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Groundwater Resources Program

Digital Surfaces and Thicknesses of Selected Hydrogeologic Units of the Floridan Aquifer System in Florida and Parts of Georgia, Alabama, and South Carolina

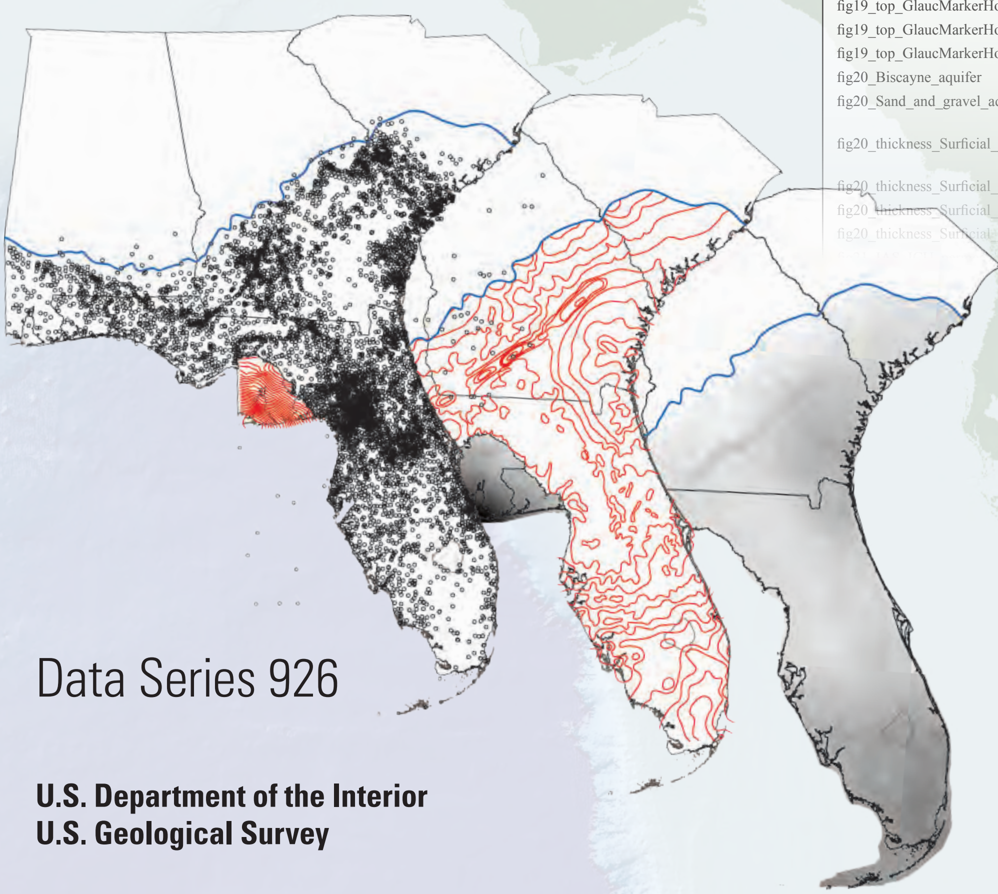

Table 1–1. Content provided in the Floridan framework geodatabase.

Layer	Title
Primary layers	
fig02_Xsection_Lines	Cross-section lines
fig02_Xsection_wells	Cross-section well locations
fig05_Floridan_Geology_Outcrops	Generalized geologic map of the southeastern United States
fig06_Positive_structural_elements	Positive structural features within the study area
fig06_Structural_features	Structural features in the study area
fig12_ClosedDepressions_density_poly	Frequency of closed depressions in relation to major springs in study area
fig12_Springs_all	Spring locations in Florida, Georgia, and Alabama
fig12_Woodvillekarst	Extent of the Woodville Karst Plain
fig17_bot_UpperDolostoneUnit_raster	Raster surface depicting the bottom of the Avon Park Formation upper dolostone unit
fig17_top_UpperDolostoneUnit_contour	Contours for the top of the upper Avon Park dolostone unit
fig17_top_UpperDolostoneUnit_pts	Points for the top of the Avon Park dolostone
fig17_top_UpperDolostoneUnit_raster	Raster surface depicting the top of the upper dolostone unit of the Avon Park Formation
fig19_top_GlaucMarkerHorizon_contour	Contours for the top of the glauconite marker horizon
fig19_top_GlaucMarkerHorizon_pts	Points for the top of the glauconite marker horizon
fig19_top_GlaucMarkerHorizon_raster	Raster surface depicting the glauconite marker horizon
fig20_Biscayne_aquifer	Extent of the Biscayne aquifer of the surficial aquifer system
fig20_Sand_and_gravel_aquifer	Extent of the sand-and-gravel aquifer of the surficial aquifer system
fig20_thickness_Surficial_contour	Thickness contours for surficial deposits of the surficial aquifer system
fig20_thickness_Surficial_pts	Thickness data points for surficial deposits
fig20_thickness_Surficial_raster	Thickness raster surface for surficial deposits
fig20_thickness_Surficial_raster_clipped	Thickness raster surface for surficial deposits, clipped

Data Series 926

U.S. Department of the Interior
U.S. Geological Survey

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By Lester J. Williams and Joann F. Dixon

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U.S. Department of the Interior
SALLY JEWELL, Secretary

U.S. Geological Survey
Suzette M. Kimball, Acting Director

U.S. Geological Survey, Reston, Virginia: 2015

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Contents

Figures

Tables

Conversion Factors

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
	Area	
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow rate	
foot per day (ft/d)	0.3048	meter per day (m/d)

Supplemental Information

Concentrations of chemical constituents in water are given in milligrams per liter (mg/L).

Datums

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

Horizontal coordinate information is referenced to North American Datum of 1983 (NAD 83).

Altitude, as used in this report, refers to distance above the vertical datum.

Abbreviations

APPZ	Avon Park permeable zone
ASCII	American Standard Code for Information Interchange
BZ	Boulder Zone
DEM	digital elevation model
FPZ	Fernandina permeable zone
GIS	geographic information system
GWRP	Groundwater Resource Program
LAPPZ	lower Avon Park permeable zone
LISAPCU	Lisbon-Avon Park composite unit
MCU	middle confining unit (Miller's MCUI through MCUVIII)
OCAPLPZ	Ocala-Avon Park low permeability zone
OLDSPZ	Oldsmar permeable zone
TDS	total dissolved solids
UCU	upper confining unit
UPZ	uppermost permeable zone
USGS	U.S. Geological Survey
UWI	unique well identifier

Acknowledgments

The data used to develop the revised hydrogeologic framework were compiled by many different organizations and individuals. We acknowledge the contribution of Florida's five water management districts (Northwest Florida Water Management District, St. Johns River Water Management District, South Florida Water Management District, Southwest Florida Water Management District, Suwannee River Water Management District), Florida Geological Survey, Georgia Environmental Protection Division, Geological Survey of Alabama, and the South Carolina Department of Natural Resources who provided much of the data used to develop the revised hydrogeologic framework. On several occasions, Emily Richardson with the South Florida Water Management District helped locate key wells and data contained in South Florida Water Management District's DBHYDRO database. Jerry Mallams of the Southwest Florida Water Management District provided a large amount of digital well data and numerous reports concerning the hydrogeology of west-central and southwest Florida areas. Jeffery B. Davis of the St. Johns River Water Management District was particularly helpful in compiling and making available a large part geophysical log database and the hydrogeologic picks that were compiled over many years at St. Johns River Water Management District.

Jason Bellino of the U.S. Geological Survey (USGS) Tampa office assisted in scanning well logs and compiling information about the tops and bottoms of hydrogeologic units from previous regional USGS studies. We are especially grateful to Rick Spechler of the USGS Orlando office who helped locate numerous geophysical logs in the files of the USGS Orlando and Tampa offices. Ron Reese of the USGS Ft. Lauderdale office also helped locate key wells and data contained in South Florida Water Management District's DBHYDRO database. Brian Clark, Jonathan Musser, and Andrew O'Reilly, USGS, provided thorough peer reviews of the report and digital datasets. Finally, Eve Kuniansky, USGS, made significant revisions to the manuscript incorporating final comments and the editorial review of Michael Deacon. Caryl Wipperfurth, USGS, is also appreciated for illustration work and report layout.

Digital Surfaces and Thicknesses of Selected Hydrogeologic Units of the Floridan Aquifer System in Florida and Parts of Georgia, Alabama, and South Carolina

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Abstract

Digital surfaces and thicknesses of selected hydrogeologic units of the Floridan aquifer system were developed to define an updated hydrogeologic framework as part of the U.S. Geological Survey Groundwater Resources Program. The dataset contains structural surfaces depicting the top and base of the aquifer system, its major and minor hydrogeologic units and zones, geophysical marker horizons, and the altitude of the 10,000-milligram-per-liter total dissolved solids boundary that defines the approximate fresh and saline parts of the aquifer system. The thicknesses of selected major and minor units or zones were determined by interpolating points of known thickness or from raster surface subtraction of the structural surfaces. Additional data contained include clipping polygons; regional polygon features that represent geologic or hydrogeologic aspects of the aquifers and the minor units or zones; data points used in the interpolation; and polygon and line features that represent faults, boundaries, and other features in the aquifer system.

Introduction

In the fall of 2009 the U.S. Geological Survey (USGS) began a regional study of groundwater resources of the Floridan aquifer system as part of a national assessment conducted through the Groundwater Resource Program (GWRP). A major goal of these studies is to provide updated information about the current status of groundwater resources in principal aquifers and to develop tools and datasets to assist State, county, municipal agencies, as well as those of special districts formed for water-resources management, for making long-term groundwater management decisions (Reilly and others, 2008).

Purpose and Scope

The purpose of this report is to provide a georeferenced digital dataset for the revised hydrogeologic framework of the Floridan aquifer system developed for the ongoing study of groundwater availability, described in more detail in Williams and Kuniansky (2015). The dataset contains structural surfaces depicting the top and base of the aquifer system, its major and minor hydrogeologic or lithostratigraphic composite units and zones, geophysical marker horizons, and the altitude of the 10,000-milligram-per-liter (mg/L) total dissolved solids (TDS) boundary that defines the approximate fresh and saline parts of the aquifer system (appendix 1). Thicknesses of selected major and minor units or zones within the Upper and Lower Floridan aquifer system were developed by interpolating points of known thickness or by using geographic information system (GIS) tools to subtract raster surfaces contained in the dataset (herein called raster surface subtraction). Additional feature classes included in the dataset are polygons of hydrogeologic unit extents, regional polygon features that represent geologic or hydrogeologic aspects of the aquifers and the minor units or zones, data points used in the interpolation and polygon and line features that represent faults, boundaries, and other features in the aquifer system.

The dataset is provided in several downloadable compressed archives available from the USGS Web page for this report (http://pubs.er.usgs.gov/publication/ds926). The data are contained in both Esri ArcGIS and open-file formats as vector and raster data. Vector data (point, line, and polygon), also referred to herein as feature classes, are a collection of geographic features having the same geometry, attributes, and spatial reference; contour lines and clipping polygons are examples of feature classes included in the dataset. Raster data (herein referred to as rasters) are in a data format consisting of an array of equally sized cells arranged in rows and columns of a matrix. Rasters are used to represent continuous interpolated surfaces of hydrogeologic tops and thicknesses of units. ArcGIS version 9 was used in the creation of contour lines and rasters from point values, herein, thus changes to software in future versions of ArcGIS may result in slight differences in developing raster surfaces or contour lines from point data.

Sources of Data and Key Well Locations

Data collected from over 5,000 wells were used in the development of the revised hydrogeologic framework, including geophysical or lithologic logs from approximately 900 key wells, which were the primary source of information used to correlate major and minor hydrogeologic units (fig. 1). Data from these wells were obtained from numerous sources over a period of 2 years. Files containing the original correlation geophysical logs and lithologic descriptions used in the development of the hydrogeologic framework by Miller (1986) were initially used to evaluate geophysical log responses across the previously mapped units and for correlation to newer geophysical logs. Additional logs and data were then obtained from the South Florida Water Management District DBHYDRO database (http://www.sfwmd.gov/dbhydroplsql/show_dbkey_info.main_menu), St. Johns River Water Management District, and Southwest Florida Water Management District. In addition to these sources of data, digital well completion information and a limited number of geophysical logs were obtained from the Suwannee River Water Management District and Northwest Florida Water Management District. Geophysical logs and other data were scanned from paper files of the USGS Orlando, Ft. Lauderdale, Tampa, and Tallahassee offices in Florida, and the Atlanta offices in Georgia, and from files of the Florida Geological Survey, Geologic Survey of Alabama, and Georgia Environmental Protection Division.

Well Numbering System and Control Points

Wells used to construct the revised hydrogeologic framework were denoted with unique well identifiers (UWI) used throughout the dataset. Previously assigned well identifiers of Miller (1986) were updated to the State permit numbers or local identifiers wherever possible. Permitted oil and gas test wells were identified using State-assigned permit numbers. In Florida, permitted oil and gas test wells were denoted with a "P" prefix followed by the associated permit number (P1, for example). In Georgia, permitted oil and gas logs were denoted with a "GGS" prefix followed by the number assigned by the Georgia Geological Survey (GGS3114, for example). A few oil and gas test wells in Georgia that do not have an assigned GGS number were denoted with a "DP" prefix followed by the Georgia Environmental Protection Division permit number. In Alabama, permitted oil and gas test wells were denoted an "AP" prefix followed by the permit number (AP1111, for example). Deep test wells drilled for water-related investigations were identified using previously assigned water management district or State geologic survey identifiers. The uniqueness of each UWI was verified across the database to avoid duplication.

Control points also are contained in the database and were mostly used in aquifer outcrop areas where the hydrogeologic surfaces needed to be constrained to land surface or where thin units are dissected by streams. The control points are identified using a "u" flag designation in data tables contained in the dataset. Many of the geophysical logs utilized were published in Williams and others (2013).

Description of Study Area

The Floridan aquifer system underlies an area of about 100,000 square miles (mi^2) in the southeastern United States, including all of Florida and parts of Georgia, Alabama, and South Carolina (fig. 1). The Floridan is one of the principal aquifer systems of the United States and supplies much of the freshwater for all uses in the study area, except in extreme southern Florida and in the western Florida panhandle where the surficial aquifer system is principally used (Miller, 1986; Renken, 1996). The Floridan comprises a highly productive sequence of mostly Tertiary age carbonate rocks, including the Suwannee Limestone, Ocala Limestone, Avon Park Formation, and Oldsmar Formation, that are hydraulically connected to varying degrees (Miller, 1986). Many other deeper formations also are included in the Floridan depending on the area of consideration and degree of hydraulic connection of these rocks to the main carbonate rock system (fig. 2). The aquifer system is overlain by a thick sequence of clastic sediments and fine-grained low-permeability limestone, mostly of the Hawthorn Group of middle Miocene age, which forms its upper confining unit (UCU). The presence or absence of UCU changes the Floridan from fully confined to unconfined over short distances and is the principal control on the recharge and discharge patterns developed within the aquifer system.

Coastal Plain deposits in the study area are generally grouped into two principal facies: (1) predominantly warm, shallow marine, platform carbonate rocks that have been deposited in a thick continuous sequence beneath southeastern Georgia and the Florida peninsula and (2) predominantly clastic rocks that have been deposited in the Coastal Plain extending from the Fall Line (fig. 1) southward and eastward toward the Gulf of Mexico and Atlantic Ocean. These two major facies are respectively divided into the mostly carbonate Floridan aquifer system and the mostly clastic Southeastern Coastal Plain aquifer system (fig. 2).

Because of the gradational nature of the carbonate-clastic sequence, some of the updip clastic aquifers are included in the Floridan aquifer system, Southeastern Coastal Plain aquifer system, or both, as needed to portray the major elements of the groundwater-flow system being modeled or studied (Barker and Pernik, 1994; Bush and Johnston,

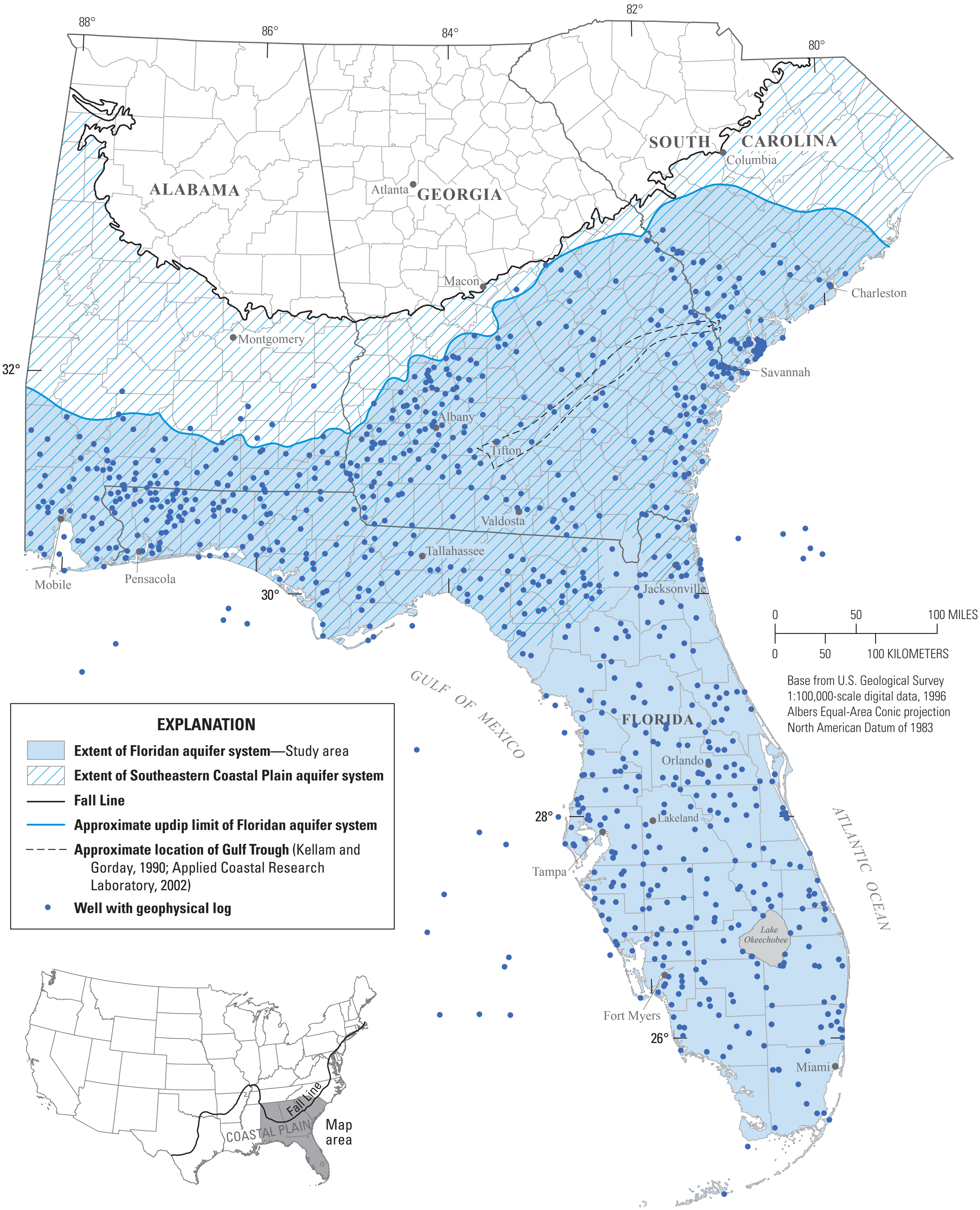

Figure 1. Study area location map showing extent of the Floridan and Southeastern Coastal Plain aquifer systems and location of key wells (modified from Williams and Kuniansky, 2015).

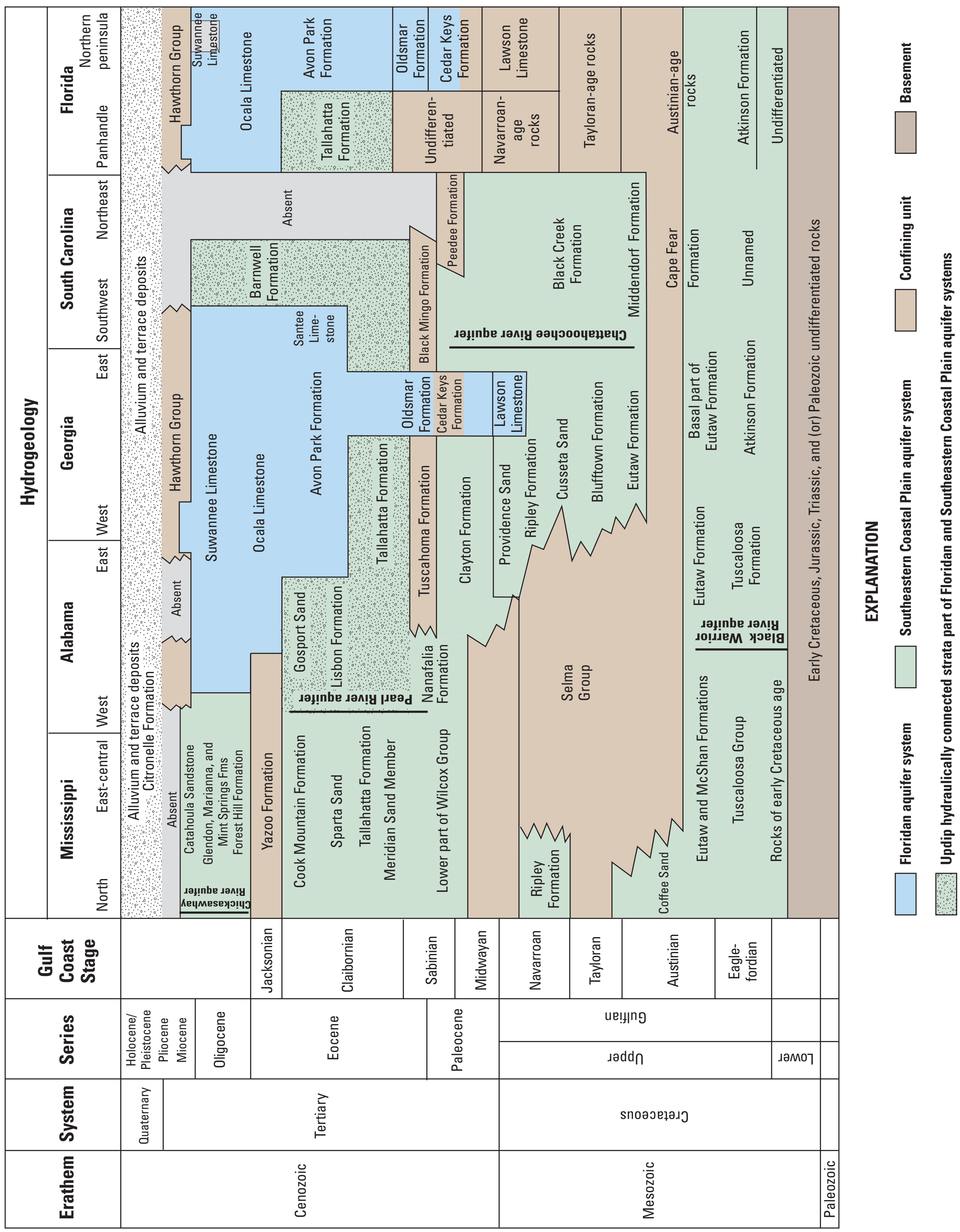

Figure 2. Generalized correlation chart showing stratigraphic units and hydrogeologic units of the Floridan and Southeastern Coastal Plain aquifer systems (Williams and Kuniansky, 2015).

1988; Campbell and Coes, 2010; Krause and Randolph, 1989; Maslia and Hayes, 1988; Payne and others, 2005). The Claiborne aquifer (McFadden and Perriello, 1983), Gordon aquifer (Brooks and others, 1985), and Lisbon aquifer (Gillett and others, 2004) are part of the regional Pearl River aquifer of the Southeastern Coastal Plain aquifer system (Renken, 1996) and are less permeable than the carbonate rocks of the Floridan aquifer system and grade laterally into the Lower Floridan aquifer. The Lisbon, Claiborne, and Gordon aquifers are shown on the correlation chart in figure 2.

Methods

Structural surfaces and thicknesses of hydrogeologic units were interpolated from scattered data points compiled mostly from correlation of geophysical and lithologic logs and data from published reports. Log measuring points were determined from information provided in the log header, digital elevation models (DEMs), the USGS National Water Information System (http://waterdata.usgs.gov/nwis/), or from digital data provided by State agencies. The depth to the top of each hydrogeologic unit was determined mostly by correlating known geophysical log response or from lithologic and available paleontological reports. Altitudes of hydrogeologic units were calculated by subtracting the depth to the top of the unit determined on the geophysical or lithologic log from the measuring point. All of the structural surfaces and two of the thickness rasters were interpolated from scattered data points using the Australian National University Digital Elevation Model method on a 1,000×1,000-meter (m) grid (Hutchinson, 1988, 1989) as implemented in ArcGIS version 9. This method can produce areas higher or lower than the data point because local trends are taken into account during the interpolation process.

The differences between actual and interpolated values determined using the Australian National University Digital Elevation Model method are summarized in table 1. Minimum and maximum residuals were mainly located in the outcrop areas of the aquifer and around features such as the Gulf Trough in Georgia where abrupt changes in altitude over short distances caused some higher minimum and maximum differences as a result of the averaging of values that occurs across 1,000×1,000-m grid cells. Actual values within 5 feet (ft) of the corresponding interpolated digital hydrogeologic surface ranged from 77 to 97 percent of the total number of values for all surfaces (fig. 3).

Table 1. Summary statistics showing difference between actual and interpolated altitudes and thickness of hydrogeologic units and surfaces.

[Count refers to the number of data points used in comparing actual and interpolated values. Mean, minimum, maximum, and absolute mean error are statistical measures between the actual and interpolated values. Positive numbers indicate interpolated value is greater than actual value and negative numbers indicate interpolated value is less than actual value. mg/L, milligrams per liter]

Top of hydrogeologic unit or thickness	Count	Minimum difference (feet)	Maximum difference (feet)	Mean difference (feet)	Mean absolute error (feet)
Top of Floridan aquifer system	5,143	–328	303	–0.81	5.75
Top of Ocala-Avon Park lower-permeability zone	143	–9.29	31.44	0.27	1.58
Top of Avon Park permeable zone (aggregated)	144	–18.29	13.76	0.017	2.13
Top of Lisbon-Avon Park composite unit (LISAPCU)	640	–132.77	61.9	–2.796	6.39
Top of middle Avon Park composite unit	240	–75.42	17.61	–0.59	2.29
Top of regional surface that defines base of Upper Floridan aquifer (top of middle confining and composite units)	780	–119.49	70.8	–2.36	5.24
Top of Bucatunna clay confining unit	142	–79.48	63.88	–0.95	5.41
Top of regional Lower Floridan aquifer	778	–120	84.72	–2.55	7.3
Top of Lower Floridan aquifer below LISAPCU	644	–109.49	63.73	–2.03	6.8
Top of lower Avon Park permeable zone	279	–25.94	81.75	0.32	2.14
Top of glauconite marker unit	151	–15.39	25.97	–0.09	2.41
Top of Oldsmar permeable zone (OLDSPZ)	174	–21.27	26.83	–0.22	1.97
Top of low resistivity zone below OLDSPZ	156	–21.52	33.79	0.007	2.6
Top of base of Floridan aquifer system	469	–42.77	40.83	–0.16	4.04
Top of 10,000-mg/L total dissolved solids boundary	561	–166.28	181.14	0.4	6.01
Thickness of surficial materials	5,227	–261.74	304.4	–0.41	3.77
Thickness of the upper confining unit	4,196	–135.91	266.45	–0.37	7.19

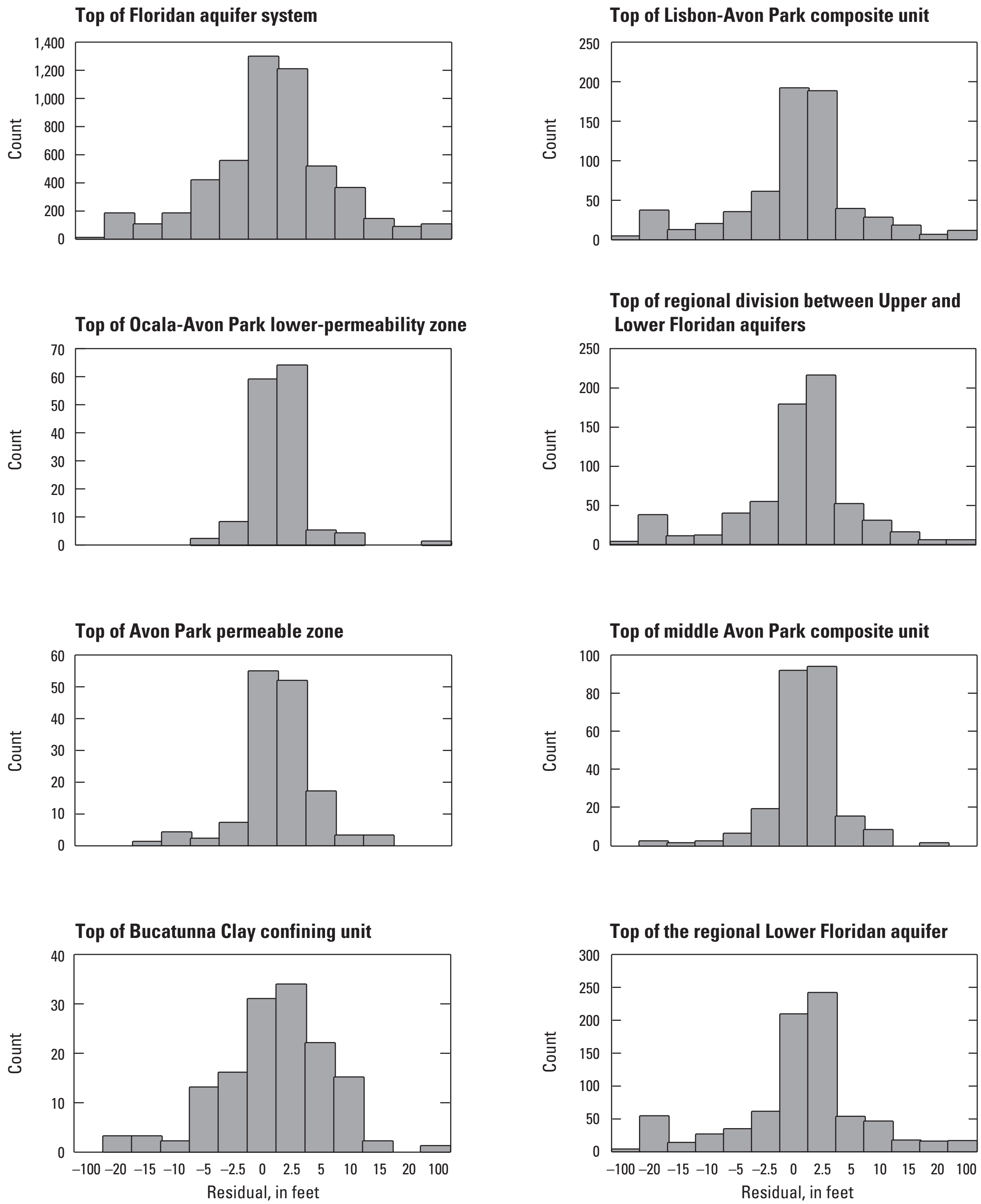

Figure 3. Histograms of residuals between actual hydrogeologic unit altitudes determined on well logs and altitudes of the interpolated hydrogeologic surface.

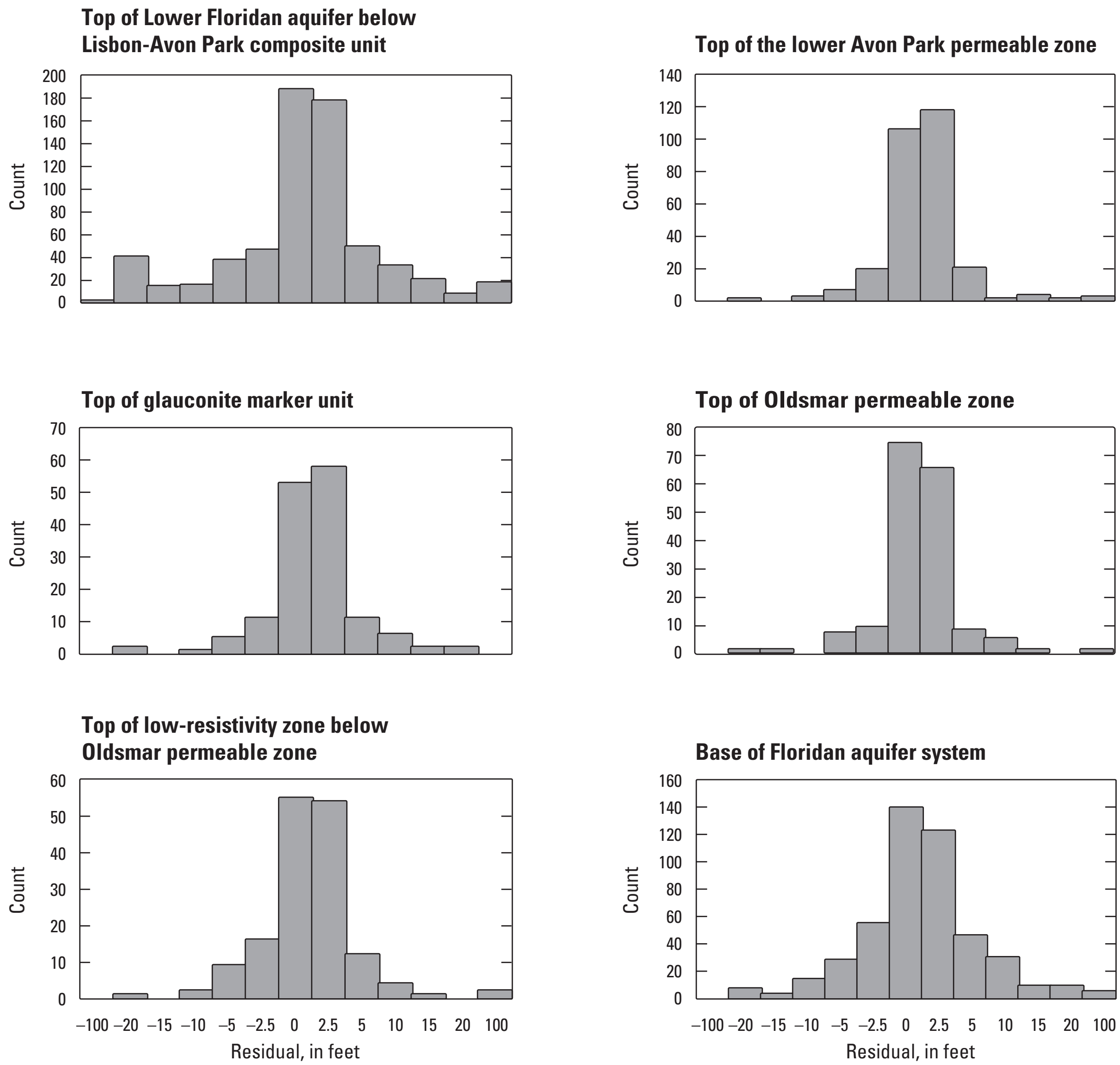

Figure 3. Histogram of residuals between actual hydrogeologic unit altitudes determined on well logs and altitudes of the interpolated hydrogeologic surface.—Continued

In the outcrop areas of the Floridan aquifer system, it was necessary to constrain some of the interpolated hydrogeologic surfaces to prevent them from inadvertently rising above land surface. To accomplish this, the top of the aquifer system was first interpolated using scattered data points without control to produce an unconstrained raster surface. This surface was then compared to the land surface DEM and reclassified to identify cells having altitudes above land surface. Using these cells as control points, the top of the Floridan was re-interpolated, setting the altitude of these cells equal to land surface altitude (minus any overlying materials). Subsequently, each of the underlying units was constrained to its overlying unit. To preserve thickness of each unit in the outcrop area, the altitude of the top of each successively deeper unit was set to a minimum of 10 ft below the overlying hydrogeologic surface. Although this approach does not produce erosional pinch-out of the units, as would be expected in some of the outcropping areas, a minimal thickness for each unit is maintained.

Thickness rasters were constructed by either using interpolation of scattered data points or surface subtraction as needed for the presentation in this report. For the surficial aquifer system and UCU, interpolation of scattered data points was used to depict the thickness of each of these units, rather than the top and bottom of each, primarily because the discontinuous nature of one or both of these units in many parts of the study area precluded explicit interpolation of their top and bottom surfaces. By using interpolation, the surficial aquifer system and UCU were essentially treated as a depositional “blanket” (over the Floridan aquifer system) whose thickness was based on scattered data points and supplemented by additional control points to delineate where these units pinch out. Interpolation also was necessary to estimate the thickness of the Floridan aquifer system and thickness of the Upper Floridan aquifer because of the large disparity between the number of data points representing the top (approximately 4,200) and base (approximately 700) of the aquifer system.

Raster surface subtraction was used for most of the remaining units of the system. These units had extents that could be “paired” together for subtraction and generally had approximately equal numbers of points representing the top and bottom of the units. The subtraction of two unit surfaces produces thicknesses that are consistent with the interpreted altitudes of the corresponding overlying and underlying digital surfaces. Thickness could not be estimated by subtraction in areas where paired surfaces did not overlap.

The hydrogeologic surfaces and thickness rasters presented in this dataset represent a continuous grid of interpolated values intended for regional-scale applications. The gridded data values may be limited for local-scale use resulting from areas of sparse well control, inaccurate log datums, uncertain hydrogeologic unit extents, interpolation limitations, and the size of the grid cell and averaging over the area of the cell. Data control points are included in the dataset so that other interpolation approaches and finer grid-cell sizes can be used if needed for future applications.

Digital Surfaces and Thicknesses of Hydrogeologic Units

The two major groundwater flow systems in the study area include the surficial aquifer system and the Floridan aquifer system. These systems interact with each other to varying degrees and are separated over much of their extent by the low-permeability sequence of clastic sediments known as the UCU of the Floridan aquifer system. The Floridan is underlain everywhere by low-permeability rocks called the lower confining unit, which separates high-permeability rocks of the Floridan aquifer system from older, deeper aquifers of the Southeastern Coastal Plain aquifer system.

The Floridan aquifer system can be progressively divided from more generalized regional units that cover the entire aquifer system into more detailed, thinner hydrogeologic zones of subregional extent (fig. 4). This report provides digital surfaces, for both the regional and subregional units, that can be used to represent the interpolated geometry of the aquifer system.

Regionally, the Floridan aquifer system is divided into two aquifers: the Upper Floridan aquifer, which consists of the uppermost permeable zone of the aquifer system, and the Lower Floridan aquifer, which consists of the lowermost permeable zones of the aquifer system and includes the largest part of the brackish- and saline-water system. Zones of higher and lower permeability have been mapped within both aquifers (Williams and Kuniansky, 2014) and represent localized or subregional areas where hydraulic properties are substantially higher or lower than the bulk properties of the aquifer unit in which they are contained.

The Upper and Lower Floridan aquifers are separated by discontinuous overlapping lithostratigraphic and hydrogeologic units of subregional extent. From top to bottom, these units are the Bucatunna clay confining unit, the Lisbon-Avon Park composite unit, and the middle Avon Park composite unit. The hydrogeologic framework and constituent units and zones of the Floridan aquifer system are described in more detail in Williams and Kuniansky (2015).

GIS Formats Used for the Digital Dataset

GIS software (ArcGIS 10.1) was used to construct digital raster surfaces representing the tops of major and minor hydrogeologic units in the Floridan aquifer system. In addition, GIS was used to generate a number of thickness rasters, structural contours, faults, extent polygons, and point features.

This dataset is downloadable as a series of compressed archives with the data contained in several different formats. The ds926.gdb.zip archive contains an Esri 10.1 file geodatabase composed of point, line, and polygon feature classes in addition to the rasterized structural surfaces. Because ArcGIS software is required to open and read the Esri 10.1 file geodatabase, the data also are provided in

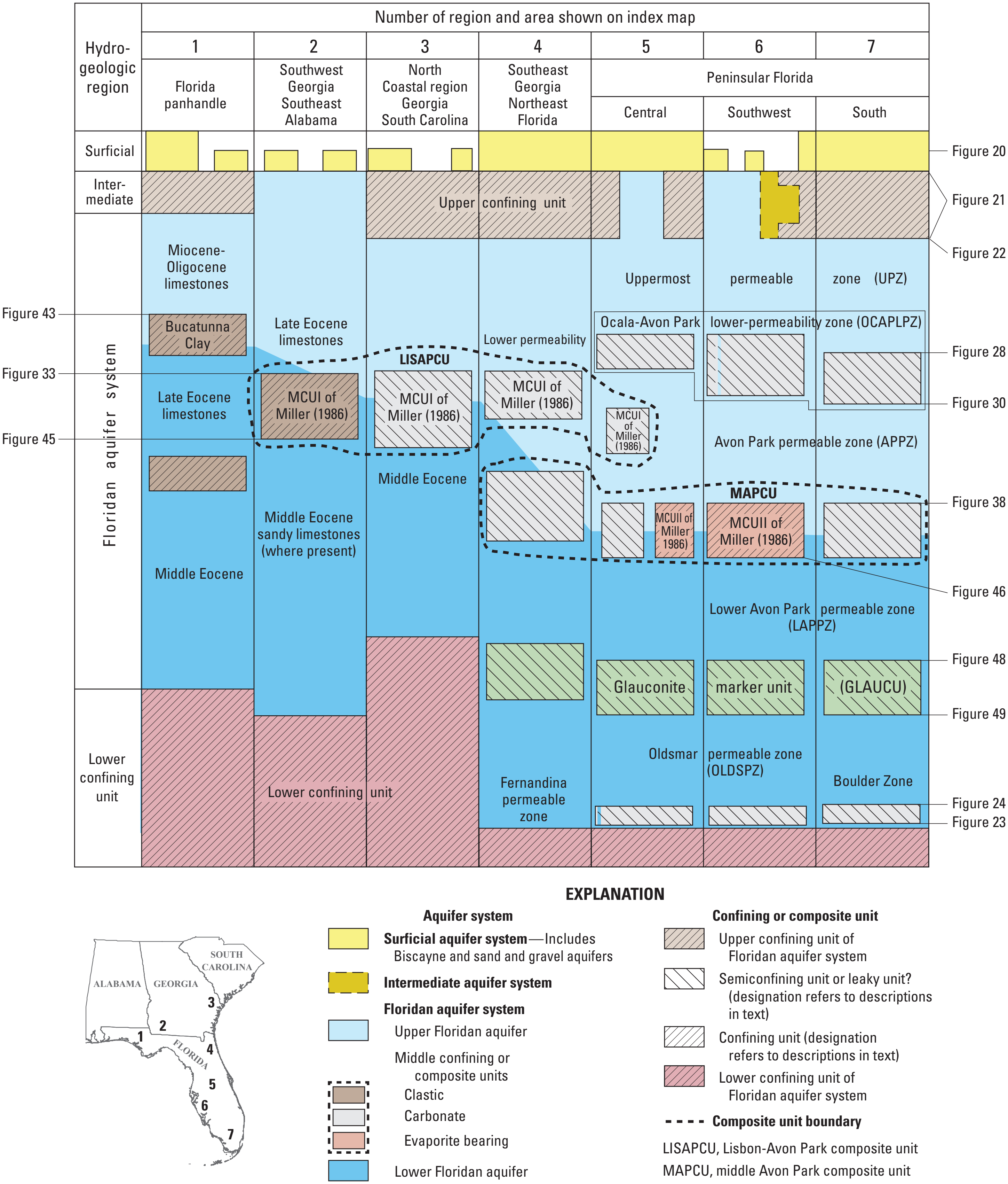

Figure 4. Schematic cross section showing regional and subregional aquifers, composite units, and confining units of the Floridan aquifer system (Williams and Kuniansky, 2015).

Esri shapefile and American Standard Code for Information Interchange (ASCII) formats that can be read by a wide variety of GIS systems. The compressed archive ds926_shapefiles.zip is a subset of the file geodatabase and contains all of the vector (point, line, and polygon) features in the Esri shapefile format. The compressed archive ds926_ASCII_rasters.zip contains the digital structural and thickness rasters in a plain ASCII format.

All geospatial datasets use a custom Albers Conical Equal Area projection with standard parallels and central meridian for the study area as follows; North American Datum of 1983, standard parallels at 29.5 and 45.5 degrees, and central meridian at –84 degrees.

Organization of Dataset

The feature classes in this dataset are mostly organized by figure number used in the companion report (Williams and Kuniansky, 2015). During the review process, some of the original figure numbers were changed and the current figure number from Williams and Kuniansky (2015) is correctly noted on figure 4 herein, but not all figure numbers included in the filenames are correct. Within the dataset, structural surfaces and thickness figures are represented by at least three feature classes, including contour, point, and a gridded raster surface. Features that appear on multiple figures, such as the Gulf Trough, faults, and aquifer boundary lines, are placed in the other features dataset. Polygon feature classes used to clip rasters and contour lines to the desired extent of the hydrogeologic unit are included in the dataset. The clipping polygons, however, may not necessarily represent the full extent of the unit in offshore areas. Clipping boundaries were drawn on the basis of data availability and usually were extended several miles offshore.

A complete list of the contents of the Floridan aquifer system framework geodatabase is provided in the appendix. An abbreviated naming convention was used in the dataset. The general format is a multipart name first identifying the figure or plate number, followed by descriptive hydrogeologic unit indicators, and ending with the nature of the data. The last part of the feature name describes the general nature of the feature, including terms such as “contours” (vectorized contour lines), “extent” (generalized clipping polygon), “pts” (point data used for contouring), and “raster” (gridded raster surface). Additional conventions used in the dataset include features containing phrases such as “saline_areas” (generalized polygon regions depicting the area of the hydrogeologic unit estimated to contain greater than 10,000 mg/L of TDS), “head_diff_wells” (wells used to calculate head differences across lower-permeability units), “regions” (polygon regions depicting different areas of a composite unit that has different hydraulic properties), and “geo_units” (polygon regions depicting the rock-stratigraphic unit at the top of the hydrogeologic unit). This report also includes thickness rasters and other features not presented in Williams and Kuniansky (2015).

Surficial Aquifer System

Post-Miocene deposits in the study area can generally be grouped into three units. From oldest to youngest, these are (1) marginal marine to shallow marine sand, clay, and limestone mostly of Pliocene age; (2) sandy, locally shelly and carbonaceous marine terrace deposits of mostly Pleistocene age; and (3) fluvial sand, gravel and (or) residuum of Holocene age. Collectively, the permeable beds of these three subdivisions are included in the surficial aquifer system. Parts of the post-Miocene sequence have been given aquifer names in places where they yield large volumes of groundwater. These local-to-subregional aquifers include the sand and gravel aquifer in the western Florida panhandle (Hayes and Barr, 1983) and the lower Tamiami (Shoemaker and Edwards, 2003), grey limestone (Reese and Cunningham, 2000), and Biscayne aquifers (Fish and Stewart, 1991) in southern Florida.

The thickness raster for the surficial aquifer system was constructed from approximately 5,200 data points and an additional 1,400 control points. Thickness values were determined from lithologic logs, geophysical logs, or both. The Florida Aquifer Vulnerability Assessment dataset (Arthur and others, 2007), and Southwest Florida Water Management District dataset (Arthur and others, 2008) were major sources of information used. In addition, a large number of control points were provided by the St. Johns River Water Management District, and additional points were obtained from the South Florida Water Management District DBHYDRO database. Thickness rasters and related features of the surficial aquifer system are listed in table 2.

Residuum thickness in southwestern Georgia and southeastern Alabama was calculated by subtracting the top of the Floridan aquifer system from a land surface DEM. The resultant raster (table 2) provides an estimate of the thickness of weathered limestone residuum formed above the top of the aquifer system. Because this raster was constructed by surface subtraction, the estimated thickness may also include any overlying alluvium or surficial deposits. The residuum thickness raster was clipped to an extent polygon (table 2), which is the estimated area of residuum determined from (1) geologic maps and (2) information obtained from area wells and test borings.

Upper Confining Unit

Low-permeability deposits of Miocene age underlie most of the study area, except for a fairly wide band in central and northwestern peninsular Florida and southwestern Georgia where they have been eroded away. The thickest and most extensive Miocene unit in the study area is the Hawthorn Group (fig. 2), discussed further in Scott (1988, 1990). In general, the Hawthorn composes a thick, generally clastic, highly variable sequence of low-permeability rock that, where present, is considered to be the UCU of the Floridan aquifer system and is identified as the intermediate confining unit (ICU) in Florida. Locally, permeable beds of the Hawthorn are included in the intermediate aquifer system (IAS) in Florida (Knochenmus, 2006; Miller, 1990) and the Brunswick aquifer system in Georgia (Clarke and others, 1990).

The thickness raster for the UCU (table 2) was interpolated using data from approximately 4,600 wells. The data points used in the interpolation were obtained from the same sources listed earlier for the surficial aquifer system. To indicate the relative degree of confinement of the Floridan aquifer system, the UCU thickness raster was classified into three polygon regions: (1) confined areas more than 100 ft thick, (2) thinly confined areas less than 100 ft thick, and (3) unconfined areas where the UCU is absent (table 2).

Table 2. Thickness rasters and other related features for the surficial aquifer system and upper confining unit.

[UCU, upper confining unit; IAS, intermediate aquifer system; ICU, intermediate confining unit]

Feature class[1]	Type	Description
fig16_thickness_Surficial_raster[2]	Thickness	Thickness of undifferentiated surficial materials above the UCU
fig16_Biscayne_aquifer	Extent polygon	Extent of the Biscayne aquifer
fig16_Sand_and_gravel_aquifer	Extent polygon	Extent of the sand and gravel aquifer
thickness_residuum_ss[3]	Thickness	Thickness of residuum overlying limestone in outcrop areas
residuum_extent	Extent polygon	Extent of areas that have weathered limestone residuum overlying the Floridan aquifer system
plate3_thickness_UCU_raster[2, 4]	Thickness	Thickness of the UCU
plate3_thickness_UCU_regions[4]	Extent polygon	Polygon regions of the UCU based on thickness
ucu_extent_poly[4]	Extent polygon	Generalized extent of the UCU
fig17_IAS_ICU_permeable_zone_extent	Extent line	Extent of permeable beds within the UCU

[1]Feature class name is that listed for geodatabase. Point and contour features not listed.

[2]Derived by interpolating thickness at individual data points.

[3]Derived by subtracting the top of the Floridan aquifer system from land surface digital elevation model.

[4]Includes the ICU and IAS in Florida.

Top of the Floridan Aquifer System

The top of the Floridan aquifer system is indicated by the start of a vertically continuous sequence of permeable carbonate rocks beneath the UCU or surficial aquifer system. Although high permeability is the major criterion established by Miller (1986) to indicate the top of the Floridan, in practice, either a distinct change in water level in the drilling annulus or an increase in artesian flow is commonly used to identify the top of permeable strata. By using permeability as the criterion, lower-permeability carbonate rocks at the top of the Floridan are commonly excluded from the aquifer system, even though these rocks may have some hydraulic connection to it. The geologic units forming the top of the aquifer system are depicted using a polygon feature class (table 3).

The structural surface representing the top of the Floridan aquifer system (table 3) was constructed using data from approximately 5,200 wells. In addition to these data points, control points were also used to constrain the top of the aquifer to land surface in outcrop areas where necessary. A polygon (fas_general_area_poly) was used to clip the raster surface and contours to the updip extent and along coastlines. Because few offshore points were available, the surface was clipped to the State coastline boundaries even though the Floridan extends offshore. A more extensive surface could be generated by including the sparse data points provided in the dataset that lie beyond the current extent of the surface; however, additional control points may be necessary constrain the surface to the seafloor and other hydrogeologic surfaces.

Table 3. Structural and thickness rasters for the Upper Floridan aquifer.

[FAS, Floridan aquifer system; UF, Upper Floridan aquifer; UPZ, uppermost permeable zone; OCAPLPZ, Ocala-Avon Park lower-permeability zone; APPZ, Avon Park permeable zone; MAPCU, middle Avon-Park confining unit]

Feature class[1]	Type	Description
fig19_top_FAS_raster	Structural	Top of FAS, UF, and UPZ
fig19_top_FAS_geologic_units	Extent polygon	Extent of geologic units forming top of FAS
fas_general_area_poly	Extent polygon	Used for clipping, shows the general extent of system
fig28_top_OCAPLPZ_raster	Structural	Top of the OCAPLPZ (base of UPZ)
thickness_OCAPLPZ_raster_ss[2]	Thickness	Thickness of the OCAPLPZ
fig30_top_APPZ_raster	Structural	Top of the APPZ (base of OCAPLPZ)
thickness_APPZ_raster_ss[3]	Thickness	Thickness of the APPZ
fig38_top_MAPCU_raster	Structural	Top of the MAPCU (base of APPZ)
fig38_top_MAPCU_regions	Extent polygon	Extent of units forming the MAPCU
mcu_regional_raster	Structural	Base of the UF
fig32_thickness_UF_raster	Thickness	Thickness of the UF

[1]Feature class name is that listed for geodatabase. Point and contour features not listed.

[2]Derived by subtracting top of OCAPLPZ from top of FAS.

[3]Derived by subtracting top of MAPCU from top of APPZ.

Upper Floridan Aquifer

The Upper Floridan aquifer includes the uppermost or shallowest permeable zones in the Floridan aquifer system. In the northern half of the study area, this aquifer is generally treated as a single hydrogeologic unit and is the undifferentiated part of the Upper Floridan aquifer. In the southern half, including most of central and southern Florida, the Upper Floridan aquifer can be differentiated into three distinct hydrogeologic units, namely the

- uppermost permeable zone (UPZ),
- Ocala-Avon Park lower-permeability zone (OCAPLPZ), and
- Avon Park permeable zone (APPZ).

The structural surfaces for the UPZ, OCAPLPZ, and the APPZ are generally contiguous in their extent and were constructed as a series of paired surfaces where the base of each overlying unit is the top of the next deeper unit (table 3). The UPZ includes the Suwannee permeable zone (Hutchinson, 1992) and permeable zones in the basal part of the Arcadia Formation and within an unnamed limestone of Oligocene age (Reese and Richardson, 2008).

The OCAPLPZ forms a subregional leaky zone within the Upper Floridan aquifer that directly underlies the uppermost permeable zone. The OCAPLPZ includes fine-grained, less-permeable carbonate rocks mostly within the Ocala Limestone in southwestern Florida, where it has been called the lower-Suwannee-Ocala semiconfining unit (Hutchinson, 1992), the Ocala semi-confiner (Clayton and McQuown, 1994), and the Ocala low-permeability zone (LaRoche, 2007). The OCAPLPZ also includes relatively less-permeable carbonate rocks in the upper part of the Avon Park Formation in southeastern Florida within MCUI of Miller (1986) and the "semiconfining unit" of Lukasiewicz (1992). Reese and Richardson (2008, p. 30) mapped the OCAPLPZ as a leaky unit above the APPZ and called it "MC1" in southern Florida. The term "lower-permeability" used herein for the OCAPLPZ is not established in the literature; however, the carbonates of the OCAPLPZ are not low in permeability (the hydraulic conductivity is not less than 10^{-3} feet per day [ft/d] and often greater than 10 ft/d) but several orders of magnitude less permeable than the cavernous or preferential flow zones within the Upper Floridan aquifer. Reese and Richardson (2008, p. 30, fig. 13) mapped it as an extensive hydrogeologic unit above the APPZ and called it "MC1" of the middle confining unit.

The APPZ (Reese and Richardson, 2008) is a highly permeable zone in central and southern Florida that is mapped overlying relatively thick beds of permeable fractured and cavernous dolostone including beds of relatively lower permeability limestone, dolomitic limestone, and dolostone. The structural surface representing the top of the APPZ (table 3) was redefined in this study to include all highly permeable and less permeable rock between the underlying middle Avon Park composite unit and overlying OCAPLPZ. The redefined unit, informally called the "aggregated Avon Park permeable zone," represents several permeable zones grouped into a single hydrogeologic unit of the Upper Floridan aquifer.

Regionally, the Upper Floridan aquifer is defined and bounded by two raster surfaces in the dataset. The top of the Upper Floridan aquifer is represented by the top of the Floridan aquifer system raster surface, which was developed using data points representing the top of the vertically continuous carbonate rock section or in unconfined areas it is the base of surficial materials overlying the carbonate rock section. The base of the Upper Floridan aquifer is represented by the top of a surface called the regional middle confining and composite unit (MCU) surface (table 3). The regional MCU represents a continuous surface developed using data points that include the middle Avon Park composite unit in peninsular Florida, Lisbon-Avon Park composite unit in northern Florida and all of Georgia, southeast Alabama, and South Carolina, and the Bucatunna clay confining unit in the western panhandle of Florida and southwest Alabama (described in the next section). The units that form the top of the regional MCU are defined with a polygon feature class (table 3).

Middle Confining and Composite Units

In the approximate middle part of the Floridan aquifer system, a series of discontinuous lower-permeability units of subregional extent are utilized to divide the aquifer system into the Upper and Lower Floridan aquifers. In the revised framework (Williams and Kuniansky, 2015), the numbered, discontinuous middle confining units previously defined by Miller (1986, p. B55–B63) were substantially revised and the numbered middle confining unit terminology abandoned. Although the term "confining unit" is not totally abandoned herein and in Williams and Kuniansky (2015), a new term, "composite unit," is introduced for lithostratigraphic units that cannot be defined as either a confining or aquifer unit over its entire extent. The confining and composite units that divide the aquifer system into the Upper and Lower Floridan aquifers from shallowest to deepest are the

- Bucatunna clay confining unit,
- Lisbon-Avon Park composite unit, and
- Middle Avon Park composite unit.

Digital structural surfaces and thickness rasters for each of the three subregional units are listed in table 4. The first two "composite units" have subregions delineated on the basis of variations in permeability and the relative degree of confinement that these units provide between the Upper and Lower Floridan aquifers. These composite units include confining material, semiconfining material, and in some areas, aquifer material that may have properties similar to those of the Upper and Lower Floridan aquifers, but are included in the litho-stratigraphic composite unit to consistently divide the aquifer system into the Upper and Lower Floridan aquifers. These raster surfaces are intended to be used in combination with an accompanying polygon feature class that depicts regional variations of relative permeability or "leakiness" (table 4). In some regions, the hydraulic properties may be well known, whereas in other areas, the hydraulic properties need to be inferred from geologic assessment of the materials that compose the unit of that region. The character of the different regions of each of the subregional middle confining and composite units are discussed further in Williams and Kuniansky (2014). The Bucatunna clay confining unit consists of a single lithostratigraphic unit and does not require polygon regions to define spatial variation in properties.

For regional representation of the "middle confining and composite unit (MCU)," the Lisbon-Avon Park composite unit, middle Avon Park composite unit, and Bucatunna clay confining unit were combined to produce the regional MCU raster (table 4). Although this surface is derived principally from each of the middle confining and composite units, it is generalized where two or more units overlap.

Table 4. Structural and thickness rasters for the middle confining and composite units of the Floridan aquifer system.

[LISAPCU, Lisbon-Avon Park composite unit; LF, Lower Floridan aquifer; MAPCU, middle Avon Park composite unit; LAPPZ, lower Avon-Park permeable zone; MCU, middle confining unit]

Feature class[1]	Type	Description
fig33_top_LISAPCU_raster	Structural	Top of the LISAPCU
fig45_top_LF_below_LISAPCU_raster	Structural	Top of the LF below LISAPCU (base of LISAPCU)
thickness_LISAPCU_raster_ss[2]	Thickness	Thickness of the LISAPCU
fig33_top_LISAPCU_regions	Extent polygon	Regional variations of the confining unit
fig38_top_MAPCU_raster	Thickness	Top of the MAPCU
fig38_top_MAPCU_regions	Extent polygon	Regional variations of confining unit
thickness_MAPCU_raster_ss[3]	Thickness	Thickness of the MAPCU
fig46_top_LAPPZ_raster	Structural	Top of the LAPPZ (base of MAPCU)
fig43_top_Bucatunna_raster	Structural	Top of the Bucatunna clay confining unit
fig43_bot_Bucatunna_raster	Structural	Base of the Bucatunna clay confining unit
thickness_Bucatunna_raster_ss[4]	Thickness	Thickness of the Bucatunna clay confining unit
mcu_regional_raster	Structural	Top of the regional middle composite and confining unit surface
fig44_top_LF_MCU_regions	Extent polygon	Regional variations of confining unit
fig44_top_LF_raster	Structural	Base of the regional MCU (top of regional LF)
thickness_MCU_regional_raster_ss[5]	Thickness	Thickness of the regional MCU

[1]Feature class name is that listed for geodatabase. Point and contour features not listed.

[2]Derived by subtracting top of the LF below LISAPCU from top of LISAPCU.

[3]Derived by subtracting top of LAPPZ from top of MAPCU.

[4]Derived by subtracting base of from top of Bucatunna clay confining unit.

[5]Derived by subtracting top of regional Lower Floridan aquifer from top of regional middle composite and confining unit (MCU) raster.

Lower Floridan Aquifer

The Lower Floridan aquifer includes (1) all permeable and less-permeable zones below the middle Avon Park composite unit in peninsular Florida, (2) the Bucatunna clay confining unit in the western panhandle of Florida and contiguous areas in Alabama, and (3) the Lisbon-Avon Park composite unit in the northern part of the study area. Digital structural surfaces and thickness rasters for the Lower Floridan aquifer and its subregional units are listed in table 5.

Subregional units of the Lower Floridan aquifer include the

- undifferentiated Lower Floridan aquifer in northern part of the Floridan aquifer system, defined herein as the Lower Floridan aquifer below the Lisbon-Avon Park composite unit (LISAPCU);
- updip clastic units, namely the Lisbon, Claiborne, and Gordon aquifers, as defined by polygon regions in Alabama, Georgia, and South Carolina, respectively. These units form updip clastic-equivalent aquifers of the predominantly carbonate Lower Floridan aquifer rocks considered to be part of the Southeastern Coastal Plain aquifer system (Renken, 1996);
- Lower Floridan aquifer beneath the Bucatunna clay confining unit in the western panhandle of Florida;
- lower Avon Park permeable zone (LAPPZ) in central and southern peninsular Florida, defined by its stratigraphic position in the Avon Park Formation below major evaporite units of the middle Avon Park composite unit;
- glauconite marker unit in central and southern peninsular Florida, distinguished by relatively low permeability and a distinctive geophysical log pattern and roughly equivalent in extent to the overlying and underlying units; and the
- Oldsmar permeable zone (OLDSPZ) in central and southern peninsular Florida, distinguished by relatively high permeability and a distinctive geophysical log pattern. Cavernous zones of the OLDSPZ include the
    - Boulder zone (BZ) in the southern Florida region (saline water zones), and
    - Fernandina permeable zone (FPZ) in northeastern Florida and southeastern Georgia region (fresh- and saline-water zones).

Table 5. Structural and thickness rasters for the Lower Floridan aquifer.

[LF, Lower Floridan aquifer; LISAPCU, Lisbon-Avon Park composite unit; LAPPZ, lower Avon-Park permeable zone; OLDSPZ, Oldsmar permeable zone; FAS, Floridan aquifer system]

Feature class[1]	Type	Description
fig45_top_LF_below_LISAPCU_raster	Structural	Top of the LF below LISAPCU
fig46_top_LAPPZ_raster	Structural	Top of the LAPPZ
fig48_top_GlaucUnit_raster	Structural	Top of the glauconite marker unit (base of LAPPZ)
thickness_LAPPZ_raster_ss[2]	Thickness	Thickness of the LAPPZ
thickness_GlaucUnit_raster_ss[3]	Thickness	Thickness of the glauconite marker unit
fig43_bot_Bucatunna_raster	Structural	Base of the Bucatunna clay confining unit (top of LF)
fig49_top_OLDSPZ_raster	Structural	Top of the OLDSPZ (base of GlaucUnit)
fig21_LowResZone_below_OLDSPZ_raster	Structural	Top of the low-resistivity zone below the OLDSPZ (base of OLDSPZ)
thickness_OLDSPZ_raster_ss[4]	Thickness	Thickness of the OLDSPZ
fig44_top_LF_raster	Structural	Top of regional LF (base of the regional middle confining unit)
fig20_base_FAS_raster	Structural	Base of the Floridan aquifer system
fig50_thickness_LF_raster_ss[5]	Thickness	Thickness of the regional LF

[1]Feature class name is that listed for geodatabase. Point and contour features not listed.

[2]Derived by subtracting top of the glauconite marker unit from top of the LAPPZ.

[3]Derived by subtracting top of the OLDSPZ from top of the glauconite marker unit.

[4]Derived by subtracting top of the low-resistivity zone below the OLDSPZ from the top of the OLDSPZ.

[5]Derived by subtracting base of the FAS from the top of the LF.

Base of Floridan Aquifer System

The base of the Floridan aquifer system is marked by rocks of relatively low permeability that are collectively included in the lower confining unit. The rocks that form the base of the Floridan range in age from late Eocene to late Paleocene, depending on the area considered. Similar to other hydrogeologic units of the aquifer system, many different formations and rock types were used to construct the basal surface of the Floridan. Data from 488 wells were used to construct the surface; the data points were obtained from geophysical logs used in cross sections and from logs collected at deep oil test and injection wells where the base was penetrated. In areas of sparse well control, the base was estimated below the exploration depth of some wells by considering the general dip of the basal units along cross-sectional lines.

In some parts of the Floridan aquifer system, its effective base may lie at a higher altitude than depicted by the base of aquifer system raster (table 5). In north-central, central, and southern Florida, a low-resistivity zone indicating low permeability, thus the potential effective base of the aquifer system, lies between the base of the OLDSPZ and the base of the aquifer system. O'Reilly and others (2002, p. 24) revised the base of the Floridan upward in Orange County, Florida, and surrounding areas so that the low-resistivity evaporitic interval is excluded from the aquifer system in that area. Thus, in this report, the equivalent surface representing the low-resistivity zone could be used as the effective base of the Floridan (table 5).

Salinity Boundaries

The interface between freshwater and saltwater was defined in this study by the 10,000-mg/L TDS boundary (table 6). This boundary usually represents a relatively thin transition from fresh to saline water. Reese (1994, 2000, 2004) and Reese and Memberg (2000) showed that the salinity transition zone from 10,000 mg/L to greater than 35,000 mg/L usually spans a few tens of feet to several hundred feet.

The raster surface representing the altitude of the estimated 10,000-mg/L TDS boundary (table 6) was constructed using geophysical logs and water-sample data from 257 wells. In addition to these data points, an additional 309 wells were used to represent the base of the aquifer system in areas where the aquifer contains water having less than 10,000 mg/L TDS. The resulting interpolated raster surface represents the altitude of the 10,000-mg/L TDS boundary or the physical base of the system, depending the presence or absence of saline water in the lower part of the aquifer.

Several polygon features showing the approximate position of the freshwater-saltwater boundary in selected hydrogeologic units were developed by intersecting the 10,000-mg/L TDS surface with the hydrogeologic unit surface. From this, polygon extents were constructed that represent saline areas for selected hydrogeologic units (table 6).

Table 6. Structural and thickness rasters and features depicting salinity boundaries in the Floridan aquifer system.

[APPZ, Avon Park permeable zone; LF, Lower Floridan aquifer; LISAPCU, Lisbon-Avon Park composite unit; LAPPZ, lower Avon-Park permeable zone; OLDSPZ, Oldsmar permeable zone; TDS, total dissolved solids; mg/L, milligrams per liter; >, greater than]

Feature class[1]	Type	Description
fig21_LowResZone_below_OLDSPZ_saline_areas	Extent polygon	Area where estimated TDS >10,000 mg/L at base of OLDSPZ
fig22_thickness_FAS_saline_areas	Thickness	Area where estimated TDS >10,000 mg/L is present in the lower part of the aquifer system
fig30_top_APPZ_saline_areas[2]	Extent polygon	Area where estimated TDS >10,000 mg/L at top of APPZ
fig45_top_LF_below_LISAPCU_saline_areas[3]	Extent polygon	Area where estimated TDS >10,000 mg/L at top of LF below LISAPCU
fig46_top_LAPPZ_saline_areas[4]	Extent polygon	Area where estimated TDS >10,000 mg/L at top of LAPPZ
fig49_top_OLDSPZ_saline_areas	Extent polygon	Area where estimated TDS >10,000 mg/L at top of OLDSPZ
fig50_thickness_LF_saline_areas	Extent polygon	Area where estimated TDS >10,000 mg/L at top of LF
fig55_top_est_10000_TDS_boundary_raster	Structural	Altitude of the estimated 10,000-mg/L boundary
fig55_top_est_10000_TDS_areas	Extent polygon	Areas depicting regions of the 10,000-mg/L map
fig56_Thickness_FWZ_FAS_raster	Thickness	Thickness of the "freshwater" part of the Floridan aquifer system

[1]Feature class name is that listed for geodatabase. Point and contour features not listed.

[2]Derived by intersecting the estimated 10,000-mg/L surface with the top of the APPZ.

[3]Derived by intersecting the estimated 10,000-mg/L surface with the top of the LF below LISAPCU.

[4]Derived by intersecting the estimated 10,000-mg/L surface with the top of the LAPPZ.

Other Features

Several additional feature classes in the dataset not described earlier include raster surfaces for geophysical marker horizons, an interpolated raster of regional transmissivity for the Upper Floridan aquifer (Kuniansky and others, 2012), an aquifer-wide potentiometric map for May 2010 (Kinnaman and Dixon, 2011), cross-section lines, key well location points used for the framework development, and feature classes representing the major structural features in the study area. County and State boundaries and feature classes representing the major streams are included as base-map features.

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Appendix 1

Table 1–1. Content provided in the Floridan framework geodatabase.

[OCAPLPZ, Ocala-Avon Park low permeability zone; APPZ, Avon Park permeable zone; LISAPCU, Lisbon-Avon Park composite unit; MAPCU, middle Avon Park confining unit; LAPPZ, Lower Avon Park permeable zone; BZ, Boulder Zone; FPZ, Fernandina permeable zone; mg/L, milligrams per liter]

Layer	Title
Primary layers	
fig02_Xsection_Lines	Cross-section lines
fig02_Xsection_wells	Cross-section well locations
fig05_Floridan_Geology_Outcrops	Generalized geologic map of the southeastern United States
fig06_Positive_structural_elements	Positive structural features within the study area
fig06_Structural_features	Structural features in the study area
fig12_ClosedDepressions_density_poly	Frequency of closed depressions in relation to major springs in study area
fig12_Springs_all	Spring locations in Florida, Georgia, and Alabama
fig12_Woodvillekarst	Extent of the Woodville Karst Plain
fig17_bot_UpperDolostoneUnit_raster	Raster surface depicting the bottom of the Avon Park Formation upper dolostone unit
fig17_top_UpperDolostoneUnit_contour	Contours for the top of the upper Avon Park dolostone unit
fig17_top_UpperDolostoneUnit_pts	Points for the top of the Avon Park dolostone
fig17_top_UpperDolostoneUnit_raster	Raster surface depicting the top of the upper dolostone unit of the Avon Park Formation
fig19_top_GlaucMarkerHorizon_contour	Contours for the top of the glauconite marker horizon
fig19_top_GlaucMarkerHorizon_pts	Points for the top of the glauconite marker horizon
fig19_top_GlaucMarkerHorizon_raster	Raster surface depicting the glauconite marker horizon
fig20_Biscayne_aquifer	Extent of the Biscayne aquifer of the surficial aquifer system
fig20_Sand_and_gravel_aquifer	Extent of the sand-and-gravel aquifer of the surficial aquifer system
fig20_thickness_Surficial_contour	Thickness contours for surficial deposits of the surficial aquifer system
fig20_thickness_Surficial_pts	Thickness data points for surficial deposits
fig20_thickness_Surficial_raster	Thickness raster surface for surficial deposits
fig20_thickness_Surficial_raster_clipped	Thickness raster surface for surficial deposits, clipped
fig21_IAS_ICU_permeable_zone_extent	Extent lines for permeable zones of the intermediate aquifer system and Brunswick aquifer system
fig21_thickness_UCU_units	Polygons representing thickness of the upper confining unit of the Floridan aquifer system
fig22_top_FAS_generalized_contour	Generalized contours for the top of the Floridan aquifer system
fig22_top_FAS_geologic_units	Geologic units forming top of the Floridan aquifer system
fig23_base_FAS_contour	Contours for the base of the Floridan aquifer system
fig23_base_FAS_geologic_units	Geologic units forming base of the Floridan aquifer system
fig23_base_FAS_pts	Points for the base of the Floridan aquifer system
fig23_base_FAS_raster	Raster surface depicting the base of the Floridan aquifer system
fig24_LowResZone_below_OLDSPZ_contour	Contours for the top of the low-resistivity interval below the Oldsmar permeable zone
fig24_LowResZone_below_OLDSPZ_pts	Points for the top of the Oldsmar permeable zone
fig24_LowResZone_below_OLDSPZ_raster	Raster surface depicting the top of the low-resistivity interval below the Oldsmar permeable zone
fig24_LowResZone_below_OLDSPZ_saline_areas	Polygon regions depicting saline areas within low-permeability rocks near base of the Oldsmar permeable zone
fig25_thickness_FAS_contour	Contours for thickness of the Floridan aquifer system
fig25_thickness_FAS_pts	Points for the thickness of the Floridan aquifer system
fig25_thickness_FAS_raster	Raster surface depicting the thickness of the Floridan aquifer system
fig25_thickness_FAS_saline_areas	Polygon regions depicting saline areas within the Floridan aquifer system
fig28_Head_difference_wells	Points where head differences were calculated across the OCAPLPZ

Table 1–1. Content provided in the Floridan framework geodatabase.—Continued

[OCAPLPZ, Ocala-Avon Park low permeability zone; APPZ, Avon Park permeable zone; LISAPCU, Lisbon-Avon Park composite unit; MAPCU, middle Avon Park confining unit; LAPPZ, Lower Avon Park permeable zone; BZ, Boulder Zone; FPZ, Fernandina permeable zone; mg/L, milligrams per liter]

Layer	Title
Primary layers—Continued	
fig28_Head_gradient_areas	Head gradient regions (up or down) for the OCAPLPZ
fig28_top_OCAPLPZ_contour	Contours for the top of the OCAPLPZ
fig28_top_OCAPLPZ_extent	Clipping boundary extent for the OCAPLPZ
fig28_top_OCAPLPZ_extent_line	Boundary line for the OCAPLPZ
fig28_top_OCAPLPZ_pts	Points for the top of the OCAPLPZ
fig28_top_OCAPLPZ_raster	Raster surface depicting the altitude of the top of the OCAPLPZ
fig30_Limestone_line	Limestone boundary for the APPZ (Reese and Richardson, 2008)
fig30_top_aggregated_APPZ_contour	Contours for the top of the APPZ
fig30_top_aggregated_APPZ_extent	Clipping boundary extent of the APPZ
fig30_top_aggregated_APPZ_pts	Points for the top of the APPZ
fig30_top_aggregated_APPZ_raster	Raster surface depicting the top of the APPZ
fig30_top_aggregated_APPZ_saline_areas	Polygon regions depicting saline areas for the APPZ
fig32_thickness_UF_contour	Contours for the thickness of the Upper Floridan aquifer
fig32_thickness_UF_lowPerm_units	Polygon regions of low permeability units forming the base of the Upper Floridan aquifer
fig32_thickness_UF_pts	Points for the thickness of the Upper Floridan aquifer
fig32_thickness_UF_raster	Raster surface depicting the thickness of the Upper Floridan aquifer
fig33_top_LISAPCU_contour	Contours for the top of the LISAPCU
fig33_top_LISAPCU_extent	Clipping boundary extent for the LISAPCU
fig33_top_LISAPCU_MCUI_dolostone	Polygon regions of low-permeability units forming the LISAPCU
fig33_top_LISAPCU_pts	Points for top of the LISAPCU
fig33_top_LISAPCU_pts_constrained	Points for top of the LISAPCU, constrained
fig33_top_LISAPCU_raster	Raster surface depicting the top of the LISAPCU
fig33_top_LISAPCU_regions	Polygon regions of low-permeability units forming the LISAPCU
fig38_top_MAPCU_contour	Contours for the top of the MAPCU
fig38_top_MAPCU_extent	Clipping boundary extent for the MAPCU
fig38_top_MAPCU_head_diff_wells	Points where head differences were calculated across the MAPCU
fig38_top_MAPCU_MCUII_IB_III_pts	Points for the top of the MAPCU
fig38_top_MAPCU_raster	Raster surface depicting the top of the MAPCU
fig38_top_MAPCU_regions	Polygon regions of low-permeability units forming the MAPCU
fig43_bot_Bucatunna_raster	Raster surface depicting the bottom of the Bucatunna clay confining unit
fig43_top_Bucatunna_contour	Contours for the top of the Bucatunna clay confining unit
fig43_top_Bucatunna_extent	Clipping boundary extent for the Bucatunna clay confining unit
fig43_top_Bucatunna_pts	Points for the top of the Bucatunna clay confining unit
fig43_top_Bucatunna_raster	Raster surface depicting the top of the Bucatunna clay confining unit
fig43_top_Bucatunna_regions	Clipping boundary extent for the Bucatunna clay confining unit
fig44_top_LF_contour	Contours for the top of the Lower Floridan aquifer
fig44_top_LF_MCU_regions	Polygon regions depicting the low-permeability units that overlie the Lower Floridan aquifer
fig44_top_LF_pts	Points for the top of the Lower Floridan aquifer
fig44_top_LF_raster	Raster surface depicting top of the Lower Floridan aquifer

Table 1–1. Content provided in the Floridan framework geodatabase.—Continued

[OCAPLPZ, Ocala-Avon Park low permeability zone; APPZ, Avon Park permeable zone; LISAPCU, Lisbon-Avon Park composite unit; MAPCU, middle Avon Park confining unit; LAPPZ, Lower Avon Park permeable zone; BZ, Boulder Zone; FPZ, Fernandina permeable zone; mg/L, milligrams per liter]

Layer	Title
Primary layers—Continued	
fig45_top_LF_below_LISAPCU_contour	Contours for the top of the first permeable zone below the LISAPCU
fig45_top_LF_below_LISAPCU_extent	Clipping boundary extent for the first permeable zone below the LISAPCU
fig45_top_LF_below_LISAPCU_pts	Points for the top of the Lower Floridan aquifer below the LISAPCU
fig45_top_LF_below_LISAPCU_pts_constrained	Points for the top of the Lower Floridan aquifer below the LISAPCU, constrained
fig45_top_LF_below_LISAPCU_raster	Raster surface depicting top of the Lower Floridan aquifer below the LISAPCU
fig45_top_LF_below_LISAPCU_saline_areas	Polygon regions depicting saline areas within the first permeable zone below the LISAPCU
fig46_top_LAPPZ_contour	Contours for the top of the LAPPZ
fig46_top_LAPPZ_extent	Clipping boundary extent for the LAPPZ
fig46_top_LAPPZ_pts	Points for the top of the LAPPZ
fig46_top_LAPPZ_raster	Raster surface depicting the top of the LAPPZ
fig46_top_LAPPZ_saline_areas	Polygon regions depicting saline areas of the LAPPZ
fig48_top_GlaucUnit_contour	Contours of the top of the glauconite marker unit
fig48_top_GlaucUnit_extent	Clipping boundary extent for the glauconite marker unit
fig48_top_GlaucUnit_pts	Points for the top of the glauconite marker unit
fig48_top_GlaucUnit_raster	Raster surface depicting top of the glauconite marker unit
fig48_top_GlaucUnit_regions	Polygon regions of the glauconite marker unit
fig49_top_OLDSPZ_BZ_area_Miller	Polygon extent of the BZ region of the Oldsmar permeable zone
fig49_top_OLDSPZ_contour	Contours for the top of the Oldsmar permeable zone
fig49_top_OLDSPZ_extent	Clipping boundary extent for the Oldsmar permeable zone
fig49_top_OLDSPZ_FPZ_area_Miller	Extent of the FPZ region of the Oldsmar permeable zone
fig49_top_OLDSPZ_pts	Points for the top of the Oldsmar permeable zone
fig49_top_OLDSPZ_raster	Raster surface depicting the top of the Oldsmar permeable zone
fig49_top_OLDSPZ_saline_areas	Polygon regions depicting saline areas of the Oldsmar permeable zone
fig50_thickness_LF_contour	Contours for thickness of the Lower Floridan aquifer
fig50_thickness_LF_pts	Points for the thickness of the Lower Floridan aquifer
fig50_thickness_LF_raster	Raster surface depicting the thickness of the Lower Floridan aquifer
fig50_thickness_LF_saline_areas	Polygon regions depicting saline areas of the Lower Floridan aquifer
fig51_Springs	Spring locations used in the transmissivity map
fig51_Transmissivity	Raster surface for transmissivity of the Upper Floridan aquifer
fig51_Transmissivity_wells	Estimated transmissivity of the Upper Floridan aquifer
fig53_Major_GW_divides	Major groundwater divides of the Floridan aquifer system
fig53_May2010_Potentiometric_contour	Potentiometric surface contours of the Upper Floridan aquifer in May 2010
fig53_May2010_Potentiometric_wells	Well locations used in the development of the potentiometric surface map for the Upper Floridan aquifer in May 2010
fig54_Apalachicola_salinity_feature	Extent of the Apalachicola salinity feature
fig54_top_est_10000_TDS_areas	Polygon regions for the 10,000 mg/L total dissolved solids boundary feature
fig54_top_est_10000_TDS_boundary_contour	Estimated altitude of the 10,000 mg/L total dissolved solids boundary
fig54_top_est_10000_TDS_boundary_pts	Points for the top of the 10,000 mg/L total dissolved solids boundary
fig54_top_est_10000_TDS_boundary_pts_Control	Points and control points for the top of the 10,000 mg/L total dissolved solids boundary
fig54_top_est_10000_TDS_boundary_raster	Raster surface generated for the 10,000 mg/L total dissolved solids boundary across the study area

Table 1–1. Content provided in the Floridan framework geodatabase.—Continued

[OCAPLPZ, Ocala-Avon Park low permeability zone; APPZ, Avon Park permeable zone; LISAPCU, Lisbon-Avon Park composite unit; MAPCU, middle Avon Park confining unit; LAPPZ, Lower Avon Park permeable zone; BZ, Boulder Zone; FPZ, Fernandina permeable zone; mg/L, milligrams per liter]

Layer	Title
Primary layers—Continued	
fig55_thickness_FWZ_FAS_contours	Contours for the freshwater thickness of the Floridan aquifer system
fig55_thickness_FWZ_FAS_pts	Points for the freshwater thickness of the Floridan aquifer system
fig55_thickness_FWZ_FAS_raster	Raster surface generated for the freshwater thickness of the Floridan aquifer system
mcu_regional_contour	Contours for top of the middle confining unit of the Floridan aquifer system
mcu_regional_pts	Point features used for the top of the regional middle confining unit (base of Upper Floridan aquifer)
mcu_regional_pts_constrained	Point features used for the top of the regional middle confining unit (base of Upper Floridan aquifer), constrained
mcu_regional_raster	Raster surface depicting the top of the regional middle confining unit (base of Upper Floridan aquifer)
plate1_key_wells	Key well sites
plate1_WellClusterSites	Well cluster sites
plate1_Xsection_Lines	Cross-section lines used in study
plate1_xsection_wells	Wells used in cross-sections
plate3_hawthorn_absent	Area where upper confining unit is thin or absent beneath the surficial aquifer
plate3_thickness_UCU_contours	Contours for thickness of the upper confining unit of the Floridan aquifer system
plate3_thickness_UCU_pts	Point features for the thickness of the upper confining unit
plate3_thickness_UCU_raster	Raster surface depicting the thickness of the upper confining unit
plate3_thickness_UCU_regions	Thickness regions of the upper confining unit
plate3_Updip_limit_confining_unit	Line showing approximate updip limit of the upper confining unit of the Floridan aquifer system
plate3_Updip_limit_upper_Floridan	Line showing the updip limit of the permeable upper Floridan aquifer system in a local area
plate4_Top_FAS_contours_20	Potentiometric surface contours for the top of the Floridan aquifer system—20 foot interval
plate4_Top_FAS_contours_50	Potentiometric surface contours for the top of the Floridan aquifer system—50 foot interval
plate4_Top_FAS_geo_units	Geologic units forming the top of the Floridan aquifer system
plate4_Top_FAS_pts	Points for the top of the Floridan aquifer system
plate4_Top_FAS_pts_constrained	Points for the top the Floridan aquifer system, constrained
plate4_Top_FAS_raster	Raster surface depicting the top of the Floridan aquifer system
plate5_base_FAS_contours	Contours for the base of the Floridan aquifer system
plate5_base_FAS_geo_units	Geologic units forming the base of the Floridan aquifer system
plate5_base_FAS_pts	Point features used for the base of the Floridan aquifer system
plate5_base_FAS_raster	Raster surface depicting the base of the Floridan aquifer system
plate6_thickness_FAS_contours	Contours for thickness of the Floridan aquifer system aquifer
plate6_thickness_FAS_pts	Point features for the thickness of the Floridan aquifer system
plate6_thickness_FAS_raster	Raster surface depicting the thickness of the Floridan aquifer system
plate6_thickness_FAS_saline_areas	Polygon regions depicting saline areas within the Floridan aquifer system
thickness_aggregated_APPZ_pts	Points for the thickness of the APPZ
thickness_aggregated_APPZ_raster_ss	Raster surface depicting the thickness of the aggregated APPZ
thickness_Bucatunna_pts	Points for the thickness of the Bucatunna clay confining unit
thickness_Bucatunna_raster_ss	Raster surface depicting the thickness of the Bucatunna clay confining unit

Table 1–1. Content provided in the Floridan framework geodatabase.—Continued

[OCAPLPZ, Ocala-Avon Park low permeability zone; APPZ, Avon Park permeable zone; LISAPCU, Lisbon-Avon Park composite unit; MAPCU, middle Avon Park confining unit; LAPPZ, Lower Avon Park permeable zone; BZ, Boulder Zone; FPZ, Fernandina permeable zone; mg/L, milligrams per liter]

Layer	Title
Primary layers—Continued	
thickness_GlaucUnit_pts	Points for the thickness of the glauconite marker unit
thickness_GlaucUnit_raster_ss	Raster surface depicting the thickness of the glauconite marker unit
thickness_LAPPZ_pts	Points for the thickness of the LAPPZ
thickness_LAPPZ_raster_ss	Raster surface depicting the thickness of the LAPPZ
thickness_LISAPCU_MCUI_pts	Points for the thickness of the LISAPCU
thickness_LISAPCU_raster_ss	Raster surface depicting the thickness of the LISAPCU
thickness_MAPCU_MCUII_IB_III	Points for the thickness of the MAPCU
thickness_MAPCU_raster_ss	Raster surface depicting the thickness of the MAPCU
thickness_MCU_regional_pts	Points for the thickness of the regional middle confining unit
thickness_MCU_regional_raster_ss	Raster surface depicting the thickness of the middle confining unit
thickness_OCAPLPZ_pts	Points for the thickness of the OCAPLPZ
thickness_OCAPLPZ_raster_ss	Raster surface depicting the thickness of the OCAPLPZ
thickness_OLDSPZ_pts	Points for the thickness of the Oldsmar permeable zone
thickness_OLDSPZ_raster_ss	Raster surface depicting the thickness of the Oldsmar permeable zone
thickness_residuum_ss	Raster surface depicting the thickness of residuum in southwestern Georgia and southeastern Alabama
thickness_UCU_residuum_pts	Points depicting the thickness of the upper confining unit or limestone residuum
thickness_UPZ_pts	Points for the thickness of the UPZ
thickness_UPZ_raster_ss	Raster surface depicting the thickness of the UPZ
Base-map layers	
countybnd_2m	County boundaries for states represented in the study area
fourstates2m	Region of four states spanning the study area
hydro_2m	Hydrography represented in the study area
lake_okeechobee	Lake Okeechobee outline
lakes_2m	Lakes represented in study area
streams_2m	Streams represented in study area
Other features	
alluvium_major_streams_buffer	Polygon regions of alluvial areas
fas_extent_line	Updip extent line of the Floridan aquifer system
fas_extent_line_clipped	Updip extent line of the Floridan aquifer system - clipped
fas_extent_poly	Extent of the Floridan aquifer system
fas_general_area_poly	General area of the Floridan aquifer system
fas_low_perm_areas_gulf_trough	Extent of the low-permeable areas of the Floridan aquifer system in the Gulf Trough
fas_outcrops_poly	Outcropping areas of the Floridan aquifer system
faults_Miller	Faults in the study area (Miller, 1986)
residuum_extent_poly	Polygon region depicting the weathered limestone residuum of the Floridan aquifer system
surficial_generalized_extent	Polygon region of the surficial thickness greater than 10 feet
ucu_extent_poly	Polygon regions of the upper confining unit of the Floridan aquifer system
uf_permeable_extent_line	Line showing the approximate updip limit of permeable rocks forming the Upper Floridan aquifer

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