RE-ENGINEERING WATER STORAGE IN THE EVERGLADES

Risks and Opportunities

Committee on Restoration of the Greater Everglades Ecosystem

Water Science and Technology Board

Board on Environmental Studies and Toxicology

Division on Earth and Life Sciences

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

THE NATIONAL ACADEMIES PRESS
Washington, D.C.
www.nap.edu

In-Ground Reservoirs

Two in-ground reservoirs constructed in former quarries are planned for the Lake Belt area of Miami-Dade County. A third smaller, shallower in-ground reservoir also is planned for western Palm Beach County near the L-8 canal. The following discussion focuses on the proposed reservoirs in the Lake Belt, but similar construction concerns may apply to the L-8 reservoir as well.

After mining companies have quarried 1.7 billion tons of limerock over a 30+ year period, surface reservoirs extending to depths of approximately 80 feet are planned in the Lake Belt rock mining area of Miami-Dade County, west of the City of Miami (Figures 2-1, 2-11, 2-12). Two quarries with a total surface area of 9,700 acres and a total storage capacity of 280,000 acre-feet are anticipated to accommodate inflows averaging approximately 250,000 acre-feet annually.

The reservoirs will occupy 9,700 acres of land in a region that is currently undeveloped and could, in theory, be part of the land acquired for restoration. However, these areas are within a footprint for which mining companies already have requested permits to excavate, and they are likely to be mined whether or not the quarries are eventually converted into storage reservoirs. To convert the quarries at the end of active mining into reservoirs that can store water for use as a supply to the Everglades during dry weather periods, seepage barriers must be created to limit the infiltration of groundwater from the surrounding aquifer and to hold the stored water within the reservoirs. (Indeed, the quarries are currently filled with water from groundwater infiltration during the mining period.) The technology required to create these seepage barriers at the required scale in permeable limestone has not yet been developed or tested, and hence both costs and feasibility associated with this storage component are uncertain. As in the case of any surface reservoir, water will be lost to evaporation from the free surface. However, the net evaporative losses will not exceed evaporative losses that would occur from standing water in a quarry lake of equivalent size that was filled with water that had infiltrated from the surrounding aquifer. In other words, replacing a quarry lake with a quarry reservoir will have no net effect on evaporative losses from the system as a whole.

Timing of construction of the Lake Belt reservoirs is constrained by a number of factors. First, the pilot studies to assess costs and feasibility of technologies for creating seepage barriers must be completed, and in turn, these require completion of excavation at the quarries to be used in the pilot studies. The pilot-project management plan indicates that the pilot project will not be completed until after 2010 (USACE and SFWMD, 2002b). Following selection of final sites and sizes of the reservoirs, mining activities may take a decade or more before the quarries will be available for water storage, resulting in an estimated date of 2036 for completion of the final phases of construction. There also are questions about whether the selected seepage technology will be able to withstand blasting occurring in nearby, active quarries (USACE and SFWMD, 2002b). If the technology is sensitive to blasting effects, construction could be further delayed until mining is completed at other quarries in the vicinity.

FIGURE 2-11. Approximate location of Lake Belt storage. SOURCE: Information on locations of existing and proposed storage components from USACE and SFWMD.

Although development of the Lake Belt reservoirs involves loss of wetland or other habitat in an area adjacent to the restoration footprint, this land likely would be lost to the restoration in any case (based on current land-use plans for the Lake Belt region). While the reservoirs will not displace agricultural activities or urban development, the estimated land costs totaling over $255 million provided in the plan suggest that land costs per acre for these reservoirs will exceed those for the conventional reservoirs in the Kissimmee Basin and the EAA. In addition, construction costs associated with creating the seepage barriers will be high. The estimated construction costs of $783 million far exceed the total construction costs for the conventional surface-water reservoirs. Depending on the long-term integrity of the seepage barriers, there may be additional maintenance and repair costs to consider as well. Operational costs in terms of pumping and distribution should be similar to those of other surface reservoirs.

Water-Quality Considerations

Water quality of the stormwater runoff used to supply Lake Belt reservoirs will depend on land uses in the drainage areas from which the runoff is derived. The Northern Lake Belt reservoir will receive local basin runoff and, ultimately, some water recovered from WCA 3A/3B seepage-management efforts. The Central Lake Belt reservoirs are intended to store excess water from WCAs 2 and 3, routed to the reservoirs via improved L-37 and L-33 borrow canals. Most local basins likely will be in urban/suburban land use, but some lands used for intensive agriculture also may contribute runoff. Consequently, some water supplying these reservoirs is likely to be contaminated with constituents usually associated with these land uses: elevated nutrients (nitrogen and phosphorus) and oxygen-demanding biodegradable natural organic matter; suspended solids; potentially pathogenic microorganisms of animal and possibly human origin; a variety of heavy metals, including zinc, cadmium, and lead; and low levels of a wide variety of synthetic organic contaminants (e.g., herbicides, pesticides, and polycyclic aromatic hydrocarbons) used on urban landscapes or formed in urban environments.

Certain characteristics of the reservoirs may lead to improvements in the quality of the water stored there for extended periods. The morphometry of the reservoirs—steeply sloping sides, small littoral zones, and large mean and maximum depths—should promote settling of suspended material and minimize resuspension of bottom sediments by wind-induced mixing. If annual nutrient loading rates are not too high and water residence times are fairly long, nutrients will be assimilated by algae and conveyed to the bottom by natural settling processes, such that the reservoirs may have moderately high water clarity and relatively low chlorophyll levels, making them suitable for certain kinds of aquatic-based recreational activities.

On the other hand, reservoir morphometry also is likely to promote strong thermal stratification in the water column that may persist for long periods (possibly several years). This will lead to highly anoxic conditions in the stagnant hypolimnion (cooler bottom layer of water), which is likely to comprise a large fraction of the total volume of Lake Belt reservoirs, and to the build-up of undesirable constituents, including sulfide, ammonia, methane, dissolved iron, and manganese. This will cause a large fraction of the stored water to be unsuitable for municipal water supply—or at least render it much more difficult and expensive to treat. In addition, such water would violate state water-quality standards for direct release into surface drainage canals in the Everglades drainage network, although it could be made to meet state standards by treatment involving aeration before release. Alternatively, it may be desirable to maintain oxygenated conditions throughout the water column of Lake Belt reservoirs by installing aeration devices in the reservoirs. Although such devices are technically feasible, they would be costly to operate and maintain, given the size and depths of the reservoirs (and the volumes of water that would need to be aerated).

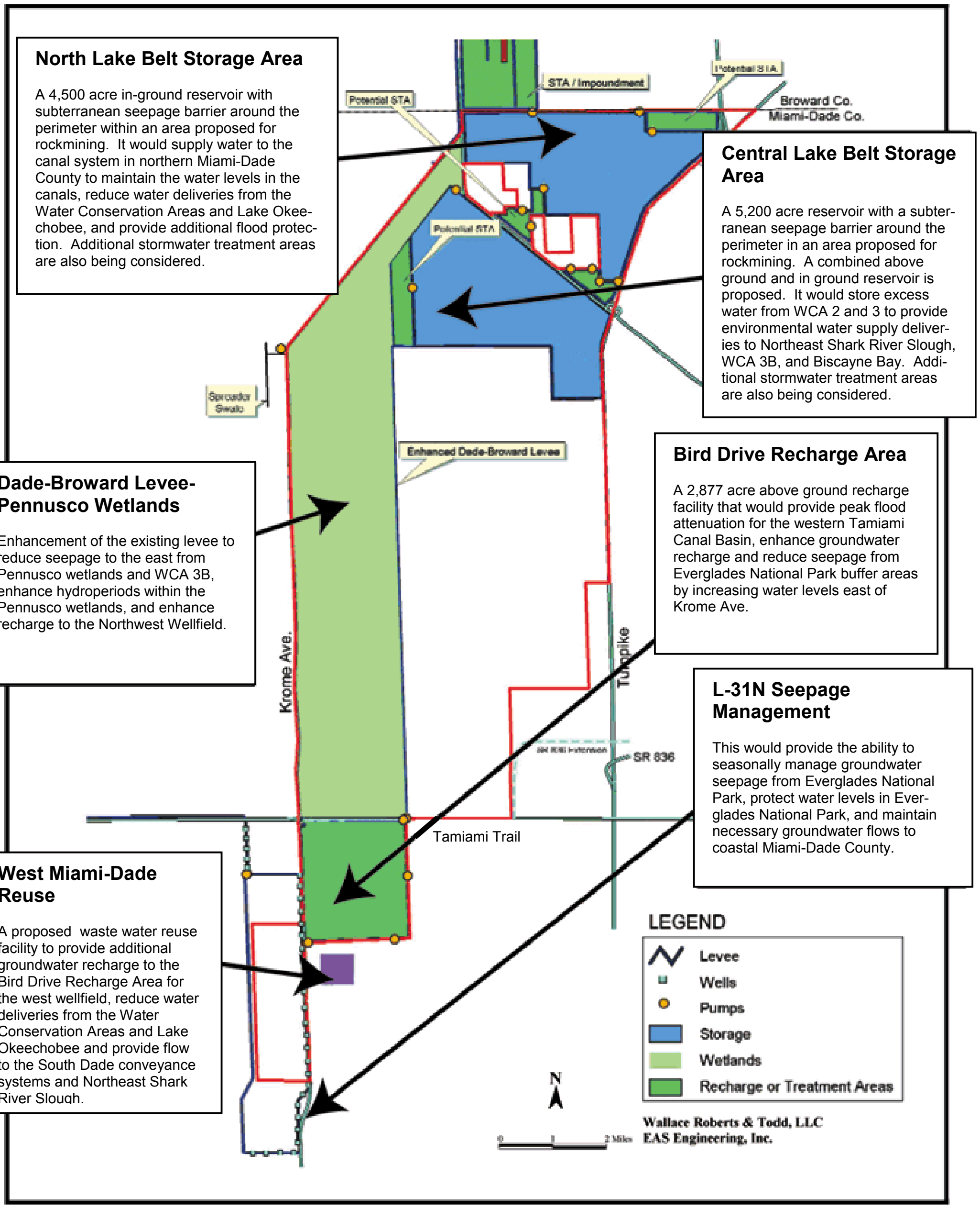

FIGURE 2-12. Map showing the location of the proposed Central and North Lake Belt Storage Areas, L-31N Seepage Management, and the West Miami-Dade Wastewater Reuse Facility. Water Conservation Areas 3A and 3B Levee Seepage Management would be located just north of this map and the proposed reuse facility associated with the Miami-Dade South Wastewater Treatment Plant about 15 miles to the south.
SOURCE: Available online at *http://sflwww.er.usgs.gov/publications/ofr/02-325/introduction.html.*

The major ion composition of the lakes also could be an issue. Constructed in a limestone stratum, the lakes will have hard water (high in calcium, magnesium and bicarbonate alkalinity). Although these constituents are desirable from many perspectives, they have the potential to substantially increase the hardness and ionic strength of water flowing through the southern Everglades, a system driven primarily by rainfall chemistry and thus historically a soft-water environment. The flora and possibly associated fauna of this part of the Everglades are adapted to soft water, and major shifts in plant community composition could result from use of the Lake Belt to supplement water flows to the Everglades during periods of low rainfall.

Finally, water-quality concerns regarding the Lake Belt reservoirs include the potential for contamination of the shallow Biscayne Aquifer, which is used for drinking-water supply. This potential depends on the source and level of pre-storage treatment applied to water that will be added to the reservoirs, as well as on the hydraulic connection that remains between the reservoirs and the aquifer once seepage barriers have been constructed. The Lake Belt Pilot Project includes a water-quality evaluation to address these concerns.

Changes in the groundwater flow field associated with reservoir construction and operation could also affect operations at municipal well-fields near the Lake Belt. The pilot project includes a regional hydrologic evaluation to evaluate these potential impacts.

Seepage Management

Differences in hydraulic head across levees that bound the Water Conservation Areas and Everglades National Park result in significant seepage losses to the east, toward the coast through adjacent canals. For the overall Everglades system, the Governor's Commission for a Sustainable South Florida (1997) estimated seepage losses at over one million acre-feet per year, a significant amount in relation to other components of the Restoration Plan. Seepage management reduces the losses or recovers this water and returns it to the Everglades as a water conservation measure. Two locations are planned for this Restoration Plan component:

- *Everglades National Park Seepage Management*. The purpose of this project (Figure 2-12) is to improve water deliveries to Northeast Shark River Slough and restore wetland hydropatterns in Everglades National Park by reducing levee and groundwater seepage and increasing sheet flow. This will be accomplished by a levee cutoff wall along levee L-31N, south of the Tamiami Trail, which reduces groundwater flows during the wet season and by capturing the groundwater with a series of wells adjacent to L-31N, then back-pumping those flows to Everglades National Park. This project is expected to conserve about 162,000 acre feet annually (J. Obeysekera, SFWMD, written communication, May 2004). This conserved volume, and the value for WCA 3A/3B below, is estimated from modeling the difference between seepage at these sites without the Restoration Plan (2050 Base) and with it (D13R).
- *Water Conservation Areas 3A and 3B Levee Seepage Management*. The goal of this project is to reduce seepage loss from these WCAs in order to improve hydroperiods within the Conservation Areas by allowing higher water levels in the borrow canals and longer inundation within the marsh areas that are located east of the WCAs and west of US Highway 27. New levees will be constructed west of US Highway 27 from the North New River Canal to the Miami (C-6) Canal to separate seepage water from the urban