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POLICY ANALYSIS:

SOUTH FLORIDA GROUNDWATER – TECHNOLIGICAL AND POLICY SOLUTIONS FOR AN UNSUSTAINABLE THIRST

BY

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Executive Summary

Despite relatively abundant water resources, Florida faces the prospect of demand exceeding supply within 40 years. Particularly in the south of the state, heavy reliance on groundwater sources of freshwater presents an unsustainable situation for a region with an increasing population. In this paper, we consider some of the major challenges to water supplies in South Florida and discuss potential technological and policy solutions to these problems.

The South Florida Water Management District is the largest in the state by population and accounts for the majority of the state's freshwater use. Much of this water comes from groundwater sources, such as the Biscayne Aquifer. As a result of rapid urbanization in the second half of the twentieth century, these groundwater sources are increasingly becoming contaminated by saltwater intrusion and chemical and biological contaminants, and experiencing lower rates of replenishment from rainfall. This has placed further stress on groundwater resources, forming a positive feedback cycle which produces further contamination and rapid depletion.

In order to combat these threats, South Florida is currently seeking alternative supply projects to reduce demand on groundwater sources. These projects include physical and technical approaches such as contamination prevention, desalination of brackish groundwater, water reuse and aquifer storage, and policy options such as encouraging water conservation, establishment of water reservations, restoration of the Everglades and restrictions on water use. We discuss each of these solutions, particularly in view of the policy considerations for their implementation. In addition, we examine potential alternative solutions such as changing agricultural practices, managing population growth and physical methods such as cisterns and pipeline projects. By analyzing these potential solutions, South Florida can look towards sustainable use of water resources - an objective shared with many other regions of the United States.

Introduction

On average, enough water falls annually on the state of Florida to fill nearly twelve million Olympic sized swimming pools, which averages out to over 30,000 swimming pools full each day[1] (Florida Department of Environmental Protection [FDEP], 2009a; "How big is Florida", 2005; Fédération Internationale de Natation, 2009). Florida has more than 50,000 miles of rivers, streams and waterways, and nearly 1,200 statute miles of coastline (The Florida Council of 100 [FC100], 2003, p. 7). These vast natural resources provide the basis for agriculture, maritime industry, tourism, and recreation. Water is the defining economic, social, and cultural factor for the state. However, Florida's water resources have drastically changed since humans settled there. After more than a century of drainage, canal, and other water control projects meant to make the state more profitable and habitable, only about fifty percent of Florida's original wetlands remain. (Ingebritsen, McVoy, Glaz & Park, 1999, p. 96). Engineered changes, such as large-scale drainage and the construction of levees and canals, allowed for large population growth. The newly available land and water resources allowed agriculture to thrive, paving the way for later urbanization. Unfortunately, the acts that allowed for this development in central and south Florida also led to multiple water quality and environmental problems, which governments and the local population are now forced to deal with (Light & Dineen, 1994, p. 47-84). Surface waters have been heavily polluted from fertilizers and storm water runoff, and this can leech into aquifers. Ninety percent of Floridians depend on groundwater for their potable water, but the aquifers have been overdrawn and overstressed (FC100, 2003, p. 8). The increasing demand, particularly among South Florida's 7.5 million or so residents, cannot be met by the groundwater supply. According to a recent Natural Resources Defense Council (NRDC) study by Tetra Tech, Florida's water supply is expected to be at extremely high risk by 2050, such that demand will exceed supply (Natural Resources Defense Council [NRDC], 2010, p. 1).

This paper looks at the major issues facing South Florida's water supply, both to surface and groundwater sources, and the proposed technical and policy solutions currently being deployed to address these challenges. We also propose additional solutions that should be considered to ensure sustainable water supply for the region.

Background

Water Management Districts

Florida is divided into five water management districts, with the South Florida Water Management District (SFWMD) being the largest (Figure 1). SFWMD serves 16 counties in the southern portion of the state, covering about 7.5 million residents from the Florida Keys, greater Miami area, West Palm Beach, Orlando, and other well-known regions (South Florida Water Management District [SFWMD], 2010a). SFWMD withdraws the most freshwater annually, as can be seen in Figure 2, even though most of the state's precipitation falls in the northern portion of the state. The same trend holds for SFWMD's withdrawals even when considering fresh groundwater and fresh surface water separately, as can be seen in Figure 3.

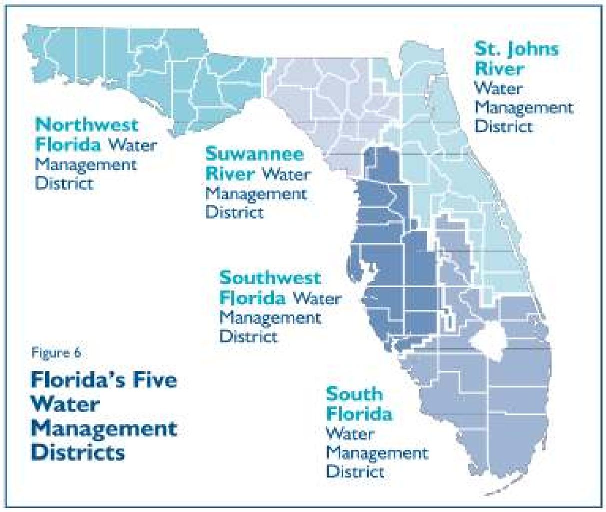

Figure 1. Florida's Five Water Management Districts (FC100, 2003, p. 9).

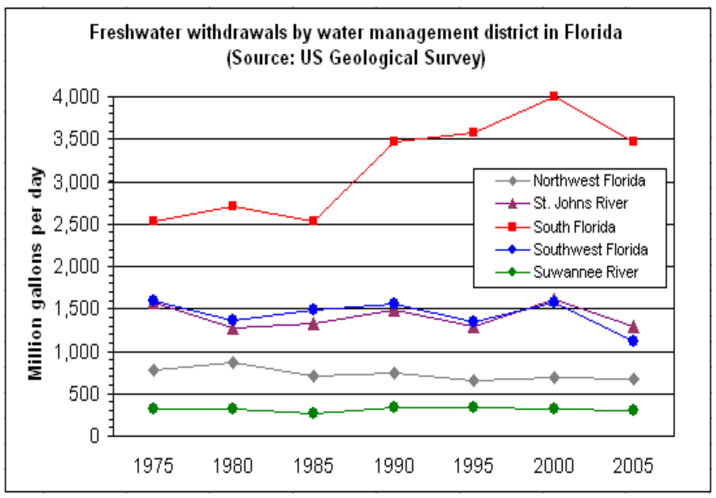

Figure 2. Total freshwater withdrawal by Florida water management district (USGS, 2010a).

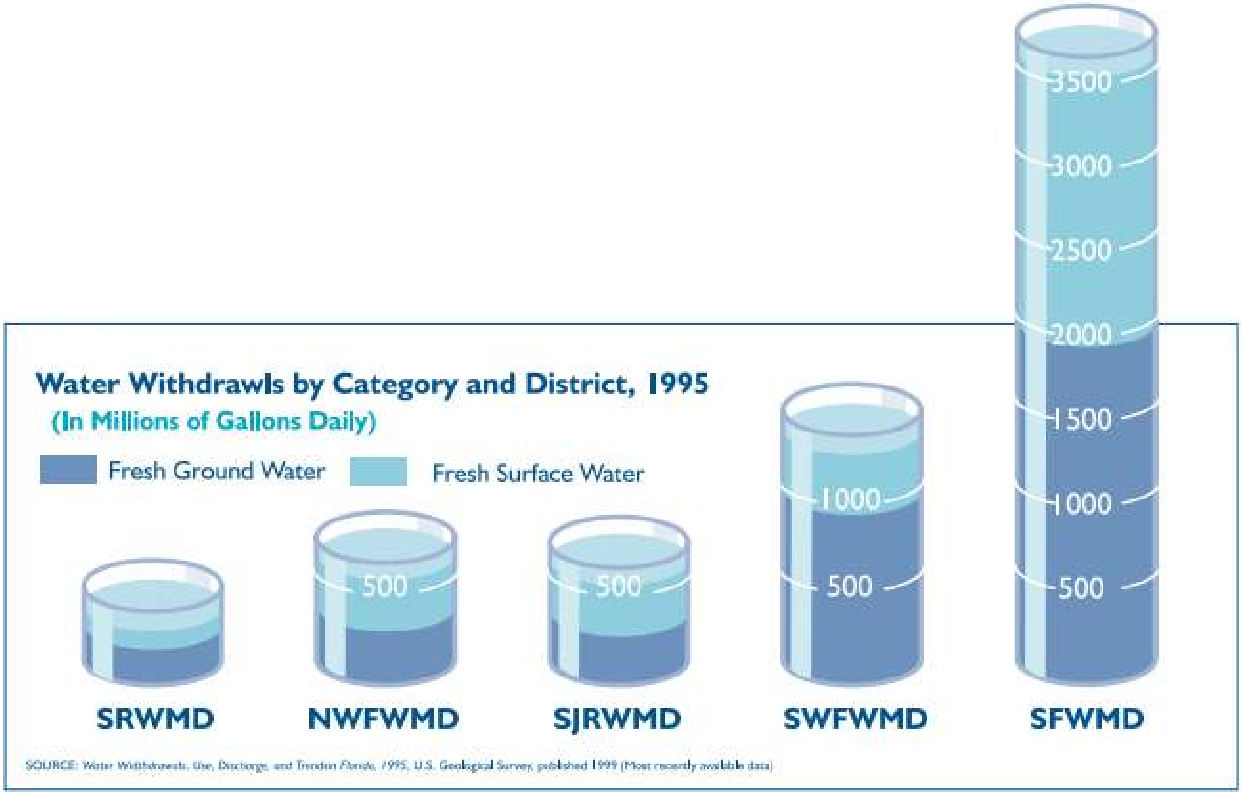

Figure 3. Freshwater withdrawal by category and district (FC100, 2003, p. 9).

Aquifers

Florida's aquifer system includes several aquifers that cover different parts of the state. The Floridan aquifer lies beneath almost the entire state, and is one of the most productive aquifers in the world (Cervone, 2003). The Floridan aquifer system is subdivided into the Upper and Lower Floridan aquifers. The Upper Floridan is more permeable, and is separated from the Lower Floridan by a middle confining unit of clay, limestone or dolomite. In northern regions of the state, such as within the Suwannee River Water Management District, the Upper Floridan provides almost all the water for public, self-supplied domestic, self-supplied commercial-industrial, and agricultural supplies. In these areas, the Lower Floridan either does not exist or is not used for water supply (Grubbs, 1998, p. 3). However, in South Florida the Floridan becomes brackish (a mixture of salt and freshwater instead of pure freshwater) in the Upper level and saline in the Lower level, and thus is unfit for consumption. Figure 4 is a representation of where the Floridan aquifer is used for potable (drinking, or other household uses) water. As can be seen in this figure, South Florida is unable to use the Floridan aquifer for freshwater.

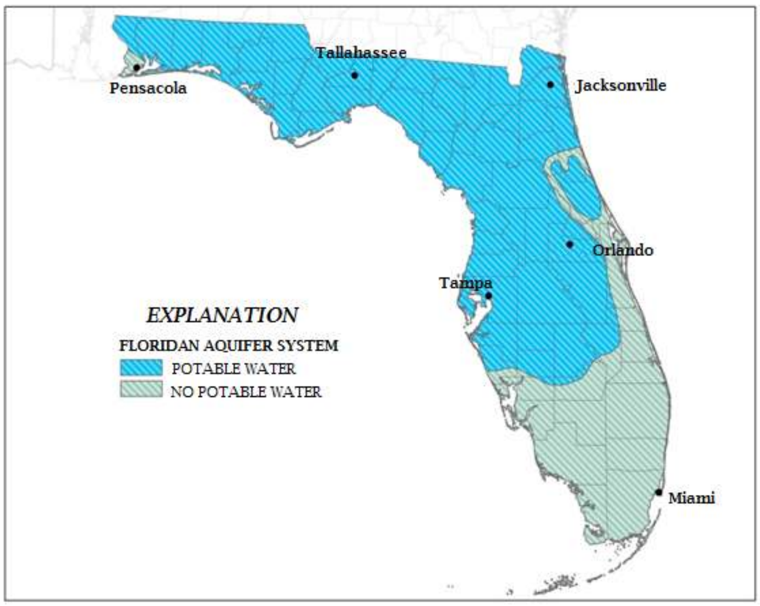

Figure 4. The Floridan Aquifer is brackish in the southern portion of the state (FDEP, 2007).

Instead, the Biscayne Aquifer, which is found along the southern tip of the state, provides freshwater to the SFWMD. In some of the northern and western areas of the SFWMD the Surficial Aquifer System provides additional water, but generally only for domestic, commercial, or small municipal supplies (FDEP, 2007). The Surficial Aquifer System refers to any "otherwise undefined aquifers that are present at the land surface" (FDEP, 2007). Figure 5 shows the relevant aquifer systems overlaid.

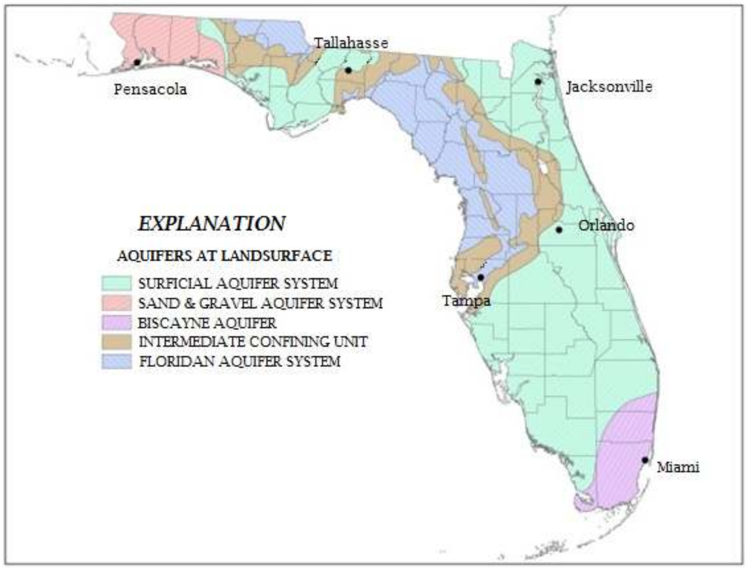

Figure 5. The Floridan aquifer covers Florida, with the Biscayne and Surficial aquifers above it in the Southern and Eastern portion of the state (FDEP, 2007).

Surficial aquifers are shallow beds of sand and shells less than 100 feet underground, and in Florida the surficial aquifer is separated from the Floridan Aquifer by a confining unit consisting of a bed of less permeable soil (Cervone, 2003). Figure 6, from a USGS report, shows a profile view of Florida's aquifers.

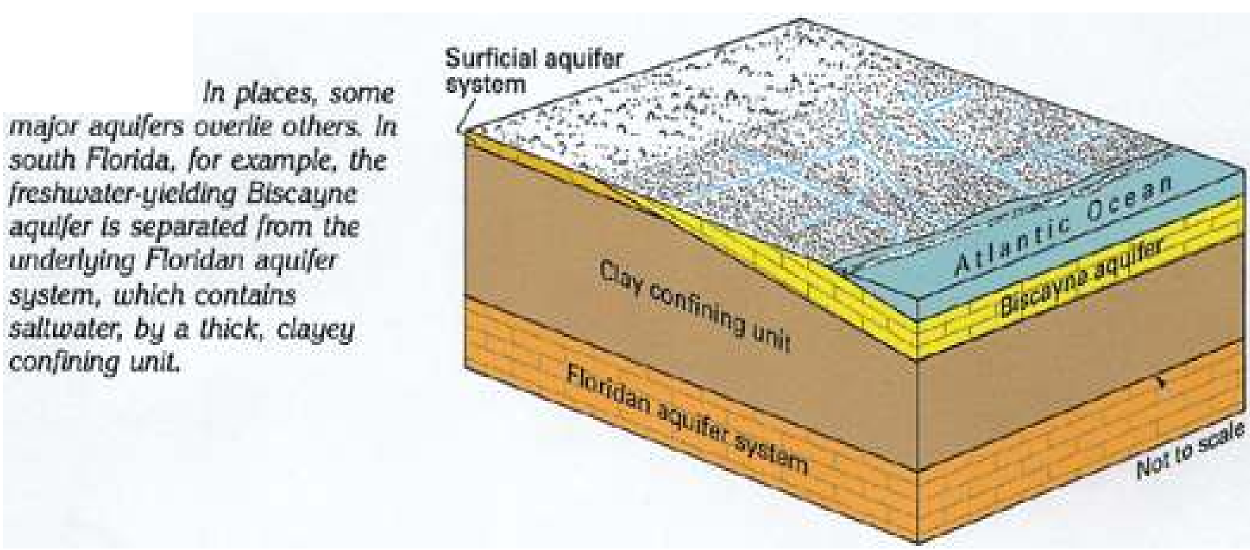

Figure 6. Profile view of aquifer layers (Miller, 1990).

As groundwater is pumped out for human use or flows out into other bodies of water naturally, it must be replenished. This can either happen by infiltration, surface water-groundwater interactions, or by humans pumping water back in to depleted aquifers.

Infiltration is the natural process during which rainwater seeps through soil down into the groundwater. The rate of infiltration, - how fast rainwater can seep down into the aquifer - depends on many factors, such as the type of soil, the intensity and duration of the rainstorm, the slope of the land, and the type of land cover. Of these, land cover is the factor most affected by human influences. For example, land that is covered by woods has a different infiltration rate than land covered by grass or land covered by pavement. Generally speaking, the more "urban" a land cover (for example, a parking lot or building), the lower the infiltration rate (or, the lower the rate at which the soil can absorb rainfall). Infiltration can also be specified using runoff coefficients, which instead describe the percentage of water that runs off (rather than infiltrates) given the type of surface. These coefficients vary depending on the method used to calculate runoff, however, to give an idea of the range of these factors, one technique (the Rational Method) calculates that the runoff coefficient for a flat lawn is around 0.10 and the coefficient for a wooded area is 0.15, whereas asphalt or concrete has a coefficient of 0.95 (North Carolina Department of Environment & Natural Resources, 2007, p. 3-2). This is due to the fact that "urban" surfaces tend to be less permeable than natural ones, so in urban settings less of the rain permeates the ground surface and more of the water becomes runoff (Stankowski, 1972, p. B219).

Human activity can also modify surface-groundwater interactions. Typically, these interactions occur where rivers, lakes, or shorelines connect to the water table. When groundwater levels are higher than surface water levels, the groundwater seeps out into the surface water. When surface water levels are higher than groundwater levels, the surface water seeps into the groundwater. This occurs naturally, and can vary by season or location. However, when human activity results in the lowering of groundwater or surface water levels, this may reverse the direction of the interaction. Thus, human activity can indirectly influence groundwater replenishment by changing surface water levels. In addition, groundwater replenishment can be altered by directly pumping water into aquifers, which is discussed in detail in a later section. The Floridan Aquifer is mostly recharged by rain in the northern portion of the state, where it is unconfined or only semi-confined. Though Florida receives close to 50 inches of rain annually, recharge rates are typically less than half of this (United States Geological Survey [USGS], 2010a). From what is known about aquifer replenishment, it is possible to conclude that the presence of humans in these regions is a major cause for these lower recharge rates.

Because the Biscayne Aquifer is porous and close to the surface, it is easily replenished by rainwater (Miller, 1990). Figure 7 shows the recharge zones for the Biscayne Aquifer.

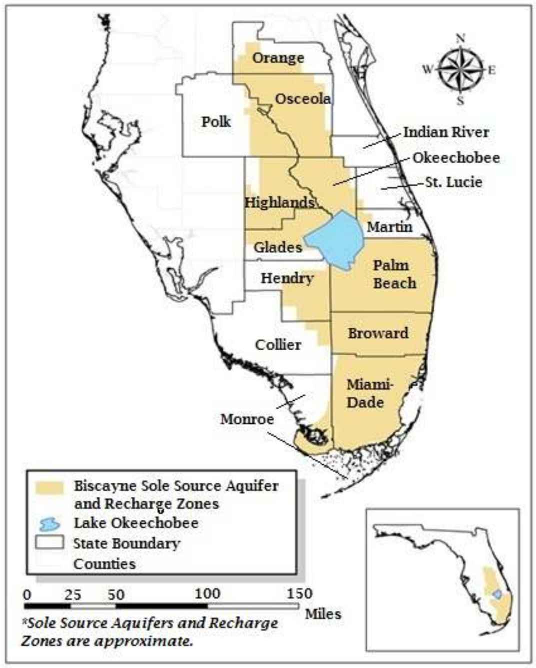

Figure 7. Biscayne Aquifer Recharge Zones (Environmental Protection Agency [EPA], 2010).

Figure 8 shows the differences in population density in South Florida from 1980 to 2000. By comparing Figures 7 and 8, it can be seen that much of the recharge area of the Biscayne Aquifer has experienced increases in population density. Although exact figures are not available, it is reasonable to assume that this increase in population density has led to an increase in impervious areas and a subsequent decrease in recharge rates for the Biscayne Aquifer, in a similar phenomenon to what is observed for the Floridan Aquifer.

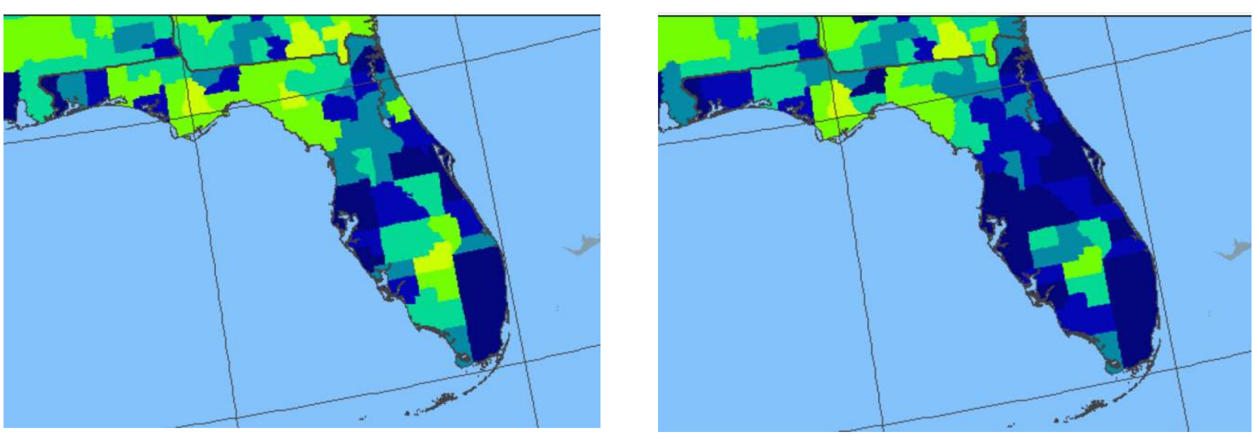

Figure 8. Population density in 1980 (left) versus 2000 (right). Darker colors indicate higher densities (National Atlas of the United States, 2010).

Threats and risks to groundwater

Contamination

The effect of increased imperviousness as a result of urbanization on aquifer recharge was outlined above. However, increased imperviousness can decrease the amount of water recharging the aquifer, but it can also increase the amount of storm water runoff. Urban runoff tends to have much higher levels of contaminants, so this storm water runoff is more polluted than what the runoff would have been from a natural surface. In South Florida, this contaminated runoff can enter the aquifers through streams and canals. Though overall water quality in the Everglades has not changed substantially due to the natural ability of the ecosystem to "clean" water, areas where excess water is pumped into the wetlands from flood-prone agricultural and urban areas has seen drops in water quality (McPherson, Hendrix, Klein & Tyus, 1976, p. 69). During times of drought, nutrient levels also tend to be above normal, especially in regions linked to agriculture (Perry, 2008, p. 569). Additionally, during rain events it is common that regulatory standards for contaminants such as fecal coliform are exceeded on Florida beaches (Brownell *et al*, 2007, p. 3747). Several bodies of surface water in Florida were placed on the 303(d) List in 1998, indicating that these areas do not meet water quality standards as specified by the Clean Water Act (FDEP, 2010a). Because of surface-ground water interactions, the presence of contaminants in surface water creates concern for the quality of groundwater.

Groundwater can also be polluted directly by chemicals. Fertilizers used above ground or leaks in underground sewage and industrial waste tanks and pipes can leech contaminants into the groundwater systems (Harvey & McCormick, 2009, p. 185). The Floridan aquifer system is especially vulnerable to leeching contaminants because of the numerous springs and sinkholes over it, which provide a direct line into the groundwater system (USGS, 2010a). In the northern portion of the state, the upper level of the Floridan is also vulnerable due to the lack of a confining layer above it. The Biscayne Aquifer is especially susceptible to contamination from leaks and spills because it is highly permeable (USGS, 2009). Pollutants can easily seep through the ground or enter through the numerous canals that run over the aquifer. Figure 9 shows an example of instances from private wells where two different contaminants were found in levels exceeding acceptable concentrations. Instances of both contaminants are clustered around predominantly agricultural areas above the surficial aquifer. This means a high amount of contaminants leeching into a highly permeable groundwater source – something that could easily occur in South Florida over the Biscayne Aquifer.

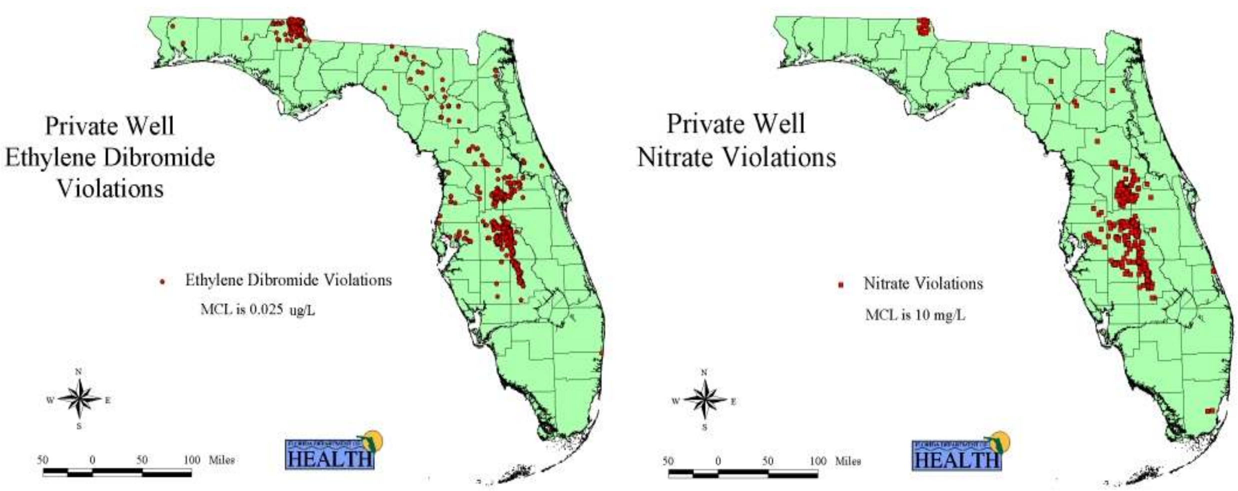

Figure 9. Contaminants tend to enter the groundwater supply in the surficial aquifer near large sources of contaminants (Florida Department of Health, 2010).

Aquifers can also be contaminated by saltwater. When water levels get low enough near the coast, saltwater encroaches into the aquifer underground or through canals – a process known as saltwater intrusion (Miller, 1990). If this occurs, that portion of the aquifer may be unfit for potable use without costly desalination treatment.

Saltwater intrusion is a very real threat in South Florida due to the Biscayne Aquifer's highly permeable edges and proximity to both the coast and miles of human-constructed canals. In early November 2010, the SFWMD began planning for the possible effects of climate change, with the main threat to the water supply being seawater leaking into groundwater as the surrounding ocean level rises (Climate Signals, 2010). This kind of contamination can also be directly linked to depletion - namely, lowering groundwater levels through pumping or drainage canals creates an imbalance that causes saltwater to intrude inland (Miller, 1990). Data from a USGS report on groundwater in Florida (see Figure 10) shows the how the saltwater intrusion phenomenon works. Because most of the drinking water in South Florida comes from groundwater, and the groundwater supply is close to the surface below very permeable layers of limestone, the drinking water supply in the Biscayne Aquifer is particularly susceptible to saltwater contamination (Cervone, 2003).

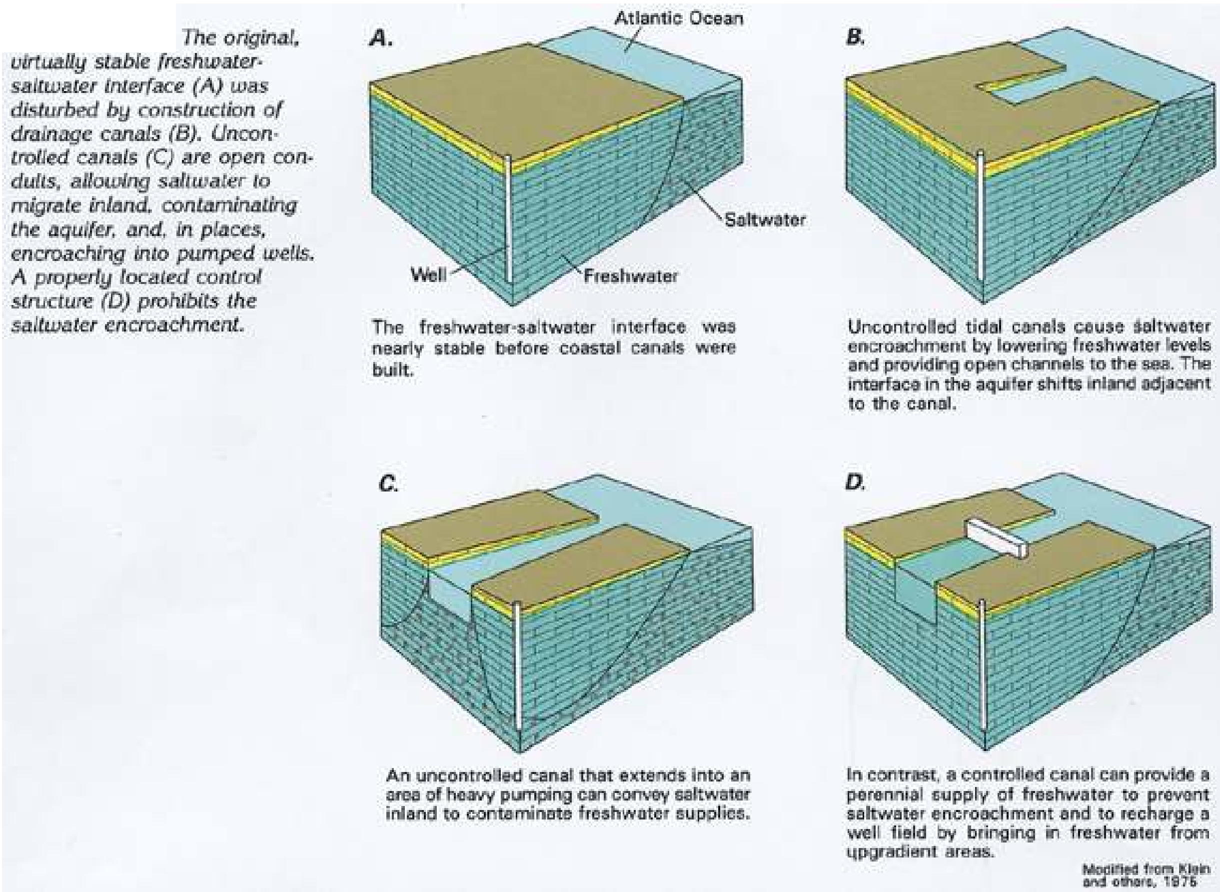

Figure 10. Saltwater intrusion mechanisms (Miller, 1990).

Contamination by chemical (such as fertilizer or industrial wastes) or biological (such as sewage) contaminants is a threat to South Florida's surface and groundwater supplies. In 2008, testing by the Florida Department of Environmental Protection (FDEP) found large regions of surface water were contaminated by sewage, fertilizer or manure pollution (Florida Water Coalition, 2010). Wetland ecosystems, such as the Everglades, traditionally influence groundwater recharge and discharge, sediment and toxicant retention, and nutrient processing/water quality (Maltby & Dugan, 1994, p. 33). However, with degradation of the Everglades and increased loadings and stressors, some parts of the aquifers have already been tainted by these contaminants, as well as by saltwater intrusion. Groundwater in the Biscayne aquifer beneath some of the more urban areas of South Florida contains nutrients and coliform bacteria from septic tanks and seepage from polluted canals (McPherson, Hendrix, Klein & Tyus, 1976, p. 72). In the past, programs have intentionally disposed of treated and semi-treated wastewater in the deeper parts of the Floridan aquifer (Garcia-Bengochea & Vernon, 1970, p. 1454).

Depletion

As discussed above, depletion of water sources can exacerbate saltwater contamination. However, depletion also causes other problems. From 1950 to 2000, total withdrawals from the Floridan Aquifer (including withdrawals by other states) increased by 500 percent (Berndt & Marella, 2005, p. 14). Figure 11 shows how total groundwater withdrawals in Florida have increased, in comparison with somewhat steady surface water withdrawals.

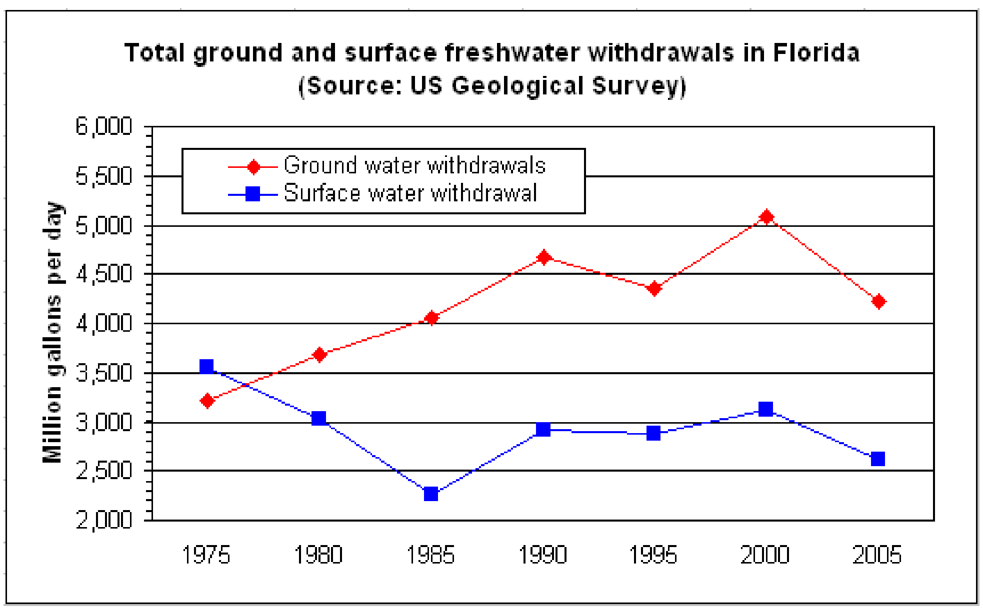

Figure 11. Total freshwater withdrawals in Florida (USGS, 2010a).

Figure 12 demonstrates the change in groundwater freshwater and saline withdrawals as well as changes in public supply from 1985 to 2005. Darker colors indicate a higher level of withdrawal.

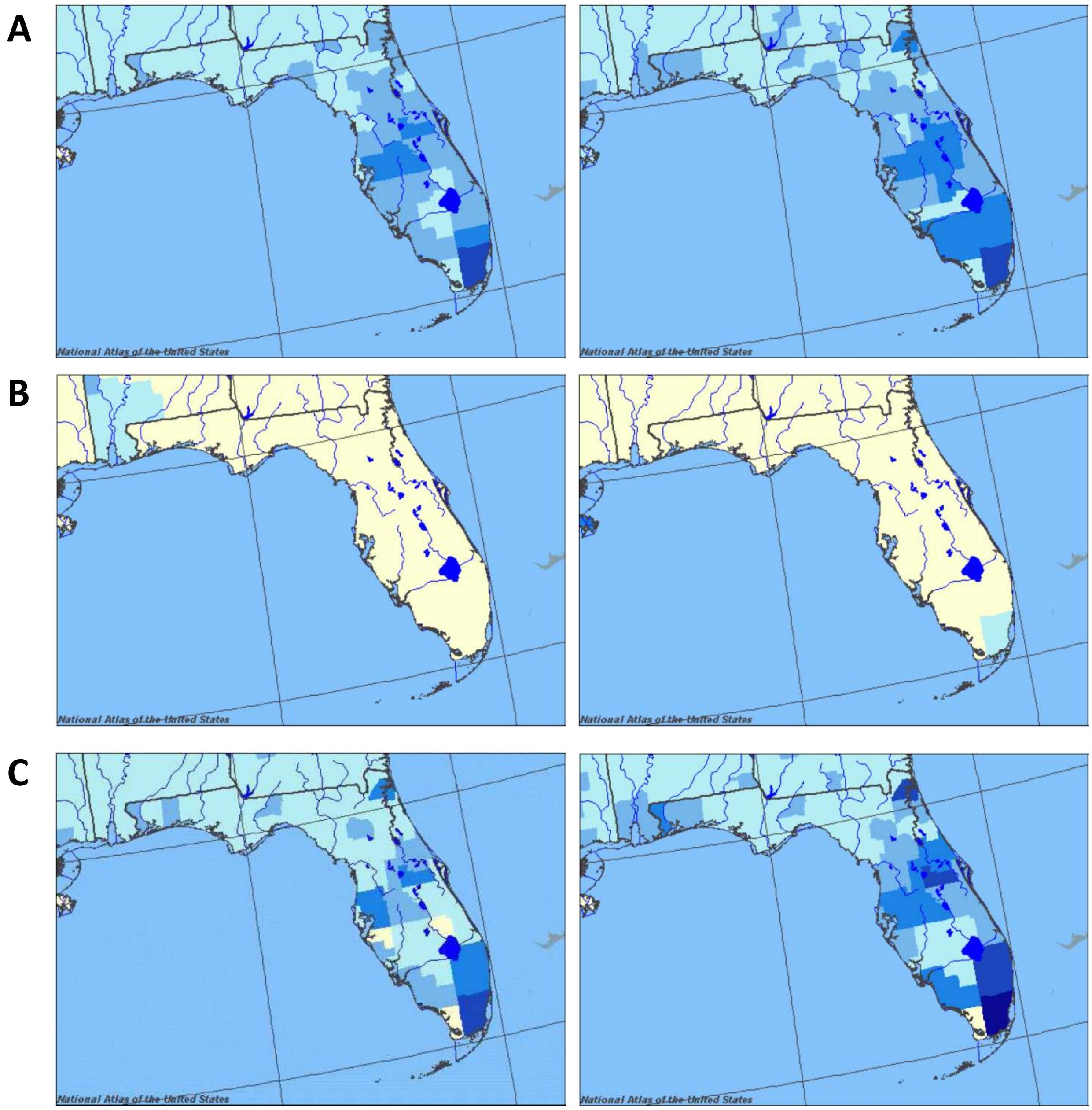

Figure 12. Comparison of 1985 (left panels) and 2005 (right panels) levels of freshwater groundwater withdrawals (A), saline groundwater withdrawals (B) and public supply freshwater groundwater withdrawals (C) (National Atlas of the United States, 2010).

In the 1980s, the Tampa Bay region experienced the effect of groundwater depletion firsthand when Pinellas County pumped too much groundwater and was forced to build a $158 million seawater desalination plant to meet the area's water needs (Goodnough, 2007).

As mentioned previously, of the five water districts in Florida, the SFWMD withdraws the largest amount of freshwater (USGS, 2010a). SFWMD has traditionally received all of its groundwater from the Biscayne Aquifer, but has recently also began to withdraw from the Floridan Aquifer, as requests for additional permits to withdraw from the Biscayne Aquifer were denied in 2005. This decision spurred the Miami-Dade Water and Sewer Department to develop a new plan that includes the (expensive) desalination of brackish water from the Floridan aquifer in order to meet South Florida water demand (Jackson, 2010), (USGS, 2010b). Excessive groundwater pumping has lowered water levels in lakes and wetlands and reduced river and spring flows, harming ecosystems as well as recreation (SFWMD, 2010b). Lowering the water-table also accelerates sinkhole formation (Cervone, 2003).

Water is essential for human and economic activities and in Florida approximately 60 percent of the total freshwater supply comes from groundwater (FDEP, 2008). This water is utilized for a variety of purposes, as can be seen in Figure 13. With aquifers providing 90 percent of the state's drinking water and more than 60 percent of the state's freshwater usage in agriculture and industry (a majority of the non-potable demand), depletion or contamination of South Florida's fresh groundwater resources is a significant threat to the health and prosperity of the population in this region (Cervone, 2003).

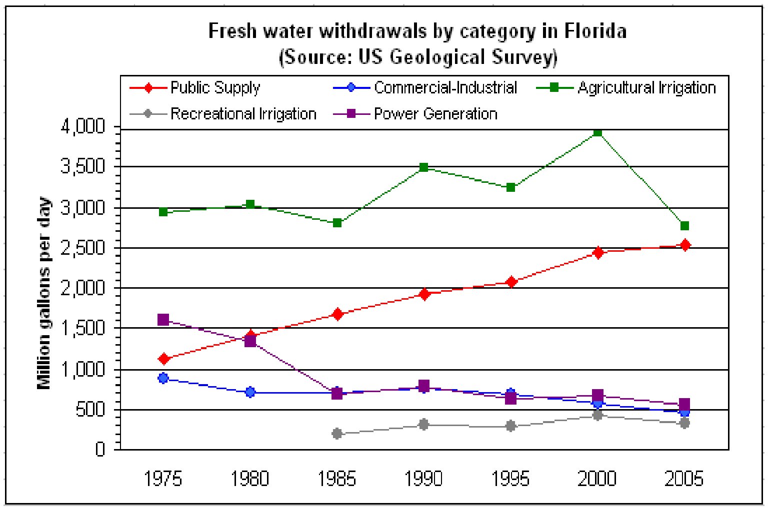

Figure 13. Uses of freshwater in Florida (USGS, 2010a).

Current Water Supply Mitigation Projects

SFWMD is currently seeking "alternative supply" projects to help reduce demand on South Florida's groundwater. In 2005, the state legislature enacted the Water Protection and Sustainability Program to encourage protection, cooperation and the development of alternate supply projects (SFWMD, 2010c). This program has funded development projects to increase saltwater and brackish water supplies, water reuse, storm water usage, and any other source designated as nontraditional in a regional water supply plan. Additional projects are being developed in other areas to protect existing aquifer stores. It is estimated that by 2025 Floridians will use an additional 2.0 billion gallons of water per day, with much of this increased demand occurring within the SFWMD. Florida's water management districts identified 327 alternative water supply projects that hope to receive funding from the Water Protection and Sustainability Trust Fund. When all the projects are completed, they will provide an additional 761 million gallons a day of water. However, many of these projects are on hold and several have been canceled due to the current economic climate. Even if all the projects still on the table were completed, they would be adding less than 40 percent of the expected 2025 demand (FDEP, 2010b, p. 2).

Contamination Prevention

To prevent saltwater encroachment via canals, several large barriers have been constructed at the coastal ends of the canals. These canal-control structures can be lowered when the water levels drop low enough to allow saltwater intrusion, preventing saltwater from moving up the canals (Miller, 1990). The majority of salt-water intrusion actually occurred before 1946, when these control structures were not in place. However, since 1952, the structures have been used to stabilize the salt-water intrusion and to manage flooding and groundwater level changes (USGS, 2004).

Desalination

There are currently 30 brackish and two seawater desalination plants in South Florida, with seven additional brackish plants under construction. Within the next few years, these desalination plants will have the capacity to produce 250 million gallons of potable water daily (SFWMD, 2010d).

Water Reuse

Water reuse eases demand on traditional sources of water, and is especially popular in South Florida for irrigating golf courses and other landscaped areas, washing cars, and filling ponds (SFWMD, 2010e). Despite the SFWMD's stated intent to increase reuse, a 2004 FDEP report found that SFWMD only reused 23 percent of wastewater, even though it had the highest public supply demand per capita (FDEP, 2004). In 2009, while some areas of South Florida had 100 percent reuse (Kissimmee), others, such as the Lower East Coast area of the SFWMD (which includes Miami-Dade, Broward, Monroe, and Palm Beach counties), reused far less than this (between 4 and 35 percent) (FDEP, 2009b). Overall, the district only reused 29.1 percent of wastewater, an improvement from 2003, but still below the state overall reuse of 43.3 percent. Wastewater from Broward and Miami-Dade counties alone counts for 63 percent of wastewater treated by SFWMD, but only 6 percent of that is reused (SFWMD, 2010e). Thus, this is one currently operating mitigation strategy that could be drastically improved.

Aquifer Storage and Recovery

Aquifer Storage and Recovery (ASR) entails injecting and storing water in an aquifer during times of excess so that it can later be recovered during times of drought. ASR has been used in Florida for decades, and most Florida facilities store water in the upper Floridan Aquifer, where the aquifer is brackish or saline. SFWMD is working with the U.S. Army Corps of Engineers to conduct pilot tests on two ASR systems in order to determine how ASR can be used in the Comprehensive Everglades Restoration Plan (CERP).

Water Reservations

SFWMD is developing water reservations to “secure the long-term availability of water” for environmental reasons: “when a water reservation rule is in place, volumes and timing of water at specific locations are protected for the natural system ahead of new consumptive uses such as urban water supply wells or development.” (SFWMD, 2010f)

Everglades Restoration

In 2000, local, state, and federal decision-makers approved a plan to "restore the Everglades" (Layzer, 2006, p. 404). Florida is now working towards this restoration, with the goals of improving aquifer levels, biodiversity, and water quality. While the destruction of the Everglades caused many problems, from increased contaminant loading to altering the natural flow of water, one of the major changes was altering the use of area that previously was able to allow slow seepage of rain and marsh water in order to replenish the aquifers. If the Everglades are successfully restored, this will greatly improve the replenishment of the aquifers in the area.

The Comprehensive Everglades Restoration Plan (CERP) includes expansion of water supplies to restore the environment and partially meet the needs of a growing population. CERP plans to build 18 reservoirs along with many innovative alternative water supplies (FC100, 2003, p. 5).

Water Restrictions

SFWMD encourages regulations to restrict water use, especially in times of minimal rainfall. Currently, there is a Year-Round Conservation Measures Landscape Irrigation rule in place, which establishes limits on landscape watering; however, county and city ordinances can differ from what SFWMD suggests (SFWMD, 2010g). Restrictions are fairly short-term solutions for low supply periods.

Water Conservation

Conservation is one of the easiest ways to reduce demand for groundwater. SFWMD has several tools available online to help residents conserve, from tips and suggestions to a water use calculator. However, as mentioned, South Florida residents have the highest water consumption rates in the state, using 179 gallons per day compared to the state average of 158 gallons per day, so there is large scope for improvement in water conservation (SFWMD, 2008, p. 3). It is estimated that in South Florida as much as half of this usage goes towards outdoor irrigation, and that up to 50 percent of that water is lost to evaporation (SFWMD, 2008, p. 3). While several counties in the SFWMD, such as Miami-Dade and Broward, have year-round twice-a-week landscaping limits, other counties, such as Palm Beach, and some cities, such as Ft. Lauderdale, are allowing watering three-times-a-week. The SFWMD has suggested that switching to twice-a-week landscape irrigation across the entire district could reduce overall demand by up to 10 percent. Given current practices, mandates on irrigation may be one of the best ways to reduce wasteful watering and conserve water. However, even a 10 percent reduction in demand will not make up for the anticipated population growth and unsustainable demand. This area is one in which local authorities and SFWMD can achieve significant results by first establishing regulations that curb wasteful water practices, and then by targeting resident behavior with regard to water conservation. More consumer information on xeriscaping, conservative plumbing fixtures, and water costs (such as installing easy to read meters so residents can monitor their own usage easily) could all help to conserve water.

Alternative Solutions and Policy Implications

Change Agricultural Practices

Currently, agricultural demands for freshwater are substantial, and they draw extensively from groundwater sources (Marella, 2010, p. 1). If reused water could be used for irrigation, this would free up aquifer water for potable uses. While the use of semi-treated wastewater (or greywater) to supplement water demands is not a new concept and is already being pursued by the SFWMD, it is not being utilized to the full extent possible. Importantly, developing the reuse program enough to offset agricultural demand will face several logistical hurdles. Large-scale greywater distribution systems would need to be installed in order to adequately meet crop needs. Whether the state or the farmer pays for this distribution system, it will take some time before the infrastructure is available. The larger this distribution system, and the more farms it must reach, the longer this lag time will be. Additionally, given current reuse rates, it may not be possible to distribute reused water to all farms, so a way of fairly determining which farms receive reused water must be developed.

Agricultural practices in South Florida have the potential to be adjusted to use less water. Some farmers have been able to use vertical planters to conserve water, and the movement for "vertical farms" in urban settings is growing (Despommier, 2011, Wagner, 2010). The principle behind vertical planting is that by growing plants in vertical compartments the farmer is able to achieve a much greater planting density while using less water than a traditional farm. In 2008, SFWMD used funds from the WaterSIP program to help fund one such project at Hydro Fresh Farms in Fort Pierce. The project cost approximately $120,000, but increased the farm's capacity by 40,000 plants while decreasing the water usage by nearly 40 million gallons a year (SFWMD, 2011). While a complete shift to vertical farms may be unrealistic for immediate implementation, using hydroponic, hydro-stacking, and other vertical growing mechanisms can drastically reduce water needs. Vertical planters and other conservation tools can save water, but they also come with a price to implement. In policy terms, this will likely require incentives for farmers and agricultural corporations to invest in the upfront cost of these technologies, as the potential cost savings as a result of the decreased water use may not initially be large (given relatively cheap current water prices). There is already one successful example of using funds from the SFWMD

Water Savings Investment Program (Water SIP) to subsidize the technology shift, which could potentially be applied to other farms and perhaps supplemented by federal funding. The Natural Resources Conservation Service will be providing $74 million for fiscal year 2011 and $60 million for fiscal year 2012 on for the Agricultural Water Enhancement Program (AWEP) (Natural Resources Conservation Service [NRCS], 2011). AWEP is already being used to fund projects in Florida intended to reduce water use (and specifically groundwater withdrawals) by changing irrigation methods. Additionally, the Everglades is considered a priority region for AWEP, and thus may be more likely to receive AWEP funding (NRCS, 2009, p. 1). Further reliance on AWEP to change agricultural practices is a reasonable goal.

Genetically engineered (also known as genetically modified, or GM) crops also have the potential to help reduce agricultural water demands. On a global level, such technologies have been on the UN agenda since the Swedish report “Water – More Nutrition Per Drop” was released in 2004 (“Study advocates water-conserving GM crops”, 2004). GM crops such as tropical maize are already widespread across the world, and even rank in the top as far as demand and importance in international agriculture (Anami, De Block, Machuka & Lijsebettens, 2009, p. 17). The initial development of new GM crops does necessitate capital costs, but these could be addressed using the same mechanisms discussed above. Genetically engineered crops must additionally overcome social obstacles, as there is an ongoing debate over the safety and nutrition of genetically engineered crops (“Are genetically modified crops safe?”, 2006). The state (or federal) government would have to conduct research and develop stringent regulations to provide conclusive data on the safety of these products before some American consumers would be willing to accept the product. An alternative to GMO crops would be to switch to less water intensive crops developed via traditional plant breeding techniques. These crops face limited barriers to market entry compared to GMOs, yet use less water than current crops. On a similar note, the method of irrigation can greatly reduce water use. In the 1990s, citrus crop irrigation shifted from flooding techniques to a practice known as micro-irrigation. In 2001, when 80% of citrus crops were watered using micro-irrigation, this resulted in water savings of 90 billion gallons (Hassell, 2004). Yet, only 31 percent of Florida's crops are watered using micro-irrigation, and over 50 percent are watered using water-intensive "seepage" methods such as flood irrigation (York, Parsons & Walker-Coleman, 2000, p. 2).

Managing Population Growth

One of the biggest problems facing South Florida stems from the fact that the population in the region is booming. Stricter zoning and permitting requirements could slow the growth in South Florida until more sustainable water sources are found. In the United States two main kinds of regulations have been used in an attempt to slow population growth/urbanization: locally imposing urban containment policies to control the amount and type of settlement in a certain region, and state-mandated growth management requirements for local governments (Wassmer, 2006, p. 25). The State of Florida has a growth management plan that is vertically, horizontally, and internally consistent, and findings have shown that it may be able to reduce urban area (Wassmer, 2006, p. 32, 34).The question is whether this reduction in urban area will be (a) enough to alleviate water issues and (b) uniform across the state. As with many resources, decreasing use in one place often leads to an increase elsewhere, and if this increase continues to be in South Florida, the growth management plan will be ineffective at helping conserve South Florida's groundwater.

Even if growth is stopped, the question of whether there is a way to shrink our ecological footprint remains. A government buyback of property, especially given the current housing market, could remove land from urban use and allow for restoration. Land purchasing programs could be especially effective around the borders of the Everglades, where restoration projects and the Everglades Land Acquisition project are already underway (SFWMD, 2009). The government could also purchase land around hazardous sites, retired landfills, wastewater treatment plants, and other areas generally perceived to have less market value. These areas are also where there tends to be social injustice as a result of environmental damage – so-called 'environmental injustice' - and providing fair prices to residents could help alleviate some of these issues (Bullard, Mohai, Saha & Wright, 2007, p. vii).

A policy to slow or even stop and reverse population growth in South Florida will be politically difficult. In addition to the logistical problems of *how* to best control growth without harming the economy, there are also social implications, and additionally, the policy must outweigh people's desire to live in the 'Sunshine State' and along South Florida's white beaches. History has shown that Florida's population growth is surprisingly steadfast – despite a crumbling housing market and the recession, Florida remained one of the fastest-growing states in the nation (Parker, 2010).

Pipeline construction

A common saying in Florida is "80 percent of the population and public consumption is south of I-4; 80 percent of the water resources are north of I-4."(FC100, 2003, p.17) One idea for how to alleviate water stress in the southern portion of the state is to create a pipeline that would bring water down from the northern portion of the state. However, this approach faces significant political barriers, as residents "north of I-4" are not always accepting of this idea, since they are not without their own water struggles. In addition, it is feared that this is not a sustainable solution and that moving large amounts of water without addressing consumption will simply expand the area facing water supply shortages in the future [2] (Pittman, 2009), (“Worst fears realized”, 2003).

Cisterns

Up until World War II, a major part of South Florida - the Florida Keys - received water only from rain. A recent movement in the Keys has led to an increased interest in cisterns, which are essentially storage tanks that collect rainwater (Conklin, 2008). Cisterns (or other rainwater harvesting mechanisms) are easy to implement in new construction and renovation projects (Yudelson, 2010). Marco Island has looked into using grants from the SFWMD Water SIP to fund cisterns. They note that “… the average number of rain events sufficient to fill a cistern is 7 events during the 8-month dry season, and 14 events during the wet season. The total number of rain events during the rainy season has averaged over 60 events of various volumes each year for 5 years. This indicates that very limited, if any, supplemental irrigation is needed during this wet period.” (City of Marco Island, 2010) Cisterns are a very practical solution to offset the public water supply. An average sized 1,200 square foot roof can harvest as much as 50 thousand gallons of water per year in South Florida (Boshears, 2010). If hypothetically approximately two million of SFWMD’s constituents installed cisterns with collection rates on this scale, this would offset 100 billion gallons of water each year - approximately 10 percent of SFWMD’s current withdrawal, and almost 14 percent of the entire state’s 2025 increased demand. If all 7.5 million South Florida residents installed cisterns with collection rates on this scale, the collected rainwater would meet over 50 percent of Florida’s 2025 increased demand.

Water Pricing

A study conducted jointly by four of Florida's five water management districts found that water use decreases with increases in water price, and that a utility can decrease water use without decreasing profits by taking advantage of this revised pricing structure (Southwest Florida Water Management District, 2011). Raising the price of water in Florida is not unreasonable – the state currently has some of the lowest rates in the nation. Compared to a city like Houston, which is similar in climate to much of South Florida, Florida's average water bill is almost a third of that of Houston (SFWMD, 2008, p. 3).

Conclusions and Relevance

Headlines such as "Drought just tip of water problems" and "Florida Faces Vanishing Water Supply" are becoming more and more common in South Florida, despite the state's natural abundance of rain and pristine groundwater sources (Crabbe, 2008; NPR, 2007). Current measures, though helpful, have not been able to fully balance the system such that human and ecosystem demands do not exceed natural supplies. However, many more solutions could be pursued to help protect and sustain South Florida's groundwater. In this paper, we have discussed some of these potential solutions and examined the technical and political factors that may affect their introduction.

Unfortunately, the problems facing South Florida are not unique. Figure 14 shows a map and original caption demonstrating that an issue such as saltwater intrusion can be widespread.

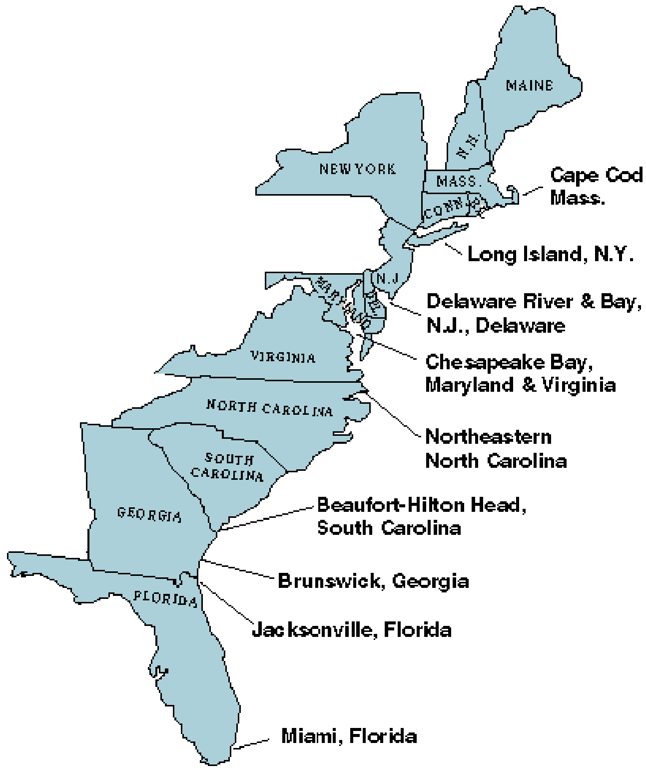

Figure 14. This map shows where saltwater is intruding into freshwater wells along the Atlantic coast. Saltwater intrusion is a naturally occurring phenomenon, but over- pumping of groundwater to meet rapid population growth has aggravated the problem for many Eastern cities (NPR, 2007).

Florida needs to take decisive actions to find alternative water supply sources before it is too late. Communities along the Colorado River Basin and in parts of the Northeast, among others, are considering similar questions – what can be done to protect our groundwater, where can we draw from to meet our public, agricultural, and industrial demands, and ultimately, are we going to run out of water? The solutions outlined in this paper are a start to answering these questions.

Notes

1 Based on an average annual rainfall of 54 inches,[i] the area of Florida being 58,560 square miles,[ii] the size of an Olympic swimming pool as 2,500 m^3,[iii] and 365 days in a year.

2 See http://www.whoseflorida.com/misc_pages/bad_idea_for_florida_water.htm or http://www.democraticunderground.com/discuss/duboard.php?az=view_all&address=104x468946 for more consenting opinions.

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