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Challenges to Water Resources Sustainability in Florida

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CHALLENGES TO WATER RESOURCES SUSTAINABILITY IN FLORIDA

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ABSTRACT

The State of Florida has approximately 16 million residents. The per capita daily water use is over 0.643 m^3 [*ca.* 170 gallons] which also includes large agricultural and industrial activities. Florida attracts more than 70 million tourists per year who come to the state to enjoy its beaches, lakes and springs, as well as many commercial attractions. Unique natural systems such as the Everglades depend on adequate supplies of water. Approximately 90 percent of Florida's potable water originates from ground water sources contained in four main aquifer systems. Over the long term, the state receives between 1.0 and 1.8 meters of rain annually, with an average of about 1.4 meters that is not evenly distributed. Most of the rain is lost to evapo-transpiration and runoff, leaving at most 0.13 – 0.17 m for aquifer recharge. Agriculture accounts for 47% of the total water withdrawals followed by municipal withdrawals of 33% of the total. Agriculture accounts for even a larger percentage of the total consumptive use. Challenges to Florida's water resource sustainability are many, including regional distribution issues, drought and flood cycles, and contamination. There is periodic discussion concerning the possibility of transferring water from abundant sources in the less populated northern part of the state to the more highly populated regions in central and southern Florida. The Everglades restoration plans and related conservation efforts are, or will soon be, pumping treated water into aquifers for storage and later recovery (Aquifer Storage Recovery). This ASR water must be treated to drinking water standards before it is injected and after it is later removed. In the Everglades region, this recovered water is then put into canals. Contaminants such as petroleum fuels, pesticides, fertilizers, human and animal wastes, salt water, etc., enter aquifers through infiltration or pumping, placing aquifer water quality at risk. Surface waters and wetlands are similarly threatened. To have sustainable water quality and supply, Floridians must prevent aquifer contamination, increase conservation practices, reduce runoff and surface water contamination, and determine cost-effective ways to provide water to areas in need. An overview of Florida's efforts to perform water supply planning at the metropolitan, regional and statewide levels is presented, and emerging challenges and issues are discussed.

INTRODUCTION

The challenges of meeting water supply sufficiency for Florida's current population of some 16 million people that grows by several hundred each week, have attracted much attention. In the mid-to-late 1990's, the continuing thirst for water in the greater Tampa Bay region led to political intrigue which came to be known as "water wars" (Rand 2003). This is not unique to Florida, of course, but the problem became more visible and took on a broader state – wide scope with the publication of a document prepared by an influential group of Florida business leaders (The Florida Council of 100, 2003; Arndorfer et al. 2003; Dunkelberger 2003). The Council of 100's report issued several recommendations to its target audience of state political and business leaders:

● establish a Water Supply Commission to make sure that the state's growing population has sufficient water and that the environment is sustained.

● establish a Water Data Center to consolidate water data and make the information more widely available to the public.

● establish a Science Advisory Council.

● encourage partnerships, including those involving representatives of the public and private sectors, to help solve water storage and distribution problems.

● determine the practicality of a statewide distribution system to provide water for the state's growing population and to ensure environmental protection.

The last recommendation has stimulated heated discussion in Florida, but especially in the northern part of the state where there is presently an abundant supply and where the state's most productive springs are located.

REGIONAL WATER RESOURCE DISTRIBUTION ISSUES

One could argue that the first four recommendations of the Florida Council of 100 merit some consideration since Florida is a geographically large state and its water resources are managed by five independent Water Management Districts (WMDs) that were created along hydrological boundaries (Fernald and Purdum 1998). While the state's water plan is developed centrally by the Florida Department of Environmental Protection (FDEP) in conjunction with the five WMDs (FDEP 2001), the latter are mostly responsible for its implementation. However, the prospect of transferring presumably large volumes of water from the northern part of the state to the more populated areas in the south caused sufficient outcry that Florida's Governor apparently decided not to pursue the Florida Council of 100's recommendations during the 2004 legislative session (Bruno 2003, 2004a, 2004b). While this contentious issue will not be formally addressed by the state government in the near term, it is clear that the uneven distribution of water throughout Florida will keep water resources (and possible future water transfers) in the headlines for many years. The citizens in the north appear ready to resist such transfers should such regional water transfers ever be aggressively pursued (Burt 2003). Ironically, at least one local government in south Florida also voiced its opposition to long distance water transfers (Morgan 2003). It's clear that the state's current water policy governing water resources management, *i.e.* "local sources first," will be retested as the state's population continues to grow. Note, however, that Florida law does provide for intra-state transfers should the need arise.

Florida is not the only state to face controversies concerning possible intra-state water transfers. Other states have similar water distribution problems where water short areas can benefit from such transfers. Arizona, California, Colorado, and New York have relied on large-scale water transfers for many years. One might ask what is being done in these water thirsty areas to help solve local and regional "water crises" and to defuse or at least delay the onset of new "water wars." In some cases, the solution has been to look for water in areas outside of city limits, often involving great distances. For states located in coastal areas, the prospect of sea water desalination needs be considered, and, in fact, is already being practiced in Florida, as discussed in more detail below. Water conservation is now a required component of water supply planning in many areas. Cities must prove that they have implemented water conserving practices such as low-flush toilets and higher efficiency clothes washing machines. Water management districts frequently apply restrictions on watering lawns during periods of drought. Clearly, local and state governments must become more proactive and enact more stringent regulations governing water use and conservation when conditions warrant such actions.

WATER DEMANDS

The distribution of current water withdrawals in Florida is shown in Table 1. Agriculture withdraws 47% followed by urban water supply at 33%. Agriculture is responsible for an even larger proportion of the withdrawals that is consumed.

Table 1. Current mix of water withdrawals in Florida (Florida DEP 2001)

Category	%
Agriculture	47%
Public Supply	33%
Domestic Self Supply	4%
Industrial/Commercial/Electric	8%
Recreation/Irrigation	8%

These demands are expected to increase due to the continued growth of all sectors of the Florida economy and associated population. Active efforts are underway to manage this demand by a variety of water conservation practices.

Water Conservation

The Florida Department of Environmental Protection (DEP) coordinates water conservation activities statewide (Florida DEP 2002). The primary recommendations of the Florida Water Conservation Initiative to reduce demands are listed below (Florida DEP 2002):

- Agricultural irrigation – cost share programs to implement irrigation Best Management Practices, more use of mobile irrigation labs to evaluate irrigation efficiency, improvements in the recovery and recycling of irrigation water, and greater use of reclaimed water for irrigation.
- Landscape Irrigation – more efficient irrigation system design, installation, and operation, and by reducing the amount of landscaping that requires intensive irrigation.
- Water Pricing – implement water conserving rate structures that will reduce wasteful use both in ordinary times and during droughts.

- Industrial, Commercial, and Institutional – certification that implements industry-specific Best Management Practices, and through water use audits, improved equipment design and installation, and greater use of reclaimed water.
- Indoor Water Use – increase the proportion of Florida homes and businesses that use water-efficient toilets, clothes washers, showerheads, and dishwashers.
- Reuse of Reclaimed Water – pricing incentives, more metering of its use, and by making progress on increasing reuse in Southeast Florida.

COST-EFFECTIVENESS OF OPTIONS

Several groups have estimated the cost of providing water from surface and groundwater sources or reducing withdrawals by a variety of demand management practices. The reported range in unit costs in $/1,000 liters is shown in Table 2. Ground water is the major source of water and is relatively inexpensive with costs in the range from $0.05 to 0.34/1,000 liters. Alternative sources such as brackish ground water and surface water are more expensive due to added treatment costs and more limited availability. Conservation is an option to supply augmentation. Reducing outdoor water demand has a high cost-effectiveness since customers tend to overwater and can easily reduce this demand. Indoor water conservation unit costs vary more widely. Retrofitting toilets is the most cost-effective investment for two reasons: 1) the new toilets use considerably less water, and 2) these new toilets can greatly reduce or eliminate leaks if flapperless toilets are installed (Mayer et al. 2004). Water providers use a variety of financial incentives including having the utility pay the entire cost for the retrofit. Desalination is now being used more frequently in Florida as its cost has been reduced.

Table 2. Range of unit costs for various water supply and demand management options (Florida DEP 2002).

	$/1,000 liters	
Category	Minimum	Maximum
Water Supply Options		
Fresh ground water	0.05	0.34
Brackish ground water	0.18	0.61
Surface water	0.21	0.85
Conservation options		
Outdoor-SFWMD	0.03	0.21
Indoor-SFWMD	0.05	1.00
Non-agriculture-SWFWMD	0.05	0.50
Agriculture-SWFWMD	0.08	1.43
Retrofits-SJRWMD	0.03	0.45
Toilet replacement-SJRWMD	0.13	0.95
Desalination of seawater-SWFWMD	0.55	0.90

The Water Pricing Working Group of the Water Conservation Initiative has developed seven recommendations on how pricing related strategies can be used to manage demand (Water Conservation Initiative 2001):

- phase – in conservation rate structures.
- require special rates during droughts.
- integrate market principles within Florida water law.
- improve the cost-effectiveness analysis.
- require metering and sub-metering.
- phase – in informative billing.
- adopt additional state guidance on water supply development subsidies.

WATER RESOURCES SUSTAINABILITY

The water resources issue in Florida has had a checkered history. Original water flow patterns were altered throughout the past century, for purposes including flood control and drainage, water supply, and navigation. The integrity of riverine and estuarine ecosystems was rarely considered in early times. This is now changing as many restoration projects abound in Florida. The most visible and by far the most extensive and expensive restoration projects involve remediation of the Kissimmee River channel that had been "straightened" years ago, and the restoration of the Florida Everglades, the latter being the largest public works project currently underway in the U.S.A.

The Everglades Ecosystem

Steinman et al. (2004) revisited much of the history of the south Florida hydrological modifications that took place in the 20th Century. The Central and Southern Florida Project for flood control and water supply was a massive undertaking to move water through the south Florida system and included pumping stations and flood control structures. The authors indicated that natural water flow was disconnected from its historical patterns to achieve social objectives that included protecting the growing population from storm induced flooding and augmenting water supply for agricultural and urban areas. In more recent times, the needs of nature have been incorporated into water resources planning. Now, re-directing fresh water delivery to the Everglades, Florida Bay and the rivers and canals that drain into estuaries on both coasts is the most critical task. The overarching plan for water in south Florida is called the Comprehensive Everglades Restoration Plan (CERP). The CERP is a program with over 60 active areas or "elements" whose completion over the next several decades will result in the expenditure of more than $10 billion. At least several hundred million m^3 of water per day will be stored on the land in newly constructed reservoirs or injected into the Upper Floridan aquifer under the ASR program. This water storage should reduce the need for inter-basin transfers of water in the future.

The benefits of this program, as related by Steinman et al. (2004), include reducing evaporative loss of stored water by using ASR and allowing Lake Okeechobee to experience a more natural hydroperiod. The latter should result in a revitalized aquatic vegetation community in the lake and stimulate more nutrient uptake and fish production. Potential concerns related to the CERP strategy include unanticipated impacts of a changing hydraulic head on the Upper Floridan aquifer, the pre-treatment costs for the

ASR program, water quality impacts of the injected water in the aquifer itself and quality concerns as the water is pumped out of the aquifer at a later date. Some of the actions to be conducted in the CERP program are, in effect, large scale experiments, and their outcome will depend, in part, on pilot studies that will provide water managers with better guidance when critical decisions have to be made.

Contaminants in the Everglades

In addition to restoring water flows to resemble their historical patterns, efforts are being made to reduce the water pollution burden in the Everglades. Removal of phosphorus from waters exiting Lake Okeechobee, the Everglades Agricultural Area, and urbanized southeast Florida has led to the construction of created wetlands in systems called storm water treatment areas. Success will be declared when water entering and residing within the Everglades contains no more than 10 μg/L of total phosphorus, the recently established standard that has been set for water in the Everglades (SFWMD and FDEP 2004). Reduction in total phosphorus levels in the system has already been noted although levels still exceed the new standard in several locations. The 10 μg/L standard requires advanced treatment methods since it approximates the background level of phosphorus. Whether this goal is technically achievable is an open question. Even if it is technically feasible, it may not be very cost-effective in that these same large sums of money could be spent in other ways that would be more beneficial to the Everglades, e.g., controlling other pollutants and/or providing a better flow regime.

If the only water pollution contaminant of concern in the Everglades was phosphorus, then, over time the phosphorus control program might meet water quality objectives. Unfortunately, the toxic contaminant, mercury, has been, and will remain, a threat to ecosystem integrity in the Everglades. Rather than cause changes in the plant community like phosphorus does, mercury has contaminated the food chain to levels that have resulted in most of the fish in the Everglades system being covered by a public health advisory. This advisory recommends that fish consumption be severely restricted or avoided to protect humans from serious neurological damage that can be caused by this poisonous element. Mercury entered the Everglades system primarily from the atmosphere, through a variety of pathways which involved mostly local or regional sources, but also had global components. Municipal waste and medical incinerators in south Florida have been considered primary local/regional sources, whereas mercury circulating in the earth's atmosphere due to both natural and human causes, provides the global source. Mercury has been accumulating in the Everglades for many decades but a definite increase in accumulation was noted in soil cores starting during the 1940's and continuing until the mid-1990's (Rood et al. 1995). While concentrations of mercury in largemouth bass in the Everglades have yet to show significant declines, there is evidence that mercury levels in water have begun to decline, perhaps in response to reductions in emissions as well as changing hydrological conditions.

Contaminants Elsewhere in Florida

Challenges to the sustainability of Florida's water resources extend beyond meteorologically driven hydrologic conditions, state-wide population growth, and the unique situation in the Everglades. Human activities have resulted in the release of a myriad of contaminants all over the state. The Florida Department of Environmental Protection conducts a biannual study of the waters of the state, in compliance with the Clean Water Act (FDEP 2003). There is considerable variability in adherence with the state's water quality standards, with more violations seen in the populated central and southern areas of the state, and also in areas with high agricultural activity. Perhaps the most frequently violated standards are those for dissolved oxygen and the nutrient elements, nitrogen and phosphorus. After these substances, the violations vary from location to location, but most can be ascribed to non-point source pollutants.

In recent years, research projects have targeted various known or potential problem areas related to individual or groups of contaminants. A few examples of recent research related to contaminant issues are provided here:

- Increased nitrate concentrations in Florida springs, with emphasis on Silver Springs, the second largest spring in the state were reviewed. Nitrate concentrations have doubled in the last 50 years, now reaching close to 1 mg/L as N. While the value does not appear to be alarmingly high, that nitrogen content, in conjunction with other plant nutrients, including phosphorus, is sufficient to stimulate the growth of aquatic vegetation in amounts that concern water resource managers (Mytyk and Delfino 2004).
- A wetland in the Florida panhandle was contaminated with lead and acid from a battery rendering plant and which eventually became listed as a CERCLA Superfund site. Very high levels of lead were found in the wetland vegetation, soil and water, but it appears that this ecosystem was effective in attenuating this toxic metal and prevented it from moving downstream into a much larger river system. In this situation, the wetland system provided a service to humanity by sequestering the lead and preventing further water resource deterioration downstream (Odum et al. 2000).
- Lake Apopka in central Florida once supported a highly popular largemouth bass fishery. Through a variety of natural and human related events, the lake became highly eutrophic and the bass fishery collapsed. Efforts to remediate the eutrophication focused on the creation of wetlands in areas that had once been prime agricultural land. This required a study of the potential for the soils to release phosphorus once they became inundated. Selected chemical additives were found to be good sequestering agents that would bind the phosphorus upon inundation and would restrict the release of this nutrient which otherwise would have further aggravated the eutrophication status of the lake (Ann et al. 2000).
- Over 30 industrial and hazardous waste sites were studied pursuant to the Clean Water Act for their potential to release priority organic pollutants to neighboring waterways. While much was known of the involvement of these chemicals in causing ground water contamination in shallow aquifers, much less was known of their potential to be carried off site by runoff, etc., and enter streams and rivers. The most serious contributors to sediment and water contamination throughout the state were former wood treating sites that released excessive amounts of chemicals to adjoining waterways.

Certain polynuclear aromatic hydrocarbon compounds involved at these contaminated sites are known human carcinogens (Miles and Delfino 1999).

SUMMARY

Water resources sustainability in Florida is challenged by many natural and anthropogenic factors. Most of these problems can be resolved by timely and effective action and prevented in the future by proper control actions. While mostly natural conditions create flood or drought conditions, it is the human response that creates problems for society. If our society would continue to adopt measures aimed at fostering water conservation and the prevention of water pollution, waters in the state will become more available for the use and enjoyment of posterity. The allocation of water to areas outside of their present location, when necessary, is logistically possible but will Florida's citizens approve inter-basin transfers? The use of technology to convert sea water to potable water will become more prevalent and more efficient in the future as the state's population continues the grow, but it is unknown to what extent society will be willing to pay substantially more money for its drinking water. Contamination of the state's waters from point and non-point sources, including the release of toxic chemicals, must be controlled, reduced and eventually rendered negligible.

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