Integrated Water Resource Planning: Using All of the Puzzle Pieces

W. Kirk Martin

Integrated Water Resource Planning (IWRP) is a concept that has not realized its full potential, despite a great deal of rhetoric given to the subject. Increasing regulatory limits on conventional freshwater supplies has caused a few water services providers to engage in water resource planning. These efforts are begun with the intention of taking a comprehensive view where all potential water resource management options are considered, only to find that a few tweaks to current programs can satisfy projected demands well into the future. For this reason, few fully integrated planning efforts have been completed in Florida, and for the most part, the state has been able to rely on a combination of water supply planning efforts at the water management district level, and master planning at the utility services level. However, new drivers and constraints will demand that a more holistic approach be used—one that weighs all resource and management options against a wide range of quantitative and qualitative criteria in the efforts to develop best-value solutions and long-range sustainability.

Restrictions on Conventional Groundwater Resources

Region by region, use of traditional water supply sources has been restricted to protect or improve wetland environments, spring and stream flows, lake and groundwater levels, and groundwater quality (Figure 1). Large-scale regional restrictions and prohibitions of water use started in the Tampa Bay region in the 1980s with the Tampa Bay and Southern Water Use Caution Areas, migrated south to the lower west coast in the 1990s with implementation of Maximum Developable Limits, then eastward to the lower east coast in the 2000s with the adoption of the Water Availability Rule. Similar restrictions have now moved north with the Central Florida Water Initiative and the North Florida Water Partnership. In each case, time- or criteria-sensitive water use caps, or even reduction requirements, are placed on the traditionally most-used and least-costly sources available. These restrictions have, in some cases, created demand for increased conservation, wastewater reuse, or brackish water development, but in most cases, concepts of integrated planning and total water management have not been required.

The state is now facing a new slate of issues that will tip the scales to more comprehensive planning and management, such as:

- Continually increasing limits on conventional water supplies
- Numeric nutrient limits statewide
- Total maximum daily loads (TMDLs) proposed for hundreds of locations

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- Elimination of ocean outfalls for wastewater disposal in south Florida
- Specific target reuse requirements in certain regions
- Sea-level rise and associated potential for salt water intrusion and increased flooding

Whereas water supply issues and limitations may have driven water resource planning efforts in the past, nutrient management and response to sea-level rise may be the more critical drivers in the future.

Emerging Constraints on Water Resource Management

After much technical and political wrangling, numeric nutrient criteria (NNC) have now been established for Florida's rivers and streams, springs, lakes, and for a majority of the state's estuaries (Figure 2). Still pending are the remaining estuaries around the state, the tidal reaches of some rivers and streams, and the south Florida canal network. These rules

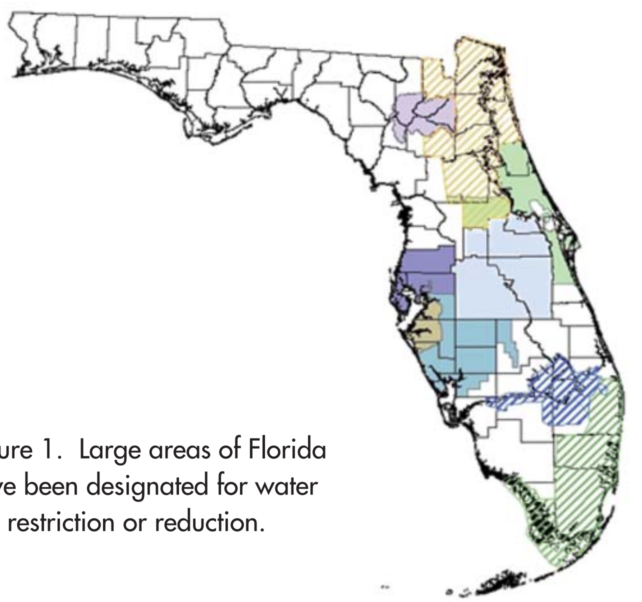

Figure 1. Large areas of Florida have been designated for water use restriction or reduction.

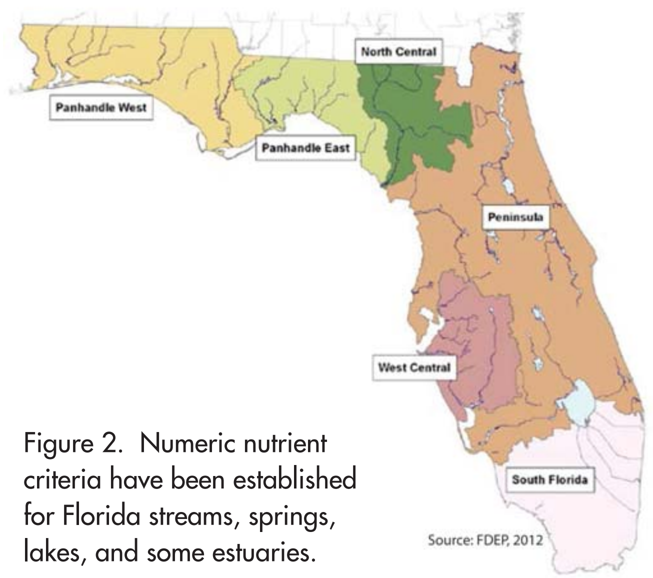

Figure 2. Numeric nutrient criteria have been established for Florida streams, springs, lakes, and some estuaries.

will significantly reduce allowable nutrient discharges to waters of the state.

While there has been a certain sigh of relief that the Florida Department of Environmental Protection (FDEP) NNC rules will prevail as being more scientific, more defensible, and more flexible than those promulgated by the United States Environmental Protection Agency (USEPA), the facts are that NNC will still require major (meaning costly) system upgrades and/or changes in standard practice for wastewater and stormwater management throughout the state. For wastewater systems, this means substantial expansion of reuse programs of all kinds, improvements in the level of wastewater treatment, reductions in inflow and infiltration to collection systems, groundwater storage and recharge, and alternative wastewater disposal programs. For stormwater systems, it means increased retention and detention, higher levels of treatment, improvements to conveyance and collection, and development of larger-scale and seasonal storage concepts.

One of the responses to the NNC will be development of TMDLs and basin management action plans (BMAPs). The TMDL/BMAP process has proven to be a successful program to improve water quality around the state, as the process typically involves a local initiative, including a variety of interested stakeholders focused on common objectives of meaningful improvements in water quality that are realistic and cost-effective. The resulting programs typically represent a comprehensive set of strategies, including permit limits on wastewater facilities, urban and agricultural best management practices, conservation programs, and financial assistance and revenue generating activities, which are designed to implement the pollutant reductions established by the TMDL. There have been over 50 TMDLs established in Florida (Figure 3) to date and numerous BMAPs implemented in response (Figure 4); many more are proposed, especially now that the NNC rules identify the TMDL process as a means to establish site-specific nutrient criteria for a given water body. Like the NNC, the TMDL/BMAP process will mean substantial and costly upgrades to wastewater and stormwater infrastructure and alternative management practices for control, conveyance, treatment, storage, use, and disposal.

While people may disagree on the nature and causes of climate change, sea-level rise has been established as a very real and measurable phenomenon for over 200 years in the United States. The Cape Hatteras lighthouse in North Carolina has been moved four times—more than half a mile inland since its initial construction in 1802—due to encroaching sea levels. At Florida's oldest gaging station in Key West, sea level has shown an average 2.24 mm

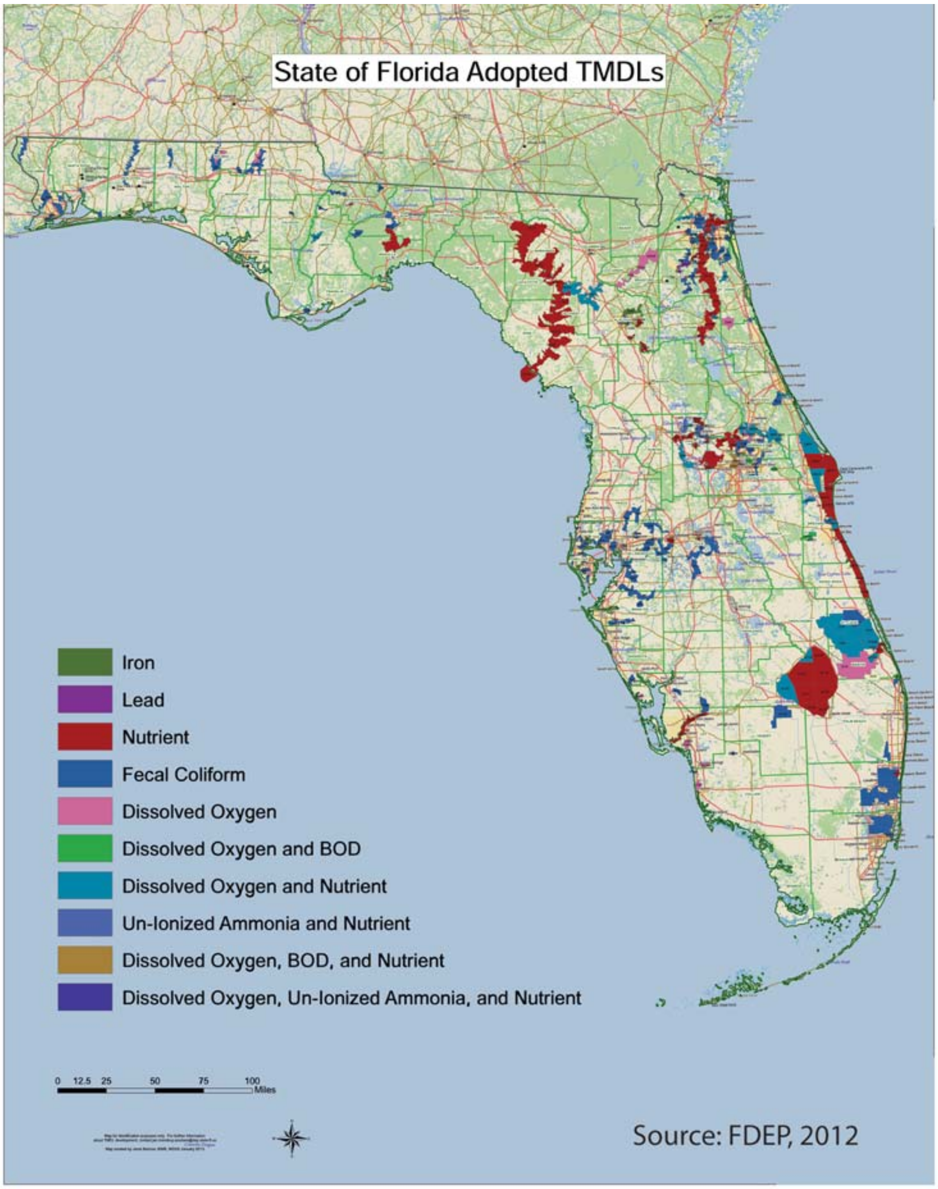

Figure 3. Total maximum daily load limits have been established for more than 50 waterbodies in Florida.

rise per year for a century (Figure 5). Sea-level rise is already starting to impact some older stormwater outfalls to the point where they do not discharge during high tides and sea water backs up regularly to flood streets and neighborhoods through stormwater piping (Figure 6). Continued sea-level rise will exacerbate periodic tidal and stormwater flooding episodes and increase the potential for saline water intrusion into coastal aquifers.

In southeast Florida, the Ocean Outfall Rule adopted in 2008 requires the elimination of some 300 mil gal per day (mgd) of existing wastewater disposal capacity by 2025 (Figure 7). Other key components of the rule require that 60 percent of the municipal wastewater produced in the region be reused in a beneficial manner. Discussions are ongoing as to what will constitute a beneficial use of wastewater and how the specific criteria of the rule will be met, but whatever the outcome, substantial changes are coming in the way wastewater is managed in south Florida. Major reuse programs will be developed, wastewater treatment upgrades will be implemented, and large-scale cooperative agreements between utilities will be structured for better regional wastewater management. However, the highly urbanized environment that characterizes much of south Florida, plus aging wastewater infrastructure concentrated along the coast, have historically made conventional reuse programs difficult or prohibitively expensive to implement. Creative

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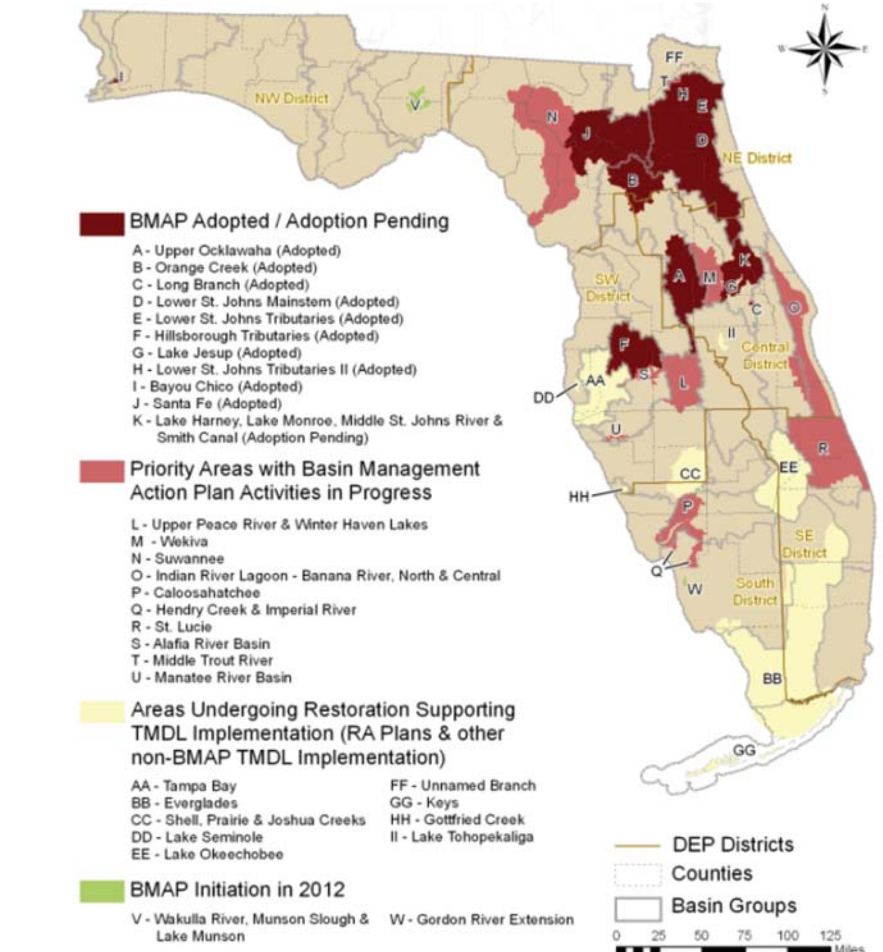

Source: FDEP, 2012

Figure 4. Basin management action plans have been implemented for large areas of Florida's watersheds.

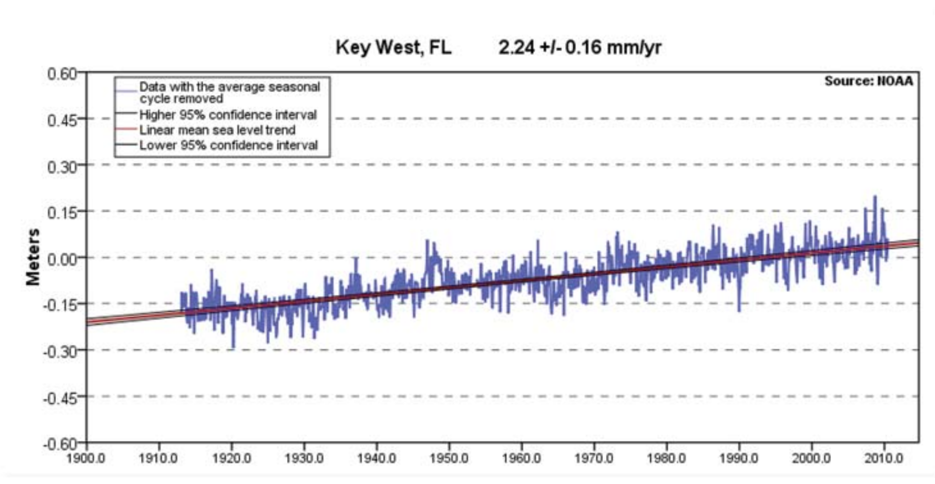

Figure 5. Sea levels have risen an average of 2.24 mm per year for more than a century.

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thinking developed as part of fully-integrated planning initiatives will be required.

Springflow reduction and declining water quality are becoming of increasing concern in the north and north-central parts of Florida. Tourists often cite the beaches, the Florida Keys, or numerous theme parks as priority targets for a visit, but Florida springs are one of the truly special features of the state and protection of their integrity is a high priority for most Floridians. The relationships of springflow quantity and quality to groundwater use, groundwater levels, rainfall cycles, and stormwater management can be complex, which is all the more reason that potential impacts to springs be undertaken as part of a more integrated planning effort. Additional drivers for IWRP are currently less defined, but will have to be addressed as various state, federal, and local rulemaking initiatives are pursued. Some of the potential issues include: specific limits on per capita use, increased regionalization, statewide stormwater regulation, landscape codes and land use restrictions, and coordination with major environmental restoration programs, such as the Comprehensive Everglades Restoration Plan/Central Everglades Planning Project.

Traditional Versus Integrated Water Resource Planning

Traditional water resource management has historically placed potential water sources into separate silos, with little opportunity for shared benefit and often with diverging goals and objectives. Limited water supply sources are turned rapidly into liquid waste streams, and rainfall is usually drained quickly from the land in the name of flood protection. Resulting wastewaters and stormwaters are treated as liabilities and undesirable environmental impacts are created by both withdrawal and disposal practices. Integrated water management, conversely, treats wastewaters and stormwaters as valuable resources, with multiple use and reuse opportunities resulting in an improved environment, enhanced system efficiencies, and greater resource reliability, sustainability, and economic viability (Figure 8).

To some extent, integrated water management is about reconnecting the various aspects of the hydrologic cycle in a way that makes the most sense for a given location and set of resources. But, it also means creating a diversity of supply sources and finding ways to blur the boundaries among stormwater, raw groundwater and surface water, treated potable water, treated wastewater, and other

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Figure 6. Sea-level rise is already impacting coastal stormwater outfalls on a regular basis.

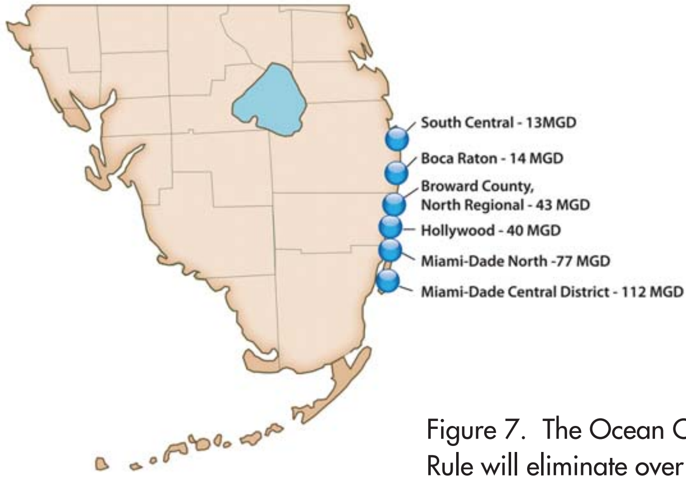

Figure 7. The Ocean Outfall Rule will eliminate over 300 mgd of current wastewater disposal capacity.

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sources. To properly develop an integrated water resource program, numerous technical, economic, and regulatory drivers have to be defined; a myriad of water resource alternatives appropriately characterized; and a wide range of management solutions optimized using decision support tools to make the right decisions on demand management, supply development, and water quality objectives.

Integrated Water Resource Planning Process and Outcomes

The IWRP process entails defining a clear set of objectives and performance metrics, properly characterizing a complete set of water supply and water resource management options, evaluating each alternative against a variety of selected criteria, and developing the best set of alternatives to meet the objectives of the program. Identified alternatives for water supply, wastewater management, reclaimed water use, stormwater management, and environmental quality are typically evaluated for a wide range of quantitative and qualitative criteria. These criteria may include such things as system reliability, seasonality of supply, capital and operational costs, environmental or hydrologic impacts, aesthetic impacts, local control, safety and security, public acceptance, regulatory acceptance, resulting water quality, power efficiency, carbon footprint, and uncertainties and risks (Figure 9).

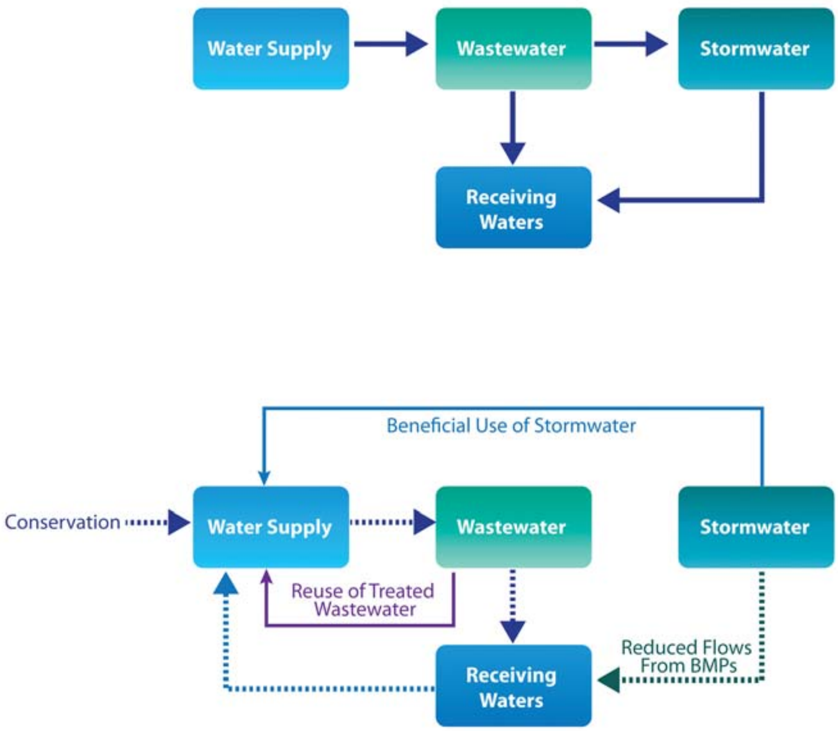

Figure 8. Traditional versus integrated water resource management.

Higher weighting may be applied to certain criteria to customize the evaluation to stakeholder interests, and hybrids of the various options may be grouped to provide the highest scoring water management alternatives for a given theme. Stakeholder involvement is critical to establish the right objectives, weightings, and combinations of potential alternatives. Utilization of decision support simulation models is typically required to address the complex interrelationships of water management alternatives and performance objectives. Both stakeholder involvement and decision support models help in promoting public buy-in to the process and outcome.

The IWRP has been proven to work well in developing the right balance of economic, social, and environmental objectives, even in complex systems where there may be intense competition for the resources or a difficult public and/or political environment. The IWRP facilitates the development of well-defined goals and constraints, considers all potential water sources and demands, and provides a focus on creating a sustainable water supply program to meet long-term needs. Multipurpose and multibenefit solutions are stressed and tradeoffs between various alternatives are quantified to facilitate decision support. The resulting plan typically provides a diversity of supply and management options and identifies the most effective combination of alternative solutions unique to the given location and resources. The resulting interdependencies between the various resource management alternatives can be very complex, as each decision to improve one aspect of the system can trigger multiple changes, benefits, and/or challenges that radiate through the system (Figure 10). However, the benefits of a well-developed IWRP include improved utility reliability and efficiency, greater cost-effectiveness, improved quality of receiving waterbodies, improved flood management, enhanced urban and natural environments, increased resiliency to extreme climatic events, and increased public awareness, trust, advocacy, and quality of life.

Integrated Water Resource Planning for Florida

As IWRP is more widely implemented in Florida, unique and creative ideas will be developed, as utilities or regions seek the best value solutions for their particular area. The slate of available resource management options will expand dramatically and solutions not yet discovered will be developed. However, some likely outcomes can be predicted.

Wastewater reuse will continue to expand. Beneficial reuse of treated municipal wastewater has been evolving for decades, from disposal of unwanted waste, to a useful irrigation source when convenient and cost-effective, and to a desirable commodity deserving of market pricing. It has become part of mainstream utility management in many places in Florida, and some utilities are looking beyond just providing reuse to the nearest golf course and instead seeking more strategic uses and locales that will provide the most benefit to the utility or the resource. This movement toward more strategic reuse applications may take the form of supplying a nearby industry competing for a limited resource, providing for managed aquifer recharge at a critical location via infiltration or direct injection, rehydrating a wetland system impacted by current or planned water use, or developing a groundwater salinity barrier to allow continued or expanded use of an aquifer threatened by saltwater intrusion.

Additionally, ready or not, indirect and even direct potable reuse is likely coming to many drinking water supplies. Much progress has been made in the last few years in advancing the concept of indirect potable reuse, but the relative cost has been high, causing some utilities to look at "direct" potable reuse. While people seem to accept water that has been "processed" by nature, the facts are that the technology exists to treat water extremely well through methods that es-

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sentially accelerate and concentrate the same processes nature has used to clean all of earth's "pristine" water for the past 4 billion years.

Groundwater will continue to play a predominant role in meeting water demands around the state. This may seem antithetical to the relentless message that groundwater is overused; however, there is much more to be learned about managing the vast groundwater resources through more robust hydrologic investigation, better understanding of model limitations, conjunctive use with surface water supplies, storage of various freshwater resources within marginal aquifer units, and managed recharge of both fresh and brackish aquifers.

Stormwater harvesting has been practiced on a limited basis in communities with adequate storage facilities or in places with an extensive network of canals and control structures. However, effective stormwater harvesting can be difficult due to the very temporal nature of storms, the concurrent requirements to minimize flooding, and the need to maintain environmental flows and levels. While new technologies and approaches are being developed in urban retention and runoff treatment, pervious surfaces, and subsurface storage, there are limits to the percentage of capture that can be accomplished without very extensive and expensive systems for collection, detention, conveyance, and storage (Figure 11).

Seasonal water storage is a key water management element that needs to be implemented. There is no shortage of water in Florida—just a discrepancy in seasonal supply and demand. Use of local- and regional-scale reservoirs will increase, and despite some difficult starts to date, aquifer storage and recovery (ASR) is still one of the best alternatives for seasonal storage of all kinds of water sources with regard to cost and efficiency. Florida is ubiquitously underlain with brackish water aquifers ripe to be recharged more rapidly than nature is currently doing with seasonally available fresh water; however, ASR implementation has stalled in Florida due to its unjustified perception as a potential pollutant source. The facts are that in most ASR applications, the aquifer water is improved for more than 99 percent of measured chemical and physical constituents, but because one or two parameters may be outside of the range of drinking water standards, the technology has been difficult to implement and a highly valuable water management tool is greatly underutilized.

Conservation will continue to play a major role in improving water supply management programs. The United States is currently using less water than it did in 1980, despite having 70 million more people and a doubling of the gross domestic product (Fishman, 2011). Much of this is due to resource management improvements in the power industry and in agriculture, but many public utilities have seen their per capita use rates drop by 15 to 25 percent, and in some cases, by as much as 50 percent. These gains have all been accomplished without any serious compromise to lifestyle, wholesale replacement of household plumbing fixtures (40 percent of household use), or really tackling the lawn irrigation issue (50 percent of household use); more, however, can be done. Despite widely reported shortages in water supply in many areas, losses from existing utility piping systems average 17 percent in the U.S (ASCE, 2009), with some older cities losing much more. While the cost to repair is high, the fix could buy a great deal of time before more exotic solutions need be applied. Few industries would tolerate losses of this magnitude.

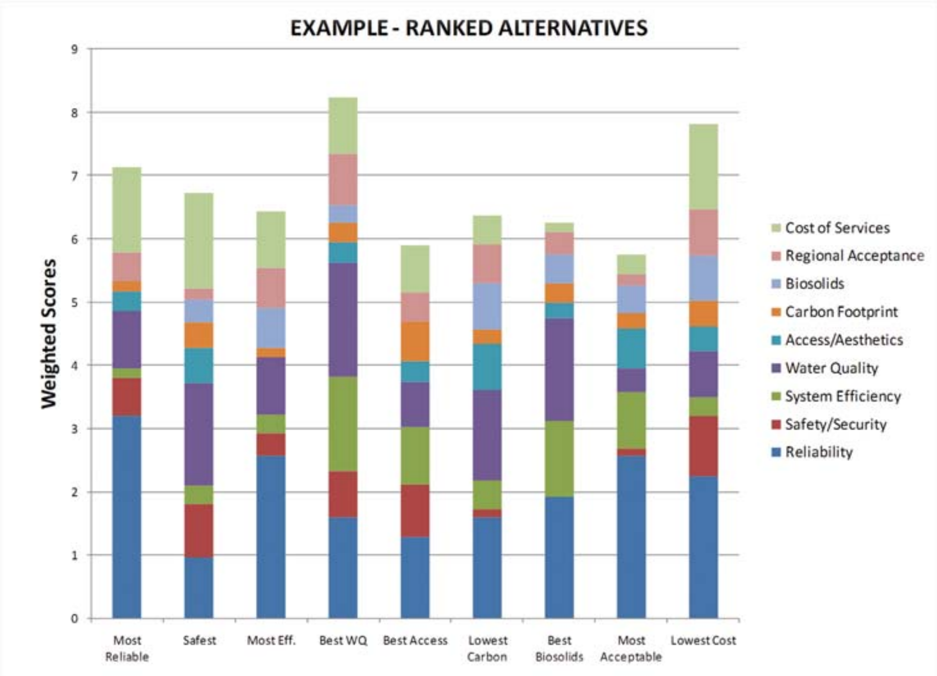

Figure 9. Examples of water management options ranked by performance measure.

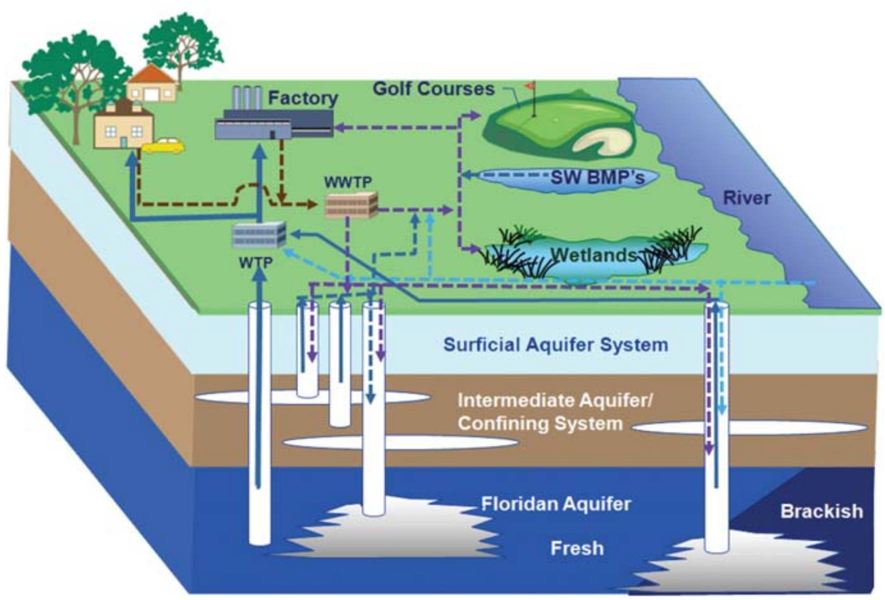

Figure 10. Interrelationships of the components of an integrated water resource plan can be complex.

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The water—energy nexus is real. While it is common knowledge that it takes a lot of water to make energy and a lot of energy to make water, limited widespread benefit is being realized from the link. Improvements in water management have been made separately in both industries, but the real synergies are still yet to come. Co-location and co-management of water, wastewater, and power facilities can provide many benefits, including thermal efficiencies to certain water treatment processes, energy recovery from various wastewater treatment processes, raw water supply and waste stream dilution from the large volume of water cycled for power generation, lowered power cost for treatment and distribution, and water-based storage of thermal or kinetic energy from intermittent solar and wind sources. Adding energy extraction from solid-waste facilities means another level of opportunity, if all of these components can be brought together under a "utility campus" umbrella. Each utility has something to learn from others about the management of water, and the merger of power and water utilities may happen in the future as a means of using that critical common resource more effectively.

Brackish water and seawater desalination will also continue to play a role in meeting future water demands. Disposal of concentrated brines, however, will continue to be a "make or break" issue in implementing desalination, especially in areas outside of south Florida where deep well injection has historically not been an option. Concentrate injection into very deep cretaceous aquifers may become more prevalent, although early test well data suggests limited disposal capacities. Also, the use of saline groundwater may be the cheaper alternative to very expensive pretreatment of saline surface waters. Ultimately, the co-location of desalination facilities with large capacity power generation facilities may be the best implementation of this alternative.

Development of public-private partnerships for water supply development and improved water management will continue to expand as a working concept. There are 42 million acres in Florida, each receiving, on average, in excess of 4 ft of rainfall per year. Opportunities exist for working with large land holders to create dispersed water storage, shallow reservoir development, increased groundwater recharge, and dispersed water supply development, all at a lower cost than public ownership, debt, and operation (Figure 12). Much still remains to be worked out, including identifying a reasonable framework for valuation and trade, recognizing a public value for a private initiative, and developing a consensus on the costs and benefits.

Developing institutional and nonstructural initiatives that promote better water management is also an option; examples include:

- Land code modifications for new development or significant redevelopment that require irrigation utility lines and/or improved stormwater retention via elevated storage, cisterns, etc.
- More creative water pricing that includes the cost of resource development and management.
- An incentive-based transfer of development rights-type processes that recognizes water supply the way that some programs currently recognize wetlands, wildlife habitat, or environmental restoration.

Figure 11. Stormwater harvesting for irrigation in Cape Coral.

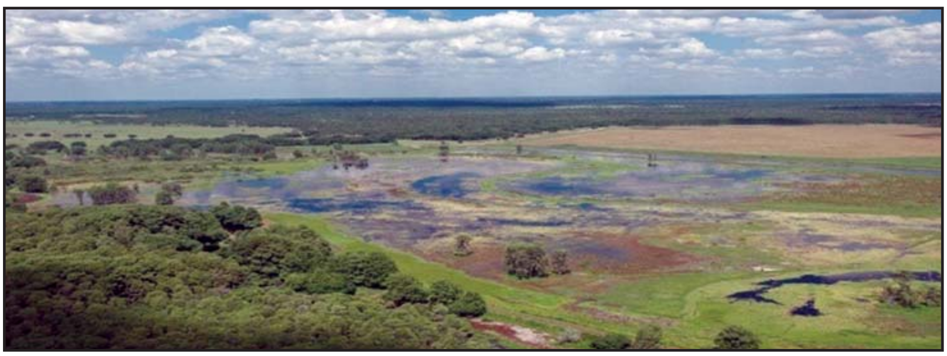

Figure 12. Public-private partnerships for improved water storage and groundwater recharge.

Conclusions

Many water resource challenges lie ahead for the citizens of Florida. However, Florida is a water-rich state and this blue planet on which it resides currently has as much water as it's ever had and more than enough to meet human needs long into the future; it just does not happen to be where and when it is needed all of the time. Water crises, therefore, are not created so much by absolute water scarcity as much as by inequitable distribution and inadequate planning and management. Water resource issues also tend to be regional, and even local; taking shorter showers in Tallahassee, for instance, does not help anyone in Tampa. Integrated water resource planning will help address management challenges and priorities in a way that is most appropriate for each utility or region and make the most of the water that is available.

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