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Balancing Urban Water Demand and Supply in Florida: Overview of Tools Available to Water Managers[1]

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Introduction

Many Florida communities experience periodic water shortages or have serious concerns about balancing water usage and supplies (Goodnough 2007). As the state seeks to balance economic growth and development with protection of its natural resources, managing water becomes a high priority for policy makers and utility managers. This document discusses alternative strategies that can be used by water utility managers to balance water demand and supply in the residential sector, which accounts for roughly 37 percent of Florida's freshwater use (Marella 2008).

These strategies can be grouped into two broad categories: (1) increases in the stock of water resources available for public supply and (2) water demand management. The available stock of water resources can be expanded by constructing desalination plants, capturing surface water, re-using water (e.g., reclaimed water supply), and reducing unrecovered system loss. In turn, demand for water can be influenced through water rates, education and awareness strategies, rebates for efficient fixtures and other conservation technologies and practices, and mandatory or voluntary restrictions on water use. We briefly discuss three key trends that shape water supply and demand management in the state, and present an overview of specific tools that communities could consider for managing their water resources.

Trends Influencing Public Water Supply Management

Three trends shape water supply and allocation nationwide and in Florida: (1) population growth, (2) demand for in-stream water uses and environmental costs of groundwater withdrawals, and (3) concerns about potential impact of climate change (Dziegielewski and Kiefer 2008).

Despite improved water use efficiency, Florida's rapid population growth led to an approximately 30 percent increase in water withdrawals for public

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supply between 1990 and 2005 (Marella 2008). The population of Florida increased by 14.7 percent between April 2000 and July 2008 (U.S. Census Bureau 2008), and is estimated to continue growing at about 37,000 residents each year between 2008 and 2010 (UF BEBR 2009) (which is about 0.2% of the state population in 2008). Providing adequate water to the growing population is a serious concern for water managers.

These concerns are heightened by the potential for long-term climate change. Any change in rainfall, evaporation, groundwater recharge, or runoff due to climate variability and change would affect freshwater availability and demand. In a hotter, drier climate, which has been predicted by some if atmospheric concentrations of greenhouse gases continue to increase (referred to as *global warming* or *climate change*), residential water demand would increase due to more irrigation and other outdoor water uses. In turn, water resources would diminish due to less rainfall and more evaporation of fresh water, as well as salt water intrusion into aquifers in the state's coastal areas. Sea level rise also poses a risk to the water supply from water storage reservoirs constructed in the low-lying areas of south Florida (Stanton and Ackerman 2007).

Additional withdrawals from traditional ground and surface water sources have met growing public resistance due to the recognition of water values for in-stream uses, such as aquatic ecosystem support, recreational uses, and assimilative capacity to maintain water quality (Dziegielewski and Kiefer 2008). For example, there were numerous opponents of the recent decision to allow the Seminole County utilities to withdraw water from the St. Johns River (WJXT-TV 2009). Likewise, the hidden costs of groundwater withdrawals have become increasingly apparent. These include lower aquifer levels and higher pumping costs, sinkholes and land subsidence, saltwater intrusion along the coasts, and lower water levels for springs and wetlands fed by groundwater (Molle and Berkoff 2009). While population growth will increase water demand and climate changes may exacerbate water shortages, the ability to increase water supply using traditional sources (such as ground and surface water sources) is limited.

Expanding Stocks of Water Resources Available for Public Supply

In Florida, some water systems have turned to *alternative* water sources and water-source diversification as primary strategies to manage the stock of water resources for public supply. Mainly, this includes desalinizing saltwater and brackish water, capturing and storing surface water during the wet season, and using reclaimed water and stormwater (SFWMD 2009a; SCES 2003).

Desalination

The use of nonpotable salt or brackish water, i.e., "water treated through desalination or diluted with fresher water to meet drinking water standards" (Marella 2004), has increased from about 2 million gallons per day (mgd) in 1970 to about 95 mgd in 2000. Despite the significant increase in water desalination, nonpotable water in Florida accounts for just 1.2 percent of the states freshwater withdrawals, which equaled 8,192 mgd in 2000 (Marella 2004).

Few desalination plants in Florida are designed to use seawater. The two oldest plants are in Key West, with a capacity of 3 mgd (Akpoji 2008). A large ocean water desalinization plant, Tampa Bay Seawater Desalination Plant, was recently built in Hillsborough County. It is currently producing between 16 and 20 mgd (Conner 2009). Another seawater desalination plant is being constructed in Flagler County (SJRWMD 2009a), and the St. Johns River Water Management District is considering construction of a new plant in Duval County (Hunt 2009). While seawater desalination offers a way to expand water use for public supply, this expansion comes at significant capital and operation costs. The seawater desalination process can cost five times more than treatment processes for water from traditional sources, and the costs keep going up (USGS 2009). For example, the estimated cost of water from the Tampa Bay Seawater Desalination Plant in 2006 was $3.19 per thousand gallons (Bernett 2007), compared to the average charge for water in the southern United States in 2004 at $2.5 per thousand gallons (AWWA and Raftelis 2006). In addition to high capital and operation costs, sea water desalination can pose environmental risks due to significant energy requirements (i.e., high carbon emissions) and the disposal of the by-product of desalination—briny concentrate (Grose 2008).

In comparison with seawater, brackish water is characterized by lower concentrations of dissolved salts, and hence, lower energy costs for desalination. Brackish water is typically pumped from the ground near the coast. In 2000, nine Florida counties were using desalination or groundwater dilution to supplement public supplies (Broward, Charlotte, Collier, Indian River, Lee, Martin, Palm Beach, St. Lucie, and Sarasota) (Marella 2004). All totaled, there are more than 130 desalination plants in Florida, and more are under construction (Akpoji 2008).

Surface and Rain Water Capture and Storage

Another option for supply expansion is storage reservoirs to collect excess surface water during the rainy season. Fifty-five percent of Florida's annual rainfall occurs during the four-month period from June to September (Fernald and Purdum 1998). Excess surface and rain water is captured in Florida for later use by public utility companies and individual citizens. For example, Tampa Bay Water uses a reservoir to skim water from the Tampa Bypass Canal and the Alafia and Hillsborough Rivers during the rainy season. The reservoir is capable of holding 15 billion gallons of water that can be used to supplement Tampa Bay Water's water supply during Florida's dry season (Pittman 2009; Tampa Bay Water 2007). This large reservoir system is currently undergoing an extensive repair process which will be completed in 2012 (Pittman 2009). Another example is the Taylor Creek Reservoir in Orange and Osceola Counties that is used by the city of Cocoa to withdraw about 8.8 mgd to supplement groundwater sources (city of Cocoa 2009). Currently, the Taylor Creek Reservoir drains about 60 square miles of watershed. The project to divert water from St. Johns River into the reservoir to increase water withdrawals by 40 mgd is under way (SJRWMD 2009b). Another example is the proposed stormwater collection project by Broward and Palm Beach Counties (Reid 2009). On an individual scale, many residents of the Florida Keys rely on cisterns (individual household rainwater reservoirs) to supplement their water supply during the dry season (FKAA 2008).

Reclaimed Water

Water reclamation is defined by the Florida Department of Environmental Protection as:

> taking domestic wastewater, giving it a high degree of treatment, and using the resulting high-quality reclaimed water for a new, beneficial purpose. Extensive treatment and disinfection ensure that public health and environmental quality are protected (FDEP 2009).

Reclaimed water can be used for many non-drinking water applications, such as landscaping and fire suppression. The use of reclaimed water in Florida has increased from 584 mgd in 2003 (SCES 2003) to 660 mgd in 2007 (Miller 2007). Reclaimed water can replace or supplement drinking water. In 2005, about half of the reclaimed wastewater was used for urban or agricultural irrigation, or industrial use, and one-third was used for aquifer recharge (Marella 2008). The city of Tampa is currently considering using highly treated wastewater as a supplemental drinking water supply in 2010. Specifically, the proposal would allow a new treatment plant to purify the wastewater to drinkable quality, and then inject it into the ground for natural filtration before it flows into the Hillsborough River, the city's primary source of drinking water (Wade 2009).

Although the public perception of reclaimed water is improving, there are serious concerns associated with pathogens in all water, particularly reclaimed water. Some raise the concern about the ability of wastewater treatment to remove hormones from the water. There is a need for an education-and-information campaign to educate the public about the use of reclaimed water for irrigation. For example, irrigating with reclaimed water in container nurseries is discussed in Yeager et al. (2009). Lawns irrigated with reclaimed water will require fertilizer adjustments for the high nutrient content in the water and for potential increases in nutrient runoff from urban areas relying on reclaimed water. More information about water reuse in Florida can be found for the Florida Department of Environmental Protection Water Reuse Program at http://www.dep.state.fl.us/water/reuse/flprog.htm.

Water Demand Management

"Demand reduction programs allow some agencies to balance supply and demand at a cost that is below the economic, social, and environmental cost of new supply development" (Baumann and Boland 1996: 9). Demand management is inherently related to the choices households make, and unlike water supply management, it requires the active participation of water users. Demand management tools available to water utilities typically fall under one of the following categories: quantity controls, economic incentives, education/awareness programs, and non-economic incentives.

Quantity Control: Water Use Restrictions

In Florida, outdoor irrigation restrictions prohibit lawn watering for specific days of the week. For example, in the St. Johns River Water Management District (SJRWMD), landscape irrigation is limited to "no more than two days a week during daylight saving time and to no more than one day a week during Eastern Standard Time" (SJRWMD 2009c). Furthermore, landscape irrigation in the SJRWMD is prohibited between 10 A.M. and 4 P.M. (SJRWMD 2009c). County and city governments are authorized to enforce irrigation restrictions imposed by the Florida Water Management Districts. Violations can result in fines. Residents can submit a petition for variance, and propose an alternative irrigation schedule. More about irrigation restrictions imposed by Water Management Districts can be found online as follows:

- Northwest Florida Water Management District: http://www.nwfwmd.state.fl.us/
- Saint Johns River Water Management District: http://www.sjrwmd.com/wateringrestrictions/index.html
- South Florida Water Management District: http://www.sfwmd.gov/
- Southwest Florida Water Management District: http://www.swfwmd.state.fl.us/conservation/restrictions/
- Suwannee River Water Management District: http://www.srwmd.state.fl.us/FAQ.aspx?QID=110

When enforced, irrigation restrictions can be very effective in the short term. For example, restrictions have resulted in water use reductions of about 17 percent in Orange and Hillsborough Counties, and up to 21.5 percent in south Florida (Olmsted 2008). Despite their demonstrated effectiveness, irrigation restrictions are only imposed during severe droughts, and are generally not considered to be a long-term solution. Also, during economic downturns, local governments' financial and human resources may be too limited to conduct effective monitoring and enforcement of water restrictions.

Economic Incentives: Conservation Water Rate Structures

Conservation rate structures provide consumers with a price incentive to conserve water or to use it more efficiently. Although there is a variation in the type of conservation rates that utilities can use, all conservation water rates share one thing in common: the more water consumers use, the higher their water bills will be. For example, given ascending block rates, households using 5,000 gallons per month might pay $3.00 per thousand gallons while households using 10,000 gallons per month might pay $4.50 per thousand gallons. In theory, consumers respond to higher water prices by purchasing less water. However, when water prices are low, consumers are relatively insensitive to price increases. National studies show that, on average, residential customers respond to a 10 percent increase in water rates with only a 1 to 3 percent reduction in water usage (AWWA 2000). Florida water users are somewhat more sensitive to rate hikes; a 10 percent increase in water rates is expected to generate a 4 to 8 percent drop in water use (Whitcomb 2005). More information about conservation water rates can be found in Borisova et al. (2009) and Rawls and Borisova (2009).

Economic Incentives: Seasonal and Drought Rates

Water rates can increase during the seasons of higher demand or low-water availability. For example, Miami-Dade County Water and Sewer used seasonal rates from 1998 to 2004, alternating between two different five-block structures, each of which was in effect for six months (Whitcomb 2005). Drought rate structures are often used during periods of severe water shortages. Drought rates are additional fees or prices for water usage during drought conditions that provide a strong economic incentive for households to conserve water. Unlike conservation rates, drought and seasonal rates only address short-term water shortages.

Retrofits and Rebates

Retrofit programs involve modifying existing household appliances and fixtures with devices that improve water use efficiency. This includes faucet aerators, toilet displacement dams, low-flow showerheads, and the like. Related programs offer rebates to consumers replacing inefficient appliances, for example, with low-volume toilets, front-loading clothes washers, and certain dishwashers. In addition, the Water Savings Incentive Program (WaterSIP) in the South Florida Water Management District (SFWMD) offers:

> matching funds up to $75,000 to water providers and large users for installing water-saving technology such as automatic flushing devices for hydrants, indoor plumbing retrofits, soil moisture and rain sensors, and large-area "smart" irrigation system controllers (SFWMD 2009b).

The USGAO (2000) provides a good description of program costs, savings, and duration of six toilet retrofit/replacement programs. These occurred primarily during the 1990s in Tampa (Florida), Hillsborough County (Florida), Austin (Texas), Los Angeles (California), New York (New York), and Phoenix (Arizona). For the six programs, 2.3 million low-flow toilets were distributed free or through rebate programs. Estimated water savings ranged from 23.4 to 53.8 gallons per toilet per day, and total water savings were 102.0 mgd. Average costs per toilet were $175.72, and the total cost of the programs was $409.6 million. Every dollar spent on the program resulted in about 0.25 gallons saved per day. Over ten years, it adds up to about 900 gallons saved; in other words, cost of the program per gallon saved over a ten-year period is $0.001.

Extensive studies of retrofits and replacements were conducted by Mayer et al. (2000; 2003; 2004) with over 100 homes in Tampa (Florida), Seattle (Washington), and San Francisco (California). In each case, homes were retrofitted with faucet aerators, low-flow showerheads, and high-efficiency toilets and clothes washers. These studies identified leakage—primarily from faulty toilet valves—as being responsible for a large amount of water loss. Reduction of water waste from leaks accounted for the majority of the retrofit savings in Tampa and San Francisco. Toilet replacement accounted for the highest savings for Seattle, and second-most for San Francisco and Tampa Bay.

Educational Programs

For years, local governments, utilities, universities, and regulatory agencies have sought to raise public awareness about water conservation. These efforts can take the form of in-school education programs, workshops, social advertisements, information inserts in utility bills, internet sites, etc. In some cases, these efforts are very successful. For example, in 2002, the Saint Johns River Water Management District implemented a comprehensive public awareness campaign (Burnette 2003). Survey results indicated that after the campaign, public knowledge of general water conservation techniques increased by 10 percent, while public knowledge of specific ways to conserve water increased by 22 percent (Burnette 2003). Still, more research is needed to examine the effect of different types of programs on different groups of water users and in different areas of Florida.

Certification

Certification programs can be used to indicate that specific yards, buildings, or communities meet specific water efficiency standards. Such certification can be used to apply for economic subsidies such as rebates and grants; to differentiate from competitors, for instance, in real estate; or to gain social status for individual households. One such certification program, Florida WaterStar℠, is a voluntary program focused on indoor and outdoor water use efficiency for new and existing homes. Certification for this program is offered by St. Johns River, South Florida, and Southwest Florida Water Management Districts. Several local governments and utility companies offer rebates for homes certified by WaterStar℠ (SJRWMD 2008; 2009d). For more information, visit online http://www.floridawaterstar.com/. The University of Florida offers a similar program for water-efficient landscaping. The Florida-Friendly Landscaping™ program offers certification to individual homeowners if their landscaping satisfies requirements listed in the program's yard certification check list. Certified homeowners receive a yard sign that signifies the yard as Florida-Friendly (UF-FYN 2009a). Florida-Friendly Community Awards also can be given to water-efficient communities (UF-FYN 2009b). A list of other certification programs available to real estate developers and individual homeowners is available online at http://fyn.ifas.ufl.edu/professionals/awards.htm (UF-FYN 2009b).

Pros and Cons of Demand Management Programs

When considering demand management options, communities and policy makers should consider the pros and cons compared to the management of the stock of water resources available for public supply. Demand management has several advantages (AWE 2008; AWWA 2000; Cavanagh et al. 2002; Wang et al. 2005):

- **Cost:** Demand management programs are often much less expensive to implement than projects that increase supply. Supply projects sometimes go over budget, taking more time and money than originally estimated. This is less common with demand management programs.

- **Environmental benefits:** Decreasing demand for water can reduce the stress on aquifers and aquatic ecosystems, including endangered species and culturally significant sites like the Everglades.

- **Infrastructure benefits:** Decreasing demand for water could slow the impact of population growth on water supply and distribution infrastructure. This could save money in the long term.

There are some challenges associated with demand management that could make supply management options seem more attractive. They include (AWE 2008; AWWA 2000; Whitcomb 2005; Wang et al. 2005):

- **Effectiveness**: To be effective, demand management requires the active participation of water users. This can make it difficult to predict changes in demand from a specific demand management strategy. Residential customer responses depend on demographics, attitudes, types and ages of customers' houses, weather events, etc. For example, while a utility can guarantee itself a 10 percent increase in supply with a particular water supply expansion project, it is much more difficult to predict reduction in water use from retrofit programs or conservation pricing.

- **Public perception**: Water users have varying views concerning the need for conservation. Some consumers may not understand why demand management programs are being implemented. In particular, some customers resist any increase in water rates. When conservation programs are more cost-effective than supply expansion, or if conservation programs meet some other critical community goal, this needs to be communicated to the public.

- **Effect on utilities' revenues**: In some cases, successful demand management can reduce utility revenue. Less water demand often means less water sold. Decision support tools, demand forecasting, and revenue stabilization funds can be used to mitigate revenue shortfalls. Effective demand management should postpone or reduce the costs of future supply expansion.

- **Impact on low-income customers**: Conservation rates, drought rates, and other demand management policies may have a disproportionate impact on low-income consumers. Many of these water users spend a large portion of their income to meet basic needs, even after cutting back on discretionary water use. For these households, increased water rates typically translate only to higher water bills, not less water use.

Conclusions

Communities, water utilities, and state and regional water resource managers have a portfolio of strategies to address limited water supply and growing water demand. Expanding available water supplies could have crucial benefits for areas with rapid population growth. When designed properly, both traditional and alternative water supply projects can successfully and cost-effectively supplement traditional water sources. However, increasing the available water supply is usually expensive. Water demand management is often more cost-effective than increasing supplies, but produces less certain outcomes. Specific strategies must be selected based on costs and effectiveness, and tailored to local conditions that include public opinion, political considerations, cost/difficulty of program implementation and administration, funding issues, and staff expertise/availability.

As Florida continues to address critical water issues, it is likely that a number of different strategies will be necessary throughout the state. We have highlighted some of these strategies. More research and public discussion will help ensure that additional solutions also are developed.

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