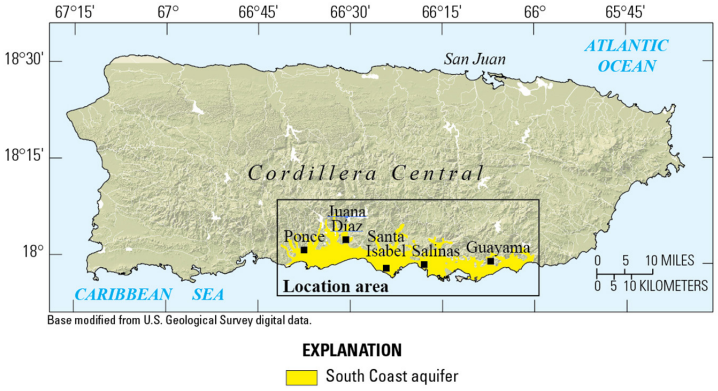
Caribbean-Florida Water Science Center Newsletter Summer 2016

U.S. Geological Survey
Caribbean-Florida Water Science Center Newsletter

USGS Report Summarizing Hydrologic Conditions in Puerto Rico



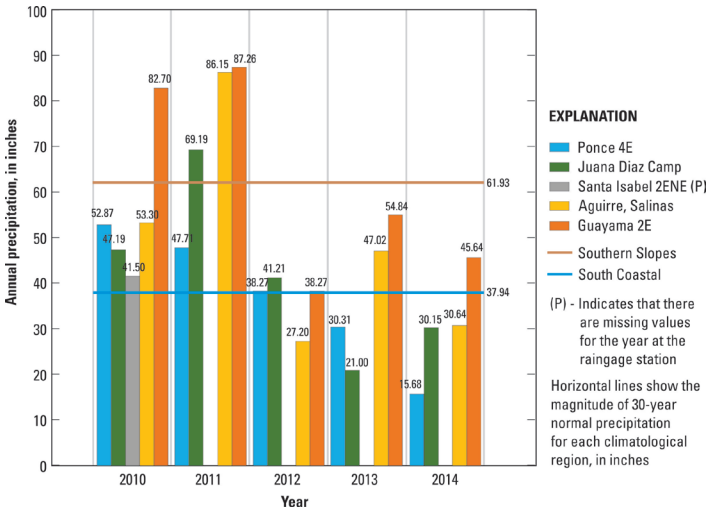
Location of South Coast Province and South Coast aquifer, Puerto Rico.

Hydrologic conditions in the South Coast aquifer of Puerto Rico during 2010-2015 were described in a recently released Open-File Report written by Sigfredo Torres-Gonzalez and Jose M. Rodriguez. The U.S. Geological Survey documents hydrologic conditions in Puerto Rico and provides hydrologic data that can help improve understanding of the water resources of the region. Groundwater from the South Coast aquifer is the principal source of potable water for towns along the southern coast of the island and also a primary source of water for agricultural irrigation.

The hydrologic data summarized in the report indicate that (1) groundwater levels declined as much as 40 feet in the Salinas area and 11 feet in the Guayama area during 2012–14; (2) groundwater withdrawals for agricultural irrigation increased from 6.0 to 10.5 million gallons per day, or 75 percent, from 2010 to 2012; and (3) total groundwater withdrawals increased from 29.3 to 32.4 million gallons per day from 2010 to 2012. The quantity and quality of water in the aquifer is primarily affected by variations in aquifer recharge as a result of changing rainfall or modes of irrigation; however, the spatial patterns and magnitude of water withdrawals for all uses have a secondary impact on the quantity and quality of water in the aquifer.

National Oceanic and Atmospheric Administration data from climatological stations indicate that the 30-year normal precipitation for the period 1991–2010 in the South Coastal and Southern Slopes climatological regions was about 37.74 and 61.61 inches, respectively; the 30-year moving average precipitation for the period 1985–2014 was 37.94 and 61.80 inches, respectively, for these regions. The mean annual precipitation during 2012–14 was 13 percent below the 30-year moving average for the South Coastal climatological region and 7.7 percent below for the Southern Slopes climatological region. When rainfall is below the 30-year moving average, recharge is diminished and groundwater levels decline. Annual precipitation over the extent of the South Coast aquifer, which includes a large part of the South Coastal and Southern Slopes climatological regions, was 39.42, 37.25, and 34.89 inches per year for 2012, 2013, and 2014, respectively.

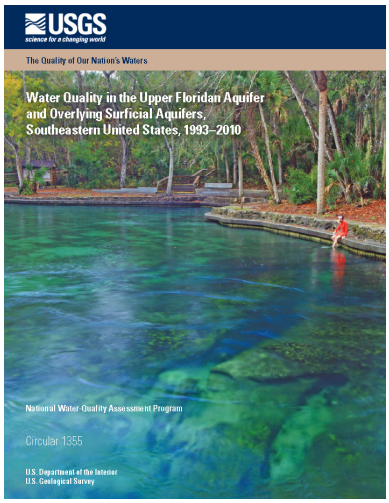
Water level declines reduce the thickness of freshwater in the unconfined parts of the South Coast aquifer. Additionally, the pumping-induced migration of poor-quality water from deep or seaward areas of the aquifer can contribute to reductions in the thickness of freshwater in the aquifer. The reduction in the freshwater saturated thickness of the aquifer in areas near Ponce, Juana Díaz, Salinas, and Guayama is of particular concern because the total saturated thickness of the aquifer is thinner in these areas. Total dissolved solids concentration in groundwater samples indicates a small increasing trend with time in Ponce, Santa Isabel, Salinas, and Guayama. Diminished aquifer recharge during 2012 to 2015 and, to a lesser extent, increased groundwater withdrawals have reduced the freshwater saturated thickness of the aquifer. The reduction in freshwater saturated thickness of the aquifer may affect freshwater resources available for public water supply and agriculture. A prolonged time period with reduced aquifer recharge may have substantial implications for groundwater levels and fresh groundwater availability.



Annual precipitation measured at National Weather Service rainfall stations, and 30-year moving normal precipitation for the South Coastal and Southern Slopes climatological regions, South Coast aquifer, Puerto Rico, 2010-14.

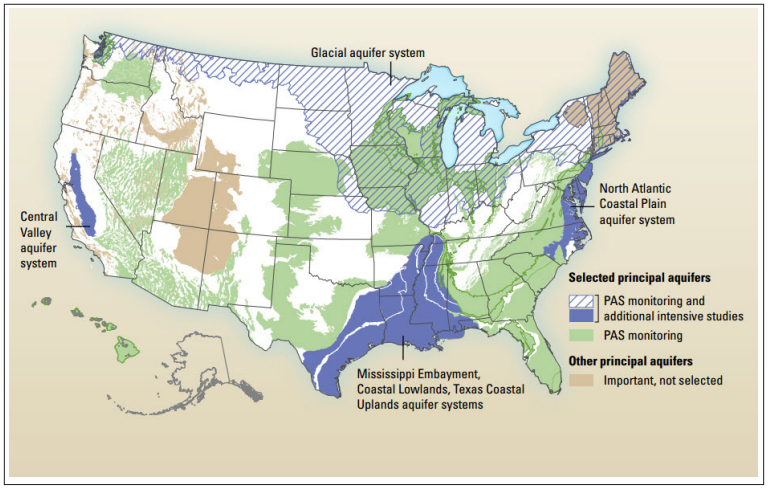
USGS National Water-Quality Assessment (NAWQA) Data Collection in Florida

In 1991, the NAWQA program was established to provide nationally consistent long-term data sets and information about the quality of the Nation's streams and groundwater. NAWQA studies provide information on current water-quality conditions, a baseline for trend evaluation, and an improved understanding of the factors that affect water quality. Groundwater studies for the NAWQA program provide information on the quality of water in shallow monitoring wells, domestic-supply wells, and public-supply wells. Results from groundwater studies within the state of Florida are summarized in a recently released *USGS Circular.*

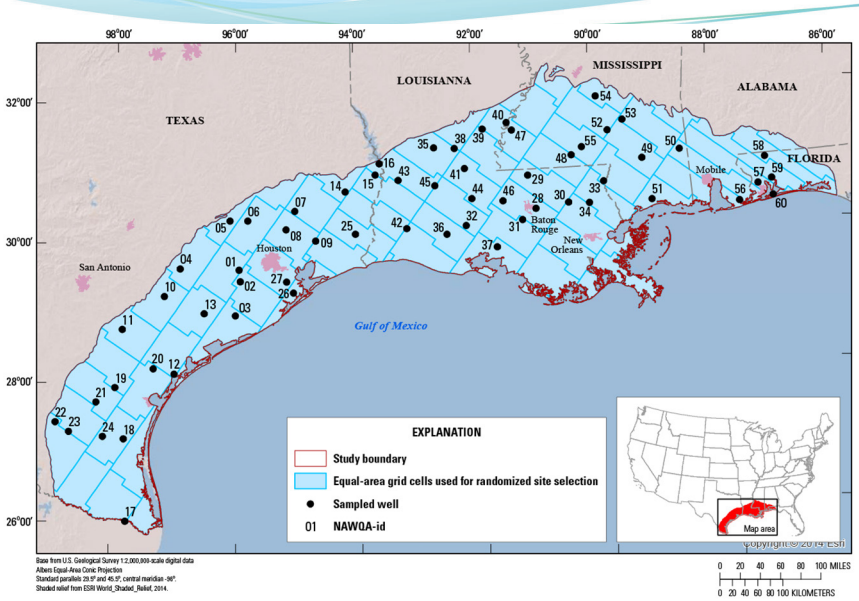


In the third decade (2013-2023) of the NAWQA program the USGS has initiated a *Principal Aquifer Survey* designed to assess the quality and availability of groundwater used for public supply. Nineteen aquifers from the 62 principal aquifers underlying the United States were selected for regional assessment. Three of the selected principal aquifers, the Coastal Lowlands, Floridan, and Biscayne, underlie parts of Florida. Well selection is determined using an equal area grid and random well selection process. The focus of the Survey is on the quality of raw water. Results of the sampling will be made publicly available through USGS databases and publications. Owner information and specific well locations are not released to the public. This is not compliance sampling; however well owners will be informed of constituent concentrations exceeding Maximum Contaminant Levels (MCLs). Although many of the constituents sampled do not have MCLs, this information may help improve the understanding of the occurrence of natural and (or) human-related constituents in public supply wells. In addition, samples will be evaluated for the age of groundwater from each supply well. This information has proven valuable for understanding the groundwater system from which water supplies are withdrawn. The constituents to be analyzed in each well are listed in the following table.

Constituents sampled as part of the Principal Aquifer Survey	
Field Measurements	dissolved oxygen, pH, specific conductance, temperature, alkalinity, turbidity and water levels
Basic Suite	major inorganics, nutrients, dissolved organic carbon, trace elements
Pesticides	(200+) pesticides and metabolites
VOCs	(90+) volatile organic compounds
Pharmaceuticals	human health pharmaceuticals, hormones
Radionuclides	radon, radium isotopes (224, 226, 228), polonium-210, lead-210, gross alpha and beta
Microbial Indicators	total coliform, E. coli bacteria, enterococci bacteria, somatic and F-specific coliphage
Age-Dating	tritium, helium, SF_6, dissolved gases, ^{14}C and ^{13}C, oxygen & deuterium stable isotope ratios



Principal aquifers in the United States selected for monitoring in the Principal Aquifer Survey and for additional intensive study.

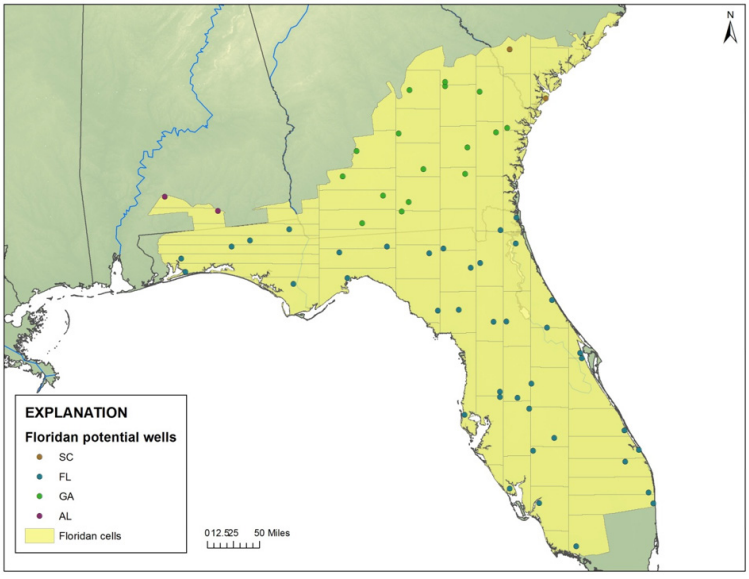


Map showing the 60 public supply wells sampled as part of the Coastal Lowlands Principal Aquifer Survey; 4 of the 60 public supply wells were located in Florida.

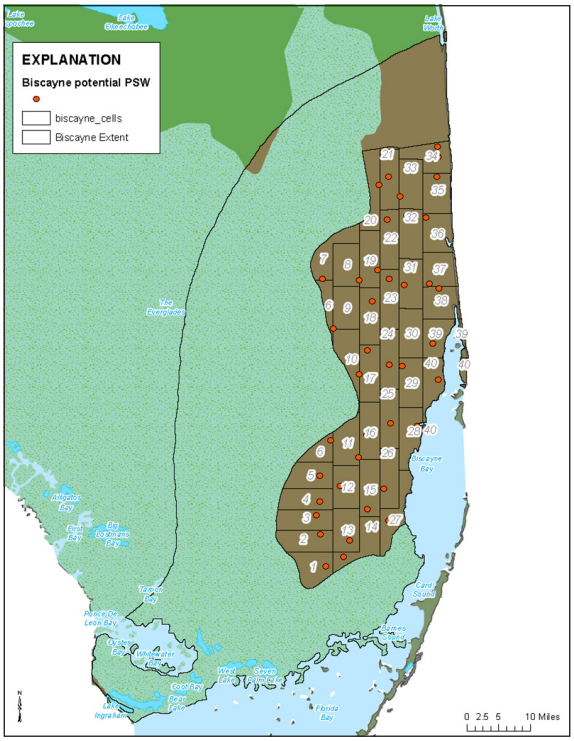
The Floridan aquifer system is composed of a sequence of Tertiary-aged carbonate rocks which cover parts of five states - Mississippi, Alabama, Florida, Georgia, and South Carolina. The Floridan aquifer system is the primary source of drinking water for nearly 10 million people and supports water needs for agriculture, industry, and tourism throughout most of the southeastern coastal region. Withdrawals from the Floridan are largest in Georgia and Florida, where it provides the majority of public and irrigation water supply. In 2015, 60 public supply wells within the Upper Floridan aquifer were sampled as part of the Floridan Principal Aquifer Survey; 40 of the 60 public supply wells were located within the state of Florida.

The Coastal Lowlands aquifer system is composed of unconsolidated to partially consolidated sand, silt, and clay of Oligocene to Holocene age which cover parts of five states – Texas, Louisiana, Mississippi, Alabama, and Florida. In 2013, 60 public supply wells were sampled as part of the Coastal Lowlands Principal Aquifer Survey; 4 of the 60 public supply wells were located within the state of Florida.

The Biscayne aquifer is the primary source of water for about 4 million people in Broward and Miami-Dade Counties in southeastern Florida. A total of 40 public supply wells will be sampled as part of the Biscayne Principal Aquifer Survey in 2016.



Map showing study area and public supply well site locations for the Floridan Principal Aquifer Survey.



Map showing study area and public supply well site locations for the Biscayne Principal Aquifer Survey.

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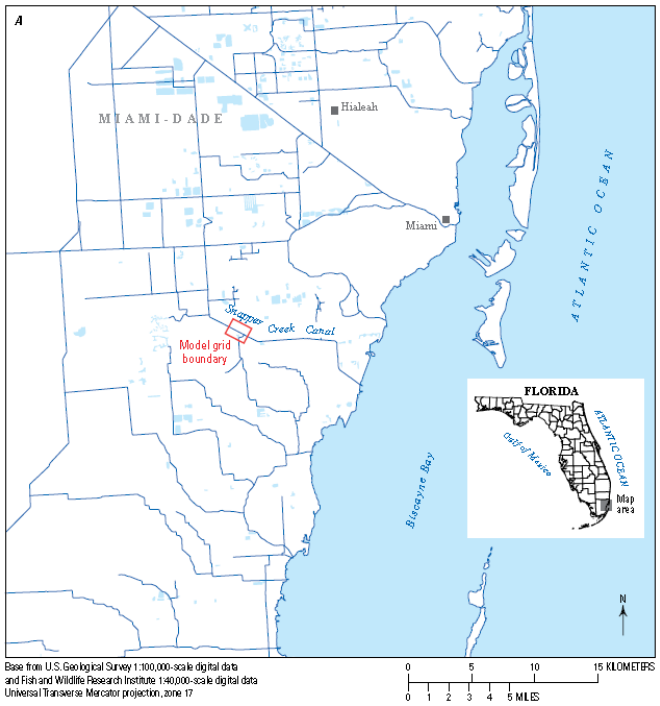
Cooperative study in Miami Dade Co. addresses the effects of well-field pumping on canal leakage

The *USGS Scienti ic Investigations Report 2015-5095*, describing relations between well-field pumping and induced canal leakage in east-central Miami-Dade County, was released in late 2015. A groundwater flow model and stable isotope data were used to characterize the relations between production well pumping and canal leakage. The groundwater flow model was developed and calibrated to assess relations between pumping at the study area and the Snapper Creek Canal leakage in Miami-Dade County, Florida, from June 2010 to July 2011.



Location of the Snapper Creek Canal and the model grid boundary.

The groundwater flow model, MODFLOW-NWT, was used to construct the model. Rainfall and evapotranspiration data were used in the Recharge Package to estimate groundwater recharge. Groundwater flux between the Snapper Creek Canal and the Biscayne aquifer was represented with the Constant-Head Boundary Package. Pumping stresses were represented by using the Multi-Node Well Package. The head-dependent model boundary was represented by using the General Head Boundary Package.

Trial-and-error and inverse methods were used to calibrate the model. Model sensitivities to geologic heterogeneity, non-laminar flow, and controlling boundary heads were evaluated. The calibrated model was used to estimate background and induced canal leakage. Background canal leakage was defined as the canal leakage that occurs without pumping and in response to processes such as rainfall and changes in canal stage. Induced leakage was defined as the canal leakage caused by pumping in the study area.

Photograph showing Snapper Creek Canal.

Canal leakage induced by pumping was quantified as a percentage of total canal leakage during pumping events. The percentage of leakage during pumping increased non-linearly with pumping rate. For example, when pumping increased from 0.5 to 1.9 cubic meters per second, canal leakage increased from about 15 to 33 percent of pumpage, respectively.

The model results likely serve as an upper limit for well-field interaction with surface-water features in Miami-Dade County, given the proximity of the pumping wells to the Snapper Creek Canal (about 50 meters). Moreover, the amount of induced leakage is likely affected not only by local pumping but also by pumping at neighboring well fields because water demand is presumably area-wide during the dry season and contributes to widespread lowering of groundwater levels along the model boundaries.

Results from the groundwater model and the isotope data analysis were consistent and demonstrate the importance of groundwater/surface-water interactions in the shallow flow zone. Results also indicate that pumping in the local well field and in neighboring well fields influences canal leakage, causing the water in the production wells to be a mix of local groundwater and water from the canal. Both sets of results confirm that geologic heterogeneity in the study area controls the pathways of flow.

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Dam Failure Analysis for the Lago Matrullas Dam

The *USGS Scienti ic Investigations Report 2015-5065* describing a hydrologic and hydraulic study to assess the potential hazard to human life and property associated with the hypothetical failure of the Lago de Matrullas Dam was completed by the USGS in cooperation with the Puerto Rico Electric Power Authority. The hydrologic study yielded outflow hydrographs and peak discharges for Lago de Matrullas and other subbasins in the Río Grande de Manatí hydrographic basin for three extreme rainfall events: (1) a 6-hour probable maximum precipitation (PMP) event, (2) a 24-hour PMP event, and (3) a 100-year-recurrence, 24-hour rainfall event. The hydraulic study simulated

Location of Lago de Matrullas in the Río Grande de Manatí hydrographic basin, Puerto Rico.

the hypothetical dam failure of Lago de Matrullas using hypothetical flood hydrographs generated from the hydrologic study and selected dam breach parameters.

The flood wave resulting from the failure was downstream-routed through the lower reaches of the Río Matrullas, the Río Toro Negro, and the Río Grande de Manatí for determination of water-surface profiles developed from the event-based hydrologic scenarios and "sunny day" (no precipitation) conditions. The Hydrologic Modeling System (HEC–HMS) and the River Analysis System (HEC–RAS) computer programs, developed by the Hydrologic Engineering Center (HEC) of the U.S. Army Corps of Engineers, were used for the hydrologic and hydraulic modeling, respectively. The flow routing in the hydraulic analyses was performed using the unsteady-state flow module available in the HEC–RAS model.

Results from the simulated dam failure of the Lago de Matrullas Dam using the HEC–RAS model for the 6- and 24-hour PMP events showed peak discharges at the dam of about 3,150 and 3,600 m^3/s, respectively. Dam failure during the 100-year-recurrence, 24-hour rainfall event resulted in a peak discharge of about 2,100 m^3/s directly downstream from the dam. Dam failure

Aerial photograph of the Lago de Matrullas reservoir looking upstream. Photograph courtesy of the Puerto Rico Electric Power Authority.

under sunny day conditions produced a peak discharge of about 1,700 m^3/s at the dam assuming the antecedent lake level was at the morning-glory spillway invert elevation. Flood-inundation maps prepared as part of the study depict the flood extent and provide valuable information for preparing an Emergency Action Plan. Results of the failure analysis indicate that a failure of the Lago de Matrullas Dam could cause flooding to many of the inhabited areas along stream banks from the Lago de Matrullas Dam to the mouth of the Río Grande de Manatí. Among the areas most affected are the low-lying regions in the vicinity of the towns of Ciales, Manatí, and Barceloneta. The delineation of the flood boundaries near the town of Barceloneta considered the effects of a levee constructed during 2000 at Barceloneta in the flood plain of the Río Grande de Manatí to provide protection against flooding to the near-by low-lying populated areas. The results showed overtopping can be expected in the aforementioned levee during 6- and 24-hour probable-maximum-precipitation dam failure scenarios. No overtopping of the levee was simulated, however, during dam failure scenarios under the 100-year recurrence, 24-hour rainfall event or sunny day conditions.

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Recent Publications from the Caribbean-Florida Water Science Center

Cunningham, K.J., 2015, Seismic-sequence stratigraphy and geologic structure of the Floridan aquifer system near "Boulder Zone" deep wells in Miami-Dade County, Florida: *U.S. Geological Survey Scientific Investigations Report 2015–5013, 28 p.*

Hughes, J.D., Sifuentes, D.F., and White, J.T., 2016, Potential Effects of Alterations to the Hydrologic System on the Distribution of Salinity in the Biscayne Aquifer in Broward County, Florida: *U.S. Geological Survey Scientific Investigations Report 2016–5022, 114 p.*

Hughes, J.D., Sifuentes, D.F., and White, J.T., 2016, SEAWAT model used to evaluate the potential effects of alterations to the hydrologic system on the distribution of salinity in the Biscayne aquifer in Broward County, Florida: *U.S. Geological Survey Data Release.*

Marella, R.L., 2015, Water withdrawals in Florida, 2012: *U. S. Geological Survey Open-File Report 2015-1156, 10 p.*

Marella, R.L., and Dixon, J.F., 2015, Agricultural irrigated land-use inventory for Jackson, Calhoun, and Gadsden Counties in Florida, and Houston County in Alabama, 2014: *U. S. Geological Survey Open-File Report 2015-1170, 14 p*

Marella, R.L. and Dixon, J.F., 2015, Agricultural irrigated land-use inventory for Osceola County, Florida, October 2013-April 2014: *U. S. Geological Survey Open-File Report 2014-1257, 8 p.*

McBride, W.S., and Wacker, M.A., 2015, Depth-dependent groundwater quality sampling at City of Tallahassee test well 32, Leon County, Florida, 2013: *U. S. Geological Survey Open-File Report 2014-1255, 13 p.*

Molina-Rivera, W.L., 2015, Source, use, and disposition of freshwater in Puerto Rico, 2010: *U. S. Geological Survey Fact Sheet 2015-3044, 6 p.*

Nemec, Katherine, Antolino, Dominick, Turtora, Michael, and Foster, Adam, 2015, Relations between well-field pumping and induced canal leakage in east-central Miami-Dade County, Florida, 2010–2011: *U.S. Geological Survey Scientific Investigations Report 2015–5095, 65 p.*

Prinos, S.T., and Dixon, J.F., 2016, Data, Statistics, and Geographic Information System Files, Pertaining to Mapping of Water Levels in the Biscayne Aquifer, Water Conservation Areas, and Everglades National Park, Miami-Dade County, Florida, 2000-2009: *U.S. Geological Survey data release Scientific data associated with USGS SIR 2016-5005*

Prinos, S.T., and Dixon, J.F., 2016, Statistical analysis and mapping of water levels in the Biscayne aquifer, water conservation areas, and Everglades National Park, Miami-Dade County, Florida, 2000–2009: *U.S. Geological Survey Scientific Investigations Report 2016–5005, 42 p.*

Prinos, S.T., and Valderrama, Robert, 2015, Changes in the saltwater interface corresponding to the installation of a seepage barrier near Lake Okeechobee, Florida: *U.S. Geological Survey Open-File Report 2014–1256, 24 p.*

Shoemaker, W.B., Anderson, F., Barr, J.G., Graham, S.L., and Botkin, D.B., 2015, Carbon exchange between the atmosphere and subtropical forested cypress and pine wetlands: *Biogeosciences, v. 12, 2285-2300, doi:10.5194/bg-12-2285-2015*

Sukop, M.C. and Cunningham, K.J., 2015, Geostatistical Borehole Image-Based Mapping of Karst-Carbonate Aquifer Pores: Groundwater, *http://onlinelibrary.wiley.com/doi/10.1111/gwat.12354/ abstract*

Swain, E.D., Krohn, Dennis, and Langtimm, C.A., 2015, *Numerical computation of hurricane effects on historic coastal hydrology in Southern Florida: Ecological Processes*

Swancar, Amy, 2015, Comparison of evaporation at two central Florida lakes, April 2005–November 2007: *U. S. Geological Survey Open-File Report 2015-1075, 16 p.*

Telis, P.A., Xie, Zhixiao, Liu, Zhongwei, Li, Yingru, and Conrads, P.A., 2015, The Everglades Depth Estimation Network (EDEN) Surface-Water Model, Version 2: *U.S. Geological Survey Scientific Investigations Report 2014–5209, 42 p.*

Torres-Sierra, Heriberto, and Gómez-Fragoso, Julieta, 2015, Dam failure analysis for the Lago de Matrullas Dam, Orocovis, Puerto Rico: *U.S. Geological Survey Scientific Investigations Report 2015–5065, 54 p.*

Torres-González, Sigfredo, and Rodríguez, J.M., 2016, Hydrologic conditions in the South Coast aquifer, Puerto Rico, 2010–15: *U. S. Geological Survey Open-File Report 2015-1215, 32 p.*

Williams, L.J., and Dixon, J.F., 2015, Digital surfaces and thicknesses of selected hydrogeologic units of the Floridan aquifer system in Florida and parts of Georgia, Alabama, and South Carolina: *U. S. Geological Survey Data Series 926, 24 p.*

Williams, L.J., and Kuniansky, E.L., 2015, Revised hydrogeologic framework of the Floridan aquifer system in Florida and parts of Georgia, Alabama, and South Carolina: *U. S. Geological Survey Professional Paper 1807, 140 p., 23 pls.*

The USGS Water Mission Area (WMA) has the principal responsibility within the Federal Government to provide the hydrologic information and interpretation needed by others to achieve the best use and management of the Nation's water resources. The WMA actively promotes the use of its information products by decision makers to:

- Minimize loss of life and property as a result of water-related natural hazards, such as floods, droughts, and land movement.
- Effectively manage groundwater and surface-water resources for domestic, agricultural, commercial, industrial, recreational, and ecological uses.
- Protect and enhance water resources for human health, aquatic health, and environmental quality.
- Contribute to wise physical and economic development of the Nation's resources for the benefit of present and future generations.

If you have an environmental or resource-management issue that you would like to investigate in partnership with the USGS, please contact any of our senior management staff (listed below). Projects are supported primarily through the *USGS Cooperative Water Program*. This is a program through which any State, County, local, or regional agency may work with the USGS to fund and conduct a monitoring or investigation project.

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