimated depth and location of seepage meter 2 to test corehole HE-1118 shows the meter is positioned over rocks or sediments that were not recovered in the test corehole, it is not possible to verify any geologic explanation for the relatively high seepage rates. However, based on samples of rock dredged from the canal during construction, the rock samples can have inch-scale diameter, semivertical, solution-enlarged porosity, it is possible that seepage meter 2 is seated above this type of large-scale pore network in the Caloosahatchee Formation. Seepage meters 1, 3, and 4 produced relatively low seepage rates (fig. 13). Correlation of the bottom position of seepage meter 1 to the GPR profile and test corehole HE-1118 suggests the meter is seated on the upper contact of the Caloosahatchee Formation (fig. 12). Correlation of the bottom position of seepage meters 3 and 4 suggests these meters are seated in a shelly sandstone with low hydraulic conductivity (see appendix, test corehole HE-1118) at a depth of about 16 ft below ground level. Positioning of seepage meters 3 and 4 in a hydrogeologic unit with low hydraulic conductivity suggests that the relatively low seepage rates are geologically controlled.

The combined use of data from seepage meters, GPR, and continuously drilled test coreholes can be used to gain an accurate understanding of subsurface hydraulic properties. Continuous borehole images can provide critical hydrogeologic information over zones of no core recovery, such as in this study where borehole images, if available, could have been used

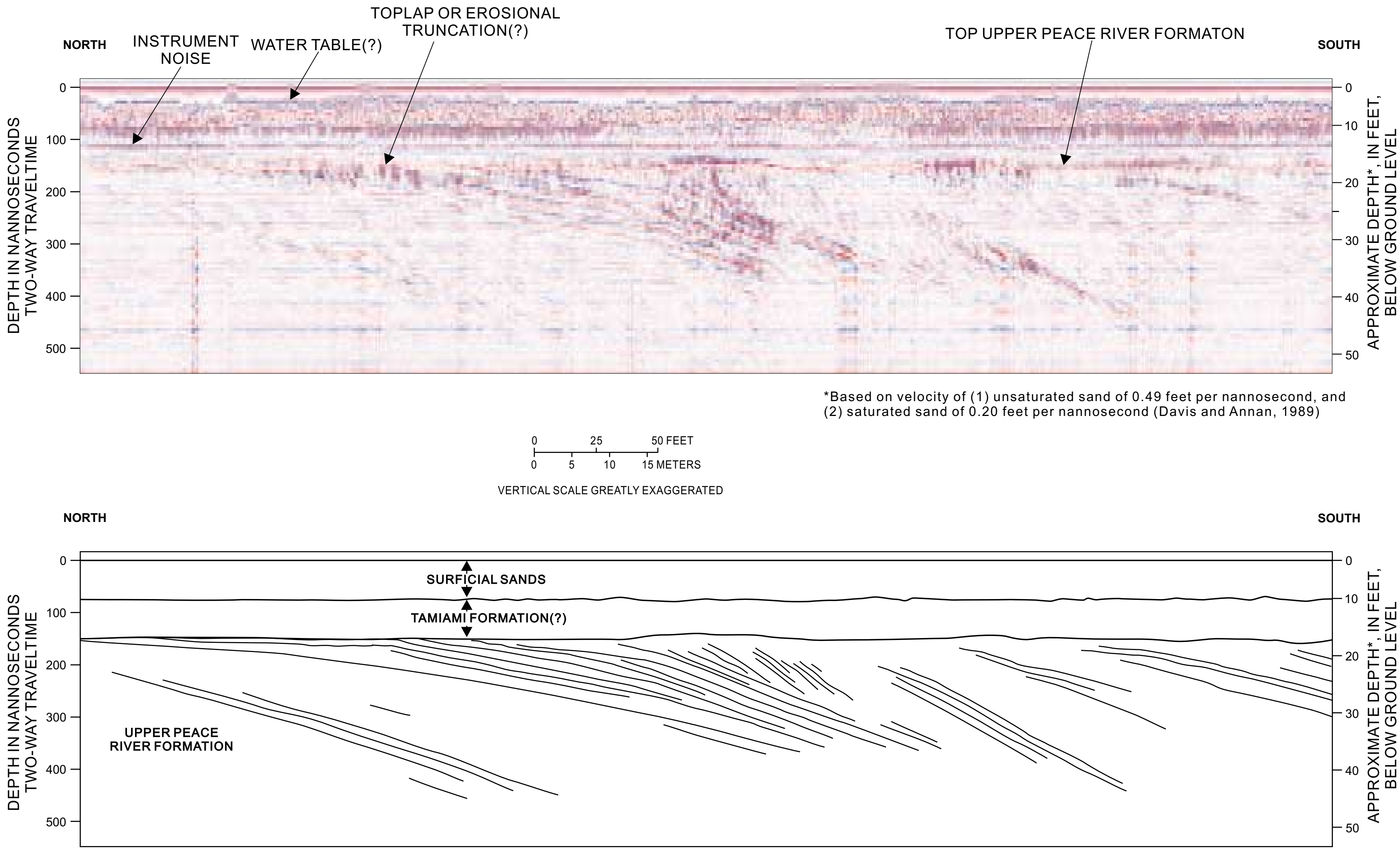

Figure 11. Ground-penetrating radar profile and interpretation from the Indian Mound site in Glades County. The radar profile shows parallel, oblique prograding reflections that are interpreted to be images of low angle, accretionary foreset beds. This geophysical technique profiles a unique view into the internal geometry of the sediments, producing information that can be used for interpretation of depositional environments and hydraulic conductivity. A deep sand pit is located about 500 feet north of the profile, which suggests the entire profile is imaging a quartz sand lithology. (See fig. 1 for site location).

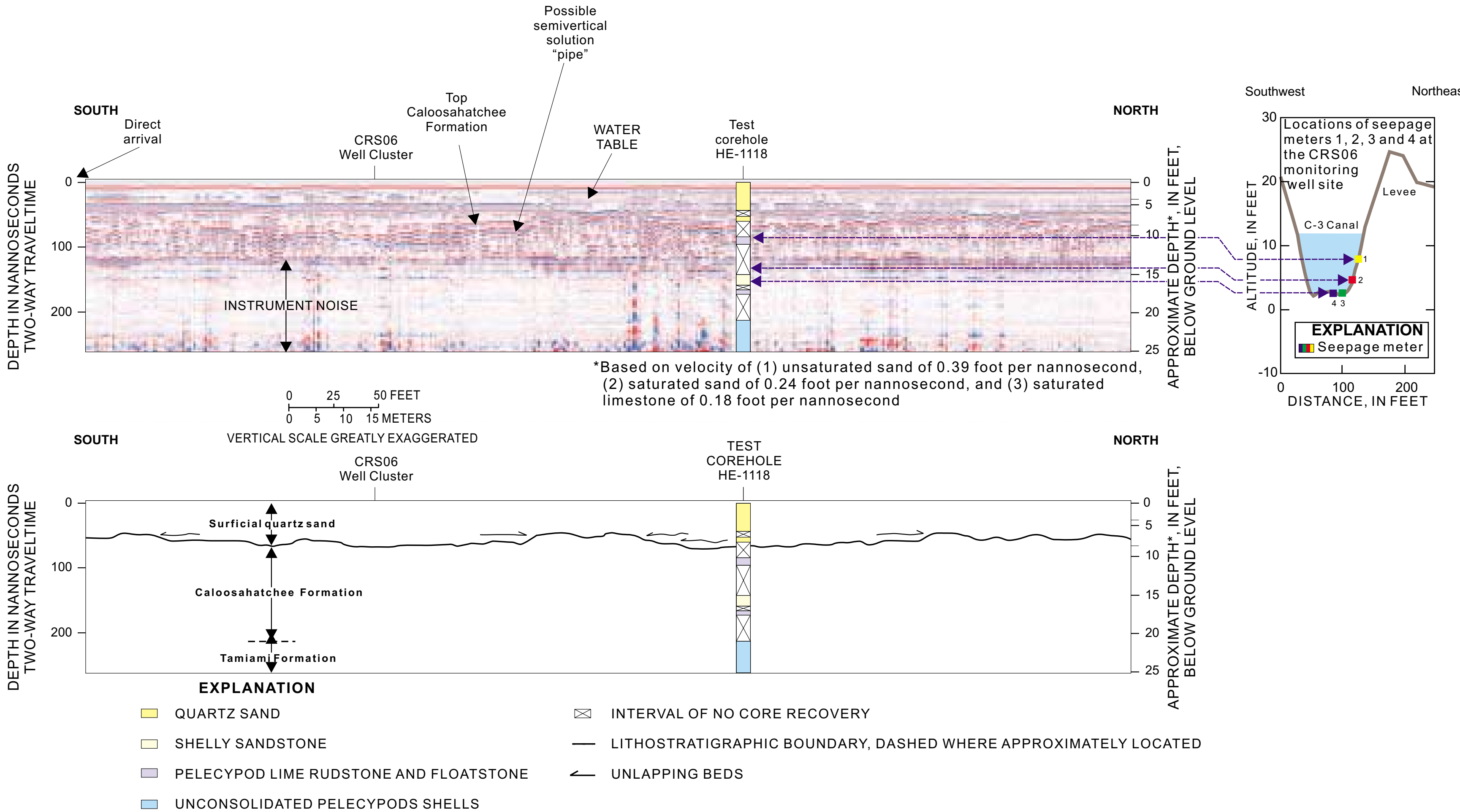

Figure 12. Correlation of ground-penetrating radar profile, test corehole HE-1118, and seepage meters at the CRS06 monitoring well site in Hendry County. All four seepage meters are seated in the Caloosahatchee Formation. (See fig. 1 for site location)

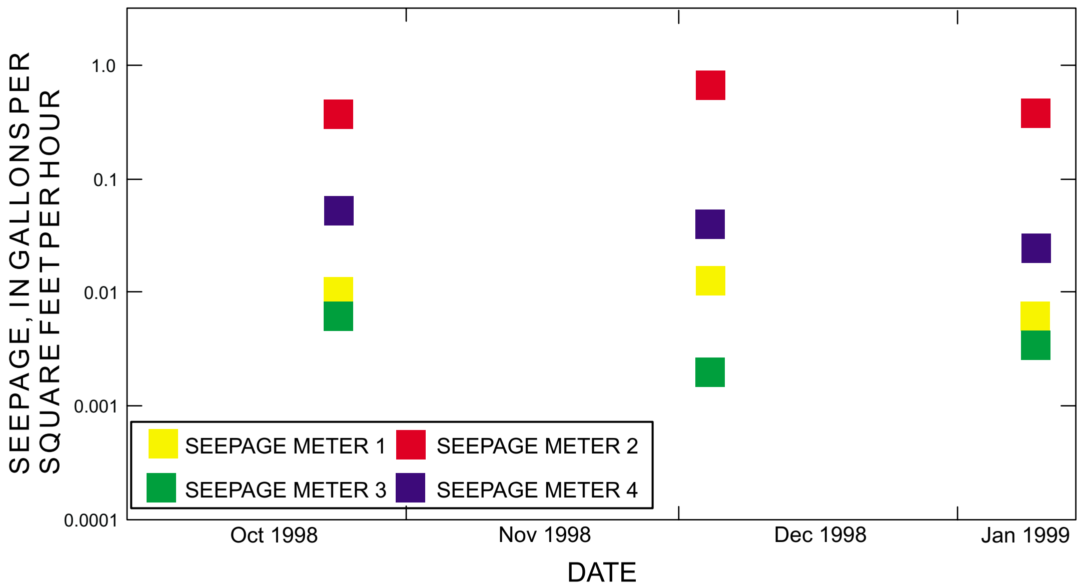

Figure 13. Average ground-water seepage data collected at the CRS06 monitoring well site in Hendry County, October 1998 to January 1999. Data collected by Belanger (1999). Original units were in milliliters per square meter per hour.

to accurately correlate between the seat position of seepage meters 1 and 2 and the core intervals that lacked recovery.

SUMMARY AND CONCLUSIONS

The Caloosahatchee River Basin, located in southwestern Florida, encompasses 1,200 mi^2 of land. The Caloosahatchee River receives water from Lake Okeechobee, runoff from the watershed, and seepage from the ground-water systems; it loses water through drainage to the Gulf of Mexico and through withdrawals for public-water supply, agriculture, and natural needs. Projected water-supply needs indicate the Caloosahatchee River will not meet future demands, and the Caloosahatchee River Basin could be further stressed if the river water is used to accommodate restoration of the Everglades. Water managers and planners need to know how much water will be used within the Caloosahatchee River Basin and how much water is contributed by Lake Okeechobee, runoff, and ground water. In this study, marine seismic-reflection and GPR techniques were used to support evaluation of potential exchange of water between the river and ground-water systems. Seven test coreholes were drilled to calibrate lithostratigraphic units and their estimated hydraulic conductivities to surface-geophysical profiles.

A continuous marine seismic-reflection survey was collected over much of the entire Caloosahatchee River and part of San Carlos Bay. Subhorizontal reflections assigned to the Tamiami Formation intersect the river bottom along a 9-mi segment just west of Moore Haven. In an area between the western side of Lake Hicpochee and La Belle, oblique and sigmoidal progradational reflections assigned to the upper Peace River Formation probably intersect the floor of the river. These progradational reflections image a regional-scale deltaic depositional system containing quartz sands with low to moderate estimated hydraulic conductivities. For a 6-mi length of the river between La Belle and Franklin Lock, deeper structures possibly created by karstic collapse influence the geometries of parallel reflections that intersect the river channel. Here, reflections assigned to the Buckingham Limestone Member of the Tamiami Formation, a confining unit, and reflections assigned to the clastic zone of the sandstone aquifer are likely connected with the river bottom. Beneath these shallow reflections, relatively higher amplitude parallel reflections of the carbonate zone of the sandstone aquifer are well displayed in the seismic-reflection profiles. A deltaic depositional system that displays oblique progradational reflections assigned to the upper Peace River Formation underlies San Carlos Bay. Almost everywhere beneath the river, a diffuse ground-water flow system is in contact with the channel bottom. Between Ortona Lock and Lake Hicpochee, however, limestones of the Tamiami Formation may intersect the river channel, suggesting local conduit flow between the surface and ground-water systems.

The GPR profiles of an area about 2 mi north of the depositional axis of the deltaic depositional system between Lake Hicpochee and La Belle show that the progradational clinoforms seen in seismic records from the Caloosahatchee River are present within about 17 ft of the ground surface. The GPR profiles show that the uppermost southward dipping, oblique progradational reflections of the Peace River Formation are terminated by a toplapping or erosional discontinuity. These clinoformal reflections represent clean quartz sands that are probably characterized by moderate hydraulic conductivity. The areal distribution of the clinoformal reflections could be mapped using GPR methods.

In general, results of this study indicate that:

- Seismic-reflection profiles are necessary to accurately correlate hydrogeologic units between wells because the geometries of south Florida hydrostratigraphic units contain complex stratal geometries;
- Seismic-reflection profiles can be used to image and map the boundary between the clastic zone and carbonate zone of the sandstone aquifer, which is part of the intermediate aquifer system;
- Seismic-reflection profiles can be used to infer the distribution and quality of the connection between the bottom of the Caloosahatchee River and ground-water systems;
- Seismic-reflection profiles are useful in defining regional-scale depositional systems that are templates for the regional-scale hydraulic properties of the regional ground-water systems;
- Shallow collapse structures within the Peace River and Arcadia Formations that could be related to karst within the limestone of the Floridan aquifer system can be imaged with seismic-reflection methods;
- GPR methods have potential to image the shallow portion of the subsurface above the Caloosahatchee River bottom, which was not imaged in the marine seismic-reflection profiles;
- GPR profiles can be useful in defining depositional environments of near-surface siliciclastics, and thus, used in mapping the shallow distribution and degree of the permeability of a ground-water system; and
- Understanding the connection between seepage meters and hydraulic properties of the subsurface rocks is possible by combining GPR methods, continuous test coreholes, and continuous borehole images.

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APPENDIX

Lithologic Descriptions of Cores Drilled for This Study

[Items in the descriptions are arranged in the following order: rock type with modifiers, color, grain size, sorting, roundness, accessory grains, porosity, hydraulic conductivity, environment, and comments. However, not all of these items are included in every description. Latitude and longitude datums NAD 83]

Local well identifier
GL-323
GL-325
GL-326
GL-327
GL-329
HE-1118
L-5809

GL-323 Test Corehole

Florida Geological Survey well number	W-18069
GWSI number	GL-323
Total depth	401 feet
Cored from	0 to 401 feet
County	Glades
Location	SE, sec. 25, T42S, R29E
Latitude	26° 47′ 38″
Longitude	81° 21′ 42.5″
Elevation	21 feet
Completion date	May 7, 1999
Other types of logs available	Resistivity, gamma ray, spontaneous potential
Owner	U.S. Geological Survey
Driller	Florida Geological Survey
Core described by	Kevin J. Cunningham
Fill	0 to 10 feet
Lake Flirt Marl Formation	10 to 10.9 feet
Undifferentiated	10.9 to 25 feet
Tamiami Formation	25 to 47(?) feet
Upper Peace River Formation	47(?) to 225.2 feet
Lower Peace River Formation (?)	225.2 to 255.3 feet
Arcadia Formation	255.3 to 401 feet
Water-table aquifer	0 to 38(?) feet

Depth (feet below land surface)	Lithologic description of GL-323 test corehole
0.0-10.0	Fill.
10.0-10.9	Quartz sand interbedded with gastropod lime wackestone; moderate yellowish brown 10YR 6/2; mainly very fine to fine quartz sand; *Helisoma* gastropods; 25 percent intergrain porosity; moderate hydraulic conductivity; friable.
10.9-19.3	No recovery.
19.3-25.0	Mixed lithology of quartz sand and pelecypods and gastropods; probably caved sediments.
25.0-26.0	Quartz sand; yellowish gray 5Y 7/2; black N1 phosphorite and heavy minerals; mainly very fine to fine quartz sand; minor very fine to fine phosphorite and heavy mineral grains; trace clay; 2 percent phosphorite and heavy mineral grains; 25 percent intergrain porosity; moderate hydraulic conductivity; friable; trace clay matrix.
26.0-37.0	No recovery.
37.0-38.0	Caved sand and shells.
38.0-38.8	Quartz sand; yellowish gray 5Y 7/2; black N1 phosphorite and heavy minerals; mainly very fine to fine quartz sand; minor sand- to pebble-sized fossils, terrigenous clay, and very fine to fine phosphorite and heavy mineral grains; abundant pelecypod shells and fragments; 2 percent phosphorite and heavy mineral grains; 20 percent intergrain porosity; low hydraulic conductivity; friable, minor clay matrix.
38.8-42.0	Quartz sand; very light gray N8 and yellowish gray 5Y 7/2; black N1 phosphorite and heavy minerals; mainly very fine to fine quartz sand; minor sand- to pebble-sized fossils, clay and lime mud, and very fine to fine phosphorite and heavy mineral grains; abundant pelecypod shells and fragments; minor barnacles; 2 percent phosphorite and heavy mineral grains; 15 percent intergrain porosity; low hydraulic conductivity: friable; minor clay and lime mud matrix.
42.0-47.0	Quartz sand; very light gray N8 and yellowish gray 5Y 7/2; black N1 phosphorite and heavy minerals; mainly very fine to fine quartz sand; minor medium quartz sand, sand- to pebble-sized fossils, clay and lime mud, and very fine to fine phosphorite and heavy mineral grains; minor pelecypod shells and fragments; 2 percent phosphorite and heavy mineral grains; trace mica; 20 percent intergrain porosity; low hydraulic conductivity; friable; minor clay and lime mud matrix.
47.0-49.0	Quartz sand; yellowish gray 5Y 7/2; black N1 phosphorite and heavy minerals; mainly very fine to fine quartz sand; minor terrigenous clay, and very fine to fine phosphorite and heavy mineral grains; 2 percent phosphorite and heavy mineral grains; trace mica; 20 percent intergrain porosity; low hydraulic conductivity; friable; minor clay matrix.
49.0-51.5	No recovery.
51.5-54.5	Caved sediments.
54.5-61.0	Quartz sand; yellowish gray 5Y 7/2; black N1 phosphorite and heavy minerals; mainly very fine to fine quartz sand; minor very fine to fine phosphorite and heavy mineral grains; trace terrigenous clay; 2 percent phosphorite and heavy mineral grains; trace mica; 25 percent intergrain porosity; moderate hydraulic conductivity; friable; trace clay matrix; bioturbated.
61.0-69.0	Quartz sand; yellowish gray 5Y 7/2 and light olive gray 5Y 5/2; black N1 phosphorite and heavy minerals; mainly very fine to fine quartz sand; minor terrigenous clay and very fine to fine phosphorite and heavy mineral grains; 2 percent phosphorite and heavy mineral grains; trace mica; 10-15 percent intergrain porosity; low hydraulic conductivity; soft; minor clay matrix; irregular, disrupted clay laminations; bioturbated.
69.0-70.0	No recovery.
70.0-84.0	Quartz sand; yellowish gray 5Y 7/2 and light olive gray 5Y 5/2; black N1 phosphorite and heavy minerals; mainly very fine to fine quartz sand; minor terrigenous clay and very fine to fine phosphorite and heavy mineral grains; 2 percent phosphorite and heavy mineral grains; trace mica; 10-15 percent intergrain porosity; low hydraulic conductivity; soft; minor clay matrix; irregular, disrupted clay laminations; bioturbated.
84.0-85.0	No recovery.
85.0-102.0	Quartz sand; yellowish gray 5Y 7/2 and light olive gray 5Y 5/2; black N1 phosphorite and heavy minerals; mainly very fine quartz sand; minor fine quartz sand, terrigenous clay and very fine to fine phosphorite and heavy mineral grains; 2-4 percent phosphorite and heavy mineral grains; trace mica; 10-15 percent intergrain porosity; low hydraulic conductivity; soft; minor clay matrix; irregular, disrupted clay laminations; bioturbated.

Depth (feet below land surface)	Lithologic description of GL-323 test corehole
102.0-105.6	Interbedded quartz sand and diatomaceous mudstone; yellowish gray 5Y 7/2; black N1 phosphorite and heavy minerals; mainly very fine quartz sand and terrigenous clay; minor very fine to fine phosphorite and heavy mineral grains; diatoms; 5-15 percent phosphorite and heavy mineral grains; trace mica; 5-15 percent intergrain porosity; very low hydraulic conductivity.
105.6-108.0	No recovery.
108.0-123.5	Diatomaceous mudstone; yellowish gray 5Y 7/2; black N1 phosphorite and heavy minerals; mainly terrigenous clay; minor silt and very fine quartz sand, and very fine to fine phosphorite and heavy mineral grains; diatoms; 2-10 percent phosphorite and heavy mineral grains; trace mica; 5 percent microporosity; very low hydraulic conductivity; minor interbedding with very fine quartz sand.
123.5-125.0	No recovery.
125.0-130.0	Diatomaceous mudstone; yellowish gray 5Y 7/2; black N1 phosphorite and heavy minerals; mainly terrigenous clay; minor silt and very fine quartz sand, and very fine to fine phosphorite and heavy mineral grains; diatoms; 2-10 percent phosphorite and heavy mineral grains; trace mica; 5 percent microporosity; very low hydraulic conductivity; minor interbedding with very fine quartz sand.
130.0-133.0	Quartz sand; yellowish gray 5Y 7/2 and light olive gray 5Y 5/2; black N1 phosphorite and heavy minerals; mainly very fine to fine quartz sand; minor terrigenous clay and very fine to fine phosphorite and heavy mineral grains; 2-15 percent phosphorite and heavy mineral grains; trace mica; 10 percent intergrain porosity; low hydraulic conductivity; friable; mainly fine to coarse quartz sand at base of unit.
133.0-140.0	Diatomaceous mudstone; yellowish gray 5Y 7/2; black N1 phosphorite and heavy minerals; mainly terrigenous clay, silt and very fine quartz sand; minor very fine to medium phosphorite and very fine heavy mineral grains; diatoms; 2-20 percent phosphorite and heavy mineral grains; trace mica; 5 percent microporosity; very low hydraulic conductivity.
140.0-145.0	Diatomaceous mudstone interlaminated with quartz sand; yellowish gray 5Y 7/2; black N1 phosphorite and heavy minerals; mainly terrigenous clay, silt and very fine quartz sand; minor fine to coarse quartz sand, very fine to medium phosphorite, and very fine heavy mineral grains; diatoms; 2-20 percent phosphorite and heavy mineral grains; trace mica; 5 percent microporosity; very low hydraulic conductivity.
145.0-151.0	No recovery.
151.0-160.0	Diatomaceous mudstone interlaminated with quartz sand; yellowish gray 5Y 7/2; black N1 phosphorite and heavy minerals; mainly terrigenous clay, silt and very fine quartz sand; minor fine to coarse quartz sand, very fine to medium phosphorite, and very fine heavy mineral grains; diatoms; 2-20 percent phosphorite and heavy mineral grains; trace mica; 5 percent microporosity; very low hydraulic conductivity.
160.0-170.0	Quartz sand with very minor interlaminations of diatomaceous mudstone; yellowish gray 5Y 7/2; black N1 phosphorite and heavy minerals; mainly medium to coarse quartz sand; minor silt to fine quartz sand, terrigenous clay, very fine to coarse phosphorite, and very fine heavy mineral grains; diatoms; trace to 5 percent phosphorite and heavy mineral grains; trace mica; 20-25 percent intergrain porosity; low to moderate hydraulic conductivity; minor clay matrix.
170.0-180.5	Quartz sand with very minor interlaminations of diatomaceous mudstone; yellowish gray 5Y 7/2; black N1 phosphorite and heavy minerals; mainly fine to medium quartz sand; minor silt to very fine quartz and coarse sand, terrigenous clay, very fine to medium phosphorite, and very fine heavy mineral grains; trace to 5 percent phosphorite and heavy mineral grains; trace mica; 20-25 percent intergrain porosity; low to moderate hydraulic conductivity; minor clay matrix.
180.5-181.0	No recovery.
181.0-189.5	Quartz sand; yellowish gray 5Y 7/2; black N1 phosphorite and heavy minerals; mainly fine to medium quartz sand; minor silt to very fine quartz sand, terrigenous clay, very fine to medium phosphorite, and very fine heavy mineral grains; trace to 5 percent phosphorite and heavy mineral grains; trace mica; 20-25 percent intergrain porosity; low to moderate hydraulic conductivity; minor clay matrix.
189.5-191.0	No recovery.
191.0- 219.5	Quartz sand; yellowish gray 5Y 7/2; black N1 phosphorite and heavy minerals; mainly very fine to fine quartz sand; minor silt quartz sand, terrigenous clay, very fine to fine phosphorite, and very fine heavy mineral grains; 5-20 percent phosphorite and heavy mineral grains; trace mica; 20-25 percent intergrain porosity; low hydraulic conductivity; minor clay matrix; bioturbated; very fine laminations of terrigenous mudstone between 203 and 203.4 feet; thin white pelecypod shells at 217.75.

Depth (feet below land surface)	Lithologic description of GL-323 test corehole
219.5-221.6	Quartz sand interlaminated with terrigenous mudstone; yellowish gray 5Y 7/2, light olive gray 5Y 5/2, olive gray 5Y 4/1; black N1 phosphorite and heavy minerals; mainly very fine to fine quartz sand and terrigenous clay; minor silt quartz sand, very fine to fine phosphorite, and very fine heavy mineral grains; 5-20 percent phosphorite and heavy mineral grains; trace mica; <5-25 percent intergrain porosity; very low hydraulic conductivity.
221.6-224.3	Terrigenous mudstone with minor interbeds of quartz sand; olive gray 5Y 3/2, yellowish gray 5Y 7/2; black N1 phosphorite and heavy minerals; mainly terrigenous clay; minor silt-sized and very fine to fine quartz sand, very fine to fine phosphorite, and very fine heavy mineral grains; 5-20 percent phosphorite and heavy mineral grains; trace mica; 20 percent intergrain porosity in quartz sand; very low hydraulic conductivity.
224.3-225.2	Quartz sand; yellowish gray 5Y 7/2; black N1 phosphorite and heavy minerals; mainly very fine to fine quartz sand; minor silt-sized and medium to small pebble-sized quartz sand, very fine sand- and small pebble-sized phosphorite, and very fine heavy mineral grains; 20-30 percent phosphorite and heavy mineral grains; trace mica; 20 percent intergrain porosity; low hydraulic conductivity.
225.2-231.0	Dolosilt, terrigenous mudstone and quartz silt; yellowish gray 5Y 7/2; mainly very fine quartz sand, quartz silt, dolosilt and clay; minor silt-sized and fine sand, very fine to coarse phosphorite grains, and very fine heavy mineral grains; 5-30 percent phosphorite and heavy mineral grains; 5 percent microporosity; very low hydraulic conductivity; trace very thin, white pelecypod shells.
231.0-244.1	Silty and sandy terrigenous mudstone and quartz silt; yellowish gray 5Y 7/2; mainly very fine quartz sand, quartz silt and clay; minor silt-sized and fine sand, very fine to coarse phosphorite grains, and very fine heavy mineral grains; 5-30 percent phosphorite and heavy mineral grains; 5 percent microporosity; very low hydraulic conductivity; trace very thin, white pelecypod shells.
244.1-248.1	Lime mudstone with abundant phosphorite grains; yellowish gray 5Y 7/2 to white N9; black N1 phosphorite grains produce a salt and pepper appearance; mainly clay-sized lime mud and very fine phosphorite grains; minor silt-sized and very fine sand, very fine heavy mineral grains, and fine to medium phosphorite grains; 30-50 percent phosphorite and trace heavy mineral grains; 5 percent microporosity; very low hydraulic conductivity; chalky texture.
248.1-251.0	No recovery.
251-253.3	Quartz sand and phosphorite with micrite matrix; yellowish gray 5Y 7/2 to white N9; black N1 phosphorite grains produce a salt and pepper appearance; mainly clay-sized lime mud, very fine phosphorite grains, and silt-sized and very fine sand, very fine heavy mineral grains, and fine to medium phosphorite grains; 30-50 percent phosphorite and trace heavy mineral grains; 5 percent microporosity; very low hydraulic conductivity; chalky texture.
253.3-259.4	Lime mudstone with abundant phosphorite grains; pale greenish yellow to white N9; black N1 phosphorite grains; mainly clay-sized lime mud and very fine phosphorite grains; very fine heavy mineral grains, and fine to medium phosphorite grains; 5-40 percent phosphorite and trace heavy mineral grains; minor pelecypods; 5 percent microporosity; very low hydraulic conductivity; chalky texture; abrupt contact and possible erosional discontinuity at 255.3 feet.
259.4-261.0	No recovery.
261.0-268.7	Lime mudstone and pelecypod floatstone with lime mudstone matrix; pale greenish yellow 10Y 8/2 to yellowish gray 5Y 7/2 to white N9; black N1 phosphorite grains; mainly clay-sized lime mud and very fine to fine phosphorite grains; minor very fine to fine quartz sand, very fine heavy mineral grains, medium sand- to very small pebble-sized phosphorite grains, and pebble-sized pelecypods; 5-40 percent phosphorite and trace heavy mineral grains; 10-20 percent quartz sand; trace bryozoans; 5 percent microporosity; very low hydraulic conductivity; chalky texture; abrupt contact at 266.9 feet; up to large pebble-sized phosphate pebbles between 268.6 and 268.7 feet.
268.7-269.0	Lime mudstone and bryozoan floatstone with lime mudstone matrix; yellowish gray 5Y 7/2 to white N9; black N1 phosphorite grains; mainly clay-sized lime mud and very fine to fine phosphorite grains; minor very fine heavy mineral grains, medium sand- to very small pebble-sized phosphorite grains, and pebble-sized bryozoans; 5-20 percent phosphorite and trace heavy mineral grains; bryozoans (including chielostomes and *Cyclostomata*) 5 percent microporosity; very low hydraulic conductivity; chalky texture; irregular abrupt contact with 1-mm thick blackened crust at top (268.7 feet) and up to 2 centimeters of microtopography; probable top of Arcadia.
269.0-271.0	No recovery.

Depth (feet below land surface)	Lithologic description of GL-323 test corehole
271.0-276.3	Lime mudstone and bryozoan floatstone with lime mudstone matrix; yellowish gray 5Y 7/2 to white N9; black N1 phosphorite grains; mainly clay-sized lime mud and very fine to fine phosphorite grains; minor very fine heavy mineral grains, medium sand- to very small pebble-sized phosphorite grains, and pebble-sized bryozoans; 5-20 percent phosphorite and trace heavy mineral grains; 5 percent microporosity; very low hydraulic conductivity; chalky texture; bryozoans between 271 and 273.5 feet.
276.3-278.0	No recovery.
278.0-280.5	Interbedded lime mudstone and oyster lime floatstone with lime mudstone matrix; yellowish gray 5Y 7/2 to white N9; black N1 phosphorite grains; mainly clay-sized lime mud and very fine to fine phosphorite grains; minor very fine heavy mineral grains; 5-20 percent phosphorite and trace heavy mineral grains; 5 percent microporosity; very low hydraulic conductivity; chalky texture.
280.5-281.0	No recovery.
281.0-287.7	Interbedded lime mudstone, dolosilt and pelecypod lime floatstone with lime mudstone matrix; yellowish gray 5Y 7/2 to white N9; black N1 phosphorite grains; mainly clay-sized lime mud, silt-sized dolomite and very fine to fine phosphorite grains; minor medium sand- and small pebble-sized phosphorite grains, and very fine heavy mineral grains; 5-30 percent phosphorite and trace heavy mineral grains; 5 percent microporosity; very low hydraulic conductivity; moldic pelecypods; bioturbated; abundant intraclasts of lithology between 288 and 292 feet.
287.7-288.0	No recovery.
288.0-292.0	Dolosilt; yellowish gray 5Y 8/1; black N1 phosphorite grains; mainly silt-sized dolomite; minor very fine to fine phosphorite grains and very fine heavy mineral grains; trace to 5 percent phosphorite and trace heavy mineral grains; 5 percent microporosity; very low hydraulic conductivity; possible unconformity between 287.7 and 288 feet.
292.0-297.0	Terrigenous mudstone; pale olive 5Y 6/2; black N1 phosphorite grains; mainly clay; minor very fine to fine phosphorite grains and very fine heavy mineral grains; trace to 5 percent phosphorite and trace heavy mineral grains; 5 percent microporosity; very low hydraulic conductivity; horizontal laminations; up to large pebble-sized chert clasts in lower ½ inch of interval.
297.0-299.0	Terrigenous mudstone; yellowish gray 5Y 7/2, light olive gray 5Y 5/2; black N1 phosphorite grains; mainly clay; minor very fine to medium phosphorite grains and very fine heavy mineral grains; 5-20 percent phosphorite and trace heavy mineral grains; 5 percent microporosity; very low hydraulic conductivity.
300.0-306.0	Pelcypod lime floatstone and lime wackestone; pale olive 10 Y 6/2, yellowish gray 5Y 7/2 to white N9; black N1 phosphorite grains; mainly clay-sized lime mud; minor very fine to medium phosphorite grains, very fine heavy mineral grains, and pebble-sized fossils; 5-20 percent phosphorite and trace heavy mineral grains; minor pelecypods, bryozoans and gastropods; 5 percent microporosity; very low hydraulic conductivity.
306.0-324.0	Interbedded phosphorite sand with lime mudstone matrix, pelecypod lime floatstone with lime mudstone matrix, and lime mudstone with abundant phosphorite grains; pale olive 10 Y 6/2, yellowish gray 5Y 7/2, olive gray 5Y 3/2; black N1 and light olive gray 5Y 5/2 phosphorite grains; mainly very fine to fine phosphorite grains and clay-sized lime mud; minor medium to coarse phosphorite grains, very fine heavy mineral grains, and pebble-sized fossils; 20-75 percent phosphorite and trace heavy mineral grains; minor pelecypods; 5 percent microporosity; very low hydraulic conductivity.
324.0-328.0	Lime mudstone with abundant phosphorite grains and pelecypod lime floatstone with lime mudstone matrix; yellowish gray 5Y 8/1; black N1 and light olive gray 5Y 5/2 phosphorite grains; mainly clay-sized lime mud; minor very fine to fine phosphorite grains, very fine heavy mineral grains, and pebble-sized fossils; 10-20 percent phosphorite and trace heavy mineral grains; minor pelecypods and gastropods; 5 percent microporosity; very low hydraulic conductivity.
328.0-331.0	No recovery.
331.0-341.0	Lime mudstone with abundant phosphorite grains and pelecypod lime floatstone with lime mudstone matrix; yellowish gray 5Y 8/1; black N1 and light olive gray 5Y 5/2 phosphorite grains; mainly clay-sized lime mud; minor very fine to fine phosphorite grains, very fine heavy mineral grains, and pebble-sized fossils; 10-20 percent phosphorite and trace heavy mineral grains; minor pelecypods and gastropods; 5 percent microporosity; very low hydraulic conductivity.
341.0-351.0	Lime mudstone with abundant phosphorite grains and pelecypod lime floatstone with lime mudstone matrix; yellowish gray 5Y 8/1; black N1 and light olive gray 5Y 5/2 phosphorite grains; mainly clay-sized lime mud; minor very fine to fine phosphorite grains, and very fine heavy mineral grains; 10-20 percent phosphorite and trace heavy mineral grains; 5 percent microporosity; very low hydraulic conductivity.

Depth (feet below land surface)	Lithologic description of GL-323 test corehole
351.0-359.0	Quartz and phosphorite sand; yellowish gray 5Y 7/2; black N1 and light olive gray 5Y 5/2 phosphorite grains; mainly silt- to very fine sand-sized quartz grains and very fine phosphorite grains; minor very fine heavy mineral grains; 50 percent phosphorite and trace heavy mineral grains; 10 percent intergrain porosity; low hydraulic conductivity; abundant dolosilt and terrigenous mudstone matrix.
359.0-359.2	Lime mudstone with abundant phosphorite grains and pelecypod lime floatstone with lime mudstone matrix; yellowish gray 5Y 8/1; black N1 and light olive gray 5Y 5/2 phosphorite grains; mainly clay-sized lime mud; minor very fine to fine phosphorite grains, and very fine heavy mineral grains; 10-20 percent phosphorite and trace heavy mineral grains; 5 percent microporosity; very low hydraulic conductivity.
359.2-361.0	No recovery.
361.0-370.0	Lime mudstone with abundant phosphorite grains and pelecypod lime floatstone with lime mudstone matrix; yellowish gray 5Y 8/1; black N1 and light olive gray 5Y 5/2 phosphorite grains; mainly clay-sized lime mud; minor very fine to fine phosphorite grains, and very fine heavy mineral grains; 10-20 percent phosphorite and trace heavy mineral grains; 5 percent microporosity; very low hydraulic conductivity.
370.0-371.0	Dolosilt; yellowish gray 5Y 7/2; black N1 and light olive gray 5Y 5/2 phosphorite grains; mainly silt-sized dolomite; minor very fine to fine phosphorite grains and very fine heavy mineral grains; trace to 5 percent phosphorite and trace heavy mineral grains; 5 percent microporosity; very low hydraulic conductivity.
371.0-377.8	Terrigenous mudstone; olive gray 5Y 3/2; mainly clay-sized terrigenous clay; 5 percent microporosity; very low hydraulic conductivity; very fine horizontal laminations.
377.8-379.0	Phosphorite sand with terrigenous clay matrix; yellowish gray 5Y 7/2; black N1 and light olive gray 5Y 5/2 phosphorite grains; mainly very fine to medium sand-sized phosphorite grains; minor coarse to small pebble-sized phosphorite grains; clay-sized terrigenous clay; 90 percent phosphorite and trace heavy mineral grains; 10 percent intergrain porosity; low hydraulic conductivity.
37.9.0-401.0	No recovery.

GL-325 Test Corehole

Florida Geological Survey well number	W-18070
GWSI number	GL-325
Total depth	200.5 feet
Cored from	0 to 200.5 feet
County	Glades
Location	NW, SE, sec. 35, T42S, R29E
Latitude	26° 46′ 21.5″
Longitude	81° 23′ 37.9″
Elevation	25.5 feet
Completion date	June 19, 1999
Other types of logs available	Induction, gamma ray, resistivity, spontaneous potential
Owner	U.S. Geological Survey
Driller	Florida Geological Survey
Core described by	Kevin J. Cunningham
Fill	0 to 15.9 feet
Lake Flirt Marl Formation	15.9 to 18.6 feet
Undifferentiated Fort Thompson, Caloosahatchee	18.6 to 22.5 feet
Tamiami Formation	22.5 to 22.6 feet
Upper Peace River Formation	22.6 to 128.3 feet
Lower Peace River Formation	128.3 to 200.5 feet
Water-table aquifer	0 to 55 feet

Depth (feet below land surface)	Lithologic description of GL-325 test corehole
0.0-0.5	No recovery.
0.5-3.4	Fill.
3.4-5.0	No recovery.
5.0-7.6	Fill.
7.6-10.0	No recovery.
10.0-13.0	Fill.
13.0-15.0	No recovery.
15.0-15.9	Fill.
15.9-16.6	Marl; yellowish gray 5Y 8/1; mainly clay-sized micrite and silt and very fine to fine quartz sand; well sorted; subangular to subrounded; 20 percent quartz sand; 15 percent moldic porosity; very low hydraulic conductivity; soft wet; hard dry.
16.6-18.6	Quartz sand; dark yellowish brown 10YR 4/2; mainly very fine to medium quartz sand; trace clay; well sorted; subangular to subrounded; 20 percent quartz sand; trace clay; 25 percent intergrain porosity; moderate hydraulic conductivity; soft wet; unconsolidated; abundant organics.
18.6-18.8	Pelecypod-rich quartz sand yellowish gray 5Y 7/2; mainly fine to medium quartz sand; minor medium to pebble-sized fossils; well sorted; subangular to subrounded; 45 percent pelecypods (including *Chione*); 25 percent intergrain porosity; moderate hydraulic conductivity; soft wet.
18.8-20.0	No recovery.
20.0-21.6	Caved quartz sand from Lake Flirt Formation.
21.6-22.5	Pelcypod-rich quartz sand; yellowish gray 5Y 7/2; mainly fine to medium quartz sand; minor medium to pebble-sized fossils; well sorted; subangular to subrounded; 45 percent pelecypods (including *Chione*); 25 percent intergrain porosity; moderate hydraulic conductivity; soft wet.
22.5-22.6	Pelecypod lime floatstone with quartz sand-rich lime mudstone matrix; dark gray to medium dark gray N3 to N4; mainly fine quartz sand; minor medium to very coarse quartz sand and medium to pebble-sized fossils; well sorted; subangular to subrounded; 45 percent quartz sand; 15 percent pelecypods; 5 percent moldic porosity; low hydraulic conductivity; very hard wet; well consolidated.
22.6-30.0	No recovery (driller reports that this interval is “soft” quartz sand based rig response while drilling interval).
30.0-30.8	Quartz sand; light olive gray 5Y 6/1; black N1 phosphorite and heavy mineral grains; mainly fine to medium quartz sand; minor quartz silt to very fine and coarse to very coarse quartz sand, and very fine to fine phosphorite and heavy mineral grains; moderately sorted; subangular to subrounded; 5 percent mainly phosphorite and subordinate heavy mineral grains; 25 percent intergrain porosity; moderate hydraulic conductivity; soft wet; very poorly consolidated.
30.8-36.9	Quartz sand; yellowish gray 5Y 8/1; black N1 phosphorite and heavy mineral grains; mainly fine to medium quartz sand; minor quartz silt to very fine and coarse to very coarse quartz sand, and very fine to fine phosphorite and heavy mineral grains; moderately sorted; subangular to subrounded; 5 percent mainly phosphorite and subordinate heavy mineral grains; 25 percent intergrain porosity; moderate hydraulic conductivity; soft wet; very poorly consolidated.
36.9-37.5	No recovery.
37.5-39.9	Quartz sand; yellowish gray 5Y 8/1; black N1 phosphorite and heavy mineral grains; mainly fine to medium quartz sand; minor quartz silt to very fine and coarse to very coarse quartz sand, and very fine to fine phosphorite and heavy mineral grains; moderately sorted; subangular to subrounded; 5 percent mainly phosphorite and subordinate heavy mineral grains; 25 percent intergrain porosity; moderate hydraulic conductivity; soft wet; very poorly consolidated.
39.9-40.5	No recovery.

Depth (feet below land surface)	Lithologic description of GL-325 test corehole
40.5-42.0	Quartz sand; yellowish gray 5Y 8/1; black N1 phosphorite and heavy mineral grains; mainly fine to medium quartz sand; minor quartz silt to very fine and coarse to very coarse quartz sand, and very fine to fine phosphorite and heavy mineral grains; moderately sorted; subangular to subrounded; 5 percent mainly phosphorite and subordinate heavy mineral grains; 25 percent intergrain porosity; moderate hydraulic conductivity; soft wet; very poorly consolidated.
42.0-47.0	Quartz sand; yellowish gray 5Y 8/1; black N1 phosphorite and heavy mineral grains; mainly very fine to medium quartz sand; minor quartz silt to coarse quartz sand and very fine to fine phosphorite and heavy mineral grains; moderately to well sorted; subangular to subrounded; 5-10 percent mainly phosphorite and subordinate heavy mineral grains; 25 percent intergrain porosity; moderate hydraulic conductivity; soft wet; very poorly consolidated; trace coarse sand grains.
47.0-48.0	No recovery.
48.0-50.0	Quartz sand; yellowish gray 5Y 8/1; black N1 phosphorite and heavy mineral grains; mainly very fine to medium quartz sand; minor quartz silt and coarse quartz sand, and very fine to fine phosphorite and heavy mineral grains; moderately to well sorted; subangular to subrounded; 5-10 percent mainly phosphorite and subordinate heavy mineral grains; 25 percent inter-grain porosity; moderate hydraulic conductivity; soft wet; very poorly consolidated; trace coarse sand grains.
50.0-54.5	Quartz sand; yellowish gray 5Y 7/2; black N1 phosphorite and heavy mineral grains; mainly very fine to fine quartz sand; minor quartz silt and medium to coarse quartz sand, very fine phosphorite and heavy mineral grains; well sorted; subangular to subrounded; 10 percent mainly phosphorite and subordinate heavy mineral grains; trace mica; 25 percent intergrain porosity; moderate hydraulic conductivity; soft wet; very poorly consolidated; trace medium to coarse quartz grains.
54.5-55.0	No recovery.
55.0-59.4	Quartz sand; yellowish gray 5Y 7/2; light olive gray 5Y 5/2 and olive gray 5Y 3/2 clay; black N1 phosphorite and heavy mineral grains; mainly very fine to fine quartz sand; minor quartz silt and medium quartz sand, very fine phosphorite and heavy mineral grains; well sorted; subangular to subrounded; 10-15 percent mainly phosphorite and subordinate heavy mineral grains; trace mica; 20 percent intergrain porosity; low hydraulic conductivity; soft wet; very poorly consolidated; common irregular thin (≤1 mm thick) clay laminations and trace clay matrix; trace medium quartz grains.
59.4-60.0	No recovery.
60.0-68.9	Quartz sand; yellowish gray 5Y 7/2 sand; light olive gray 5Y 5/2 and olive gray 5Y 3/2 clay; black N1 phosphorite and heavy mineral grains; mainly very fine quartz sand; minor quartz silt and fine quartz sand, very fine phosphorite and heavy mineral grains; well sorted; mainly angular to subangular and subordinate subrounded; 10-15 percent mainly phosphorite and sub-ordinate heavy mineral grains; trace mica; 20 percent intergrain porosity; low hydraulic conductivity; soft wet; very poorly consolidated; minor irregular thin (<1-3 mm thick) clay laminations, clay-rich sand laminations and clay matrix; trace medium quartz grains.
68.9-70.5	No recovery.
70.5-77.0	Quartz sand; yellowish gray 5Y 7/2 sand; black N1 phosphorite and heavy mineral grains; mainly very fine to fine quartz sand; minor quartz silt and medium to very coarse quartz sand, very fine phosphorite and heavy mineral grains; well to mod-erate sorted; mainly angular to subangular very fine to fine quartz grains and subangular to subrounded quartz sand; 10-15 percent mainly phosphorite and subordinate heavy mineral grains; trace mica; 20 percent intergrain porosity; low hydraulic conductivity; soft wet; very poorly consolidated; minor thin clay-rich sand laminations; minor medium to coarse quartz grains floating in fine to very fine matrix; trace very coarse quartz grains; approximately 10 degrees inclined planar thinly laminated quartz sand between 73.5 and 75.5 feet.
77.0-80.2	Quartz sand; yellowish gray 5Y 7/2 sand; light olive gray 5Y 5/2 and olive gray 5Y 3/2 clay; black N1 phosphorite and heavy mineral grains; mainly very fine to fine quartz sand; minor quartz silt and very fine phosphorite and heavy mineral grains; well sorted; mainly angular to subangular and subordinate subrounded; 10-15 percent mainly phosphorite and subordinate heavy mineral grains; trace mica; 15-20 percent intergrain porosity; low hydraulic conductivity; soft wet; poorly consoli-dated; minor irregular thin clay laminations; common clay and dolosilt(?) matrix; common burrows.
80.2-80.5	No recovery.
80.5 - 84.0	Quartz sand; yellowish gray 5Y 7/2 sand; light olive gray 5Y 5/2 and olive gray 5Y 3/2 clay; black N1 phosphorite and heavy mineral grains; mainly very fine to fine quartz sand; minor quartz silt and very fine phosphorite and heavy mineral grains; well sorted; mainly angular to subangular and subordinate subrounded; 10-15 percent mainly phosphorite and subordinate heavy mineral grains; trace mica; 15-20 percent intergrain porosity; low hydraulic conductivity; soft wet; poorly consoli-dated; minor irregular thin clay laminations; common clay and dolosilt(?) matrix; common burrows.

Depth (feet below land surface)	Lithologic description of GL-325 test corehole
84.0-86.7	Quartz sand; yellowish gray 5Y 7/2 and light olive gray 5Y 5/2; black N1 phosphorite and heavy mineral grains; mainly very fine to fine quartz sand; minor quartz silt and very fine phosphorite and heavy mineral grains; well sorted; mainly angular to subangular and subordinate subrounded; 10-15 percent mainly phosphorite and subordinate heavy mineral grains; trace mica; 10-15 percent intergrain porosity; low hydraulic conductivity; soft wet; abundant clay and dolosilt(?) matrix; common burrows that result in a mottled appearance.
86.7-87.0	No recovery.
87.0-91.0	Quartz sand; yellowish gray 5Y 7/2 and light olive gray 5Y 5/2; black N1 phosphorite and heavy mineral grains; mainly very fine to fine quartz sand; minor quartz silt and very fine phosphorite and heavy mineral grains; well sorted; mainly angular to subangular and subordinate subrounded; 10-15 percent mainly phosphorite and subordinate heavy mineral grains; trace mica; 10-15 percent intergrain porosity; low hydraulic conductivity; soft wet; abundant clay and dolosilt(?) matrix; common burrows that result in a mottled appearance.
91.0-93.5	Quartz sand; yellowish gray 5Y 7/2 and minor light olive gray 5Y 5/2; black N1 phosphorite and heavy mineral grains; mainly very fine quartz sand; minor quartz silt and fine quartz sand and very fine phosphorite and heavy mineral grains; well sorted; mainly angular to subangular and subordinate subrounded; 10-15 percent mainly phosphorite and subordinate heavy mineral grains; trace mica; 15-20 percent intergrain porosity; low hydraulic conductivity; soft wet; trace clay matrix.
93.5-100.0	Quartz sand; yellowish gray 5Y 7/2; black N1 phosphorite and heavy mineral grains; mainly very fine quartz sand; minor quartz silt and fine quartz sand and very fine phosphorite and heavy mineral grains; well sorted quartz sand; mainly angular to subangular and subordinate sub rounded; 15 percent mainly phosphorite and subordinate heavy mineral grains; trace mica; 15 percent intergrain porosity; low hydraulic conductivity; soft wet; minor clay and dolosilt(?) matrix; burrowed; irregular laminations.
100.0-102.8	Quartz sand; yellowish gray 5Y 7/2; black N1 phosphorite and heavy mineral grains; mainly very fine quartz sand; minor quartz silt and fine quartz sand and very fine phosphorite and heavy mineral grains; well sorted; mainly angular to subangular and subordinate subrounded; 15-20 percent mainly phosphorite and subordinate heavy mineral grains; trace mica; 15-20 percent intergrain porosity; low hydraulic conductivity; soft wet; very minor clay and dolosilt(?) matrix; burrowed; irregular laminations.
102.8-112.0	Quartz sand; yellowish gray 5Y 7/2 and light olive gray 5Y 5/2; black N1 phosphorite and heavy mineral grains; mainly very fine quartz sand; minor quartz silt and very fine phosphorite and heavy mineral grains; well sorted; angular to subangular; 15-20 percent mainly phosphorite and subordinate heavy mineral grains; trace mica; 15 percent intergrain porosity; low hydraulic conductivity; soft wet; minor clay and dolosilt(?) matrix; burrowed; minor irregular laminations of quartz sand with abundant clay and dolosilt(?) matrix.
112.0-120.0	Quartz sand; light olive gray 5Y 5/2 and olive gray 5Y 3/2; black N1 phosphorite and heavy mineral grains; mainly very fine quartz sand; minor quartz silt and fine quartz sand and very fine phosphorite and heavy mineral grains; well sorted; mainly angular to subangular and subordinate subrounded; 15 percent mainly phosphorite and subordinate heavy mineral grains; trace mica; 15 percent intergrain porosity; low hydraulic conductivity; soft wet; abundant clay and dolosilt(?) matrix; burrowed; minor irregular laminations of sandy clay.
120.0-121.0	Diatomaceous mudstone; light olive gray 5Y 5/2; black N1 phosphorite and heavy mineral grains; mainly clay-sized; very fine phosphorite and heavy mineral grains; diatoms, siliceous spicules and small foraminifers, 15 percent mainly phosphorite and subordinate heavy mineral grains; 5 percent microporosity; low hydraulic conductivity; firm when wet.
121.0-124.0	Interlaminated sandy terrigenous mudstone and quartz sand; light olive gray 5Y 5/2 and olive gray 5Y 3/2; black N1 phosphorite and heavy mineral grains; mainly clay and very fine quartz sand; minor very fine phosphorite and heavy mineral grains; well sorted; angular to subangular; diatoms, siliceous spicules, undifferentiated small foraminifers, small benthic foraminifers; 10-20 percent mainly phosphorite and subordinate heavy mineral grains; 15 percent intergrain porosity in sand laminations; 5 percent microporosity in clay laminations; very low to low hydraulic conductivity; firm wet; burrowed.
124.0-127.7	Interlaminated sandy terrigenous mudstone and quartz sand; light olive gray 5Y 5/2 and olive gray 5Y 3/2; black N1 phosphorite and heavy mineral grains; mainly clay and very fine quartz sand; minor very fine phosphorite and heavy mineral grains; well sorted; angular to subangular; diatoms, siliceous spicules, undifferentiated small foraminifers(?); 10-20 percent mainly phosphorite and subordinate heavy mineral grains; 15 percent intergrain porosity in sand laminations; 5 percent microporosity in clay laminations; very low to low hydraulic conductivity; firm wet; burrowed; *Planolites* trace fossil at 126.7 feet.

Depth (feet below land surface)	Lithologic description of GL-325 test corehole
127.7-128.3	Quartz conglomerate; light olive gray 5Y 6/1black N1 to dark gray N3 phosphorite and black N1 heavy mineral grains; mainly very fine sand- to large pebble-sized quartz grains; minor very fine sand sized to medium pebble sized phosphorite grains and very fine heavy mineral grains; poorly sorted; angular to subangular very fine to fine quartz grains and subangular to subrounded medium sand- to pebble-sized quartz grains; 10-25 percent mainly phosphorite and subordinate heavy mineral grains; 15 percent intergrain porosity; low hydraulic conductivity; soft wet; poorly consolidated; quartz pebbles up to 2.5 cm wide; minor clay matrix.
128.3-130.0	Dolosilt; yellowish gray 5Y 7/2; black N1 phosphorite and heavy mineral grains; mainly silt-sized dolomite; minor very fine quartz sand and subordinate fine quartz sand, and very fine phosphorite and heavy mineral grains; well sorted; mainly angular to subangular and subordinate subrounded; minor quartz sand; 10-15 percent mainly phosphorite and subordinate heavy mineral grains; 5 percent microporosity; low hydraulic conductivity.
130-131	Quartz sand with dolosilt matrix; yellowish gray 5Y 7/2; black N1 phosphorite and heavy mineral grains; mainly silt-sized dolomite; minor very fine quartz sand and subordinate fine quartz sand, and very fine phosphorite and heavy mineral grains; well sorted; mainly angular to subangular and subordinate subrounded; 10-80 percent quartz sand; 10-15 percent mainly phosphorite and subordinate heavy mineral grains; 5 percent microporosity; very low hydraulic conductivity.
131.0-134.5	Sandy dolosilt and quartz sand with dolosilt matrix; yellowish gray 5Y 7/2; black N1 phosphorite and heavy mineral grains; mainly silt-sized dolomite and very fine to fine quartz sand; minor medium to very coarse quartz sand, very fine to coarse phosphorite grains and very fine heavy mineral grains; moderately sorted; mainly angular to subangular and subordinate subrounded; 10 percent mainly phosphorite and subordinate heavy mineral grains; 5 percent microporosity; very low hydraulic conductivity; medium to very coarse quartz grains floating in dolosilt and finer quartz sand matrix.
134.5-135.5	Dolosilt; yellowish gray 5Y 7/2; black N1 phosphorite and heavy mineral grains; mainly silt-sized dolomite and very fine quartz sand; minor fine quartz sand, very fine phosphorite grains and heavy mineral grains; fine sand-sized to small pebble-sized fossils; well sorted; mainly angular to subangular and subordinate subrounded; 20-30 percent quartz sand; 10 percent mainly phosphorite and subordinate heavy mineral grains; 10 percent undifferentiated fossil fragments; 5 percent microporosity; very low hydraulic conductivity.
135.5-136.7	Sandy dolosilt and lime mudstone; yellowish gray 5Y 8/1; black N1 phosphorite and heavy mineral grains; mainly silt-sized dolomite and very fine quartz sand; minor fine quartz sand, very fine phosphorite and heavy mineral grains; fine sand-sized to small pebble-sized fossils; well sorted; mainly angular to subangular and subordinate subrounded; 20-40 percent quartz sand; 10 percent mainly phosphorite and subordinate heavy mineral grains; 5 percent pelecypods and undifferentiated fossil fragments; 5 percent microporosity; very low hydraulic conductivity.
136.7-140.5	No recovery
140.5-145.0	Pelecypod lime floatstone with sandy pelecypod lime wackestone and mud-dominated lime packstone matrix; yellowish gray 5Y 8/1; black N1 phosphorite and heavy mineral grains; mainly medium sand-sized to small pebble-sized fossils, clay-sized micrite and very fine quartz sand; minor fine quartz sand, and very fine phosphorite and heavy mineral grains; well sorted; mainly angular to subangular and subordinate subrounded; pelecypods and gastropods; 20-45 percent quartz sand; 5-10 percent mainly phosphorite and subordinate heavy mineral grains; 15 percent moldic porosity; low hydraulic conductivity.
145.0-150.5	Pelecypod lime rudstone with sandy pelecypod mud-dominated and grain-dominated packstone matrix; yellowish gray 5Y 8/1 and white N9; black N1 phosphorite and heavy mineral grains; mainly medium sand-sized to large pebble-sized fossils, clay-sized micrite and very fine quartz sand; minor fine quartz sand, and very fine phosphorite and heavy mineral grains; well sorted; mainly angular to subangular and subordinate subrounded; pelecypods and gastropods; 20-45 percent quartz sand; 5-10 percent mainly phosphorite and subordinate heavy mineral grains; 25 percent moldic porosity; moderate hydraulic conductivity.
150.5-151.1	Lime mudstone; pale olive 5Y 6/2; black N1 phosphorite and heavy mineral grains; mainly clay-sized micrite; minor very fine to fine quartz sand and very fine phosphorite and heavy mineral grains; well sorted; mainly angular to subangular and subordinate subrounded; trace pelecypods; minor quartz sand; trace mainly phosphorite and subordinate heavy mineral grains; 5 percent microporosity; very low hydraulic conductivity; percentage of quartz increase upwards.
151.1-154.5	Interlaminated sandy dolosilt and quartz sand with dolosilt matrix; pale olive 5Y 6/2; black N1 phosphorite and heavy mineral grains; mainly clay-sized micrite and very fine quartz sand; minor fine quartz sand, fine sand- to pebble-sized fossils, and very fine phosphorite and heavy mineral grains; well sorted; mainly angular to subangular and subordinate subrounded; 10-30 percent undifferentiated fossils and pelecypods; 20-70 percent quartz sand; trace mainly phosphorite and subordinate heavy mineral grains; 5 percent microporosity; very low hydraulic conductivity; thinly laminated; borrows parallel to horizontal laminations.

Depth (feet below land surface)	Lithologic description of GL-325 test corehole
154.5-157.9	Quartz sandstone with abundant micrite matrix; light greenish gray 5GY 8/1; black N1 phosphorite and heavy mineral grains; mainly clay-sized micrite and very fine quartz sand; minor fine quartz sand and very fine phosphorite and heavy mineral grains; well sorted; mainly angular to subangular and subordinate subrounded; 20-30 percent undifferentiated fossils and trace echinoid spines; 5 percent mainly phosphorite and subordinate heavy mineral grains; 5 percent microporosity; very low hydraulic conductivity; abundant micrite matrix.
157.9-159.0	Quartz sandstone with abundant micrite matrix; light greenish gray 5GY 8/1; black N1 phosphorite and heavy mineral grains; mainly clay-sized micrite and very fine quartz sand; minor fine to coarse quartz sand, fine sand- to medium pebble-sized fossils, very fine to coarse phosphorite and very fine heavy mineral grains; moderately sorted; mainly angular to subangular and subordinate subrounded; 10-20 percent undifferentiated fossils and pelecypods; 5 percent mainly phosphorite and subordinate heavy mineral grains; 5 percent microporosity; very low hydraulic conductivity; abundant micrite matrix.
159.0-160.5	No recovery.
160.5-161.1	Quartz sandstone with abundant micrite matrix; light greenish gray 5GY 8/1; black N1 phosphorite and heavy mineral grains; mainly clay-sized micrite and very fine quartz sand; minor fine to coarse quartz sand, fine sand- to medium pebble-sized fossils, very fine to coarse phosphorite and very fine heavy mineral grains; moderately sorted; mainly angular to subangular and subordinate subrounded; 10-20 percent undifferentiated fossils and pelecypods; 5 percent mainly phosphorite and subordinate heavy mineral grains; 5 percent microporosity; very low hydraulic conductivity; abundant micrite matrix.
161.1-164.2	Pelecypod lime rudstone with sandy lime mudstone and quartz sandstone matrix; yellowish gray 5Y 8/1 and light greenish gray 5GY 8/1; black N1 phosphorite and heavy mineral grains; mainly clay-sized micrite, fine quartz sand and fine sand- to large pebble-sized fossils; minor very fine and medium to coarse quartz sand, very fine to fine phosphorite and heavy mineral grains; moderately sorted; mainly angular to subangular and subordinate subrounded; pelecypods and trace bryozoans; 5 percent mainly phosphorite and subordinate heavy mineral grains; 10 percent intergrain porosity; low hydraulic conductivity; quartz sandstone has abundant micrite matrix; large pebble-sized bryozoans in the upper 3 inches of interval.
164.2-166.0	Pelecypod lime rudstone with quartz sand matrix; yellowish gray 5Y 8/1 and light greenish gray 5GY 8/1; black N1 phosphorite and heavy mineral grains; mainly clay-sized micrite, fine quartz sand and fine sand- to large pebble-sized fossils; minor very fine and medium to coarse quartz sand, very fine to medium phosphorite and heavy mineral grains; well sorted; mainly angular to subangular and subordinate subrounded; pelecypods and undifferentiated fossils; 5 percent mainly phosphorite and subordinate heavy mineral grains; 10 percent intergrain porosity; low hydraulic conductivity.
166.0-169.1	Interbedded pelecypod-rich quartz sand and pelecypod rudstone with quartz sand matrix; pale olive 10Y 6/2; black N1 phosphorite and heavy mineral grains; mainly clay-sized micrite, fine quartz sand, fine sand- to large pebble-sized fossils; minor very fine and medium to coarse quartz sand, and very fine phosphorite and heavy mineral grains; well sorted; mainly angular to subangular and subordinate subrounded; pelecypods and trace barnacles and echinoid spines; 10-15 percent mainly phosphorite and subordinate heavy mineral grains; 20-25 percent intergrain porosity; low hydraulic conductivity.
169.1-170.5	No recovery.
170.5-174.2	Interbedded pelecypod-rich quartz sand and pelecypod rudstone with quartz sand matrix; pale olive 10Y 6/2; black N1 phosphorite and heavy mineral grains; mainly clay-sized micrite, fine quartz sand, fine sand- to large pebble-sized fossils; minor very fine and medium to coarse quartz sand, and very fine phosphorite and heavy mineral grains; well sorted; mainly angular to subangular and subordinate subrounded; pelecypods and trace barnacles and echinoid spines; 10-15 percent mainly phosphorite and subordinate heavy mineral grains; 20-25 percent intergrain porosity; low hydraulic conductivity.
174.2-175.5	Quartz sand; light olive gray 5Y 6/1; black N1 phosphorite and heavy mineral grains; mainly fine quartz sand; minor very fine and medium quartz sand, and very fine to fine phosphorite and heavy mineral grains; well sorted; mainly angular to subangular and subordinate subrounded; 20 percent undifferentiated fossils and pelecypods; 15 percent mainly phosphorite and subordinate heavy mineral grains; 25 percent intergrain porosity; low hydraulic conductivity.
175.5-180.5	No recovery
180.5-183.2	Quartz sand; yellowish gray 5Y 8/1; black N1 phosphorite and heavy mineral grains; mainly very fine quartz sand; minor fine quartz sand, fine sand- to small pebble-sized fossils, and very fine phosphorite and heavy mineral grains; well sorted; mainly angular to subangular and subordinate subrounded; undifferentiated fossils and pelecypods; 10 percent mainly phosphorite and subordinate heavy mineral grains; 20 percent intergrain porosity; low hydraulic conductivity; minor clay matrix.

Depth (feet below land surface)	Lithologic description of GL-325 test corehole
183.2-185.0	Quartz sand; yellowish gray 5Y 8/1; black N1 phosphorite and heavy mineral grains; mainly very fine quartz sand; minor fine quartz sand, fine sand- to small pebble-sized fossils, and very fine phosphorite and heavy mineral grains; well sorted; mainly angular to subangular and subordinate subrounded; <5 percent undifferentiated fossils and pelecypods; 10 percent mainly phosphorite and subordinate heavy mineral grains; 15 percent intergrain porosity; low hydraulic conductivity; minor clay matrix.
185.0-189.1	Sandy terrigenous mudstone; light olive gray 5Y 6/1; black N1 phosphorite and heavy mineral grains; mainly clay and very fine quartz sand; minor fine quartz sand and very fine phosphorite and heavy mineral grains; well sorted; mainly angular to subangular; 20-60 percent quartz sand; minor small benthic foraminifers; 15 percent mainly phosphorite and subordinate heavy mineral grains; 5 percent microporosity; very low hydraulic conductivity; burrowed in part; thin horizontal laminations.
189.1-190.5	No recovery.
190.5-194.2	Sandy terrigenous mudstone; light olive gray 5Y 6/1; black N1 phosphorite and heavy mineral grains; mainly clay and very fine quartz sand; minor fine and coarse quartz sand and very fine phosphorite and heavy mineral grains; moderately sorted; mainly angular to subangular; 20-60 percent quartz sand; minor small benthic foraminifers; 15 percent mainly phosphorite and subordinate heavy mineral grains; 5 percent microporosity; very low hydraulic conductivity; burrowed in part; thin horizontal laminations; more species diversity in benthic foraminifers than interval 185 to 189.1 feet.
194.2-194.3	Sandy dolosilt; light greenish gray 5GY 8/1; black N1 phosphorite and heavy mineral grains; mainly silt-sized dolomite and very fine quartz sand; minor fine and coarse quartz sand and very fine to coarse phosphorite grains and very fine heavy mineral grains; moderately sorted; mainly angular to subangular; 15 percent mainly phosphorite and subordinate heavy mineral grains; 5 percent microporosity; very low hydraulic conductivity; burrowed in part; thin horizontal laminations.
194.3-200.5	No recovery.

GL-326 Test Corehole

Florida Geological Survey well number	W-18073
GWSI number	GL-326
Total depth	39.5 feet
Cored from	0 to 39.5 feet
County	Glades
Location	SW, SW, sec. 30, T42S, R32E
Latitude	26° 46′ 59″
Longitude	81° 10′ 17″
Elevation	16 feet
Completion date	July 24, 1999
Other types of logs available	Induction, gamma ray, resistivity, spontaneous potential
Owner	U.S. Geological Survey
Driller	Florida Geological Survey
Core described by	Kevin J. Cunningham
Fill	0 to 7.0 feet
Undifferentiated	7.0 to 9.3 feet
Caloosahatchee Formation	9.3 to 17.75 feet
Top Tamiami Formation	17.75 feet
Water-table aquifer	0 to 33.3 feet
Top Tamiami confining zone	33.3 feet (electrical logs contributed to selection of tops)

Depth (feet below land surface)	Lithologic description of GL-326 test corehole
0.0-7.0	Fill; very pale orange 10YR 8/2, pale yellowish brown 10YR 6/2.
7.0 -8.0	Fill with a clast of *Helisoma* lime rudstone with quartz sand-rich wackestone matrix; light gray N7; possible top Fort Thompson at 7 feet based on clast of *Helisoma*-Fort Thompson lithology, color change to light gray, and comparison to depth of base of fill along Caloosahatchee River bank; poor sample quality.
8.0-9.0	No recovery.
9.0-9.3	Quartz sand; dark gray N3 to medium light gray N6, 10 YR 2/2 humus; mainly fine to medium quartz sand; minor clay, very fine and medium quartz and clay to very fine humus; well sorted; subangular to subrounded; local abundant clay; up to 5 percent humus; 25 percent intergrain porosity; low to moderate hydraulic conductivity; soft to friable wet; loose unconsolidated sand to semiconsolidated clay-rich sand and very thinly laminated clay (2-mm thick).
9.3-9.5	Rubble of pelecypod lime rudstone with quartz sand-rich grain dominated packstone matrix; very pale orange 10YR 8/2; mainly medium quartz sand; minor very fine to fine and coarse quartz sand, and fine sand-sized to medium pebble-sized fossils and fossil fragments; well sorted; subangular to subrounded; 25 percent quartz sand; 15 percent intergrain porosity; low to moderate hydraulic conductivity; sample is rubble.
9.5-10.9	Pelecypod lime floatstone with quartz sand-rich, skeletal wackestone matrix; very pale orange 10YR 8/2; mainly very fine to medium quartz sand; minor coarse quartz sand and fine sand-sized to very large pebble-sized fossils and fossil fragments; well sorted; subangular to subrounded; pelecypods and bryozoans; 20-30 percent quartz sand; 15 percent moldic, root-mold, intergrain porosity; low to moderate hydraulic conductivity; very hard wet; well consolidated; 1-mm diameter, semivertical root molds.
10.9-14.0	No recovery.
14.0-14.5	Rubble of limestone and pelecypod shells.
14.5-17.0	No recovery.
17.0-17.8	Pelecypod lime rudstone with quartz sand-rich marly matrix and loose oyster fragments; yellowish gray 5Y 8/1, medium light gray N6 to very light gray N8; very fine sand-sized to very large pebble-sized fossils and fossil fragments, clay-size marl; minor very fine quartz sand; moderately sorted; subangular to subrounded; pelecypods and subordinate oysters and bryozoans; 10 percent quartz sand; 5-25 percent intergrain porosity; low to moderate hydraulic conductivity; soft wet; marl matrix.
17.8-25.0	No recovery.
25.0-27.5	Loose pelecypod shells; very pale orange 10YR 8/2, medium dark gray N4 to very light gray N6; coarse sand-sized to medium pebble-sized fossils and fossil fragments; minor very fine to medium quartz sand; well sorted; subangular to subrounded; 95 percent pelecypods and subordinate gastropods; 5 percent quartz sand; trace marl; 25-35 percent intergrain porosity; moderate to high hydraulic conductivity; unconsolidated, loose shells; most shells broken; trace matrix of sandy marl.
27.5-28.0	Quartz sand; light gray N7 to very light gray N8; N1 heavy minerals; mainly fine to medium quartz sand; minor very fine and coarse quartz; well sorted; subangular to subrounded; 5 percent pelecypod shells; trace heavy minerals; 25 percent intergrain porosity; moderate hydraulic conductivity; soft wet; unconsolidated.
28.0-29.5	No recovery.
29.5-31.0	Loose pelecypod shells with quartz sand and clay matrix; yellowish gray 5Y 7/2, very pale orange 10YR 8/2, medium dark gray N4 to very light gray N6; medium sand-sized to small pebble-sized fossils and fossil fragments; minor very fine to medium quartz sand; well sorted; subangular to subrounded; 80 percent pelecypods and subordinate gastropods; 10 percent quartz sand; 10 percent clay; 20 percent intergrain porosity; low hydraulic conductivity; soft wet; unconsolidated.
31.0-31.5	Loose pelecypod shells; very pale orange 10YR 8/2, medium dark gray N4 to very light gray N6; coarse sand-sized to medium pebble-sized fossils and fossil fragments; minor very fine to medium quartz sand; well sorted; subangular to subrounded; 95 percent pelecypods and subordinate gastropods; 5 percent quartz sand; trace marl; 25-35 percent intergrain porosity; moderate to high hydraulic conductivity; unconsolidated, loose shells; most shells broken; trace matrix of sandy marl.

Depth (feet below land surface)	Lithologic description of GL-326 test corehole
31.5-33.3	Quartz sand; very light gray N8, yellowish gray 5Y 8/1; N1 phosphate grains and heavy minerals; mainly fine to medium quartz sand; minor very fine and coarse quartz; well sorted; subangular to subrounded; 5 percent pelecypod shells; trace heavy minerals; 25 percent intergrain porosity; moderate hydraulic conductivity; soft wet; unconsolidated.
33.3-33.5	Quartz sand; light olive gray 5Y 6/1; N1 phosphate grains and heavy minerals; mainly fine to medium quartz sand; minor very fine and coarse quartz, and medium sand-sized to medium pebble-sized pelecypod shells; well sorted; subangular to subrounded; 20 percent pelecypod shells; 10 percent clay matrix; trace heavy minerals; 15 percent intergrain porosity; low hydraulic conductivity; soft wet; unconsolidated.
33.5-34.5	No recovery.
34.5-37.0	Mixture of pelecypod shells, quartz sand and clay; sediments is light olive gray; shells are very pale orange 10YR 8/2, medium dark gray N4 to very light gray N6; coarse sand-sized to medium pebble-sized fossils and fossil fragments, and very fine to medium quartz sand; minor coarse quartz sand; well sorted; subangular to subrounded; 60 percent pelecypods and subordinate gastropods; 35 percent quartz sand; 5 percent clay; 10 percent intergrain porosity; low hydraulic conductivity; soft wet; unconsolidated, loose shells; most shells broken; trace matrix of sandy marl.
37.0-38.5	Clay with abundant pelecypod shells and minor quartz sand; light olive gray 5Y 5/2; olive gray 5Y 4/1; granule to small pebble-sized shells; minor very fine to fine quartz sand and medium to very large pebble-sized shells; well sorted; subangular to subrounded; 35 percent pelecypod shells and subordinate gastropods; 5 percent quartz sand; 5 percent intergrain porosity; very low hydraulic conductivity; firm wet; semiconsolidated; gradational with unit above.
38.5-39.5	No recovery.

GL-327 Test Corehole

FGS well number	W-18074
GWSI number	GL-327
Total depth	454 feet
Cored from	0 to 454 feet
County	Glades
Location	SW, sec. 22, T42S, R32E
Latitude	26° 48′ 2.7″
Longitude	81° 07′ 5.2″
Elevation	14 feet
Completion Date	April 13, 2000
Other types of logs available	Resistivity, gamma ray, spontaneous potential
Owner	USGS
Driller	FGS
Core described by	Kevin J. Cunningham
Fill	0 to 19.8(?) feet
Undifferentiated	19.8(?) to 33 feet
Tamiami Formation	33 to 141 feet
Upper Peace River Formation	141 to 446.5 feet
Lower Peace River Formation(?)	446.5 to 454 feet (based on gamma-ray log)
Water-table aquifer	0 to 28.9 feet
Tamiami confining zone	28.9 to 39 feet
Lower Tamiami aquifer	39 to 98.8 feet

Depth (feet below land surface)	Lithologic description of GL-327 test corehole
0.0-8.8	Fill
8.8-10.0	No recovery
10.0-19.3	Fill(?)
19.3-19.8	Quartz sand; yellowish gray 5Y 8/1; mainly very fine to fine quartz sand; minor medium to coarse quartz sand; moderate to well sorted quartz sand; 25 percent intergrain porosity; moderate hydraulic conductivity; friable; 10-30 percent broken pelecypod shells
19.8-20.3	Quartz sand; dark gray N3; mainly very fine to fine quartz sand; minor medium quartz sand; well sorted quartz sand; 25 percent intergrain porosity; low hydraulic conductivity; moderately friable; abundant dark organic material in matrix
20.3-23.0	No recovery
23.0-23.2	Quartz sand; dark gray N3; mainly very fine to fine quartz sand; minor medium quartz sand; well sorted quartz sand; 25 percent intergrain porosity; low hydraulic conductivity; moderately friable; abundant dark organic material in matrix
23.2-24.0	No recovery
24.0-25.5	Quartz sand; pale yellowish brown 10YR 6/2 to white N9; mainly very fine to fine quartz sand; minor medium to very coarse quartz sand; well sorted quartz sand; 25 percent intergrain porosity; moderate hydraulic conductivity; friable
25.5-28.0	No recovery
28.0-28.9	Quartz sand; pale yellowish brown 1OYR 6/2 to white N9; mainly very fine to fine quartz sand; minor medium to very coarse quartz sand; well sorted quartz sand; 25 percent intergrain porosity; moderate hydraulic conductivity; friable
28.9-31.2	Quartz sand with abundant pelecypods; yellowish gray 5Y 8/1; mainly fine quartz sand; minor very fine and medium quartz sand; pelecypods up to large pebble size; well sorted quartz sand; poorly sorted quartz sand and shells; 25 percent intergrain porosity; low hydraulic conductivity; 40-50 percent pelecypod shells; clay matrix
31.2-33.0	No recovery
33.0-34.5	Quartz sand with lime mudstone matrix; brownish black 5YR 2/1 to grayish black N2; mainly fine quartz sand; minor very fine and medium quartz sand; well sorted quartz sand; very poorly sorted quartz sand and shells; low hydraulic conductivity; 20-40 percent gastropods (*Helisoma*); fresh-water environment
34.5-35.4	Quartz sand; pale yellowish brown 1OYR 6/2; mainly fine quartz sand; minor very fine and medium to coarse quartz sand; pelecypods up to large pebble size; moderate to well sorted quartz sand; moderate hydraulic conductivity; friable
35.4-35.8	Quartz sand with abundant pelecypods; yellowish gray 5Y 8/1; mainly fine quartz sand; minor very fine and medium to coarse quartz sand; pelecypods up to large pebble size; moderate to well sorted quartz sand; low hydraulic conductivity; friable; 40-50 percent pelecypod shells; marl matrix
35.8-37.0	No recovery
37.0-37.8	Fill
37.8-39.0	Quartz sand with abundant pelecypods; yellowish gray 5Y 8/1; mainly fine-medium quartz sand; minor very fine and coarse quartz sand; pelecypods up to large pebble size; moderate to well sorted quartz sand; low hydraulic conductivity; friable; 40-50 percent pelecypod shells (including *Chione*); marl matrix
39.0-41.0	Gastropod and pelecypod lime rudstone and floatstone with matrix of quartz-sand-rich lime wackestone and mud-dominated lime packstone or quartz sand with lime mudstone matrix; medium dark gray N4 to medium light gray N6; mainly very fine to fine quartz sand; coarse sand to very large pebble-sized fossils; well sorted quartz sand; 20-40 percent moldic and vuggy porosity; high hydraulic conductivity; hard; fossils mainly low-spiraled gastropods and minor pelecypods
41.0-45.0	No recovery

Depth (feet below land surface)	Lithologic description of GL-327 test corehole
45.0-46.8	Pelecypod lime rudstone and floatstone with matrix of quartz-sand-rich lime wackestone and mud-dominated lime packstone or quartz sand with lime mudstone matrix; medium dark gray N4 to light gray N7; mainly very fine to fine quartz sand; coarse sand to very large pebble-sized fossils; well sorted quartz sand; 20-40 percent moldic and vuggy porosity; high hydraulic conductivity; hard; fossils mainly pelecypods (including *Chione*) and minor gastropods
46.8-51.0	No recovery
51.0-51.4	Rubble of lithology from interval between 45 and 46.8 feet.
51.4-61.0	No recovery
61.0-61.5	Unconsolidated pelecypod lime rudstone and quartz sand matrix; medium dark gray N4 to medium light gray N6; mainly medium to coarse quartz sand and minor very fine and very coarse quartz sand; mainly coarse to granule-sized fossils; moderate to well sorted quartz sand; sand and shells poorly sorted; 25 percent intergrain porosity; moderate hydraulic conductivity; friable; fossils mainly broken pelecypods; 30 percent quartz sand
61.5-66.0	No recovery
66.0-68.4	Unconsolidated pelecypod lime rudstone and quartz sand matrix; medium dark gray N4 to medium light gray N6; mainly medium to coarse quartz sand and minor very fine and very coarse quartz sand; mainly coarse to small pebble-sized fossils; moderate to well sorted quartz sand; sand and shells poorly sorted; 25 percent intergrain porosity; moderate hydraulic conductivity; friable; fossils mainly broken pelecypods; 30 percent quartz sand
68.4-69.3	Quartz sand with abundant pelecypods; medium dark gray N4 to medium light gray N6; mainly medium quartz sand and minor fine and coarse quartz sand; mainly coarse to small pebble-sized fossils; well sorted quartz sand; sand and shells poorly sorted; *25* percent intergrain porosity; moderate hydraulic conductivity; friable; 30 percent broken pelecypod shells
69.3-71.0	No recovery
71.0-71.2	Quartz sand with abundant pelecypods; medium dark gray N4 to medium light gray N6; mainly medium quartz sand and minor fine and coarse quartz sand; mainly coarse to small pebble-sized fossils; well sorted quartz sand; sand and shells poorly sorted; 25 percent intergrain porosity; moderate hydraulic conductivity; friable; 30 percent broken pelecypod shells
71.2-76.0	No recovery (driller “felt” soft sand drilling through interval)
76.0-80.0	Quartz sand with abundant pelecypods; yellowish gray 5Y 8/1 and medium gray N5 to light gray N7; mainly medium quartz sand and minor fume and coarse quartz sand; mainly coarse to granule-sized fossils; well sorted quartz sand; sand and shells poorly sorted; 30 percent intergrain porosity; moderate hydraulic conductivity; friable; 40-60 percent broken pelecypod shells
80.0-81.0	No recovery
81.0-84.9	Quartz sand with abundant pelecypods; yellowish gray 5Y 8/1 and medium gray N5 to light gray N7; mainly medium quartz sand and minor fume and coarse quartz sand; mainly coarse to small-pebble sized fossils; well sorted quartz sand; sand and shells poorly sorted; 30 percent intergrain porosity; moderate hydraulic conductivity; friable; 40-60 percent broken pelecypod shells
84.9-86.0	No recovery
86.0-89.9	Quartz sand with abundant pelecypods; yellowish gray 5Y 8/1 and medium gray N5 to light gray N7; mainly medium quartz sand and minor fine and coarse quartz sand; mainly coarse to small-pebble sized fossils; well sorted quartz sand; sand and shells poorly sorted; 30 percent intergrain porosity; moderate hydraulic conductivity; friable; 40-60 percent broken pelecypod shells
89.9-91.0	No recovery
91.0-94.0	Quartz sand with abundant pelecypods; yellowish gray 5Y 8/1 and medium gray N5 to light gray N7; mainly medium quartz sand and minor fine and coarse quartz sand; mainly coarse to small-pebble sized fossils; well sorted quartz sand; sand and shells poorly sorted; 30 percent intergrain porosity; moderate hydraulic conductivity; friable; 40-60 percent broken pelecypod shells

Depth (feet below land surface)	Lithologic description of GL-327 test corehole
94.0-95.4	Quartz sand with abundant pelecypods; yellowish gray 5Y 8/1 and medium gray N5 to light gray N7; mainly medium quartz sand and minor fume and coarse quartz sand; mainly coarse to small pebble sized fossils; well sorted quartz sand; sand and shells poorly sorted; 30 percent intergrain porosity; moderate hydraulic conductivity; friable; 40-60 percent broken pelecypod shells, bryozoans and barnacles
95.4-96.0	No recovery
96.0-98.8	Unconsolidated pelecypod lime rudstone with matrix of quartz sand with minor clay matrix; yellowish gray 5Y 8/1 and medium gray N5 to light gray N7; mainly medium quartz sand and minor fine and coarse quartz sand; mainly medium to large-pebble sized fossils; sand and shells very poorly sorted; 20 percent intergrain porosity; low to moderate hydraulic conductivity; 60-80 percent broken pelecypod shells, gastropods and barnacles
98.8-99.1	Sandy, silty, gastropod-rich terrigenous mudstone; brownish gray 5Y 4/1 to brownish black 5YR 2/1; mainly very fine to medium quartz sand; mainly medium to granule-sized fossils; very low hydraulic conductivity; firm
99.1-99.6	Pelecypod-rich terrigenous mudstone; pale yellowish brown 1OYR 6/2; very low hydraulic conductivity; firm; 50 percent pelecypods
99.6-100.9	Pelecypod-rich, silty terrigenous mudstone; brownish gray 5YR 4/1; granule to medium pebble-sized fossils; very low hydraulic conductivity; firm; minor pelecypods
100.9-101.0	No recovery
101.0-104.3	Pelecypod-rich, silty terrigenous mudstone; brownish gray 5YR 4/1 to light brownish gray 5YR 6/1; medium sand to granule-sized fossils; very low hydraulic conductivity; firm; minor fragments of thin-shelled pelecypods
104.3-106.0	No recovery
106.0-110.3	Pelecypod-rich, silty terrigenous mudstone; brownish gray 5YR 4/1 to light brownish gray 5YR 6/1; medium sand to granule-sized fossils; very low hydraulic conductivity; firm; minor fragments of thin-shelled pelecypods
110.3-111.0	No recovery
111.0-123.0	Silty terrigenous mudstone; light brownish gray 5YR 6/1; very low hydraulic conductivity; firm; trace diatoms
123.0-127.0	Silty terrigenous mudstone; light brownish gray 5YR 6/1; very low hydraulic conductivity; firm; minor siliceous spicules; trace benthic foraminifera
127.0-132.0	Silty quartz sand; yellowish gray 5Y 8/1; low hydraulic conductivity; calcareous terrigenous mudstone matrix
132.0-139.0	Quartz sand; yellowish gray 5Y 8/1; mainly fine to medium quartz sand and minor very fine and coarse to very coarse quartz sand; well sorted quartz sand; low hydraulic conductivity; 10-20 percent broken fossil fragments; minor marl matrix; intraclasts of sandstone
139.0-140.0	Quartz sand; yellowish gray 5Y 8/1; mainly medium quartz sand and minor fine and coarse to very coarse quartz sand; well sorted quartz sand; low hydraulic conductivity; 10-20 percent broken fossil fragments; very minor marl matrix; intraclasts of sandstone
140.0-141.0	No recovery
141.0-141.2	Rubble of quartz sandstone; medium dark gray N4 to medium gray N5; mainly very fine to fine quartz sand and minor medium quartz sand; well sorted quartz sand; mainly vuggy porosity; moderate hydraulic conductivity; calcite cemented; vuggy porosity may be associated with a possible unconformity at 141 feet
141.2-141.5	Quartz sandstone; yellowish gray 5Y 8/1; mainly medium quartz sand and minor fine and coarse to very coarse quartz sand; moderately sorted quartz sand; mainly vuggy porosity; moderate hydraulic conductivity; hard
141.5-146.0	No recovery
146.0-146.2	Rubble
146.2-151.0	No recovery

Depth (feet below land surface)	Lithologic description of GL-327 test corehole
151.0-155.0	Quartz sand; yellowish gray 5Y 8/1; mainly medium to coarse quartz sand and minor fine and very coarse quartz sand; moderately sorted quartz sand; 1-2 percent phosphorite and heavy minerals; trace mica; 25 percent intergrain porosity; low to moderate hydraulic conductivity; minor clay matrix
155.0-156.0	No recovery
156.0-160.1	Quartz sand; yellowish gray 5Y 8/1; mainly medium to coarse quartz sand and minor fine and very coarse quartz sand; moderately sorted quartz sand; 1-2 percent phosphorite and heavy minerals; trace mica; 25 percent intergrain porosity; low to moderate hydraulic conductivity; minor clay matrix
160.1-161.0	No recovery
161.0-165.3	Quartz sand; yellowish gray 5Y 8/1; mainly medium to coarse quartz sand and minor fine and very coarse quartz sand; moderately sorted quartz sand; 1-2 percent phosphorite and heavy minerals; trace mica; 25 percent intergrain porosity; low to moderate hydraulic conductivity; minor clay matrix
165.3-166.0	No recovery
166.0-167.0	Quartz sand; yellowish gray 5Y 8/1; mainly medium to coarse quartz sand and minor fine and very coarse quartz sand; moderately sorted quartz sand; 1-2 percent phosphorite and heavy minerals; trace mica; 25 percent intergrain porosity; low to moderate hydraulic conductivity; minor clay matrix
167.0-170.5	Quartz sand; yellowish gray 5Y 8/1; mainly fine to medium quartz sand and minor very fine and coarse to very coarse quartz sand; moderately sorted quartz sand; 1-2 percent phosphorite and heavy minerals; 25 percent intergrain porosity; low to moderate hydraulic conductivity; minor clay matrix
170.5-171.0	No recovery
171.0-173.7	Quartz sand; yellowish gray 5Y 8/1 to very light gray N8; mainly fine quartz sand and minor very fine and medium quartz sand; well sorted quartz sand; 2-5 percent phosphorite and heavy minerals; trace mica; 30 percent intergrain porosity; moderate hydraulic conductivity; friable; trace clay matrix; bioturbated
173.7-176.0	No recovery
176.0-180.8	Quartz sand; light olive gray 5Y 6/1; mainly very fine to fine quartz sand and minor medium to coarse quartz sand; well sorted quartz sand; 5 percent phosphorite and heavy minerals; trace mica; 20-25 percent intergrain porosity; low hydraulic conductivity; friable; trace clay matrix; bioturbated
180.8-181.0	No recovery
181.0-190.7	Quartz sand; light olive gray 5Y 6/1; mainly very fine to fine quartz sand and minor medium to coarse quartz sand; well sorted quartz sand; 5 percent phosphorite and heavy minerals; trace mica; 20-25 percent intergrain porosity; low hydraulic conductivity; friable; trace clay matrix; bioturbated
190.7-191.0	No recovery
191.0-210.7	Quartz sand; light olive gray 5Y 6/1; mainly very fine to fine quartz sand and minor medium quartz sand; well sorted quartz sand; 5 percent phosphorite and heavy minerals; trace mica; 20-25 percent intergrain porosity; low hydraulic conductivity; friable; trace clay matrix; bioturbated
210.7-211.0	No recovery
211.0-220.4	Quartz sand; light olive gray 5Y 6/1; mainly very fine to fine quartz sand and minor medium quartz sand; well sorted quartz sand; 5 percent phosphorite and heavy minerals; trace mica; 20-25 percent intergrain porosity; low hydraulic conductivity; friable; trace clay matrix; bioturbated
220.4-221.0	No recovery
221.0-225.7	Quartz sand; light olive gray 5Y 6/1; mainly very fine to fine quartz sand and minor medium quartz sand; well sorted quartz sand; 5 percent phosphorite and heavy minerals; trace mica; 20-25 percent intergrain porosity; low hydraulic conductivity; friable; trace clay matrix; bioturbated
225.7-226.0	No recovery

Depth (feet below land surface)	Lithologic description of GL-327 test corehole
226.0-255.6	Quartz sand; yellowish gray 5Y 8/1; mainly very fine to fine quartz sand and trace medium quartz sand; well sorted quartz sand; 5-10 percent phosphorite and heavy minerals; trace mica; 20 percent intergrain porosity; low hydraulic conductivity; friable; trace to minor clay matrix; bioturbated
255.6-256.0	No recovery
256.0-265.5	Quartz sand; yellowish gray 5Y 8/1; mainly very fine to fine quartz sand and trace medium quartz sand; well sorted quartz sand; 5-10 percent phosphorite and heavy minerals; trace mica; 20 percent intergrain porosity; low hydraulic conductivity; friable; trace to minor clay matrix; bioturbated
265.5-266.0	No recovery
266.0-270.8	Quartz sand; yellowish gray 5Y 8/1; mainly very fine to fine quartz sand and trace medium quartz sand; well sorted quartz sand; 5-10 percent phosphorite and heavy minerals; trace mica; 20 percent intergrain porosity; low hydraulic conductivity; friable; trace to minor clay matrix; bioturbated
270.8-271.0	No recovery
271.0-275.7	Quartz sand; yellowish gray 5Y 8/1; mainly very fine to fine quartz sand and trace medium quartz sand; well sorted quartz sand; 5-10 percent phosphorite and heavy minerals; trace mica; 20 percent intergrain porosity; low hydraulic conductivity; friable; trace to minor clay matrix; bioturbated
275.7-276.0	No recovery
276.0-280.1	Quartz sand; yellowish gray 5Y 8/1; mainly very fine to fine quartz sand and trace medium quartz sand; well sorted quartz sand; 5-10 percent phosphorite and heavy minerals; trace mica; 20 percent intergrain porosity; low hydraulic conductivity; friable; trace to minor clay matrix; bioturbated
280.1-290.4	Quartz sand; yellowish gray sand 5Y 8/1 and light olive gray 5Y 6/1 clay laminations; mainly very fine to fine quartz sand and trace medium quartz sand; well sorted quartz sand; 20 percent intergrain porosity; low hydraulic conductivity; friable; trace clay matrix; bioturbated; uncommon thick laminations (0.25-1.0 inch thick)
290.4-291.0	No recovery
291.0-300.5	Quartz sand; yellowish gray sand 5Y 8/1 and light olive gray 5Y 6/1 clay laminations; mainly very fine to fine quartz sand and trace medium quartz sand; well sorted quartz sand; 20 percent intergrain porosity; low hydraulic conductivity; friable; trace clay matrix; bioturbated; uncommon thick laminations (0.25-1.0 inch thick)
300.5-301.0	No recovery
301.0-305.8	Quartz sand; yellowish gray sand 5Y 8/1 and light olive gray 5Y 6/1 clay laminations; mainly very fine to fine quartz sand and trace medium quartz sand; well sorted quartz sand; 20 percent intergrain porosity; low hydraulic conductivity; friable; trace clay matrix; bioturbated; uncommon thick laminations (0.25-1.0 inch thick)
305.8-306.0	No recovery
306.0-310.6	Quartz sand; yellowish gray sand 5Y 8/1 and light olive gray 5Y 6/1 clay laminations; mainly very fine to fine quartz sand and trace medium quartz sand; well sorted quartz sand; 20 percent intergrain porosity; low hydraulic conductivity; friable; trace clay matrix; bioturbated; uncommon thick laminations (0.25-1.0 inch thick)
310.6-311.0	No recovery
311.0-315.0	Quartz sand; yellowish gray sand 5Y 8/1 and light olive gray 5Y 6/1 clay laminations; mainly very fine to fine quartz sand and trace medium quartz sand; well sorted quartz sand; 20 percent intergrain porosity; low hydraulic conductivity; friable; trace clay matrix; bioturbated; uncommon thick laminations (0.25-1.0 inch thick)
315.0-316.0	No recovery
316.0-317.8	Quartz sand; yellowish gray sand 5Y 8/1 and light olive gray 5Y 6/1 clay laminations; mainly very fine to fine quartz sand and trace medium quartz sand; well sorted quartz sand; 20 percent intergrain porosity; low hydraulic conductivity; friable; trace clay matrix; bioturbated; uncommon thick laminations (0.25-1.0 inch thick)

Depth (feet below land surface)	Lithologic description of GL-327 test corehole
317.8-320.9	Quartz sand; yellowish gray sand 5Y 8/1 and light olive gray 5Y 6/1 clay laminations; mainly fine quartz sand, minor very fine and trace medium quartz sand; well sorted quartz sand; 20 percent intergrain porosity; low hydraulic conductivity; friable; trace clay matrix; bioturbated; uncommon thick laminations (0.25-1.0 inch thick)
320.9-321.0	No recovery
321.0-324.6	Quartz sand with clay interlaminations and interbeds; yellowish gray sand 5Y 8/1 and light olive gray 5Y 6/1 clay laminations and beds; varying from mainly fine to medium quartz sand with minor very fine and coarse quartz sand to mainly medium to coarse quartz sand with minor very fine to medium quartz sand; moderate to well sorted quartz sand; 20 percent intergrain porosity in coarse quartz sand; coarser cycle top moderate and finer cycle base low; friable quartz sand; trace clay matrix; bioturbated; cyclic l- to 6-foot thick coarsening upward cycles; clay laminations within cycles thin upwards; thinly laminated to medium bedded in part (0.25 to 6 inches thick)
324.6-326.0	No recovery
326.0-328.6	Quartz sand with clay interlaminations and interbeds; yellowish gray sand 5Y 8/1 and light olive gray 5Y 6/1 clay laminations and beds; varying from mainly fine to medium quartz sand with minor very fine and coarse quartz sand to mainly medium to coarse quartz sand with minor very fine to medium quartz sand; moderate to well sorted quartz sand; 20 percent intergrain porosity in coarse quartz sand; coarser cycle top moderate and finer cycle base low; friable quartz sand; trace clay matrix; bioturbated; cyclic 1- to 6 foot thick coarsening upward cycles; clay laminations within cycles thin upwards; thinly laminated to medium bedded in part (0.25 to 6 inches thick)
328.6-331.0	No recovery
331.0-335.0	Quartz sand with clay interlaminations and interbeds; yellowish gray sand 5Y 8/1 and light olive gray 5Y 6/1 clay laminations and beds; varying from mainly fine to medium quartz sand with minor very fine and coarse quartz sand to mainly medium to coarse quartz sand with minor very fine to medium quartz sand; moderate to well sorted quartz sand; 20 percent intergrain porosity in coarse quartz sand; coarser cycle top moderate and finer cycle base low; friable quartz sand; trace clay matrix; bioturbated; cyclic 1- to 6-foot thick coarsening upward cycles; clay laminations within cycles thin upwards; thinly laminated to medium bedded in part (0.25 to 6 inches thick)
335.0-336.0	No recovery
336.0-339.8	Quartz sand with clay interlaminations and interbeds; yellowish gray sand 5Y 8/1 and light olive gray 5Y 6/1 clay laminations and beds; varying from mainly fine to medium quartz sand with minor very fine and coarse quartz sand to mainly medium to coarse quartz sand with minor very fine to medium quartz sand; immoderate to well sorted quartz sand; 20 percent intergrain porosity in coarse quartz sand; coarser cycle top moderate and finer cycle base low; friable quartz sand; trace clay matrix; bioturbated; cyclic 1- to 6-foot thick coarsening upward cycles; clay laminations within cycles thin upwards; thinly laminated to medium bedded in part (0.25 to 6 inches thick)
339.8-341.0	No recovery
341.0-342.5	Quartz sand with clay interlaminations and interbeds; yellowish gray sand 5Y 8/1 and light olive gray 5Y 6/1 clay laminations and beds; varying from mainly fine to medium quartz sand with minor very fine and coarse quartz sand to mainly medium to coarse quartz sand with minor very fine to medium quartz sand; moderate to well sorted quartz sand; 20 percent intergrain porosity in coarse quartz sand; coarser cycle top moderate and finer cycle base low; friable quartz sand; trace clay matrix; bioturbated; cyclic 1- to 6-foot thick coarsening upward cycles; clay laminations within cycles thin upwards; thinly laminated to medium bedded in part (0.25 to 6 inches thick)
342.5-345.0	No recovery
345.0-348.6	Quartz sand with clay interlaminations and interbeds; yellowish gray sand 5Y 8/1 and light olive gray 5Y 6/1 clay laminations and beds; varying from mainly fine to medium quartz sand with minor very fine and coarse quartz sand to mainly medium to coarse quartz sand with minor very fine to medium quartz sand; moderate to well sorted quartz sand; 20 percent intergrain porosity in coarse quartz sand; coarse- cycle top moderate and finer cycle base low; friable quartz sand; trace clay matrix; bioturbated; cyclic l- to 6 foot thick coarsening upward cycles; clay laminations within cycles thin upwards; thinly laminated to medium bedded in part (0.25 to 6 inches thick)
348.6-350.0	No recovery

Depth (feet below land surface)	Lithologic description of GL-327 test corehole
350.0-354.1	Quartz sand with clay interlaminations and interbeds; yellowish gray sand 5Y 8/1 and light olive gray 5Y 6/1 clay laminations and beds; varying from mainly fine to medium quartz sand with minor very fine and coarse quartz sand to mainly medium to coarse quartz sand with minor very fine to medium quartz sand; moderate to well sorted quartz sand; 20 percent intergrain porosity in coarse quartz sand; coarser cycle top moderate and finer cycle base low; friable quartz sand; trace clay matrix; bioturbated; cyclic 1-to 6-foot thick coarsening upward cycles; clay laminations within cycles thin upwards; thinly laminated to medium bedded in part (0.25 to 6 inches thick)
354.1-355.0	No recovery
355.0-357.9	Quartz sand with clay interlaminations and interbeds; yellowish gray sand 5Y 8/1 and light olive gray 5Y 6/1 clay laminations and beds; varying from mainly fine to medium quartz sand with minor very fine and coarse quartz sand to mainly medium to coarse quartz sand with minor very fine to medium quartz sand; moderate to well sorted quartz sand; 20 percent intergrain porosity in coarse quartz sand; coarser cycle top moderate and finer cycle base low; friable quartz sand; trace clay matrix; bioturbated; cyclic 1- to 6-foot thick coarsening upward cycles; clay laminations within cycles thin upwards; thinly laminated to medium bedded in part (0.25 to 6 inches thick)
357.9-361.0	No recovery
361.0-364.4	Quartz sand with clay interlaminations and interbeds; yellowish gray sand 5Y 8/1 and light olive gray 5Y 6/1 clay laminations and beds; varying from mainly fine to medium quartz sand with minor very fine and coarse quartz sand to mainly medium to coarse quartz sand with minor very fine to medium quartz sand; moderate to well sorted quartz sand; 20 percent intergrain porosity in coarse quartz sand; coarser cycle top moderate and finer cycle base low; friable quartz sand; trace clay matrix; bioturbated; cyclic 1- to 6-foot thick coarsening upward cycles; clay laminations within cycles thin upwards; thinly laminated to medium bedded in part (0.25 to 6 inches thick)
364.4-366.0	No recovery
366.0-367.6	Quartz sand with clay interlaminations and interbeds; yellowish gray sand 5Y 8/1 and light olive gray 5Y 6/1 clay laminations and beds; varying from mainly fine to medium quartz sand with minor very fine and coarse quartz sand to mainly medium to coarse quartz sand with minor very fine to medium quartz sand; moderate to well sorted quartz sand; 20 percent intergrain porosity in coarse quartz sand; coarser cycle top moderate and finer cycle base low; friable quartz sand; trace clay matrix; bioturbated; cyclic 1- to 6-foot thick coarsening upward cycles; clay laminations within cycles thin upwards; thinly laminated to medium bedded in part (0.25 to 6 inches thick)
367.6-371.0	No recovery
371.0-375.5	Quartz sand with clay interlaminations and interbeds; yellowish gray sand 5Y 8/1 and light olive gray 5Y 6/1 clay laminations and beds; varying from mainly fine to medium quartz sand with minor very fine and coarse quartz sand to mainly medium to coarse quartz sand with minor very fine to medium quartz sand; moderate to well sorted quartz sand; 20 percent intergrain porosity in coarse quartz sand; coarser cycle top moderate and finer cycle base low; friable quartz sand; trace clay matrix; bioturbated; cyclic 1- to 6-foot thick coarsening upward cycles; clay laminations within cycles thin upwards; thinly laminated to medium bedded in part (0.25 to 6 inches thick)
375.5-376.0	No recovery
376.0-377.7	Interlaminated mudstone and quartz sand; light olive gray 5Y 6/1 quartz sand and light olive gray 5Y 6/1 to olive gray 5Y 4/1clay laminations and beds; mainly clay and medium to small pebble-sized quartz sand; very low to low hydraulic conductivity;
377.7-381.0	No recovery
381.0-384.6	Interlaminated mudstone and quartz sand; light olive gray 5Y 6/1 quartz sand and light olive gray 5Y 6/1 to olive gray 5Y 4/1clay laminations and beds; mainly clay and medium to small pebble-sized quartz sand; very low to low hydraulic conductivity;
384.6-385.1	Quartz sandstone; yellowish gray sand 5Y 8/1 and light olive gray 5Y 6/1 clay laminations and beds; mainly fine to medium quartz sand and minor very fine quartz sand; well sorted quartz sand; low hydraulic conductivity; hard; well cemented; possible unconformity at 384.6 feet
385.1-424.5	No recovery (probably unconsolidated sand based on gamma ray)

Depth (feet below land surface)	Lithologic description of GL-327 test corehole
424.5-424.7	Quartz sandstone; yellowish gray sand 5Y 8/1 and light olive gray 5Y 6/1 clay laminations and beds; mainly fine to medium quartz sand and minor very fine and coarse to small pebble-sized quartz sand; well sorted quartz sand; low hydraulic conductivity; hard; well cemented with lime mudstone matrix; possible unconformity at 384.6 feet
424.7-430.5	Interlaminated mudstone and quartz sand; light olive gray 5Y 6/1 quartz sand and olive gray 5Y 4/1clay laminations and beds; mainly clay and very fine quartz sand; very low hydraulic conductivity; bioturbated; clay matrix; abrupt contact or unconformity at 424.7 feet
430.5-435.4	Quartz sand with clay matrix; light olive gray 5Y 6/1 quartz sand and olive gray 5Y 4/l clay laminations and beds; mainly fine to coarse quartz sand and minor very coarse quartz sand; very low hydraulic conductivity; bioturbated; clay matrix
435.4-436.0	No recovery
436.0-446.5	Quartz sand; light olive gray 5Y 6/1 quartz sand and olive gray 5Y 4/1clay laminations and beds; mainly very fine to very coarse quartz sand and minor very coarse quartz sand; 20 percent phosphorite and heavy minerals; low hydraulic conductivity; bioturbated; trace to abundant clay matrix; fuming upward cycle and thicken upward of clay laminations from 446.5 to 424.7 feet
446.5-453.7	Mudstone; olive gray 5Y 4/1; very low hydraulic conductivity; high-angle slickensides; possible unconformity at 446.5 suggested by apparent abrupt contact and sharp decrease in gamma ray
453.7-454.0	No recovery

GL-329 Test Corehole

FGS well number	W-18075
GWSI number	GL-329
Total depth	431 feet
Cored from	0 to 431 feet
County	Glades
Location	SW, SW, sec. 25, T42S, R31E
Latitude	26° 47′ 7.4″
Longitude	081° 11′ 13.5″
Elevation	34 feet
Completion date	June 12, 2000
Other types of logs available	None
Owner	USGS
Driller	FGS
Core described by	Kevin J. Cunningham
Fill	0 to 17 feet
Undifferentiated	17 to 29 feet
Tamiami Formation	29 to 153.3 feet
Upper Peace River Formation	153.3 to 393.4 feet
Lower Peace River Formation(?)	393.4 to 431 feet
Water-table aquifer	0 to 69.6 feet
Tamiami confining zone	69.6 to 93.2 feet
Lower Tamiami aquifer	93.2 to 206 feet

Depth (feet below land surface)	Lithologic description of GL-329 test corehole
0.0-17.0	Fill
17.0-17.1	Peat; black N1; low hydraulic conductivity
17.1-17.4	Quartz sand; brownish gray 5YR 4/1; mainly very fine to fine quartz sand; well sorted quartz sand; 25 percent intergrain porosity; moderate hydraulic conductivity; minor organics in matrix
17.4-22.0	No recovery
22.0-24.0	Quartz sand; brownish gray 5YR 4/1; mainly very fine to medium quartz sand; well sorted quartz sand; 20 percent intergrain porosity; moderate hydraulic conductivity; abundant dark organic material in matrix
24.0-24.7	Unconsolidated pelecypod and gastropod lime rudstone and quartz sand matrix; brownish gray 5YR 4/1; mainly very fine to medium quartz sand; minor to very large pebble-sized fossils; well sorted quartz sand; very poorly sorted fossils and sand; 20 percent intergrain porosity; moderate hydraulic conductivity; one sample of hard limestone contains laminated calcrete filling voids indicating a possible exposure surface in interval
24.7-28.0	No recovery
28.0-28.5	Pelecypod lime rudstone with chalky lime packstone and grainstone matrix; very pale orange 10YR 8/2; mainly coarse to medium pebble-sized pelecypods; moderate hydraulic conductivity
28.5-29.0	Quartz sand; pale yellowish brown 10YR 6/2; mainly very fine to medium quartz sand; minor coarse quartz sand and coarse to medium pebble-sized pelecypods; moderately sorted quartz sand; 25 percent intergrain porosity; moderate hydraulic conductivity; minor broken pelecypod shells
29.0-30.2	Quartz sand; very light gray N8; mainly fine to medium quartz sand; minor very fine and coarse to very coarse quartz sand and very coarse to granule-sized pelecypods; trace medium pebble-sized pelecypods; moderately sorted quartz sand; 25 percent intergrain porosity; moderate hydraulic conductivity; 20-30 percent broken pelecypod shells
30.2-32.5	No recovery
32.5-32.6	Quartz sand; very light gray N8; mainly fine to medium quartz sand; minor very fine and coarse to very coarse quartz sand and very coarse to granule-sized pelecypods; trace medium pebble-sized pelecypods; moderately sorted quartz sand; 25 percent intergrain porosity; moderate hydraulic conductivity; 20-30 percent broken pelecypod shells
32.6-36.0	No recovery
36.0-36.3	Rubble of loose pelecypod and gastropod shells up to large pebble size and one large pebble composed of laminated calcrete, possible exposure surface in interval
36.3-41.0	No recovery
41.0-42.8	Unconsolidated pelecypod lime rudstone with quartz sand matrix; light gray N7; mainly fine to medium quartz sand; minor very fine and coarse quartz sand and coarse to granule-sized fossils; well sorted quartz sand; poorly sorted fossils and sand; pelecypods, gastropods and barnacles; 20 percent intergrain porosity; moderate hydraulic conductivity
42.8-46.0	No recovery
46.0-46.9	Unconsolidated pelecypod lime rudstone with quartz sand matrix; light gray N7; mainly fine to medium quartz sand; minor very fine and coarse quartz sand and coarse to granule-sized fossils; well sorted quartz sand; poorly sorted fossils and sand; pelecypods, gastropods and barnacles; 20 percent intergrain porosity; moderate hydraulic conductivity
46.9-51.0	No recovery
51.0-54.3	Quartz sand with abundant broken pelecypod shells; light gray N7; mainly fine to medium quartz sand; minor very fine and coarse quartz sand and coarse to granule-sized fossils; well sorted quartz sand; poorly sorted fossils and sand; 20 percent intergrain porosity; moderate hydraulic conductivity
54.3-56.0	No recovery

Depth (feet below land surface)	Lithologic description of GL-329 test corehole
56.0-58.0	Quartz sand with abundant broken pelecypod shells; very pale orange 10YR 8/2; mainly fine to medium quartz sand; minor very fine quartz sand and coarse to granule-sized fossils; well sorted quartz sand; poorly sorted fossils and sand; pelecypods, gastropods and barnacles; 30 percent intergrain porosity; moderate hydraulic conductivity
58.0-61.0	No recovery
61.0-64.5	Quartz sand with abundant broken pelecypod shells; yellowish gray 5Y 8/1; mainly fine quartz sand; minor very fine and medium quartz sand and coarse to granule-sized
81.3-86.0	No recovery
86.0-93.2	Quartz sand with abundant broken pelecypod shells; yellowish gray 5Y 8/1; mainly medium quartz sand; minor very fine to fine and coarse quartz sand; minor very coarse to granule-sized fossils; well sorted quartz sand; poorly sorted quartz sand and shells; 40-50 percent pelecypods, bryozoans, barnacles, gastropods, serpulid tubes; 25 percent intergrain porosity; moderate hydraulic conductivity
93.2-96.0	No recovery
96.0-96.7	Quartz sand with abundant broken pelecypod shells; yellowish gray 5Y 8/1; mainly medium quartz sand; minor very fine to fine and coarse quartz sand; minor very coarse to granule-sized fossils; well sorted quartz sand; poorly sorted quartz sand and shells; 40-50 percent pelecypods, bryozoans, barnacles, gastropods, serpulid tubes; 25 percent intergrain porosity; moderate hydraulic conductivity
96.7-101.0	No recovery
101.0-102.3	Quartz sand with abundant broken pelecypod shells; yellowish gray 5Y 8/1; mainly medium to coarse quartz sand; minor very fine to fine quartz sand; minor very coarse to granule-sized fossils; well sorted quartz sand; poorly sorted quartz sand and shells; 40-50 percent pelecypods, bryozoans, barnacles, gastropods, serpulid tubes; 25 percent intergrain porosity; moderate hydraulic conductivity
102.3-102.5	Quartz sand with abundant broken pelecypod shells and clay matrix and quartz sandstone; yellowish gray 5Y 8/1 and medium gray N5 sandstone; mainly medium to coarse quartz sand; minor very fine to fine quartz sand; minor very coarse to granule-sized fossils; minor very fine to medium quartz sandstone; well sorted quartz sand; poorly sorted quartz sand and shells; 40-50 percent pelecypods, bryozoans, barnacles, gastropods, serpulid tubes; sand 25 percent intergrain porosity and sandstone 10 percent intergrain and moldic porosity; low hydraulic conductivity; clay matrix in sand; well-cemented, hard quartz sandstone; sandstone is broken into fragments probably by drilling
102.5-106.0	No recovery
106.0-110.3	Quartz sand and quartz sandstone with broken pelecypod shells; yellowish gray 5Y 8/1 and medium gray N5 sandstone; mainly fine to medium quartz sand and sandstone; minor fine and coarse quartz sand and sandstone; minor very coarse to granule-sized fossils; moderately to well sorted quartz sand and sandstone; poorly sorted quartz sand and shells; 30-40 percent pelecypods; low hydraulic conductivity; minor clay matrix in sand; hard quartz sandstone with a lime mudstone matrix; sandstone is broken into fragments probably by drilling
110.3-111.0	No recovery
111.0-112.5	Quartz sand; yellowish gray 5Y 8/1; mainly fine to very coarse quartz sand; minor very fine and granule quartz sand; minor medium sand- to small pebble-sized phosphorite grains; poor to moderately sorted quartz sand; poorly sorted quartz sand and shells; 10-25 percent pelecypods, barnacles, gastropods; 5 percent phosphorite and heavy minerals; 25 percent intergrain porosity; moderate hydraulic conductivity
112.5-122.0	Quartz sand; yellowish gray 5Y 8/1; mainly fine to coarse quartz sand; minor very fine and very coarse quartz sand; minor medium to very coarse phosphorite grains; moderately sorted quartz sand; trace to 5 percent pelecypods, barnacles, gastropods; 5 percent phosphorite and heavy minerals; 25 percent intergrain porosity; moderate hydraulic conductivity
122.0-130.5	Quartz sand; yellowish gray 5Y 8/1; mainly fine sand; minor very fine and medium to very coarse quartz sand; minor medium to very coarse phosphorite grains; moderately to well sorted quartz sand; 5 percent phosphorite and heavy minerals; 25 percent intergrain porosity; low to moderate hydraulic conductivity
130.5-131.0	No recovery

Depth (feet below land surface)	Lithologic description of GL-329 test corehole
131-131.9	Quartz sand; yellowish gray 5Y 8/1; mainly very fine sand; minor very fine and trace medium to coarse quartz sand; minor medium to coarse phosphorite grains; moderately to well sorted quartz sand; 5 percent phosphorite and heavy minerals; 25 percent intergrain porosity; moderate hydraulic conductivity
131.9-133.8	Quartz sand and sandstone; yellowish gray 5Y 8/1; mainly fine to coarse sand; minor very fine and very coarse to granule-sized quartz sand; minor medium to coarse phosphorite grains; poorly to moderately sorted quartz sand; 5 percent phosphorite and heavy minerals; minor pelecypods in sandstone
133.8-136.0	No recovery
136.0-141.0	Quartz sand and sandstone; yellowish gray 5Y 8/1; mainly fine to coarse sand; minor very fine and very coarse to granule-sized quartz sand; minor medium to coarse phosphorite grains; poorly to moderately sorted quartz sand; minor pelecypods in sandstone 5 percent phosphorite and heavy minerals; abundant pelecypods (including oysters); sand 25 percent intergrain porosity and sandstone 10 percent intergrain and moldic porosity; sandstone low hydraulic conductivity and sand moderate hydraulic conductivity; friable quartz sand; well-cemented, hard sandstone
141.0-142.5	Quartz sandstone; yellowish gray 5Y 8/1; mainly fine to coarse sand; minor very fine and very coarse to granule-sized quartz sand; moderately sorted quartz sandstone; 10 percent intergrain and moldic porosity; low hydraulic conductivity; well-cemented, hard sandstone
142.5-143.0	Quartz sand; yellowish gray 5Y 8/1; mainly medium to very coarse sand; minor very fine to fine and granule-sized quartz sand; minor medium to very coarse phosphorite grains; moderately sorted quartz sand; 5 percent phosphorite and heavy minerals; minor broken pelecypod shells; 25 percent intergrain porosity; moderate hydraulic conductivity; friable
143.0-146.0	No recovery
146.0-149.7	Quartz sand and minor quartz sandstone; yellowish gray 5Y 8/1; mainly medium to very coarse sand and sandstone; minor very fine to fine and granule-sized quartz sand and sandstone; minor medium to very coarse phosphorite grains; moderately sorted quartz sand and sandstone; 5 percent phosphorite and heavy minerals; minor broken pelecypod shells; sand 25 percent intergrain porosity and sandstone intergrain and moldic porosity; sand moderate hydraulic conductivity and sandstone low hydraulic conductivity; friable quartz sand; well-cemented, hard sandstone
149.7-151.0	No recovery
151.0-153.15	Quartz sand; yellowish gray 5Y 8/1; mainly coarse to very coarse sand; minor very fine to medium and granule-size quartz sand; minor medium to very coarse phosphorite grains; moderately sorted quartz sand; 5 percent phosphorite and heavy minerals; minor broken pelecypod shells; 25 percent intergrain porosity; moderate hydraulic conductivity; friable
153.15-153.3	Unconsolidated quartz sand-rich, foraminifera lime grainstone; very pale orange 10YR 8/2; minor very fine to fine quartz sand; well sorted quartz sand; minor mica; 25 percent intergrain porosity; low to moderate hydraulic conductivity; friable; abrupt contact above and below
153.3-154.2	Quartz sand; yellowish gray 5Y 8/1; mainly fine to coarse sand; minor very fine and very coarse to granule-size quartz sand; minor very fine to granule-size phosphorite grains; moderately sorted quartz sand; 5-10 percent phosphorite and heavy minerals; 25 percent intergrain porosity; moderate hydraulic conductivity; friable; chalky cement matrix in uppermost 2 inches possibly related to an unconformity
154.2-156.0	No recovery
156.0-162.3	Quartz sand; very light gray N8; mainly very fine to coarse sand; minor very coarse to granule-sized quartz sand; poorly to moderately sorted quartz sand; 25 percent intergrain porosity; low to moderate hydraulic conductivity; friable
162.3-163.9	Quartz sand with pelecypods; very light gray N8; mainly very fine to coarse sand; minor very coarse to granule-sized quartz sand; poorly to moderately sorted quartz sand; abundant large pelecypods; 25 percent intergrain porosity; low to moderate hydraulic conductivity; friable
163.9-165.3	Quartz sand; very light gray N8; mainly very fine to coarse sand; minor very coarse to granule-sized quartz sand; poorly to moderately sorted quartz sand; 25 percent intergrain porosity; low to moderate hydraulic conductivity; friable
165.3-166.0	No recovery

Depth (feet below land surface)	Lithologic description of GL-329 test corehole
166.0-169.3	Quartz sand; very light gray N8; mainly very fine to coarse sand; minor very coarse to granule-sized quartz sand; poorly to moderately sorted quartz sand; 25 percent intergrain porosity; low to moderate hydraulic conductivity; friable
169.3-171.0	No recovery
171.0-177.0	Quartz sand; very light gray N8; mainly very fine to coarse sand; minor very coarse to granule-sized quartz sand; poorly to moderately sorted quartz sand; 25 percent intergrain porosity; low to moderate hydraulic conductivity; friable
177.0-178.0	No recovery
178.0-185.0	Quartz sand; very light gray N8; mainly very fine to coarse sand; minor very coarse to granule-sized quartz sand; poorly to moderately sorted quartz sand; 25 percent intergrain porosity; low to moderate hydraulic conductivity; friable
185.0-186.0	No recovery
186.0-187.5	Quartz sand; very light gray N8; mainly very fine to coarse sand; minor very coarse to granule-sized quartz sand; poorly to moderately sorted quartz sand; 25 percent intergrain porosity; low to moderate hydraulic conductivity; friable
187.5-190.0	No recovery
190.0-192.0	Quartz sand; very light gray N8; mainly very fine to coarse sand; minor very coarse to granule-sized quartz sand; poorly to moderately sorted quartz sand; 25 percent intergrain porosity; low to moderate hydraulic conductivity; friable
192.0-195.0	No recovery
195.0-195.1	Rubble of sandstone
195.1-200.0	No recovery
200.0-204.3	Quartz sand; very light gray N8; mainly very fine to coarse sand; minor very coarse to granule-sized quartz sand; poorly to moderately sorted quartz sand; 25 percent intergrain porosity; low to moderate hydraulic conductivity; friable
204.3-206.0	No recovery
206.0-206.1	Quartz sandstone; very light gray N8; mainly medium to coarse sand; minor fine and very coarse sized quartz sand; poorly to moderately sorted quartz sand; 10 percent intergrain porosity; low hydraulic conductivity; hard, well-cemented sandstone; possible unconformity at top
206.1-210.3	Quartz sand with minor clay laminations; yellowish gray 5Y 8/1 sand and light olive gray 5Y 6/1 clay laminations; varying from mainly fine to medium quartz sand with minor very fine and coarse quartz sand to mainly very fine to coarse quartz sand; moderately sorted quartz sand; 20-25 percent intergrain porosity in coarse quartz sand; coarser lower cycle moderate hydraulic conductivity and finer upper cycle low hydraulic conductivity; friable quartz sand; trace clay matrix; cyclic 1- to 5-foot thick fining upward cycles; clay laminations within cycles thicken and increase in abundance upwards
210.3-212.0	No recovery
212.0-218.0	Quartz sand with minor clay laminations; yellowish gray 5Y 8/1 sand and light olive gray 5Y 6/1 clay laminations; varying from mainly fine to medium quartz sand with minor very fine and coarse quartz sand to mainly very fine to coarse quartz sand; moderately sorted quartz sand; 20-25 percent intergrain porosity in coarse quartz sand; coarser lower cycle moderate hydraulic conductivity and finer upper cycle low hydraulic conductivity; friable quartz sand; trace clay matrix; cyclic 1- to 5-foot thick fining upward cycles; clay laminations within cycles thicken and increase in abundance upwards
218.0-220.0	No recovery
220.0-224.0	Quartz sand with minor clay laminations; yellowish gray 5Y 8/1 sand and light olive gray 5Y 6/1 clay laminations; varying from mainly fine to medium quartz sand with minor very fine and coarse quartz sand to mainly very fine to coarse quartz sand; moderately sorted quartz sand; 20-25 percent intergrain porosity in coarse quartz sand; coarser lower cycle moderate hydraulic conductivity and finer upper cycle low hydraulic conductivity; friable quartz sand; trace clay matrix; cyclic 1- to 5-foot thick fining upward cycles; clay laminations within cycles thicken and increase in abundance upwards
224.0-226.0	No recovery

Depth (feet below land surface)	Lithologic description of GL-329 test corehole
226.0-230.0	Quartz sand with minor clay laminations; yellowish gray 5Y 8/1 sand and light olive gray 5Y 6/1 clay laminations; varying from mainly fine to medium quartz sand with minor very fine and coarse quartz sand to mainly very fine to coarse quartz sand; moderately sorted quartz sand; 20-25 percent intergrain porosity in coarse quartz sand; coarser lower cycle moderate hydraulic conductivity and finer upper cycle low hydraulic conductivity; friable quartz sand; trace clay matrix; cyclic 1- to 5-foot thick fining upward cycles; clay laminations within cycles thicken and increase in abundance upwards
230.0-234.0	No recovery
234.0-239.5	Quartz sand with minor clay laminations; yellowish gray 5Y 8/1 sand and light olive gray 5Y 6/1 clay laminations; varying from mainly fine to medium quartz sand with minor very fine and coarse quartz sand to mainly very fine to coarse quartz sand; moderately sorted quartz sand; 20-25 percent intergrain porosity in coarse quartz sand; coarser lower cycle moderate hydraulic conductivity and finer upper cycle low hydraulic conductivity; friable quartz sand; trace clay matrix; cyclic 1-to-5 foot thick fining upward cycles; clay laminations within cycles thicken and increase in abundance upwards
239.5-241.0	No recovery
241.0-245.4	Quartz sand with minor clay laminations; yellowish gray 5Y 8/1 sand and light olive gray 5Y 6/1 clay laminations; varying from mainly fine to medium quartz sand with minor very fine and coarse quartz sand to mainly very fine to coarse quartz sand; moderately sorted quartz sand; 20-25 percent intergrain porosity in coarse quartz sand; coarser lower cycle moderate hydraulic conductivity and finer upper cycle low hydraulic conductivity; friable quartz sand; trace clay matrix; cyclic 1- to 5-foot thick fining upward cycles; clay laminations within cycles thicken and increase in abundance upwards
245.4-251.0	No recovery
251.0-251.6	Quartz sand with minor clay laminations; yellowish gray 5Y 8/1 sand and light olive gray 5Y 6/1 clay laminations; varying from mainly fine to medium quartz sand with minor very fine and coarse quartz sand to mainly very fine to coarse quartz sand; moderately sorted quartz sand; 20-25 percent intergrain porosity in coarse quartz sand; coarser lower cycle moderate hydraulic conductivity and finer upper cycle low hydraulic conductivity; friable quartz sand; trace clay matrix; cyclic 1- to 5-foot thick fining upward cycles; clay laminations within cycles thicken and increase in abundance upwards
251.6-255.0	No recovery
255.0-256.7	Quartz sand with minor clay laminations; yellowish gray 5Y 8/1 sand and light olive gray 5Y 6/1 clay laminations; varying from mainly fine to medium quartz sand with minor very fine and coarse quartz sand to mainly very fine to coarse quartz sand; moderately sorted quartz sand; 20-25 percent intergrain porosity in coarse quartz sand; coarser lower cycle moderate hydraulic conductivity and finer upper cycle low hydraulic conductivity; friable quartz sand; trace clay matrix; cyclic 1- to 5-foot thick fining upward cycles; clay laminations within cycles thicken and increase in abundance upwards
256.7-260.0	No recovery
260.0-262.7	Quartz sand with minor clay laminations; yellowish gray 5Y 8/1 sand and light olive gray 5Y 6/1 clay laminations; varying from mainly fine to medium quartz sand with minor very fine and coarse quartz sand to mainly very fine to coarse quartz sand; moderately sorted quartz sand; 20-25 percent intergrain porosity in coarse quartz sand; coarser lower cycle moderate hydraulic conductivity and finer upper cycle low hydraulic conductivity; friable quartz sand; trace clay matrix; cyclic 1- to 5-foot thick fining upward cycles; clay laminations within cycles thicken and increase in abundance upwards
262.7-270.0	No recovery
270.0-275.4	Quartz sand with minor clay laminations; yellowish gray 5Y 8/1 sand and light olive gray 5Y 6/1 clay laminations; varying from mainly fine to medium quartz sand with minor very fine and coarse quartz sand to mainly very fine to coarse quartz sand; moderately sorted quartz sand; 20-25 percent intergrain porosity in coarse quartz sand; coarser lower cycle moderate hydraulic conductivity and finer upper cycle low hydraulic conductivity; friable quartz sand; trace clay matrix; cyclic 1- to 5-foot thick fining upward cycles; clay laminations within cycles thicken and increase in abundance upwards
275.4-280.0	No recovery
280.0-283.8	Quartz sand with minor clay laminations; yellowish gray 5Y 8/1 sand and light olive gray 5Y 6/1 clay laminations; varying from mainly fine quartz sand with minor very fine and medium quartz sand to mainly very fine to coarse quartz sand; moderately sorted quartz sand; 20-25 percent intergrain porosity in coarse quartz sand; coarser lower cycle moderate hydraulic conductivity and finer upper cycle low hydraulic conductivity; friable quartz sand; trace clay matrix; cyclic 1- to 5-foot thick fining upward cycles; clay laminations within cycles thicken and increase in abundance upwards

Depth (feet below land surface)	Lithologic description of GL-329 test corehole
283.8-290.0	No recovery
290.0-292.5	Quartz sand with minor clay laminations; yellowish gray 5Y 8/1 sand and light olive gray 5Y 6/1 clay laminations; varying from mainly fine quartz sand with minor very fine and medium quartz sand to mainly very fine to coarse quartz sand; moderately sorted quartz sand; 20-25 percent intergrain porosity in coarse quartz sand; coarser lower cycle moderate hydraulic conductivity and finer upper cycle low hydraulic conductivity; friable quartz sand; trace clay matrix; cyclic 1- to 5-foot thick fining upward cycles; clay laminations within cycles thicken and increase in abundance upwards
292.5-300.0	No recovery
300.0-305.2	Quartz sand with minor clay laminations; yellowish gray5Y 8/1 sand and light olive gray 5Y 6/1 clay laminations; varying from mainly fine quartz sand with minor very fine and medium quartz sand to mainly very fine to coarse quartz sand; moderately sorted quartz sand; 20-25 percent intergrain porosity in coarse quartz sand; coarser lower cycle moderate hydraulic conductivity and finer upper cycle low hydraulic conductivity; friable quartz sand; trace clay matrix; cyclic 1- to 5-foot thick fining upward cycles; clay laminations within cycles thicken and increase in abundance upwards
305.2-310.0	No recovery
310.0-312.7	Quartz sand with minor clay laminations; yellowish gray 5Y 8/1 sand and light olive gray 5Y 6/1 clay laminations; varying from mainly fine quartz sand with minor very fine and medium quartz sand to mainly very fine to coarse quartz sand; moderately sorted quartz sand; 20-25 percent intergrain porosity in coarse quartz sand; coarser lower cycle moderate hydraulic conductivity and finer upper cycle low hydraulic conductivity; friable quartz sand; trace clay matrix; cyclic 1- to 5-foot thick fining upward cycles; clay laminations within cycles thicken and increase in abundance upwards
312.7-320.0	No recovery
320.0-323.0	Quartz sand with minor clay laminations; yellowish gray 5Y 8/1 sand and light olive gray 5Y 6/1 clay laminations; varying from mainly fine quartz sand with minor very fine and medium quartz sand to mainly very fine to coarse quartz sand; moderately sorted quartz sand; 20-25 percent intergrain porosity in coarse quartz sand; coarser lower cycle moderate hydraulic conductivity and finer upper cycle low hydraulic conductivity; friable quartz sand; trace clay matrix; cyclic 1- to 5-foot thick fining upward cycles; clay laminations within cycles thicken and increase in abundance upwards
323.0-330.0	No recovery
330.0-334.5	Quartz sand with minor clay laminations; yellowish gray 5Y 8/1 sand and light olive gray 5Y 6/1 clay laminations; varying from mainly fine quartz sand with minor very fine and medium quartz sand to mainly very fine to coarse quartz sand; moderately sorted quartz sand; 20-25 percent intergrain porosity in coarse quartz sand; coarser lower cycle moderate hydraulic conductivity and finer upper cycle low hydraulic conductivity; friable quartz sand; trace clay matrix; cyclic 1- to 5-foot thick fining upward cycles; clay laminations within cycles thicken and increase in abundance upwards
334.5-335.0	No recovery
335.0-336.0	Quartz sand with minor clay laminations; yellowish gray 5Y 8/1 sand and light olive gray 5Y 6/1 clay laminations; varying from mainly fine quartz sand with minor very fine and medium quartz sand to mainly very fine to coarse quartz sand; moderately sorted quartz sand; 20-25 percent intergrain porosity in coarse quartz sand; coarser lower cycle moderate hydraulic conductivity and finer upper cycle low hydraulic conductivity; friable quartz sand; trace clay matrix; cyclic 1- to 5-foot thick fining upward cycles; clay laminations within cycles thicken and increase in abundance upwards
336.0-341.0	No recovery
341.0-343.3	Quartz sand with minor clay laminations; yellowish gray 5Y 8/1 sand and light olive gray 5Y 6/1 clay laminations; varying from mainly fine quartz sand with minor very fine and medium quartz sand to mainly very fine to coarse quartz sand; moderately sorted quartz sand; 20-25 percent intergrain porosity in coarse quartz sand; coarser lower cycle moderate hydraulic conductivity and finer upper cycle low hydraulic conductivity; friable quartz sand; trace clay matrix; cyclic 1- to 5-foot thick fining upward cycles; clay laminations within cycles thicken and increase in abundance upwards
343.3-344.0	No recovery

Depth (feet below land surface)	Lithologic description of GL-329 test corehole
344.0-346.8	Quartz sand with minor clay laminations; yellowish gray 5Y 8/1 sand and light olive gray 5Y 6/1 clay laminations; varying from mainly fine quartz sand with minor very fine and medium quartz sand to mainly very fine to coarse quartz sand; moderately sorted quartz sand; 20-25 percent intergrain porosity in coarse quartz sand; coarser lower cycle moderate hydraulic conductivity and finer upper cycle low hydraulic conductivity; friable quartz sand; trace clay matrix; cyclic 1- to 5-foot thick fining upward cycles; clay laminations within cycles thicken and increase in abundance upwards
346.8-350.7	Quartz sand; yellowish gray 5Y 8/1; mainly very fine to fine quartz sand with minor medium quartz sand; well sorted quartz sand; 5 percent phosphorite and heavy minerals; 25 percent intergrain porosity; low to moderate hydraulic conductivity; trace clay matrix
350.7-354.0	No recovery
354.0-370	Quartz sand; yellowish gray 5Y 8/1; mainly very fine to fine quartz sand with minor medium quartz sand; well sorted quartz sand; 5 percent phosphorite and heavy minerals; 25 percent intergrain porosity; low to moderate hydraulic conductivity; trace clay matrix
370.0-373.4	Quartz sand with minor clay laminations; yellowish gray 5Y 8/1 sand and olive gray 5Y 4/1 clay laminations; varying from mainly fine quartz sand with minor very fine and medium quartz sand to mainly very fine to coarse quartz sand; moderately sorted quartz sand; 20-25 percent intergrain porosity in coarse quartz sand; coarser lower cycle moderate hydraulic conductivity and finer upper cycle low hydraulic conductivity; friable quartz sand; trace clay matrix; cyclic 1- to 5-foot thick fining upward cycles; clay laminations within cycles thicken and increase in abundance upwards
373.4-375.0	No recovery
375.0-376.8	Quartz sand with minor clay laminations; yellowish gray 5Y 8/1 sand and olive gray 5Y 4/1 clay laminations; varying from mainly fine quartz sand with minor very fine and medium quartz sand to mainly very fine to coarse quartz sand; moderately sorted quartz sand; 20-25 percent intergrain porosity in coarse quartz sand; low to moderate hydraulic conductivity; friable quartz sand; trace clay matrix
376.8-380.8	Quartz sand; yellowish gray 5Y 8/1; mainly very fine to fine quartz sand with minor medium quartz sand; well sorted quartz sand; 5 percent phosphorite and heavy minerals; 25 percent intergrain porosity; low to moderate hydraulic conductivity; trace clay matrix
380.8-381.0	No recovery
381.0-384.8	Quartz sand; yellowish gray 5Y 8/1; mainly fine to medium quartz sand with minor very fine and coarse quartz sand; well sorted quartz sand; 5 percent phosphorite and heavy minerals; 25 percent intergrain porosity; moderate hydraulic conductivity; trace clay matrix; uncommon clay laminations
384.8-391.0	No recovery
391.0-392.8	Quartz sand; yellowish gray 5Y 8/1; mainly fine to medium quartz sand with minor very fine and coarse quartz sand; well sorted quartz sand; 5 percent phosphorite and heavy minerals; 25 percent intergrain porosity; moderate hydraulic conductivity; trace clay matrix; uncommon clay laminations
392.8-393.0	No recovery
393.0-393.4	Quartz sand; yellowish gray 5Y 8/1; mainly fine quartz sand with minor very fine and medium quartz sand; well sorted quartz sand; moderate hydraulic conductivity
393.4-394.6	Mudstone; olive gray 5Y 4/1; very low hydraulic conductivity
394.6-410.0	No recovery
410.0-410.5	Mudstone; olive gray 5Y 4/1; very low hydraulic conductivity
410.5-411.2	Mudstone; olive gray 5Y 4/1; very low hydraulic conductivity
411.2-416.5	No recovery
416.5-417.5	Mudstone; olive gray 5Y 4/1; very low hydraulic conductivity
417.5-431.0	No recovery

HE-1118 Test Corehole

Florida Geological Survey well number	W-18072
GWSI number	HE-1118
Total depth	26.75 feet
Cored from	0 to 26.75 feet
County	Hendry
Location	NE, sec. 19, T43S, R31E
Latitude	26° 44′ 08″
Longitude	81° 15′ 55″
Elevation	22 feet
Completion date	July 23, 1999
Other types of logs available	Induction, gamma ray, resistivity, spontaneous potential
Owner	U.S. Geological Survey
Driller	Florida Geological Survey
Core described by	Kevin J. Cunningham
Pamlico Sand	0 to 8.5 feet
Caloosahatchee Formation	8.5 to 21 feet
Top Tamiami Formation	21 feet
Water-table aquifer	0 to 8.5 feet
Confining zone	8.5 to 21 feet
Top subaquifer of surficial aquifer	21 feet (electrical logs contributed to selection of tops)

Depth (feet below land surface)	Lithologic description of HE-1118 test corehole
0.0-2.0	Quartz sand; pale yellowish brown 10YR 6/2; N1 black heavy minerals; mainly very fine to medium quartz sand; minor silt-sized quartz, coarse quartz sand, pelecypods up to large pebble size, lithoclasts up to large pebble size, and very fine heavy minerals; moderately sorted; subangular to subrounded; 3 percent pelecypods including *Chione*; trace heavy minerals; 30 percent intergrain porosity; moderate hydraulic conductivity; soft wet; loose, unconsolidated sand.
2.0-6.0	Quartz sand; mottled very pale orange 10YR 8/2, grayish orange 10YR 7/4; mainly very fine to medium quartz sand; minor silt-sized quartz, coarse to very coarse quartz sand, and very fine heavy minerals; moderately sorted; subangular to subrounded; trace black heavy minerals; 30 percent intergrain porosity; moderate hydraulic conductivity; soft wet; loose, unconsolidated sand.
6.0-7.0	No recovery
7.0-7.9	Quartz sand; mottled very pale orange 10YR 8/2, grayish orange 10YR 7/4; mainly very fine to medium quartz sand; minor silt-sized quartz, coarse to very coarse quartz sand, and very fine heavy minerals; moderately sorted; subangular to subrounded; trace black heavy minerals; 30 percent intergrain porosity; moderate hydraulic conductivity; soft wet; loose, unconsolidated sand.
7.9-10.3	No recovery.
10.3-11.3	Pelecypod lime floatstone with quartz sand-rich, skeletal wackestone matrix; very pale orange 10YR 8/2, grayish orange 10YR 7/4; mainly very fine to medium quartz sand; minor coarse quartz sand and fine sand-sized to large pebble-sized fossils and fossil fragments; well sorted; subangular to subrounded; pelecypods and bryozoans; 20-40 percent quartz sand; 15 percent moldic, root-mold, intergrain porosity; low to moderate hydraulic conductivity; very hard wet; well consolidated; 1-mm diameter, semivertical root molds.
11.3-15.0	No recovery.
15.0-16.4	Shelly sandstone; very pale orange 10YR 8/2; mainly clay-size marl, very fine to medium quartz sand and medium sand-sized to very large pebble-sized fossils and fossil fragments; well sorted; subangular to subrounded; 40 percent fossils (pelecypods and subordinate gastropods); 10 percent intergrain porosity; low hydraulic conductivity; soft wet; marl matrix
16.4-16.7	Pelecypod rudstone with quartz sand-rich marly matrix; pale yellowish brown 10YR 6/2; very fine sand-sized to very large pebble-sized fossils and fossil fragments, clay-size marl, very fine to medium quartz sand; minor coarse quartz sand; moderately sorted; subangular to subrounded; pelecypods and subordinate gastropods; 20 percent quartz sand; 10 percent intergrain porosity; low hydraulic conductivity; soft wet; marl matrix.
16.7-17.0	No recovery.
17.0-17.6	Pelecypod-oyster rudstone with quartz sand-rich, grain-dominated, skeletal packstone matrix; yellowish gray 5Y 8/1, medium light gray N6 to light gray N7; very fine sand-sized to very large pebble-sized fossils and fossil fragments, clay-size marl, very fine to medium quartz sand; minor coarse quartz sand; moderately sorted; subangular to subrounded; pelecypods and subordinate gastropods; 20 percent quartz sand; 30 percent moldic porosity; low to moderate hydraulic conductivity; soft wet; marly matrix.
17.6-21.0	No recovery.
21.0-26.0	Loose pelecypod shells; very pale orange 10YR 8/2, medium dark gray N4 to very light gray N6; coarse sand-sized to medium pebble-sized fossils and fossil fragments; minor very fine to medium quartz sand; well sorted; subangular to subrounded; 90 percent pelecypods and subordinate gastropods and barnacles; 5 percent quartz sand; 5 percent clay; 35 percent intergrain porosity; moderate hydraulic conductivity to high; unconsolidated, loose shells; most shells broken; very minor matrix of sandy clay; interval from 21-26 feet represented by a single sample bag.
26.0-26.8	No recovery.

L-5809 Test Corehole

Florida Geological Survey well number	W-18071
GWSI number	L-5809
Total depth	100 feet
Cored from	0 to 100 feet
County	Lee
Location	NE, sec. 26, T43S, R27E
Latitude	26° 42′ 57″
Longitude	81° 35′ 27″
Elevation	8 feet
Completion date	July 11, 1999
Other types of logs available	Induction, gamma ray, resistivity, spontaneous potential
Owner	U.S. Geological Survey
Driller	Florida Geological Survey
Core described by	Kevin J. Cunningham
Pamlico Sand(?)	0 to 2.6 feet
Bee Branch Member of Caloosahatchee Marl(?)	2.6 to 4.5 feet
Buckingham Member of Tamiami Formation	4.5 to 38.9 feet
Peace River Formation	38.9 to 100 feet
Water-table aquifer	0 to 4.5 feet
Upper confining unit	4.5 to 40 feet
Clastic zone of sandstone aquifer	40 to 90.75 feet
Top carbonate zone of sandstone aquifer	90.75 feet
Note	Well had artesian flow after reaching total depth, possibly from the carbonate zone of the sandstone aquifer

Depth (feet below land surface)	Lithologic description of L-5809 test corehole
0.0-2.6	Quartz sand; light brownish gray 5YR 6/1, dark yellowish brown 10YR 4/2, dusky yellowish brown 10YR 2/2; mainly very fine to fine quartz sand; minor silt-sized quartz and medium quartz sand; well sorted; subangular to subrounded; trace clay in lower part of interval; 15-25 percent intergrain porosity; low to moderate hydraulic conductivity; soft wet; loose sand; abundant organics particles; recent rootlets.
2.6-4.5	Pelecypod lime floatstone with skeletal grainstone and quartz sand-rich lime mudstone matrix; very pale orange 10YR 8/2, moderate yellowish brown 10YR 5/4; mainly medium sand-sized to granule-sized fossil fragments and lime mud; minor very fine to fine quartz sand and pebble-sized fossils; well sorted; angular to subrounded; ≤30 percent quartz sand; 20 percent vuggy and micro porosity; low to moderate hydraulic conductivity; very hard to firm wet; weathered to a chalky texture in part; mostly samples of rubble.
4.5-6.6	Marl; very pale orange 10YR 8/2; mainly clay-sized micrite and clay; minor quartz silt and very fine to very large pebble-sized fossils; ≤5 percent skeletal fragments and pelecypods; very low porosity; very low hydraulic conductivity; firm wet; hard dry.
6.6-7.0	No recovery.
7.0-10.9	Marl; very pale orange 10YR 8/2; mainly clay-sized micrite and clay; minor quartz silt and very fine to very large pebble-sized fossils; ≤5 percent skeletal fragments and pelecypods; very low porosity; very low hydraulic conductivity; firm wet; hard dry.
10.9-12.0	No recovery.
12.0-13.1	Marl; very pale orange 10YR 8/2; mainly clay-sized micrite and clay; minor quartz silt and very fine to very large pebble-sized fossils; ≤5 percent skeletal fragments and pelecypods; very low porosity; very low hydraulic conductivity; firm wet; hard dry.
13.1-14.0	Marly terrigenous mudstone; yellowish gray 5Y 8/1, very pale orange 10YR 8/2; mainly clay and clay-sized micrite; minor very fine to fine quartz sand; 5-20 percent quartz sand; 5-10 percent small benthic foraminifers; trace shark's teeth and fish scales; subangular to subrounded; very low porosity; very low hydraulic conductivity; firm wet; hard dry.
14.0-16.8	Marly terrigenous mudstone; light olive gray 5Y 6/1 and 5Y 5/2; dark yellowish orange 10YR 6/6 phosphate grains; mainly clay and clay-sized micrite; minor very fine to fine quartz sand and very fine to fine phosphate grains; 5-20 percent quartz sand; 5-10 percent small benthic foraminifers; ≤5 percent phosphate grains; trace shark's teeth and fish scales; subangular to subrounded; very low porosity; very low hydraulic conductivity; firm wet; hard dry.
16.8-17.0	No recovery.
17.0-21.0	Marly terrigenous mudstone; light olive gray 5Y 6/1 and 5Y 5/2; dark yellowish orange 10YR 6/6 phosphate grains; mainly clay and clay-sized micrite; minor very fine to fine quartz sand and very fine to fine phosphate grains; 5-20 percent quartz sand; 5-10 percent small benthic foraminifers; ≤5 percent phosphate grains; trace shark's teeth and fish scales; subangular to subrounded; very low porosity; very low hydraulic conductivity; firm wet; hard dry.
21.0-22.0	No recovery.
22.0-26.2	Terrigenous mudstone; light olive gray 5Y 6/1; dark yellowish orange 10YR 6/6 phosphate grains; mainly clay; minor very fine to fine quartz sand and very fine to fine phosphate grains; 5-20 percent quartz sand; ≤10 percent small benthic foraminifers and ≤20 percent phosphate grains in sand laminations; trace shark's teeth and fish scales; angular to subrounded; very low porosity; very low hydraulic conductivity; firm wet; hard dry; sand occurs in thin to thick laminations.
26.2-26.6	Quartz sand with clay matrix; yellowish gray 5Y 7/2; dark yellowish orange 10YR 6/6 phosphate grains; mainly very fine quartz sand; minor fine quartz sand and very fine to fine phosphate grains; well sorted; subangular to subrounded; 10 percent small benthic foraminifers; 15 percent phosphate grains; 15 percent intergrain porosity; low hydraulic conductivity; soft wet.
26.6-27.0	No recovery.
27.0-28.5	Quartz sand with clay matrix; yellowish gray 5Y 7/2; dark yellowish orange 10YR 6/6 phosphate grains; mainly very fine quartz sand; minor fine quartz sand and very fine to fine phosphate grains; well sorted; subangular to subrounded; 10 percent small benthic foraminifers; 15 percent phosphate grains; 5-15 percent intergrain porosity; very low to low hydraulic conductivity; soft wet; thin to thick laminations and thin beds of clay, quartz sand and phosphate sand; fines upward to a clay cap.
28.5-31.5	Quartz sand with clay matrix; yellowish gray 5Y 8/1, light olive gray 5Y 6/1; moderate yellowish brown 10YR 5/4 and brownish gray 5YR 4/1 phosphate grains; mainly very fine quartz sand; minor fine quartz sand and very fine to fine phosphate grains; well sorted; subangular to subrounded; 40 percent phosphate grains; 1 percent small benthic foraminifers; trace pelecypods, fish scales; 5-15 percent intergrain porosity; very low to low hydraulic conductivity; soft wet; thin to thick laminations and thin beds of clay, quartz sand and phosphate sand; fines upward to a clay cap; possible mud cracks at 30.9 feet.

Depth (feet below land surface)	Lithologic description of L-5809 test corehole
31.5-36.8	Interbedded terrigenous mudstone, quartz sand and phosphate sand; yellowish gray 5Y 8/1, light olive gray 5Y 6/1, olive gray 5Y 4/1; black N1 phosphate grains; mainly very fine quartz sand; minor fine quartz sand and very fine to fine phosphate grains; well sorted; subangular to subrounded; 40 percent phosphate grains; 1 percent small benthic foraminifers; trace pelecypods, fish scales, siliceous spicules; 5-15 percent intergrain porosity; very low to moderate hydraulic conductivity; soft wet; thin to thick laminations and thin beds of clay, quartz sand and phosphate sand.
36.8-37.0	Dolosilt; light olive gray 5Y 6/1; mainly silt-sized dolomite; 5 percent microporosity; very low hydraulic conductivity.
37.0-37.6	Quartz sand; light olive gray 5Y 6/1; black N1 phosphate grains; mainly very fine quartz sand; minor fine to small pebble-sized quartz sand and very fine to small pebble-sized phosphate grains; moderately sorted; subangular to subrounded; 25 percent phosphate grains; 15 percent intergrain porosity; low hydraulic conductivity; soft wet; base of fining upward unit with top at 31.5 feet; possible erosional unconformity at 37.6 feet.
37.5-38.9	Pelecypod lime floatstone with quartz sand-rich lime mudstone matrix; yellowish gray 5Y 8/1; mainly fine quartz sand; minor very fine to small pebble-sized quartz and up to very large pebble-sized fossils; moderately sorted; subangular to subrounded; pelecypods and minor cerithiids(?); 10 percent intergrain porosity; low hydraulic conductivity; hard wet; limestone appears chalky and weathered, possible subaerial unconformity at top.
38.9-40.0	Quartz sand; light olive gray 5Y 6/1; black N1 phosphate grains; mainly very fine quartz sand; minor fine to small pebble-sized quartz sand and very fine to granule-sized phosphate grains; moderately sorted; subangular to subrounded; 3 percent phosphate grains; 10-25 percent intergrain porosity; low to moderate hydraulic conductivity; soft to firm wet; grades upward from clean sand at base to micrite matrix at top.
40.0-41.0	No recovery.
41.0-44.6	Quartz sand; yellowish gray 5Y 8/1; black N1 phosphate grains; mainly fine to medium quartz sand; minor very fine and coarse to granule-sized quartz sand, very fine to granule-sized phosphate grains and very fine heavy minerals; moderately sorted; subangular to subrounded; 3 percent phosphate grains; trace heavy minerals; 25 percent intergrain porosity; moderate hydraulic conductivity; soft wet; friable; frosted quartz sand grains; trace very irregular clay laminations.
44.6-46.0	No recovery.
46.0-48.0	Quartz sand; yellowish gray 5Y 8/1; black N1 phosphate grains; mainly fine to medium quartz sand; minor very fine and coarse to granule-sized quartz sand, very fine to granule-sized phosphate grains and very fine heavy minerals; moderately sorted; subangular to subrounded; 3 percent phosphate grains; trace heavy minerals; 25 percent intergrain porosity; moderate hydraulic conductivity; soft wet; friable; minor frosted quartz grains.
48.0-50.0	No recovery.
50.0-55.3	Quartz sand; yellowish gray 5Y 8/1; black N1 phosphate grains; mainly very fine to medium quartz sand; minor coarse quartz sand, very fine to medium phosphate grains, very fine heavy minerals; moderately to well sorted; subangular to subrounded; 3 percent phosphate grains; trace mica and heavy minerals; 25 percent intergrain porosity; moderate hydraulic conductivity; soft wet; friable; minor frosted quartz grains.
55.3-55.5	No recovery.
55.5-59.5	Quartz sand; yellowish gray 5Y 8/1; black N1 phosphate grains; mainly very fine to fine quartz sand; minor medium quartz sand, very fine to fine phosphate grains and very fine heavy minerals; well sorted; subangular to subrounded; 3 percent phosphate grains; trace mica and heavy minerals; 25 percent intergrain porosity; moderate hydraulic conductivity; soft wet; friable.
59.5-60.5	No recovery.
60.5-63.7	Quartz sand; yellowish gray 5Y 8/1; black N1 phosphate grains; mainly very fine to fine quartz sand; minor medium quartz sand, very fine to fine phosphate grains and very fine heavy minerals; well sorted; subangular to subrounded; 3 percent phosphate grains; trace mica and heavy minerals; 20 percent intergrain porosity; moderate hydraulic conductivity; soft wet; friable.
63.7-65.5	Quartz sand; yellowish gray 5Y 8/1, light olive gray 5Y 6/1; black N1 phosphate grains; mainly very fine to fine quartz sand; minor medium to coarse quartz sand, very fine to medium phosphate grains and very fine heavy minerals; moderately sorted; subangular to subrounded; 2 percent phosphate grains; minor clay matrix and heavy minerals; 15 percent intergrain porosity; low hydraulic conductivity; soft wet; friable.
65.5-66.0	No recovery.

Depth (feet below land surface)	Lithologic description of L-5809 test corehole
66-67.5	Quartz sand; yellowish gray 5Y 8/1, light olive gray 5Y 6/1; black N1 phosphate grains; mainly very fine to medium quartz sand; minor coarse quartz sand, very fine to medium phosphate grains and very fine heavy minerals; moderately sorted; subangular to subrounded; 2 percent phosphate grains; minor clay matrix and heavy minerals; 15 percent intergrain porosity; low hydraulic conductivity; soft wet; friable.
67.5-68.5	Quartz sand; light olive gray 5Y 6/1; black N1 phosphate grains; mainly very fine to medium quartz sand; minor coarse quartz sand, very fine to medium phosphate grains and very fine heavy minerals; moderately sorted; subangular to subrounded; 2 percent phosphate grains; abundant clay matrix; trace heavy minerals; 10 percent intergrain porosity; low hydraulic conductivity; soft wet; friable.
68.5-70.5	Quartz sand; yellowish gray 5Y 8/1, light olive gray 5Y 6/1; black N1 phosphate grains; mainly very fine to medium quartz sand; minor coarse quartz sand, very fine to medium phosphate grains and very fine heavy minerals; moderately sorted; subangular to subrounded; 2 percent phosphate grains; minor clay matrix and heavy minerals; 15 percent intergrain porosity; low hydraulic conductivity; soft wet; friable.
70.5-71.0	No recovery.
71.0-71.5	Quartz sand; yellowish gray 5Y 8/1, light olive gray 5Y 6/1; black N1 phosphate grains; mainly very fine to medium quartz sand; minor coarse quartz sand, very fine to medium phosphate grains and very fine heavy minerals; moderately sorted; subangular to subrounded; 2 percent phosphate grains; minor clay matrix and heavy minerals; 15 percent intergrain porosity; low hydraulic conductivity; soft wet; friable.
71.5-74.4	Quartz sand; yellowish gray 5Y 8/1; black N1 phosphate grains; mainly fine to medium quartz sand; minor very fine and coarse to granule-sized quartz sand, very fine to very coarse phosphate grains and very fine heavy minerals; moderately sorted; subangular to subrounded; 2 percent phosphate grains; trace clay matrix; minor heavy minerals; 15-25 percent intergrain porosity; moderate hydraulic conductivity; soft wet; friable.
74.4-75.5	No recovery
75.5-80.2	Quartz sand; yellowish gray 5Y 8/1; black N1 phosphate grains; mainly fine to medium quartz sand; minor very fine and coarse to granule-sized quartz sand, very fine to very coarse phosphate grains and very fine heavy minerals; moderately sorted; subangular to subrounded; 2 percent phosphate grains; trace clay matrix; minor heavy minerals; 25 percent intergrain porosity; moderate hydraulic conductivity; soft wet; friable.
80.2-80.5	No recovery.
80.5-80.7	Quartz sand; yellowish gray 5Y 8/1; black N1 phosphate grains; mainly fine to medium quartz sand; minor very fine and coarse to medium pebble-sized quartz sand, very fine to small pebble-sized phosphate grains and very fine heavy minerals; moderately sorted; subangular to subrounded; 2 percent phosphate grains; minor heavy minerals; 25 percent intergrain porosity; moderate hydraulic conductivity; soft wet; friable.
80.7-85.5	No recovery.
85.5-87.5	Quartz sand; yellowish gray 5Y 8/1; black N1 phosphate grains; mainly very fine to fine quartz sand; minor medium quartz sand, very fine to fine phosphate grains and very fine heavy minerals; well sorted; subangular to subrounded; 2 percent phosphate grains; minor heavy minerals; 25 percent intergrain porosity; moderate hydraulic conductivity; soft wet; friable; trace thin clay laminations.
87.5-90.5	No recovery.
90.5-90.7	Quartz sand; yellowish gray 5Y 8/1; black N1 phosphate grains; mainly very fine to fine quartz sand; minor medium quartz sand, very fine to fine phosphate grains and very fine heavy minerals; well sorted; subangular to subrounded; 2 percent phosphate grains; minor heavy minerals; 25 percent intergrain porosity; moderate hydraulic conductivity; soft wet; friable; trace thin clay laminations; a few clasts of up to medium pebble-sized quartz sandstone and phosphate above the basal surface at 90.75 that are loose in core box.
90.8-91.7	Pelecypod lime floatstone with skeletal wackestone matrix; very light gray N8; mainly micrite; minor very fine to pebble-sized fossils; skeletal fragments and pelecypods; 20 percent moldic porosity; low hydraulic conductivity; hard wet; very well consolidated; minor root molds about 1 mm in diameter; very local blackened upper surface.
91.7-94.0	Pelecypod lime rudstone with skeletal grainstone to grain-dominated packstone matrix; grayish orange 10YR 7/4; mainly very fine sand-sized to large pebble-sized fossils; pelecypods, skeletal fragments, gastropods; trace corals and bryozoans; 30 percent moldic and intergrain porosity; high hydraulic conductivity; hard wet; well consolidated.
94.0-100.0	No recovery.