TECHNICAL PUBLICATION SJ2006-2

DISTRICT WATER SUPPLY PLAN 2005

APPENDIXES

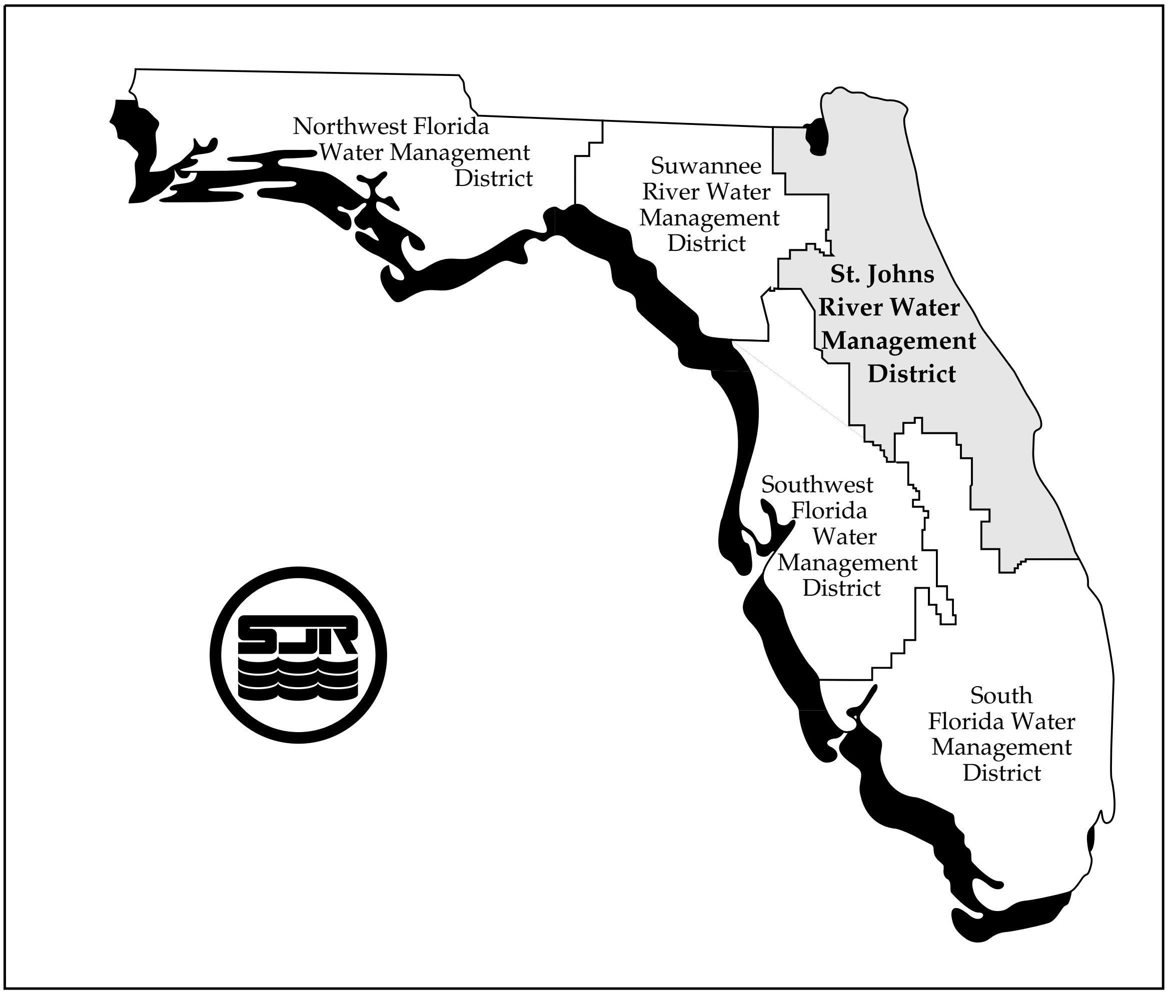
Technical Publication SJ2006-2

District Water Supply Plan 2005

Appendixes

St. Johns River Water Management District
Palatka, Florida

2006



The St. Johns River Water Management District (SJRWMD) was created by the Florida Legislature in 1972 to be one of five water management districts in Florida. It includes all or part of 18 counties in northeast Florida. The mission of SJRWMD is to ensure the sustainable use and protection of water resources for the benefit of the people of the District and the state of Florida. SJRWMD accomplishes its mission through regulation; applied research; assistance to federal, state, and local governments; operation and maintenance of water control works; and land acquisition and management.

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APPENDIX

APPENDIX A—CHAPTER 40C-8, *F.A.C.*, MINIMUM FLOWS AND LEVELS ESTABLISHED TO DATE

MINIMUM FLOWS AND LEVELS ESTABLISHED TO DATE

This document is available as a .PDF file at the following internet address:

floridaswater.com/rules/pdfs/40C-8.pdf

APPENDIX B—MINIMUM FLOWS AND LEVELS PRIORITY LIST AND SCHEDULE

Year 2005

Water Body Type	Water Body Name	County	Voluntary Peer Review
Rivers	St. Johns River at Lake Monroe	Seminole/Volusia	Yes
	St. Johns River at SR50	Brevard/Orange	Yes
Aquifers (springs)	Blue Spring	Volusia	Yes
	DeLeon Springs	Volusia	Yes
	Gemini Springs	Volusia	Yes
	Green Springs	Volusia	Yes
Lakes	None		
Wetlands	None		
Re-evaluations	Dias	Volusia	

Year 2006

Water Body Type	Water Body Name	County	Voluntary Peer Review
Rivers	None		
Aquifers (springs)	Apopka Spring	Lake	Yes
Lakes	Avalon	Orange	
	Banana	Seminole	
	Bear Gully	Seminole	
	Bel-Air	Seminole	Yes
	Big Bass	Marion	
	Deforest	Seminole	Yes
	East Crystal	Seminole	Yes
	Flat	Lake	
	Gleason	Volusia	

	Hiawassee	Orange		
	Horseshoe	Seminole		
	Johns	Orange		
	Johnson	Clay		
	McGarity	Volusia		
	Pebble	Clay		
	Rose	Orange		
	Sawgrass	Lake		
	Theresa	Volusia		
	West Crystal	Seminole	Yes	
Wetlands	None			
Re-evaluations	Ashby	Volusia		
	Banana	Putnam		
	Colby	Volusia		
	Como	Putnam		
	Little Lake Como	Putnam		
	Prevatt	Orange		
	Shaw	Volusia		
	Three Island Lake (Sixma)	Volusia		
	Trone	Putnam		

Year 2007				
Water Body Type	**Water Body Name**	**County**	**Voluntary Peer Review**	
Rivers	None			
Aquifers (springs)	Bugg Spring	Lake	Yes	
Lakes	Mt. Plymouth	Lake		
	Lucy	Orange		
Wetlands	None			
Re-evaluations	Rock Springs	Orange	Yes	
	Wekiwa Springs	Orange	Yes	

Year 2008				
Water Body Type	**Water Body Name**	**County**	**Voluntary Peer Review**	
Rivers	Ocklawaha	Marion/Putnam	Yes	
	Silver River	Marion	Yes	
Aquifers (springs)	Silver Springs	Marion	Yes	
Lakes	McCoy	Orange		
Wetlands	None			
Re-evaluations	To be determined			

APPENDIX C—DECISION MODEL DESCRIPTION

DECISION MODEL DESCRIPTION

Groundwater optimization models were used to obtain the groundwater deficits outlined in this DWSP for east-central Florida and Volusia model areas. The groundwater optimization model makes maximum use of existing and proposed groundwater supplies while meeting specified environmental protection goals and constraints. Costs are not a part of this modeling procedure. Deficits are identified in quantity by model area.

Although not utilized for the purposes of the DWSP 2005, the economic optimization model is described here. This model considers alternatives to existing and proposed wells and all associated costs. The objective is to minimize the costs of meeting projected demands while selecting from a number of existing, proposed, and alternative sources, yet still meeting environmental protection goals and constraints. This task would not be necessary if all future water supply needs could be met by optimizing groundwater withdrawal. A number of alternative water supply strategies may satisfy individual user requirements but may fail in other areas, including political constraints, “local sources first” policies, environmental protection goals, or costs. The decision models may be used to help water resource managers sort through the possibilities and examine a subset of water supply plans that satisfy additional criteria such as variations on demand area or individual well equity, maximum distances from sources to demand areas, the conditions for external routing between interconnects, and county-only or district-only sources.

No one set of decision model output may be considered to be the solution to future water resource problems. However, the decision model may be rerun and refined as necessary to gain additional information and insight about the water supply problem, the simulation model, and projected future water demands.

Purpose and Scope

The scope of the decision-modeling approach is limited to examining steady-state water allocation scenarios on a macroscale using given available resources and is subject to computer hardware and software limitations.

This modeling approach applies a combined optimization / simulation technique which incorporated SJRWMD groundwater flow and transport simulation models for the model area. Two optimization models, the east-central Florida and the Volusia models, were utilized for the purpose of DWSP 2005. These optimization models incorporated quantity and quality considerations to determine optimum groundwater allocation strategies which satisfy future water supply demands and minimize adverse environmental impacts at specified locations.

Model Objectives

The objective of the decision-modeling for the purposes of DWSP 2005 was to maximize the use of existing and proposed groundwater supplies while constraining the environmental impacts at sensitive areas to identify groundwater deficits for each model area. However, the model is capable of minimizing the total cost of providing water for a regional area and exploring other management objectives, such as minimizing environmental impacts while calculating the cost of providing water. Model objective functions may be easily revised to assist water supply managers in comparing or contrasting different water supply strategies.

Modeling Framework

The optimization models identify optimum water allocation scenarios to meet 2025 demands by applying conditions of equity for all demand areas. Projected demands are met with a combination of existing and proposed groundwater sources, potential new fresh and brackish groundwater sources, surface water, and external routing between existing public suppliers. The models identify public water supply demand areas having potential deficits due to limitations placed on the model in the form of environmental constraints. Deficits are also identified when the combination of existing proposed, and alternative water sources fail to satisfy all projected future water supply demands. Deficits identified by the model can be due to the sensitivity of wetland drawdown, spring flow, lake level, water quality, or equity constraints.

Both groundwater optimization and economic optimization models rely on the widely used three-dimensional groundwater simulation model MODFLOW (McDonald and Harbaugh 1988; Harbaugh and McDonald 1996), a saltwater upconing model (CH2M HILL 1998), the General Algebraic Modeling System (GAMS) (Brook et al. 1996), and the CPLEX linear and mixed integer programming solvers (CPLEX Optimization 1996).

Figure 1 illustrates how constraints are incorporated in the optimization / decision-modeling process. Model inputs for both processes include aquifer responses to pumping, 1995 and projected 2025 water demands, a set of existing and proposed well withdrawal sites with capacities, 1995 and projected 2025 (non-optimized) surficial heads, spring discharges, chloride concentrations, environmental and hydrologic constraints, and equity constraints. These inputs are obtained from GIS information, water quality data, well characteristics, and historical or projected well withdrawal rates. The data are used as input to the groundwater flow and water quality (transport) models. The flow and transport models provide the aquifer responses to pumping. Finally, the aquifer responses are used as input to the groundwater optimization model and economic optimization model.

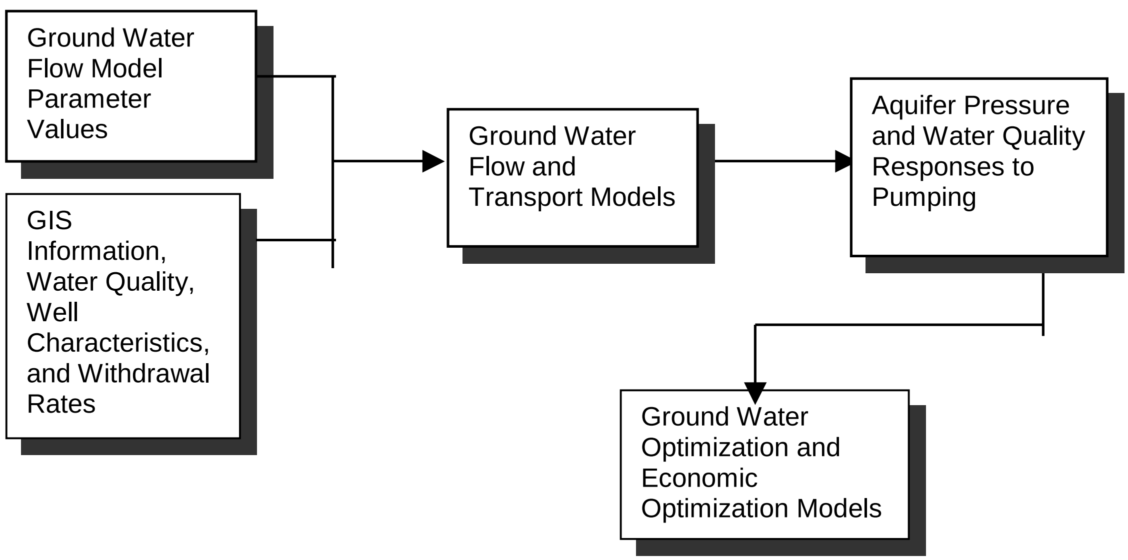

Figure 1. Incorporation of constraints in the optimization/decision model

Figure 2 depicts the decision-modeling process (not utilized for the purposes of DWSP 2005). The upper half of the figure illustrates the process for existing and potential groundwater sources only. The lower half shows the process considering alternatives to existing and potential groundwater sources and is considerably more complex.

In the first process, model inputs include aquifer responses to pumping obtained from groundwater flow and transport models, projected water demands, and environmental and hydrologic constraints. The optimization model simulates all possible scenarios and generates a groundwater withdrawal strategy that meets the specified constraints and identifies any resulting demand deficit locations. The constraints may then be reviewed or revised, and other changes may be made to the model inputs. This process may be repeated as many times as necessary to achieve satisfactory results.

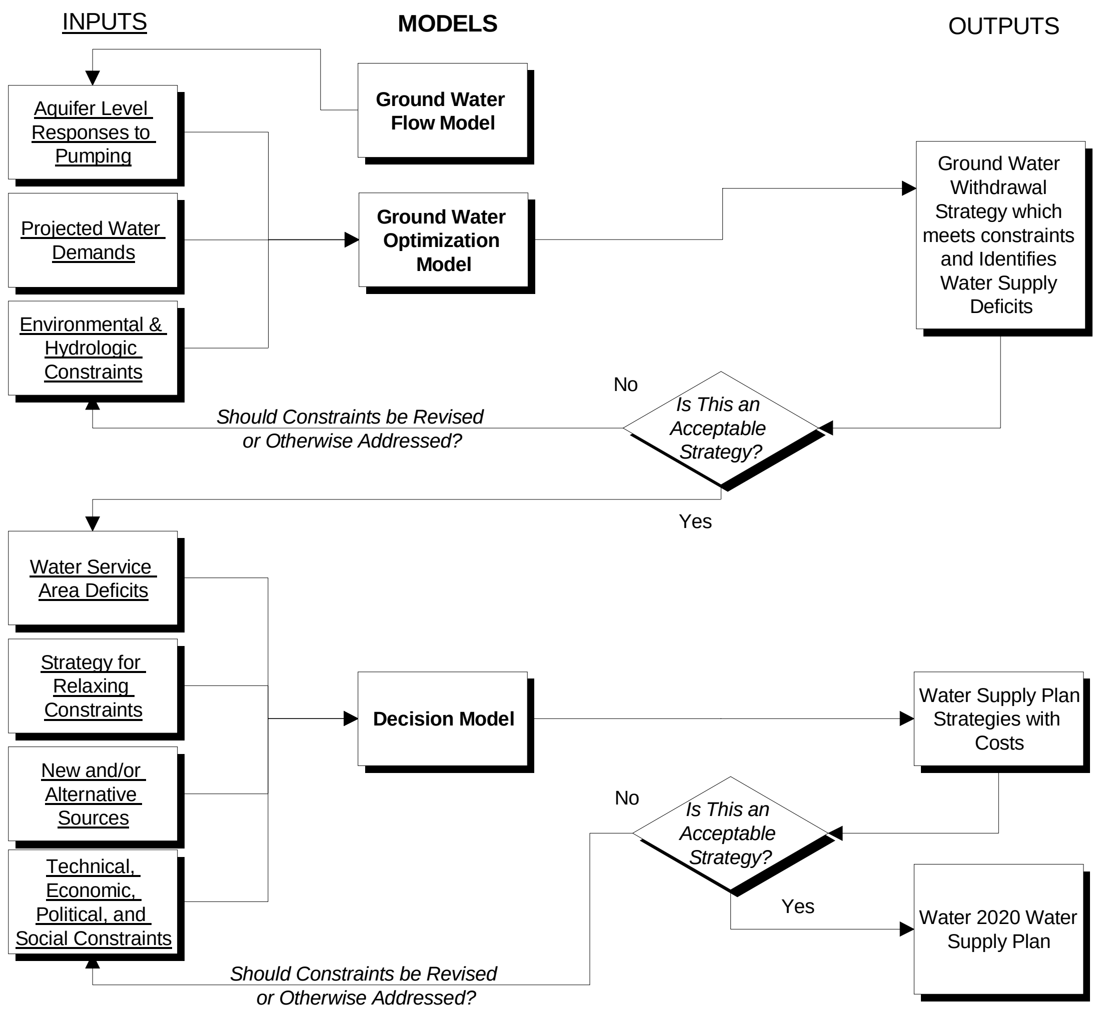

Figure 2. Decision-modeling process (not utilized for the purposes of DWSP 2005)

Groundwater optimization model output includes well withdrawal rates; the aquifer response to withdrawal rates in terms of surficial drawdown, spring discharge and water quality; and deficits identified at each demand area. Existing economic optimization model formulations assume that there is no impact due to surface water withdrawal at the proposed surface water sites at rates within the specified capacities.

The optimization process identifies demand areas that may have potential water resource problems, or deficits, subject to the specified constraints. It may be necessary to find alternatives to existing and potential groundwater sources to eliminate any deficits found by the groundwater optimization model. Although not utilized for DWSP 2005 purposes the economic optimization model can then be used to determine the optimal water supply strategy which considers all of the information in the groundwater optimization model, but also includes alternatives to existing and potential sources.

The process outlined in the lower half of figure 2 includes all the inputs for the groundwater optimization model with the addition of public supply demand area deficits, a strategy or strategies for relaxing constraints, a number of alternative water supplies, and any technical, economic, political, or social constraints as well as distances from alternative sources to demand areas (approximated as straight lines), fixed costs (construction, capital, etc.) for alternative sources and unit costs (operating and maintenance) for existing, proposed, and alternative sources.

Using the specified inputs, the model is run to output a water supply plan with cost data. If this plan is acceptable, it may be selected for use. If not, the constraints may be revised or otherwise addressed. Some environmental constraints may be relaxed, while political and social considerations can also be addressed with additional decision model runs.

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APPENDIX D—UNCERTAINTY ANALYSIS

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT WATER SUPPLY PLANNING UNCERTAINTIES

ABSTRACT

Water supply planning requires prediction of future conditions. Included are predictions of the future water supply needs and environmental and financial impacts of alternative water supply development scenarios. Any and all attempts to predict future conditions will be imperfect. Therefore, uncertainty is encountered and introduced in each step of the planning process. This paper discusses the sources of uncertainty in the St. Johns River Water Management District water supply planning process, major steps taken to minimize and manage uncertainty, the likely impact of the remaining uncertainty, and decision making implications.

Uncertainty in the water supply planning process is associated with the prediction of future water use, the estimation of water supply deficits, and the estimation of costs for developing water supply options and alternatives.

The recommended approach to address this uncertainty is to (1) identify sources of uncertainty, (2) define nature and effect of each source, (3) manage each source to minimize its effect to the extent possible, and (4) apply a flexible approach to the long term planning and decision process.

WATER SUPPLY PLANNING GOALS AND MAJOR STEPS

The primary goal of water supply planning is to identify acceptable alternative approaches for meeting future water needs, including both human needs and natural system needs. The process requires estimation of all future water needs and the identification and evaluation of alternatives adequate to meet these needs.

Major steps include the following:

- Estimation of future water supply needs
- Estimation of future water supply deficits
- Alternative development and evaluation
- Plan selection

Water Supply Needs

Estimation of future water supply needs requires estimation of future population, agricultural activity, and commercial and industrial activities within the planning area, as well as within individual water supply service areas. It also requires estimation of the environmental and hydrologic conditions necessary to maintain healthy natural systems within lakes, rivers, springs, and wetlands.

Water Supply Deficits

Water supply source deficits are the difference between water supply needs and the quantity of water a source can supply. If an existing or preferred source cannot meet all future needs then alternative sources must be identified and evaluated.

Alternatives

Alternative development and evaluation involves identification of alternative sources of supply and alternative resource management and development techniques. Once identified, each alternative is evaluated based on (1) its ability to meet all, or a portion of, future water supply needs (both human and natural system needs), (2) the total cost of the alternative, and (3) the relative ability to implement the alternative.

Plan Selection

Once the alternative evaluation is complete, certain alternatives will be identified as technically and environmentally feasible, while others may be identified as infeasible. All options and alternatives that have been determined to be technically and environmentally feasible will be included in the resulting water supply plan. The plan will be as inclusive as possible. However, the least cost-acceptable solution will also be identified to help guide economically sound options development and facilities planning for individual water users.

WATER SUPPLY PLANNING TOOLS

The St. Johns River Water Management District (SJRWMD) water supply planning process is an ambitious regional planning initiative. It involves estimation of future water supply needs for one of the fastest growing regions in the state of Florida. It involves development of environmental, hydrologic, and water quality criteria to define natural system needs, and the development and evaluation of complex water supply management alternatives. All planning activities are conducted with public involvement and the participation of all affected and interested parties is actively solicited.

Because of the magnitude and complexity of the task at hand, several tools have been developed to assist in the planning process, including the following:

- Groundwater flow models
- Groundwater allocation models
- Economic optimization models

Each of these models is designed to help define and evaluate the nearly limitless number of options and alternatives available within the planning area. The groundwater flow models provide a particularly important function. These models estimate the hydrologic and water quality response of the aquifer system to groundwater withdrawals and provide the basic foundation for all other planning tools.

SOURCES OF UNCERTAINTY

Water Supply Needs (Water Use Projections)

Water use projections are typically based on knowledge of historical use and assumptions about the future. This is equally true for both complex demand models and for simple demand equations. In areas or times of stable growth, historical use has been found to be a reliable indicator of aggregate future water use. In the public water supply use category, areas that are “built-out” to their permitted or physical capacity are typical of this group. There are numerous examples of such areas in the District, particularly in municipalities located near the center cores of heavily urbanized metropolitan areas, as well as in mobile home parks or older planned developments. Knowledge of historical use is also found to be fairly reliable for the other major use categories, such as in areas or among crops that are well established.

Recently however, urban and commercial development in key counties within the District has occurred at such a rapid pace that it is difficult to predict with any great level of certainty when the rate of development will level off. In these areas, the uncertainty associated with water use projections is high, compared to the more stable, urbanized areas. However, projections must be made so that strategies can be developed to preserve the continued viability of water related resources while meeting the growing need for water. Projections are made by SJRWMD using the best available information, but are recognized as having inherent uncertainty.

There are multiple issues of uncertainty associated with water use projections, many of which are interrelated. For instance, in the public supply category, there is uncertainty over the extent of geographic area that will fall within a given utility's service area. There is uncertainty over whether the composition of the aggregate demand will be altered significantly in favor of one or another sector (i.e., single vs. multifamily residential, commercial vs. residential). This uncertainty could impact total demand estimates and ratios of average day demand to maximum day demand made with current information. There is the unknown element of where or when new developments will occur, or even whether growth in known planned developments will progress as scheduled. In some areas, large planned developments have taken considerably longer to get off the ground, impacting the timing of increases in water use. Other uncertainties in the public supply category relate to the potential impact of water conserving technologies at both the utility and the user level, and the extent to which reuse of reclaimed water can diminish demand for potable water.

Public Supply

SJRWMD developed population-based public supply water use projections, calculated using the median projections of population growth published by the Bureau of Economic and Business Research (BEBR) and historic estimates of per capita use. The District's projections assumed a constant per capita use throughout the planning period and no change in the composition of the aggregate demand.

According to BEBR median projections, SJRWMD total population is expected to increase from about 3.52 million in 1995 to 5.88 million in 2025, an increase of 67%. The portion of the population served by public supply utilities is expected to increase from 2.96 million to 5.08 million, or nearly 72%. It is this expected increase in public supply population that drives increased water supply needs.

BEBR recognizes uncertainty in the population projections and quantifies this uncertainty by publishing an expected range in population, including low and high projections as well as the median or expected projection.

Considering total growth within the fifteen (15) SJRWMD counties that contribute to the public supply demand, BEBR estimated population growth rates range from a low of 1.15% per year, to a high of 2.62% per year, with a median projected growth rate of 1.91% per year. Over a projected 30-year period (1995 to 2025), this fairly narrow range in projected growth rate can represent a rather large uncertainty in actual population growth. For example, compared to the median growth rate, the low BEBR growth rate would be about 53% of the projected median population growth, whereas the high BEBR growth rate would be about 154% of the median project growth. This range in population growth estimates is considered a good estimate of the possible range of public supply growth. Therefore, the predicted 72% growth in public supply demand could actually range from a low of about 39% to a high of approximately 111%, with the median value of 72% being the most likely.

Agricultural Irrigation

In the agricultural use category, uncertainty is related more to the question of how much acreage will be in production than to crop irrigation requirements. District-wide agricultural water use is expected to change little during the planning period. Agricultural irrigation use totaled 584 million gallons per day (mgd) in 1995 and is projected to total 522 mgd in 2025, a decrease of 11%. The major change will be redistribution of irrigational water use as agricultural land use and cropping patterns change.

Agriculture has made great advances in the development and adoption of more efficient irrigation practices, and it is unlikely that significant changes in water use will occur in response to better irrigation management practices. There is some question over which of the several methods for estimating irrigation demand should be used in demand calculations, especially for citrus crops, which represent almost 45% of the total agricultural water use. Water use permit allocations issued by SJRWMD are based on 30-year mean Blaney-Criddle estimates of supplemental irrigation requirements. These tend to be high compared to measurements of actual use. For example, the Blaney-Criddle estimate for citrus supplemental irrigation requirements is roughly 60% higher on average than measurements of actual use. However, out of deference to the agricultural community, SJRWMD agreed to use the Blaney-Criddle estimates in the Water Supply Assessment (WSA) for all crops except fern and potatoes. The irrigation requirements for the latter two crops were obtained from the District Benchmark Farms Project, with the approval of the agricultural community.

On average over all the crops and counties, the Blaney-Criddle estimates were approximately 20% higher than estimates of actual use reported in the District Annual Water Use Survey, which use measurements of actual rainfall for the year. This range is interpreted by SJRWMD as the range of uncertainty in estimates of crop supplemental irrigation requirements.

However, SJRWMD believes the greatest uncertainty in projecting agricultural water use lies in how much acreage will be in production, where production will occur, and which crops will be grown. Urbanization has taken a toll on agriculture, and is likely to continue to encroach on agricultural land found on the fringes of major urban centers. Increased market competition and erratic, damaging climate have also combined to make agriculture a less stable economic venture than in the past. An abrupt decline in a competitive market could stimulate interest in certain crops or new, higher value crops could be introduced. Higher value crops tend to require more reliable water sources, which would increase demand for irrigation water. Nothing on the horizon points to these events, however they cannot be ruled out.

Recreation (Golf Course Irrigation)

While it is certain that the golf course industry will continue to grow, it is difficult to determine how much of their irrigation needs will be obtained from ground or surface water sources as opposed to being obtained from reuse of reclaimed water or above ground retention ponds. Districtwide golf course irrigation totaled 99 mgd in 1995, and is expected to increase to 156 mgd by 2025, a significant increase. Estimates of future water use for the golf course industry are acknowledged in the WSA to be among the less reliable of the water use categories, because of the uncertainty associated with the source. There is also uncertainty associated with the calculation of irrigation demand. The golf course industry has made significant progress in the adoption of better irrigation management, and many of the larger, more affluent courses now use computers to manage their irrigation. Greens are irrigated at a different rate than are roughs and fairways. Without knowing the ratio of greens to roughs and fairways, it is difficult to correctly assess the irrigation demand of an entire system.

Commercial and Industrial

The historic trend in the commercial/industrial/institutional category has been one of relatively insignificant growth compared to growth in the public supply sector. However, in some areas there is evidence of new activity in the commercial sector, again on the fringes of larger metropolitan areas. The uncertainty lies in the intensity and duration of this growth phase, and what its ultimate impact on overall water use will be. Currently, these demands are expected to decline slightly, from 134 mgd in 1995 to 129 mgd by 2025.

Thermoelectric Power Generation

Deregulation of the electric power utilities, expected to occur within a few years, has lead to significant uncertainty in water use projections for thermoelectric power plants. No one has a clear understanding of how deregulation will change the current industry. However, the large majority of water used in this industry is saline surface water. It is unlikely that even significant changes in water use for electric power will impact demand for groundwater by these few utilities.

Natural Systems Needs (Withdrawal Constraints)

Water withdrawal constraints applied in the water supply planning process are of three types.

- Minimum flows and levels (MFLs)
- Native vegetation (primarily wetlands drawdown)
- Groundwater quality

In aggregate, the water withdrawal constraints define natural systems needs. That is, the purpose of the withdrawal constraints is to insure that a proposed groundwater withdrawal scenario will protect natural systems, including the aquifer, and will not cause unacceptable harm. The water withdrawal constraints are designed to parallel consumptive use permitting criteria, as much as practical at a regional planning scale. The constraints applied in the water supply planning process are described in detail in the *Water 2020 Constraints Handbook* (St. Johns River Water Management District and CH2M HILL 2005).

Minimum Flows and Levels (MFLs)

Minimum flows and levels are flow values or water levels below which significant harm to the water resource or ecology of the region would occur. MFLs are established for specific water bodies by the SJRWMD Governing Board; based on results of site-specific investigations. The water bodies are selected, and the MFLs are established, from a priority list also approved by the Governing Board.

Within the planning area, MFLs have been established for a number of lakes and certain streams including the Wekiva River. As a result, specific minimum mean flow values have been established for the major springs within the Wekiva River basin. These values are used as constraints in the groundwater allocation and decision models to evaluate various water supply withdrawal scenarios and water supply alternatives. Where established by the SJRWMD Governing Board, there is no institutional uncertainty associated with actual MFL values. That is, these values have been defined by Governing Board action. However, there can be some uncertainty that adopted MFLs do indeed adequately protect the intended resource. The District addresses this concern through monitoring of hydrologic and ecological conditions.

To protect lakes with established MFLs, the adopted minimum average lake level is used as a planning constraint. Using this constraint, the allowable change in average lake level is used as the maximum allowable change in the surficial aquifer water level, as determined by application of the regional groundwater flow model. This approach implies that eventually a reduction in the average surficial aquifer level adjacent to a lake will result in an equal reduction in the average lake level.

Many lakes exist within the planning area and only a small subset has adopted MFLs at this time. SJRWMD plans to adopt MFLs for many additional lakes. For that reason, a generalized constraint, set equal to a 0.5-foot reduction in average lake level, was assumed for selected lakes not currently covered by adopted MFLs.

Similarly, many significant springs exist within the planning areas that do not have adopted MFLs at this time. In order to protect these springs and to provide for future MFLs determinations, a maximum reduction of 15% of historic median spring flow is used as the constraint for springs not currently covered by adopted MFLs. There is some uncertainty introduced by this procedure because actual adopted MFLs, for individual water bodies, may vary from the assumed values. However, these surrogate planning values have been set based on experience in setting MFLs for lakes and springs, and the associated level of uncertainty, on a regional basis, should be rather small.

Native Vegetation

Changes in a wetland's hydrologic regime, including a lowering of the average water level, may affect the structure and species composition of the vegetative community. Changes in the basic vegetative community within a wetland is considered significant harm, according to current SJRWMD consumptive use permitting criteria, and is to be avoided. The wetland constraint establishes maximum drawdown values for specific wetland community types, which if exceeded are likely to result in the replacement of dominant vegetative species by those characteristic of drier community types.

Ten wetland types were identified and a specific maximum allowable drawdown limit was established for each. These limits range from 0.35 to 1.20 feet. This approach is very similar to the lake level MFLs approach and implies that eventually a reduction in the average surficial aquifer level adjacent to a wetland will result in an equal reduction in the average wetland water level.

Uncertainty Associated With Prediction of Lake Level and Wetlands Water Level Reductions

Uncertainty associated with prediction of lake level and wetland water level reductions is associated with the ability to accurately predict changes in surficial aquifer water levels and in the hydrologic linkage of the surface water feature (lake or wetland) with the surficial aquifer. Uncertainty associated with prediction of surficial aquifer water level changes is discussed in the groundwater flow models section of this paper. This discussion focuses on uncertainty associated with the hydrologic linkage between lakes and wetlands and the surficial aquifer.

In the water supply planning analysis, a change in average surficial aquifer water level is assumed to result in an equal change in average lake or wetland water level. This will be true only if there is a hydraulic connection between the surface water feature and the surficial aquifer, and where surface water inflow into the lake or wetland is negligible. The lake and wetlands drawdown constraint actually identifies areas where significant harm may occur, or has the opportunity to occur. Drawdown constraints can help identify areas where significant harm is likely to occur, when care is taken in identification of lake and wetland control points most vulnerable to changes in surficial aquifer levels.

In general terms, lakes and wetlands can be divided into two types, based on tributary area characteristics. These are, *isolated* lakes and wetlands, and *flow through* lakes and wetlands, as illustrated in Figure 1. Isolated lakes and

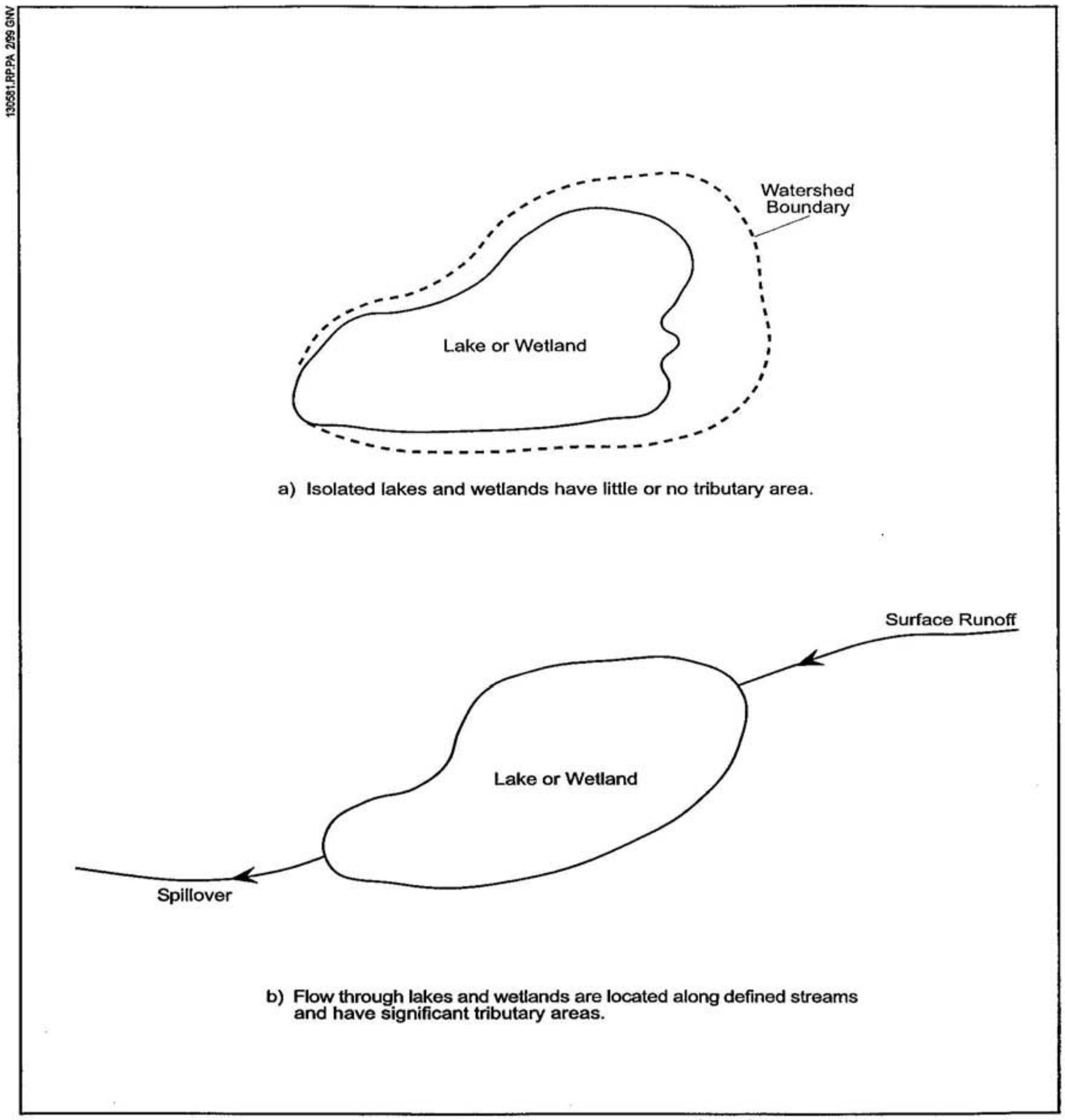

Figure 1. Isolated and Flow Through Lakes and Wetlands.

wetlands have little or no tributary area. The major source of inflow is direct rainfall and the major source of outflow is evapotranspiration and seepage to groundwater (recharge to the surficial aquifer). Water levels in isolated systems that are hydraulically connected to the surficial aquifer are likely to respond as assumed. That is, a change in the average surficial aquifer water level will result in an equal change in the average lake or wetland water level.

Flow through lakes and wetlands, on the other hand, are part of larger surface water systems. They receive significant inflow from upstream tributary areas and discharge, or spillover, to downstream hydrologic systems. In this case, reduction in the surficial aquifer water levels beneath the wetland is unlikely to influence water levels within the wetland. Even if the rate of groundwater seepage (i.e. recharge) is increased, it is likely that this effect will be reflected in reduced spillover volume rather than reduced water levels.

In summary, the uncertainty associated with changes in lake or wetlands water levels, resulting from changes in surficial aquifer water levels results primarily from uncertainty related to the quantity of direct surface water inflow received from upstream tributary area and the degree of hydraulic connection with the surficial aquifer.

Groundwater Quality

The Floridan aquifer was formed as a result of marine deposits and is composed of limestone and dolomites, with varying hydraulic properties. The uppermost parts of the aquifer generally contain fresh water and with depth water quality deteriorates, with concentration of chlorides and other dissolved constituents approaching that of seawater. Conceptually, fresh water exists as a lens that is underlain by denser, highly mineralized brackish-to-saline water.

If fresh water is withdrawn at too great a rate, the underlying mineralized water can replace the fresh water and the aquifer water quality will deteriorate. The purpose of the water quality constraint is to protect the fresh water portion of the Floridan aquifer and to prevent deterioration in water quality that would result in exceedence of primary and / or secondary drinking water standards for dissolved constituents.

The water quality constraint used in the water supply planning analysis is to allow increased withdrawals as long as the quality of the water withdrawn does not exceed the current drinking water standard of 250 parts per million (ppm) chloride concentration, or the existing chloride concentration if it is currently greater than 250 ppm.

Uncertainty associated with the application of this criterion is associated with the accuracy of the water quality data for the Floridan aquifer and with the prediction of water quality changes as a function of pumping rate and duration.

GROUNDWATER FLOW MODELS

Introduction

Groundwater flow models are used to predict the long-term response of the aquifer system to water supply withdrawal. Under natural conditions aquifers exist in a state of dynamic equilibrium. That is, over long periods of time, recharge and discharge virtually balance. Water supply withdrawals upset the natural balance and, if operated at near steady state conditions, will eventually generate a new balance. In the short term, water is withdrawn from storage. In the long term, this water is replaced in the aquifer by increased recharge, or a decrease in natural discharge, or a combination of both.

Groundwater flow models are used to quantify these recharge / discharge / water supply withdrawal relationships for a given aquifer system and water supply withdrawal scenario. These models are mathematical representations of the physical system. As such, they produce estimates of aquifer response to water supply withdrawal, expressed in terms of changes in Floridan aquifer pressure (potentiometric surface elevation), surficial aquifer water levels, recharge rates, and spring flow discharges.

For the water supply planning process, the important variables are those that significantly impact water supply withdrawal decision making. These are the changes in surficial aquifer water levels beneath sensitive wetlands and changes in spring flow. The groundwater flow models have been developed by SJRWMD to provide the best predictions currently available of the response of the Floridan and surficial aquifers to various water supply withdrawal scenarios.

There are several sources of model uncertainty including: limitations inherent in the available model computer codes; horizontal and vertical resolution (discretization) of the model framework; uncertainty in the model input data; and uncertainty in model calibration.

Groundwater Model Peer Review

All major groundwater models developed by SJRWMD, including the east-central Florida, Volusia, and northeast Florida groundwater flow models are subject to periodic peer review as these models are constructed and updated.

Limitations in Model Computer Codes

By inputting an area's unique relevant hydrologic parameters, modelers create a computer code that is used to construct a groundwater flow simulation model. The hydrologic parameters that describe the real system are applied within the framework of the model computer code and thereby result in a groundwater flow model.

The model code used in the water supply planning models is MODFLOW— a generally accepted groundwater systems simulation developed by the U.S. Geological Survey (USGS) that has been used by hydrogeologists throughout the United States for more than 15 years.

The regional groundwater flow models will do a good job of predicting 2025 Floridan aquifer drawdowns and spring flows, and they will do a reasonably good job of identifying potential Floridan water quality trouble spots. However, the model’s abilities’ to accurately predict 2025 drawdown in the surficial aquifer and in the wetlands is hampered, in part by limitations inherent in MODFLOW.

MODFLOW’s governing equations accurately describe the groundwater hydrology, but only the Floridan spring flow and evapotranspiration (ET) portions of the surface-water hydrology can be explicitly computed in a reasonably straightforward manner. MODFLOW allows capture of water due to reduced Floridan spring flows caused by drawdown in the Floridan. Similarly, MODFLOW allows capture of water due to reduced ET as a result of water-table drawdown in the surficial aquifer. ET capture tends to offset water table drawdown as does surface water capture. However, MODFLOW’s equations do not adequately describe capture of runoff (surface and subsurface) in response to drawdown in the surficial aquifer caused by changes in leakage rates through the confining beds that overlie the Upper Floridan aquifer.

MODFLOW’s DRAIN or RIVER functions can compute changes in surface discharge from the surficial, but only if composite fixed heads and composite

DRAIN or RIVER coefficients can be determined for individual model grid cells. Those parameters are difficult to accurately determine, especially in grid cells that contain more than one ditch, stream, or river.

Since MODFLOW does not account for hydrologic connectivity of wetlands with other wetlands, streams, or with upland drainage, where such connectivity exists, surface water routing is not simulated or quantified from one grid cell to another. This factor causes MODFLOW to overestimate drawdown in the surficial because it doesn't allow for surface water inflow to help offset the effects of local drawdown caused by increased downward leakage. MODFLOW's inability to adequately describe surface water capture (discussed previously) exacerbates the problem.

Horizontal and Vertical Discretization

Model horizontal grid discretization is large (2,500 feet on each side) with respect to the size of certain types of wetlands. For example, in the coastal zone of the District, many wetlands are elongate and coast-parallel, and, in many cases, their narrow dimensions are considerably smaller than 2,500 feet. The geometry of wetlands (size, shape, grid cell overlap) cannot be explicitly described in MODFLOW. Storage coefficients for the surficial aquifer must therefore be a composite value of that part of the grid cell that represents free-water surfaces and that which represents land surfaces. It is important to recognize that storage coefficient considerations will not affect the current steady-state models, but it will have an effect on future transient simulations.

Horizontal grid discretization can affect the areal extent of the deficits computed by the decision/optimization model. For example, the deficit amount for a large grid cell will likely be larger than that for a smaller grid cell because it will likely contain more pumping sites. It is possible that the sheer number of affected deficit small grid cells might account for the same amount of deficit in a larger cell of the same equivalent area contained in the smaller cells. In a more highly discretized model, the tendency will be for a smaller total area to be included in deficit areas; hence, some pumping cells could escape being labeled as deficit cells.

Vertical discretization refers to the number of aquifer and confining bed layers simulated. Aquifers simulated with only one layer cannot account for vertical anisotropy; that is, the tendency for horizontal aquifer hydraulic conductivities to be greater than their vertical hydraulic conductivities. Such anisotropy tends to allow water within the aquifer itself to more easily flow horizontally than vertically. Subdividing the aquifer vertically into several layers can account for vertical anisotropy by incorporating quasi-confining beds that couple the individual layers and offer resistance to vertical flow between the aquifer layers. Confining beds can be similarly discretized.

Vertical discretization of vertically anisotropic aquifers tends to simulate Floridan pumping cones of depression that are shallower and that are of larger aerial extent than would be the case if that aquifer would be simulated as only one layer. Shallower, broader Floridan cones of depression would tend to reduce downward leakage from the surficial aquifer in the areas nearest the pumping centers but would tend to increase downward leakage near the outermost edges of the cone.

More highly discretized models result in models with more grid cells, sometimes many multiples of those contained in the current SJRWMD models. This presents data and computational problems that are beyond the scope of this discussion, but they are substantial.

ERRORS IN MODEL INPUT DATA

Bias and Random Errors

All model input data are subject to errors. There are essentially two types of error—bias error and random error. Bias error occurs when data are collected in such a manner that measurements are biased toward values that are consistently too high or too low. Bias error typically occurs when the measurement technique is flawed. Random error occurs when some of the measurements are too high while others are too low. Random errors are inherent in all measurements to one degree or another, but tend to cancel out over a series of many measurements.

Measured model input data are carefully collected to eliminate bias errors and to minimize random errors to the extent possible. The following discussion lists major sources of random error in model input data.

Spring Flow Measurements

The accuracy of USGS-measured Floridan aquifer spring flows are typically rated as good, meaning that the gauging technician believes the measurement is accurate to within 10% of its actual value. In recent years, springs in the District have been measured from 6 to 12 times per year. Previously, most springs were measured only twice per year, with Blue Spring (8 times / yr.) and Silver Spring (8 times / yr. *and* computed daily discharge) being the exceptions. The errors in discharge measurements are random errors and are not believed to contain bias error. Therefore, during any year that contains 8timeweighted discharge measurements, the random errors should tend to balance out, leaving a reasonably accurate determination of the average discharge for that year. Multiyear average discharges are even more accurate.

Rainfall Measurements

Rainfall in Florida is highly variable, both temporally and spatially. SJRWMD must assume that the gauged rainfall data are accurate. Theissen polygons or other methods are used to interpolate between stations.

Land-Surface Elevations

Land-surface altitudes are gleaned from USGS topographic maps or from the USGS topographic databases. In either case, those data are considered the gold standard for data derived by indirect means, such as photogrammetry augmented by known control points in surveyed benchmarks. Even so, the USGS rates their interpolated topographic data as accurate to within plus or minus one-half a contour interval (+- 2.5 feet for 1:24,000, 7.5’ quadrangle map sheets). It is believed that the USGS understates the accuracy of their maps. Nevertheless, some error exists even here.

Water Level Measurements

Water level measurements in Floridan aquifer wells are used to develop potentiometric surface data points from which potentiometric maps are constructed. Almost all water level measurements are collected with an accuracy of 0.01 foot. Potentiometric map data points are fixed in space and time but the potentiometric maps are constructed from numerous data that were not all collected at the same time. Thus, the maps represent a snapshot in time that may actually span one or more weeks. Further, the data at the data points are interpolated in space by either an experienced hydrologist or by a computer. Regardless of which does the best job, there is some error inherent in the potentiometric maps.

Thickness of Geologic Strata

There is uncertainty in determining aquifer and confining bed thicknesses. Such information is obtained from geologic data gathered from individual wells or test holes and then, by interpolation, rendered into areal maps.

Transmissivity and Leakance

Floridan aquifer transmissivity (T) and upper confining bed leakance (L) typically are first rough-estimated using available aquifer test data and are then fine-tuned as part of the iterative calibration process. This process is aided in spring basins where the actual groundwater flux is known in terms of gauged spring flow. Calibrated Ts and Ls are typically within +- 20% to 30%.

Recharge

Uncertainty in net recharge to the surficial aquifer is derived from uncertainties in: rainfall data; estimates of runoff (surface and subsurface) to streams and ditches; evapotranspiration rates; and estimates of recharge from septic systems, rapid infiltration basins, recharge due to lawn and agricultural irrigation, and other types of surface and subsurface applications.

Model Calibration Errors

In brief, the steady-state model calibration process consists of adjusting the soft input parameters of Floridan aquifer transmissivities (T) and upper confining bed leakance coefficients (L) so the model output response due to pumping or other imposed hydraulic stresses matches the hard data, such as observed aquifer heads and spring flows. An important aspect of the initial calibration effort consists of determining the proper boundary conditions for the model.

Nonsteady-state calibration typically occurs after steady-state calibration is accomplished. Here, the previously determined boundary condition coefficients, Ts, and Ls are held unchanged and aquifer and confining bed storage coefficients are adjusted to match aquifer responses due to pumping or other hydraulic stresses observed over a given period of time.

The steady-state calibration process typically yields nonunique working combinations of T and L for individual grid cells. These working combinations can yield calibrated Floridan aquifer responses within a few percent even though the individual Ts and Ls may be considerably less accurate. This is adequate for predicting steady-state aquifer responses in the Floridan but the errors in L directly affect the leakage rates to and from the surficial and, hence, can cause errors in the computed drawdowns in the surficial.

Models are typically considered calibrated if the computed Floridan aquifer heads match observed heads within approximately 2 feet (+,-), whereas the wetland drawdown constraint can be as small as 0.35 foot. It is unlikely that the accuracy of the computed wetlands drawdown in the less-well-calibrated surficial aquifer exceeds the calibration criterion for the calibrated Floridan aquifer where fluxes are reasonably well-known.

There may be considerable lag between the time that 2025 drawdowns are seen in the Upper Floridan and when they are seen in the surficial aquifer. Where Upper Floridan confining beds are thin or permeable, drawdowns in the surficial will be reasonably contemporaneous with those in the Upper Floridan. Where confining beds are thick or less permeable, drawdowns in the surficial can lag those in the Upper Floridan by several years. The steady-state versions of the models will not account for lag but the transient versions will be able to simulate drawdown in wetlands as a function of time.

Water Allocation and Economic Optimization Models

The water allocation model and the decision model are closely related linear programming applications. These models are based on proven mathematical optimization algorithms. The water allocation model duplicates the hydrologic response predicted by the groundwater flow models and is designed to optimize groundwater withdrawals given aquifer response and water withdrawal constraints. The decision model is an extension of the groundwater allocation model and is designed to identify the least expensive alternative sources to meet the identified water supply deficits.

The water allocation and decision models rely on input data provided by other aspects of the planning process, including groundwater flow model results and the withdrawal constraints. All uncertainties associated with these planning steps are carried forward, but no new significant sources of uncertainty are introduced by proper application of the groundwater allocation model. With accurate input data these models will always provide accurate results.

The decision model does require life cycle cost estimates associated with development of the alternative water supplies considered. Cost estimates are developed at the cost curve or conceptual planning level of accuracy. As such, there is a significant degree of uncertainty associated with any individual facility cost estimate. For example, the estimated cost of a surface water treatment plant located on Lake Griffin, or a given water transmission main could be in error as much as 50%. This is because at this regional planning scale, exact sites or routes have not been identified and site-specific conditions cannot be accounted for. At this level of planning, it is important that the relative differences in costs among alternatives be accurately represented, and that the costs for all alternatives be developed on a consistent and comparable basis.

UNCERTAINTY MANAGEMENT

Uncertainty cannot be avoided, but to a great extent it can be managed. Major areas of uncertainty, previously discussed, include the accuracy of water use projections, uncertainties associated with the application of lake and wetland drawdown constraints, and the accuracy of predicted surficial aquifer water level changes using existing models and hydrogeologic data.

Water Use Projections

The major area of uncertainty associated with the 2025 water-use projection is the accuracy of the projected growth in the public supply category. Growth in public supply water use represents the vast majority of the expected growth in water use by 2025. Public supply water use projections are based on expected population growth, using median growth estimates published by the Bureau of Economic and Business Research (BEBR) and historic per capita use.

As previously discussed, BEBR quantifies uncertainty associated with population projections by publication of low estimates and high estimates, in addition the median or expected estimate. For the 15 SJRWMD counties that contribute to public supply water use, the annual population growth rates associated with the low, median and high projections are 1.15%, 1.91% and 2.62% respectively. Uncertainty is managed by using the median or expected value population predictions and associated growth rate. In this manner, it is equally likely that the difference between actual 2025 population and predicated population will be higher or lower than the values used in the planning process. That is, the median values provide the most unbiased estimate available.

It is informative to note that the actual population growth rate for the fifteen SJRWMD public supply counties between 1995 and 2003 is 2.19% per year, which compares well with the predicted, 30-median growth rate of 1.91% per year.

Application of Lake and Wetlands Drawdown Constraints

If the average water levels of lakes and wetlands are reduced sufficiently, dominant vegetative patterns will change. This change is considered significant harm under current SJRWMD water use permitting criteria. The relationship between reduction in long-term average water levels and changes in vegetation type is fairly well known. However, water levels in lakes and wetlands respond to many variables and only one, surficial aquifer water level, is affected by groundwater pumping. Other important hydrologic variables include the lake or wetlands tributary area size, soils type, land use, and other characteristics that may influence the lake or wetland water budget. Therefore, a level of uncertainty exists related to the cause and effect relationship between reduction in surficial aquifer water levels and resulting reduction in water levels in nearby lakes and wetlands as previously discussed. This uncertainty is managed, in the planning process, by careful selection of the lakes and wetlands used as control points in the decision model.

The control points used in the decision model were chosen to geographically cover the entire planning area and to represent those lakes and wetlands most likely to be affected by reductions in surficial aquifer water levels. The selected control points are primarily isolated lakes and wetlands as illustrated on Figure 1. Lakes or wetlands that are directly connected to larger surface water hydrologic systems were not chosen as control points because reduction in surficial aquifer water levels near these flow-through systems is unlikely to result in reduction in the lake or wetland water levels. That is, only sensitive isolated lakes and wetlands were used as water supply withdrawal control points in the application of the decision model.

Because the response of individual lakes or wetlands cannot be accurately predicted at this regional planning scale, the results of the groundwater allocation and decision models are open to some interpretation. Specifically, an exceedance of the drawdown constraint at a given lake or wetland control point does not necessarily mean that the lake or wetland drawdown limit *will* be exceeded; it means that the limit *may* be exceeded, depending on effects of other hydrologic variables not directly included in the analysis. Without a doubt, a decrease in the surficial aquifer level beneath a lake or wetland will increase the potential for seepage (i.e. recharge) from the surface water body to the aquifer. However, the actual magnitude of the increased seepage will depend on the degree of hydraulic connection between the two hydrologic systems, and surface water inflow, as well as the magnitude of surficial aquifer drawdown.

Groundwater Flow Models

The most significant uncertainty associated with application of the groundwater flow models is the accuracy of predicted surficial aquifer water levels. Although many groundwater-modeling uncertainties exist, as previously discussed, this is the most important for two reasons. First, water supply deficits are controlled, for the most part, by the wetlands drawdown constraint. That is, wetland drawdown considerations control the total volume of water that can be withdrawn from the aquifer without causing unacceptable harm. This constraint is more important to limiting water supply withdrawal from the Floridan aquifer, than the MFLs constraints (including springflow concerns), and the Floridan aquifer water quality constraint. Second, prediction of surficial aquifer water levels is one of the least accurate of the parameters predicted by the groundwater flow models.

The uncertainty associated with the surficial aquifer water level projections is mitigated somewhat by the fact that the absolute accuracy of the projected surficial aquifer water levels is not as important as the predicted change in water levels due to an increase in water supply withdrawal. That is, the important variable, for water supply decision-making, is the change in predicted water levels, rather that the exact value of the predicted water level. It is generally believed that the range of uncertainty associated with prediction of surficial water level change is considerably less than the uncertainty associated with prediction of exact surficial water level elevations.

Although many factors influence surficial aquifer drawdown resulting from a given Floridan aquifer drawdown, the most important, currently included in the model, is likely the leakance value (L), which is an indicator of the degree of hydraulic connection between the surficial aquifer and the Floridan aquifer. Very high leakance indicates a well-connected system and a very low leakance indicates nearly independent hydrologic systems. Therefore, where leakance is high, the change in surficial aquifer levels, due to increased Floridan aquifer withdrawals, will be greater than where leakance is low, all else being equal.

As previously discussed, leakance is a calibration parameter. Reasonable leakance (L) and transmissivity (T) values are assumed and these values are adjusted until predicted potentiometric elevations match observed potentiometric elevations, within an allowable range. Under theses conditions, the model is considered *calibrated*. There is however, a range of leakance values that could be used in the model and still meet calibration criteria.

In an effort to quantify the degree of uncertainty associated with predicted change in surficial aquifer water levels, the leakance values were adjusted, within the range of model calibration, to determine the resulting change in predicted surficial aquifer water levels and in estimated water supply deficits. The adjustment was a one-way adjustment, assessing only the effects of decreasing the leakance. This leakance sensitivity analysis was performed as part of the original SJRWMD 2000 DWSP but was not repeated for the current 2005 DWSP.

It has also been noted that there is uncertainty related to the length of time between a water supply withdrawal and an observed response in the surficial aquifer and affected wetlands. This lag time, while important for interpreting monitoring results, has no bearing on water supply planning or decision-making. Because the surficial aquifer will eventually react to any lowering of the Floridan aquifer potentiometric pressure and thereby impact sensitive wetlands, the planning effort strives to prevent such events from ever occurring.

Planning Level Cost Estimates

All cost estimates developed in the water supply plan are conceptual, planning-level cost estimates. As such, any individual estimate for a given treatment plant or transport facility, for example, may be in error by as much as 50%. This is essentially true for all regional planning activities.

The accuracy of the individual cost estimates is, however, not as important to the planning process as the relative life-cycle costs of alternative water supply sources.It is important for the costs associated with various water supply sources such as fresh groundwater, brackish groundwater, and surface water from the St. Johns River, to be accurate relative to each other. That is, if all life-cycle cost estimates are either 25% high or 25% low, the cost estimates will still be relatively comparable and will well serve their primary purpose for comparison.

Steps were taken to ensure that all conceptual planning level life cycle cost estimates used in the water supply planning process were compatible and comparable. Early in the process, a consistent set of cost estimating and economic criteria was established so that all cost estimates were based on the same set of assumptions. In this manner, the uncertainty associated with conceptual planning level cost estimates was minimized.

DECISION MAKING IMPLICATIONS

It is acknowledged that there are considerable areas of uncertainty in the regional water supply planning process. Each source of uncertainty has relative degrees of importance and can often be minimized, or at least managed.

Planning uncertainty will never be fully eliminated. Therefore, waiting until all is known is not an option. The best decisions possible must be made based on our current understanding, recognizing that this understanding may change in the future.

Water supply planning and decision making must proceed on a regional scale. Individual (user-by-user) decision making is no longer a valid approach to long-term water supply decision-making and resource management, for large portions of SJRWMD. This is definitely true for east-central Florida where the Floridan aquifer currently provides a single-source water supply with approximately 1,000 public supply wells in operation. Regional interactions of the individual withdrawals must be considered in both planning and permitting. Individual wellfields cannot be examined in isolation if adverse impacts are to be avoided and if adequate affordable water supplies are to be developed.

Although not perfect, the water supply planning tools and procedures developed by SJRWMD are the best water supply planning tools currently available for the planning area. These tools and procedures provide the most comprehensive regional scale water supply planning approach currently available.

We must recognize and acknowledge the limits of the current analysis. An exact upper limit on Floridan aquifer withdrawal cannot be established at this time. However, water supply alternatives based on the lower end of the maximum withdrawal estimates will present less impact risk to resources than will water supply alternatives based on the higher end of the maximum withdrawal estimates. Cost follows an inverse relationship. The lower risk alternatives that involve development of alternative water supplies involve higher costs. Therefore, decision making will involve a risk versus cost assessment.

New institutional relationships may be needed to implement regional solutions. At the very least, a significant level of cooperation will be needed among the individual public supply utilities currently operating within the priority water resource caution areas.

The water supply plan will be updated at least every 5 years, possibly more often, and continuous upgrades and revisions to the planning tools will be necessary to improve the accuracy and reduce the uncertainty in future updates. Therefore, it is important to maintain flexibility in the process and, to the greatest extent possible, maximize choices available and characterize the choices in terms of relative cost and risk. The worst-case scenario of course is to construct high-risk water supply facilities that later have to be abandoned because of unacceptable environmental impacts.

It is clear that an adaptive approach will be needed both for long-term resource monitoring and management and to provide the new information necessary to improve future prediction and to decrease uncertainty.

REFERENCES

St. Johns River Water Management District and CH2M HILL. 2005. *Water 2020 Constraints Handbook.* Special Publication SJ2005–SP8. Palatka, Fla.: St. Johns River Water Management District.

APPENDIX E—DESCRIPTIONS AND CRITIQUES OF AVAILABLE CONSERVATION PRACTICES

EVALUATION AND SELECTION OF WATER CONSERVATION PRACTICES

SJRWMD has evaluated the potential water savings and costs related to water conservation practices for the purpose of selecting those for which there is a reasonable degree of confidence that money and effort spent to promote them will result in a worthwhile return in water savings. Some commonly accepted practices are not included among those selected as a result of this analysis. These generally are practices that were assumed in the past to be effective without data to demonstrate their actual effectiveness. Some of these practices have been shown by research to be ineffective, less effective than previously thought, or effective at saving water but not cost-effective. Insufficient data are available to dependably assess the effectiveness of some others, while still others may be effective when carefully managed, but are not dependable.

Cost-effective water conservation practices were selected for further analysis on the basis of an extensive nationwide literature review performed by HDR Engineering; further literature review and econometric modeling performed by Burton and Associates, and other available information. Selected practices are indicated by a check box (☑) at the end of their assessments and are identified in Table F-1.

Table F-1. Conservation practices selected for water savings and cost estimates

Conservation Practice	Selected Yes/No
Automatic irrigation shutoff retrofit incentives	No
Automatic shutoff outdoor devices	No
Clothes washer replacement incentives	No
Cooperative funding	Yes
Discontinue preferential irrigation meter rates	Yes
Education—Professional	Yes
Education—Public	Yes
Education—Youth	Yes
Efficient development incentives	Yes
Efficient dishwashers in new construction	No
Faucet aerator and showerhead retrofit incentives	Yes
Hot water on-demand in new construction	No
Individual meters in new construction	Yes
Indoor audits and leak detection	Yes
Informative billing	Yes
Investigations	Yes
Irrigation area restrictions in new construction	Yes
Irrigation day restrictions	Yes
Irrigation system audits	Yes
Irrigation system construction code	Yes
Irrigation system improvement incentives	Yes
Irrigation system inspection and repair at resale	Yes

Conservation Practice	Selected Yes/No
Landscape code	Yes
Landscape demonstration sites	No
Landscape incentives	No
Landscape professional licensing	Yes
Meter replacement	Yes
Metering of all water uses	Yes
Monthly customer billing	No
Outreach	Yes
Override of green lawn deed restrictions	Yes
Pipe insulation	No
Pressure balancing and reduction	No
Private utility regulation	No
Rate structure	Yes
Regulatory permit conditions	Yes
Retrofit at resale	Yes
Submetering retrofit incentives	Yes
Technical assistance	Yes
Toilet retrofit incentives	Yes
Utility system audits	Yes
Utility system leak detection and repair	Yes
Water budgeting	No
Waterless urinals	No
Weather sensing irrigation controllers	No

CONSERVATION PRACTICE ASSESSMENTS

AUTOMATIC IRRIGATION SHUTOFF RETROFIT INCENTIVES

PURPOSE: Turn off irrigation systems when naturally occurring rainfall provides adequate moisture for plants.

PRACTICE: Interconnect a rain sensor, soil moisture sensor, or other device with the irrigation system controller to override the automatic starting time.

IMPLEMENTATION RESPONSIBILITY: Water supply utilities, local governments

ASSESSMENT: This has been required by Florida law since 1992. SJRWMD CUPs also require this practice where appropriate. Therefore, effects of this practice should already be experienced, although the benefits are doubtful. SJRWMD sponsored a project to retrofit homes with rain sensor automatic shutoff devices and found that the project did not produce the expected water savings even though the devices were known to be installed correctly and still operating properly at the end of the study period. This practice is not selected for use in calculation of water savings at this time because of that project.

AUTOMATIC SHUTOFF DEVICES FOR NON-IRRIGATION OUTDOOR WATER USES

PURPOSE: Prevent unattended hoses or other devices from running unattended.

PRACTICE: Adopt or amend an ordinance to require automatic shutoff devices on hose and equipment for using water outdoors.

IMPLEMENTATION RESPONSIBILITY: Local governments

ASSESSMENT: Preparing and processing the ordinance is the only significant cost for local governments. The required automatic shutoff devices are inexpensive for users but there is no evidence that such a regulation would save significant amounts of water. Market penetration is likely to be low because of the difficulty of detecting non-compliant water users. Both immediate and long-term effectiveness are limited by enforcement difficulty.

CLOTHES WASHER REPLACEMENT INCENTIVES

PURPOSE: Reduce the amount of water needed for washing clothes.

PRACTICE: Promote washing machine replacement by offering rebates.

IMPLEMENTATION RESPONSIBILITY: Water supply utilities, local governments

ASSESSMENT: Low-water-use clothes washers cost three to five times the price of conventional washing machines. The amount of water to be saved is relatively low in relation to the cost of the replacement appliance. This is not a cost-effective alternative.

COOPERATIVE FUNDING

PURPOSE: Encourage water suppliers and major users to implement conservation practices and programs.

PRACTICE: Provide cost sharing to support cost effective projects that implement or promote efficient water use.

IMPLEMENTATION RESPONSIBILITY: SJRWMD

ASSESSMENT: Cooperative Funding is an approach for use by SJRWMD to influence implementation of local government and water supply utility conservation practices. The cost effectiveness of this practice depends on the effectiveness of the funded projects and the amount of financial leverage of the cost sharing. Based on past SJRWMD experience, cooperative funding creates positive relations between SJRWMD and participating local governments and utilities. ☑

DISCONTINUATION OF PREFERENTIAL RATES FOR IRRIGATION METERS

PURPOSE: Eliminate an incentive for excessive or wasteful water use by raising the cost of public supply irrigation water to that of water used indoors.

PRACTICE: Cease installing new irrigation meters and cease charging a lower rate for water that passes through existing irrigation meters. Alternatively, additional incentives to conserve can be provided by requiring irrigation meters on all properties where irrigation is practiced and charging a higher rate for any water, which passes through those meters than for water used indoors.

IMPLEMENTATION RESPONSIBILITY: Water supply utilities

ASSESSMENT: The utility can adopt this practice at a time when making general rate adjustments and may not incur a significant cost in making the change. Prices for water should rise for the high water use consumer because price elasticity is the mechanism by which water would be saved by this practice. One hundred percent market penetration is attainable. Increased rates and conservation rate structures have limited life spans as people become accustomed to paying the higher bills. Therefore, rates should be reviewed and adjusted periodically as necessary to maintain impact. ☑

EDUCATION, PROFESSIONAL

PURPOSE: Provide education on water conservation best management practices to builders, plumbers, landscapers, property managers, etc.

PRACTICE: Require professionals to take training as a condition of getting an occupational license.

IMPLEMENTATION RESPONSIBILITY: Water supply utilities, local governments

ASSESSMENT: It is not possible to calculate the cost-effectiveness of professional education because the amount of water to be saved is unknown. However, professional education contributes to the adoption of various practices that result in known water savings and which probably would not be adopted without outreach and education. Cost may be minimized by taking advantage of existing available training from the Florida Yards and Neighborhoods program, the Florida Irrigation Society, Florida Nurserymen, Grower and Landscape Association, or other organizations. ☑

EDUCATION, PUBLIC

PURPOSE: Facilitate and promote awareness, appreciation, knowledge and a willingness to change personal behaviors, or take responsible actions, to conserve and protect water resources.

PRACTICE: Develop a customer and / or public education program. A public information program may be developed in partnership with multiple utilities and SJRWMD. Such a program may include such things as public service announcements or paid media advertising; monthly bill stuffers with water conservation tips; water efficient landscape demonstration gardens; exhibits at trade shows, fairs, and malls; community organization lectures; media information program brochures, posters, and awards.

IMPLEMENTATION RESPONSIBILITY: Water supply utilities, local governments

ASSESSMENT: Calculating the cost-effectiveness of public education is very difficult because the amount of water saved is unknown, but public education contributes to the adoption of various practices that result in known water savings and which may not be adopted without it. Expenditures for public education also vary based on the technique employed, the message to be delivered, and the target audiences. ☑

EDUCATION, YOUTH

PURPOSE: Facilitate and promote awareness, appreciation, knowledge, and a willingness to change personal behaviors, or take responsible actions, to conserve and protect water resources.

PRACTICE: Develop a youth education program. A youth education program may be developed in partnership with multiple utilities and SJRWMD. The youth programs should focus on schools, teachers, youth organizations and family groups. Interactive educational activities could include classroom and school presentations, family science nights, and water festivals.

IMPLEMENTATION RESPONSIBILITY: Water supply utilities, local governments

ASSESSMENT: Calculating the cost-effectiveness of youth education is very difficult because the amount of water saved is unknown. However, education generally is regarded as an essential adjunct to make other specific practices more effective and there is a strong demand for SJRWMD's educational materials. ☑

EFFICIENT DEVELOPMENT INCENTIVES

PURPOSE: This practice focuses on allowing increased density when developers adopt new water conservation practices. The stated purpose is to encourage land developers to design water efficient projects.

PRACTICE: Provide incentives such as increased density or reduced fees to persuade developers to adopt new practices. Water saving devices and practices could be required or encouraged in the development review process as part of the approval criteria for developments to be awarded additional density, or for specific large-scale development approval such as developments of regional impact (DRI), or developments of a sub-DRI threshold determined appropriate by the local government.

IMPLEMENTATION RESPONSIBILITY: Local Governments

ASSESSMENT: This can be cost effective if managed well. It can be applied during existing development review and permitting processes with minimal additional cost. Some incentives, such as increased density, would not incur a direct cost on the local government or developer. The application of this approach may be limited by environmental regulations. ☑

EFFICIENT DISHWASHERS IN NEW CONSTRUCTION

PURPOSE: Require low-water-use dishwashers in new construction.

PRACTICE: Adopt or amend an ordinance to require low-water-use dishwashers in new construction.

IMPLEMENTATION RESPONSIBILITY: Local governments

ASSESSMENT: Preparing and processing the ordinance is the only significant cost for local governments. It can be implemented through existing plumbing inspections programs. This is cost-effective and should have 100% penetration of the intended new construction market. However, the amounts of water to be saved are relatively minor compared to many other practices and market forces are moving toward energy and water efficient dishwashers. A regulation to require them may have little effect.

FAUCET AERATOR AND SHOWERHEAD RETROFIT INCENTIVES

PURPOSE: Reduce unnecessary indoor water use by limiting flow rates.

PRACTICE: Implement a program to retrofit buildings constructed prior to 1994 with shower heads and sink faucets or aerators with maximum flows of 2.5 gallons per minute. Retrofit programs may be handled in a variety of ways involving varying degrees of direct participation and monetary contribution by the utility or local government and the water users.

IMPLEMENTATION RESPONSIBILITY: Water supply utilities, local governments

ASSESSMENT: A large number of units can be replaced at relatively low overall cost because of the low-unit cost. Measurable water savings are cumulative over years. ☑

HOT WATER ON DEMAND IN NEW CONSTRUCTION

PURPOSE: Reduce the amount of water run through faucets and showers while waiting for hot water.

PRACTICE: Adopt or amend an ordinance to require installation of hot water on demand hardware in new construction. Two types of hot water on demand hardware are available: (1) recirculating pipe systems that constantly run water back through the water heater (not energy efficient) and (2) individual heating units immediately adjacent to the faucet.

IMPLEMENTATION RESPONSIBILITY: Local governments

ASSESSMENT: Preparing and processing the ordinance is the only significant up front cost to the local government. This practice can be implemented through existing plumbing inspections programs. This practice is not selected to be promoted because the quantity of water saved by it is relatively small in relation to the cost.

INDIVIDUAL METERS IN NEW MULTIFAMILY CONSTRUCTION

PURPOSE: Make the customer aware of his water consumption habits and associate it with a direct monetary value, thus creating a motivation for the customer to conserve water.

PRACTICE: Adopt or amend an ordinance to prohibit the installation of new master water meters in existing multi-occupant buildings and to require all newly constructed individual units within multi-occupant buildings, complexes, or developments to be equipped with individual water meters.

IMPLEMENTATION RESPONSIBILITY: Local governments

ASSESSMENT: Preparing and processing the ordinance and the additional work involved in reading meters and processing data are the only significant costs to the local government. This approach has been observed to be effective in significantly reducing water use for individual dwelling units. It can be implemented through existing plumbing inspection programs. This is cost-effective and should have 100% penetration of the intended new construction market. The cost to the developer is relatively minor when seen as part of total construction costs. ☑

INDOOR AUDITS AND LEAK DETECTION

PURPOSE: Reduce loss of unused water resulting from leakage and efficient water use at end user sites.

PRACTICE: Implement a program to assist customers in identifying leakage and wasteful water use practices at their use sites, including indoor and outdoor uses for individual and multifamily dwellings, offices, and commercial properties.

IMPLEMENTATION RESPONSIBILITY: Water supply utilities, local governments

ASSESSMENT: It is not possible to calculate the cost-effectiveness of indoor audits and leak detection because the amount of water saved is unknown. These programs require the expense of ongoing dedicated staffing and can reach only a small number of people. Providing indoor audits and leak detection at public expense may be useful for small areas with severe water supply problems but generally is not cost-effective.

INFORMATIVE BILLING

PURPOSE: Provide information to consumers so they may better understand the financial benefits of conservation.

PRACTICE: Convert to an envelope style monthly billing system and individually bill all metered sites. Include the following types of information in each monthly bill.

- Water conservation tip or bill stuffers
- Water use for the current billing month
- Previous month's water use
- Corresponding month's water use for the previous year
- Rate per gallon / cubic foot

IMPLEMENTATION RESPONSIBILITY: Water supply utilities

ASSESSMENT: It is very difficult to calculate the cost-effectiveness of informative billing. Such a program must be ongoing to maintain effectiveness but the cost of this practice is low once initially implemented. Surveys indicate that this practice can be effective with well designed inserts. ☑

INVESTIGATIONS

PURPOSE: Identify new or better means for achieving water conservation.

PRACTICE: Perform studies to examine the effectiveness of new or alternative practices aimed at achieving more efficient water use.

IMPLEMENTATION RESPONSIBILITY: SJRWMD

ASSESSMENT: A large body of information already exists on the topic of how to apply water more efficiently. Additional studies on most types of indoor water use or of irrigation systems would be of marginal value. The primary topic, about which little is known, is the water needs of specific irrigated plants types. SJRWMD has completed studies of landscape and golf course water use and is participating in a study sponsored by the Florida Department of Agriculture and Consumer Services to determine water needs for plant establishment. The cost-effectiveness and market penetration of such work are difficult to quantify but the results could be very long lasting. ☑

IRRIGATION AREA RESTRICTIONS IN NEW CONSTRUCTION

PURPOSE: Reduce landscape irrigation water use.

PRACTICE: Amend local building site requirements to limit the amount or percentage of a land parcel in which an irrigation system may be installed.

IMPLEMENTATION RESPONSIBILITY: Local governments

ASSESSMENT: Preparing and processing the ordinance is the only significant upfront cost. This practice can be implemented through existing plumbing inspection programs. Property owners' costs for the irrigation systems would be reduced. Additional long-term savings are achieved for the property owner by reduced water use. Significant long-term water savings can be achieved at a very favorable cost ratio and with thorough market penetration. ☑

IRRIGATION DAYS AND/OR HOURS RESTRICTIONS

PURPOSE: Reduce excessive irrigation and loss of irrigation water through evaporation.

PRACTICE: SJRWMD has a rule limiting landscape irrigation to the hours between 4:00 p.m. and 10:00 a.m. Less water is needed when irrigating in the evening or early morning hours because of the reduction in evaporation. However, many people continue to apply the same amount of water to their lawns and landscapes regardless of what time they irrigate. Therefore, limiting the number of days on which landscape irrigation is allowed could help assure a reduction in use. Studies have shown that an irrigation frequency of two days per week is adequate for the requirements of most plants and can reduce consumption below that of unrestricted irrigation. A rule limiting landscape irrigation to two days per week is under consideration.

IMPLEMENTATION RESPONSIBILITY: SJRWMD, local governments

ASSESSMENT: The primary costs associated with rule implementation for SJRWMD relate to outreach and education. Costs associated with rule enforcement would be paid primarily by local governments. Local governments may adopt SJRWMD's rules by ordinance and use existing police or code enforcement staff to enforce the ordinance. Effectiveness of these restrictions would be dependent on the level of outreach / education and enforcement. ☑

IRRIGATION SYSTEM AUDITS (MOBILE IRRIGATION LABORATORY)

PURPOSE: Reduce unnecessary and wasteful use of water for landscape irrigation.

PRACTICE: Implement a program to have professional irrigation system auditors evaluate irrigation systems for efficiency and proper maintenance and management.

IMPLEMENTATION RESPONSIBILITY: Water supply utilities, local governments

ASSESSMENT: It is not possible to calculate the cost-effectiveness of irrigation system audits because the amount of water saved is unknown. Audits do not save water by themselves. They create an awareness of an opportunity to save water by taking additional action. These programs require the expense of ongoing dedicated staffing and can reach only a small number of people. Providing irrigation system audits of residential lawn and landscape irrigation systems at public expense may be useful for small areas with severe water supply problems but generally is not cost-effective elsewhere. This approach could result in significant water savings for agriculture. ☑

IRRIGATION SYSTEM CONSTRUCTION CODE

PURPOSE: Improve efficiency of landscape irrigation systems.

PRACTICE: Adopt or amend an ordinance or amend existing regulations to require that all new installations of landscape irrigation systems must comply with Appendix F of the Florida Building Code or Appendix F with modifications based on Florida Irrigation Society January 2002 standards.

IMPLEMENTATION RESPONSIBILITY: Local governments

ASSESSMENT: High, potential water savings exists for landscape irrigation. Preparing and processing the ordinance is the only significant upfront cost to the local government. This practice is known to be potentially effective in significantly reducing the quantity of water required for landscape irrigation. It can be implemented through existing plumbing inspections programs. This practice should have 100% penetration of the intended new construction market. ☑

IRRIGATION SYSTEM IMPROVEMENT INCENTIVES

PURPOSE: Reduce unnecessary and wasteful use of water for landscape irrigation.

PRACTICE: Implement a program to retrofit individual landscape irrigation systems with irrigation controllers that are capable of irrigating different areas at different frequencies or with low-volume and microirrigation (previously known as trickle irrigation) for shrubs and other non-turf areas. Retrofit programs may be handled in a variety of ways involving varying degrees of direct participation and monetary contribution by the utility or local government and the water users.

IMPLEMENTATION RESPONSIBILITY: Water supply utilities, local governments

ASSESSMENT: High, potential water savings exists for improving landscape irrigation system efficiency. Inefficient irrigation systems make it necessary to over irrigate some areas in order to get sufficient water onto other parts of the landscape. Substantial amounts of water potentially could be saved though system retrofits. Conversely, an effectively managed incentive program would require staff commitment to assure that retrofits were installed properly and the extent of retrofit required to make many residential irrigation systems efficient may be close to complete replacement, meaning a high per system cost for both the property owner and the entity sponsoring the program. ☑

IRRIGATION SYSTEM INSPECTION AND REPAIR AT RESALE

PURPOSE: Improve efficiency of landscape irrigation systems.

PRACTICE: Adopt or amend an ordinance or amend existing regulations to require permanent irrigation systems to be inspected and certified to be in good repair and proper operating condition at the time when a property is sold. This certification would be required before a deed could be registered to the new owner.

IMPLEMENTATION RESPONSIBILITY: Local governments

ASSESSMENT: Legal issues concerning the recording of deeds and impacts on local government staffing levels and office area would need to be addressed. However, this could be cost-effective and should have high penetration of the intended resale property population where reasonable to implement. ☑

LANDSCAPE CODE

PURPOSE: Reduce the amount of water needed for landscape irrigation.

PRACTICE: Adopt or amend an ordinance to require the use of waterwise landscaping principals, including limits on the use of landscaping that requires irrigation.

IMPLEMENTATION RESPONSIBILITY: Local governments

ASSESSMENT: Preparing and processing the ordinance is the only significant cost to the local government. This practice can be implemented through existing building inspection programs and should have 100% penetration of the intended new construction market. However, the initial cost of landscaping materials and the irrigation system to optimize water use with them will be higher for the consumer. This practice is selected because of the great quantity of water that is used for landscape irrigation even though having a landscape with low water needs does not assure that the homeowner will limit irrigation to match needs. ☑

LANDSCAPE DEMONSTRATION SITES

PURPOSE: Educating the public about how to make attractive landscapes with water efficient designs and plant selection.

PRACTICE: Construct a new garden or modify an existing garden according to waterwise landscaping principles. Gardens that are co-funded by SJRWMD have signage to acknowledge the water management District's contribution.

IMPLEMENTATION RESPONSIBILITY: Water supply utilities, local governments

ASSESSMENT: As with all educational practices, it is extremely difficult to calculate the cost-effectiveness of landscape demonstrations. Landscape demonstration sites require ongoing high-quality maintenance and can quickly take on an unkept appearance. SJRWMD's experience with cooperatively funded landscape demonstration gardens has been extremely mixed, from excellent to dismal.

LANDSCAPE INCENTIVES

PURPOSE: Reduce the amount of water needed for landscape irrigation.

PRACTICE: Implement a program to encourage the installation of low-water-use plants in new landscaping and the replacement of turf areas with low-water-use plants in existing landscaping. Such a program may include public education, monetary incentives (such as rebates for purchases of low water use plants), and technical assistance. .

IMPLEMENTATION RESPONSIBILITY: Water supply utilities, local governments

ASSESSMENT: It would be very difficult to calculate the cost-effectiveness of landscape incentives. Such a program must be accompanied by a change in irrigation practice or no water will be saved. Modification to irrigation systems may be needed to change the amount of water used. Therefore, it would be necessary to combine this practice with an irrigation system improvement program. Administration of the program may be complex and would require thorough planning and careful management. This practice should not be dismissed because of the high, potential water savings for landscape irrigation but it is not selected at this time.

LANDSCAPE PROFESSIONAL LICENSING

PURPOSE: Have greater assurance of competency and accountability of landscape professionals.

PRACTICE: Adopt or amend an ordinance to require licensing of persons providing landscape and irrigation system installation and maintenance services.

IMPLEMENTATION RESPONSIBILITY: Local governments

ASSESSMENT: It would be very difficult to calculate the cost-effectiveness of professional licensing. This practice could be an effective way to reduce landscape water needs but existence of a landscape with low water needs does not assure that the homeowner will limit irrigation to match needs. Market penetration depends on local enforcement and the program must be ongoing to maintain effectiveness. This practice should be applied in concert with professional education. ☑

METER REPLACEMENT

PURPOSE: Assure that water distributed through the utility system is accounted for by accurate customer meters and meter reading procedures. Accurate data utilized in synchrony with accurate billing methods should provide a methodology that will allow the utility to identify problems or losses throughout the distribution system and ultimately reduce unaccounted for water losses. It also assures that the water user is appropriately charged for the water.

PRACTICE: Implement a periodic meter replacement program. Replace or recondition all meters that have exceeded the manufacturer's recommended volume or age. Periodic meter replacement is recommended over testing and reconditioning or replacing identified faulty meters because it is less expensive.

IMPLEMENTATION RESPONSIBILITY: Water supply utilities

ASSESSMENT: Meter replacement provides for more accurate customer billing and may increase bills sharply for customers whose meters are replaced, thereby giving them an incentive to use water more efficiently, and it provides the utility with useful system management information. Meter replacement generally is cost-effective because it increases utility revenue. ☑

METERING OF ALL WATER USES

PURPOSE: Improve water use accountability records for currently unmetered uses and users to obtain a more accurate assessment of system efficiency and unaccounted water.

PRACTICE: Begin metering or implementing an alternative recording method to determine the quantity of water used by all known but currently unmetered users. Include such uses as water treatment plant processes; flushing water mains; firefighting; firefighter training; street cleaning; irrigation of schools, parks, and other public lands; decorative water features; swimming pools; construction sites; storm drain flushing; and sanitary sewer flushing. This may include first identifying unmetered uses.

IMPLEMENTATION RESPONSIBILITY: Water supply utilities, local governments

ASSESSMENT: Two valuable things are accomplished by this practice. It provides for previously unmetered customers to be billed at metered rates, thereby giving them an incentive to use water more efficiently, and it provides the utility with useful, system management information. The amount of water saved by metered billing will vary with local conditions but can be estimated with price elasticity models. ☑

MONTHLY CUSTOMER BILLING

PURPOSE: Allows customers the ability to associate monthly water use patterns with water use and the resulting water and sewer costs. Also, allows customer the ability to monitor the effectiveness of implemented water conservation or water use pattern changes by providing them with the tools to visualize water use reductions and reduced water charges.

PRACTICE: Convert from quarterly or bimonthly billing intervals, if currently in use, to monthly.

IMPLEMENTATION RESPONSIBILITY: Water supply utilities

ASSESSMENT: It would be difficult to calculate the cost-effectiveness of changing to a more frequent billing interval. Initial cost could be high for the utility to revamp its billing system. Ongoing costs for processing and mailing also increase. Monthly bills will be smaller than bimonthly bills which may cause them to have less impact. The value of this practice is uncertain ☒

OUTREACH

PURPOSE: Promote awareness, appreciation, knowledge, and a willingness to change personal behaviors, or take responsible actions, to conserve and protect water resources.

PRACTICE: Develop and distribute water conservation literature. Maintain and update water conservation information on SJRWMD Web sites. Conduct an annual paid advertising media campaign. Seek news articles, editorials, and TV and radio news coverage. Promote conservation through SJRWMD's StreamLines. Give presentations to appropriate groups and organizations. Provide youth, community and professional education programs. Coordinate with elected and appointed officials and their staffs to address water conservation on a local basis.

IMPLEMENTATION RESPONSIBILITY: SJRWMD

ASSESSMENT: It is not possible to calculate the cost-effectiveness of education and information because the amount of water saved is unknown. Expenditures on outreach also vary based on the technique employed, the message to be delivered, and the target audiences. However, outreach generally is regarded as an essential adjunct to make other specific practices more effective**.** ☑

OVERRIDE OF GREEN LAWN DEED RESTRICTIONS

PURPOSE: Reduce the amount of water needed for landscape irrigation.

PRACTICE: Adopt an ordinance or amend existing regulations to nullify deed restrictions requiring that specified minimum areas or percentages of a land parcel must be planted and/or maintained as turfgrass or lawn or which prohibit the use of water efficient landscapes. Green lawn deed restrictions are private contracts, which can be overridden by local, state, or federal laws.

IMPLEMENTATION RESPONSIBILITY: Local governments

ASSESSMENT: It would be very difficult to calculate the cost-effectiveness of eliminating green lawn deed restrictions. However, it is known that some people have attempted to implement Xeriscaping, but have been prevented from doing so by neighborhood organizations that enforced such covenants. Further, this ordinance would not require costly enforcement. Therefore, this practice is recommend on the basis of its minimal cost. ☑

PIPE INSULATION

PURPOSE: Reduce the amount of water run through faucets and showers while waiting for hot water.

PRACTICE: Amend the local building code to require installation of insulation on hot water pipes.

IMPLEMENTATION RESPONSIBILITY: Local governments

ASSESSMENT: Preparing and processing the ordinance is the only significant cost. This approach is known to be potentially effective in reducing water use. It can be implemented through existing plumbing inspection programs. This is inexpensive and should have 100% penetration of the intended new construction market. However, this practice is likely to less effective than the hot water on demand method, which research indicates does not save large quantities of water.

PRESSURE BALANCING AND REDUCTION

PURPOSE: Reduce water loss through leaks in water supply utility distribution system.

PRACTICE: Install valves and pumps as needed to make system pressure more uniform, thereby reducing zones where higher pressures must be maintained in order to maintain minimum acceptable pressure in other parts of the system.

IMPLEMENTATION RESPONSIBILITY: Water supply utilities

ASSESSMENT: Both the cost of this practice and the amount of water to be saved, if any, will vary locally depending on the system configuration and other factors. Effectiveness of this practice will vary with local conditions, particularly the age of the system, and decisions concerning the implementation of this practice should be made locally.

PRIVATE UTILITY REGULATION BY COUNTIES

PURPOSE: Provide a legal means for requiring privately owned water supply and wastewater treatment utilities to practice water conservation and reuse of reclaimed water.

PRACTICE: Florida counties have the option of directly regulating private utility operations, including rates, if the county desires to exercise that right. Counties frequently delegate the regulation of private utilities to the Florida Public Service Commission. However, a county can take that authority back if it desires. Local regulation of private utilities may facilitate implementation of water conservation and reuse by allowing greater flexibility.

IMPLEMENTATION RESPONSIBILITY: County governments

ASSESSMENT: The amount of water, if any, that this practice may save is uncertain. Water use could go up if managed poorly. This practice could be an effective way to reduce water use but is not selected at this time because of uncertainly concerning the its effectiveness.

RATE STRUCTURE

PURPOSE: Provide water customers with an economic incentive for avoiding excessive or wasteful water use while also providing an adequate quantity of water for essential needs at a reasonable price.

PRACTICE: Adopt a variable water rate schedule that provides adequate water for essential needs at a moderate price but increases the price significantly for additional increments of water to discourage excessive or wasteful use. Such rates may vary seasonally.

IMPLEMENTATION RESPONSIBILITY: Water supply utilities, local governments

ASSESSMENT: The utility can adopt this practice at a time when making general rate adjustments and may not incur a significant cost in making the change. Prices for water should rise for the high-water-use consumer because price elasticity is the mechanism by which water is saved by this practice. One hundred percent market penetration is attainable. Increased rates and conservation rates structures have limited life spans as people become accustomed to paying higher bills. Therefore, rates should be reviewed periodically and adjusted as necessary to maintain impact. ☑

REGULATORY PERMIT CONDITIONS

PURPOSE: Require consumptive use permittees to implement selected conservation practices and encourage them to implement others.

PRACTICE: Consumptive use permits include specific best management and public education requirements. Permittees also may negotiate for such incentives as longer permits and a shortened or eased permit application processing exchange for additional voluntary extra water conservation efforts.

IMPLEMENTATION RESPONSIBILITY: SJRWMD

ASSESSMENT: Consumptive use permit conditions are the primary means by which SJRWMD implements water conservation. Cost-effectiveness and market penetration are all high. Development of permit conditions is a routine part of the permitting process. Conditions apply to all permittees for the duration of the permit. ☑

RETROFIT AT RESALE

PURPOSE: Facilitate installation of ultra low-flow plumbing devices to reduce indoor water use in older structures.

PRACTICE: Adopt an ordinance to require the retrofit of ultra low-flow plumbing devices in all buildings built prior to 1994 at such times as they are resold and make registration of the deed contingent on proof that the retrofit has been performed. Include, at a minimum, toilets requiring no more than 1.6 gallons per flush and shower heads, kitchen sink faucets, and bathroom basin faucets with flows no greater than 2.5 gallons per minute.

IMPLEMENTATION RESPONSIBILITY: Local governments

ASSESSMENT: Legal issues concerning the recording of deeds and impacts on local government costs would need to be addressed. However, this could be cost-effective and should have high penetration of the intended resale property population where reasonable to implement. Millions of toilets, sinks, and showers were installed prior to the current code and thousands of structures built to the older standards are resold each year. This practice could greatly accelerate retrofit of older structures with a very minor additional cost to property transactions. ☑

SUBMETERING RETROFIT INCENTIVES

PURPOSE: Make the individual user aware of his water consumption habits and associate it with a direct monetary value, thus creating a motivation for the customer to conserve water.

IMPLEMENTATION RESPONSIBILITY: Water supply utilities, local governments

PRACTICE: Implement an incentive program to retrofit individual water metering devices into existing multifamily dwellings and multi-occupant business or commercial structures.

ASSESSMENT: Submeter retrofit has been shown to be a consistently successful means of reducing water use. Measurable water savings are cumulative over years. Costs to utilities are quickly recovered through increased revenues. ☑

TECHNICAL ASSISTANCE

PURPOSE: Enhance the ability of local governments, utilities, and other major water users to assess conservation needs and opportunities and develop conservation programs.

PRACTICE: Provide information about water conservation practices and planning, developing, and implementing local water conservation programs.

IMPLEMENTATION RESPONSIBILITY: SJRWMD

It would be very difficult to calculate the cost-effectiveness of technical assistance. However, the cost to SJRWMD of providing such assistance is low, the practice creates good will among local governments and utilities, and it is required by Florida Statutes in some instances. Market penetration is indeterminate as the party needing assistance generally initiates a request rather than SJRWMD targeting all or a particular group of local governments or utilities. ☑

TOILET RETROFIT INCENTIVES

PURPOSE: Reduce unnecessary indoor water use by limiting flow rates.

PRACTICE: Implement a program to retrofit buildings constructed prior to 1994 with ultra low-flow toilets requiring a maximum of 1.6 gallons per flush. Retrofit programs may be handled in a variety of ways involving varying degrees of direct participation and monetary contribution by the utility or local government and the water users.

IMPLEMENTATION RESPONSIBILITY: Water supply utilities, local governments

ASSESSMENT: Toilet replacement has been shown to be a successful means of reducing water use. Measurable water savings are cumulative over years. ☑

UTILITY SYSTEM AUDITS

PURPOSE: Provide baseline information to identify opportunities to improve water use efficiency and reduce system losses and unnecessary or wasteful uses, and to assess progress toward improving efficiency and reducing waste. Having good data regarding water use and system conditions is essential to the success of may parts of a water conservation program, even though having the data does not directly save water by itself.

PRACTICE: Perform annual audits of production, treatment, and distribution systems and develop measurements of end-user water use for indoor and outdoor uses. Utility system audits should include known unmetered water uses and users as well as unaccounted for water. System audits are now required as part of the SJRWMD consumptive use permitting process and SJRWMD provides a form and certain minimum audit requirements. However, more frequent and thorough audits are recommended.

IMPLEMENTATION RESPONSIBILITY: Water supply utilities

ASSESSMENT: It is difficult to calculate the cost-effectiveness of utility system audits. However, the information gained from the system audit is essential for efficient system management and selection of cost effective water conservation practices. Utilities should audit their systems regularly to maintain operating efficiency. Such programs should be ongoing to maintain effectiveness. ☑

UTILITY SYSTEM LEAK DETECTION AND REPAIR

PURPOSE: Reduce loss of unused water resulting from leakage in the transmission and distribution system.

PRACTICE: Implement a leak detection and repair program for older parts of the utility’s transmission and distribution system.

IMPLEMENTATION RESPONSIBILITY: Water supply utilities

ASSESSMENT: Cost-effectiveness of this practice depends on the age and condition of the system. The cost could be greater than the value of the water saved. A utility system audit can be used to determine the need for a leak detection and repair program. SJRWMD currently requires any utility exceeding 10% unaccounted for water to implement leak detection and repair. ☑

WATER BUDGETING

PURPOSE: Increase efficiency of landscape irrigation water use.

PRACTICE: Allow specified quantities of water for landscape irrigation and cease supplying water to customers who reach their limits for specified time periods.

IMPLEMENTATION RESPONSIBILITY: Water supply utilities, local governments

ASSESSMENT: Neither local governments nor utilities have the legal authority in Florida to directly regulate water use. That authority resides solely with the water management districts. This practice by local governments or utilities would encroach on the exclusive statutory authority of water management districts to regulate water use. SJRWMD will continue to regulate water use exclusively through its consumptive use permitting program.

WATERLESS URINALS

PURPOSE: Reduce water use for flushing urinals.

IMPLEMENTATION RESPONSIBILITY: Local governments

PRACTICE: Amend the local building code to require installation of waterless urinals when new urinals are installed in public buildings.

ASSESSMENT: Preparing and processing the ordinance is the only significant cost. This practice is known to be effective in reducing water use. It can be implemented through existing plumbing inspections programs. This is cost-effective and should have 100% penetration of the intended new construction market. ☑

WEATHER SENSITIVE IRRIGATION CONTROLLERS

PURPOSE: Reduce the amount of water used for landscape irrigation.

PRACTICE: Amend the local building code to require installation of weather sensitive controllers on in-ground irrigation system controllers. This practice should not be confused with the use of automatic shutoff devices already required by Florida law. Weather sensitive irrigation controllers are more complex and expensive devices that include a microprocessor to determine the landscape's need for irrigation on the basis of such factors as temperature, humidity, evapotranspiration, etc.

IMPLEMENTATION RESPONSIBILITY: Local governments

ASSESSMENT: Preparing and processing the ordinance is the only significant cost to the local governments. Controllers may cost consumers several hundred dollars and some types require ongoing professional maintenance. This is not an established technology and debate continues regarding its effectiveness. It may not save any more water than can be saved with a good manual controller.

APPENDIX F—METHODOLOGIES USED TO DERIVE ESTIMATED WATER SAVINGS AND COSTS FOR INDIVIDUAL CONSERVATION PRACTICES

METHODOLOGY FOR CALCULATING WATER SAVINGS AND COSTS FOR WATER CONSERVATION PRACTICES

Potential new savings and costs for local governments, water supply utilities, and end users were calculated for each selected conservation practice by county and then combined into groups for summary purposes. Savings and costs for SJRWMD conservation regulatory practices are not included in this analysis because the savings already are being realized and any new costs to continue these practices beyond those already being incurred are considered to be negligible.

Costs and water savings of water conservation practices were determined on the basis of a literature review performed by HDR Engineering, further literature review and econometric modeling performed by Burton and Associates, as reported in Cost Effectiveness of Residential Water Conservation Practices (2004), and other available information.

Data from the 2000 U.S. census were used to determine the numbers of dwelling units, households, person per household, bathrooms per household, and year of dwelling unit construction. Household and dwelling data, as well as water use data, were projected to 2005 from 2000 data to separate the effects of conservation practices applied to existing structures and irrigation systems from those applicable to new construction and installations. Residential retrofit costs are calculated using the number of dwelling units but residential water savings are calculated using the number of households (occupied units) to avoid overestimating savings.

Only initial capital costs are calculated for all practices except outreach and education because these practices must incur high ongoing expenses to achieve their intended results. The 20-year (2006 through 2025) total cost of outreach and education types of practices are used as surrogates of capital costs for those practices.

The conservation practices were grouped for the purpose of calculating water savings and cost according to whether they apply to indoor or outdoor water use and to new construction or older structures, as listed below. Many of the calculations for conservation practices pertaining to existing construction, both indoor and outdoor, include a multiplier of 0.5 to account for the assumed 50% target population penetration. The costs for outreach and education are divided between all of the selected direct water savings practices in proportion to the total costs of the practices after all other costs have been calculated.

Indoor Water Conservation Practice Group for Existing Structures

<u>Local Government Ordinances</u>

Retrofit at resale

<u>Consumer Assistance and Incentives</u>

Faucet aerator and showerhead retrofit incentives

Toilet retrofit incentives

Submetering retrofit incentives

Outdoor Water Conservation Practice Group for Existing Structures

Local Government Ordinances

- Irrigation system inspection and repair at resale
- Override of green lawn deed restrictions
- Two-day per week irrigation restrictions

Utility Operational Practices

- Discontinue preferential irrigation meter rates

Consumer Assistance and Incentives

- Irrigation system improvement incentives

Indoor Water Conservation Practice Group for New Construction

Local Government Ordinances

- Efficient development incentives
- Individual meters in new multifamily construction

Outdoor Water Conservation Practice Group for New Construction.

Local Government Ordinances

- Efficient development incentives
- Individual meters in new construction
- Irrigation area restrictions
- Irrigation system construction code
- Landscape code
- Two-day per week irrigation restrictions

Utility Operational Practices

- Discontinue preferential irrigation meter rates

Consumer Assistance and Incentives

- Landscape demonstration sites

Generally Applicable to Both Indoor and Outdoor Water Use in New or Existing Structures

Utility Operational Practices

- Informative billing
- Metering all water uses
- Meter replacement
- Rate structure
- Utility system audits
- Utility system leak detection and repair

Consumer Assistance and Incentives

- Education–Professional
- Education–Public
- Education–Youth

INDOOR WATER CONSERVATION PRACTICES FOR EXISTING STRUCTURES

Low Flow Plumbing. Three of the four practices under this heading, faucet aerator and showerhead retrofit incentives, toilet retrofit incentives, and retrofit at resale, relate to retrofitting predominantly residential indoor plumbing. Therefore, they are considered together in order to avoid double-counting of water savings.

Estimates were made of the equivalent numbers of completely retrofitted dwellings, including kitchen sink faucets, bathroom faucets, shower heads, and toilets, for the two periods: 1983 and earlier; and 1984 through 1993; for each county. These time periods are based on laws concerning the allowable rate of water flow through indoor plumbing fixtures that were in effect during those intervals. No restrictions to plumbing flow capacity existed in Florida prior to 1984. Toilets installed prior to that time used five gallons or more per flush. The Florida Building Code began limiting toilet flows to 3.5 gallons per flush in 1984. This limit was in effect through 1993. Toilet flow was further limited to 1.6 gallons per flush and sink faucet and shower flows were limited to 2.5 gallons per minute by federal law beginning on January 1, 1994 (Title 42 - The Public Health and Welfare, Chapter 77 - Energy Conservation).

The quantity of estimated water savings for indoor residential retrofits was estimated by multiplying one-half of the number of occupants by the water savings per occupant.

$$\text{water saved} = \text{number of occupants} \times 0.5 \times \text{water saved per occupant}$$

The cost of implementing indoor retrofits was estimated by multiplying the number of bathrooms by the cost per bathroom ($325). This cost includes professional toilet installation and homeowner installation of sink aerators and showerheads. Showerheads and sink aerators were assumed to be absorbed in the bathroom retrofitting cost as the cost of these items is considerably less than the variability in bathroom retrofit cost.

$$\text{cost of practice} = \text{number of bathrooms} \times \text{cost of retrofit}$$

Submetering Retrofits. According to EPA, only 4% of existing multifamily dwellings have individual water meters. That leaves a potential retrofit target population of 96% of multifamily units. Literature sources indicate an average water use reduction of 28% in multifamily unit water use when metered compared to premetered use for the same units. Indoor water use of 75 gallons per capita per day (gpcpd) was assumed.

$$\text{water saved} = 0.28 \times 75 \text{ X number of household} \times \text{people per household} \times 0.96 \times 0.5$$
$$\text{cost of practice} = \text{number of multifamily units} \times 0.96 \times 0.5 \times \text{cost of retrofit}$$

OUTDOOR WATER CONSERVATION PRACTICES FOR EXISTING STRUCTURES

Improved Landscape Irrigation System Efficiency. Four of the selected outdoor water conservation practices for existing construction (irrigation system inspection and repair at resale, override of green lawn deed restrictions, discontinue preferential irrigation meter rates, and irrigation system improvement incentives) relate to reducing excess landscape irrigation water use, focusing particularly on turfgrass. Therefore, they are considered together in order to avoid double counting of water savings.

This procedure grouped multifamily with single-family residences because they, and other water uses, are grouped together when countywide public water supply utility and domestic self-supply water use are calculated by SJRWMD. Studies indicate that 40% to 60% of public supply water use in the Florida peninsula goes to landscape irrigation.

Mobile irrigation laboratories, which have performed numerous residential irrigation system audits have determined that residential landscape irrigation systems typically operate at efficiencies between 25% and 50% with a mean of approximately 40%. This level of efficiency leaves substantial margin for improvement to be achieved by system modifications but it is unlikely that tens of thousands of people can be persuaded to spend $2,000 or more to rebuild their irrigation systems to achieve greater efficiency. Therefore, decreased water use for existing irrigation systems is projected to come from improved maintenance and management resulting from consumer education. Mobile irrigation laboratory findings indicate that water use can be reduced by approximately 15% for the average residential irrigation system through better management and proper maintenance without modifications to the system. Commercial and institutional landscape irrigation systems on public water supplies are treated as residential systems because it generally is not possible to segregate these uses from public supply water use totals. Golf course irrigation water use is not considered because these systems generally are better managed and maintained than residential systems and are likely to already operate at a higher efficiency level. Outdoor water use is assumed to be 50% of total public supply and domestic self-supply water use. The calculation of water savings for this practice is as follows:

$$\text{water saved} = \text{gallons per day (gpd) of water use} \times 0.5 \times 0.15 \times 0.5)$$

Two hundred dollars per system is allotted for do-it-yourself homeowners to replace sprinkler heads and make minor repairs for capital costs. Further replacements at later dates is considered to be maintenance and is not included here. Other water use reduction results for improved system management. The necessary changes in behavior are to be motivated through public education and increased water cost.

$$\text{cost of practice} = \text{dwelling units} \times 0.5 \times \$200$$

Two Days per Week Irrigation Restrictions. An addition 15% was deducted from the total water savings resulting from improved irrigation system efficiency to account for the effect of limiting landscape irrigation to two days per week, based on data from the HDR literature search.

INDOOR WATER CONSERVATION PRACTICES FOR NEW CONSTRUCTION

Low Flow Plumbing. Ultra low-flow toilets, sink faucets, and showerheads have been required by federal law since 1994. Therefore, no further decrease in water use is attributed to these features for future construction. The only practice considered in this category is mandatory installation of individual meters in new multifamily construction. It is assumed that the current proportion of multifamily buildings equipped with submeters would remain constant at 4% for newly constructed multifamily dwellings through 2025 if submetering is not required by law. Therefore, water savings were calculated on the basis of the remaining 96% of newly constructed units times the previously identified 28% reduction for metered multifamily households.

water saved = number of new multifamily households × 0.96 × 0.28
cost of practice = number of new multifamily units × 0.96 × cost of submeters

OUTDOOR WATER CONSERVATION PRACTICES FOR NEW CONSTRUCTION

Efficient Landscape Irrigation Systems. All selected outdoor water conservation practices for new construction relate directly or indirectly to reducing excess landscape irrigation through improved efficiencies, except irrigated area restrictions and two-day-per-week irrigation restrictions. Therefore, these practices are considered together in order to avoid double-counting of water savings. Efficiency improvements come from improved irrigation system quality and management. Motivation to improve efficiency is intended to come from a combination of public information and increased water cost.

As previously mentioned, existing residential irrigation systems operate at an approximate average efficiency of 40%. Better designed residential landscape irrigation systems can reasonably attain operating efficiencies of 60% to 75%. Therefore, 60% is set as a minimum goal for this analysis. The difference in water use between 40% and 60% efficiency is assumed to be the amount of increased future water use that can be saved by irrigation system design improvements and better management in new construction. This is an increase in efficiency of 50% [(0.6–0.4) / 0.4] which results in a 33% decrease in water required to pass through the irrigation system to meet actual plant needs. Outdoor water use applicable to this practice is assumed to be 50% of the 2025 projected increase in total public supply and domestic self-supply water use. Golf course water use again is not included. The calculation of water savings from irrigation system design improvements and better management is as follows:

water saved = gpd of increased 2025 water use × 0.5 × 0.33
cost of practice = number of new irrigation systems × cost of system upgrades

Irrigation Area Restrictions. Irrigation area restrictions in new construction can reduce water use simply by reducing system capacity. The calculation of water savings from irrigation area limitations is based on limiting irrigation to 70% of landscapable area of a parcel, as suggested in the SJRWMD model landscape water conservation ordinance. This is a reduction from the current average of 85% of the landscapable area of a parcel being equipped with spray or overhead irrigation. The proportional decrease in irrigation area is 19% [=(86–70) / 85]. This calculation is based on the amount of remaining outdoor water use after efficiency improvements have been realized in order to avoid double counting. The number of irrigation systems was estimated by projecting the annual rate of new single family dwelling construction, derived from census data, through to 2025.

$$\text{water saved} = \text{gpd of remaining outdoor water use after efficiency improvements} \times 0.19$$

No capital cost was attributed to irrigation area restrictions in new construction, irrigation system construction code, landscape code, or discontinuation of preferential irrigation meter rates. Administering these ordinances or policies would cost no more than administering previously existing ordinances or policies concerning the same topics. No unit costs were attributed to efficient development incentives because such incentives typically are tradeoffs in density of land use that are made during site plan review. Only the cost of installing better designed irrigation systems is considered.

Two Days per Week Irrigation Restrictions. An additional 15% was deducted from the total water savings resulting from improved efficiency and area restrictions to account for the effect of limiting landscape irrigation to two days per week, based on data from the HDR literature search.

GENERALLY APPLICABLE PRACTICES FOR INDOOR AND OUTDOOR WATER USE IN NEW OR EXISTING STRUCTURES

These practices fall into two groups: (1) practices that affect customer water bills. Such as metering of all water uses, meter replacement, and rate structure, which focuses on raising the cost to the excessive consumer, and (2) outreach and education to heighten awareness and knowledge of the value of conservation and how to achieve it.

Practices That Affect Customer Water Bills. A study performed for SJRWMD showed that public supply water use could be reduced an average of 5% for the eight studied utilities with only moderately stepped increasing block rates (PBS&J 1998) . More extreme increases in rates probably would effect greater decreases in water use. Many utilities within SJRWMD have increasing block rate structures but have prices per thousand gallons below the national average even in their highest tiers. Therefore, it is assumed that a 5% overall reduction from present levels of water supply utility pumpage can be achieved through rate adjustments and other practices that affect the amount of billing. Any savings that may be achieved through increased metering and meter replacement are also the result of increasing cost to the consumer and, therefore, are assumed to be accounted for in altered rate structures to avoid double-counting. No cost is attributed to the practice because periodic rate adjustments and other specified practices are a routine part of the utility business.

$$\text{water saved} = \text{public supply pumpage} \times 0.05$$

No water savings or costs have been calculated for water supply utility audits or leak detection because these already are required by SJRWMD consumptive use permitting regulations and are being practiced by well-managed utilities, where needed, without legal impetus. Therefore, both the water savings and costs should already be realized. Improvement in these areas probably is possible, but lack of data prevents dependable estimates of potential water savings and costs from being calculated at this time.

Outreach and Education. No water savings is attributed directly to outreach and education, to avoid double-counting with the direct savings of other practices that are promoted by education. However, outreach and education contribute to the adoption of various water-saving practices that probably would not be adopted without outreach and education. Also, expenditures on outreach and education vary based on the technique employed, the message to be delivered, and the target audiences.

The cost of education / public information is based on recent SJRWMD budgets for these purposes and assumes some amount of matching funds from local sources annually for 20 years. Follow-up surveys after recent annual media campaigns indicate a rate of success that likely could lead to a 50% adoption rate for the conservation practices discussed above by 2025. These costs are divided between all of the selected direct water savings practices in proportion to the total costs of the practices after all other costs have been calculated.

$$\text{cost of practice} = \$2{,}000{,}000 \text{ per year} \times 20$$

APPENDIX G—RESULTS OF CALCULATIONS OF WATER SAVINGS AND COSTS FOR INDIVIDUAL CONSERVATION PRACTICES

Table G-1. Existing indoor and outdoor water use

CONSERVATION PRACTICE	Indoor Existing								Outdoor Existing	
	Faucet aerator, showerhead, toilet retrofits, 1984 and older		Faucet aerator, showerhead, toilet retrofits, 1985 - 1994		Submetering retrofits		Indoor Existing Total		Outdoor Existing Total (improved irrigation efficiency)	
COUNTY	gpd saved	cost ($)	gpd saved	cost ($)	gpd saved	cost ($)	gpd saved	cost ($)	gpd saved	cost ($)
Alachua	4,179,594	10,920,817	912,717	3,588,460	690,379	9,943,493	5,782,690	24,452,771	1,222,906	9,391,630
Baker	375,797	841,060	94,323	319,906	5,558	67,781	475,678	1,228,747	163,029	887,854
Bradford	471,027	1,190,448	87,436	321,955	10,877	141,078	569,340	1,653,481	7,505	856,762
Brevard	9,378,506	26,247,686	2,576,329	10,579,392	1,041,459	14,390,266	12,996,294	51,217,343	2,627,765	20,426,002
Clay	2,390,389	9,651,927	807,926	4,976,619	147,577	1,842,051	3,345,892	16,470,598	885,479	6,695,013
Duval	16,977,715	68,600,713	3,167,871	19,278,578	2,029,038	26,308,370	22,174,624	114,187,660	5,355,348	26,518,408
Flagler	589,213	2,810,365	381,246	2,616,955	43,382	683,091	1,013,841	6,110,411	406,565	3,996,431
Indian River	2,075,617	9,453,050	654,188	4,204,972	288,833	4,252,323	3,018,637	17,910,345	756,440	5,903,407
Lake	3,502,749	15,360,932	1,190,194	7,438,714	194,301	2,902,274	4,887,244	25,701,920	3,316,925	12,720,797
Marion	4,287,185	18,674,990	1,547,145	9,694,241	228,375	3,320,733	6,062,705	31,689,964	1,293,986	14,762,880
Nassau	961,910	4,235,333	319,684	1,985,680	90,087	1,224,112	1,371,680	7,445,125	1,036,217	3,223,854
Okeechobee	671,118	2,607,698	199,248	1,059,201	20,084	241,118	890,450	3,908,017	3,073	1,387,418
Orange	16,382,422	63,429,773	4,712,773	27,728,166	2,522,638	32,781,581	23,617,832	123,939,520	6,516,470	40,183,752
Osceola	2,447,001	9,534,865	1,190,577	6,518,301	327,861	4,164,077	3,965,438	20,217,243	5,894	10,151,976
Putnam	1,486,063	6,388,554	313,050	1,856,370	44,382	585,274	1,843,495	8,830,197	474,518	2,774,255
St. Johns	1,890,671	8,914,262	702,622	4,702,747	235,241	3,474,911	2,828,534	17,091,920	931,622	7,958,416
Seminole	6,797,384	28,411,800	2,165,188	13,992,215	849,427	10,801,482	9,811,999	53,205,497	3,097,824	15,444,041
Volusia	9,126,718	39,951,780	2,190,915	13,811,265	958,130	13,245,277	12,275,763	67,008,323	2,885,587	17,349,864
Education		10,501,131		2,902,300		1,216,214		**14,619,644**		**3,874,222**
SJRWMD TOTAL	**83,991,077**	**337,727,182**	**23,213,431**	**137,576,036**	**9,727,629**	**131,585,506**	**116,932,137**	**606,888,724**	**30,987,151**	**204,506,982**
SJR Total mgd	**84**		**23**		**10**		**117**		**31**	
Capital cost per gallon per day		**4.02**		**5.93**		**13.53**		**5.19**		**6.60**
Formulae	water saved = number of occupants X water saved per occupant X 0.5	cost of practice = number of bathrooms X cost of professional toilet installation and homeowner installation of sink aerators and showerheads [$325] X 0.5	water saved = number of occupants X water saved per occupant X 0.5	cost of practice = number of bathrooms X cost of professional toilet installation and homeowner installation of sink aerators and showerheads [$325] X 0.5	water saving = water saving per unit (27%) X 75 average gpcpd X 80% of multifamily units X 0.5 X people per unit	cost of practice = number of unmetered multifamily units X 0.9 X 0.5 X cost of retrofit ($600)	**Subtotal** It was assumed that a 50% target population penetration rate is reasonable to achieve from the present through 2025 for all retrofit practices.		**Subtotal** water saved = (public % domestic self-supply X 0.5) X 0.15 X 0.5	Cost of this practice is $200 for handyman homeowners to replace sprinkler heads and make minor repairs.

Note: (m)gpd = (million) gallons per day

Table G-2. New indoor and outdoor water use

	Indoor New		Outdoor New					
CONSERVATION PRACTICE	**Indoor New TOTAL (Individual meters in new multifamily)**		**Improved Irrigation Efficiency**		**Limit Irrigation to 70% of Landscapable Area (down from 85% current ave.)**		**Outdoor New TOTAL**	
COUNTY	**gpd saved**	**cost ($)**	**gpd saved**	**cost ($)**	**gpd saved**	**cost ($)**	**gpd saved**	**cost ($)**
Alachua	564,597	5,957,551	1,957,427	49,235,955	1,787,209	0	4,306,332	49,235,955
Baker	3,120	26,936	439,539	2,525,933	113,194	0	635,644	2,525,933
Bradford	2,435	23,303	1,868	1,300,876	14,027	0	18,279	1,300,876
Brevard	767,709	8,066,292	3,890,016	83,351,685	4,360,690	0	9,488,313	83,351,685
Clay	214,850	1,915,142	2,321,360	42,535,472	901,556	0	3,706,353	42,535,472
Duval	1,313,322	12,919,404	8,275,653	101,163,135	7,920,488	0	18,625,562	101,163,135
Flagler	111,622	1,187,978	2,731,032	33,177,640	17,716	0	3,161,061	33,177,640
Indian River	348,901	3,828,820	1,571,589	33,558,483	1,018,443	0	2,978,537	33,558,483
Lake	327,148	3,452,022	7,690,164	95,318,090	1,317,073	0	10,358,323	95,318,090
Marion	182,921	1,913,798	3,028,623	55,337,258	1,485,939	0	5,191,746	55,337,258
Nassau	99,415	947,760	2,799,339	14,493,798	129,163	0	3,367,777	14,493,798
Okeechobee	5,090	46,719	5,577	2,455,348	4,310	0	11,370	2,455,348
Orange	2,741,334	25,933,820	15,905,178	169,187,303	5,056,948	0	24,106,445	169,187,303
Osceola	877,975	7,770,037	47,854	93,240,449	-4,915	0	49,380	93,240,449
Putnam	8,419	83,820	654,120	3,939,551	630,854	0	1,477,720	3,939,551
St. Johns	390,229	3,948,884	4,828,473	45,108,404	293,883	0	5,890,709	45,108,404
Seminole	915,851	8,731,124	6,715,362	76,525,730	3,455,586	0	11,696,589	76,525,730
Volusia	603,814	6,426,288	5,751,877	69,563,831	4,103,039	0	11,333,154	69,563,831
Education		**1,185,098**		8,578,716		4,076,522		**12,655,238**
SJRWMD TOTAL	**9,478,754**	**94,364,798**	**68,615,051**	**980,597,660**	**32,605,203**	**4,076,522**	**116,403,292**	**984,674,182**
SJR Total mgd	**9**		**69**		**33**		**116**	
Capital cost per gal		**9.96**		**14.29**		**0.13**		**8.46**
	Subtotal						**Subtotal**	
Formluae	water saved = average % savings per househould X household water use (ave. occupants X 75 gpd) X number of households	cost of practice = new units X unit cost	water saved = (projected increase in public supply and domestic self-supply gpd X 0.5 X 0.33 water use reduction	cost of practice = number of new systems X increased cost of optimized system ($1,500)	water saved = ((85-70)/85) X projected water use at improved efficiency level	No cost is directly ascribed to this practice because it would be implemented as a part of the development review and building inspection processes.		

Table G-3. Generally applicable practices and grand totals

	Generally Applicable							
CONSERVATION PRACTICE	**Education**		**Rate Structure and Other Cost Factors**		**Generally Applicable TOTAL**		**GRAND TOTAL**	
COUNTY	**gpd saved**	**cost ($)**	**gpd saved**	**cost ($)**	**gpd saved**	**cost ($)**	**gpd saved**	**cost ($)**
Alachua	0		1,801,654	0	1,801,654	0	13,678,178	89,037,906
Baker	0		241,291	0	241,291	0	1,518,761	4,669,471
Bradford	0		8,702	0	8,702	0	606,261	3,834,423
Brevard	0		4,038,852	0	4,038,852	0	29,918,933	163,061,323
Clay	0		1,446,460	0	1,446,460	0	9,599,034	67,616,225
Duval	0		7,823,616	0	7,823,616	0	55,292,472	254,788,608
Flagler	0		1,110,728	0	1,110,728	0	5,803,817	44,472,459
Indian River	0		1,210,516	0	1,210,516	0	8,313,031	61,201,055
Lake	0		3,845,711	0	3,845,711	0	22,735,352	137,192,829
Marion	0		2,062,659	0	2,062,659	0	14,794,017	103,703,900
Nassau	0		1,201,411	0	1,201,411	0	7,076,499	26,110,537
Okeechobee	0		4,690	0	4,690	0	914,673	7,797,502
Orange	0		9,275,873	0	9,275,873	0	66,257,955	359,244,396
Osceola	0		16,501	0	16,501	0	4,915,188	131,379,706
Putnam	0		621,114	0	621,114	0	4,425,265	15,627,823
St. Johns	0		2,112,554	0	2,112,554	0	12,153,648	74,107,624
Seminole	0		4,664,659	0	4,664,659	0	30,186,923	153,906,391
Volusia	0		4,643,236	0	4,643,236	0	31,741,553	160,348,306
Education	0	See note below.		5,767,512		5,767,512		38,101,714
SJRWMD TOTAL	**0**	**0**	**46,130,227**	**5,767,512**	**46,130,227**	**5,767,512**	**319,931,562**	**1,896,202,199**
SJR Total mgd	**0**		**46**		**46**		**320**	
Capital cost per gal		**0.00**		**0.13**		**0.13**		**5.93**
		40,000,000			**Subtotal**		**Grand Total**	
Formulae	Costs are District wide, assumed at $2,000,000 per year for 20 years ($40 million). This amount is not shown here because no water savings can be attributed directly to education. This cost instead is distributed across other conservation practices in proportion to the total quantity of water saved by that practice.		Five (5) percent reduction based on PBS&J, 1997.	No cost is attributed to these practices because they should be normal utility operating costs.				

APPENDIX H—EAST-CENTRAL FLORIDA OPTIMIZATION RESULTS FOR THE ST. JOHNS RIVER WATER MANAGEMEHT DISTRICT 2005 WATER SUPPLY PLANNING PROCESS

MEMORANDUM

DATE: October 18, 2005

TO: Barbara A. Vergara, Director, Division of Water Supply Management BV

THROUGH: Douglas A. Munch, Director, Division of Ground Water Programs

FROM: Eugene O. Agyei, Hydrologist, Division of Ground Water Programs EOA

SUBJECT: East-Central Florida (ECF) Optimization Results for the St. Johns River Water Management District 2005 Water Supply Planning Process

Introduction

This memo presents results of the ECF optimization model forecasting the deficits in ground water resource development based on meeting environmental, political, and operational water resource constraints. These deficits are used to investigate the potential magnitude of alternative sources that may be required to meet projected 2025 water demands. The ECF optimization model was developed by the St. Johns River Water Management District's (District's) Division of Ground Water Programs in close association with the Division of Water Supply Management for use as a water supply management tool to assess the utilization of water to meet future water supply demand in the ECF model domain. This memo shows the results of a variety of scenarios conducted in the ECF model region based upon projected 2025 public water supply demands.

Methodology

This work is the continuum of many years of modeling for the ECF ground water flow model area. The optimization model brings together a USGS MODFLOW-based ground water flow model, a Linear Programming (LP) optimization model, the best available data for projected water demand in the year 2025, environmental resources impact limits, and utility operation constraints. The two most influential constraints are drawdown limits at wetland control points and changes in ground water discharge at springs. Drawdown constraints are set for wetlands based on wetland type and ranged from 0.35 ft to 1.20 ft. Spring discharge constraints are set to adopted minimum flow values where established or to screening level discharge values (allowable 15% decline from long term average).

This optimization modeling includes a two-step process of deficit and decision modeling analyses. The deficit run is first conducted to assess whether the available ground water resources will support proposed water demands without unacceptable impacts. A deficit of a given magnitude is determined if the current water demands exceed available ground water resources. The objective of the decision analysis therefore, is to satisfy the remaining deficit by drawing water from available alternative sources.

The decision model thus draws water from alternative sources to satisfy projected demand while minimizing the cost of setting up these alternative sources (including already existing wells) at the same time. To satisfy this objective, the decision model incorporates a constraint that requires that the total amount of water from all alternative sources be *at least* enough to satisfy the projected demand. This "greater than" or "equal to" constraint compels the model to develop water from alternative sources that occasionally equals the generated deficit. In other words, the total water developed from alternative sources could be greater than or equal to the total deficit but not less.

The three major uses of water in the ECF area are public supply, self-supplied domestic, commercial/ industrial/ institutional, and agricultural. Only public supply wells pumping more than 100,000 gpd were considered in the optimization model. Public supply utilities withdrawing less than 100,000 gpd and the remainder of the self-supplied uses are considered as background sources in the optimization model. Withdrawals for self-supply uses are considered to be relatively small and widely spread out; making them less likely to accept alternative water supply systems. The background sources, according to the projected 2025 water-use data, cumulatively account for about 179.42 mgd of water-use. This includes an additional 4.00 mgd from public supply wells that are pumping under 100,000 gpd.

Optimization Model Scenarios

Deficit runs:

Baseline (BL) case scenario: This scenario is based strictly on the proposed water demands and prescribed environmental resource constraints. The purpose of the baseline simulation is to identify deficits (shortfalls) in a utility's ability to withdraw enough ground water to meet the 2025 demand while satisfying the overall environmental constraints.

Leakance uncertainty (LU): Vertical leakance is the main parameter in the ECF model that controls the connection between the Floridan aquifer system (FAS) from which water is withdrawn for use, and the unconfined surficial aquifer system (SAS). The SAS receives infiltration from rainfall and provides recharge to the FAS, acting as the main source of water to the FAS in the ECF model. The spatial distribution and actual magnitude of vertical leakance cannot be known with certainty; therefore it is the main calibration parameter. Varying the calibrated leakance within a range between 0.67 to 1.50 times the calibrated leakance produces simulated water levels and spring flows acceptably close to actual measurements. The uncertainty in the baseline deficits was accounted for by the range of deficit values computed using a low (0.67 x calibrated) leakance input and a high (1.50 x calibrated) leakance input to generate the sensitivity matrix required by the optimization model to estimate drawdowns.

No equity runs were considered in this analysis. Uncertainty in the model's prediction is based on runs conducted at low and high leakance as explained above.

2

Decision runs

ALT 1: This alternative attempts to use ground water only to balance the baseline deficits. The sources of ground water include those from existing, proposed, and potential new wells.

ALT 2u: This alternative assesses the uncertainty in the use of water that could be developed from alternative sources. The alternative sources considered were new Floridan aquifer wells and surface water. Political constraints are not applied in this alternative.

ALT 4: This alternative is used to balance the deficits accrued from the baseline run. The water supply alternatives for this scenario consist of existing wells, new Floridan aquifer wells, and surface water. It also includes a political boundary constraint that prohibits the transfer of water from new sources across a county boundary.

ALT 8: This alternative is similar to ALT 4 but the political boundary constraint prohibits the transfer of water from new sources across county or water management district boundaries.

Results

The optimization model suggests there is some expected water supply shortfall between projected demand and withdrawals that could be sustained while protecting water resources and related natural systems. The simulation results from ALT 2u show that shortfall ranges from 107.09 mgd (at the low leakance end) to 253.14 mgd (at the high leakance end). ALT 1 indicates that solving the deficit problem with ground water sources only may not be possible as indicated by a total remaining deficit of 129.49 mgd in Table 2.

To balance the shortfall between these extremes, the decision model suggests the development of surface water ranging from 78.85 mgd (at the low leakance end) to 193.53 mgd (at the high leakance end) and new fresh ground water in the range of 29.98 mgd (at the low leakance end) to 61.55 mgd (at the high leakance end). This high value of new fresh ground water suggested for development at the high leakance end implies that many existing wells would have to cease to operate (as shown by the development of 354.22 mgd from existing wells) in areas where ground water withdrawals from the Floridan aquifer most directly impact water levels in the unconfined surficial aquifer causing unacceptable wetland impacts. Therefore, the model simulates the development of limited amounts of new fresh ground water in areas that manifest less surficial aquifer impact at the cost of reducing or eliminating withdrawals at existing well locations.

Discussion

The optimization modeling work is based on ground water flow and optimization models developed during the District's 2000 Water Supply Planning Process (*Water 2020*). Since that time, both the regional ground water flow model and elements of the optimization model have been updated to reflect the most current changes in the plans of the user group for 2025. Comparison with *Water 2020* (see Table 9) shows significant differences in the corresponding Alternatives 4 and 8. These differences are due to the following reasons: (a) changes and updates in projected 2025 water demand data, (b) reconfiguration of the locations from which new fresh ground water wells could be developed in the ECF model region in the 2025 model, (c) reconfiguration of public supply utility service areas in the 2025 model, (d) reduction of the number of surface water sources in the 2025 model region from seven to four and limitation of their capacities to 50 mgd and (e) changes and updates in the recharge data currently being used to run the District's ECF ground water flow model associated with proposed reclaimed water reuse projects and additional quantities of water required to meet outdoor irrigation demands. Even in the light of these changes, the model continues to suggest that alternative water supplies (from both ground and surface water) in the range of approximately 107 to 254 mgd will be required to provide a solution to the problem. The uncertainty associated with the optimization evaluation described herein is common in ground water modeling exercises because of the limitations associated with data availability and quality.

Based on the projected 2025 demand of 787.73 mgd for all uses and the various scenarios considered for these analyses, the projected available supply of fresh ground water only, as shown in Table 8, could range from 595.19mgd to 710.56 mgd. This range of available ground water is based on the set of management scenarios investigated and the spatial location of existing wells and projected locations of new supplies. Different model management scenarios and different well configurations could produce different results.

Table 1 Optimization deficit runs (*flows reported in million gallons per day - mgd*)

			Baseline	**Leakance uncertainty**	
County	1995 demand	2025 demand	Calibrated leakance	Low End	High End
Brevard*	3.87	12.24	0.00	0.00	0.00
Lake*	23.75	62.34	8.64	7.50	28.84
Marion*	1.14	1.82	0.00	0.00	0.00
Orange	162.05	275.49	74.40	53.35	129.12
Osceola*	35.25	74.97	18.83	12.47	37.35
Polk*	7.82	12.54	0.00	0.00	0.00
Seminole	49.04	89.01	35.23	29.87	46.08
Sumter*	0.14	26.71	0.00	0.00	0.00
Volusia*	27.20	53.18	6.49	4.90	11.75
Total	**310.28**	**608.18**	**143.64**	**107.09**	**253.14**

Table 2 ALT1- Optimization decision runs (*flows reported in million gallons per day - mgd*)

			ALT 1			
County	1995 demand	2025 demand	Existing wells	New fresh wells	New brackish wells	Remaining deficit
Brevard*	3.87	12.24	12.24	0.00	0.00	0.00
Lake*	23.75	62.34	51.43	0.34	0.00	10.57
Marion*	1.14	1.82	1.81	0.00	0.00	0.00
Orange	162.05	275.49	196.22	10.07	0.00	69.19
Osceola*	35.25	74.97	53.51	12.94	0.00	8.52
Polk*	7.82	12.54	12.25	0.29	0.00	0.00
Seminole	49.04	89.01	50.94	0.00	4.22	33.85
Sumter*	0.14	26.71	26.71	0.00	0.00	0.00
Volusia*	27.20	53.18	45.82	0.00	0.00	7.36
Total	**310.28**	**608.30**	**450.93**	**23.64**	**4.22**	**129.49**

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Table 3 ALT4- Optimization decision runs (*flows reported in million gallons per day - mgd*)

			ALT 4			
County	1995 demand	2025 demand	Existing wells	New fresh wells	New brackish wells	Surface water
Brevard*	3.87	12.24	12.24	0.00	0.00	0.00
Lake*	23.75	62.34	54.79	0.00	0.00	7.60
Marion*	1.14	1.82	1.81	0.00	0.00	0.00
Orange	162.05	275.49	198.33	0.00	0.00	77.20
Osceola*	35.25	74.97	55.32	13.10	0.00	6.50
Polk*	7.82	12.54	10.95	1.60	0.00	0.00
Seminole	49.04	89.01	47.15	0.00	4.10	37.80
Sumter*	0.14	26.71	26.71	0.00	0.00	0.00
Volusia*	27.20	53.18	46.14	0.00	0.00	7.00
Total	**310.28**	**608.30**	**453.44**	**14.70**	**4.10**	**136.10**

Table 4 ALT 8- Optimization decision run (*flows reported in million gallons per day - mgd*)

			ALT 8			
County	1995 demand	2025 demand	Existing wells	New fresh wells	New brackish wells	Surface water
Brevard*	3.87	12.24	12.24	0.00	0.00	0.00
Lake*	23.75	62.34	54.91	0.00	0.00	7.40
Marion*	1.14	1.82	1.81	0.00	0.00	0.00
Orange	162.05	275.49	198.06	0.00	0.00	77.50
Osceola*	35.25	74.97	54.41	14.00	0.00	6.50
Polk*	7.82	12.54	12.19	0.40	0.00	0.00
Seminole	49.04	89.01	47.19	0.00	4.10	37.80
Sumter*	0.14	26.71	26.71	0.00	0.00	0.00
Volusia*	27.20	53.18	46.14	0.00	0.00	7.00
Total	**310.28**	**608.30**	**453.66**	**14.40**	**4.10**	**136.20**

Table 5 ALT 2u- Optimization decision run (*flows reported in million gallons per day - mgd*)

			ALT 2u-LOW LEAKANCE			
County	1995 demand	2025 demand	Existing wells	New fresh wells	New brackish wells	Surface water
Brevard*	3.87	12.24	12.24	0.00	0.00	0.00
Lake*	23.75	62.34	54.84	9.29	0.00	1.19
Marion*	1.14	1.82	1.81	0.00	0.00	0.00
Orange	162.05	275.49	233.13	9.51	0.00	42.72
Osceola*	35.25	74.97	62.50	11.18	0.00	0.00
Polk*	7.82	12.54	12.54	0.00	0.00	0.00
Seminole	49.04	89.01	59.13	0.00	0.00	30.03
Sumter*	0.14	26.71	26.71	0.00	0.00	0.00
Volusia*	27.20	53.18	48.28	0.00	0.00	4.91
Total	**310.28**	**608.30**	**501.18**	**29.98**	**0.00**	**78.85**

Table 6 ALT 2u- Optimization decision run (*flows reported in million gallons per day - mgd*)

			ALT 2u – HIGH LEAKANCE			
County	1995 demand	2025 demand	Existing wells	New fresh wells	New brackish wells	Surface water
Brevard*	3.87	12.24	12.24	0.00	0.00	0.00
Lake*	23.75	62.34	39.01	18.93	0.00	4.24
Marion*	1.14	1.82	1.81	0.00	0.00	0.00
Orange	162.05	275.49	138.21	8.28	0.00	128.99
Osceola*	35.25	74.97	39.35	34.34	0.00	1.28
Polk*	7.82	12.54	12.54	0.00	0.00	0.00
Seminole	49.04	89.01	42.92	0.00	0.00	47.50
Sumter*	0.14	26.71	26.71	0.00	0.00	0.00
Volusia*	27.20	53.18	41.43	0.00	0.00	11.77
Total	**310.28**	**608.30**	**354.22**	**61.55**	**0.00**	**193.53**

* Partial Counties in the ECF model region.

Note: These model results are only used by the District to estimate the total amount of potential resource impact from projected ground water supply development and to conceptualize possible solution; they do not indicate any specific utility water supply reduction preferred or proposed by the District.

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Table 7 Projected average daily flows from the Floridan aquifer used in ECF model simulations.

Withdrawal (or use) type	1995 (mgd)	2025 (mgd)
Public supply	314.45	612.31
Self-supplied (commercial/industrial/institutional)	46.97	38.07
Self-supplied (domestic)	36.04	36.04
Agricultural	130.37	101.31
Abandoned Free-flowing wells	2.27	0.00
Model-wide total withdrawal	**530.10**	**787.73**

Table 8 Ground water availability based on simulation results (*flows reported in million gallons per day - mgd*)

Model run	Existing wells [mgd]	Background use**	New fresh wells	New brackish wells	**Total available**
Baseline	464.63	179.42	0.00	0.00	**644.05**
ALT 1	450.93	179.42	23.64	4.22	**658.21**
ALT 2u (Low leakance)	501.18	179.42	29.98	0.00	**710.58**
ALT 2u (High leakance)	354.22	179.42	61.55	0.00	**595.19**
ALT 4	453.44	179.42	14.70	4.10	**651.66**
ALT 8	453.66	179.42	14.40	4.10	**651.58**

** Background use comprises self-supplied (commercial/industrial/institutional), self-supplied (domestic), and agricultural use. These sum up to 175.42 mgd plus 4 mgd of public supply that do not satisfy the 100,000 gpd pumping requirement.

Table 9 Comparison of 2020 and 2025 simulation results (*flows reported in million gallons per day - mgd*)

Water sources	**ALT 4**		**ALT 8**	
	2020	**2025**	**2020**	**2025**
New fresh ground water wells	14.0	14.7	32.0	14.4
New brackish ground water wells	4.0	4.1	0.0	4.1
Surface water	150.0	136.1	196.0	136.2
Existing wells (including background)	597.5	632.9	537.0	633.1
Total water developed	**765.5**	**787.8**	**765.5**	**787.8**

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APPENDIX I—GROUNDWATER YIELDS AND DEFICITS FOR DISTRICT WATER SUPPLY PLAN 2005

Water Supply Solutions, Inc.

Technical Memorandum

To: Barbara Vergara, P.G.

From: Ron Wycoff

CC: Lisa Parks

Date: October 24, 2005

Re: Groundwater Yield and Deficit Analysis for 2005 DWSP

Introduction

Fresh groundwater is the preferred source of supply for nearly all uses within the St. Johns River Water Management District (SJRWMD), including public supply. Fresh groundwater is of high quality, available in or near most demand centers and is inexpensive to treat and distribute. However, sustainable supplies are limited within priority water resource caution areas (PWRCAs). Once fresh groundwater supplies are fully developed, alternative water supplies, additional conservation measures, and use of available reclaimed water will be necessary to meet future water supply needs.

The purpose of this groundwater yield and deficit analysis is to estimate the sustainable groundwater yield and remaining water supply deficit for two major areas of SJRWMD. A water supply deficit is defined as the total estimated 2025 water supply need less the estimated sustainable fresh groundwater yield. Areas of interest include the east-central Florida (ECF) area and the Volusia County area. These areas include the vast majority of the PWRCAs and are defined by the boundaries of groundwater flow models, developed to support the SJRWMD water supply planning process.

Water Supply Evaluation Tools

The groundwater yield and deficit analysis is based on the application of water supply evaluation and planning tools developed and maintained by SJRWMD. These tools include groundwater flow models and withdrawal optimization models and each have been developed for the ECF planning area as well as for the Volusia County area. All model applications, described herein, were preformed by SJRWMD staff.

Groundwater Flow Models

Groundwater flow models simulate the hydrologic response of aquifers to water supply withdrawal. Once a groundwater flow model is developed and calibrated, for a given application area, it can be used to investigate relationships between aquifer recharge, discharge and water supply withdrawals. Responses in both the Floridan aquifer and the surficial aquifer are simulated.

The SJRWMD groundwater flow models are MODFLOW applications. MODFLOW is a general groundwater systems simulation code developed by the United States Geological Survey (USGS) and is applied by hydrogelogists worldwide. The DWSP groundwater yield applications are based on steady state average annual conditions for the base calibration year (1995) and for the current water supply planning year (2025). Differences in surficial aquifer water levels, Floridan aquifer pressure and resulting springflow discharges are of primary interest to the groundwater yield determination.

The groundwater flow models are also used to evaluate sensitivity and uncertainty. All models are simplified representations of complex natural systems. As such, there will always be uncertainty associated with the application of these models. Although uncertainty can never be fully eliminated, it can be investigated and quantified by application of the model within reasonable ranges of key parameters, reflecting the uncertainty associated with these parameters.

Withdrawal Optimization Models

The withdrawal optimization models are used to estimate the total maximum sustainable groundwater yield, from a given hydrologic system, subject to defined withdrawal constraints. The withdrawal optimization models are linear programming applications and are closely linked to the groundwater flow models. The groundwater flow models are used to fully define the hydrologic response of the aquifer resulting from water supply withdrawals from each individual well location. Once these individual responses are known, the optimization will identify the withdrawal scenario that maximizes total regional water supply yield while satisfying all withdrawal constrains including appropriate environmental constraints (all applications) and existing facility equity constrains, as well as political boundary constraints. The constraint set can be varied for each model application to determine its significance to the overall estimated sustainable groundwater yield.

ECF Optimization Runs and Results

Desired Water Supply Withdrawals

Groundwater withdrawals applied in the ECF optimization analysis are summarized in Table 1.

Table 1. Withdrawal by water use category in ECF groundwater flow model domain

Water Use Category	Withdrawal -- mgd	
	1995	2025
Public Supply	314	612
Commercial/Industrial/Institutional	47	38
Agricultural Irrigation & Recreation	130	101
Domestic Self-Supply	36	36
Flowing Wells	2	0
TOTAL Withdrawal	**529**	**787**

For the purpose of the optimization analysis, these groundwater withdrawals are divided into two groups; public supply and background. The public supply demands are active in the optimization model and the magnitude can be varied from well to well in order to identify the optimum withdrawal scenario. The remaining water use categories are not active and the withdrawal location and magnitude remain constant throughout the analysis – thus the term background.

In the current optimization analysis, a small amount of the public supply demands (4 mgd) are associated with very small suppliers (less than 0.1 mgd) and these were included in the background total. Therefore, the demands considered in the current analysis include 608 mgd active public supply and 179 mgd background.

ECF Calibrated Optimization Model Run Results

The calibrated model provides the most likely regional hydrologic response of the Floridan and surficial aquifers to existing and increased groundwater withdrawal. It is based on the best information available and the calibrated ECF groundwater flow model has been the subject of extensive peer review. These results represent expected values and are therefore appropriate for long term water supply planning and management.

The calibrated model optimization runs considered several scenarios or alternatives as follows.

Baseline – This runs considers existing well locations and well locations proposed by various water suppliers only.

Alternative 1 – This run considers the existing and proposed wells included in the baseline run, as well as additional potential wellfield locations.

Alternative 4 – This run is the same as Alternative 1 except that water cannot be transferred across county boundaries.

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Alternative 8 – This run is the same as Alternative 1 except that water cannot be transferred across county or district boundaries.

The optimization model run results, based on the calibrated groundwater flow model, are summarized in Table 2.

Table 2. ECF optimization model results

Optimization Run	Optimized ECF Groundwater Yield -- mgd	Remaining ECF Deficit -- mgd
Baseline (existing and proposed wells only)	644	144
All fresh groundwater	654	134
All fresh groundwater - no transfer of water across county boundaries)	648	140
All fresh groundwater - no transfer of water across county or district boundaries	648	140

The optimization results, based on the calibrated flow model, show relatively little sensitivity to the alternatives considered. The baseline sustainable groundwater yield is estimated to be 644 mgd, resulting in a year 2025 deficit of 144 mgd. This yield can be increased slightly by consideration of additional wellfields but the small increase is lost when the political boundary constraints are included.

ECF Uncertainty Analysis

Although the calibrated flow model represents expected conditions, it is acknowledged that modeling uncertainty exists. The greatest source of modeling uncertainty is the hydraulic linkage of the Floridan aquifer to the surficial aquifer. Confining layer leakance is the hydrologic parameter that is most important to this hydraulic linkage.

It was found that leakance values could be varied over a certain range without seriously compromising model calibration. Specifically, it was found that leakance values in the range of 67% to 150% of the calibrated values provided results within the range of calibration acceptability. Therefore, leakance uncertainty runs were conducted to investigate the sensitivity of the estimated sustainable groundwater yield and corresponding deficit to the actual leakance values used in the simulations.

A low leakance run and a high leakance run were defined to provide the desired sensitivity analysis. Low leakance corresponds to leakance values equal to 67% of the calibrated values and high leakance corresponds to leakance values equal to 150% of the calibrated values. The results of the low and high leakance sensitivity runs are compared to the baseline run in Table 3.

Table 3. Results of ECF groundwater flow model uncertainty analysis on groundwater yields and deficits

Optimization Run	Optimized ECF Groundwater Yield -- mgd	Remaining ECF Deficit -- mgd
Baseline (existing and proposed wells only)	644	144
Low Leakance	709	79
High Leakance	594	194

These results indicate a range of uncertainty in the estimated sustainable yield of about 115 mgd, from a low of 594 mgd to a high of 709 mgd. The overall expected (calibrated model) value of 644 mgd lies very close to the center of this range.

ECF Yield and Deficit Summary

In association with the East-Central Florida Water Supply Planning Initiative, which has been ongoing for several years, a stainable fresh groundwater yield estimate of 670 mgd has been used for planning purposes. This value was based on the results of the calibrated flow model used in the *Water 2020* planning process, which lead up to the 2000 DWSP, with political boundary constraints applied in the optimization modeling process. These boundary constraints prohibited the transfer of water across county and water management district boundaries. This value (670 mgd) is in close agreement with the current corresponding estimate of sustainable groundwater yield of 648 mgd.

All sustainable groundwater yield estimates are based on an optimized array of well locations and corresponding withdrawals that does not exist today and that is not currently proposed by public supply utilities in ECF.

Volusia County Optimization Runs and Results

Desired Water Supply Withdrawals

Groundwater withdrawals for Volusia County, as applied in the Volusia County withdrawal optimization analysis, are summarized in Table 4.

Table 4. Volusia County groundwater withdrawal by water use category

Water Use Category	Withdrawal -- mgd	
	1995	2025
Public Supply	48.2	86.6
Commercial/Industrial/Institutional	1.4	2.2
Agricultural Irrigation & Recreation	20	23.1
Domestic Self-Supply	3.8	4.5
TOTAL Withdrawal	**73.4**	**116.4**

Like the ECF application, groundwater withdrawals were divided into public supply and background and only public supply demands in the Volusia County portion of the model were active in the optimization analysis. Projected public supply demands (2025) totaled 86.6 mgd. Withdrawals in the background totaled 29.8 mgd for a total withdrawal of 116.4 mgd. Within the whole model domain (Volusia County plus selected adjacent areas), projected 2025 demand totaled 175.7 mgd.

Volusia Optimization Model Run Results

Establishment of minimum flows and levels (MFLs) for Blue Spring, located in southwest Volusia County, is likely to have a significant impact on the sustainable groundwater yield available for public supply within Volusia County. Therefore Blue Spring MFLs were a major focus of the Volusia groundwater yield and deficit analysis.

In addition, water supply utility equity in existing infrastructure was investigated to determine the impact on areawide sustainable groundwater yield of maintaining selected levels of existing water supply infrastructure usage.

Given the interest in Blue Spring and in infrastructure equity, the following optimization runs were defined.

Base Case – The base case run considers existing and proposed wells only and does not consider existing infrastructure equity. In addition Blue Spring MFL is set at 134 cfs.

Equity 1995 – This scenario is the same as the base case except that all wellfields will produce actual 1995 withdrawals at a minimum. Blue Spring MFL equals 134 cfs.

Equity 2025 – This scenario is similar to the Equity 1995 run except that minimum withdrawal from each wellfield is set equal to 84 percent of the desired 2025 total withdrawal. Blue Spring MFL equals 134 cfs.

Blue Spring MFL – This scenario is the same as the base case except that the Blue Spring MFL is increased to 157 cfs, which is equal to the long term average historic discharge.

The yield and deficit results, considering the public supply component, are summarized in Table 5.

Table 5. Groundwater yields and deficits based on Volusia optimization model

Optimization Run	Optimized Volusia County Groundwater Yield -- mgd	Remaining Volusia County Deficit -- mgd
Baseline (no equity) with Blue Spring MFL = 134 cfs	110.6	5.8
Equity = 100% of 1995 withdrawal with Blue Spring MFL = 134 cfs	110.4	6.0
Equity = 84% of 2025 withdrawal with Blue Spring MF = 134 cfs	107.0	9.4
No Equity with Blue Spring MFL = 157 cfs	91.2	25.2

The groundwater deficit for the Volusia County area in 2025 is modest, ranging from about 6 to 9 mgd, if the Blue Spring MFL is set equal to 134 cfs. However, if the Blue Spring MFL is set equal to 157 cfs, the 2025 water supply deficit for Volusia County increases to about 25 mgd.

APPENDIX J—VOLUSIA REGIONAL GROUNDWATER FLOW MODEL AREA RESOURCE ALLOCATION OPTIMIZATION MODEL RESULTS FOR THE ST. JOHNS RIVER WATER MANAGEMENT DISTRICT 2005 WATER SUPPLY PLANNING PROCESS

MEMORANDUM

DATE: **June 2, 2005**

TO: Barbara A. Vergara, Director, Division of Water Supply Management BV

THROUGH: Douglas A. Munch, Director, Division of Ground Water Programs

FROM: Patrick Burger, Hydrologist, Division of Ground Water Programs PB

SUBJECT: Volusia Regional Ground Water Flow Model Area Resource Allocation Optimization Model Results for the St. Johns River Water Management District 2005 Water Supply Planning Process

Introduction

Volusia County has been designated as a priority water resource caution area based on potential inability of available fresh groundwater resources to meet all reasonable anticipated future needs and to sustain the water resources and related natural systems. This memo presents the results of optimization model forecasting of potential limits in groundwater resource development (deficits) based on meeting environmental, political, and operational water resource constraints. The Volusia Optimization model was developed by the St. Johns River Water Management District's (District's) Division of Ground Water Programs in close association with the Division of Water Supply Management for use as a water supply management tool to assess impacts on the water resources from proposed ground water withdrawals in the Volusia Regional Ground Water Flow Model domain. The optimization model was designed to investigate a variety of water supply scenarios developed for the District's 2005 water supply plan.

Methodology

This work is the continuum of many years of modeling for the Volusia Ground Water Flow Model area. The optimization model brings together an USGS MODFLOW based ground water flow model, a Liner Programming (LP) optimization model, the best available data for water use demands in year 2025 (Table 1), environmental resources impact limits, and utility operation constraints. The optimization model is developed with an objective function, which is to minimize potential limits in water supply development, while meeting constraints designed to protect environmental resources. The major constraints are drawdown limits at wetlands and lakes, changes in ground water discharge at springs, changes in water quality at public supply wells, and wellfield infrastructure preservation considerations (equity). Drawdown constraints were set for wetlands based on wetland type and ranged from 0.35 ft to 1 ft of allowable drawdown and 0.5 ft of allowable drawdown at lakes with minimum levels adopted by District rule Chapter 40C-8, Florida Administrative Code). Spring discharge constraints were set to adopted minimum flow values when available or to screening level discharge values (allowable 15% decline from long term average). Chloride constraints were applied to public supply wells to prevent water quality degradation past a chloride concentration of 250 mg/L or no more then current chloride concentrations. Operation constraints were set to insure no infrastructure loses and no over pumping of a single production well.

Optimization model design considers several important water use considerations. Public supply and commercial/industrial uses were considered the only categories that have the potential for altering daily operational procedures, therefore these were the only categories available for optimization. Agricultural and domestic self-supply are considered to be generally small and widely spread out making them less easily available for alternative water supply systems. These uses were included as part of the background water use and were not changed during the optimization process. Additionally, the focus of this model is the Volusia County portion of the Volusia Ground Water Flow Model domain. The optimization model only considers the water use in the Volusia County portion of this model and all results are reported for such.

Table 1 – Water Use Projections (*Flows reported in mgd*)

Volusia Ground Water Flow Model Area		
Use Type	***1995***	***2025***
Public supply	59.3	117.8
Agricultural	26.8	30.4
Commercial/industrial	2.1	2.7
Free-flowing wells	23.1	11.8
Domestic self-supply	11.3	13.1
TOTAL	**122.6**	**175.7**

Volusia County Only		
Use Type	***1995***	***2025***
Public supply	48.2	86.6
Agricultural	20.0	23.1
Commercial/industrial	1.4	2.2
Domestic self-supply	3.8	4.5
TOTAL	**73.4**	**116.4**

Optimization Model Scenarios

Base Case Run No Equity – The "Base Case Run" optimization model run incorporates all constraints at their originally determined values. This model run determines the water resource limits when trying to obtain projected public water supply demand for utilities in the Volusia County portion of the Volusia Regional Groundwater Flow Model domain for year 2025 while meeting the environmental constraints. This scenario has the ability to greatly reduce some utilities' water use in order to obtain the most water across the model area.

Equity Run 1995 (100% 1995 Water Use Demand) – The "Equity Run 1995" optimization model run calculates water resource limits when trying to obtain projected public water supply demand for utilities in the Volusia County portion of the Volusia Regional Groundwater Flow Model domain for year 2025 while meeting the environmental constraints and maintaining 100 percent of the year 1995 groundwater withdrawal rates for all utilities.

Equity Run 2025 (84% 2025 Water Use Demand) – The "Equity Run 2025" optimization model run calculates water resource limits when trying to obtain projected public water supply demand for utilities in the Volusia County portion of the Volusia Regional Groundwater Flow Model domain for year 2025 while meeting the environmental constraints while allowing utilities to withdrawal 84 percent of the year 2025.

Blue Springs MFL Run (MFL = 157 cfs No Equity) – The "Blue Spring MFL" optimization model run calculates the water resource limits when trying to obtain projected public water supply demand for utilities in the Volusia County portion of the Volusia Regional Ground Water Flow Model domain for year 2025 while meeting the environmental constraints. In this scenario the environmental constraints incorporate an increased spring discharge constraint at Blue Spring from a possible minimum flow rate of 134 cfs to the long-term average discharge rate of 157 cfs and does not include equity. (Note: The less constraining minimum flow rate being considered at the time of preparation of this memorandum was 134 cfs. Although this rate may change in the future, the change will not effect the outcome of the optimization analysis reported here because the more constraining minimum flow rate of 157 cfs is not expected to be in effective until 2025.)

Results

The optimization model results suggest there is some expected shortfall between projected demand and allowable withdrawals in order to protect environmental resources. Depending on the water resource constraints used in the optimization model scenario, these shortfalls range from approximately 6 mgd to over 25 mgd across the Volusia County portion of the Volusia Regional Groundwater Flow Model area. The table below displays the results for the utilities in the Volusia Regional Ground Water Flow Model area included in the optimization model. In general, the incorporation of equity as a constraint tends to increase the 2025 deficits across the area because the model is restricted by existing wellfield locations and minimum groundwater production targets and must allow for more withdrawals in existing locations. Additionally, increasing the spring discharge constraint for Blue Spring indicates that many utilities would have to reduce consumption to maintain the 157 CFS long-term average spring flow. Comparison of model results reported in the water supply planning process leading to development of the 2000 District Water Supply Plan (*Water 2020*) shows that similar results are obtained for the 2025 analyses. Alternative water supply scenarios also return consistent results suggesting that surface water from locations on the St. Johns River would be a likely candidate source of water to meet expected sort falls in projected 2025 demands.

Optimization Run Results Table (*flows reported in million gallons per day – mgd*)

Utility	Demand 1995	Demand 2025	Base Case No Equity	Equity (100% 1995)	Equity (84% 2025)	Blue Springs MFL - 157 CFS No Equity
DAYTONA BEACH	12.42	18.51	2.17	2.17	1.26	2.11
DELAND	4.97	7.24	0	0	0	2.24
EDGEWATER	1.49	3.12	0	0	0	0
FWS - DELTONA	9.12	17.12	2.63	2.87	3.05	14.51
HOLLY HILL	1.16	1.71	0	0	0.28	0
LAKE BERESFORD WATER	0.17	0.25	0	0	0	0.25
LAKE HELEN	0.24	0.56	0	0	0	0
NEW SMYRNA BEACH	4.27	7.12	0	0	1.13	0
ORANGE CITY	1.33	2.92	0	0	0.17	2.92
ORMOND BEACH	4.90	9.39	0.56	0.56	2.24	0.56
PIERSON	0.12	0.16	0	0	0	0
PORT ORANGE	5.28	8.2	0	0	0.67	0
VCU	2.19	9.92	0.39	0.39	0.64	2.64
Total	**47.66**	**86.22**	**5.75**	**5.99**	**9.44**	**25.23**

Note: These model results are only used by the District to gage the total amount of potential resource impact from projected groundwater supply development and to conceptualize possible solutions; they do not indicate any specific utility water supply reductions preferred or proposed by the District.

Discussion

The optimization modeling work is based on ground water flow and optimization models developed during the District's *Water 2020* process. The models were updated to incorporate the new water supply demand projections for year 2025. The 2025 numbers are currently under review and do not necessarily reflect all ongoing permit negotiations. Comparisons with year 2020 projected demand show that year 2025 demand projections are slightly reduced. The associated results for the Optimization Model area also reflect this reduction demonstrating that slightly less resource limitation is expected. As with any model, uncertainty exists with all data and results. This represents the state of the art in water supply planning tools and has under gone peer review to provide assurances that this is a credible procedure for estimating limits on water resource development in order to avoid substantial environmental impacts.

The optimization model results can be interpreted to suggest a range of potentially available fresh groundwater supplies from the Floridan aquifer system in the Volusia County area. Based on the projected 2025 demand of 116 mgd for all uses in Volusia County and an expected range of deficits of 6 mgd to 25 mgd for the scenarios developed in these analyses, the projected available supply of fresh groundwater could range from as much as 110 mgd to as little as 91 mgd. The range of available supplies is based on this set of management scenarios investigated and the spatial location of existing wells and projected locations of new supplies. Different management scenarios and different well configurations could produce different results. It should also be noted that all models have an inherent amount of associated uncertainty with their results. Based on this uncertainty analyses conducted for the ECF optimization models the expect the range of available groundwater supplies could be 10 percent higher or 20 percent lower than values calculated here, expanding the range to 121 mgd to 73 mgd of potentially available fresh groundwater.

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APPENDIX K—PUBLIC/PRIVATE PARTNERSHIPS FOR WATER RESOURCE FACILITIES

Public/Private Partnerships for Water Resources Facilities
Discussion of Principles

Presented by:

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Florida is facing critical challenges in continuing to supply its population with our most precious resource, water. Our long used source of supply, the Floridan aquifer, simply cannot continue to withstand the increasing demands being placed upon it by our growing population.

However, like many natural resource problems, many people do not believe that the problem is critical until it directly affects them through unavailability or higher prices or both. Fortunately, our water management districts are currently identifying alternative sources of supply, because very soon the Floridan aquifer will not be adequate to meet the projected needs.

One alternative being seriously considered by the St. Johns River Water Management District is a surface water plant on the St. Johns River in central Florida. A significant challenge will be to structure the ownership and funding of such a facility. This paper discusses this challenge in the following paragraphs.

A. Public/Private Ownership, Operation and Funding

When considering public and/or private ownership, operation and funding of a water resources facility, it is first useful to examine each independently of the other and to then explore the possibilities of public/private partnerships that might incorporate the advantages of both. Therefore, the following subsections discuss the advantages and disadvantages of exclusively public ownership, operation and funding and of exclusively private ownership, operation and funding. However, it is first necessary to state some assumptions that will apply to the discussion of each case.

- o The water resources facility will serve existing and new public and private utilities in its service area on a wholesale basis.

- o The cash needs basis of rate making is assumed for public ownership and the utility basis of rate making as regulated by the Florida Public Service Commission (FPSC) is assumed for private ownership.

There are several components of ownership, operation and funding of a major water resources facility that are important to evaluate for both the public and private options. These components are as follows:

- o Ownership
- o Design
- o Construction
- o Financing
- o Operation
- o Rates

Each of these components of ownership, operation and funding are evaluated in the discussions of the advantages and disadvantages of public and private ownership, operation and funding presented in the following subsections.

1. Exclusively Public Ownership, Operation and Funding

Because the service area of an alternative water supply facility will be large and the facility will serve a number of existing utilities, most of which are public utilities, on a wholesale basis, public ownership, operation and funding of the facility seems to be the most logical structure to consider initially. Therefore, this section discusses the advantages and disadvantages of public ownership, operation and funding.

a. Components of Public Ownership, Operation and Funding

With regard to the components of ownership, operation and funding discussed in the previous section, the following analysis is applicable to public ownership, operation and funding.

- o Ownership—A public entity could be the owner of record for the facility and will be organized as a public utility.

- o Design—A public owner could design the facility with internal resources or contract with a private engineering/design firm for design of the facility. Most large public utilities contract for the design of major infrastructure, therefore, it is assumed that a public owner of this facility would contract for its design.

- o Construction—As with design, a public owner could construct, or build, the facility with internal resources or contract with a private firm for construction of the facility. Because most large public utilities contract for the construction of major infrastructure, it is assumed that a public owner of this facility would contract for its construction.

- o Financing—For a public owner, financing would normally be accomplished by the issuance of tax exempt revenue bonds that will be supported by the revenues of the new utility.

- o Operation—The new public utility could operate the facility with its own personnel and other resources. As with most large public utilities, the new utility may contract for specialized services such as lab analyses. The public utility could also contract with a private operator for operation of the facility.

- o Rates—A new public utility would be self regulating with regard to rates and would use the cash need basis of rate making. The FPSC will have no regulatory control under the public ownership option. Most publicly owned water utilities use the cash need basis of rate making. Under this approach, all of the cash requirements of the utility are included in its rates, including operations and maintenance costs, annual renewal and replacement costs, minor capital outlay requirements and annual debt service. Annual debt service includes the principal and interest payments for long term tax exempt debt issued to finance design and construction of the facility and other major capital items.

b. *Advantages and Disadvantages of Public Ownership, Operation and Funding*

The advantages/disadvantages of public ownership, operation and funding are as follows:

Advantages

- Low rate, tax exempt financing
- Rates match rate revenue with cash requirements
- No profit in rates
- Subsidies could be made from other governmental sources if necessary for financial viability

Disadvantages

- Limited competition to minimize costs
- Cumbersome procurement process
- All risks are born by the public owner
- "Profit" can appear as transfers to other funds of the public owner

2. *Exclusively Private Ownership, Operation and Funding*

As an alternative to public ownership, operation and funding, this section discusses the advantages and disadvantages of exclusively private ownership, operation and funding.

a. *Components of Private Ownership, Operation and Funding*

With regard to the previously identified components of ownership, operation and funding, the following analysis is applicable to exclusively private ownership, operation and funding.

- Ownership—A private entity could be the owner of record for the facility and would be organized as a public utility, regulated by the Florida Public Service Commission (FPSC).

- Design—A private owner could design the facility with internal resources or contract with a private engineering/design firm for design of the facility.

- Construction—As with design, a private owner could construct, or build, the facility with internal resources or contract with a private firm for construction of the facility.

- o Financing—Financing would be accomplished by the infusion of equity from the private owner and/or debt incurred by the private owner at available taxable market rates. Some level of tax exempt financing may be available through special programs, however, it is considered that this source of funding will be minimal.

- o Operation—The new private utility would operate the facility with its own personnel and other resources. As with most large utilities, the new utility may contract for specialized services such as lab analyses.

- o Rates—The new private utility would be regulated with regard to rates by the Florida Public Service Commission (FPSC) and will be required to use the utility basis of rate making. Under this approach, the private utility is allowed to recover its operations and maintenance costs, including an allowance for depreciation, plus a return on rate base. Rate base represents the utility's net investment in utility plant in service that is considered to be used and useful in the service of current customers.

b. ***Advantages and Disadvantages of Private Ownership, Operation and Funding***

The advantages/disadvantages of private ownership, operation and funding are as follows:

Advantages
- o Competition can minimize costs
- o All risks are born by the private owner
- o Less cumbersome procurement process

Disadvantages
- o Higher cost of financing
- o Rates do not match rate revenue with cash requirements
- o There is profit in the rates

B. ***The Financial Dynamics of Private vs. Public Rates***

The area that is most critical to the financial viability of either the public or private option for ownership, operation and funding is rate making. Rates provide the revenue stream that will support the financial requirements of either the public or private option. However, the financial dynamics of the rate making process are different for each.

The one aspect of rate making that is the same for public and private ownership is that operations and maintenance costs other than depreciation, which is not a cash item, are recovered in the rates for both. However, recovery of investment in plant and recovery of the cost of money relative to that investment is handled quite differently.

A public utility, under the cash needs basis of rate making, is allowed to recover all of the principal and interest associated with financing its investment in plant, regardless of how much of the capacity of the utility is used and useful in service to current customers. On the other hand, a private utility, under rate regulation, is allowed to recover 1) only the portion of depreciation on its investment in plant that is used and useful in service to current customers and 2) a return on rate base to represent its cost of money, or weighted cost of capital relative to its investment. Rate base represents the utility's net investment in utility plant in service, after subtracting accumulated depreciation and contributions in aid of construction (CIAC) net of accumulated amortization of CIAC, which is used and useful in service to current customers.

Therefore, a public utility is able to recover all of its cash requirements in all years of operation, whereas, a private utility may suffer cash flow deficits relative to its actual cash costs at various times throughout the life of the plant. This is because, absent future investment for expansion, growth, etc., the rate base derived from the initial investment, and normal renewal and replacement investments associated with the initial investment, is continually eroded by increasing accumulated depreciation so that in the later years of the plant financing, cash payments for principal and interest (and/or return on equity) exceed the cash received in the rates from annual depreciation and return, because the allowed return is being calculated based upon a diminishing rate base each year.

Another problematic aspect of private rate regulation is the bifurcation of regulatory authority regarding environmental compliance and rates. Specifically, the Florida Department of Environmental Protection and the State's water management districts can require a private utility to meet certain environmental standards to renew or obtain wastewater discharge and water use permits, which may require significant capital and operations and maintenance expenditures by the private utility. However, to include those expenditures in rates, the private utility must file a rate case with the FPSC. The problem is that the FPSC's application of rules and interpretations of the prudency of the utility's specific investments made in response to regulatory requirements of other agencies may result in not allowing inclusion of the utility's total investment, or operations and maintenance expenses in its rates. Even if all of the expenditures are allowed in rates, there is a considerable "regulatory lag" built in because of the time required to file and process a rate case, which must be done after the investments are made and expenses are incurred. A public owner, on the other hand, as a self-regulating entity regarding rates, can pass the total cost of environmental regulatory compliance through in its rates.

Therefore, unless special dispensations are made regarding the rate regulation process, it is difficult to conceive of a scenario in which total private ownership and operation of a regional water supply facility would be attractive to an investor owned utility under typical rate regulation and rate making principals for a regulated utility.

C. *Public/Private Partnerships*

The discussion in the prior section indicates that the financial dynamics of rate regulation upon a private owner for an alternative water supply facility may make exclusive private ownership, operation and funding problematic. However, public/private partnerships offer the possibility of achieving many of the advantages of each option, while eliminating, or at least mitigating the disadvantages.

There are a number of possibilities regarding the structure of public/private partnerships and a number of such arrangements exist today as models. Although, each circumstance is different and a thorough examination of this situation would be required before structuring any public/private partnership approach, the components of ownership, operation and funding of the project can be generally evaluated with regard to a public/private partnership approach. Such an evaluation is presented below.

1. Components of Public/Private Partnerships Regarding Ownership, Operation and Funding

With regard to the previously identified components of ownership, operation and funding, the following analysis is applicable to public/private ownership, operation and funding.

- o Ownership—A public entity could own the facility or it could host a competition where the successful private bidder could own the facility, design it and build it, with predefined terms for potential reversion to public ownership some time in the future.

- o Design/Construction—If a public entity owns the facility, it could host a competition for private design/build, design/build/operate, and/or design/build/lease/operate.

- o Financing—If a structure could be achieved that allowed tax exempt financing through a public entity it would allow for lower costs, with less pressure on rates.

- o Operation—If owned by a public entity, a competitive bid process could select the most cost effective private operator, with guarantees regarding cost ceilings.

- o Rates—Rates could be established using the cash needs approach if owned by a public entity, even if design/build/operation and/or maintenance are contracted to a private utility operator.

If the public/private partnership is structured so that a private entity owns the facility initially, it may be necessary to include a provision for transfer of ownership to a public entity at some point in the future in order to avoid the negative cash flow dynamics under private ownership in the later years of the investment in the plant, and to make the deal attractive for the private utility. Such transfer would include a fair compensation to the private owner for the assets transferred, and could include a long term operations contract with the private entity and a guarantee of operations and maintenance costs from the private entity as part of the operations and maintenance contract.

Such a transfer of ownership could allow for transition to cash needs rate making to provide the cash flow to retire the principal and interest on the long term debt that the public entity would issue to acquire the utility assets and would also allow the private entity to determine operations and maintenance costs of the facility through experience, thus allowing their inclusion at realistic guarantees in a long-term contract. If properly structured in terms of the timing of the transfer, the transition from regulated rates to cash needs rates could have an essentially neutral effect upon the actual rates charged to customers.

2. Advantages and Disadvantages of Public/Private Ownership, Operation and Funding

The advantages/disadvantages of public/private ownership, operation and funding are as follows:

Advantages	***Disadvantages***
o Potential for private sector efficiencies	o Transfer of ownership may be required
o Potential for public sector low cost financing and rate making	o Known O&M costs when transferred to public ownership

D. <u>*Conclusion Regarding Public/Private Ownership, Operation and Funding*</u>

Both public and private options have advantages and disadvantages. Models of public/private partnerships exist for similar public utility operations that have had varying degrees of success. A thorough examination of the requirements of an alternative water supply project relative to the structure and potential success of available public/private partnership models might result in the identification of a public/private partnership model that will facilitate its implementation and its short and long term cost effective operation.

One or more public/private scenarios could be modeled to determine the comparative impact of the wholesale rate per 1,000 gallons for each year in a 30-year forecast period. The model could be developed to be dynamic and interactive to allow for real time testing of "what if" scenarios. This modeling process could be structured so as to involve the stakeholders in this alternative water supply facility, namely the utilities in its service area, in a way that they can fully understand the project and the implications in terms of the long-term cost of water at the retail level.

APPENDIX L—MEMORANDUM OF UNDERSTANDING BETWEEN THE ST. JOHNS RIVER WATER MANAGEMENT DISTRICT, THE SOUTH FLORIDA WATER MANAGEMENT DISTRICT, AND THE SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT

MEMORANDUM OF UNDERSTANDING
BETWEEN
ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
AND
SOUTH FLORIDA WATER MANAGEMENT DISTRICT
AND
SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT

The *St. Johns River Water Management District* ("St. Johns"), the *South Florida Water Management District* ("South Florida"), and the *Southwest Florida Water Management District* ("Southwest Florida"), enter into this *Memorandum of Understanding* to accomplish the goals and purposes stated below.

Whereas St. Johns, South Florida, and Southwest Florida are legislatively created regional agencies of the state with abutting geographic boundaries;

Whereas St. Johns, South Florida, and Southwest Florida each have existing programs to assess hydrologic conditions, to plan for future water supply needs, to regulate consumptive uses of water, and to declare water shortages within their boundaries;

Whereas St. Johns, South Florida, and Southwest Florida desire to cooperate in the areas of water resource investigation, water supply planning, water use regulation, and water shortage management where such cooperation is prudent and efficient;

Whereas St. Johns, South Florida, and Southwest Florida find that cooperation in the areas of water resource investigation, planning, water use regulation and water shortage management is prudent and efficient in situations arising outside the context of Section 373.2295, Florida Statutes, (F.S.) *Interdistrict transfers of groundwater*,

Now therefore, St. Johns, South Florida, and Southwest Florida (collectively referred to hereinafter as the Districts), agree as follows:

This Memorandum of Understanding addresses interdistrict coordination in five subject areas, including:

Part I - Water Resource Investigations,
Part II - Water Supply Planning,
Part III - Water Use Regulation,
Part IV - Water Shortage Management, and
Part V - General Provisions.

For each subject area, a geographic area within which coordination will be applicable is described and coordination procedures are outlined.

I. Water Resource Investigations

Geographic Area: The area to be considered for water resource investigation coordination is the entirety of each of the Districts.

Coordination between districts will involve: (A) collection and management of hydrologic data and (B) data modeling.

A. Data Collection and Management - each of the districts has ongoing hydrologic data collection and management programs. These programs collect data on rainfall, evapotranspiration, surface water levels and flows, ground water levels, aquifer characteristics, water quality and water use, among other parameters. By improving consistency and exploring areas for improved efficiency and effectiveness, coordination between the districts can be beneficial to each district, as well as third parties which utilize district hydrologic data.

In order to increase efficiency and avoid unnecessary duplication of efforts, the Districts agree to cooperate as follows:

1. Coordination will be accomplished by a team of personnel from the Districts. The team shall cooperate closely with the Interdistrict Data Collection Focus Group and shall include technical staff from each district familiar with hydrologic data collection, databases, and GIS development, including at least one Data Collection Focus Group member from each district.

2. Hydrologic data contained within existing and/or future databases will be organized and sufficiently documented so that data can be easily shared by personnel of the Districts. Specific examples are listed below:

- Hydrologic, geologic, and water use permit information will be stored in databases that are available for access by appropriate district personnel.

- Geographic Information System (GIS) coverages will be shared.

Development and extension of hydrologic databases and networks will be coordinated by personnel of the Districts', with the goal being the development of a comprehensive water resources observation network.

3. Each of the districts has a number of hydrologic investigations and modeling efforts which extend beyond the boundaries of that particular district in order to encompass the entire water resource unit (e.g., an entire aquifer system) and/or to address factors which may have impacts upon the resource under investigation (e.g., water withdrawals outside of, but

influencing, a ground or surface water resource). The Districts agree to share all available existing hydrologic data, including but not limited to permitted withdrawal locations, amounts, water use types, and other related information in a form compatible with model requirements, as well as to coordinate in the collection of additional hydrologic data determined to be necessary for specific modeling purposes, for such hydrologic investigations which cross district boundaries.

4. The Districts will coordinate in the acquisition of data collection equipment and services in an effort to ensure compatibility and achieve monetary savings.

B. Hydrologic Modeling - A number of modeling efforts initiated by a particular district may transcend that district's boundaries and encompass a part of an adjacent district. It is necessary in such cases for the Districts to coordinate their respective hydrologic modeling efforts. Coordination will be aimed at assuring consistency in model development, data sets and results where model boundaries coincide or overlap.

In order to accomplish this coordination, the Districts agree to cooperate as follows:

1. Coordination will be accomplished by a team of personnel from the Districts comprised of staff members who are knowledgeable of the modeling efforts at their respective districts. The team shall meet at a minimum twice per year to review progress on specific modeling efforts and to seek input from other district team members. This coordination is in addition to coordination that may be ongoing between respective district staff involved in specific modeling efforts.

2. Coordination will include model conceptualization, selection of data points and parameters, review of calibration runs, and review of preliminary and final results, as appropriate. The Districts agree to subject each applicable modeling effort to peer review by appropriate staff from each district prior to finalization, with the common goal of a uniform interpretation. This coordination may include methodologies used to produce rainfall intensity/frequency/duration maps. Where differences result in discrepancies between model results in the vicinity of the Districts' common boundaries, the Districts shall seek to achieve consistency.

II. Water Supply Planning

Pursuant to Section 373.036(2), F.S., the Districts must, as a part of their District Water Management Plans, identify one or more water supply planning regions that singly or together encompass the entire district and prepare a Districtwide Water Supply Assessment. As part of the planning effort, the Districts are initiating water supply planning for their entire district or based upon the results of the assessments, limiting the planning area to areas where "*sources of water are not adequate for the planning period to supply water for all existing and projected reasonable-beneficial uses and to sustain the water resources and related natural systems*" subsection (373.0361(1), F.S.).

The purpose of this section is to seek consistency and coordination, as appropriate, among the Districts in these respective water supply planning initiatives. This consistency is particularly important within those local governments encompassed by more than one district as well as in other common boundary areas.

Geographic Area: The areas within which water supply planning coordination will be considered include all appropriate water supply planning regions or portions thereof within the Districts.

A. Coordination will be accomplished by a team of personnel from the Districts comprised of staff members who are knowledgeable of the water supply planning efforts at their respective district. The team shall meet at a minimum twice per year to review progress on water supply planning efforts and to seek input from other district team members.

B. In order to achieve consistency in water supply planning, the Districts agree to the following:

1. The Districts will make water use projections for their respective areas following the recommendations of the interdistrict Water Planning Coordination Group (created by DEP pursuant to Executive Order 96-297), Water Demand Projections Subcommittee, as reflected in its Final Report, dated April, 1998, as may be amended from time to time by consensus of the Districts. For all local governments divided by the Districts' boundaries, the appropriate districts will agree upon consistent population and water use estimates and projections.

2. The Districts will work together to jointly identify factors for consideration by each district when determining that regional water supply planning must be coordinated within an area and to develop consistent methods to be used to delineate the extent of the area for which planning will be coordinated.

3. When the Districts have determined that regional water supply planning must be coordinated within an area, the Districts agree to coordinate in the identification of water supply options for that area. The Districts will develop a strategy for performance of investigations of traditional and alternative water supply options and shall also cooperate in the development of joint implementation strategies for the identified water supply options.

4. When one of the Districts timely receives a complete application for funding of an alternative water supply project under subsection 373.1961(2), F.S. the district receiving the application shall consider as one factor, under its subsection 373.1961(2), F.S. program guidelines, another district's approval of funding for the same or a related alternative water supply project under its subsection 373.1961(2), F.S. program. This provision shall not obligate either district to provide funding for a water supply project located outside its boundaries.

C. In order to achieve consistency in water supply planning-related technical assistance to local governments, the Districts agree to do the following:

1. The Districts will coordinate with each other in their review of comprehensive plan amendments which involve any water supply issues which could impact another district, as follows:

a. The district receiving notification of a proposed comprehensive plan amendment involving any water supply issues which could impact another district, will notify the other district of receipt of the notice of the proposed change, and if requested, forward a copy of the pertinent information to the other district(s) upon receipt of the proposed amendment.

b. The Districts will coordinate in the preparation of comments to the Florida Department of Community Affairs (DCA) on comprehensive plan amendments of interest to each district. The district in which the change is proposed shall forward preliminary comments to the other district(s) in as timely a manner as possible prior to the date comments are due to the DCA. The district(s) receiving those preliminary comments shall respond with any recommended revisions or additional concerns in as timely a manner as possible.

c. In cases where a proposed amendment to a policy or land use designation directly involves lands which are divided by district boundaries, the appropriate districts will coordinate in developing their comments to the DCA, with each district forwarding their own comments to DCA. The coordination should consist of discussions between the districts and draft comments forwarded to each other in as timely a manner as possible prior to the deadline to send comments to DCA.

2. The Districts will coordinate in the provision of technical assistance to the local governments which are divided by water management district boundaries through the preparation and future updating of the Integrated Plan portions of each district's District Water Management Plan for each such county. Pursuant to this Memorandum of Understanding, the Districts agree to the division of responsibilities for the preparation and updating of these Integrated Plans as shown in Exhibit 1. In addition, the Districts agree to discuss major water resource projects and data with each other prior to delivery of that information to the affected local governments.

III. Water Use Regulation

Geographic Area: The area to be considered for water use regulation coordination purposes generally includes a five mile distance on either side of joint district boundaries (see Exhibit 2). In addition, for purposes of coordination between the SJRWMD and SFWMD, the area shall also include those parts of Osceola and Orange counties that lie within the boundaries of the respective districts.

A. Coordination will be accomplished by a team of personnel from the Districts comprised of staff members who are knowledgeable of the water use regulation efforts at their respective districts. The team shall meet at a minimum twice per year to review progress on water supply planning efforts and to seek input from other district team members.

B. In order to achieve a comprehensive review of proposed withdrawals of water within one water management district which may have impacts within one or more of the other districts, and in an effort to better protect the water resources of the state, within the geographic area defined above and delineated on Exhibit 2 as "water use regulation coordination area", the staff of the Districts will do the following for all proposed uses of groundwater from the Floridan aquifer equal to or greater than 1,000,000 gallons per day:

1. Whenever possible, the Districts shall notify each other prior to pre-application meetings and when requested, shall arrange a joint pre-application meeting between the affected district(s) and the applicant.

2. A copy of the Notice of Receipt of Application shall be provided to the commenting district(s), preferably no later than 7 days following actual receipt of the application. A copy of the application and supporting technical information together with the name and phone number of the reviewing hydrologist shall be included with the Notice.

3. Comments on the application should be provided to the reviewing district no later than 21 days following receipt of the application by the commenting district(s). The comments shall indicate whether a copy of subsequently submitted compliance information required under the permit is desired.

4. A copy of any correspondence between the reviewing district and the applicant should be provided to the commenting district(s) contemporaneously with either mailing or receipt. If any additional comments are necessitated by receipt of such correspondence, the commenting district(s) shall communicate these in as timely a manner as possible.

5. If comments are received from another district, these comments should be incorporated in any subsequent requests for additional information or in the staff report issued by the reviewing district, as appropriate and consistent with the reviewing district's rules.

6. A copy of the Notice of Intended or Proposed Agency Action, whichever is appropriate to the reviewing district, should be provided to the commenting district(s) contemporaneously with its provision to the applicant.

The Districts each agree to forward to the others' designated regulation contact person copies of staff reports or abstracts and actual permits (if substantially different from the staff recommendation) for all appropriate applications requesting uses of water equal to or greater than 100,000 gallons per day on an average annual basis. These documents should be provided contemporaneously with their provision to applicants.

The Districts each agree to forward monthly to the others' designated regulation contact person a copy of the Regulatory agenda, as revised at the Governing Board meeting. The agendas should be provided no later than 30 days after the Governing Board meeting date.

IV. Water Shortage Management

Geographic Area: The area to be included for water shortage management coordination is depicted in Exhibit 3.

In order to enhance the effectiveness of current and future water shortage declarations and to enhance interdistrict efficiency by avoiding unnecessary duplication of related efforts, the Districts agree to cooperate as follows:

A. Coordination will be accomplished by a team of personnel from the Districts who are familiar with each district's respective water shortage programs. This staff team will meet on a regular and as-needed basis.

B. Each district will provide the following information to the two other districts: a detailed description of the factors currently monitored to determine whether to declare a water shortage (i.e., specific hydrologic conditions, water demand, and other data), a schedule which indicates the frequency at which each of these factors is collected and analyzed, and a description of the committee or other staff arrangement which currently conducts the monitoring and analysis efforts.

C. The Districts will identify and implement appropriate means of coordinating these monitoring and analysis efforts. At a minimum, a mechanism for notifying one another of current monitoring and analysis results shall be established. When applicable, databases included or analogous to those described in the "Water Resource Investigations" and "Water Supply Planning" sections of this Memorandum of Understanding will be utilized.

D. The Districts will establish a mechanism for notifying one another of recommended and adopted water shortage orders (declarations, modifications and rescissions). At a minimum, this mechanism should fulfill the following coordination needs:

1. Any recommendation for a Governing Board issued water shortage order or emergency order, notification shall, whenever practicable, occur prior to the applicable Governing Board meeting; and

2. Any adopted Governing Board order or emergency order; timely transmittal of the signed order and samples of related permittee and/or public communication materials as soon as available.

E. The Districts will respond to each notification or transmittal (described in paragraph number 4 above), by providing any comments in as timely a manner as possible.

V. General Provisions

In order to ensure the orderly administration of this MOU, the staff of the Districts will do the following:

A. The Districts' executive directors will each designate in writing one position for each of the four areas of coordination, including Water Resource Investigations, Water Supply Planning, Water Use Regulation and Water Shortage Management, to oversee the administration of this MOU. These staff shall also serve as the principal contact persons for the districts under this MOU.

B. The Districts shall meet in April and October of each year to assess compliance with this MOU and its effectiveness in achieving the above-stated purposes and goals. Any concerns with the language of the MOU or problems with implementation may also be addressed at these meetings.

C. The responsibility for the meeting arrangements shall be rotated annually amongst the Districts, beginning with St. Johns.

D. This MOU may be amended in writing by mutual agreement of the Districts. Any district may terminate its participation in this MOU by providing 60 days written notice to the other.

E. Nothing herein should be construed to conflict with any requirement of Chapter 373, F.S., or water management district rules.

AGREED TO this 28th day of October, 1998.

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT GOVERNING BOARD

BY: ______________________
JAMES DANIEL ROACH
CHAIRMAN

BY: ______________________
OTIS MASON
SECRETARY

SOUTH FLORIDA WATER MANAGEMENT DISTRICT GOVERNING BOARD

BY: ______________________
FRANK WILLIAMSON, JR.
CHAIRMAN

BY: ______________________
SAMUEL E. POOLE, III
SECRETARY

SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT GOVERNING BOARD

BY: ______________________
JIM ALLEN
CHAIRMAN

BY: ______________________
SALLY THOMPSON
SECRETARY

MEMORANDUM OF UNDERSTANDING

EXHIBIT 1

RESPONSIBILITIES FOR THE PREPARATION OF DISTRICT WATER MANAGEMENT PLAN INTEGRATED PLANS

COUNTY	LEAD AND SUPPORT DISTRICTS		
	SJRWMD	SFWMD	SWFWMD
Charlotte		Support	Lead
Highlands		Support	Lead
Lake	Lead		Support
Marion	Lead		Support
Okeechobee	Support	Lead	
Orange	Lead	Support	
Osceola	Support	Lead	
Polk	Support	Support	Lead

Exhibit 2
Water Use Regulation Coordination Area

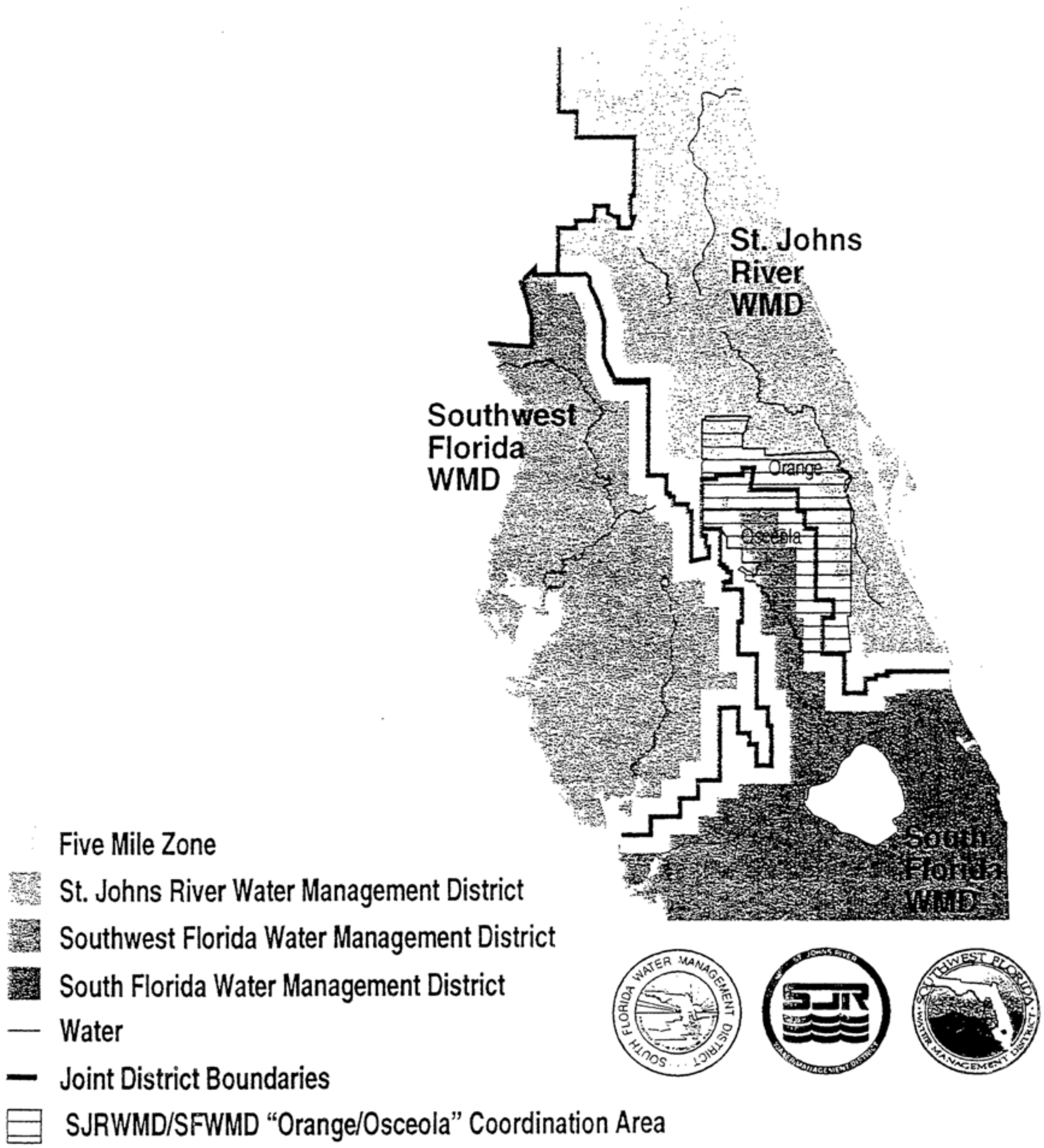

Exhibit 3
Water Shortage Coordination Area