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Hydrologic Modeling
- Analysis of Groundwater and Lake Level Data in the CFCA
- Coupled Groundwater and Hydrodynamic Surface-Water Modeling
- Freshwater-Saltwater Interface in Broward County
- Groundwater Flow and Solute Transport Models
- Integrated Model of Surface-Water and Groundwater Flow
- Modeling Effects of Deepening the SJR Shipping Channel
- Simulation of Transient Groundwater Flow in East-Central FL
- Surface-Water and Groundwater Flows to Lake Tsala Apopka
- Surface-Water influx to the Biscayne aquifer in response to wellfields

Surface Water

Water Quality Conditions

Wetlands

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An Integrated Model of Surface-Water and Groundwater Flow for Evaluating the Effects of Competing Water Demands in Miami-Dade County, Florida

Project Chief: J.D. Hughes
Cooperator: Miami-Dade Water and Sewer Department
Period of Project: October 2008 – September 2013

Problem Statement

The

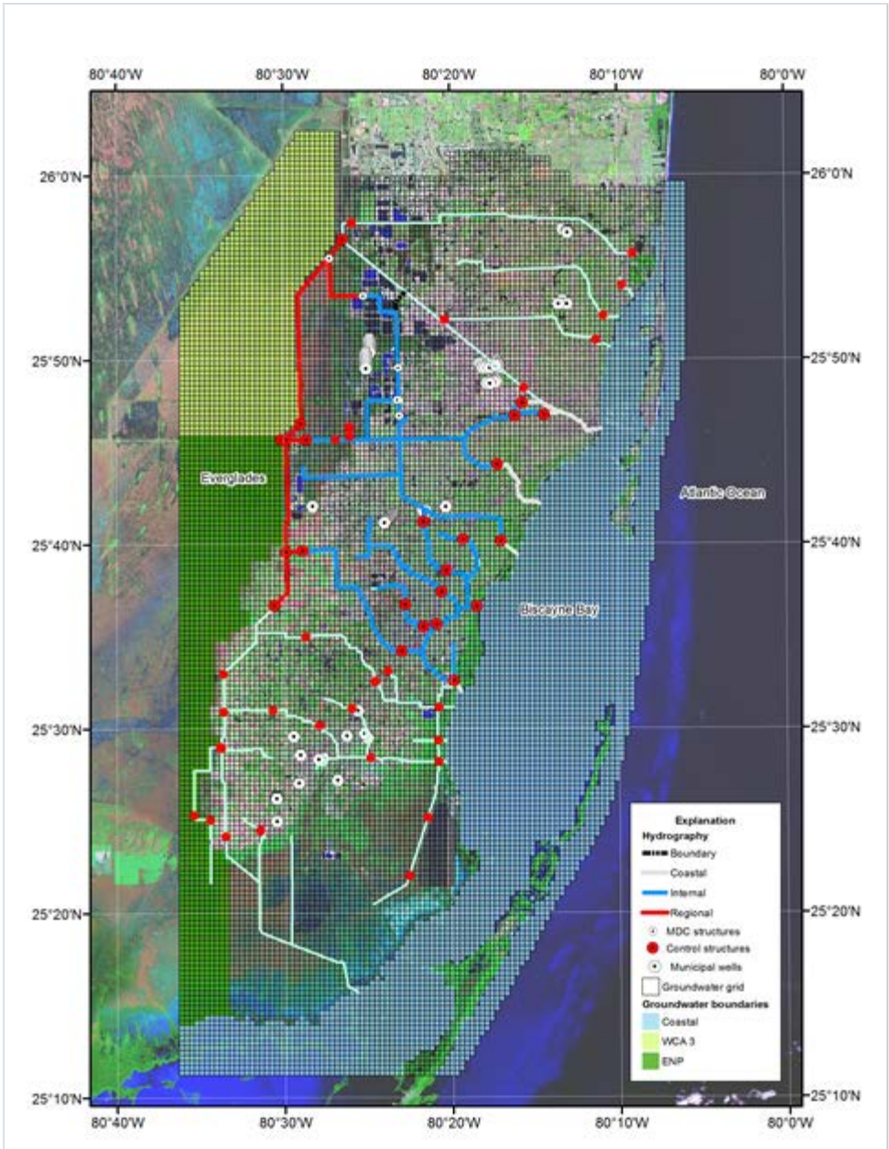

Figure 1. Model domain for the Miami-Dade County integrated surface-water/groundwater flow model.

Biscayne aquifer is the sole source of potable water in Miami-Dade County, Florida. Overlying the Biscayne aquifer is an extensive network of canals, which is hydraulically connected to the groundwater system. During the wet season, the canals drain the aquifer into the adjacent Biscayne estuary and prevent low lying areas from flooding. Conversely, the canals are used to maintain relatively high aquifer levels in coastal areas during the dry season in order to prevent saltwater intrusion. Although numerical models have been developed for the Biscayne aquifer in Miami-Dade County, these models either lack the ability to

represent surface water flow through the canal network or do not contain the resolution necessary to address water-resource issues at the county scale. Thus, an adequate tool does not exist for evaluating the effects of water management practices and well-field withdrawals on the surrounding areas.

With an increasing population and the proposed hydrologic changes as part of Everglades Restoration, Miami-Dade County is facing numerous hydrologic challenges. For example, the Miami-Dade Water and Sewer Department (WASD) is responsible for providing 5-year updates on their water use permit issued by the South Florida Water Management District (SFWMD). These permit updates require detailed numerical evaluations of the impact of municipal well fields on surface-water and groundwater levels. The Miami-Dade Department of Permitting, Environment and Regulatory Affairs (PERA) is also facing hydrologic challenges and must, for example, update well-head protection areas for certain municipal well fields.

Objectives

Develop a series of numerical models/tools that can be used to:

1) Evaluate the effect that municipal well fields have on surface-water and groundwater flows to Biscayne Bay

2) Delineate the contributing areas and drawdown-based outer protection boundaries for municipal well fields

3) Evaluate how canal management practices and/or well-field withdrawals affect Everglades National Park

4) Evaluate the effect of alternative municipal well-field operations and/or canal management on groundwater levels and surface-water discharge

5) Evaluate how increased sea levels will affect the position of the freshwater/saltwater interface in the Biscayne aquifer

6) Evaluate how additional lakes and/or backfilling of lakes in the Lake Belt Region will affect groundwater flow and the position of the freshwater/saltwater interface

Approach

To develop numerical models that can address the defined objectives, the USGS has modified and extended the FTLOADDS model of the Biscayne aquifer, Biscayne Bay, and coastal wetlands. One limitation of the Biscayne FTLOADDS model is that the surface-water system in the urban Miami-Dade County is represented as a simple head-dependent river boundary rather than a dynamic surface-water boundary implicitly coupled to the groundwater system. A significant component of this project has been the development of a dynamic surface-water routing (SWR1) process for MODFLOW-2005 and explicit representation of the surface-water system in the county-wide model being developed as part of this project.

The county-wide model is currently in the process of being calibrated to a multi-year period to ensure accurate representation of surface-water and groundwater flows and the exchange between surface water and groundwater. Following calibration, the model will be used to evaluate several scenarios of interest to Miami-Dade County regulators.

The USGS has also constructed a preliminary county-scale model that has been used to estimate contributing areas and drawdowns for the West and Northwest well fields. The model has been calibrated in the vicinity of the West and Northwest well fields, and an unconstrained stochastic approach that considers the effects of high permeability flow zones and lakes, has been used to delineate the contributing areas for the well fields. Results from this model will be used by Miami-Dade County to update current well-field protection maps for the West and Northwest well fields.

Results

The SWR1 process developed for MODFLOW-2005 as part of this study is expected to greatly improve the ability to simulate surface water/groundwater interactions in south Florida. The SWR1 process is currently being applied in several other Florida Water Science Center surface- water/groundwater interaction studies. Furthermore, the stochastic approach used to delineate well-field contributing areas, in combination with a residence-time representation of lake transport, represents a significant advancement of USGS science capabilities for quantifying the uncertainty of groundwater model predictions in the Biscayne aquifer.

Information Product(s)

Hughes, J.D., Langevin, C.D., Chartier, K.L., and White, J.T., 2012, Documentation of the Surface-Water Routing (SWR1) Process for Modeling Surface-Water Flow with the U.S. Geological Survey Modular Groundwater Model (MODFLOW-2005), U.S. Geological Survey Techniques and Methods 6-A40.

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Lohmann, M.A., Hughes, J.D., and Swain, E.D., (planned), Optimization of municipal well field withdrawals in Miami-Dade County, Florida to meet regional water availability constraints, journal publication.