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Development, Testing, and Application of a Coupled Hydrodynamic Surface-Water/Groundwater Model (FTLOADDS) with Heat and Salinity Transport in the Ten Thousand Islands/Picayune Strand Restoration Project Area, Florida
2009, Swain, Eric D.; Decker, Jeremy D.
USGS Scientific Investigations Report: 2009-5146

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Abstract:

A numerical model application was developed for the coastal area inland of the Ten Thousand Islands (TTI) in southwestern Florida using the Flow and Transport in a Linked Overland/Aquifer Density-Dependent System (FTLOADDS) model. This model couples a two-dimensional dynamic surface-water model with a three-dimensional groundwater model, and has been applied to several locations in southern Florida. The model application solves equations for salt transport in groundwater and surface water, and also simulates surface-water temperature using a newly enhanced heat transport algorithm. One of the purposes of the TTI application is to simulate hydrologic factors that relate to habitat suitability for the West Indian Manatee. Both salinity and temperature have been shown to be important factors for manatee survival. The inland area of the TTI domain is the location of the Picayune Strand Restoration Project, which is designed to restore predevelopment hydrology through the filling and plugging of canals, construction of spreader channels, and the construction of levees and pump stations. The effects of these changes are simulated to determine their effects on manatee habitat. The TTI application utilizes a large amount of input data for both surface-water and groundwater flow simulations. These data include topography, frictional resistance, atmospheric data including rainfall and air temperature, aquifer properties, and boundary conditions for tidal levels, inflows, groundwater heads, and salinities. Calibration was achieved by adjusting the parameters having the largest uncertainty: surface-water inflows, the surface-water transport dispersion coefficient, and evapotranspiration. A sensitivity analysis did not indicate that further parameter changes would yield an overall improvement in simulation results. The agreement between field data from GPS-tracked manatees and TTI application results demonstrates that the model can predict the salinity and temperature fluctuations which affect manatee behavior. Comparison of the existing conditions simulation with the simulation incorporating restoration changes indicated that the restoration would increase the period of inundation for most of the coastal wetlands. Generally, surface-water salinity was lowered by restoration changes in most of the wetlands areas, especially during the early dry season. However, the opposite pattern was observed in the primary canal habitat for manatees, namely, the Port of the Islands. Salinities at this location tended to be moderately elevated during the dry season, and unchanged during the wet season. Water temperatures were in close agreement between the existing conditions and restoration simulations, although minimum temperatures at the Port of the Islands were slightly higher in the restoration simulation as a result of the additional surface-water ponding and warming that occurs in adjacent wetlands. The TTI application output was used to generate salinity and temperature time series for comparison to manatee field tracking data and an individually-based manatee-behavior model. Overlaying field data with salinity and temperature results from the TTI application reflects the effect of warm water availability and the periodic need for low-salinity drinking water on manatee movements. The manatee-behavior model uses the TTI application data at specific model nodes along the main manatee travel corridors to determine manatee migration patterns. The differences between the existing conditions and restoration scenarios can then be compared for manatee refugia. The TTI application can be used to test a variety of hydrologic conditions and their effect on important criteria.

Additional Publication Details

Publication Type	USGS Numbered Series
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Title	Development, Testing, and Application of a Coupled Hydrodynamic Surface-Water/Groundwater Model (FTLOADDS) with Heat and Salinity Transport in the Ten Thousand Islands/Picayune Strand Restoration Project Area, Florida
Author	Swain, Eric D.; Decker, Jeremy D.
Year	2009
Series	Scientific Investigations Report
Series Number	2009-5146
Edition	-
Language	ENGLISH
Publisher	U.S. Geological Survey
Contributing Office	Florida Water Science Center
ISBN	9781411325975
Description	viii, 42 p.
Lat Bound N	0261000
Lat Bound S	0255500
Lon Bound E	-0812500
Lon Bound W	-0814500
Comments	Prepared as part of the U.S. Geological Survey Priority Ecosystems Science Initiative

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