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

Fact Sheet FS-169-96

Vertical Exchange of Ground Water and Surface Water in the Florida Everglades

Introduction and Project Objectives

Knowledge about hydrologic exchange between surface water and ground water is critical to understanding the movement of water and dissolved chemical constituents (solutes) in the Florida Everglades. This fact sheet describes a study that will quantify vertical exchange of water and solutes in the Everglades as part of the U.S. Geological Survey's (USGS) South Florida Ecosystem Program. The two sites selected for the initial investigation are shown in Figure 1. Those sites are the location of ongoing research projects concerned with movement and transformation of nutrients and mercury. Research results are being used by the South Florida Water Management District (SFWMD) to guide in the planning of Stormwater Treatment Areas, which will be large constructed wetlands designed to remove excess nutrients from agricultural drainage.

The objectives of the project described here are to (1) quantify vertical exchange of water (also referred to as seepage) between ground water and surface water, (2) use seepage estimates to assist in the development of chemical mass balances for mercury and nutrients, and (3) relate seepage fluxes to subsurface hydrogeologic properties, management of surface-water levels in canals and water conservation areas, and the regional water balance in the northern Everglades.

Background

Surface-water flows are managed extensively in the northern Everglades in order to accommodate a large and rapidly growing urban area along the Atlantic coast and an extensive agricultural area south of Lake Okeechobee. The flow of surface water is generally to the south in Water Conservation Areas, passing from one area to the next through culverts at levees. Surface flow is augmented by precipitation, which, on average, exceeds evapotranspiration in this area of the Everglades. Some surface flow is diverted to urban areas or the ocean. Seepage fluxes through wetland peat have not been measured directly in this area of the Everglades, but preliminary estimates suggest that seepage might be a significant component of the water budget.

Little is known about the hydraulic properties of Everglades wetland peat or the hardened limestone caprock that separates peat from the underlying aquifer. As a result, estimates of vertical seepage are subject to considerable uncertainty. Spatial and seasonal variation in seepage are also undocumented. Improved estimates of seepage fluxes, documentation of spatial and seasonal variation, and determination of peat and caprock hydraulic properties will help scientists to understand the influence of ground-water/surface-water interactions on nutrient and mercury mass budgets in the northern Everglades.

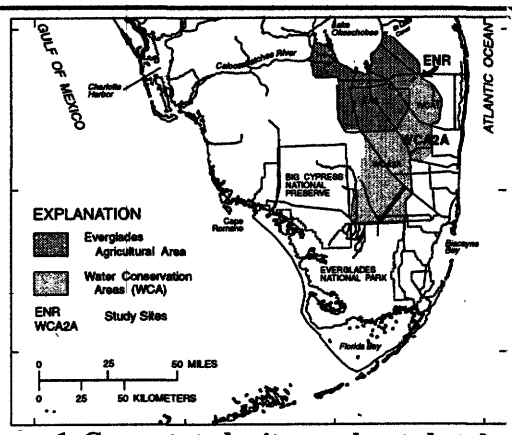

Figure 1. Current study sites are located at the Everglades Nutrient Removal (ENR) Project and in Water Conservation Area 2A (WCA-2A).

Plan of Study

The present project combines a water-balance approach and use of chemical tracers to quantify seepage fluxes of water and solute. Combining two independent techniques will reduce the overall uncertainty of estimated fluxes.

ANTICIPATED SCHEDULE:

May - September 1996: Install seepage meters, porewater samplers, surface-water stage encoders, and water-table wells. Drill caprock and emplace piezometers in surficial aquifer. Initiate data collection.

October 1996 - September 1997: Continue data collection in ENR and WCA-2A. Summarize initial results in annual report and at meetings. Expand data collection to include southern sites.

October 1997 - September 1998: Summarize a complete year of data from ENR and WCA-2A along with preliminary data from southern sites. Continue data collection and begin preparation of journal papers.

October 1998 - September 1999: Synthesize all research in a final report and in journal papers.

(1) **water balance approach:** At sites where the wetland is flooded with surface water, seepage meters (large funnels inverted and emplaced on sediment) will be used to directly measure the flux of water across the interface between surface water and wetland peat. At unflooded sites seepage fluxes will be calculated by modeling, using measurements of water-table elevation, evapotranspiration, and change in water storage in sediment over time as inputs to the model. Barge and land-based drilling is needed to install new piezometers, that is, partially screened wells open at specific levels in the aquifer. The hydraulic conductivity (a measure of how fast water flows in porous material for a given driving force) of peat and caprock will be calculated on the basis of estimated seepage fluxes and differences in water pressure (measured in piezometers) between the sediment surface and the underlying aquifer.

(2) **tracer-based approach:** Environmental tracers are

physical or chemical properties of natural waters that are useful to determine water fluxes, solute source areas, or travel times of water and solute. The tracers that are currently being tested to characterize vertical exchange of ground water and surface water in the Everglades include chloride, other major anions and cations, radioisotopes of uranium, stable isotopes of oxygen and hydrogen in water, and water temperature. The possibility of using additional tracers such as tritium-helium ratios and chlorofluorocarbons to determine ground-water age is also being explored.

Preliminary Results

The potential importance of seepage at specific sites in the Everglades can be assessed by examining surface-water levels and subsurface hydraulic heads. For example, data from the ENR (Everglades Nutrient Removal) project suggests that seepage varies both spatially and seasonally (fig. 2). Measurements of water level and subsurface hydraulic head (measured in piezometers installed beneath

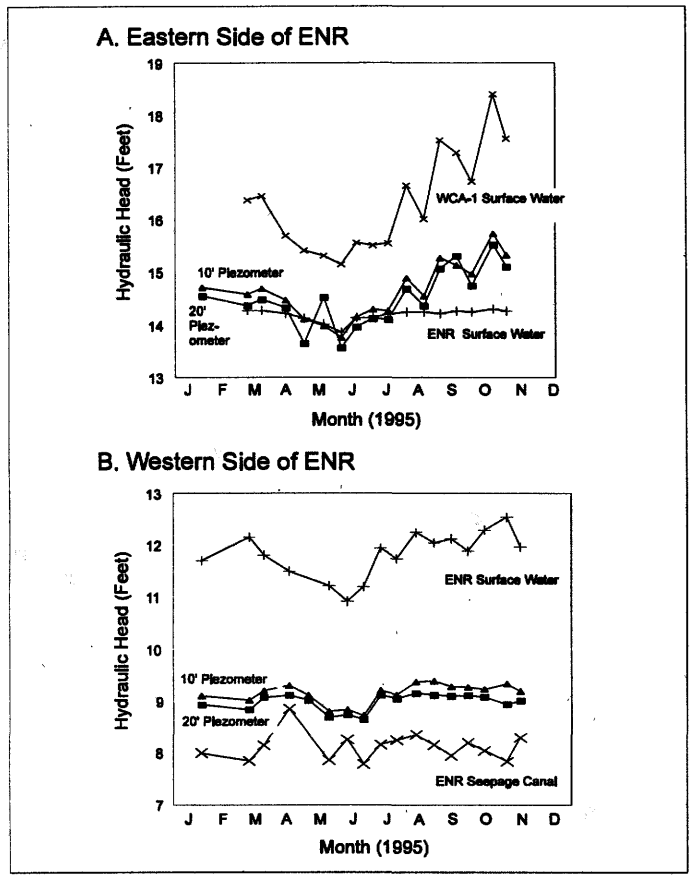

Figure 2. Spatial and seasonal variation in water levels in the ENR and in WCA-1.

ENR levees) indicate the potential for flow from theWCA-1 area east of the ENR project (where the surface-water level is higher) downward under the levee and upward into the ENR (fig. 2). The pattern of water levels on the western side of the ENR was reversed, suggesting flow of water from the ENR downward under the levee and upward into a perimeter canal surrounding the ENR project (called the seepage canal). The potential for vertical hydrologic exchange also varied seasonally at the ENR. In the spring and early summer of 1995 (April - July), water levels indicated a potential for downward seepage on both sides of the ENR (fig. 2).

Comparison of water levels and subsurface hydraulic heads determines only the direction of potential seepage fluxes. Determination of actual seepage fluxes requires additional data. Preliminary tests in the Everglades used several independent approaches to determine vertical seepage fluxes. Seepage fluxes were estimated directly using seepage meters, indirectly by modeling vertical profiles of solute concentration in the sediment, and by computing fluxes using Darcy's law, that is, on the basis of vertical differences in water pressure, and estimates of hydraulic conductivity of the wetland peat and caprock (determined by a standard test called a piezometer bail test).

A comparison of flux estimates is shown in Figure 3. Vertical hydrologic fluxes ranged between 0.05 and 1.5 centimeters per day (positive fluxes indicate upward flow from ground water to surface water). Fluxes in Figure 3 are similar in magnitude to other important water balance fluxes in the northern Everglades, such as precipitation and

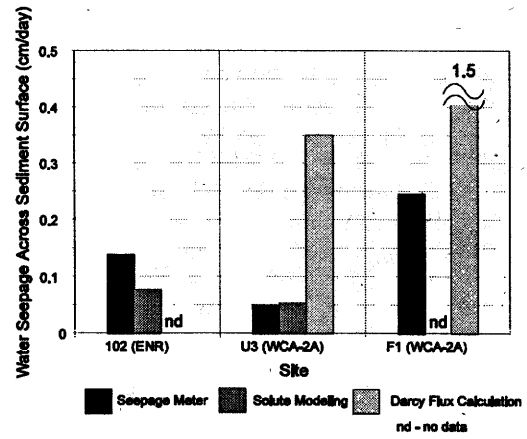

Figure 3. Water seepage fluxes across wetland surface.

evapotranspiration. Estimates of seepage meter measurements and solute modeling differed by less than a factor of 2, whereas estimates based on Darcy's law tended to be much higher than other estimates. Although these preliminary data are not sufficient to draw final conclusions about the magnitude of vertical hydrologic fluxes in the Everglades or the best method to determine fluxes, they do indicate the value of comparing results from several independent approaches to improve the accuracy of flux estimates.

Collaboration and Partnerships

The research project described here is closely linked with a number of research projects at USGS and at the South Florida Water Management District (SFWMD). USGS project scientists in Reston, Va. and Miami, Fl. are working closely with SFWMD staff in instrumenting sites and collecting data.

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