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FINAL REPORT
DECISION MODELING FOR ALTERNATIVE WATER SUPPLY STRATEGIES

by

Carol Demas
Kirk Hatfield, Ph.D.
Donald Hearn, Ph.D.

Center for Applied Optimization
University of Florida
Gainesville, Florida

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EXECUTIVE SUMMARY

Due to the increasing demands placed on Florida's water resources, the state of Florida adopted legislation in 1989 to improve water resource management and to direct future growth through planning programs. This legislation requires each water management district to completely evaluate its water needs and sources through the year 2010 and delineate critical areas identified as water resource problems. Once completed, districts are expected to develop possible alternative water supply strategies which will correct or avoid adverse or otherwise unacceptable impacts associated with the development of water supplies.

The St. Johns River Water Management District (SJRWMD) has determined that projected increases in groundwater withdrawals between 1990 and 2010 could adversely impact native vegetation, ground water quality, and spring discharges. Due to these possible adverse impacts, SJRWMD is investigating the technical, economical, and environmental feasibility of alternative water supply strategies including the development of decision models for determining minimal cost water allocation schemes which incorporate water management constraints, environmental impact constraints, cost constraints, optimization of existing groundwater source withdrawals, and alternative sources including surface water from the St. Johns River, reclaimed water, and new public interconnects. Aquifer mitigation and avoidance of impacts, lower quality sources, and conservation rate structures have not yet been incorporated.

This report outlines the development and demonstration of linear programming optimization models and mixed integer decision models for water resource management. Many different water management objectives may be explored within a single model. Models have been developed for the east-central and Volusia County study areas. Results indicate that use of surface water, public supply utility interconnects, and limited use of reclaimed water (i.e., to satisfy public supply irrigation needs and agricultural demands) may avoid potential impacts to spring discharges, aquifer head loss, and sensitive wetland areas. Existing and alternative source sites, capacities, and cost data incorporated in the model are not intended to reflect final alternatives under consideration, but serve as an example for how the decision model works.

The Water Supply Decision Modeling Project is an extension of the contract with the University of Florida for a study of optimization modeling. The previous project entitled *Water Allocation and Quality*

Optimization Modeling sought to develop a systematic modeling method for determining optimum water supply strategies that satisfy various environmental and hydrological requirements based on existing sources. This method applied a combined optimization/simulation technique which incorporates the District's current ground water flow and transport simulation models for the study area. Several site specific water resource allocation optimization models were developed for Volusia County, Florida, and were executed to investigate a variety of management objectives. These optimization models incorporated both water quantity and quality aspects of water resource management to determine optimum ground water allocation strategies which satisfy future water service demands and minimize adverse environmental impacts at specified locations. The decision modeling presented herein extends the above described optimization modeling work by incorporating the identified alternative water supply strategies including the costs for alternative water supply components. These new components are logical additions which transformed the linear programming optimization models into mixed integer programming decision models capable of performing integrated resource management functions. This project demonstrated the use of optimization/decision modeling as a valuable tool for the management of water resources. Results presented in this report are for demonstration purposes only and are not intended to reflect realistic alternative water supply strategies.

OBJECTIVES

The overall objective of the Water Supply Decision Modeling Project is to develop models which will help guide the water resource developer and manager in the process of developing appropriate future water supplies alternatives. These models will provide a means for comparison of alternate water allocation strategies.

The water supply decision models were developed with the General Algebraic Model System (GAMS) software, which has been employed successfully in the prior optimization modeling efforts. An additional objective of this project was to determine the scale of problems which can be solved by GAMS using the computer facilities at the University of Florida and the DISTRICT. The water supply decision models are flexible with respect to management objectives and geographical area. This flexibility will allow managers to investigate many different management objectives in several areas with little or no modification to the models. Two of the more pertinent management objectives for investigation are 1) minimizing the total cost of providing water for a regional area while constraining the environmental impacts at sensitive areas and 2) minimizing the environmental impacts while calculating the cost of providing water. These two objectives along with other types of management objectives will be achievable with the Decision Modeling tool developed from this project.

LINEAR PROGRAMMING OPTIMIZATION MODELS

Three-dimensional linear programming optimization models were developed and applied to east-central Florida and Volusia County, Florida. The analysis revealed general trends in both regions. Both the east-central and Volusia models identified potential water resource problem areas, or public supply utility or agricultural demand areas having deficits subject to the specified environmental constraints. A deficit is the quantity of water needed to meet a demand which cannot be withdrawn from existing groundwater supplies without violating the specified environmental constraints. Deficits found by each model are strongly dependent upon environmental constraints.

EAST-CENTRAL RESULTS

The east-central model identifies optimum water allocations scenarios to meet 2010 demands by allowing a maximum 15% decrease in Upper Floridan head over areas with low potential for vegetative harm, an upper limit of 15% loss in spring discharge, and a specified 2% , 1%, or 0% loss in Upper Floridan heads over areas with high or moderate potential for vegetative harm.

The hydraulic response of the east-central region Upper Floridan aquifer was found to be very linear. Sanlando Springs and Apopka Springs were the most sensitive springs. The models revealed deficits totaling 140-170 MGD (24% -30% of the total projected year 2010 demand) over the east-central region. Most of the deficit occurs at the Orange County East, Orlando Utilities Commission, and Deltona public supply utility demand areas.

VOLUSIA COUNTY RESULTS

The Volusia model also identified water allocation plans for meeting projected year 2010 demands permitting 15% allowable decreases in surficial aquifer head over areas with low potential for vegetative harm, an upper limit of 15% loss in spring discharges, and finally, a specified 2%, 1%, or 0% loss in surficial aquifer head over areas with high or moderate potential for vegetative harm.

The Volusia model's surficial aquifer response was not as linear as the Upper Floridan response in the east-central model; however, an additional set of influence coefficients could be generated for each environmental constraint case examined. Finally, the model results were found to be strongly dependent on the proximity to areas with a high potential for vegetative harm and relatively independent of the proximity to springs. This may be due to the coarseness of the simulation model grid in the Blue/Gemini Springs area.

Optimization modeling in the Volusia region revealed total deficits of 15-38 MGD (13%-32% of the total projected year 2010 demand). Public supply utility demand areas which displayed large deficits included Deltona, Port Orange West, Daytona Beach East, and Daytona Beach West. Thus, these areas may be good candidates for alternative water supply strategies to meet part of their projected year 2010 water demands

CONCLUSIONS

The results of linear programming optimization modeling over both regions will change considerably when constraints based on the aquifer thickness of potable water or different vegetative harm constraints are incorporated. However, the results presented in this report provide a general overview of how the models work in their specific areas.

RECOMMENDATIONS

For both the East-central and Volusia regions, additional model runs may be advised with some of the following recommendations:

- Capacities should be eliminated for each demand area in order to determine the fullest extent of water availability at each location based on hydrology and environmental constraints as opposed to existing well/treatment plant conditions
- Constraints should be added which preclude saltwater intrusion
- The GIS vegetative harm analysis should be expanded to cover entire simulation model areas and not just areas within SJRWMD boundaries
- Use of minimum flows for springs and lakes should be incorporated as they are adopted by SJRWMD in lieu of a non-specific percent decrease

SIMULATION MODELS

As part of the contract with the University of Florida it was required to assess the accuracy of the present MODFLOW simulation models and the sensitivity of model results to boundary locations and conditions, cell sizes, and solution techniques.

BOUNDARY LOCATIONS AND CONDITIONS

Current boundaries in the east-central model may be problematic for large-scale optimization modeling efforts. Though many wells withdrawal in the northwest portion of east-central region which includes Leesburg, Mt. Dora, and Tavares, these areas are not included in their entirety in the present grid. Also, the northern boundary cuts through the southern part of Deland, and could give better results if it were expanded northward by several miles. The Deltona area is in the northernmost part of the east-central grid and the southernmost part of the Volusia grid. Additional study of results in these areas may be necessary to ascertain the potential problems due to present boundary placement.

The southern boundary of the Volusia model poses the same potential problems as the northern boundary of the east-central region. Other boundary locations did not present potential or existing problems.

GRID CELL SIZE

Nonlinearities in the aquifer response may be overcome by generating influence coefficients using a strategy that perturbs well flows around the optimal well withdrawal scheme selected by the models. Since the most frequently chosen well withdrawal rate is zero, an optimal strategy for calculating influence coefficients should select to perturb well flows near zero to obtain minimum errors. Experience has shown that errors are largest at locations where a high density of wells exist. Future simulation model grids may offer enhanced accuracy if they are refined to contain no more than one well per cell, particularly in the Daytona Beach West, Port Orange West, and Deltona demand areas. These environmentally sensitive areas are either 1) classified as having a high potential for vegetative harm, or 2) near springs with critical flow constraints. Other locations exhibited an excellent linear aquifer response.

SOLUTION TECHNIQUES

It is recommended to use a conjugate gradient method solver (PCG2) with preconditioning or the newer, more efficient *Orthomin* solver available for use with MODFLOW96 (McDonald and Harbaugh, 1996) for generating the surficial aquifer layer influence coefficients of the Volusia model. This solver may offer a more computationally efficient matrix solution than the currently used Strongly Implicit Procedure (SIP) solver.

DECISION MODELS

Three-dimensional mixed-integer groundwater management decision models have been developed and applied to east-central and Volusia County, Florida. These models extend the linear programming formulation to include the costs of decisions regarding alternative water supplies. Alternative water supplies and their associated costs were investigated by consultants to SJRWMD. The alternatives included in this study were surface water, reclaimed water, interconnects between public supply utility demand areas, and new well development proposed by public supply utility areas.

The alternative supplies selected by each examined case are strongly dependent upon environmental constraints. The results presented in this report provide a general overview of how the models work in their specific areas. A number of alternative sources remain to be incorporated including lower quality sources, artificial recharge, aquifer mitigation/avoidance of impacts, and lower quality irrigation wells.

COSTS

Fixed and unit costs for existing and alternative water supply strategies were provided by consultants and were evaluated within the models. The cost data were provided on cost per thousand gallons basis in most cases. The models seek minimal cost solutions to water supply problems which meet all specified environmental protection constraints while satisfying public supply utility, agricultural, and industrial water demands.

Fixed transport costs are not large compared to fixed surface water costs. However, the existing model formulation requires a separate physical pipeline for each public demand are supplied by surface water which results in an inefficient use of pipe. Future modeling efforts could include a more efficient surface water transportation network which will consist of a main pipeline with branches to appropriate public supply demand areas. This type of distribution system is likely to incur lower fixed and unit charges, though an equitable distribution of costs may be difficult to define.

EAST-CENTRAL RESULTS

Several general trends were evident. The decision models made extensive use of surface water as an alternative source in all examined cases. Total surface water use was 134, 166, and 187 MGD for cases with environmental loss limits of 2%, 1%, and 0% at areas with high or moderate potential for vegetative harm, respectively. Most surface water use was at the Apopka, Deltona, OUC, and Orange County WRWF public supply demand areas.

Reclaimed water for agricultural use was selected by only those citrus demand areas near Lake Apopka. This reclaimed use is due to the demand areas' proximity to Apopka Spring, which has displayed high variability in its flow measurements, ranging from a low of 28.4 cfs to a high of 70.4 cfs (Rao and Clapp, 1995). Decisions regarding model results in the vicinity of Apopka Spring should not overlook this uncertainty.

The east-central model also made considerable use of interconnects. Generally, the receivers of large quantities of surface water passed much of it on to demand areas in the central and eastern portions of the simulation model area. Existing (11-13 selected) and potential (7-9 selected) interconnects were selected, with flow rates of up to 5 MGD in existing interconnects. Potential interconnects generally supported higher flow rates. The model may not capture sufficient detail with regard to interconnects in all areas. OUC, in particular, deserves additional attention as to potential interconnects, as a decision model with more detail at OUC alone may help to ascertain the lowest cost interconnect options. The precise scheme of existing interconnects within OUC, to OUC, and from OUC was not available for this study.

The alternative sources selected by each case are strongly dependent upon environmental constraints. The east-central model uses a 15% allowable decrease in Upper Floridan head at control points with low potential for vegetative harm, and a 15% allowable reduction in spring discharge. The model required that a 2%,1% or 0% loss limit be specified at Upper Floridan control points having high or moderate potential for vegetative harm. Environmental loss constraints could be revised to reflect potential for vegetative harm throughout the entire active portion of the east-central study area. Though the vegetative harm analysis was available for the portion of the east-central region within SJRWMD boundaries, better results would be obtained with a complete analysis throughout the entire active portion of the region. In addition, constraints to preclude saltwater intrusion should be incorporated in future decision model efforts and may significantly alter the resulting optimal solution.

Agricultural demands are not projected to increase from 1988. In addition, agricultural use comprises only a small fraction of the total projected water demand in the study areas. For these reasons, agricultural demands do not play a large part in the decision model. Thus, future modeling efforts may benefit from 1)eliminating the optimization of agricultural well withdrawals and 2)eliminating alternative sources for agricultural use such as reclaimed water. This would allow for a corresponding increase in detail and available alternatives at public supply demand areas.

The results presented in this report provide a general overview of how the models work in their specific areas. A number of alternative sources remain to be incorporated including lower quality sources, artificial recharge, and aquifer mitigation/avoidance of impacts.

VOLUSIA COUNTY RESULTS

Preliminary results show that the primary alternative source in Volusia County could be surface water from the St. Johns River near Sanford and DeLand with some use of interconnects and reclaimed water.

Total surface water use was 12, 24, and 46 MGD for the examined cases having 2%, 1%, and 0% surficial head loss limits from 1988 at areas with high or moderate potential for vegetative harm. Very little reclaimed water was used, either for fern growing agricultural areas or public supply demand area irrigation. From 2-3 new interconnects were selected, while 7-8 existing interconnects were selected in the three examined cases. The public supply demand areas making the greatest use of surface water were Daytona Beach West, Port Orange West, Deltona, DeLand, and Orange City. Generally, the large receivers of surface water passed on this water to demand areas in the central portions of the simulation model area which has a high potential for vegetative harm, such as the Port Orange West and Daytona Beach West demand areas. These results would be expected to change considerably when further analysis regarding potential for vegetative harm and saltwater intrusion are considered.

As with the east-central area model, results were highly sensitive to environmental constraints. It is notable that the optimum alternative water supply strategies for Deltona were similar in both the east-central and Volusia applications.

CONCLUSIONS

The decision models provide insight as to the potential tradeoffs associated with the use of alternative sources, though results are strongly dependent on environmental restrictions and may change considerably. Using the mixed-integer models developed herein, a sensitivity analysis may be performed by making slight changes in allowable limits for environmental impact and/or the specification of high, moderate, or low potential for vegetative harm, and comparing the overall solutions. In changing the model to include a new objective function of minimizing both costs and drawdowns, one can develop a chart of minimal cost vs. minimal environmental impact solutions. With the data from several runs of varying environmental restrictions or cost criteria, water resources managers may assess the impacts and tradeoffs associated with competing schemes in order to evaluate which tradeoffs are acceptable.

The University will continue incorporating consultant and SJRWMD data into the decision model as it is made available. Alternative sources including lower quality sources, artificial recharge, and avoidance of impacts/mitigation have yet to be incorporated.

RECOMMENDATIONS

The specification of a particular control point's potential for vegetative harm is critical. Specifying high or low sensitivity at a particular point may result in a different optimal solution, as the decision model seeks alternative sources rather than depressing water levels at a highly sensitive control point. A number of different runs with varying environmental sensitivities should be pursued before making definitive statements about alternative source use in the study areas.

A decision model run without well capacities should be performed to determine the best current and proposed well sites. A number of alternative sources remain to be incorporated including lower quality sources, artificial recharge, and aquifer mitigation/avoidance of impacts. The use of alternative sources would decrease if well capacities were increased at certain locations.

Constraints precluding saltwater intrusion should be incorporated and are certain to yield different results. Additional new well development should also be included in future models as new wells may provide a considerably lower-cost option to the alternatives heretofore considered.

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INTRODUCTION

The St. Johns River Water Management District has determined that projected increases in groundwater withdrawals between 1990 and 2010 could adversely impact native vegetation, groundwater quality, and spring discharges. SJRWMD is investigating the technical, environmental, and economic feasibility of alternative water supply strategies which will avoid or minimize these adverse impacts. Alternative Water supply studies include the development of decision models for determining minimal cost water allocation strategies which incorporate water management constraints, environmental impact constraints, cost constraints, optimization of existing groundwater source withdrawals, and alternative water supplies.

In east-central Florida and Volusia County, public supply demands are expected to double between 1988 and 2010. Current plans are to meet this demand with additional groundwater withdrawals from the Floridan Aquifer system. This increased demand and additional groundwater withdrawals are expected to result in water resource problems related to native vegetation, spring discharges, and salt water intrusion. Many water allocation schemes could be identified which meet individual user needs but fail to satisfy all of the district's regional water management goals or to consider the cumulative impacts of individual users.

This report outlines the use of mathematical programming to develop a tool to assist water managers in water resource allocation decisions. Both linear and mixed integer formulations are used. The linear programming optimization model uses a linear programming formulation to identify and quantify potential water deficits associated with water supply service areas. The mixed integer decision model presented provides a systematic method for determining water resource allocation strategies while maintaining environmental protection goals at minimal annualized costs. The models were developed with the widely used three-dimensional groundwater simulation model MODFLOW (McDonald and Harbaugh, 1988), the General Algebraic Modeling System (GAMS, Brooke et al., 1996) and solved with the CPLEX (*CPLEX*, 1996) linear and mixed integer programming solvers. The surficial and Upper Floridan aquifer and spring discharge response to changes in well withdrawal rates were simulated using the unit response matrix approach under the assumption that the principal of superposition is applicable. The coefficients of the unit response matrix describe the relationship between stresses (well withdrawal rates) and drawdown and at specified locations of interests; control points and springs. The models were applied to the regions of east-central Florida and Volusia County, Florida, to help identify potential water resource problem areas and the appropriate course of action required to avert these problems.

PURPOSE AND SCOPE

Due to the increasing demands placed on Florida's water resources, the state of Florida adopted legislation in 1989 to improve water resource management and to direct future growth through planning programs. This legislation requires each water management district to completely evaluate its water needs and sources through the year 2010 and delineate critical areas identified as water resource problems. Districts are expected to develop possible alternative water supply strategies which will correct or avoid adverse or otherwise unacceptable impacts associated with the development of water supplies. The Water Supply Decision Modeling Project is designed to assist the St. Johns River Water Management District (DISTRICT) in developing acceptable water supply scenarios. The purpose of this project is to demonstrate the use of decision modeling as an efficient tool for water resource management whereas the scope of this project is limited to examining water allocation scenarios given available resources only on a macroscale and subject to computer hardware and software limitations.

The decision models will help guide water resource managers in the process of developing appropriate future water supplies alternatives. These models will provide a means for comparison of alternate water allocation strategies.

The Water Supply Decision Modeling Project is an extension of the contract with the University of Florida for a study of optimization modeling. The previous project entitled *Water Allocation and Quality Optimization Modeling* (Burger et al., 1996) sought to develop a systematic modeling method for determining optimum water supply strategies that satisfy various environmental and hydrological requirements based on existing sources. This method applied a combined optimization/simulation technique which incorporates SJRWMD current ground water flow simulation models for the study area. Several site specific water resource allocation optimization models were developed for Volusia County, Florida, and were executed to investigate a variety of management objectives. These optimization models incorporated both water quantity and quality aspects of water resource management to determine optimum ground water allocation strategies which satisfy future water service demands and minimize adverse environmental impacts at specified locations. This project demonstrated the use of optimization modeling as a valuable tool for the management of water resources.

The Water Supply Decision Modeling Project extends the optimization modeling work by incorporating alternative water supply strategies including the costs for the identified alternative components. These new components in the water supply decision model are logical additions to the optimization model and will enhance its ability to perform integrated resource management functions.

The water supply decision models are developed with the General Algebraic Model System (GAMS) software, which has been employed successfully in the prior optimization modeling effort. An additional objective of this project is to determine the scale of problems which can be solved by GAMS using the computer facilities at the University of Florida and the DISTRICT. The water supply decision models are flexible with respect to management objectives and geographical area. This flexibility allows managers to investigate many different management objectives in several areas with little or no modification to the models. The management objective for investigation is to minimizing the total cost of providing water for a regional area while constraining the environmental impacts at sensitive areas.

REVIEW OF CURRENT LITERATURE

INTRODUCTION

Groundwater management models and other decision support systems have been using mathematical programming to simulate and optimize the management of aquifer systems for over thirty years. Loucks (1995) defines a decision support system (DSS) as a computer based model together with active interfaces. Decision support systems can include optimization and simulation models and geographic information systems as well as statistical and graphical packages for data analysis and display. These systems should include the following characteristics: Consistency of data entry transactions, minimal user entry actions, memory load, and learning time, compatibility of data entry with data display, and flexibility for data entry and display for supporting different user requirements and needs.

Some models are used for resource management with the mathematical program designed to minimize cost subject to quality and/or allocation constraints. Other models are useful for evaluating policy while mathematical programs are used to quantify environmental impact. Mathematical programming models consist of a set of decision variables, a set of equations constraining the decision variables, and an objective function which is optimized (maximized or minimized). Linear programming (LP) is a subset of mathematical programming wherein the constraints are linear functions of the decision variables. If the constraints are not linear functions of the decision variables the program is nonlinear (NLP). Integer programming restricts the variables to be binary valued, 0 or 1. A program that contains both integer and non-integer variables is denoted a mixed integer program (MIP). An LP model that has capacity expansion options can easily be extended to an MIP model by adding a binary decision variable for each option. A mathematical program that has uncertain parameters is termed a stochastic program. Chance constraining, a method of stochastic programming for allowing uncertainties in the equations, is commonly used in environmental control problems. Dynamic programming (DP) adds the dimension of time and state variables. Multiobjective programming (MOP) allows for more than one objective function.

LINEAR AND NONLINEAR PROGRAMMING

The first incidence of LP in the field of water resources was in 1962 (Lynn et al. (1962)). They sought to minimize the cost of a sewage treatment system. This work was followed by a rapid succession of similar studies of both LP and NLP models. Most of the early papers were for surface water quality control. Aguado's work (1974) was the first for groundwater systems. Aguado used a finite difference approximation of the equations describing 2-d horizontal steady-state groundwater flow as continuity constraints in an LP. His decision variables were h (groundwater head) and Q (groundwater flux). In addition to the discretized groundwater flow equations, Aguado's LP included a set of constraints on required discharge/recharge rates and an objective function which maximized head values. Aguado's work reflects the first of many efforts by several investigators to 'embed' discretized groundwater flow equations into the constraint sets of LP and NLP models. The embedded approach actually solves the system of equations of a numerical flow or transport model; thus this approach is desirable for those situations in which pumping is a decision variable over most of the discretized study area and when hydraulic head is constrained at multiple locations to investigate sustainable groundwater yield strategies. Alley et al. (1976) extended Aguado's technique in their investigation of aquifer management under steady state and transient conditions using the embedded method and LP for a problem with non-uniform transmissivity.

Willis et al. (1977) presented a Galerkin-type finite element method embedded technique with policy alternatives for well locations and pumping rates and state variables determined simultaneously in the optimization procedure. The model solves a succession of linear programming problems that arise from linearization of the concave objective function using a Taylor series expansion about an initial feasible decision vector. Linear subproblems are solved until there is no longer improvement in the solution.

In another use of the embedded technique, Yazicigil and Rasheeduddin (1987) used the method to determine optimal groundwater management schemes under transient and steady state conditions for a multi-aquifer system using multiobjective analysis. They report that the embedding technique suffers from numerical difficulties when applied to large-scale real world problems, particularly when commercial LP solvers are used to solve the banded matrices.

Greenburg (1995) in his comprehensive survey of mathematical programming for environmental quality control, states that the embedded approach used by Aguado may not be the best method for solving groundwater resource problems. This is because the method directly solves the discretized groundwater flow equations where hydraulic heads and decision variables at all cells of a numerically discretized management area; thus the scale of the optimization problem increases rapidly as the scale of the study area expands. Further, Greenburg suggests that the embedded technique requires a constant transmissivity, or at least very small variations within an area. The embedded method of Aguado (1974) has the potential for being an efficient way to solve the problem of water resource allocation and decision making, particularly if an advanced solution technique is employed which exploits the matrix structure. Algorithms used to solve large scale optimization problems include decomposition methods, Lagrangean relaxation methods, and interior point methods.

Previous efforts (Burger et al. (1995), Demas and Burger (1995)) in optimization modeling for the SJRWMD focused on the combined simulation/optimization approach, a powerful method in that it is capable of incorporating economic, physical and policy considerations within a single environment. The simulation equations assure that the management model correctly emulates the aquifer response to internal and external fluxes.

The combined simulation-optimization approach does not solve numerical equations from a flow or transport model but requires that a unit response matrix be generated and then embedded in the constraint set of the optimization model. This matrix contains influence coefficients which describe the rate of change of aquifer response (i.e. drawdown) to aquifer stresses such as pumping or recharge at multiple locations.

To generate the influence coefficients of the unit response matrix, a simulation model must be run once for each decision well in the optimization or decision model. Thus, the unit matrix response approach requires greater computational demands to construct the decision model than does the 'embedded' approach, where most of the computational expense is tied to solving the resultant decision model. It is important to note that simulation models alone predict heads and fluxes resulting from specified pumping rates and boundary conditions, whereas decision models constructed with either the unit matrix response or the embedded method are able to determine optimum pumping schemes while simultaneously simulating aquifer responses at multiple locations.

ADVANCED SOLUTION TECHNIQUES

Decomposition strategies described by Taha (1992) have been used to formulate and manage large-scale models. The main advantage to decomposition is efficiency. Via decomposition, it may be possible to solve large-scale problems that would otherwise be computationally infeasible. The structure of a large problem may allow the optimal solution to be determined by decomposing the problem into a group of common constraints and several independent subproblems. Sometimes decomposition separates certain controls from their effects, i.e., water service area or spring constraints can be separated from their effects (the discretized equation of ground water flow). The model can be separated into linear (or almost linear) and nonlinear portions and recoupled.

Studies in environmental economics serve as a complement to the engineering approaches of environmental control. Environmental economics studies may utilize Lagrangean relaxation, a method described by Fisher (1985). Lagrangean relaxation is a tool that is increasingly being used in large-scale mathematical programming applications. The idea is that a difficult integer programming problem may be modeled as an easier problem complicated by a set of side constraints. The problems of formulating a Lagrangean system are the following: which constraints should be relaxed, how multipliers are computed, and how a good feasible solution to the original problem can be deduced from the relaxed problem. The choice of which constraints to relax can be an art, much like the formulation itself. In spite of the effort required to implement Lagrangean relaxation, the concept is growing in popularity because it can exploit certain problem structures and it may be the only option for solving very large problems. Ahlfeld et al. (1988) used the MINOS program of Murtaugh and Sanders (1977) which applied Robinson's projected Lagrangean algorithm for solving the problem of determining optimal contaminant groundwater strategies. They conclude that their method is computationally very expensive and unsuitable for sites with a large number of potential wells.

Another method suitable for solving large-scale problems is the interior point technique which may utilize a conjugate gradient method solver. The earliest and most commonly used solver for LP problems is the simplex method. The simplex method obtains the solution by moving along edges of the solution space that connects the adjacent corners of decision variables and the number of constraints. Though simplex methods have achieved success in solving large problems, it is possible for the solver to encounter all extreme points before the optimal solution is achieved. Attempts to improve the efficiency of solvers that cut across the interior of the solution space rather than along the edges were not successful until Karmarkar (1984) produced a polynomial-time interior point method. His algorithm is primarily of interest in solving extremely large problems. The interior point method requires preconditioning of the matrix. Conjugate gradient methods offer superior efficiency in that they avoid the problem of finding the inverse of the matrix. The problem with the conjugate gradient method is that the matrix must be preconditioned.

Doughtery (1991) applies simulated annealing to optimization of groundwater management problems cast in combinatorial form. This heuristic probabilistic optimization method seeks an optimal solution by analogy with the annealing of solids and is effective for solving some large scale problems. Computational limitations lead to almost optimal solutions in practice though the theory guarantees the existence of an optimal solution. As in most groundwater optimization methods, much of the computational effort lies in the flow and transport simulation portion of the code. The practical algorithmic guidance that yields significant computational savings can make this method competitive with gradient type methods.

Sawyer et al. (1995) investigated the problem of groundwater remediation design using MIP with MODFLOW (Donald and Harbaugh (1988)) and OSL (IBM Corp. (1995).) A branch-and-bound method was implemented because it has displayed success in solving large-scale problems. The branch-and-bound technique does not solve the integer problem directly. Instead, the integer problem is transformed into a continuous problem by relaxing the integer constraints before applying the branch-and-bound principle. Branching enables the elimination of the portion of the continuos space solution that is not feasible for the integer problem. The MIP was difficult to solve because of the large number of variables involved in the remediation problem. This study showed that the ratio of total operating costs to the total fixed charge costs (c/f) played a role in the enumeration and solution time involved in solving the problem. Problems with very high c/f ratios were the easiest to solve in MIP mode. Problems with very low c/f ratios were easy to solve but much harder to solve than problems with very high c/f ratios. A low c/f ratio results when the fixed charges are minimized. The most difficult problems to solve by MIP are those with intermediate c/f ratios. The difficulty increases as the ratio tends to unity. Since these most difficult intermediate c/f ratio problems are likely to be encountered in groundwater remediation or allocation problems, the authors suggest that massively parallel computers should be used to develop the response coefficients for large-scale three-dimensional groundwater problems and that the MIP program should run in a distributed mode over a network of computers.

Ahlfeld (1987) states that the computational resources required to solve a water resources allocation problem increase nonlinearly with the number of decision variables, a few percent with the number of constraints, and about log linearly with the criterion of the clean up method if one is used. Doubling the number of potential well sites more than doubles CPU requirements, but CPU time increases logarithmically as performance critera are tightened.

In a paper describing Hydrogeological Decision Analysis, Freeze et al. (1990) discuss the two usual components in decision analysis--a simulation model for ground water flow and transport, a decision model based on a risk-cost benefit objective function, and include an uncertainty model using Bayesian stochastic process theory that encompasses geological and parameter uncertainties. With uncertainty analysis, proposed site investigation programs may be assessed for worth prior to actually taking measurements. In their application paper (1991) they present two case studies involving 1)selecting a pumping rate for an extraction well to capture an existing contaminant plume, and 2) designing a leachate collection system for a soil remediation facility. Their design approach quantifies benefits, costs, and risks for each design alternative under consideration. They attempt to answer the questions as to how many measurements should be made and where the measurements should be located.

Gorelick (1983), in his survey of groundwater management modeling methods, states that improved hydraulic management models are needed to account for aquifer parameter uncertainty, that nonlinear constraints should be included in research endeavors, that a very broad spectrum of institutional factors and real system features should be included in policy evaluation and allocation models, and that techniques such as dynamic programming, multiobjective programming, multi-time period decomposition, semi-infinite programming, and many nonlinear programming methods be joined with simulation models.

Some NLP approaches have been taken by Gorelick (1990), Gorelick et al. (1994) and Ahlfeld and Mulvey (1987). Typically the NLP approach is pursued when it is desired to improve a model's accuracy. A simulation model may include nonlinear functions to describe recharge/discharge from the surficial layer which in turn would be more accurately represented by a nonlinear programming method.

The quality or correctness of the optimization or decision model depends on the data that it utilizes. Several investigators report disparate results for measured high and low values of transmissivity in both the upper and lower aquifers for the East-Central Florida region (Tibbals (1990). CH2M HILL (1988), Jammal & Associates (1990), GeoTrans (1991)). Aguado, Sitar, and Remson (1977) perfomed a sensitivity analysis on an embedded aquifer management problem and determined that the optimal solution is more sensitive to changes in hydraulic conductivity than boundary heads. For their problem it was very important to have accurate knowledge of hydraulic conductivity in the model.

MULTIOBJECTIVE PROGRAMMING

Methods for multiobjective decision support require the use of a decision rule which is a set of rules that facilitates the ranking of alternatives. Evaluation methods may generate complete rankings, best alternatives, a set of acceptable alternatives, or an incomplete ranking of alternatives. The multiattribute utility model is the simplest and most widely used decision rule. It consists of a sum of objectives multiplied by weighted parameters. Janssen (1992) provides a survey of multiobjective decision support methods for environmental management.

Bleed et al. (1990) used decision making processes in two case studies to attempt to allocate water on large scale river systems in two countries. Both implementation plans failed as they were blocked by conflicts between those who wanted to use the river for irrigation, municipal purposes, or hydropower, and those who wished to preserve it for fish and wildlife. In the two river systems studied, the Danube and the Platte, the river systems cross important governmental boundaries, and as a consequence, complicated decision making. Many levels of government entities were involved. The decision makers had conflicting goals. Basin-wide planning and the development of alternative plans that would give decision makers a range of development options were only marginally used in the decision process, and no compromises were approved for implementation. In both cases public involvement was deemed insufficient in the early stages of planning. Effective decision making requires properly defined objectives, a specification of the social preferences assigned to each objective, a means to evaluate the performances of alternatives with respect to each objective, mechanisms to include the major stake holders in the decision making-process, completely understandable procedures for displaying tradeoffs and identifying compromise solutions, risk assessment for environmental and economic impacts, flexibility, and trust that a good faith effort is being made to arrive at a mutually acceptable solution. The major institutional requirements for effective decision making include extensive and well-defined procedures for securing and responding to public input throughout the planning and development process, and a lead organization that has the authority to address the full range of options, to engage all affected parties in negotiation, and to implement the politically chosen solution.

In his survey paper, Hipel (1992) discusses the effectiveness of applying multiobjective decision making to many different water resources problems for assisting in making informed decisions in water resources management. In a multiobjective decision method there can be several decision makers and several objectives for each decision maker, probabilistic, deterministic, or fuzzy information. The models may be static or dynamic. Ejaz et al. (1995) presented a combined simulation/optimization method for incorporating surface water quality constraints with simulation/optimization models using MODFLOW, a stream flow routing package, multiobjective programming (MOP), and the unit response matrix technique. Their method provided a means for addressing conflicts between optimizing water use and waste loading.

Roy et al. (1992) developed and demonstrated the use of multicriteria programming of water supply systems for rural areas. The problem can be decomposed into two subproblems: setting up the priority of water users and choosing the best variant of the water supply system. The relevant socio-economic criteria they evaluated included water deficiencies in areas, farm production potentials, functions and activities of the users, structures of the settlements of the areas, water demands, shares of water supply installations in overall investments, and possibilities for new interconnects between water supply systems. They utilized ELECTRE III to evaluate the priority order of users. The ELECTRE multicriterion method (Roy (1985)) uses information expressed in a fuzzy (threshold values are employed rather than one value for a parameter) context so that imprecise measurements may be used. It also employs the concepts of concordance and discordance in its search procedures for isolating the set of preferred alternatives. Because their model maintained a proper balance between the range of the decision problem and the precision of the its mathematical model they were successful in providing a simple method of determining the best water supply system for rural areas.

SUMMARY

The combined simulation/optimization approach has enjoyed use for several decades. There are two types of combined methods: the unit matrix response method and the embedded method.

The embedded method has discretized equations for groundwater flow evaluated at each node or cell of the model. These equations are evaluated as constraints in the model. Many problems of the LP, NLP, and MIP types have been solved using this method. There is a large increased dimensionality associated with embedding. The embedded method accurately simulates the aquifer response to changes in well discharge rates. It also avoids the problems associated with iterating between simulation and optimization models and has none of the nonlinearities inherent in the development of the influence coefficients. Large-scale problems may be solved by the embedded approach, but the most efficient solution techniques require special development. The embedded approach is better suited to smaller, more regular aquifer systems, particularly steady-state management problems.

The unit matrix response approach is easily utilized for large scale water management problems. Equations of the aquifer's response to a change in stimuli (pumping) are needed only at the control points deemed of interest. Thus the dimensionality of the problem is greatly reduced as compared to the embedded method. Significant computational effort is required to evaluate the influence coefficients. It may be difficult to generate a perturbation scheme that allows for a truly linear response.

Mixed integer programming has been successfully applied to the solution of water management problems in both embedded and unit matrix response methods. As the number of binary variables increases, so does the difficulty in obtaining an efficient solution.

The unit matrix response method has displayed success in previous modeling efforts. Because of the reduced dimensionality associated with this method, a larger number of binary variables may be used in the decision model. One of the study objectives is to investigate as many options for alternate water sources as computer resources and time allow. Thus, considering available hardware and software resources, the unit response matrix method is the method of choice for this endeavor.

Multiobjective decision models were investigated. There is an increased level of complexity associated with this type of modeling. The GAMS software does not have built-in multiobjective capabilities though the results of models with alternative objective functions could be compared. True multiobjective modeling is beyond the scope of this project, but it may be of interest to pursue in future decision modeling efforts.

In conclusion, decision models in the literature emphasize the need for cooperation at all levels and an adequate representation of the data, properly defined objectives, a means to evaluate the performances of alternatives with respect to each objective, mechanisms to include the major stake holders in the decision making process, understandable procedures for displaying tradeoffs and identifying compromise solutions, risk assessment for environmental and economic impacts, flexibility, and trust that effort is being made to arrive at a mutually acceptable solution. Effective decision making requires extensive and well-defined procedures for securing and responding to public input throughout the planning and development process, and a lead organization that has the authority to address the full range of options, to engage all affected parties in negotiation, and to implement the chosen solution.

BACKGROUND

MATHEMATICAL PROGRAMMING

An optimization model consists of an *objective function,* or quantity that is to be minimized or maximized, and a number of *constraints* or conditions that must be satisfied. In linear programming (LP) problems, all of the variables or unknowns in the model are continuous. Linear programming solves the problem of allocating resources among competing users in an optimal manner. Among the various possible ways of allocating given resources, the scheme which will minimize or maximize a specified objective function is chosen. The general linear programming problem is as follows: given a linear set of inequalities or equations, find values of the variables which minimize or maximize some linear function of the variables while satisfying the linear constraints, i.e. determine the values of the r decision variables x_i $(i = 1, ..., r)$ which will maximize (or minimize) the objective function z, or

$$z = c_1x_1 + c_2x_2 + \cdots + c_rx_r \tag{1}$$

subject to the m constraints

$$a_{i1}x_1 + a_{i2}x_2 + \cdots + a_{ir}x_r \ \{\geq, =, \leq\}\ b_i, \ \ i = 1, ..., m \tag{2}$$

where for each constraint one of the signs $\{\leq, =, \geq\}$ holds and a_{ij}, b_i, and c_j, are known constants. A set of x_j which satisfies the constraints is called a feasible solution. The feasible solution which yields the optimal value of the objective function is called the optimal solution. The objective is to select that particular solution or set of decision variable values which will optimize the objective function subject to the specified constraints. The x_j are the decision variables of the problem and may represent activites. When the c_j are costs associated with the x_j then z represents the total cost from operating the system at the activities x_j. Once a problem has been stated in standard linear programming form (equations 1 - 3) the usual algebraic procedure for solving it is the Simplex method (Dantzig, 1963). Several software programs are available for solving linear programming by modified and advanced Simplex methods.

A problem may be changed from minimizing an objective function to maximizing since Min z = -Max(-z). Each inequality constraint can be written as an equality constraint

$$a_{k1}x_1 + a_{k2}x_2 + \cdots + a_{kr}x_r + x_{r+1} = b_k \tag{3}$$

by adding a slack variable x_{r+1}. The dual price or shadow price of the ith constraint is a measure of the rate of increase of the objective function as the *i*th constraint is relaxed. This could mean an increase or decrease in the b_i value depending on the inequality. The reduced cost or marginal value applies to decision variables x_j, with $j \geq r+1$, whose optimal value is zero.

In many LP problems it is desirable to restrict some of the variables to integer values (e.g., a solution recommending 0.137 surface water sites would not be tolerated). The quality of the solution is markedly improved if the number of surface water sites is restricted to integer values. Further, a special type of integer value is a *binary* value which is restricted to take a value of either 1 (yes, build, go) or 0 (no, do not build, do not go). Binary variables can be used to represent decisions regarding alternative sources such as building new water treatment plants, drilling new wells, and laying down new interconnects. A mixed integer (MIP) formulation contains binary variables as well as continuous variables. Generally mixed integer problems are very difficult to solve. For an LP problem, the solution time is predictable with the time required to find a solution proportional to the number of variables and increasing as the square of the number of constraints. But with MIP formulations, as the number of binary variables increases, the solution time may increase dramatically. Even modestly sized MIP problems may make extensive CPU demands. Producing a good MIP formulation requires skill. The difference between a good formulation and a poor formulation may determine if the problem is solvable or not. One of the goals of the decision model is to include as much detail as possible regarding alternative source choices and costs within present computing constraints. Producing an efficient model formulation is critical to the success and quality of the model.

WATER RESOURCE ALLOCATION OPTIMIZATION

Optimization models were developed to investigate optimal allocation of ground water to meet year 2010 demand in the Volusia County and East Central Florida project areas. These models were developed to investigate future water allocation strategies that meet or exceed projected water service area demands and do not exceed available water resource supplies. It was assumed that adverse environmental effects could be minimized at specific locations by constraining pressure head changes (i.e. drawdown) and spring discharges losses to meet specified environmental goals. The models incorporated control points at which ground water levels changes were constrained. These points were in areas where native vegetation could be harmed by declines in the surficial aquifer due to pumping.

Optimization models were developed using data generated from numerical simulation models (e.g., information describing aquifer responses to changing stresses such as pumping). The modeling grids from the flow simulation models were incorporated in the formulations of all the optimization models . Information on needs and sources was also included in the formulation of each the optimization model. Elemental discharge rates and pressure heads given by each optimization model correspond to elemental cumulative discharges (from wells located in a grid cell) and elemental average pressure heads in associated cells defined in the flow simulation model. The term "well grid cells" refers to numerical model cells where one or more wells are located, and is used herein to denote that the optimization model identifies the cumulative well flows in each grid cell.

The general decision model formulation includes binary variables for build/do not build decisions as well as continuous variables for flow or use rates, heads, drawdowns, and costs. The decision model allows for a number of alternate water sources to be used in response to the increased public supply water demands projected for year 2010. The use of alternate water sources allows for decreased impact on surficial aquifer heads. The model objective function is now one of minimizing costs of water allocation strategies utilizing both existing and potential sources while constraining surficial aquifer drawdowns in areas of high, moderate, and low potential for vegetative harm. The model incorporates two types of cost constraints: initial *fixed* costs which are incurred when a new source must be constructed, and recurring *unit* costs, which are similar to operating and maintenance costs but include only those costs which are directly dependent on the flow or use rate of the source. For example, a technician's salary must be considered as part of the initial cost because the salary of a technician does not depend on the flow rate, while power and chemical costs are unit costs because they do depend on the flow rate. Fixed and unit charges are represented in the model on an annualized basis. Cost and other alternative source data were provided by consultants to SJRWMD.

ALTERNATIVE WATER SUPPLIES AND COSTS

Alternative water supplies investigated in the model include new public supply wells, reclaimed water for irrigation at public supply and agricultural areas, surface water, and new public supply interconnects. A brief description of each source is follows with ranges for annual fixed and unit charges.

Surface Water

Currently there are four surface water sites in the east-central region and two sites in the Volusia area. Surface water is considered for public supply use only. CH2M-Hill (1997) reported on surface water use feasibility and costs. The fixed costs of new surface water supplies range from $0.83-$1.478/1000 gallons, while the unit costs vary from $0.126-$0.194/1000, depending on the quality and quantity of surface water use.

Reclaimed Water

There are approximately 45 reclaimed water sites in the east-central region and 20 in the Volusia County area. Reclaimed water is an alternative water supply for irrigation needs of some public supply utility need areas, fern growing agricultural areas in Volusia County, and citrus growers in the east-central area. PBS&J (1997) reported on reclaimed water use feasibility and costs. The fixed costs of reclaimed water use vary from $1.41/ 1000 gallons for agricultural use in the Volusia region to $2.14 /1000 gallons for landscape irrigation at public demand areas, while the unit costs range from $0.36/1000 gallons for agricultural use to $0.47/1000 gallons for landcape irrigation at public demand areas.

Interconnects

Currently potential interconnects between public demand areas having projected year 2010 demands of over 5 MGD are considered in the east-central formulation (1 MGD in the Volusia area). LAW Engineering (1997) reported on interconnect feasibility and costs. Fixed charges for water transport vary from a low of $\$22{,}460L^{1.232}ADF^{0.43}$ for short systems to $\$43{,}180L^{0.935}ADF^{0.448}$ for long transport systems requiring more than one pump station, where L is the length in miles and ADF is the average daily flow rate in MGD. Unit charges of water transport are negligible for short transport systems and can reach $\$51{,}420ADF^{0.969}$ for long systems requiring more than one pump station.

PREVIOUS STUDIES

Several earlier studies using the combined LP optimization/simulation model approach are of note: Burger et al. (1995) investigated the Volusia subregional model and incorporated water quality constraints using a DSTRAM developed by Geraghty & Miller (1991) while Demas and Burger (1995) developed an optimization model for the east-central Florida region. These optimization models served as the basis for present model development.

HYDROGEOLOGIC FRAMEWORK

The location of the two study areas within SJRWMD is displayed in Figure 1 which corresponds to modeling studies performed by Hydrogeologic, Inc. (1992, 1994) and Williams (1996). A hydrogeologic cross-section of the Floridan Aquifer system in Figure 2. The two study areas are described below.

East-central Florida

The east-central Florida model includes all of Orlando and all or part of Lake, Seminole, Brevard, Volusia, and Osceola counties. Detailed descriptions of the area are found in Murray and Halford (1996), Tibbals (1990), and Tibbals and Frazee (1976). The source for water supply within the study area is the Floridan aquifer, one of the world's largest and most productive limestone aquifers, consisting of two distinct producing zones called the Upper Floridan and Lower Floridan aquifer systems. These two aquifers are separated by a layer of dolomitic limestone known as the middle semiconfining unit. At some locations the Upper Floridan aquifer is artesian, giving rise to 17 springs. The water quality of the Upper Floridan aquifer is generally of higher quality than that of the Lower Floridan aquifer and is the primary source of drinking water in the East-central region. Portions of the Lower Floridan aquifer are also tapped as a source of water in central and western Orange county, and in southern and south-western Seminole county. In the western portion of the east-central region, chloride, sulfate, and TDS concentrations in the Upper Floridan are below the secondary drinking water standards of 250, 250, and 500 mg/L respectively. Chloride and TDS concentrations in the Upper Floridan aquifer generally exceed secondary drinking water standards throughout Brevard county and in eastern Volusia county, where salt water exists within the Floridan aquifer system to a depth of 2,000 ft.

Volusia County

The Volusia hydrogeologic framework is discussed in detail in Williams (1996). The pertinent features are lakes, wetlands, and drainage patterns which have a direct impact on the hydrology of an active surficial system. Volusia County has about 120 lakes with areas of greater than 5 acres, mostly in karst ridge areas where high vertical hydraulic gradients and dissolution of carbonate rocks have allowed sinkholes to develop. Lakes are local points of relatively high recharge for the Upper Floridan aquifer which lies below. Wetlands provide surface storage during wet periods and can develop into recharge areas during dry seasons. They also serve as a valuable habitat for a variety of freshwater flora and fauna. Natural surface drainage is the second largest outflow after evapotranspiration

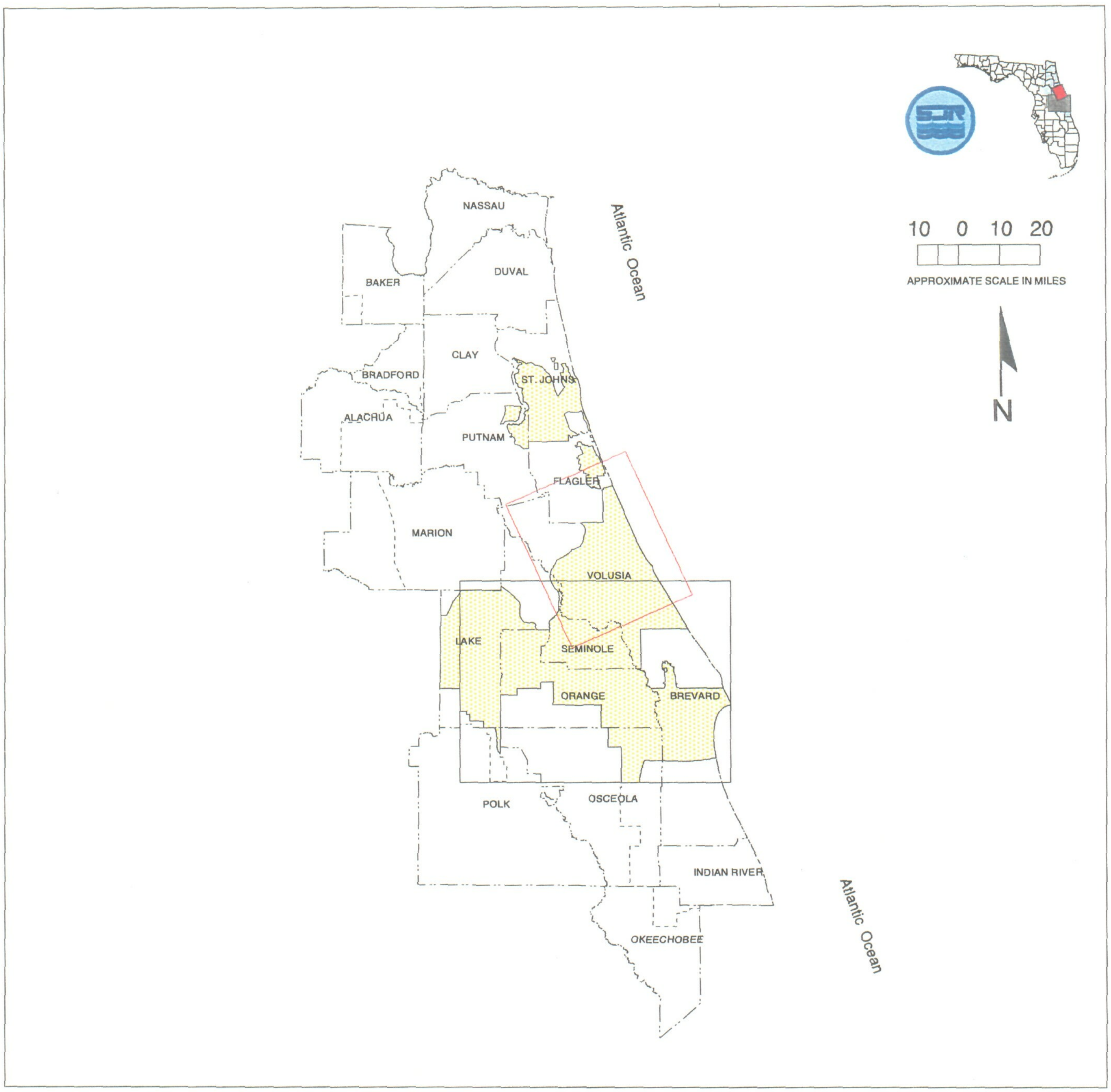
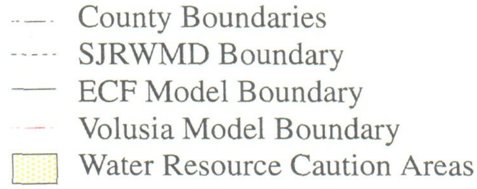


Figure 1

Location of East-central and Volusia models within the St. Johns River Water Management District with priority water resource Caution areas



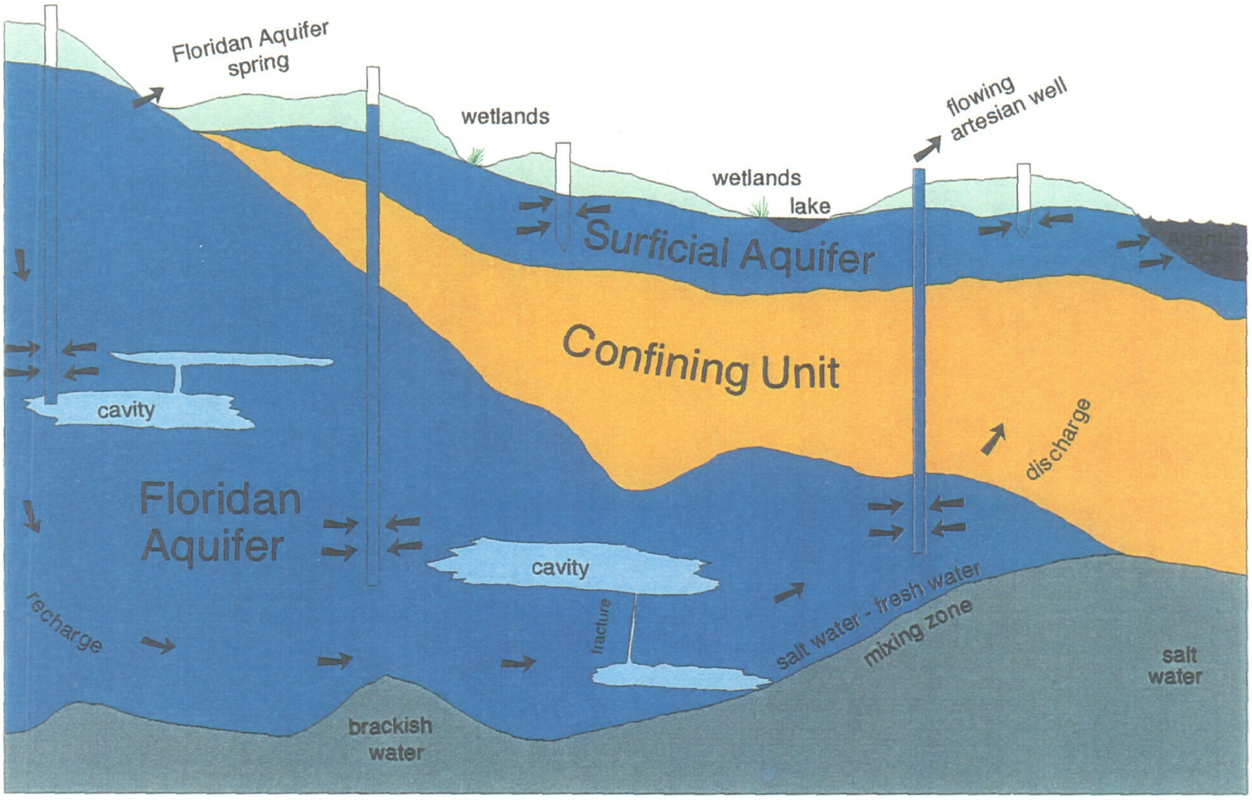


Figure 2. Hydrogeologic cross-section of the Floridan Aquifer system

from the surfical aquifer system. Most streamflow is outflow from the surficial aquifer system. Artificial drainage canals in Daytona Beach and Port Orange are responsible for large long-term declines in the elevation of the water table.

The study area consists of a series of coastal ridges and marine terraces. The main ridges are the Crescent City and De Land ridges in the western region and the Rima ridge and Atlantic Coast ridge on the coast. Almost all precipitation in karst areas drains downward or is lost to evapotranspiration. The soils vary from sandy soils of the coastal ridges which facilitate recharge to organic mucks in the wetlands and swamp lowlands which may inhibit recharge.

The hydrogeologic system consists of the surficial and Floridan aquifer systems. The surficial system is separated from the Floridan aquifer system by a sequence of confining sediments, as in the east-central region. The water quality of the Upper Floridan aquifer is generally of higher quality than the Lower Floridan and is used most often for water supply. The surficial aquifer system is critical to the overall hydrogeology of the Volusia region, serving as a storage reservoir for ground water that may eventually recharge to the Floridan aquifer system. The hydraulic conductivity of the surficial aquifer system is estimated at 4 to 110 ft/day in the northeast region and 25 to 30 ft/day in the rest of the region (Williams, 1996).

GROUNDWATER FLOW MODELS

The groundwater flow simulation model used is MODFLOW (McDonald and Harbaugh 1988) , which has been used and verified extensively in groundwater applications. The governing equation describing steady-state movement of an incompressible fluid through a porous media is

$$\frac{\partial}{\partial x}(Kxx\frac{\partial h}{\partial x})+\frac{\partial}{\partial y}(Kyy\frac{\partial h}{\partial y})+\frac{\partial}{\partial z}(Kzz\frac{\partial h}{\partial z})+W=0 \qquad (4)$$

where

Kxx, Kyy, and *Kzz* = values of hydraulic conductivity along the x, y, and z coordinate axes, which are assumed to be parallel to the primary axes of hydraulic conductivity (Lt^{-1})
h = potentiometric head (L)
W = volumetric flux per unit volume and represents sources and/or sinks of water including wells and springs (t^{-1})
t = time.

East-central Florida

A three-dimensional, finite-difference groundwater simulation model for east-central Florida was developed by HydroGeologic (1992). Specified head, head-dependent flux, and zero flux boundary conditions are employed. The model simulates spatially variable evapotranspiration, recharge, discharge, head-dependent spring flows, and outflow to agricultural and public supply utility wells. There are two active aquifer layers separated by a semiconfining unit. The finite-difference grid consists of 137 rows by 119 columns and 2 layers for a total of 32 606 cells of which only 27 802 are active due to boundary condition configurations. The smallest cells are 1 050 ft by 900 ft where the density of public supply wells is high, mostly in the Orlando metropolitan area.

Volusia

A three-dimensional finite-difference groundwater simulation model for Volusia County was developed by Williams (1996) of SJRWMD. The model incorporates an active surficial aquifer as well as the Upper and Lower Floridan aquifers. Specified head, head-dependent flux, and zero flux boundary conditions are employed. The model simulates spatially variable evapotranspiration, recharge to , and discharge from the Upper Floridan aquifer. The Floridan aquifer system simulates head-dependent spring flows and outflow to agricultural and public supply utility wells. The model results have been compared to estimated predevelopment conditions, calibrated to year 1988 postdevelopment conditions, and used for predictive simulations of projected year 2010 simulations. There are three aquifer layers separated by two semi-confining layers. The finite-difference grid was developed by Geraghty & Miller (1991). It consists of 91 model rows by 86 model columns with the rows running perpendicular to the coast and the columns running parallel to the coastline. The smallest cell measures 0.25 mile by 0.25 mile. The smallest cells were used where a high density of public supply wells exists, mostly in the coastal region. Specified flux boundaries are used for recharge areas, impermeable boundaries, areas of negligible flow, and wells. Specified head boundaries are useful for surface water areas and regional hydraulic gradients. Head-dependent flux boundaries are used to represent drains, evapotranspiration, springs, and lateral boundaries where the flux is not known. The eastern and western boundaries are of the specified-head type. There are also a number of cells internal to the grid boundaries with specified heads. These cells correspond to the St. Johns River, Lake George, Lake Monroe, and other smaller lakes. There are also a number of agricultural well cells directly adjacent to St. Johns River cells of specified head. The northern and southern boundaries of the grid are mostly zero flux.

NEEDS, SOURCES, AND SENSITIVE WETLAND AREAS

East-central Florida

The east-central model has 332 public supply utility wells serving 71 public demand areas and 362 agricultural wells serving 69 agricultural demand areas. Table 1 displays a well withdrawal summary for the region. Public supply utility area data are summarized in Table A1 for demands, Table A3 for wells, and Table A5 for reclaimed water sites in the Appendix. Table A1 of the appendix lists the public supply utility area name, and the total demands (in MGD) for year 1988 as well as projected demands for year 2010. Table A3 lists the well grid location in simulation model row and column number, whether the well withdrawal from the Upper or Lower Floridan Aquifer, year 1988 and projected year 2010 withdrawal rates in MGD, and the estimated well capacity in MGD. These wells are aggregated and totals for each cell of the simulation model are represented in the optimization model.

Table 1. Total withdrawal for east-central Florida by type

	1988 Total (MGD)	*Projected 2010 Total (MGD)*	*% of Total 2010 Withdrawal*
Public Upper Floridan	183.5	363.7	58.1
Public Lower Floridan	74.6	163.2	26.0
Agricultural	99.4	99.4	15.9
Sum	357.5	626.3	100

The 17 springs in the east-central region have discharges ranging from 0.6 to 92 cfs. Spring conductance and elevation head are constant in the simulation model so that a reduction in spring discharge is due to a reduction in Upper Floridan potentiometric head. Though minimum discharges have been established for only 8 of the 17 springs, a projected decrease in spring discharge of 15% or more from year 1988 is considered sufficient to pose a reasonable likelihood of natural systems problems (Vergara, 1994). Several springs are near public wells scheduled for large withdrawals, including Starbuck, Palm, Sanlando, and Apopka springs.

The model grid is displayed in Figure 3 along with wells, springs, reclaimed water sites, and surface water sites.

Geographical areas were denoted as having a low, moderate, or high likelihood for vegetative harm based on analysis that included the sensitivity of native plant species to dewatering as well as the non-optimized drawdown conditions. A detailed study of vegetative harm areas is available in Kinser and Minno (1995) but this study is currently under revision. Figure 4 displays the incomplete east-central area potential for vegetative harm with control points labeled. A large part of

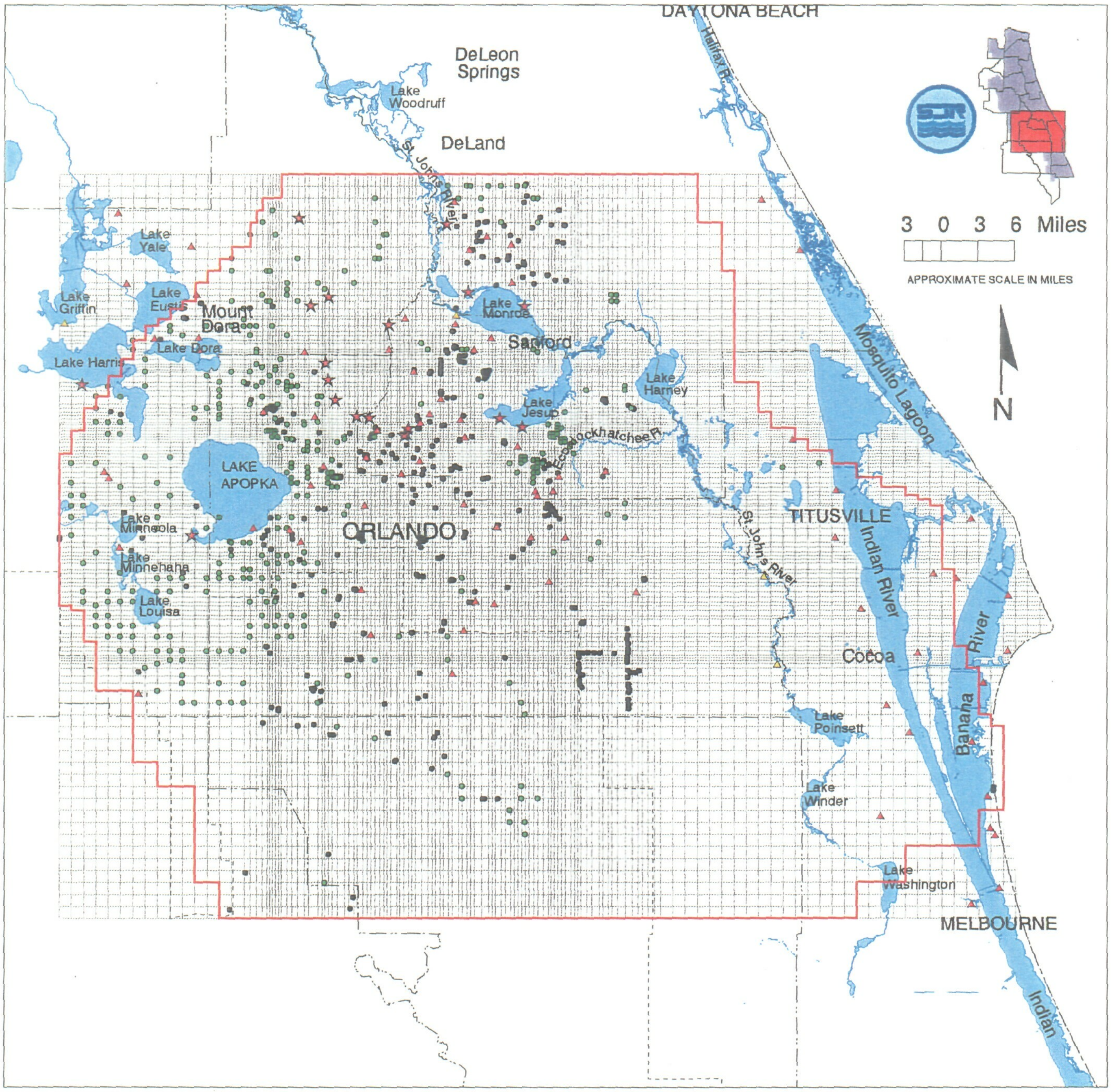


Figure 3

East-central grid with wells, springs, reclaimed water sites, andsurface water sites

	County Boundary
	SJRWMD Boundary
	ECF Active Edge
	ECF Grid
	Agricultural Wells
	Municipal Wells
	Springs
	Surface Water Sites
	Reclaimed Water Sites
	General Water Bodies

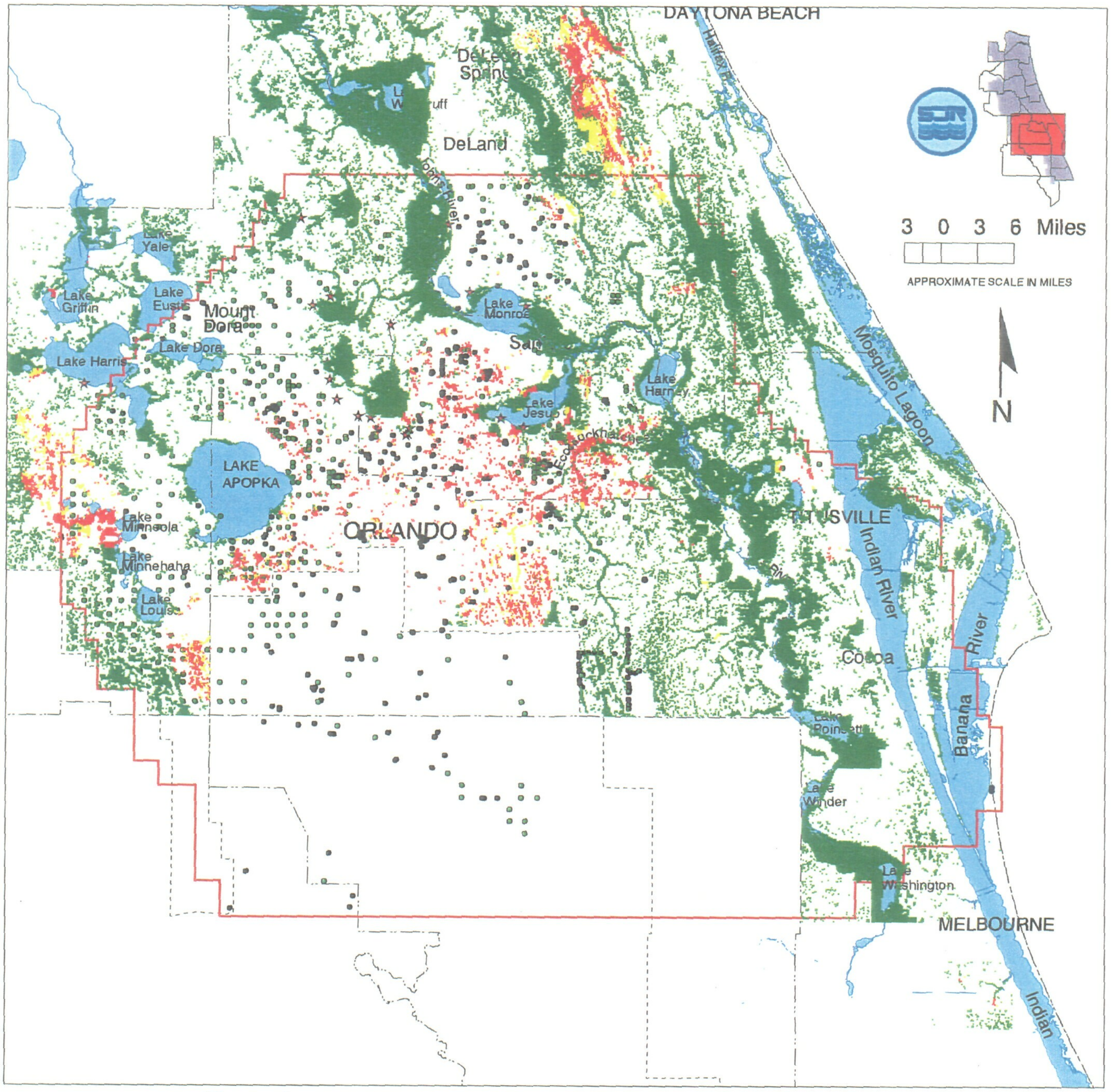
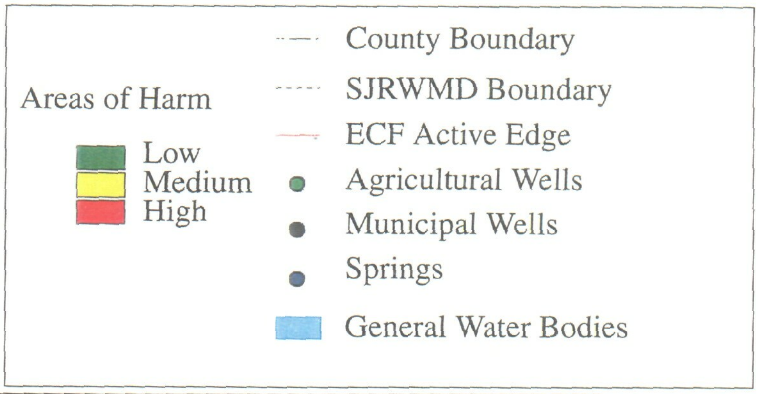


Figure 4

East-central vegitive harm.



the east-central grid lies in other water management districts. The vegetative harm study did not consider those areas.

Figure 5 shows 1988 (initial) head for the east-central region. Figure 6 displays the projected year 2010 nonoptimized Upper Floridan head while drawdowns or head reductions from year 1988 are provided in Figure 7. Significant Upper Floridan aquifer drawdowns are evident in the greater Orlando area with values of up to 26 feet in the vicinity of the OUC Martin wellfield. Other areas with large projected drawdowns include the Orange County East East regional well field, the Sanford area, and the western portion of the Cocoa wellfield.

Volusia

The Volusia region has 177 public supply utility wells serving 41 public demand areas. A total well withdrawal summary is provided in Table 2 below.

Table 2. Total withdrawal for Volusia County by type

	1988 Total (MGD)	*Projected 2010 Total (MGD)*	*% of Total 2010 Withdrawal*
Public	45.8	96.2	78.4%
Agricultural	26.6	26.6	21.6%
Sum	72.4	122.8	100%

Table A2 of the appendix lists the public supply utility area name and the total demands (in MGD) for year 1988 as well as projected demands for year 2010. Table A4 of the appendix provides a well withdrawal summary for the region with well grid location in simulation model row and column number, year 1988 and projected year 2010 withdrawal rates in MGD, and the estimated well capacity in MGD. All wells listed in Table A4 withdraw from the Upper Floridan Aquifer. These wells are aggregated and totals for each cell of the simulation model are represented in the optimization model. Table A5 provides reclaimed water site and availability data for the region.

Over 99% of the total public supply utility withdrawal is represented in the optimization model. Overall public supply utility withdrawals were 45.8 MGD in year 1988 and are projected to double to 96.2 MGD for year 2010. The largest public supply utility need area is Deltona with a projected year 2010 demand of 24.9 MGD. Daytona Beach, Port Orange, Deland, and Edgewater also have very large demands. There are 364 aggregated agricultural wells in the optimization model serving 59 agricultural need areas and a total demand of 26.6 MGD. Agricultural users include citrus, fern, livestock, nursery, turf, foliage, and vegetable farms. Fern and livestock areas comprise the largest agricultural water

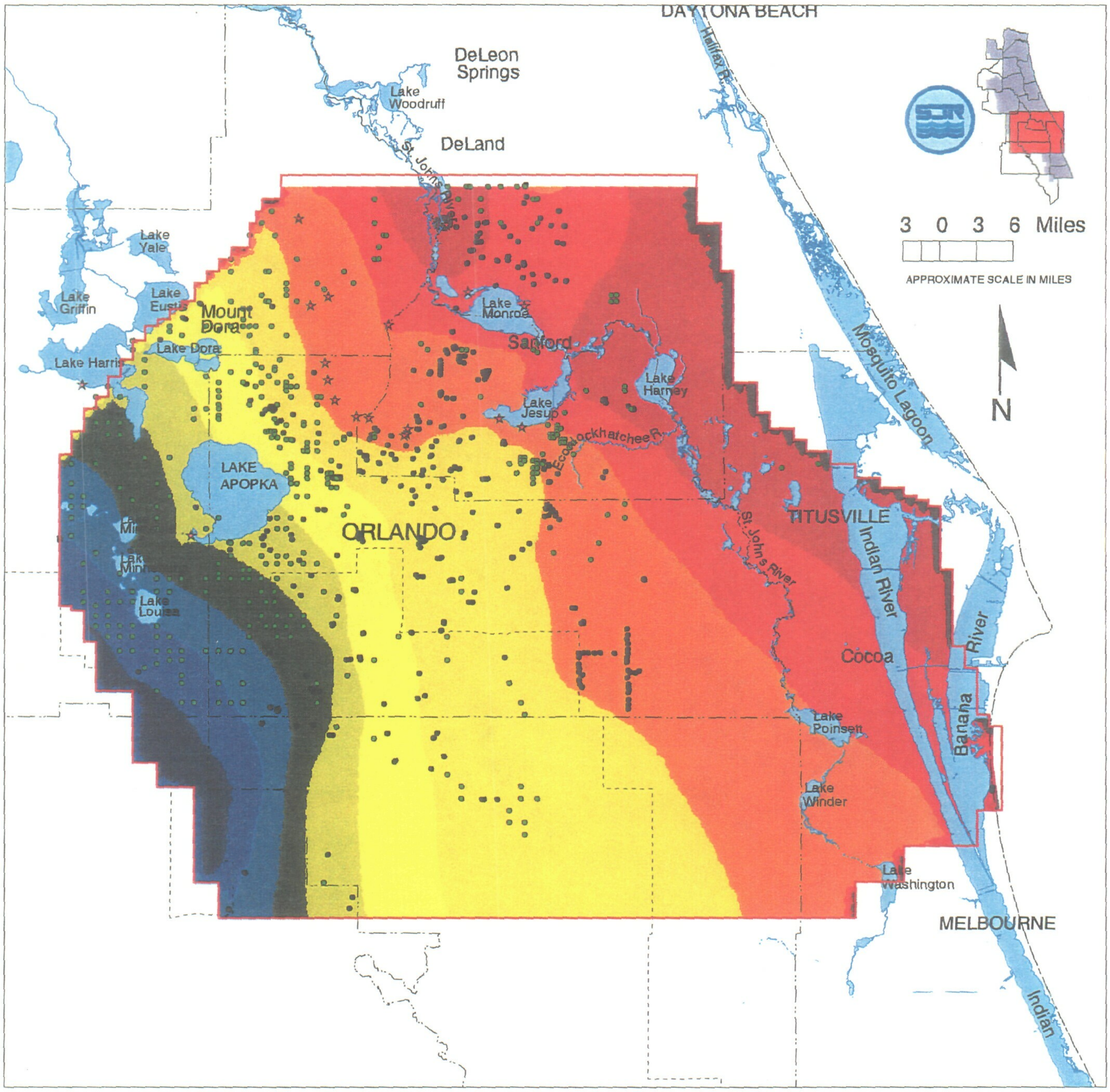
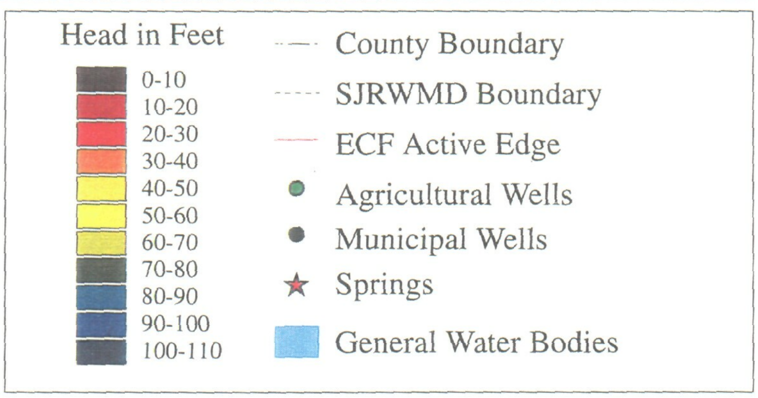


Figure 5

East-central year 1988 Upper Floridan head



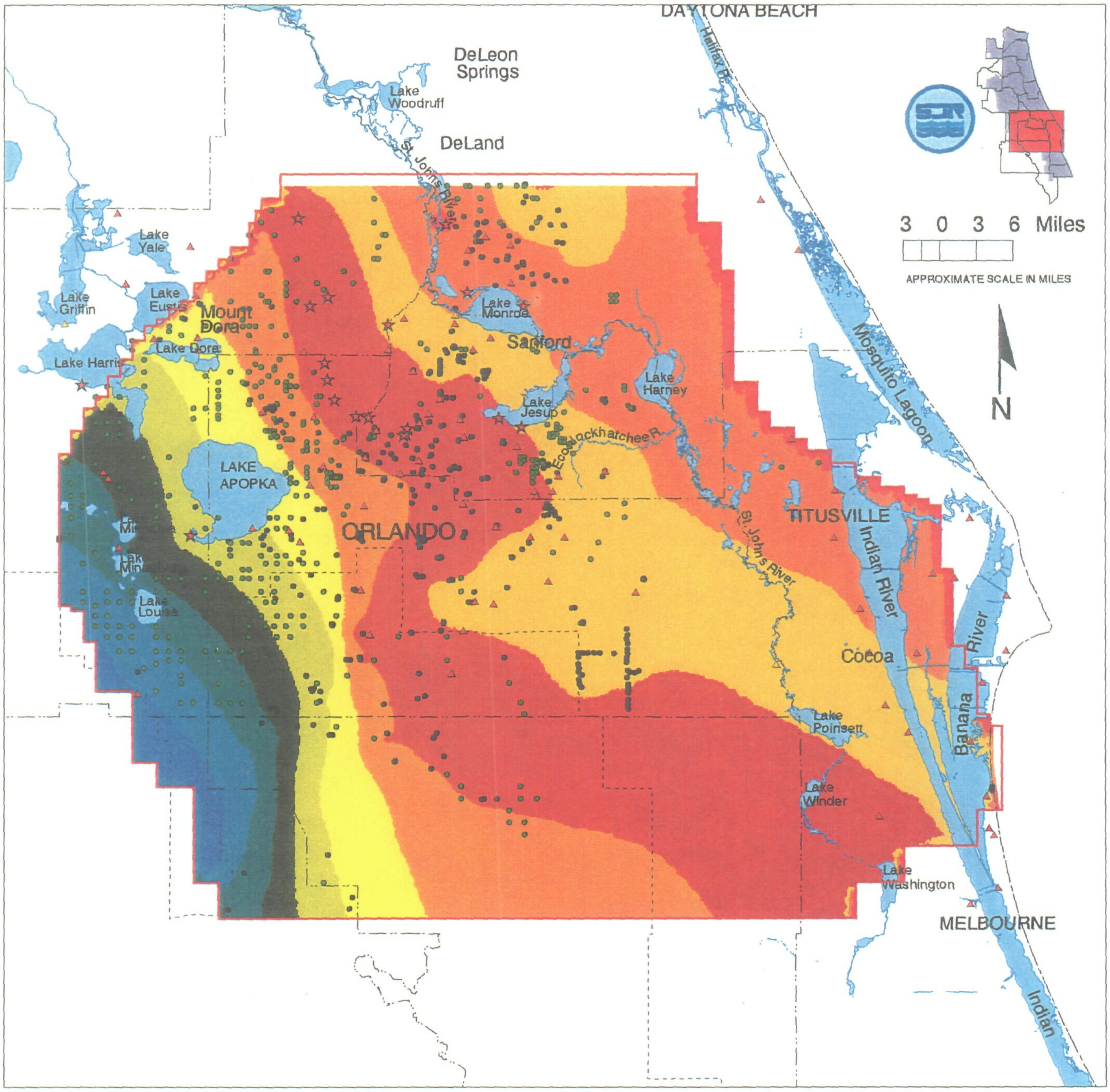


Figure 6

East-central projected year 2010 nonoptimized Upper Floridan head.

Head in Feet

- 0-10
- 10-20
- 20-30
- 30-40
- 40-50
- 50-60
- 60-70
- 70-80
- 80-90
- 90-100
- 100-110

- County Boundary
- ECF Active Edge
- SJRWMD Boundary
- Agricultural Wells
- Municipal Wells
- Springs
- General Water Bodies

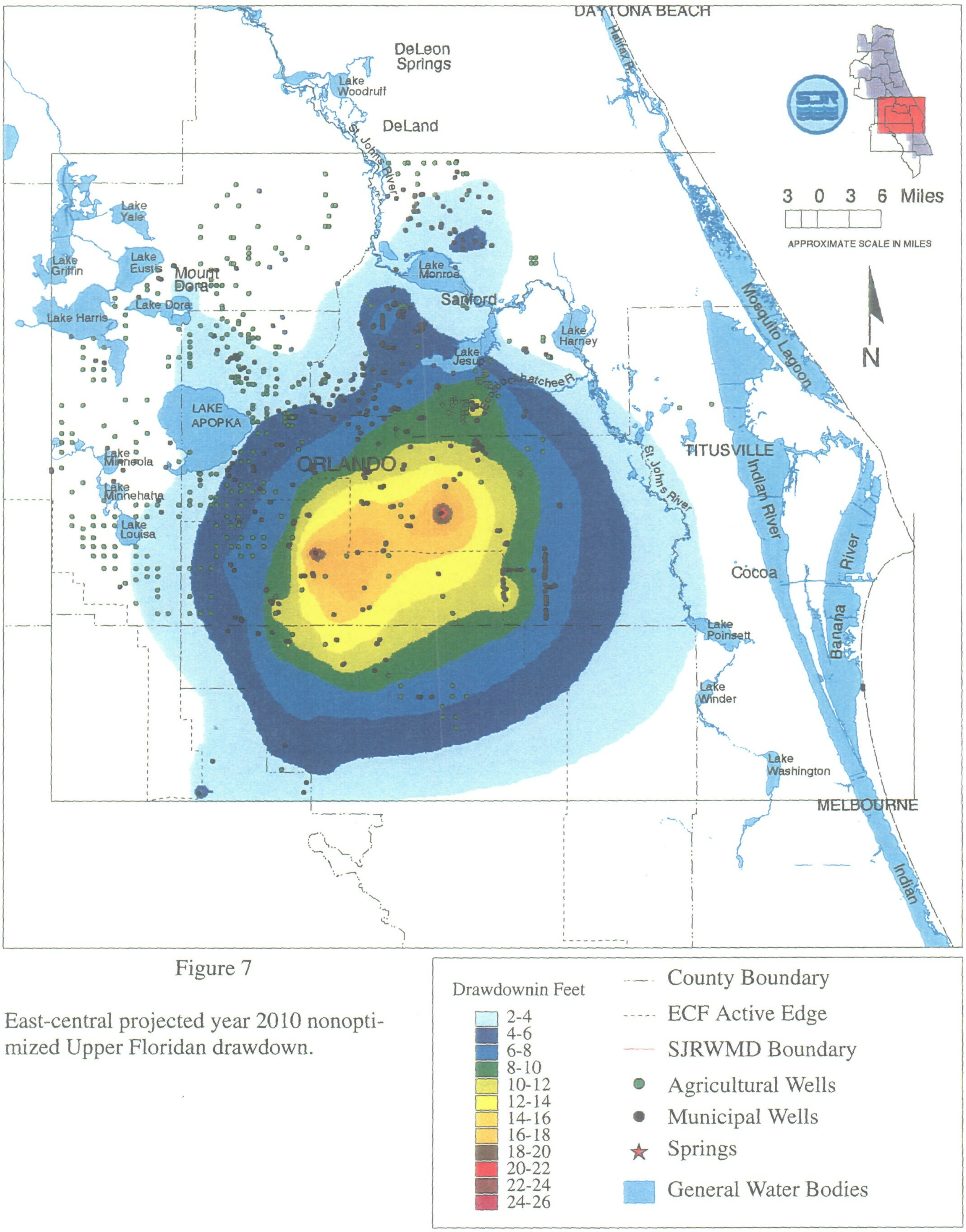


Figure 7

East-central projected year 2010 nonoptimized Upper Floridan drawdown.

demands and account for 61% and 23% of the total agricultural demand respectively. Golf course users are also included in this category though they are not strictly agricultural users.

Figure 8 displays the Volusia simulation model grid with wells, springs, reclaimed water sites, and specified head cells. Geographical areas were denoted as having a low, moderate, or high likelihood for vegetative harm based on analysis that included the sensitivity of native plant species to dewatering as well as the non-optimized drawdown conditions. A detailed study of vegetative harm areas is available in Kinser and Minno (1995) but this study is currently under revision. Figure 9 displays the Volusia area potential for vegetative harm with control points labeled. Areas having a high potential for vegetative harm include the Port Orange West and Daytona Beach Western wellfields in a four mile wide strip running approximately six miles inland and parallel to the coastline.

The surficial aquifer drawdown is defined as the surficial head reduction from simulation model year 1988 conditions. Maximum drawdowns occur at the Deltona region, Port Orange West and Daytona Beach Western wellfields. These wellfields are located in or directly adjacent to sensitive vegetative sites with high or moderate potential for vegetative harm. Deltona is also in the vicinity of Gemini Spring. The maximum drawdown of 6.79 ft is in a low harm area, in the Deltona public supply utility area. The largest fraction of head loss in the nonoptimized case was 14.59%, observed in the Port Orange West public supply area at an existing well, which lies in an area of moderate harm. Figure 10 illustrates the 1988 (initial) surficial aquifer head for the Volusia region. Figure 11 gives the nonoptimized projected year 2010 surficial head while Figure 12 provides the projected year 2010 nonoptimized drawdown or reduction from year 1988 surficial aquifer head.

Control points in the optimization model serve as locations where surficial aquifer drawdown is evaluated and possibly constrained. All 177 public supply utility well points serve as control points. Allowable drawdowns at control points are based on the potential for vegetative harm, though other considerations such as the aquifer thickness of potable water are pertinent and may be incorporated in future decision modeling efforts to preclude saltwater intrusion.

OPTIMIZATION PROCEDURES

Optimization and decision models were developed to investigate water allocation schemes to meet projected year 2010 demands. The models consist of an objective function which is minimized or maximized and a set

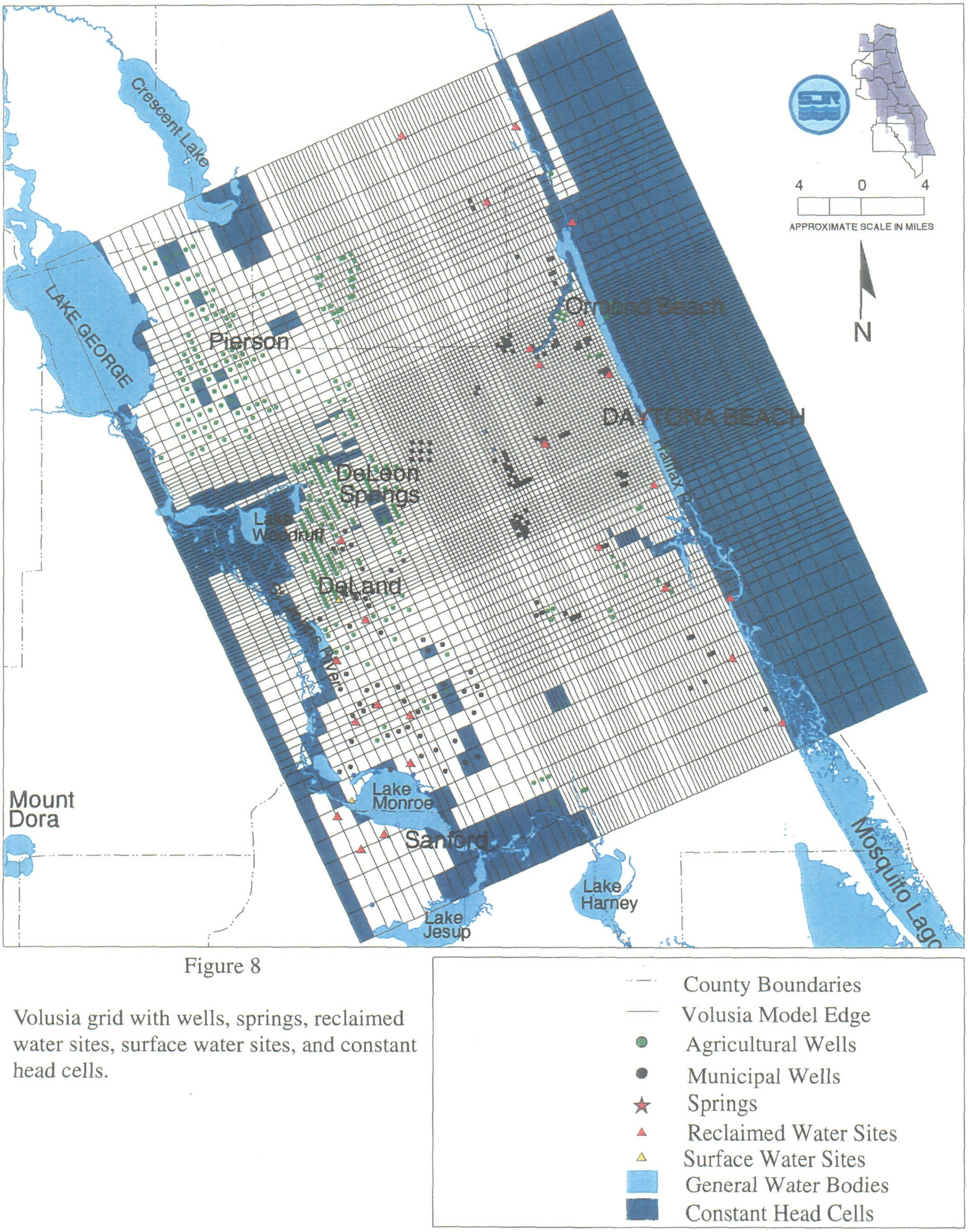


Figure 8

Volusia grid with wells, springs, reclaimed water sites, surface water sites, and constant head cells.

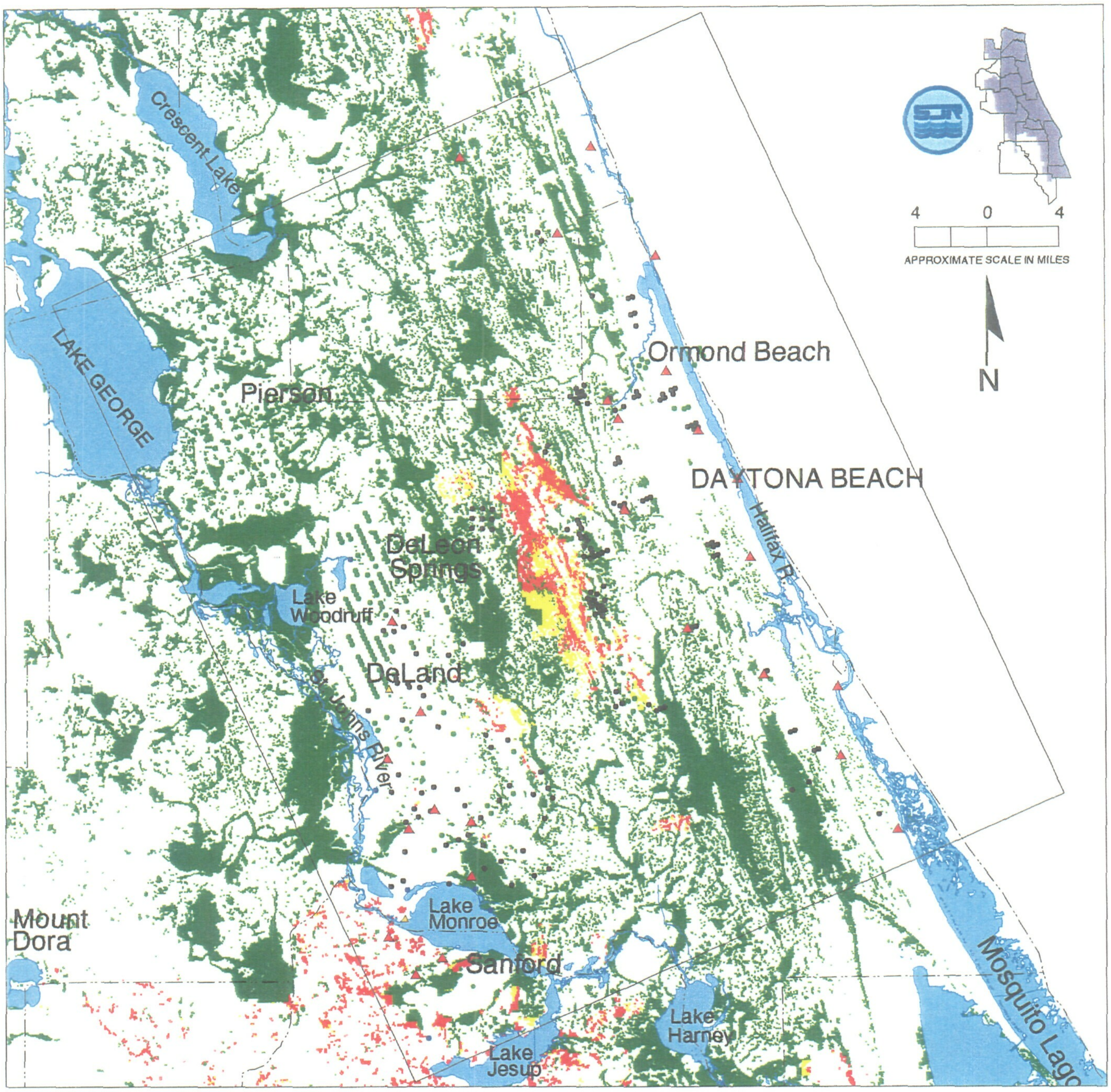


Figure 9

Volusia vegetative harm.

Areas of Harm

- Low
- Medium
- High

- County Boundaries
- Volusia Model Edge
- Agricultural Wells
- Municipal Wells
- Springs
- General Water Bodies

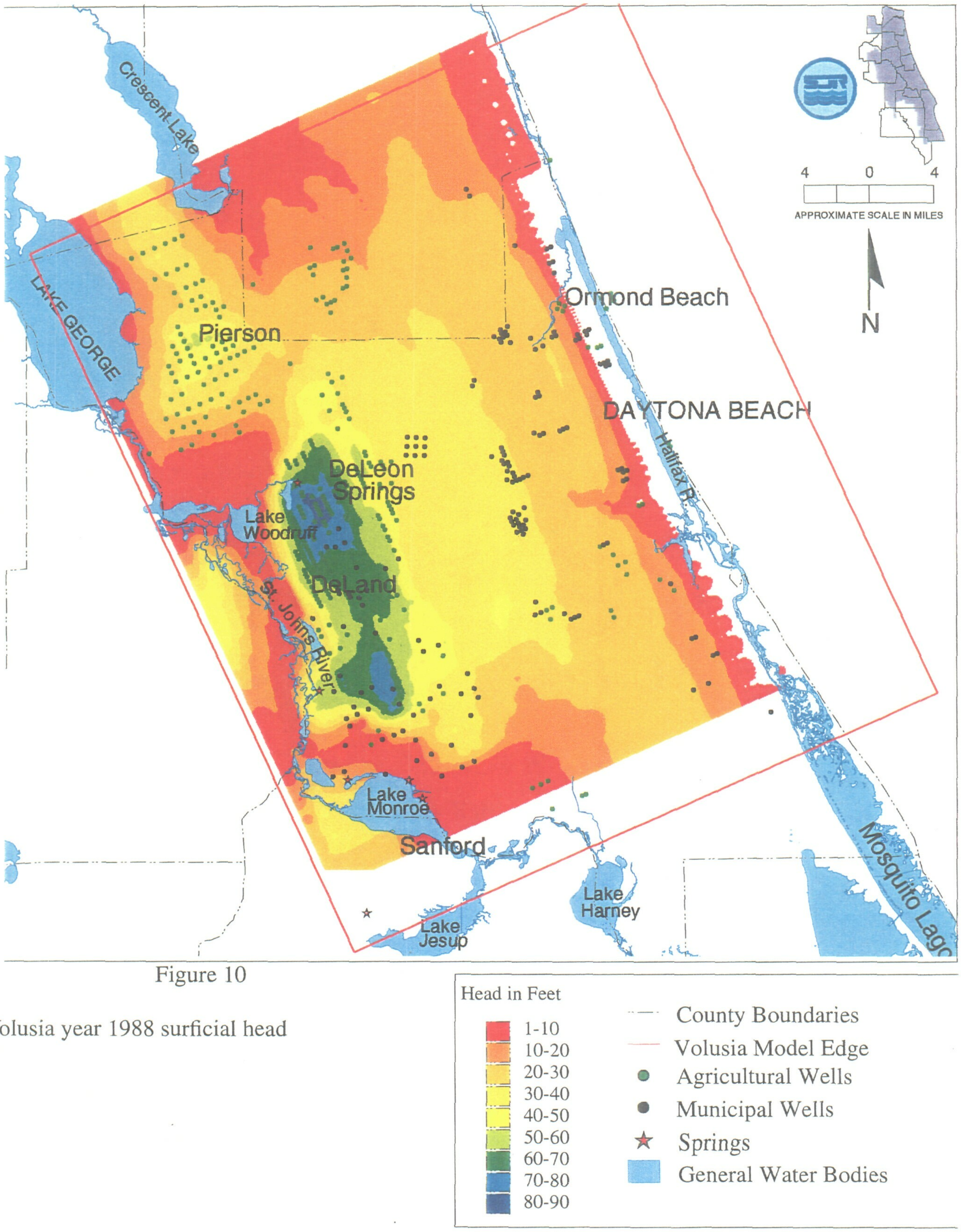


Figure 10

Volusia year 1988 surficial head

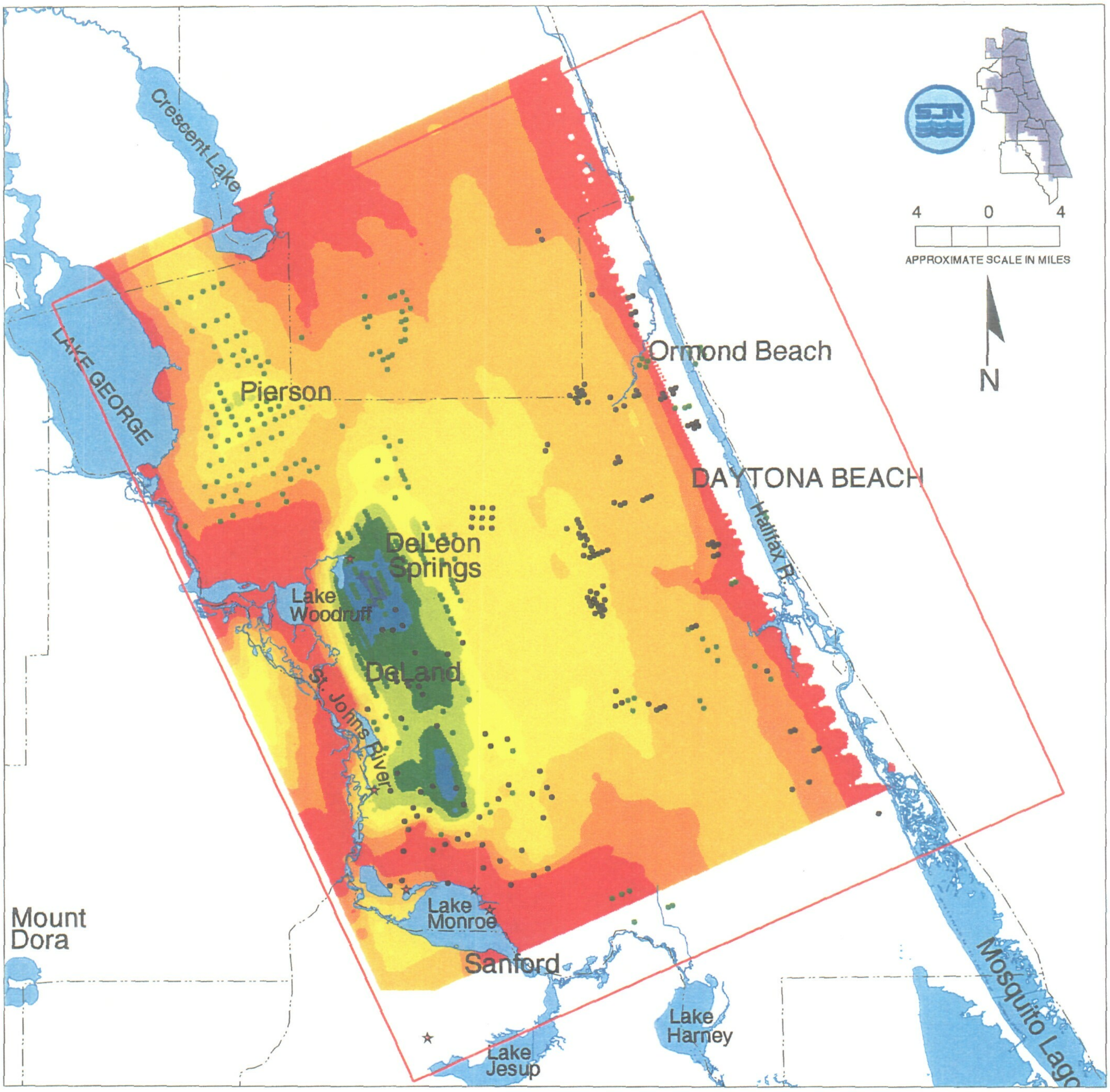
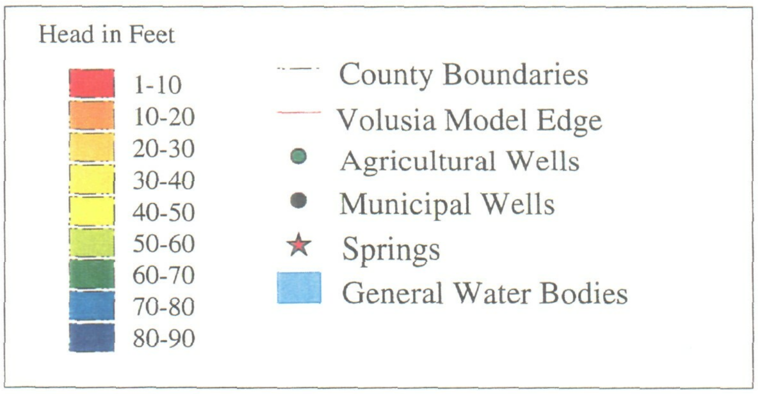


Figure 11

Volusia projected year 2010 nonoptimized surficial head



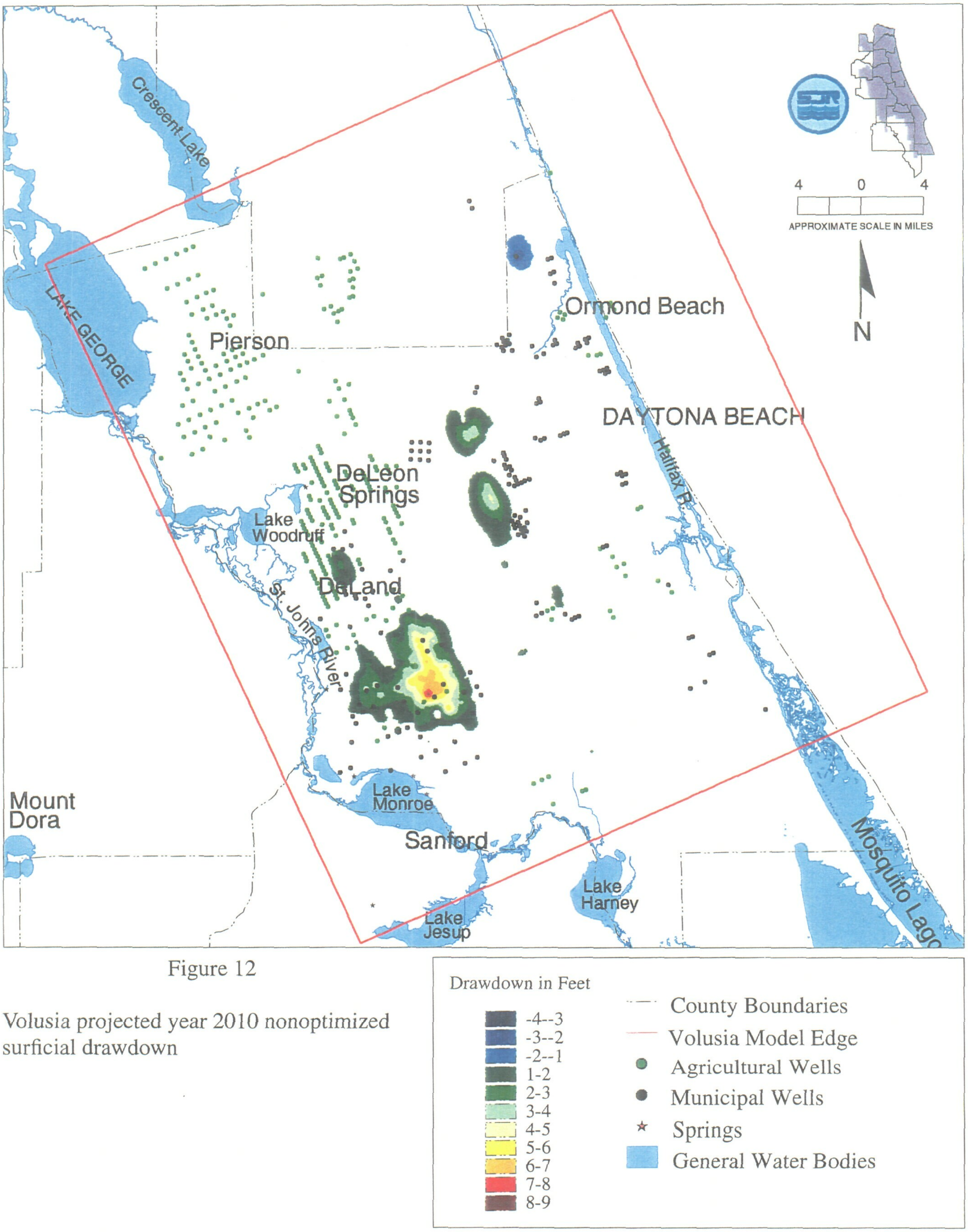


Figure 12

Volusia projected year 2010 nonoptimized surficial drawdown of constraints which must be satisfied. The models were built under the assumption that adverse environmental effects could be minimized at specific locations by constraining pressure head changes (drawdowns) and spring discharge losses to meet specified environmental goals.

OBJECTIVE FUNCTIONS

Objective functions appear as statements specifying that the value of the function be minimized or maximized. The linear programs miminize the sum of drawdowns and deficits, while the mixed integer programs minimize total costs of meeting projected year 2010 demands.

CONSTRAINTS

The optimization and decision models share a large common block of constraint equations including aquifer response , management , and nonnegativity constraints. The common block was used in different combinations to formulate different optimization models with unique goals to identify optimal allocation strategies.

The optimization models were developed to allow pressure head and/or drawdown to be constrained or optimized. Drawdown constraints at the specified control points were developed using influence coefficients that describe pressure head changes at each control point due to ground water pumping at each well grid cell. The following general drawdown constraint for a control point includes a linear combination of aquifer responses to the public supply utility and agricultural wells. Management constraints used in these optimization models define the capacity of available resources, the demand for available resources, and the resource to demand links. The first set of constraints deal with the limited capacity associated with the production of water from aquifer systems.

Public supply utility well capacities were estimated for Volusia and east-central models from municipal well capacities listed in Wellhead Protection Reports (Huang, 1995). Values for each agricultural well grid cell were set at the service area demand for which the cell supplied. Minimum withdrawal rates on municipal well grid cell were not incorporated into the optimization models to prevent existing wells from shutting off.

Public supply utility and agricultural demands were calculated using projected year 2010 discharge rates. Other parameters relevant to the optimization process include well discharge capacity limits, water demands, initial year 1988 withdrawal rates and pressure heads, and initial spring discharge head data. SJRWMD provided the information for initial well withdrawal and hydrogeologic conditions, aquifer characteristics, and model discretization through various reports and simulation model data.

The public supply well capacity limits were taken from Wellhead Protection Reports of Huang (1995) in the East Central model and from previous studies of Volusia County by Burger et al. (1995).

INFLUENCE COEFFICIENT GENERATION

A large part of the optimization modeling effort involves determining the influence coefficient tables. These influence coefficient matrices represent the change in head at various locations with respect to pumping. The target locations on which the constraints were applied, along with well location and corresponding pumping rate, were determined to develop these matrices. The influence coefficient matrices were calculated by performing multiple executions of the simulation models. One simulation was performed for each well grid cell involved in the optimization process. Computer programs written in UNIX and FORTRAN facilitated the process of determining the response matrices. These programs are provided in the Appendix.

The first step in calculating the influence coefficient matrices involved starting the simulation model with a proper initial condition. It was determined that the closer this initial condition is to the optimized pumping strategy, the better correlation there is between predicted responses of the optimization and simulation models when the optimized pumping strategy is implemented. However, because this optimized strategy is not known, a slightly modified version of the year 2010 projected pumping strategy was used as the initial condition for the flow simulation model.

The individual influence coefficients which comprise the influence coefficient matrices were calculated by individually increasing discharge rates of each well grid cell and determining the response at specified control points and all wells incorporated in the optimization process. Through execution of the simulation models, various types of influence coefficients were calculated to develop the influence coefficient matrices designated as alpha, beta, gamma, and zeta. These matrices are comprised of influence coefficients having units of feet per cubic feet per day (length per volumetric rate).

The unit response matrix method of combined simulation/optimization modeling incorporates influence coefficients and the principle of superposition to compute the system response to a unit stimulus. For groundwater management models the response matrix approach is based on the principle that the influence of discharging or recharging a single well or well cell on aquifer drawdown at a particular location may be expressed as a simple algebraic equation. Individual influence functions are then combined using the principle of superposition to obtain the aquifer response due to multiple wells. Thus a response matrix can be developed which can be expressed as

$$D_h = \sum_{h=1}^{n} \alpha_{i,h}(Q_i - qn_i) = \alpha_{1,h}(Q_1 - qn_1) + \alpha_{2,h}(Q_2 - qn_2) + \ldots + \alpha_{n,h}(Q_n - qn_n) \tag{5}$$

where

D_h = drawdown at control point h
Q_i = optimized well withdrawal rate at well i
qn_i = nonoptimized well withdrawal rate at well i
$\alpha_{i,h}$ = unit response function (influence coefficient) from well i acting on control point h
n = number of wells

The influence coefficients $\alpha_{i,h}$ of the response matrix are determined from the numerical groundwater simulation models. Since the response equations are developed only at points of interest, it is not necessary to create an equation for each active grid cell in the simulation model which allows for the dimensionality of the problem to be significantly reduced as compared to the embedded technique. Influence coefficients are obtained as follows:

1. Run simulation model with nonoptimized well withdrawal scheme qo_i. Save heads ho_h.
2. For each well to be optimized,
   -Perturb the well withdrawal rate a specified amount for a new rate of $qnew_i$ while leaving all other well withdrawal rates the same as qo_i.
   -Run the simulation model with this new withdrawal scheme. Save heads $hnew_h$
3. Generate influence coefficients by

$$\alpha_{i,h} = \frac{hnew_h - ho_h}{qnew_i - qo_i} \tag{6}$$

The following perturbations in withdrawal rate $qnew_i$ with respect to magnitude and direction were used with *wcap* representing the lesser of the capacity of the aggregate well cell or the demand of its demand area :

1. If the initial (nonoptimized) withdrawal rate is zero set $qnew_i = wcap$.
2. If the initial withdrawal rate is nonzero, set $qnew_i = 0$.

GENERAL ALGEBRAIC MODELING SYSTEM (GAMS)
The GAMS input file used to construct deficit or decision optimization models is easily revised to investigate a variety of water management objectives. All the required sets, tables, parameters, variables, equations,

and constraints are built into the model to predict strategies under a wide range of management conditions. Using the optimization input file as a skeleton, only certain values within the GAMS input file need be changed to revise the optimization model and then to determine new optimum allocation strategies under the revised objective functions and constraints. Once the optimization model is created within GAMS, it is executed using a CPLEX linear or mixed integer programming solver. Optimum values of the decision variables are determined when the optimization algorithm identifies an optimum value for the objective function (a maximum or minimum) under a satisfied constraint set. Values for decision variables include discharge rates from wells, pressure heads, and drawdowns at control point.

PROCEDURE FOR IDENTIFYING STRATEGIES

The method used to determine optimum water allocation scenarios is an iterative process and can be divided into the following five steps:

1) Solve the optimization model (LP or MIP decision model) with first estimates of influence coefficients. The optimization model represents a system of linear equations solved during the first step using GAMS. If a feasible solution to the problem exists, GAMS identifies values for decision variables that minimize (or maximize) the value of the objective function and satisfies all specified constraints. Output from the optimization models includes data depicting an optimum water allocation strategy (i.e. well withdrawal rates) and the aquifer system response to the strategy (i.e. pressure heads, drawdowns, concentrations, and concentration increases). The models identify which public supply and agricultural sources should be used, their respective flow or use rates, the pressure heads and drawdown values at the sensitive wetland control points, and deficits (LP) or costs (MIP).

2) Execute the simulation model with prescribed allocation strategy. Because the optimization model is based on linear response theory and is not a true simulation model, the optimum pumping strategy must be incorporated into an updated input file for the simulation model to permit the second step, a simulation to determine the actual response to the strategy. When simulation model responses were compared to the responses predicted by the optimization model, it was shown that the aquifer system response to pumping is generally linear in the aquifer system.

3) Compare optimization model results to simulation model predictions.

4) If hydraulic results are unacceptable calculate revised set of influence coefficients.

5) Solve the deficit or decision model with revised influence coefficients.

Steps 2-5 are repeated until an acceptable level of agreement is reached between the optimization and simulation results. If a revised set of influence coefficients are deemed necessary (step 4), the simulation model is then used to generate a new set of influence coefficients with new perturbations on the well withdrawal scheme. A revised set of response matrices can then be used to obtain a revised optimization model. With these changes, revised optimization models can be executed to determine an improved water allocation strategy.

Sensitivity analysis for influence coefficient generation has determined that the greatest source of error is the closure criterion of the simulation model. Excellent agreement between simulation model and optimization model results is obtained when the MODFLOW closure criterion is 0.0001 or less (Demas et al., 1996). Results using a closure criterion of 0.0005 have significantly more error. The error was not found to be a function of distance from simulation model boundaries.

Maximum errors are incurred where there are several adjacent cells withdrawing near a particular well cell. A nonlinear effect occurs where well withdrawal cells are in close proximity. Nonlinear responses are generally due to both a nonlinear decrease in pressure head as discharge rate increases and a nonadditive effect of drawdown when utilized well grid cells are in close proximity. Nonlinear responses can be corrected by creating a new set of response matrices based on the previously predicted strategy and incorporating these into the optimization model. The correlation between the optimization and simulation models with respect to aquifer system response increases when the response matrix calculation process incorporates an initial allocation strategy which is close to the actual optimum strategy. A revised set of response matrices can be determined using revised initial conditions that essentially match the first estimates of the optimum water allocation strategy. It must be noted that the set of influence coefficients that generate an ideal aquifer response for one set of environmental constraints may not be appropriate for another model with more (or less) restrictive environmental constraints, as the optimal well withdrawal schemes corresponding to such cases may be very different.

A method of reducing the adverse effect associated with nonlinear aquifer responses involves limiting the difference in withdrawal rate from the first to the second execution of the optimization model. By limiting this difference, the withdrawal rate range is reduced and the aquifer system responds more linearly. The perturbation scheme listed above is only one such scheme. In a scheme which does not set a minimum flow rate for existing wells, the most common well withdrawal rate selected by the optimization model will be zero. In this case, perturbations for generating influence coefficients should be close to zero for most wells.

COMPUTER RESOURCES

The computer platforms used are a UNIX based Sun SPARC20 workstation for mathematical programming and the Northeast Regional Data Center (NERDC) NERSP. A research computing initiative account (RCI) was granted by NERDC for project development. The NERSP is an IBM 9076 Scalable POWERParallel SP2 computer which consists of a group of IBM RISC System/6000 nodes. The SP2's nodes are interconnected through a high-speed packet switch to enable speedy parallel processing. The NERSP is designed for use in parallel processing and vector computing applications and was used to generate influence coefficients in a process that took approximately 48 hours for the east-central region and 24 hours for the Volusia area.

LINEAR PROGRAMMING OPTIMIZATION MODELS

METHODS

Linear programming (LP) models were developed to determine minimal environmental impact solutions to water allocation problems subject to meeting projected year 2010 demands and maintaining spring discharges above critical minimums. These models identify potential deficits at public supply utility and agricultural areas. Demand areas having deficits are those areas which may not have sufficient resources to meet projected year 2010 demands while meeting environmental constraints. The general LP model formulation is written using GAMS (1995) and solved using CPLEX (1996). The GAMS formulation consists of model sets (indices), parameters (known data), constraints, and an objective function, the quantity that must be minimized or maximized while satisfying the listed constraints. The model has been applied to the east-central and Volusia regional study areas. Though slight variations in constraints exist between the two regions, the general formulation is similar and is described below.

MODEL INDICES

Model indices (*sets* in the GAMS terminology) include *h*, the set of control points where drawdowns are constrained; *i*, the set of public supply utility wells or well grid cells; *j*, the set of public supply utility demand areas; *k*, the set of agricultural demand areas; *l*, the set of springs; and *m*, the set of agricultural wells.

MODEL PARAMETERS

Model parameters include the individual components of the unit response matrix for control points and springs, capacities or maximum withdrawal rates of wells, initial (simulation year 1988) and nonoptimized projected year 2010 hydrogeologic measurements such as heads, drawdowns, and spring discharges, projected year 2010 demands of public supply and agricultural areas, and service tables specifying which source may serve which demand area. Model parameters are listed below:

Table 3. Linear programming model parameters

parameter	*units*	*definition*
influence coefficients of the unit response matrices		
$\alpha_{i,h}$	day/ft^2	influence of public well i on control point h
$\beta_{m,h}$	day/ft^2	influence of agricultural well m on control point h
$\gamma_{i,l}$	day/ft^2	influence of public well i on spring l
$\varsigma_{m,l}$	day/ft^2	influence of agricultural well m on spring l

Table 3 --*Continued*

parameter	*units*	*definition*
service maps		
$serm_{j,i}$		
$serva_{k,m}$		
water management		
dm_j	cfd	demand of public area j
da_k	cfd	demand of ag area k
qo_i	cfd	1988 withdrawal rate of public well i
qno_i	cfd	2010 nonoptimized withdrawal rate of public well i
qao_m	cfd	1988 withdrawal rate of agricultural well m
qna_m	cfd	2010 nonoptimized withdrawal rate of agricultural well m
cv	MG/cf	0.00000748 MG/cf, converts cf to MG
capacities		
$mcap_i$	cfd	public well i
$acap_k$	cfd	agricultural well m
loss limits		
dl		minimum fraction of year 1988 head allowed at control points having low or no potential for vegetative harm
ml		minimum fraction of year 1988 head allowed at control points having moderate potential for vegetative harm
hl		minimum fraction of year 1988 head allowed at control points having high potential for vegetative harm
sp_l		minimum fraction of year 1988 discharge allowed at spring l
hydrogeologic		
ho_h	ft	1988 head of control point h
hno_h	ft	2010 nonoptimized head of control point h
el_l	ft	elevation head of spring l
cd_l	ft^2/day	spring conductance of spring l
$scrit_l$	cfd	critical minimum discharge of spring l
med_h		denotes control point h with moderate potential for vegetative harm
$high_h$		denotes control point h with high potential for vegetative harm

MODEL VARIABLES

Linear programming model variables are all continuous and include well withdrawal rates, hydrogeologic variables, cost data, and water management data. Variables are listed by type below:

Table 4. Linear programming model variables

variable	*units*	*definition*
use rates		
QP_i	cfd	total pump rate of public well cell i
$Q1_{i,j}$	cfd	pump rate of public well cell i supplying demand area j
QA_m	cfd	pump rate of agricultural well m
deficits		
QD_j	cfd	deficit of public demand area j
FDT	cfd	total public deficit
QDA_k	cfd	deficit of agricultural area k

Table 4--*Continued*

variable	*units*	*definition*
hydrogeologic		
D_h	ft	drawdown at control point h
SD_l	cfd	spring discharge at spring l
PS_l		fraction of simulated year 1988 discharge at spring l
HS_l	ft	spring head at spring l
accounting		
QD2	MGD	deficit of public demand area j
QAD2	MGD	deficit of agricultural area k
SF	MGD	total public deficit
SFA	MGD	total agricultural deficit
TD	MGD	total deficit
PCT		fraction of public demand in deficit
PCT2		fraction of agricultural demand in deficit
PCT3		fraction of total demand in deficit

The LP model formulation was created with the assumption that optimum groundwater allocation strategies would correspond to those which minimized the sum of public and agricultural deficits and the associated total system drawdown. In this formulation, the objective function appears as a statement specifying that the value of decision variable Z be minimized. Thus,

minimize

$$Z = a(\sum_j QD_j + \sum_k QDA_k) + \sum_h D_h \qquad (7)$$

minimizes total drawdowns and deficits, where a value of 1 day/ft^2 is chosen for parameter *a*.

LP MODEL CONSTRAINTS

The model formulation includes hydrogeologic constraints and water management constraints.

Hydrogeologic Constraints

Hydrogeologic constraints calculating the drawdown at control points were developed from influence coefficients that describe pressure changes at each control point created by pumping at each well grid cell. The drawdown at a control point is calculated by

$$D_h = ho_h - hno_h + \sum_i \alpha_{i,h}[QP_i - qno_i] + \sum_m \beta_{m,h}[QA_m - qna_m] \qquad (8)$$

The drawdown at a control point is limited to specifications based on the control point's potential for vegetative harm. For the east-central region and control points in the Volusia region having a low potential for vegetative harm,

$$D_h \le dl_h \tag{9}$$

Currently this limit varies from 80% to 90% of the simulation year 1988 head.

For control points having high or moderate potential for vegetative harm,

$$D_h \le ml \ \ \text{if } med_h = 1 \tag{10}$$
$$D_h \le hl \ \ \text{if } high_h = 1 \tag{11}$$

with moderate and high harm areas presently tolerating between 0% and 2% reduction from simulated year 1988 Upper Floridan head (east-central) or 1988 surficial head (Volusia).

Spring head is defined in the model similar to aquifer head above, with

$$Hs_l = hsno_l - \sum_i \gamma_{i,l}[QP_i - qno_i] - \sum_m \varsigma_{m,l}[QA_m - qna_m] \tag{12}$$

Spring discharge losses are constrained by

$$Hs_l \ge sp_l(hso_l - el_l) + el_l \tag{13}$$

The spring's fraction of simulation year 1988 discharge is given by

$$Ps_l = \frac{Hs_l - el_l}{hso_l - el_l} \tag{14}$$

The spring discharge (not currently used) may be defined by

$$SD_l = cd_l(HS_l - el_l) \tag{15}$$

with parameters cd_l, the spring conductance in ft^2/day, and el_l, the spring elevation head in feet, and variable Hs_l, the spring head at spring l in feet.

If the critical identified minimum discharge (not currently used) for a spring is available, spring discharge must exceed this critical minimum so that

$$SD_l \ge scrit_l \tag{16}$$

Public Water Management Constraints
The model uses constraints for public needs and sources to ensure that capacities of wells were not exceeded and to meet demands of public supply needs. The total withdrawal rate of a public well consists of the sum of withdrawal rates serving all public areas

$$QP_i = \sum_j Q1_{i,j} \tag{17}$$

Well withdrawal must not exceed capacities:

$$QP_i \le mcap_i \tag{18}$$

The demand constraint for public supply areas is:

$$\sum_i Q1_{i,j} servm_{j,i} + QD_j \ge dm_j \tag{19}$$

Total of all public deficits:

$$FDT = \sum_j QD_j \tag{20}$$

Agricultural Water Management Constraints
Water Managment constraints for agricultural areas include limiting use or withdrawal rates to specified capacities and satisfying water demands with available sources.

Do not exceed the operating capacity of an agricultural well:

$$QA_m \le acap_m \tag{21}$$

Satisfy demands at agricultural areas with agricultural wells:

$$\sum_m QA_m serva_{k,m} + QDA_k \ge da_k \tag{22}$$

The next set of equality constraints are used for accounting purposes.

Deficits are converted from cfd to MGD:

$$QD2_j = cvQD_j \tag{23}$$

$$QAD2_k = cvQAD_k \tag{24}$$

Total public, agricultural, and sum deficits are calculated:

$$SF = \sum_j QD2_j \tag{25}$$

$$SFA = \sum_k QAD2_k \tag{26}$$

$$TD = SF + SFA \tag{27}$$

The fraction of public, agricultural and total demand in deficit are calculated below:

$$PCT = SF / SM \tag{28}$$

$$PCT2 = SFA / SA \tag{29}$$

$$PCT3 = (SF + SA) / (SM + SA) \tag{30}$$

The following constraints specify nonnegativity:

$$Q1_{i,j} \geq 0.0 \tag{31}$$

$$QAD_k \geq 0.0 \tag{32}$$

$$QD_j \geq 0.0 \tag{33}$$

$$QA_m \geq 0.0 \tag{34}$$

In summary,

minimize

$$Z = a(\sum_j QD_j + \sum_k QDA_k) + \sum_h D_h \tag{35}$$

subject to

Hydrogeologic Constraints

$$D_h = ho_h - hno_h + \sum_i \alpha_{i,h}[QP_i - qno_i] + \sum_m \beta_{m,h}[QA_m - qna_m] \tag{36}$$

$$D_h \leq dl_h \tag{37}$$

$$D_h \leq ml \;\; if\; med_h = 1 \; or \; high_h = 1$$

$$Hs_l = hsno_l - \sum_i \gamma_{i,l}[QP_i - qno_i] - \sum_m \varsigma_{m,l}[QA_m - qna_m] \quad (38)$$

$$Hs_l \geq sp_l(hso_l - el_l) + el_l \quad (39)$$

$$Ps_l = \frac{Hs_l - el_l}{hso_l - el_l} \quad (40)$$

$$SD_l = cd_l(Hs_l - el_l) \quad (41)$$

$$SD_l \geq scrit_l \quad (42)$$

Public Water Management Constraints

$$QP_i = \sum_j Q1_{i,j} \quad (43)$$

$$QP_i \leq mcap_i \quad (44)$$

$$\sum_i Q1_{i,j} servm_{j,i} + QD_j \geq dm_j \quad (45)$$

$$FDT = \sum_j QD_j \quad (46)$$

Agricultural Water Management Constraints

$$QA_m serva_{k,m} \leq acap_m \quad (47)$$

$$\sum_m QA_m serva_{k,m} + QDA_k \geq da_k \quad (48)$$

Accounting Equality Constraints

$$QD2_j = cvQD_j \quad (49)$$

$$QAD2_k = cvQAD_k \quad (50)$$

$$SF = \sum_j QD2_j \quad (51)$$

$$SFA = \sum_k QAD2_k \quad (52)$$

$$TD = SF + SFA \quad (53)$$

$$PCT = SF / SM \quad (54)$$

$$PCT2 = SFA / SA \quad (55)$$

$$PCT3 = (SF + SA) / (SM + SA) \quad (56)$$

Nonnegativity Constraints

$$Q1_{i,j} \geq 0.0 \quad (57)$$

$$QD_j \geq 0.0 \quad (58)$$

$$QA_m \geq 0.0 \quad (59)$$

$$QAD_k \geq 0.0 \quad (60)$$

DISCUSSION

EAST-CENTRAL FLORIDA

Several model runs were made with varying constraints at aquifer heads and springs. Overall east-central LP model statistics are as follows:

- Size: 1,886 rows (constraints), 32,777 columns (variables), 154,614 nonzeroes
- CPLEX LP presolve routine eliminates 1,064 rows and 31,345 columns to yield a *reduced LP*: 664 rows, 1,274 columns and 120,854 nonzeroes
- Run time: 24.9 CPU seconds.

Three cases were examined in detail, which allowed 2% (case 1), 1% (case 2), and 0% (case 3) reduction in Upper Floridan head at control points with high or moderate potential for vegetative harm, 15% losses at control points with low potential for vegetative harm, and 15% spring discharge loss from year 1988.

Deficits

Table 5 displays the deficits found in the east-central region when allowable spring discharge losses and Upper Floridan head losses having low potential for vegetative harm were not to exceed 15%, while head losses at Upper Floridan heads at control points having high or moderate potential for vegetative harm were not to exceed 2% (Case 1), 1% (Case 2), or 0% (Case 3) from simulated year 1988 heads. Total deficits were approximately 139 MGD, 153 MGD, and 170 MGD, while the percentages of total projected year 2010 demand in deficit were 24%, 27%, and 30%, for cases 1-3, respectively. No agricultural demand areas displayed deficits.

Public demand areas with high deficits included Orange County East-ERWF, Econ, and Conway well fields, Orlando Utilities Commission Sky Lake, Kuhl, Martin, Kirkman, Pine Hills, Pershing, and Navy wellfields, Seminole County, Oviedo, Ocoee, Lake Mary, and Maitland. These public demand areas are responsible for the majority of the total deficit for each examined case.

Table 5. East-central deficits

	Loss limit at areas with high or moderate potential for vegetative harm					
	Case 3, 0%		Case2, 1%		Case 1, 2%	
Public Area	Deficit (MGD)	% of total deficit	Deficit (MGD)	% of total deficit	Deficit (MGD)	% of total deficit
Apopka	1.83	1.08%	0.58	0.38%		
Conway	0.10	0.06%	0.101	0.07%	0.101	0.07%
Deltona	13.67	8.04%	11.59	7.56%	9.67	6.98%
Eatonville	1.41	0.83%	1.41	0.92%	1.41	1.02%
Lake Mary	3.45	2.03%	2.21	1.44%	1.98	1.43%
Maitland	3.53	2.08%	3.53	2.30%		
Oakland	0.28	0.16%				
OCE Conway	7.66	4.50%	7.66	5.00%	7.66	5.53%
OCE Econ	8.00	4.71%	8.00	5.22%	8.00	5.77%
Ocoee	5.47	3.22%	5.47	3.57%	3.97	2.86%
OCE ERWF	20.25	11.91%	20.25	13.21%	20.25	14.61%
OCW Magnolia	0.02	0.01%				
OUC Conway	6.05	3.56%	3.77	2.46%	9.20	6.64%
OUC Dr. Phillips	5.83	3.43%				
OUC Highland	7.98	4.69%	7.98	5.21%	7.98	5.76%
OUC Kirkman	11.00	6.47%	11.00	7.18%	11.00	7.94%
OUC Kuhl	11.31	6.65%	11.31	7.38%	11.31	8.16%
OUC Martin	7.27	4.28%	9.31	6.07%	8.34	6.02%
OUC Navy	6.40	3.77%	6.40	4.18%		
OUC Pershing	7.00	4.12%	7.00	4.57%	7.00	5.05%
OUC Pine Hills	19.60	11.53%	19.60	12.79%	19.60	14.14%
OUC Primrose					0.30	0.22%
OUC Total	82.43	48.49%	76.37	49.83%	74.73	53.93%
Oviedo	4.48	2.63%	4.17	2.72%	4.26	3.07%
Sanford	2.47	1.46%	3.23	2.11%	3.15	2.28%
Sanlando	0.18	0.11%				
Seminole County	9.54	5.61%	7.59	4.95%	2.64	1.91%
Southern States U. Shores	0.06	0.03%				
Winter Garden	2.52	1.48%				
Winter Springs	0.74	0.43%	0.553	0.36%	0.742	0.54%
Zellwood Station	1.89	1.11%	0.53	0.34%		
Total (MGD)	169.98		153.26		138.57	
% of total demand in deficit	30.00%		27.00%		24.40%	

Aquifer Response

The LP model drawdown predictions compared to simulation model results for case 1 are illustrated in Figure 13, while improvement over the nonoptimized case is provided in Figure 14.

General agreement between optimization model and simulation model heads was found to be excellent. A maximum error of 1.46 feet was incurred at Oviedo when the closure criterion of the simulation model was set at 0.0001. This linear behavior is likely to be due to 1) the surficial layer in the simulation model is not active and 2) the closure criterion is very tight. The optimization model tends to select wells with the lowest estimated environmental impact and withdraws from these wells at or near capacity. Also, Lower Floridan wells tend to be selected more frequently than Upper Floridan wells, particularly when springs are nearby.

Maximum errors were found to be 1.46 ft., 1.43 ft., and 1.52 ft., for cases 1-3 respectively, while maximum drawdowns were 8.12 ft., 7.78 ft., and 8.0 ft. at OCPUD S Hunters Creek for the same cases. Average drawdowns were 1.82 ft., 1.49 ft., and 1.19 ft., while average errors were 0.36 ft., 0.42 ft., and 0.45 ft., respectively. Control point responses are provided in Table A6 of the appendix.

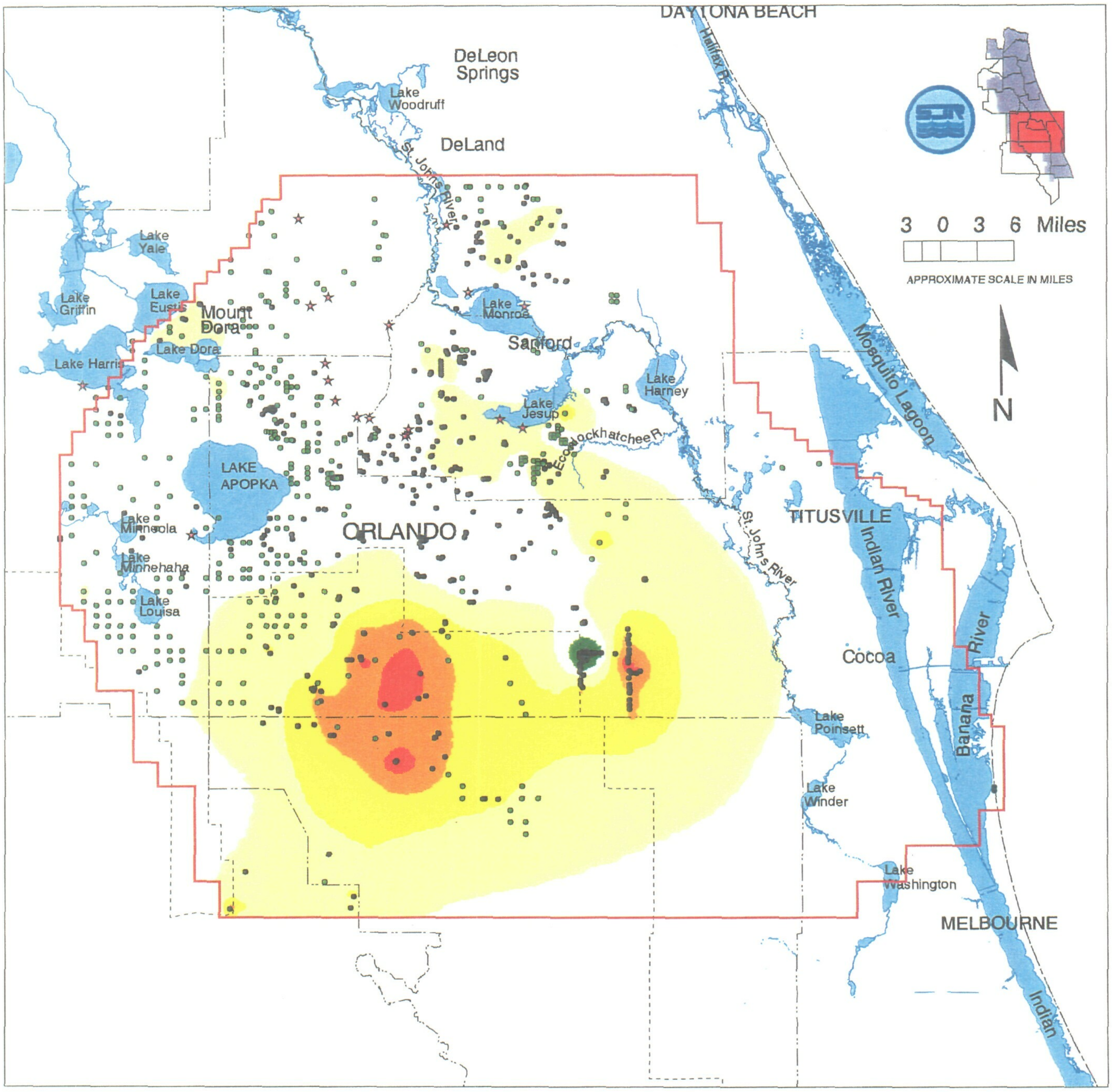


Figure 13

East-central projected year 2010 LP optimization model Upper Floridan drawdown prediction allowing 2% head loss at control points with high or moderate potential for vegetative harm and 15% spring discharge loss and head loss at control points with low potential for vegetative harm

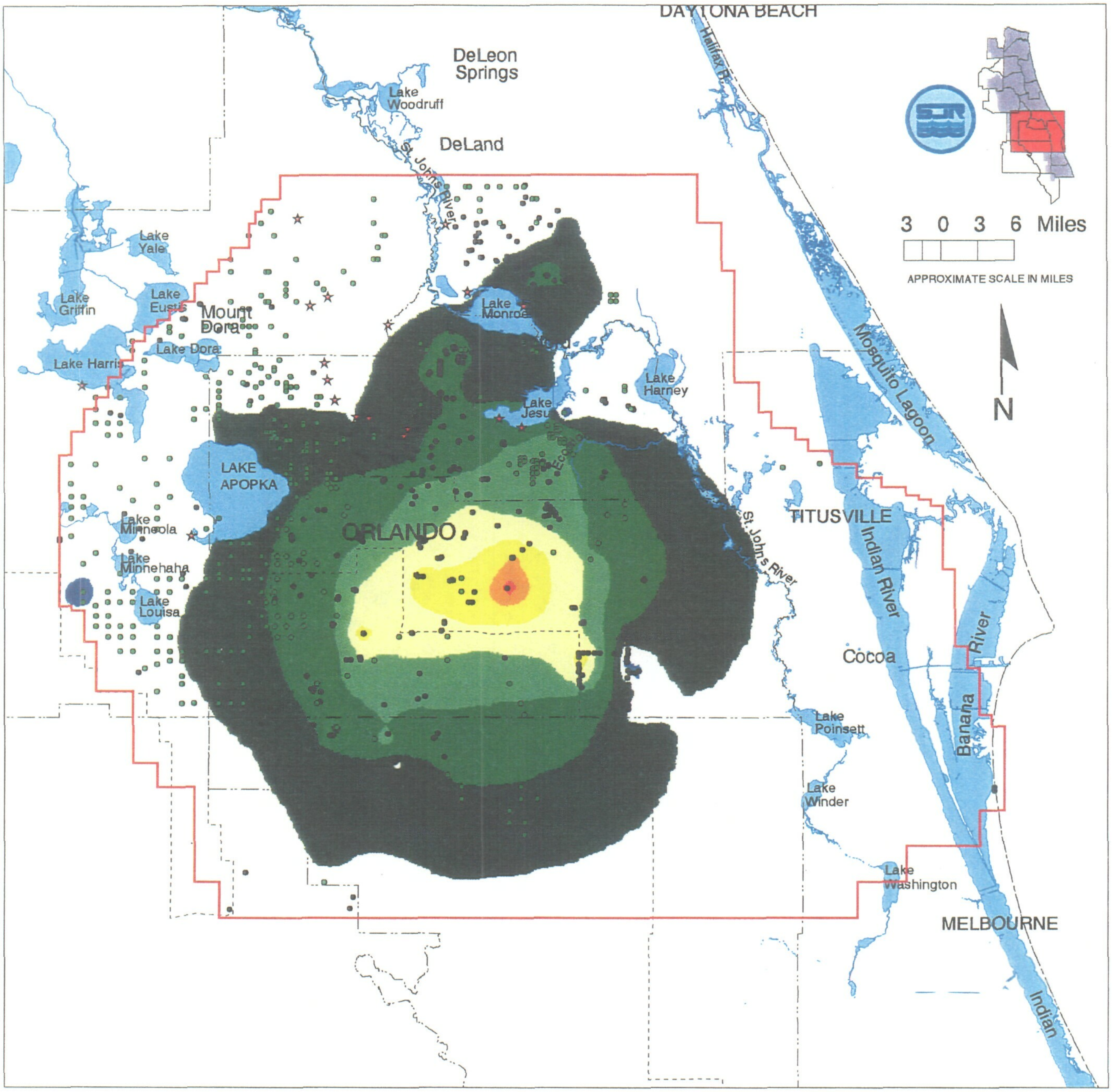


Figure 14

East-central projected year 2010 LP optimization model Upper Floridan drawdown prediction allowing 2% head loss at control points with high or moderate potential for vegetative harm and 15% spring discharge loss and head loss at control points with low potential for vegetative harm

Difference in Feet
- -6--3
- -3---1
- 1-3
- 3-6
- 6-9
- 9-12
- 12-15
- 15-18
- 18-21
- 21-24
- 24-27

- County Boundary
- SJRWMD Boundary
- ECF Active Edge
- Agricultural Wells
- Municipal Wells
- Springs
- General Water Bodies

Figure 15 below displays the comparison between optimization model predictions and simulation model results for case 1. The unit response matrix responds to changes in well withdrawal within the LP model linearly.

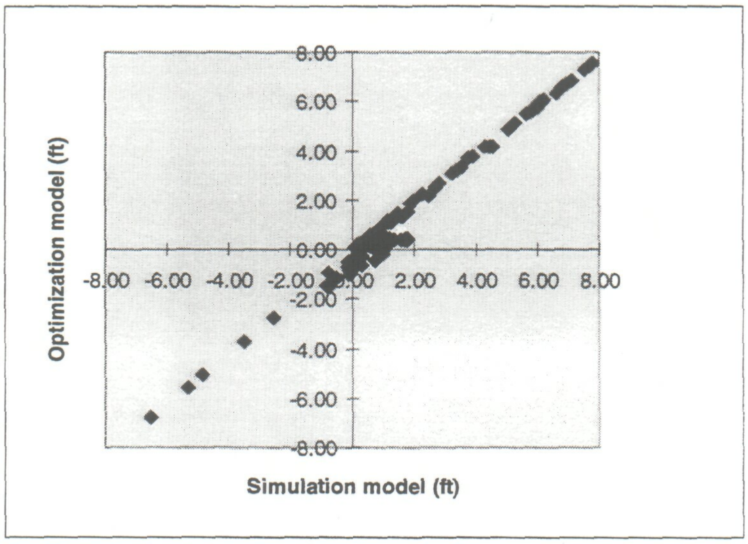


Figure 15. East-central comparison between optimization model predictions and simulation model results for case 1: 15% discharge loss at springs and head loss at control points with low potential for vegetative harm and 2% head loss at control points with high or moderate potential for vegetative harm.

Figure 16 illustrates the case 2 projected year 2010 LP model drawdown predictions, while Figure 17 shows the improvement from the nonoptimized projected year 2010 simulation.

Aquifer response to the LP model's third examined case, allowing 0% Upper Floridan head loss from 1988 at control points with high or moderate potential for vegetative harm is illustrated in Figure 18 for drawdowns from year 1988 and improvement over the nonoptimized case in Figure 19.

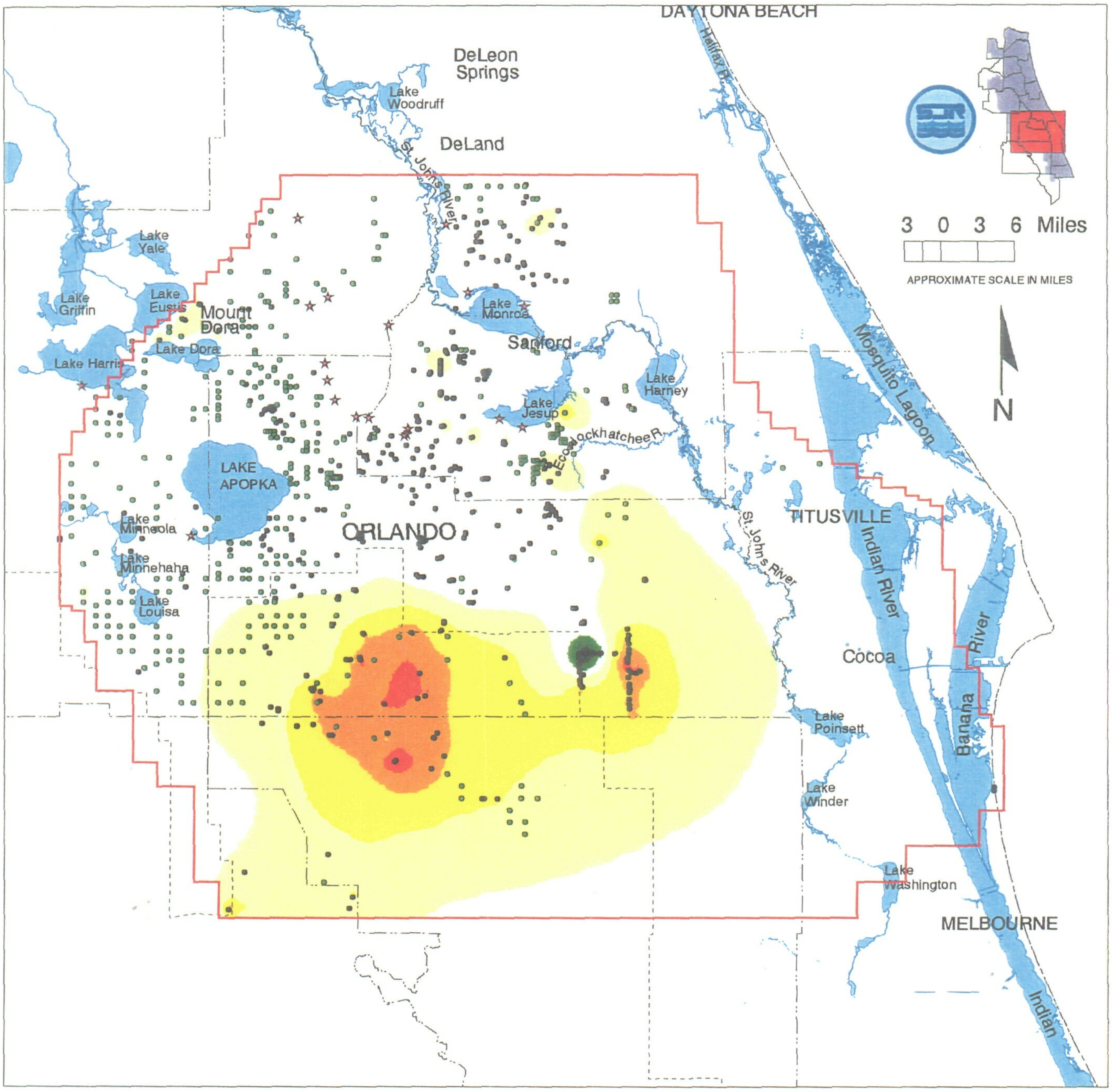


Figure 16

East-central projected year 2010 LP optimization model Upper Floridan drawdown prediction allowing 1% head loss at control points with high or moderate potential for vegetative harm and 15% spring discharge loss and head loss at control points with low potential for vegetative harm

Drawdown in Feet

-11--9
-9--7
-7--5
-5--3
-3--1
1-3
3-5
5-7
7-9
9-11
11-13

County Boundary
ECF Active Edge
SJRWMD Boundary
Agricultural Wells
Municipal Wells
Springs
General Water Bodies

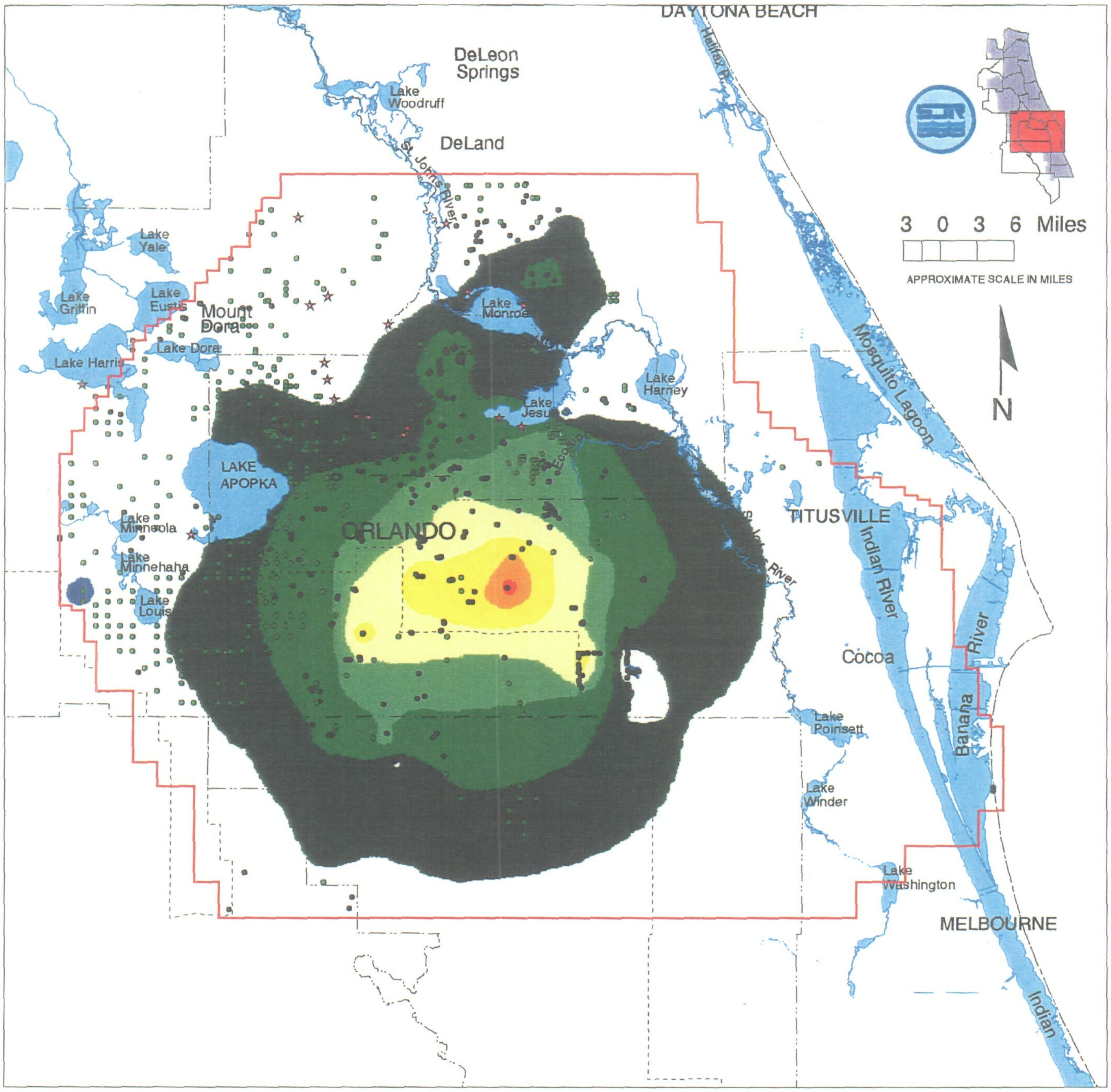


Figure 17

East-central projected year 2010 LP optimization model Upper Floridan improvement over nonoptimized case allowing 1% head loss at control points with high or moderate potential for vegetative harm and 15% spring discharge loss and head loss at control points with low potential for vegetative harm

Difference in Feet

- -6--3
- -3---1
- 1-3
- 3-6
- 6-9
- 9-12
- 12-15
- 15-18
- 18-21
- 21-24
- 24-27

- County Boundary
- SJRWMD Boundary
- ECF Active Edge
- Agricultural Wells
- Municipal Wells
- Springs
- General Water Bodies

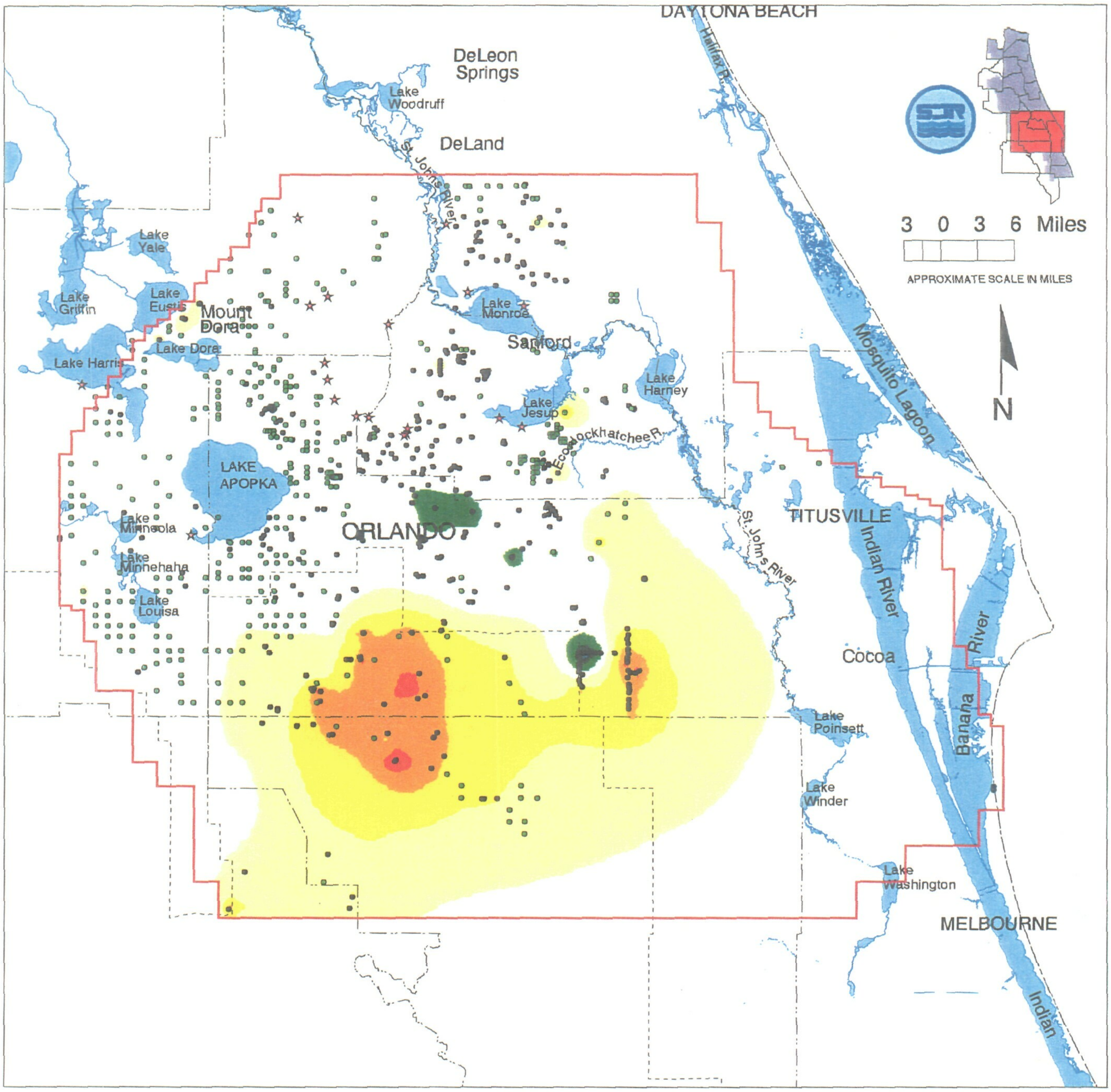
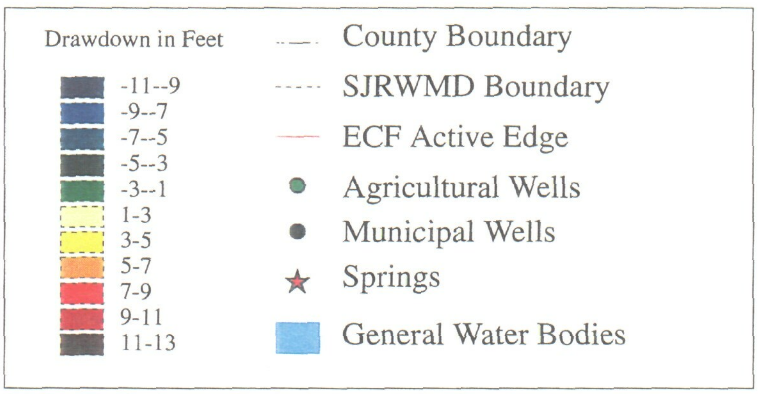


Figure 18

East-central projected year 2010 LP optimization model Upper Floridan drawdown prediction allowing 0% head loss at control points with high or moderate potential for vegetative harm and 15% spring discharge loss and head loss at control points with low potential for vegetative harm



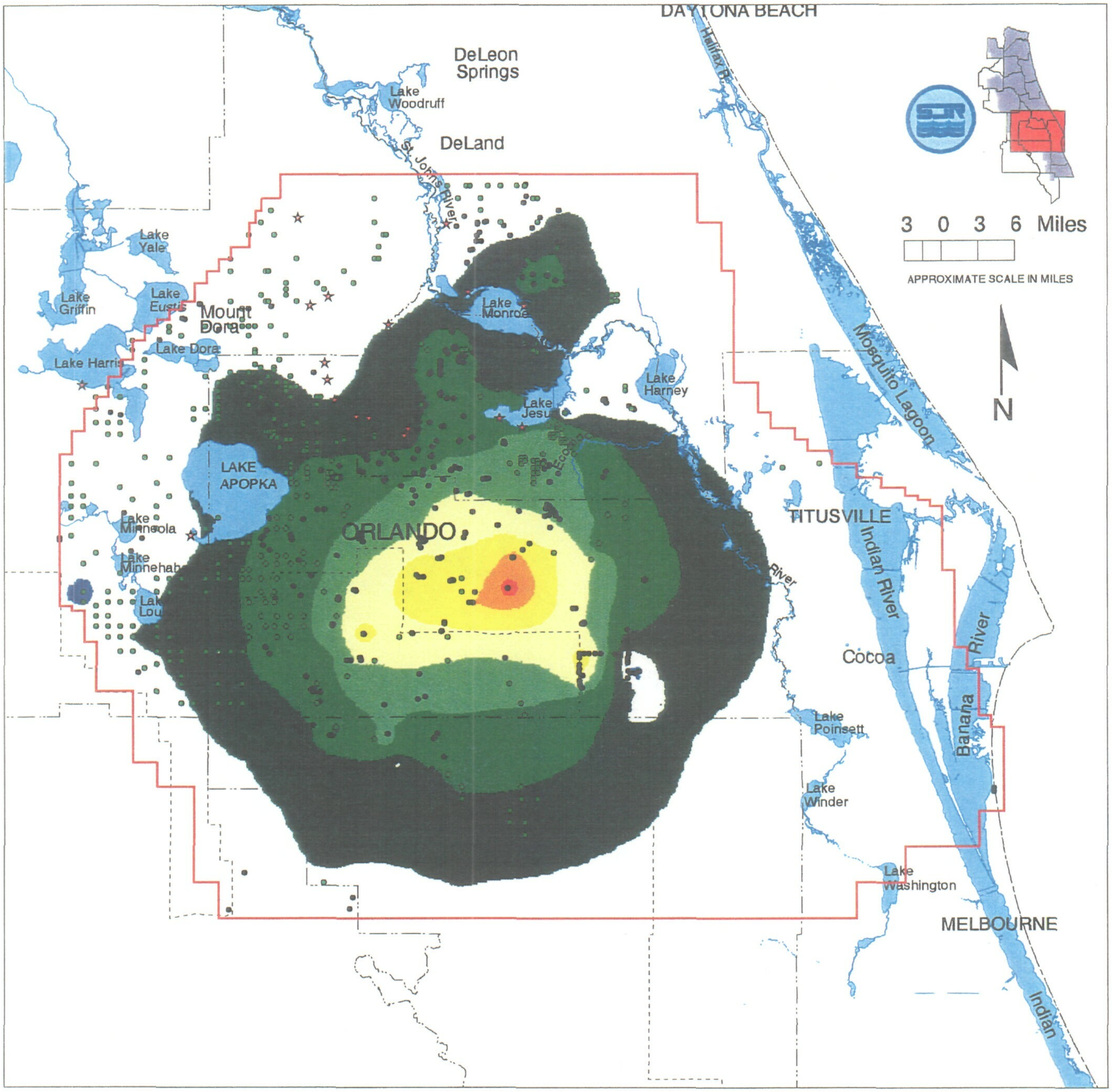


Figure 19

East-central projected year 2010 LP optimization model Upper Floridan improvement over nonoptimized case allowing 0% head loss at control points with high or moderate potential for vegetative harm and 15% spring discharge loss and head loss at control points with low potential for vegetative harm

Spring head responses are provided in Table 6 below while Table 7 gives spring discharges for the three examined cases:

Table 6. East-central spring heads

				Spring heads(ft)					
				Case 3, 0% loss		Case 2, 1% loss		Case 1, 2% loss	
Spring	Spring elevation	Simulated year 1988	Projected year 2010 nonoptimized	Simulation model	Optimization model	Simulation model	Optimization model	Simulation model	Optimization model
Messant	26.00	34.30	33.98	34.37	34.41	34.32	34.36	34.37	34.30
Seminole	34.00	35.82	35.63	35.77	35.79	35.75	35.76	35.77	35.73
Rock	30.00	30.86	30.73	30.86	30.87	30.84	30.85	30.86	30.82
Wekiva	13.00	29.81	28.25	29.81	29.97	29.60	29.75	29.81	29.57
Miami	15.00	35.75	33.53	35.81	36.08	35.52	35.77	35.81	35.49
Starbuck	25.00	35.30	32.90	35.34	35.69	35.09	35.41	35.34	35.13
Palm	25.00	35.69	33.18	35.70	36.05	35.44	35.76	35.70	35.48
Sanlando	26.00	35.98	33.39	35.91	36.31	35.70	36.02	35.95	35.74
Camp La No Che	34.00	37.23	36.83	37.03	37.05	37.01	37.03	37.03	36.98
Blue	1.00	1.76	1.72	1.74	1.74	1.73	1.74	1.74	1.73
Gemini	1.00	17.58	15.49	17.11	17.27	16.96	17.11	17.11	16.88
Island	7.00	20.78	21.21	22.21	22.34	22.11	22.24	22.21	22.12
Witherington	25.00	38.08	36.32	38.08	38.23	37.81	37.95	38.08	37.72
Lake Jessup	3.00	35.32	31.94	37.24	38.47	36.96	38.11	37.24	37.70
Clifton	3.00	33.34	29.71	35.82	37.09	35.55	36.75	35.82	36.34
Apopka	67.00	68.16	67.81	68.08	68.09	68.04	68.05	68.08	68.03
Sulphur	27.00	36.30	35.46	36.22	36.29	36.07	36.14	36.22	36.01

Table 7. East-central spring discharges

						Fraction of simulated year 1988 spring discharge						
	Simulation Model Spring discharges (cfs)						Case 3, 0%		Case 2, 1%		Case 1, 2%	
Spring	Year 1988	Nonoptimzed projected year 2010	Case 3, 0%	Case 2, 1%	Case 1, 2%	Nonoptimized projected year 2010	Simulation model	Optimization model	Simulation model	Optimization model	Simulation model	Optimization model
Messant	12.5	12.0	12.6	12.5	12.6	0.96	1.01	1.01	1.00	1.01	1.01	1.00
Seminole	27.4	24.5	26.6	26.4	26.6	0.90	0.97	0.98	0.96	0.97	0.97	0.95
Rock	53.7	45.6	53.7	52.5	53.7	0.85	1.00	1.01	0.98	0.99	1.00	0.95
Wekiva	70.0	63.5	70.0	69.2	70.0	0.91	1.00	1.01	0.99	1.00	1.00	0.99
Miami	4.5	4.1	4.6	4.5	4.6	0.89	1.00	1.02	0.99	1.00	1.00	0.99
Starbuck	14.4	11.0	14.4	14.0	14.4	0.77	1.00	1.04	0.98	1.01	1.00	0.98
Palm	6.1	4.7	6.2	6.0	6.2	0.77	1.00	1.03	0.98	1.01	1.00	0.98
Sanlando	16.2	11.9	16.1	15.7	16.1	0.74	0.99	1.03	0.97	1.00	1.00	0.98
Camp La No Che	0.3	0.3	0.3	0.3	0.3	0.88	0.94	0.94	0.93	0.94	0.94	0.92
Blue	110.0	104.2	107.1	105.7	107.1	0.95	0.97	0.97	0.96	0.97	0.97	0.96
Gemini	7.6	6.7	7.4	7.4	7.4	0.87	0.97	0.98	0.96	0.97	0.97	0.96
Island	6.8	6.9	7.5	7.4	7.5	1.03	1.10	1.11	1.10	1.11	1.10	1.10
Witherington	3.8	3.2	3.8	3.7	3.8	0.87	1.00	1.01	0.98	0.99	1.00	0.97
Lake Jessup	0.71	0.64	0.75	0.75	0.75	0.90	1.06	1.10	1.05	1.09	1.06	1.07
Clifton	1.4	1.3	1.5	1.5	1.5	0.88	1.08	1.12	1.07	1.11	1.08	1.10
Apopka	53.7	37.5	50.0	48.1	50.0	0.70	0.93	0.94	0.90	0.91	0.93	0.89
Sulphur	0.9	0.9	0.9	0.9	0.9	0.91	0.99	1.00	0.98	0.98	0.99	0.97

Well Withdrawal Rates

Well withdrawal rates for cases 1-3 are displayed in Tables A8 and A10 of the appendix for public supply utility and agricultural wells, respectively. Model results are strongly dependent on the specified capacity as is evident in comparing withdrawal rates to estimated hydraulic well capacities given in LAW Engineering (1996). It is suggested that additional LP model runs be made without the well capacity constraint. Elimination of the capacity constraint may provide information regarding the extent of possible additional well withdrawal at specific locations subject to the specified environmental constraints.

Sensitivity Analysis

Shadow (dual) prices provide a simple and effective means of sensitivity analysis. The shadow price refers to the change in the objective function produced from a unit relaxation in a binding constraint. Binding constraints have a direct effect on the objective function and they have non-zero shadow prices. A modified objective function value obtained from a relaxing of constraints can be calculated by

$$Z_{new} = Z + \Delta\ RH * SP \tag{45}$$

where Z_{new} is the new calculated value of the objective function, Z is the value of the objective function from model execution, ΔRH is the change in the right-hand side of the specified constraint, and SP is the shadow price associated with that constraint.

Shadow prices allow the water resources manager to see how the objective function changes if there is a relaxation in a binding constraint. Larger shadow prices correspond to greater potential for changing the objective function. For example, one could observe the individual effects on the objective function if each municipal demand is relaxed by 10%. Table 8 exhibits the shadow prices for public supply utility demand areas. It can be seen that the largest demand areas located near springs and areas having high or moderate potential for vegetative harm show the greatest potential for environmental mitigation if their demands are relaxed, while public utility demand areas with small water demands that are located far from springs or areas having high or moderate potential for vegetative harm have very little impact on the objective function. However, some areas with low demand may have high shadow prices due to their proximity to sensitive areas, while some areas which are not in close proximity to sensitive areas may have high shadow prices due to their large 2010 demands alone. The shadow prices in Table 8 are sorted first by descending order and then by the projected increase in water demand from year 1988.

Table 8. East-central shadow prices for public demand areas

Model Identifier	Public Supply Utility Demand Area	Projected Demand Increase from 1988 to 2010 (MGD)	% of Total Increase from 1988	Shadow Prices Loss Limit at areas with high or moderate potential for vegetative harm Case 3, 0%	Case 2, 1%	Case 1, 2%
OE5	OCPUD E ERWF	20.25	7.65%	1	1	1
DEL	Deltona	17.64	6.66%	1	1	1
APO	Apopka	17	6.42%	1	1	0.79
SEM	Seminole County	12.05	4.55%	1	1	1
OU2	OUC Martin	11.01	4.16%	1	1	1
OVI	Oviedo	8.48	3.20%	1	1	1
OU5	OUC Pine Hills	8.4	3.17%	1	1	1
O12	OUC Pershing	7	2.64%	1	1	1
OE2	OCPUD E Conway	5.16	1.95%	1	1	1
LMY	Lake Mary	5.12	1.93%	1	1	1
O10	OUC Navy	5.01	1.89%	1	1	0.99
OU7	OUC Kirkman	4.74	1.79%	1	1	1
OE3	OCPUD E Econ	4.43	1.67%	1	1	1
OCO	Ocoee	3.34	1.26%	1	1	1
WSP	Winter Springs	3.04	1.15%	1	1	1
OU6	OUC Kuhl	2.91	1.10%	1	1	1
SAF	Sanford	2.49	0.94%	1	1	1
SAN	Sanlando Utilities	1.72	0.65%	1	0.99	0.87
WGA	Winter Garden	1.08	0.41%	1	0.87	0.75
ZSU	Zellwood Station Utilities	0.93	0.35%	1	1	0.5
SSS	SSU-Univ. Shores	0.9	0.34%	1	0.99	0.98
OU1	OUC Dr. Phillips	0.87	0.33%	1	1	0.92
EAT	Eatonville	0.81	0.31%	1	1	1
MAI	Maitland	0.64	0.24%	1	1	0.99
OW6	OCPUD W Magnolia/Lake John	0.03	0.01%	1	0.6	0.51
CON	Conway	0.02	0.01%	1	1	1
OAK	Oakland	-0.01	-0.01%	1	0.59	0.51
OU4	OUC Highland	-0.1	-0.04%	1	1	1
OU3	OUC Conway	-0.79	-0.30%	1	1	1
OW3	OCPUD W Oak Meadow	-1.93	-0.73%	1	1	1
OU9	OUC Sky Lake	15.3	5.78%	1	1	0.99
OU8	OUC Primrose	-0.94	-0.36%	0.99	1	1
CAS	Casselberry	1.5	0.57%	0.98	0.99	0.97
OW5	OCPUD W WRWF	20	7.55%	0.98	0.99	0.91
OW4	OCPUD W Riverside	-2.9	-1.10%	0.98	0.99	0.92
ALT	Altamonte Springs	2.24	0.84%	0.97	0.97	0.96
WEK	Wekiva	0.06	0.02%	0.96	0.97	0.93
PAM	Park Manor	-0.04	-0.02%	0.96	0.94	0.94
LON	Longwood	1.12	0.42%	0.95	0.95	0.94
OW2	OCPUD W Hidden Springs/Kelso/Windmere	-1.93	-0.73%	0.94	0.88	0.79
WPK	Winter Park	2.94	1.11%	0.92	0.92	0.9
ZWU	Zellwood Water Users	0.19	0.07%	0.89	0.77	0.41
OE1	OCPUD E Bonneville/Corrine Terr.	-0.94	-0.36%	0.88	0.85	0.85

Table 8-- *Continued*

Model Identifier	Public Supply Utility Demand Area	Projected Demand Increase from 1988 to 2010 (MGD)	% of Total Increase from 1988	Shadow Prices Loss Limit at areas with high or moderate potential for vegetative harm Case 3, 0%	Case 2, 1%	Case 1, 2%
OW1	OCPUD W Bent Oaks/Plymouth	0.8	0.30%	0.88	0.86	0.74
SSU	Southern St. Util	0.23	0.09%	0.87	0.87	0.82
UCF	Univ. Central Fla	0.29	0.11%	0.87	0.83	0.83
CFR	Cent. Fla. Res. Park	0	0.00%	0.87	0.84	0.84
RAV	Ravenna Park	0.05	0.02%	0.86	0.87	0.87
OS4	OCPUD S Orange Wood	4.12	1.56%	0.85	0.85	0.82
WGC	Winter Garden Citrus Products	0	0.00%	0.83	0.81	0.74
O11	OUC Orange	7.2	2.72%	0.8	0.79	0.8
SWF	Sea World of Florida	0	0.00%	0.79	0.79	0.75
OE4	OCPUD E Lake Nona	1.97	0.74%	0.77	0.76	0.75
OS3	OCPUD S Meadow Woods/SRWF	10.12	3.82%	0.72	0.72	0.72
O13	OUC Stanton Energy Ctr	0	0.00%	0.72	0.71	0.71
OS2	OCPUD S Hunter's Creek	0.38	0.14%	0.69	0.68	0.67
RCU	Reedy Creek Utilities	16.54	6.25%	0.68	0.64	0.59
OS1	OCPUD S Cypress Walk/Vistana	4.88	1.84%	0.62	0.61	0.56
ZWF	Zellwood Farms	0.19	0.07%	0.61	0.53	0.29
FDC	Florida Dept. of Corrections	-0.05	-0.02%	0.61	0.6	0.59
FPL	Florida Power and Light	0.33	0.13%	0.58	0.58	0.57
CHU	Chuluota	-0.14	-0.05%	0.5	0.49	0.49
IN4	Floribra USA, Inc.	0	0.00%	0.49	0.48	0.45
ORO	Orange/Osceola Management	2.11	0.80%	0.48	0.48	0.48
CFU	Central Florida Utilities	1.76	0.66%	0.48	0.47	0.44
HHO	Hyatt House Orlando	0.42	0.16%	0.47	0.45	0.42
KIS	Kissimmee	5.28	1.99%	0.47	0.46	0.46
VOL	Volusia County	1.33	0.50%	0.47	0.47	0.46
COC	Cocoa	6.98	2.63%	0.46	0.47	0.47
MON	Montverde	0.09	0.03%	0.45	0.34	0.27
ECU	Econ Utilities	0.02	0.01%	0.44	0.44	0.43
JKV	John Knox Village	0.3	0.11%	0.4		0.39
IN5	Silver Sand (Clermont Mine)	0	0.00%	0.4	0.32	0.28
OSC	Osceola Service	1.32	0.50%	0.4	0.38	0.35
IN2	Florida Crushed Stone	0	0.00%	0.39	0.31	0.27
OCY	Orange City	3.4	1.28%	0.35	0.35	0.35
SCL	St. Cloud	2.49	0.94%	0.31	0.31	0.31
SWA	Seminole Woods Assn.	0.03	0.01%	0.27	0.27	0.27
LHE	Lake Helen	0.36	0.13%	0.23	0.21	0.21
LHY	Lake Harney	0	0.00%	0.23	0.23	0.23
IN3	Florida Rock (Lake Sand)	0	0.00%	0.22	0.19	0.18
MTD	Mt. Dora	2.11	0.80%	0.21	0.18	0.12

Table 8-- *Continued*

Model Identifier	Public Supply Utility Demand Area	Projected Demand Increase from 1988 to 2010 (MGD)	% of Total Increase from 1988	Shadow Prices Loss Limit at areas with high or moderate potential for vegetative harm		
				Case 3, 0%	Case 2, 1%	Case 1, 2%
CLE	Clermont	1.04	0.39%	0.18	0.14	0.12
MIN	Minneola	0.26	0.10%	0.18	0.14	0.11
POI	Poinciana	0.84	0.32%	0.14	0.14	0.14
EUS	Eustis	2.88	1.09%	0.12	0.1	0.07
MHN	Minneola Harbor Hills	0.73	0.27%	0.11	0.09	0.07
TAV	Tavares	2.2	0.83%	0.1	0.09	0.06
HOH	Howey in the Hills	0.13	0.05%	0.09	0.08	0.05
IN6	Silver Springs Citrus	0	0.00%	0.07	0.06	0.04
DAV	Davenport	0.73	0.28%	0.06	0.06	0.06
GRO	Groveland Park	0.5	0.19%	0.04	0.03	0.03
HAI	Haines City	1.63	0.61%	0.03	0.03	0.03
IN1	B & W Canning	0.14	0.05%	0.03	0.03	0.02
AF1	USAF BAS Civil Engineer	0	0.00%	0.02	0.02	0.02

There were no non-zero shadow prices for springs in the east-central region. Vegetative harm constraints were found to have more impact on the objective function than springs. However, in prior LP model runs which did not consider an area's potential for vegetative harm, only Rock, Sanlando, Camp La No Che, and Apopka springs were found to have considerable impact on the objective function.

A few public supply utility wells which were not selected for withdrawal had high shadow prices; these wells with their shadow prices are listed in Table 9 below.

Table 9. East-central public well shadow prices

Public Supply Utility Well	Public Supply Demand Area	Loss limit at areas with high or moderate potential for vegetative harm Case 3, 0%	Case 2, 1%	Case 1, 2%
MW76	Deltona	12.684	13.094	13.126
MW143	OCW Oak Meadows	3.624	4.136	3.664
MW74	Deltona	2.285	2.936	2.362
MW79	Deltona	2.086	2.16	2.166
MW114	OCE Conway	1.787	1.683	1.642
MW78	Deltona	1.648	1.705	1.71
MW133	OCW Plymouth	1.494	1.129	0
MW80	Deltona	1.087	1.127	1.131
MW115	OCE Conway	1.034	0.97	0.946

VOLUSIA COUNTY

Several model runs were made with varying constraints at aquifer heads and springs. Overall Volusia LP model statistics are as follows:

- Size: 8,384 rows (constraints), 8,257 columns (variables), 401,980 nonzeroes
- CPLEX LP presolve routine eliminates 7,758 rows and 7,096 columns to yield a *reduced LP*: 450 rows, 985 columns and 96,003 nonzeroes
- Run time: 34 CPU seconds.

The LP model for Volusia County was run with a variety of constraints specifying the extent of allowable surficial aquifer head loss and spring discharge loss from year 1988. Control points at areas with high or moderate potential for vegetative harm were constrained to tighter loss limits than spring discharges or control points at areas with low potential for vegetative harm. It was noted that the LP model results were very sensitive to loss limits at control points with moderate to high potential for vegetative harm, displaying much variation in final results if loss limits at those points varied by only 1%, corresponding to an equivalent pressure loss of approximately 4-6 inches from year 1988 at most control points. Table 10 below displays the variation in total deficit as a function of varying loss limits on springs and control points. Total deficits are much more sensitive to loss limits for moderate and high potential areas than at springs and control points with low potential for vegetative harm:

Table 10. Volusia deficit as a function of environmental constraints

loss limit for springs and control points with low potential for vegetative harm	loss limit for control points with moderate or high potential for vegetative harm	total deficit (MGD)	total deficit (cfd)	% of projected 2010 demand in deficit
10%	0%	41.97	5,611,580	34.88%
15%	0%	40.44	5,406,923	33.61%
20%	0%	39.14	5,232,670	32.53%
10%	1%	31	4,144,160	25.76%
15%	1%	28.99	3,875,519	24.09%
20%	1%	27.74	3,709,100	23.06%
10%	2%	22.61	3,023,198	18.79%
15%	2%	20.51	2,741,387	17.04%
20%	2%	18.49	2,471,850	15.36%
10%	5%	10.15	1,356,327	8.43%
15%	5%	5.34	714,449	4.44%
20%	5%	4.19	560,172	3.48%
10%	10%	0.94	125,583	0.78%
15%	10%	0.29	38,226	0.24%
15%	15%	0	0	0.00%

Model results were highly sensitive to constraints on moderate or high harm areas. Figure 20 below displays the total deficit as a function of environmental constraints.

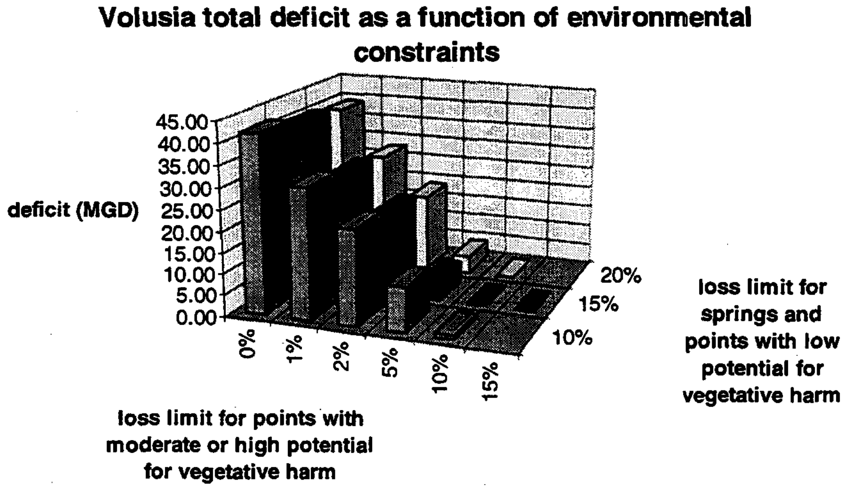


Figure 20. Volusia total deficit as a function of environmental constraints

The greatest variation in deficits occurred when the moderate and high harm losses were constrained to less than 2% of year 1988 values. For this reason, the following 3 cases were examined in greater detail:

	Loss limit on springs discharge and aquifer head at low harm areas	Loss limit on aquifer head at control points with moderate or high potential for vegetative harm
Case 1	15%	2% (about 1.5 ft maximum)
Case 2	15%	1% (about 0.75 ft maximum)
Case 3	15%	0%

Deficits

Table 11 outlines deficits obtained for cases 1-3. Deltona displays the largest deficits for all three cases, while Port Orange West, Daytona Beach East, Daytona Beach West, and Orange City also display large deficits. Almost all of the total deficit is due to public supply projected year 2010 demands with minimal deficits at agricultural areas. Total deficits amounted to approximately 13% (15.5 MGD), 20% (24.4 MGD), and 32% (38.3 MGD) of the total projected year 2010 demand for cases 1-3, respectively. Deficit quantities and locations were observed to be highly sensitive to environmental constraints. An additional 1% restriction in head loss going from case 2 to case 3 results in an additional 13.5 MGD of deficit.

Table 11. Volusia deficits

	Loss limit at areas with high or moderate potential for vegetative harm					
	case 3, 0%		case 2, 1%		case 1, 2%	
	Deficit (MGD)	% of total deficit	Deficit (MGD)	% of total deficit	Deficit (MGD)	% of total deficit
Public Deficits						
Deltona	8.88	23.23%	5.47	22.40%	4.97	32.04%
Daytona East	4.32	11.28%	4.34	17.79%	1.81	11.65%
Daytona West	3.70	9.66%	0.68	2.77%	0.78	5.02%
Orange City	3.65	9.54%	3.32	13.60%		
Port Orange West	3.21	8.39%	3.19	13.08%	3.11	20.06%
New Smyrna SR 44	2.64	6.89%	2.33	9.52%	1.59	10.23%
New Smyrna Glencoe	2.24	5.86%	1.35	5.53%	1.59	10.23%
Ormond Beach Hudson	2.15	5.62%	0.41	1.69%		
New Smyrna Samsula	1.06	2.78%	0.39	1.59%	0.20	1.30%
Volusia Four Townes	0.79	2.07%				
Deland Brandywine	0.65	1.71%				
The Trails, Inc.	0.58	1.51%	0.58	2.37%		
Ormond Beach Rima	0.46	1.21%	0.46	1.89%	0.35	2.24%
Lake Helen	0.43	1.11%	0.21	0.87%		
Orange City C. Vill.	0.39	1.01%	0.39	1.59%		
Deland Holiday Hills	0.36	0.95%				
SSU Sugar Mill	0.22	0.56%				
Volusia Gov. Center	0.20	0.52%	0.20	0.81%	0.20	1.28%
John Knox Village	0.14	0.37%	0.14	0.58%		
Sunshine Holiday Park	0.13	0.33%	0.13	0.52%		
Plantation Bay	0.12	0.32%	0.12	0.50%	0.12	0.79%
FPL Turner Plant	0.10	0.25%	0.10	0.39%	0.10	0.61%
Ellwood Titcomb	0.07	0.19%			0.09	0.59%
Holly Hill West	0.06	0.16%				
Tymber Creek	0.05	0.13%				
National Gardens			0.17	0.70%		
FPL Sanford			0.11	0.46%	0.16	1.02%
Tomoka Correc. Fac.			0.23	0.93%	0.23	1.47%
Agricultural Deficits						
F12	0.19	0.50%				
F13	0.36	0.94%				
G4	0.16	0.41%				
P21	0.25	0.64%				
T2	0.07	0.18%				
T3	0.37	0.96%				
T4	0.28	0.73%				
G5			0.09	0.36%	0.09	0.57%
P19					0.12	0.76%
Total (MGD)	38.25		24.41		15.51	
Total % in deficit	31.60%		20.20%		12.81%	

Aquifer Response

The allocation strategies determined by case 1 were incorporated into the ground water simulation model to determine the hydraulic response of the aquifer system. The case 1 LP model predicted a maximum drawdown of 7.85 ft. at Deltona control point 66 while the simulation model calculated a value of 8.06 feet. The surficial aquifer drawdown is displayed for case 1 in Figure 21. Here it can be seen that maximum drawdowns are in the Deltona area. Most other areas display drawdowns on the order of 1 ft. or less. Figure 22 shows the case 1 improvement over the nonoptimized projected year 2010 well withdrawal strategy.

The largest error between optimization model prediction and simulation model result for case 1 was 1.45 feet and occurred at Port Orange West control point/public well 23. In general, errors were slight, averaging 0.13 ft. Ideally, predicted heads and drawdowns from the simulation model match corresponding optimization model values in such a way as to form a straight line with a slope of unity. Deviations from unity are due to nonlinear effects. The formulation yields nonconservative errors pressure heads are lower in the simulation model than those predicted in the optimization model.

A comparison between optimization model predictions and simulation model results is illustrated in Figure 23 for case 1. Excellent agreement was observed between simulation and optimization models except at the Port Orange West area. Nonlinearities in this region are due to poor prediction of aquifer response and an additive effect of errors from neighboring cells with wells. There is a high concentration of wells in the Port Orange Area. Results for control point drawdowns and errors are provided in Table A7 of the appendix.

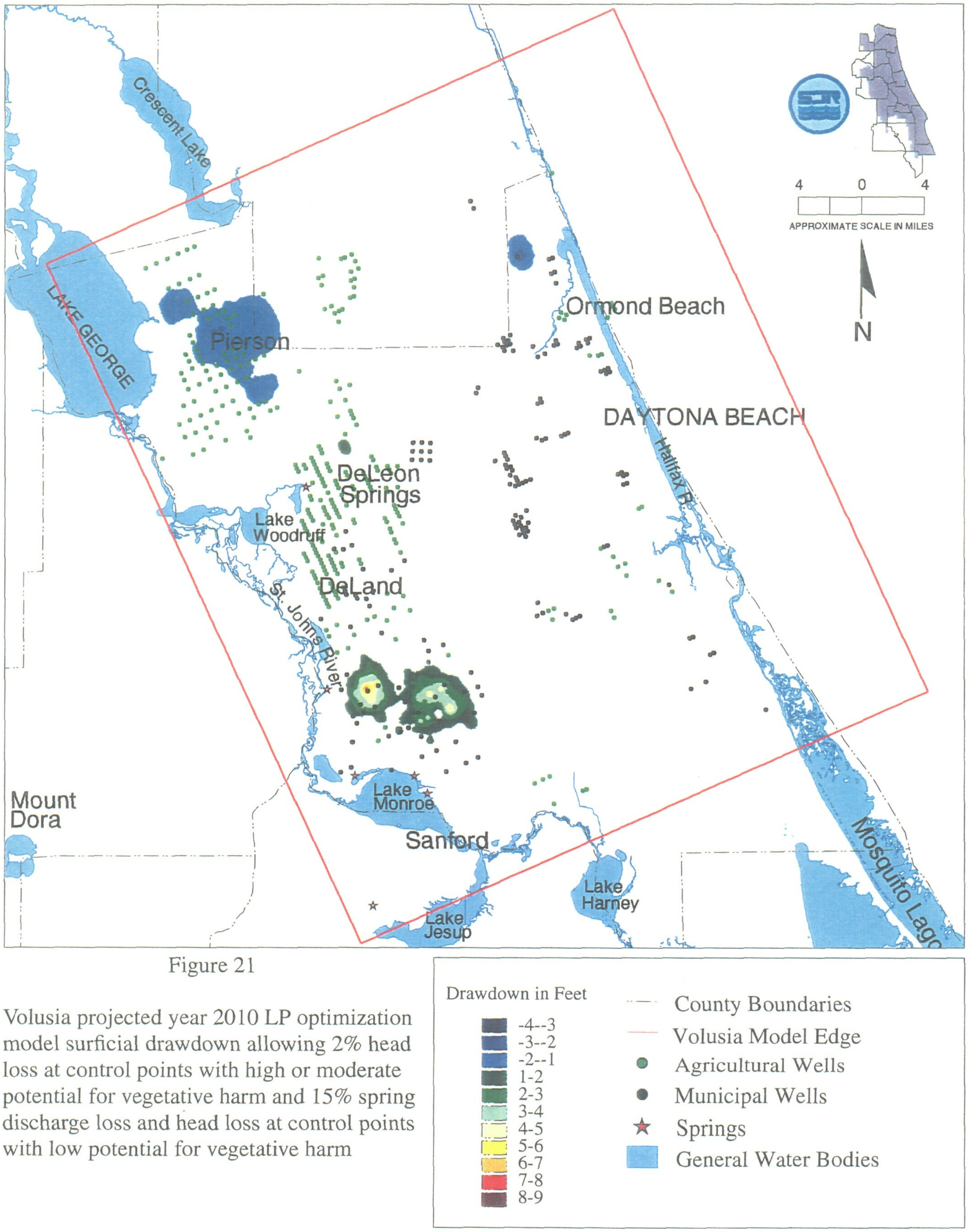


Figure 21

Volusia projected year 2010 LP optimization model surficial drawdown allowing 2% head loss at control points with high or moderate potential for vegetative harm and 15% spring discharge loss and head loss at control points with low potential for vegetative harm

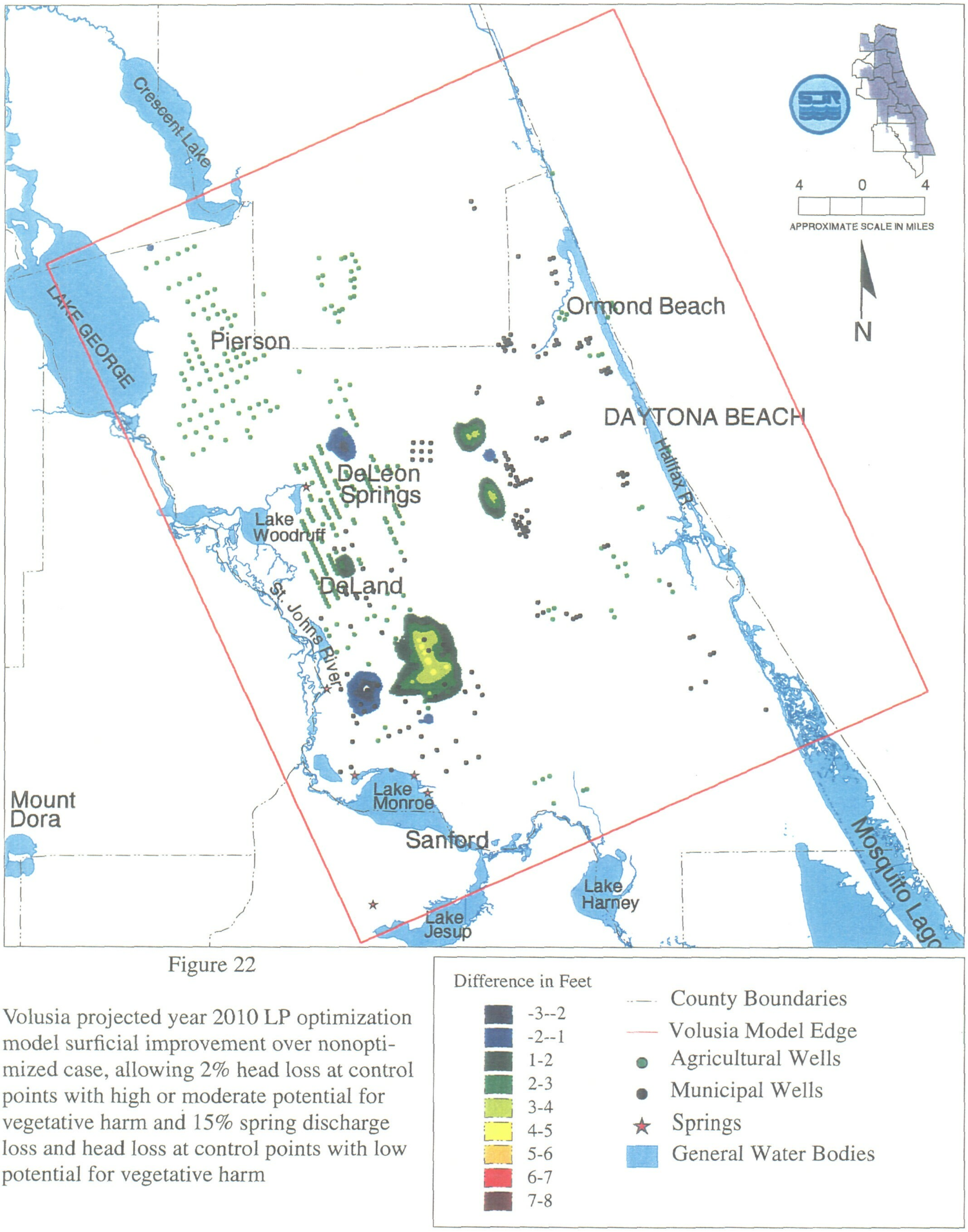


Figure 22

Volusia projected year 2010 LP optimization model surficial improvement over nonoptimized case, allowing 2% head loss at control points with high or moderate potential for vegetative harm and 15% spring discharge loss and head loss at control points with low potential for vegetative harm

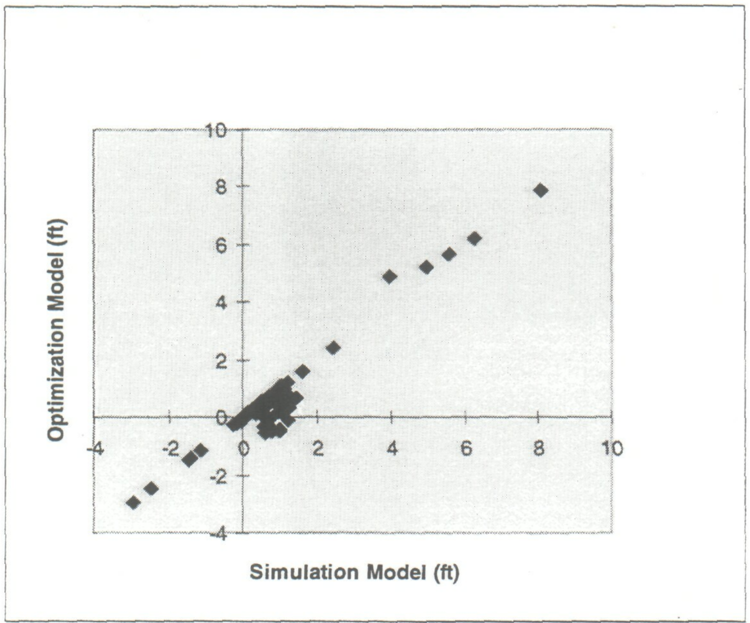


Figure 23. Comparison of optimization model predictions with simulation model results, Volusia model Case 1.

It is suggested that a conjugate gradient solver with preconditioning be used with MODFLOW for generating influence coefficients rather than the presently used SIP solver, particularly for the surficial aquifer response.

The allocation strategies determined by case 2 were incorporated into the ground water simulation model to determine the hydraulic response of the aquifer system. The case 2 LP model predicted a maximum drawdown of 9.44 ft. at Deltona control point 66 while the simulation model calculated a value of 9.89 feet. The largest error between optimization model prediction and simulation model result was 1.68 ft. and occurred at Port Orange West control point/well 24. In general, errors were slight (less than 0.5 feet) at all control points except for the Deltona and Port Orange West regions, where control points 23-39 displayed errors on the order of a foot. The surficial aquifer response was linear at all other control points with an average error of 0.16 feet. The surficial aquifer drawdown is displayed for case 2 in Figure 24. Here it can be seen that maximum drawdowns are in the Deltona area with some drawdown at other locations. Figure 25 shows the improvement over the nonoptimized projected year 2010 well withdrawal strategy.

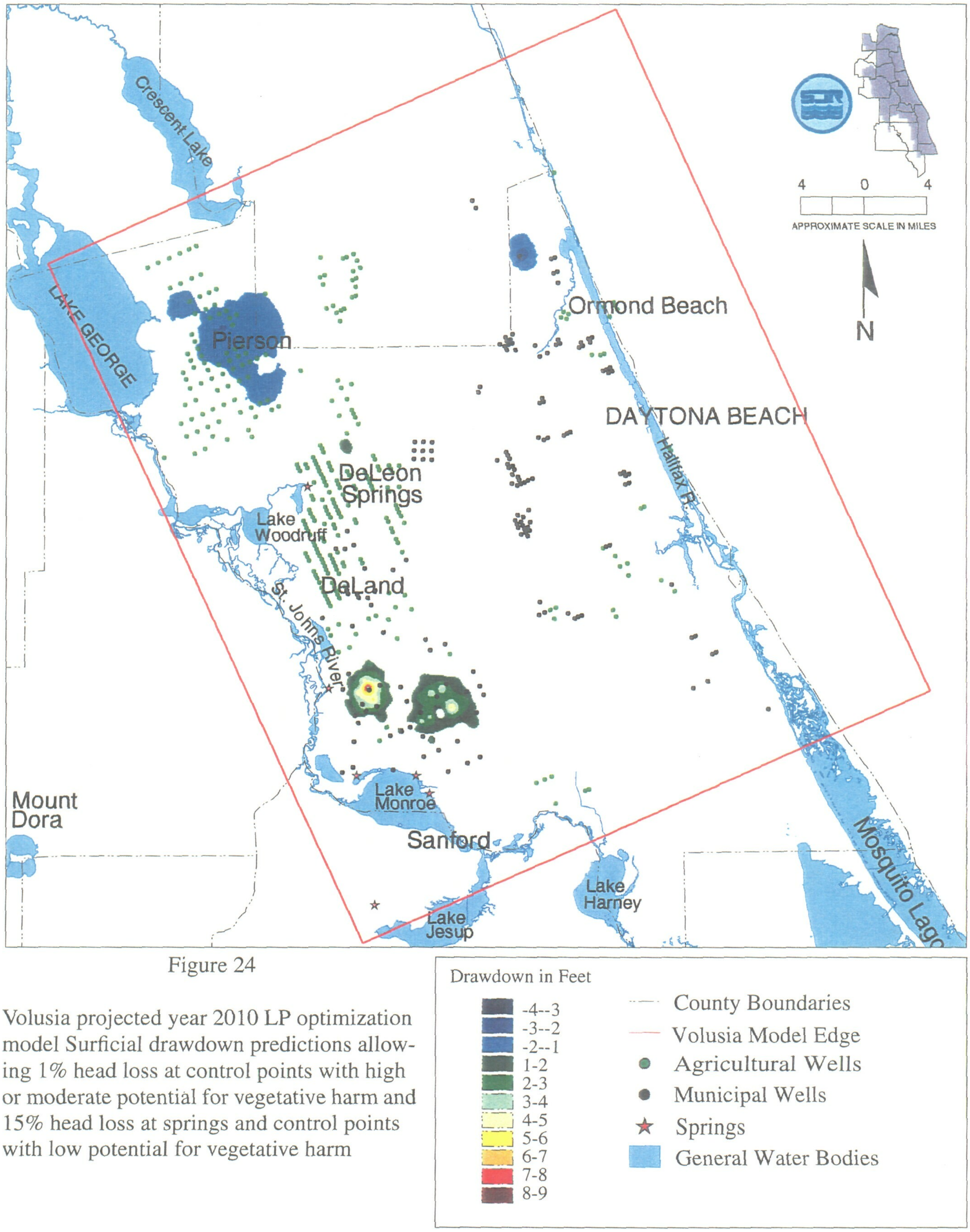


Figure 24

Volusia projected year 2010 LP optimization model Surficial drawdown predictions allowing 1% head loss at control points with high or moderate potential for vegetative harm and 15% head loss at springs and control points with low potential for vegetative harm

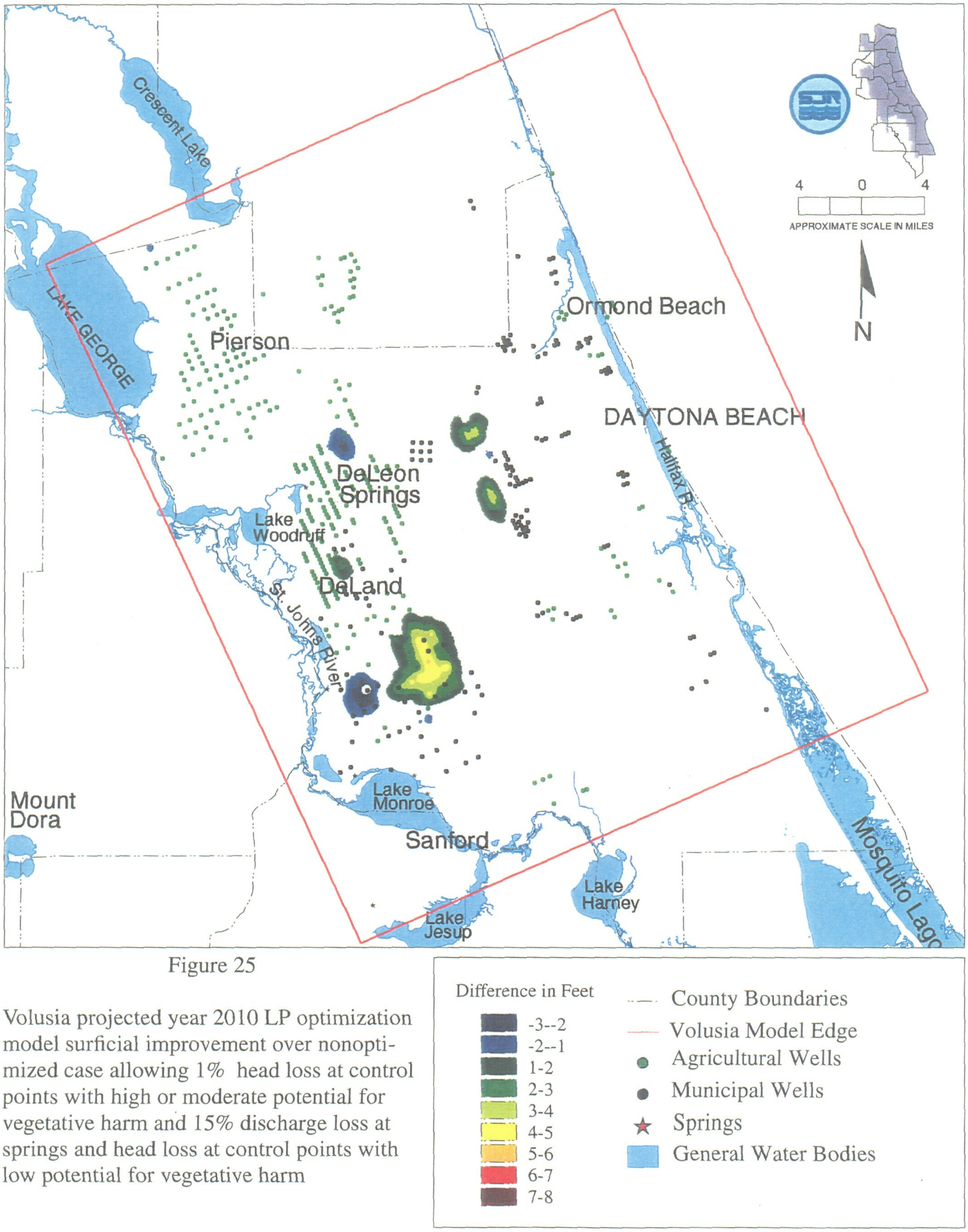


Figure 25

Volusia projected year 2010 LP optimization model surficial improvement over nonoptimized case allowing 1% head loss at control points with high or moderate potential for vegetative harm and 15% discharge loss at springs and head loss at control points with low potential for vegetative harm

The LP model using case 3 constraints predicted a maximum drawdown of 4.87 ft. at Deltona control point 61 while the simulation model calculated a value of 4.35 feet. The largest error between optimization model prediction and simulation model result was 1.97 feet and occurred at Port Orange West control point 24. In general, errors were slight (less than 0.5 feet) at all control points except for the Deltona and Port Orange West regions, where control points 23-39 displayed errors on the order of a foot. The surficial aquifer response was linear at all other control points with an average error of 0.2 feet. The surficial aquifer drawdown is displayed for case 3 in Figure 26. Here it can be seen that maximum drawdowns are in the Deltona area with most drawdowns on the order of 1 ft. or less at other locations. Figure 27 shows the improvement over the nonoptimized projected year 2010 well withdrawal strategy.

The errors between optimization model predictions for springs and simulation model results were essentially zero. Volusia spring head data are provided in Table 12 while spring discharge data are given in Table 13 below.

Table 12. Volusia spring heads

			Case 3,0% loss		Case 2, 1% loss		Case 1, 2% loss	
Spring	1988 (ft)	Projected year 2010 nonoptimized (ft)	Optimization model (ft)	Simulation model (ft)	Optimization model (ft)	Simulation model (ft)	Optimization model (ft)	Simulation model (ft)
Ponce de Leon	4.89	4.82	4.71	4.71	4.67	4.68	4.66	4.66
Blue	2.42	2.27	2.41	2.41	2.35	2.35	2.3	2.3
Gemini	12.01	10.37	10.36	10.38	10 .36	10.37	10.36	10.37

Table 13. Volusia simulation model spring discharges

	Ponce De leon	Blue	Gemini
Conductance (ft2/second)	6.94	104.17	0.74
Elevation (ft)	1	1	1
Simulation Model	cfs		
1988 discharge	27.01	147.92	8.16
2010 nonoptimized discharge	26.53	132.29	7.68
Case 1 discharge	25.42	135.42	7.9
Case 2 discharge	25.49	140.63	7.35
Case 3 discharge	25.76	146.88	7.13
Fraction of simulated year 1988 discharge			
2010 nonoptimized	0.98	0.85	0.94
Case 1	0.94	0.92	0.97
Case 2	0.94	0.95	0.90
Case 3	0.95	0.99	0.87

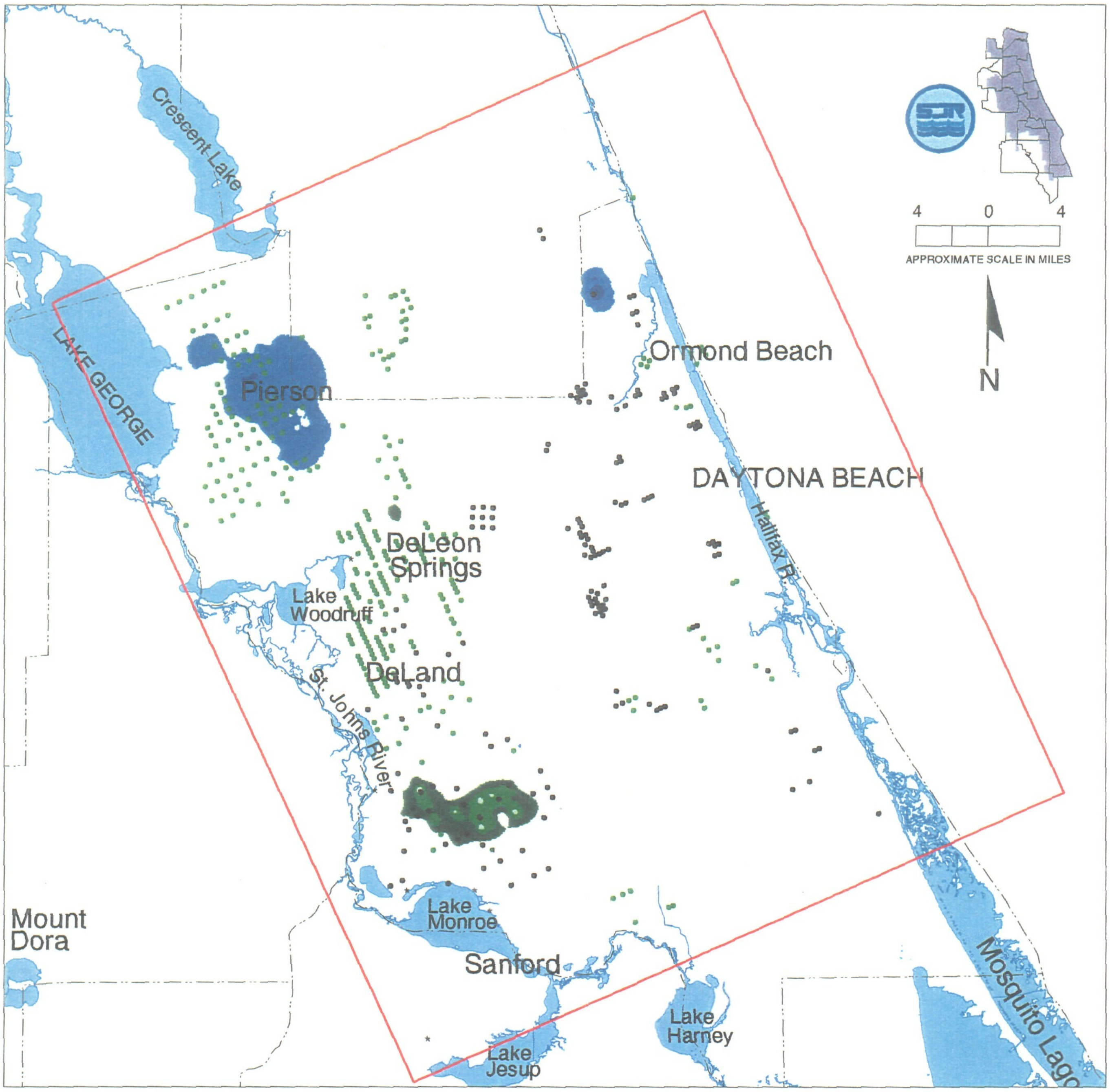


Figure 26

Volusia projected year 2010 LP optimization model Surficial drawdown, allowing 0% head loss at control points with high or moderate potential for vegetative harm and 15% discharge loss at springs and head loss at control points with low potential for vegetative harm

Drawdown in Feet

- -4--3
- -3--2
- -2--1
- 1-2
- 2-3
- 3-4
- 4-5
- 5-6
- 6-7
- 7-8
- 8-9

- County Boundaries
- Volusia Model Edge
- Agricultural Wells
- Municipal Wells
- Springs
- General Water Bodies

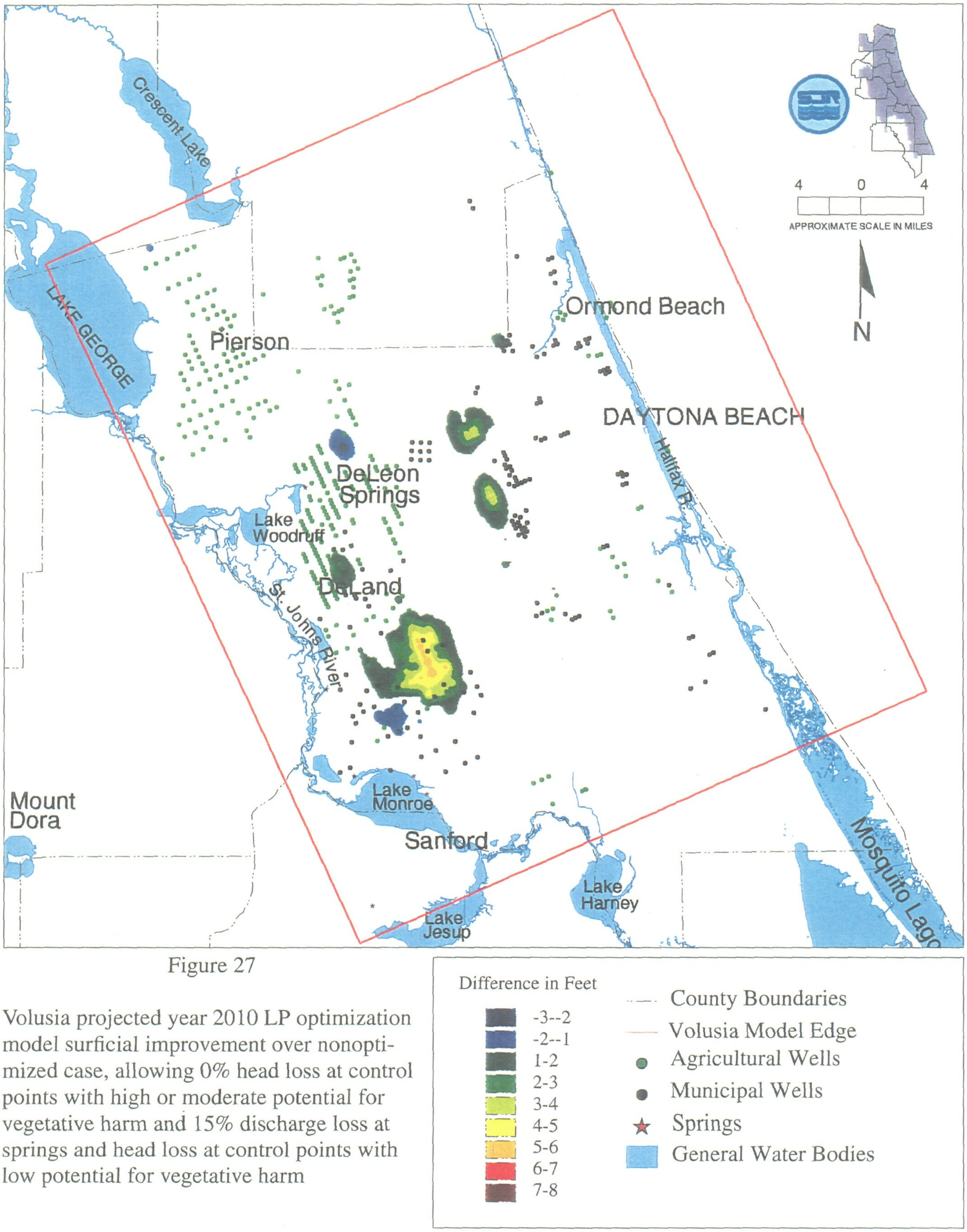


Figure 27

Volusia projected year 2010 LP optimization model surficial improvement over nonoptimized case, allowing 0% head loss at control points with high or moderate potential for vegetative harm and 15% discharge loss at springs and head loss at control points with low potential for vegetative harm

Well Withdrawal Rates

Well withdrawal rates for cases 1-3 are displayed in Tables A9 and A11 of the appendix for public supply utility and agricultural wells, respectively. Model results are strongly dependent on the specified capacity as is evident in comparing withdrawal rates to estimated well capacities. It is suggested that additional LP model runs be made without the well capacity constraint.

Sensitivity Analysis

Table 14 exhibits shadow prices for public supply utility areas. It can be seen that the largest demand areas located near springs and vegetation having high or moderate potential for vegetative harm show the greatest potential for environmental mitigation if their demands are relaxed, while public utility demand areas with very small water demands have very little impact on the objective function. Spring shadow prices were found to be negligible in the Volusia LP model.

Table 14. Volusia shadow prices for public demand areas

Model Identifier	Public Supply Utility Demand Area	Projected Year 2010 demand (MGD)	Projected Increase from 1988 (MGD)	% of Total Increase from 1988	Shadow Prices Case 3, 0% loss	Case 2, 1% loss	Case 1, 2% loss
DBE	DAYTONA BEACH EASTERN WF	7.17	17.62	35.44%	1.00	1.00	1.00
DBW	DAYTONA BEACH WESTERN WF	13.32	3.06	6.15%	1.00	1.00	1.00
DEB	DELAND - BRANDYWINE	0.90	4.59	9.24%	1.00	0.29	0.24
DEL	DELTONA	24.90	4.24	8.52%	1.00	1.00	1.00
DHH	DELAND - HOLIDAY HILLS	0.36	2.59	5.21%	1.00	0.87	0.68
DWU	DELAND	6.92	3.12	6.27%	0.72	0.49	0.42
DWW	DELAND - WOODLAND MANOR	0.16	3.14	6.32%	0.74	0.22	0.19
EDG	CITY OF EDGEWATER	4.66	1.00	2.01%	0.79	0.69	0.68
ETI	ELLWOOD TITCOMB	0.09	3.01	6.05%	1.00	0.91	1.00
FPS	FPL - SANFORD PWR PLNT	0.32	0.07	0.14%	1.00	1.00	1.00
FPT	FPL - TURNER POWER PLNT	0.10	0.85	1.72%	1.00	1.00	1.00
HDR	HACIENDA DEL RIO	0.10	2.64	5.30%	0.51	0.37	0.35
HHE	HOLLY HILL EASTERN WF	0.14	0.36	0.72%	0.71	0.66	0.45
HHW	HOLLY HILL WESTERN WF	1.38	-0.75	-1.51%	1.00	0.94	0.70
JKV	JOHN KNOX VILL.	0.14	0.40	0.79%	1.00	1.00	0.87
LBW	L BERESFORD WATER ASSN	0.33	0.46	0.92%	0.77	0.58	0.45
LHE	LAKE HELEN	0.58	0.25	0.51%	1.00	1.00	0.92
NGA	NATIONAL GARDENS	0.39	0.26	0.52%	0.90	1.00	0.46
NS4	NEW SMYRNA SR 44	2.64	0.36	0.71%	1.00	1.00	1.00
NSG	NEW SMYRNA GLENCOE WF	3.08	0.43	0.87%	1.00	1.00	1.00
NSS	NEW SMYRNA SAMSULA WF	2.64	0.46	0.93%	1.00	1.00	0.68
OB4	ORMOND BEACH SR 40	1.16	0.08	0.16%	0.94	0.94	0.47
OBD	ORMOND BEACH DIVISION	2.77	0.25	0.51%	0.74	0.74	0.41
OBH	ORMOND BEACH HUDSON	3.01	0.17	0.35%	1.00	1.00	0.50
OBR	ORMOND BEACH RIMA PROP	0.46	0.19	0.39%	1.00	1.00	1.00
OCC	OR. CITY CTRY VILLAGE	0.39	0.17	0.34%	1.00	1.00	0.99
OCY	ORANGE CITY	3.65	0.00	0.00%	1.00	1.00	0.81
POE	PORT ORANGE EASTERN WF	0.86	0.11	0.23%	0.75	0.53	0.48
POW	PORT ORANGE WEST PROP	8.57	0.00	0.00%	1.00	1.00	1.00
PTB	PLANTATION BAY	0.12	0.12	0.24%	1.00	1.00	1.00
SHP	SUNSHINE HOLIDAY PK	0.13	0.00	0.00%	1.00	1.00	0.62
SMC	SHERWOOD MEDICAL CO.	0.16	0.09	0.18%	0.52	0.37	0.34
SME	SSU SUGAR MILL 1990	0.22	0.10	0.21%	1.00	0.56	0.52
SPC	SPRUCE CREEK	0.40	0.00	0.00%	0.94	0.60	0.55
TCF	TOMOKA CORR. FACILITY	0.23	0.09	0.19%	1.00	1.00	1.00
TCU	TYMBER CREEK UTIL.	0.18	0.04	0.07%	1.00	0.99	0.51
TTI	THE TRAILS INC.	0.58	0.06	0.11%	1.00	1.00	0.53
VFT	V CTY - FOUR TOWNS	0.79	0.07	0.13%	1.00	0.83	0.68
VGC	V CTY GOVT COMPLEX	0.20	0.05	0.09%	1.00	1.00	1.00
VLM	V CTY - LAKE MARIE	0.25	0.00	0.00%	0.77	0.72	0.67
VTA	V CTY - TERRA ALTA	0.53	0.05	0.09%	0.86	0.73	0.64

CONCLUSIONS

Three-dimensional linear programming LP models were developed and applied to east-central Florida and Volusia County, Florida. The analysis revealed general trends in both regions. Both the east-central and Volusia models identified potential water resource problem areas subject to the specified environmental constraints. Deficits found by each model are strongly dependent upon environmental constraints. The east-central model identifies optimum water allocations scenarios to meet 2010 demands by allowing a maximum 15% decrease in Upper Floridan head over areas with low potential for vegetative harm, an upper limit of 15% loss in spring discharge, and a specified 2% , 1%, or 0% loss in Upper Floridan heads over areas with high or moderate potential for vegetative harm. The Volusia model also identified water allocation plans for meeting projected year 2010 demands permitting 15% allowable decreases in surficial aquifer head over areas with low potential for vegetative harm, an upper limit of 15% loss in spring discharges, and finally, a specified 2%, 1%, or 0% loss in surficial aquifer head over areas with high or moderate potential for vegetative harm.

The models revealed deficits totaling 140-170 MGD (24% -30% of the total projected year 2010 demand) over the east-central region. Most of the deficit occurs at the Orange County East, Orlando Utilities Commission, and Deltona public supply utility demand areas. LP modeling of the Volusia region revealed total deficits of 15-38 MGD (13%-32% of the total projected year 2010 demand. Public supply utility demand areas which displayed large deficits included Deltona, Port Orange West, Daytona Beach East, and Daytona Beach West. Thus, these areas may be good candidates for alternative water supply strategies to meet part of their projected year 2010 water demands

The results of LP modeling over both regions will change considerably when constraints for saltwater intrusion, minimum flows and levels, and expanded areas of vegetative harm are incorporated. However, the results presented in this report provide a general overview and demonstration of how the models work in their specific areas.

The hydraulic response of the east-central region Upper Floridan aquifer was found to be very linear. Sanlando Springs and Apopka Springs were the most sensitive springs. The Volusia model's surficial aquifer response was not as linear as the Upper Floridan response in the east-central model. An additional set of influence coefficients could be generated for each environmental constraint case examined. The model results were found to be strongly dependent on the proximity to areas with a high potential for vegetative harm and relatively independent of the proximity to springs.

RECOMMENDATIONS

LP MODELS

For both the East-central and Volusia regions, additional LP model runs may be advised with some of the following recommendations:

- Capacities should be eliminated for each demand area in order to determine the fullest extent of water availability at each location based on hydrology and environmental constraints as opposed to existing well/treatment plant conditions
- Constraints should be added which preclude saltwater intrusion
- The GIS vegetative harm analysis should be expanded to cover entire simulation model areas and not just areas within SJRWMD boundaries.
- Use of minimum flows for springs and lakes should be incorporated as they are adopted by SJRWMD in lieu of a non-specific percent decrease

SIMULATION MODELS

As part of the contract with the University of Florida it was required to assess the accuracy of the present MODFLOW simulation models and the sensitivity of model results to boundary locations and conditions, cell sizes, and solution techniques.

Boundary Locations and Conditions
Current boundaries in the east-central model may be problematic for large-scale optimization modeling efforts. Though much water resource activity takes place in the northwest portion of east-central Florida, the Leesburg/Mt. Dora/Tavares area, not all of these areas are covered in the present grid. Also, the northern boundary cuts through the southern part of Deland, and could give better results if it were expanded southward by several miles. The Deltona area is in the northernmost part of the east-central grid and the southernmost part of the Volusia grid. Additional study of results in these areas may be necessary to ascertain the potential problems due to present boundary placement.

The southern boundary of the Volusia model poses the same potential problems as the northern boundary of the east-central region. Other boundary locations did not present potential or existing problems.

Grid Cell Size
Nonlinearities in the aquifer response may be overcome by generating influence coefficients using a strategy that perturbs well flows around the

optimal well withdrawal scheme selected by the LP model. Since the most frequently chosen well withdrawal rate is zero, an optimal strategy for calculating influence coefficients should select to perturb well flows near zero to obtain minimum errors. Experience has shown that errors are largest at locations where a high density of wells exist. Future simulation model grids may offer enhanced accuracy if they are refined to contain no more than one well per cell, particularly in the Daytona Beach West and Port Orange West demand areas; these public supply utility demand areas lie in a very sensitive area having a high potential for vegetative harm. Some wells in the Deltona area were also prone to generate a nonlinear response, though cell size is appreciably larger than the Daytona Beach West and Port Orange West well cells. Here, too, particular care must be taken in choosing a proper well perturbation scheme. Other locations exhibited an excellent linear aquifer response.

Solution Techniques

It is recommended to use a conjugate gradient method solver (PCG2) with preconditioning or the newer, more efficient *Orthomin* solver available for use with MODFLOW96 (McDonald and Harbaugh, 1996) for generating the surficial aquifer layer influence coefficients of the Volusia model. This solver may offer a more computationally efficient matrix solution than the currently used Strongly Implicit Procedure (SIP) solver.

DECISION MODELS

METHODS

The general decision model formulation includes binary variables for build/do not build decisions as well as continuous variables for flow or use rates, heads, drawdowns, and costs. The decision model allows for a number of alternate water sources to be used in response to the increased public supply water demands projected for year 2010. The use of alternate water sources allows for decreased impact on surficial aquifer heads. The model objective function is now one of minimizing costs of water allocation strategies utilizing both existing and potential sources. The model incorporates two types of cost constraints: initial *fixed* costs which are incurred when a new source must be constructed, and recurring *unit* costs, which are similar to operating and maintenance costs but include only those costs which are directly dependent on the flow or use rate of the source. For example, a technician's salary must be considered as part of the initial cost because the salary of a technician does not depend on the flow rate, while power and chemical costs are unit costs because they do depend on the flow rate. Fixed and unit charges are represented in the model on an annualized basis. Actual cost data on per unit bases were provided by consultants.

ALTERNATIVE WATER SUPPLIES

Alternative water supplies investigated in the model include new public supply wells, reclaimed water for irrigation at public supply need areas, reclaimed water for irrigation of agricultural areas, surface water, and new public supply interconnects. Consultant cost data associated with the use and development of alternative water supplies were provided. A brief description of each source is listed below:

Surface Water
Currently there are four surface water sites in the east-central region and two sites in the Volusia area. These sites are along the St. Johns River (Cocoa, Titusville, and DeLand), at Lake Monroe near Sanford, and at Lake Griffin. All of the St. Johns River sites and Lake Monroe have brackish water requiring some reverse osmosis treatment. The site at Lake Griffin has fresh water requiring less treatment. Exact locations were approximated in the model study areas. Fixed and unit charges for surface water production and transport were given in CH2M-Hill's report

on surface water planning level cost estimates (1997) for each site. Fixed and unit charges for surface water were as follows:

Fixed costs

	flow range	*gallon basis*	*cf basis*
Cocoa	(19.9-108.4 MGD)	1.272-1.431 $/1000 gal	3.08 $day/(cf*year)
Titusville	(27-142.5 MGD)	1.369-1.478 $/1000 gal	3.08 $day/(cf*year)
Sanford	(48.6-279.1 MGD)	1.241-1.422 $/1000 gal	3.17 $day/(cf*year)
DeLand	(62.6-350.8 MGD)	1.223-1.38 $/1000 gal	3.17 $day/(cf*year)
Lake Griffin	(5.4 - 28 MGD)	0.830-0.915 $/1000 gal	2.19 $day/(cf*year)

Unit costs

	flow range	*gallon basis*	*cf basis*
Cocoa	(19.9-108.4 MGD)	0.194 $/1000 gal	0.53 $day/(cf*year)
Titusville	(27-142.5 MGD)	0.194 $/1000 gal	0.53 $day/(cf*year)
Sanford	(48.6-279.1 MGD)	0.194 $/1000 gal	0.53 $day/(cf*year)
DeLand	(62.6-350.8 MGD)	0.194 $/1000 gal	0.53 $day/(cf*year)
Lake Griffin	(5.4 - 28 MGD)	0.126 $/1000 gal	0.34 $day/(cf*year)

Annual transport costs from the CH2M-Hill Surface Water Planning level cost estimates report (1997) were as follows:

Short transport systems (5 miles maximum):

$$\text{Fixed charge: cost} = 22{,}460L^{1.232}ADF^{0.430} \tag{61}$$

Unit charge: negligible

Long transport systems (greater than 5 miles):

Fixed charge:

$$\text{1 pump station: cost} = 32{,}040L^{1.044}ADF^{0.44} \tag{62}$$

$$\text{2 pump stations: cost} = 43{,}180L^{0.935}ADF^{0.448} \tag{63}$$

Unit charge:

$$\text{1 pump station: cost} = 32{,}390ADF^{0.945} \tag{64}$$

$$\text{2 pump stations: cost} = 51{,}420ADF^{0.969} \tag{65}$$

where L is the length in miles and ADF is the average daily flow in MGD.

Since the model formulation allows only linear functions of decision variables such as the flow rate, equations (61)-(63) for fixed charges were approximated by linear equations as provided in Table A12 of the Appendix. Unit charge equations in the decision model formulation

rounded the power of ADF to unity. All fixed and unit charges were cast in a form having ADF in cfd. The number of pump stations required is a function of total transport distance and average daily flow. In general, only one pump station is required, though flows of over 250 MGD transported over 25 miles required 2 or more pump stations.
All public supply demand areas having large projected year 2010 demands (over 5 MGD) located within 20 miles of potential surface water sites were considered as primary destinations for surface water transport. Via public supply interconnects described below, additional water transport can be selected so as to supply other public supply demand areas acting as secondary surface water destinations.

Reclaimed Water
There are 45 reclaimed water sites in the east-central region and 20 in the Volusia County area. Specific sites, available quantities of water for reuse, and fixed and unit charges for public use of reclaimed water for irrigation and agricultural use of reclaimed water were recently reported by PBS&J (1997) and Jackson et al. (1997). Agricultural users of reclaimed water are limited to fern growing areas in the Volusia region and citrus areas in the east-central model. The decision model formulation restricts reclaimed use in public areas to comprise no more than 25% of a public demand area's total projected year 2010 demand since reclaimed use at public demand areas is for irrigation only, and 25% of the total public demand is estimated to be used for irrigation purposes. Fixed and unit charges for reclaimed water use were reported for total quantities of water replaced in the PBS&J (1997) and Jackson et al. (1997) reports, and converted to per unit flow bases for use in the decision model as follows:

Reclaimed Water for Agricultural Use
Citrus growers in east-central

		cf basis
O & M (Unit) Cost	\$711,316/year	\$1.18 day/(cf*year)
Fixed Cost	\$2,557,445/year	\$4.25 day/(cf*year)

Fern growers in Volusia

		cf basis
O & M (Unit) Cost	\$1,850,000/year	\$1.175 day/(cf*year)
Fixed Cost	\$6,070,000/year	\$3.85 day/(cf*year)

Reclaimed Water for Landscape Irrigation at Public Demand Areas

		cf basis
O & M (Unit) Cost	\$173,013/year	\$1.29day/(cf*year)
Fixed Cost	\$782,271/year	\$5.85day/(cf*year)

Interconnects

Interconnects between public supply utility demand areas may transport groundwater or surface water from a source area to a destination area. Law Engineering (1997) reported on interconnect component costs and provided a spreadsheet for calculating fixed and unit charges for different interconnect lengths and flow rates. Law also provided diagrams displaying current and proposed interconnects in the east-central and Volusia regions.

The present model formulation considers if an interconnect already exists. In the east-central and Volusia region, the existing pipelines, most of which have 6, 10, or 12-inch diameters, do not support high flow rates. However, they do denote that the right-of-way exists, and are included in the range of possibilities for use with flow rates of up to 5 MGD at no incurred fixed cost. A more realistic assessment of fixed charges for existing interconnects would consider the flow rates of existing interconnects. Though some of this data was available during model development, some details in the critical Orlando Utilities Commission and Orange County Public Utilities Division public demand areas were not provided. Additional detail in these areas would be required to consider more realistic uses of existing interconnects. Future modeling efforts may include fixed costs when existing interconnects are utilized, however, the charges would be considerably lower than the charges for potential interconnects, as no purchase of land would be required.

The transport fixed and unit charges used in the model are the linearized transport costs as described in the surface water section above, provided in Table A12 of the appendix.

Currently potential interconnects between public areas having projected year 2010 demands of over 5 MGD and less than 15 miles apart are considered in the east-central formulation. Only demand areas having deficits in the deficit model are permitted as destination areas. This restriction was employed as a result of hardware limitations. These possibilities represent a small subset of all possible public supply utility interconnections. With 91 public supply demand areas in the east-central region and two possible directions of flow for each interconnect, 16,380 binaries would be required in order to investigate the full range of interconnect possibilities in that area. Current RAM resources limit the number of binary variables in the east-central model to less than 400. In the Volusia region, where model size is not problematic, all public areas with demands of over 0.75 MGD have interconnect possibilities.

DECISION MODEL INDICES

Decision model indices include h, the set of control points where drawdowns are constrained; i, the set of public supply utility wells or well grid cells; j, the set of public supply utility demand areas; k, the set of agricultural demand areas; l, the set of springs; and m, the set of agricultural wells, q, the set of public demand areas which serve as interconnect destinations, p, the set of surface water sources, and n, the set of reclaimed water sources.

DECISION MODEL PARAMETERS

Decision model parameters include the hydrogeologic parameters of the deficit model, additional service and distance maps for sources serving demand areas, and cost parameters for existing and alternative water supplies. The annual fixed and unit charges are those supplied by consultants converted to a cfd basis.

Table 15. Decision model parameters

Parameter	*units*	*definition*
Influence coefficients of the unit response matrices		
$\alpha_{i,h}$	day/ft^2	influence of public well i on control point h
$\beta_{m,h}$	day/ft^2	influence of agricultural well m on control point h
$\gamma_{i,l}$	day/ft^2	influence of public well i on spring l
$\varsigma_{m,l}$	day/ft^2	influence of agricultural well m on spring l
distances (straight line approximations)		
$dists_{j,q}$	miles	public area j to area q
$distsp_{p,j}$	miles	surface source p to public area j
service maps		
$servm_{i,j}$		public well i to demand area j
$servs_{p,j}$		surface source p to public area j
$serva_{m,k}$		agricultural well m to agricultural area k
$servra_{n,k}$		reclaimed site n to agricultural area k
$servrm_{n,j}$		reclaimed site n to public area j
$exist_{j,q}$		existing interconnect from area j to area q
water management		
dm_j	cfd	demand of public area j
da_k	cfd	demand of agricultural area k
$at_{j,q}$		potential area transfer from j to q
qo_i	cfd	1988 withdrawal rate of public well i
qno_i	cfd	2010 nonoptimized withdrawal rate of public well i
qao_m	cfd	1988 withdrawal rate of agricultural well m
qna_m	cfd	2010 nonoptimized withdrawal rate of agricultural well m

Table 15 *--Continued*

capacities or lower limits of use ranges		
$scap_p$	cfd	Surface source p
$mcap_i$	cfd	public well i'
$acap_k$	cfd	agricultural well m
$rcap_n$	cfd	reclaimed water site n
qmx	cfd	Upper limit for existing interconnect (5 MGD)
qmn	cfd	Lower limit for potential interconnect (4 MGD)
hydrogeologic		
ho_h	ft	1988 head of control point h
hno_h	ft	2010 nonoptimized head of control point h
el_l	ft	elevation head of spring l
cd_l	ft²/day	spring conductance of spring l
$scrit_l$	cfd	critical minimum discharge of spring l
parameter	*units*	*definition*
med_h		denotes control point h with moderate potential for vegetative harm
$high_h$		denotes control point h with high potential for vegetative harm
loss limits		
dl		minimum fraction of year 1988 head allowed at control points having low or no potential for vegetative harm
ml		minimum fraction of year 1988 head allowed at control points having moderate potential for vegetative harm
hl		minimum fraction of year 1988 head allowed at control points having high potential for vegetative harm
sp_l		minimum fraction of year 1988 discharge allowed at spring l
annual costs		
cno	\$/year	nonoptimized projected year 2010 annual total costs
ful_i	0.0592/q \$dayft⁻³year⁻¹ (Volusia) 0.1117/q \$dayft⁻³year⁻¹ (ECF Upper Floridan) q=hydraulic capacity in MGD	fixed cost for new Upper Floridan public supply utility well (24" diameter)[2]
fll_i	0.2684/q \$dayft⁻³year⁻¹ (ECF Lower Floridan) q=hydraulic capacity in MGD	fixed cost for a new Lower Floridan public supply utility well (24" diameter)[2]
	0.0164 \$dayft⁻³year⁻¹	fixed cost for wellfield equipment (24" diameter)[2]
ftp_i	1 MGD 3.282\$dayft⁻³year⁻¹ 2 MGD 1.857\$dayft⁻³year⁻¹ 5 MGD 1.639\$dayft⁻³year⁻¹ 10 MGD 1.415\$dayft⁻³year⁻¹	fixed cost for urban lime softening treatment plant + aeration + filtration
fsu_p	4.142 \$dayft⁻³year⁻¹ (Sanford, DeLand) 2.344 \$dayft⁻³year⁻¹ (Lake Griffin) 3.939 \$dayft⁻³year⁻¹ (Titusville, Cocoa)	fixed cost for surface water source
fia	2.681 \$dayft⁻³year⁻¹ (Volusia fern) 4.90 \$dayft⁻³year⁻¹ (ECF citrus)	fixed cost for reclaimed water site n to agricultural area k

Table 15--*Continued*

annual cost		
fip	5.85/\$dayft^{-3}year^{-1}	fixed cost for reclaimed water site n to public area j
$icept_{j,q}$	see Appendix Table A12 (varies with distance) \$/year	fixed cost linear approximation intercept of interconnect to public area q to be multiplied by binary variable [3]
$slope_{j,q}$	see Appendix Table A12 (varies with distance)\$dayft^{-3}year^{-1}	fixed cost linear approximation slope per unit flow of interconnect to public area q [3]
$icepts_{p,j}$	see Appendix Table A12 (varies with distance) \$/year	fixed cost linear approximation intercept of surface water transport to public area j to be multiplied by binary variable [3]
$slopes_{p,j}$	see Appendix Table A12(varies with distance)\$dayft^{-3}year^{-1}	fixed cost linear approximation slope per unit flow of surface water transport to public area j [3]
ra	1.177 \$dayft^{-3}year^{-1}	unit cost for reclaimed water site n to agricultural area
$rp_{n,j}$	1.28 \$dayft^{-3}year^{-1}	unit cost for reclaimed water site n to public area j
	0.38 \$dayft^{-3}year^{-1} for distances ≥ 5 miles	unit cost of interconnect supplying public area q or surface water transport supplying public area j (destination area pays)
uw_j	0.47 \$dayft^{-3}year^{-1}	unit cost of supply well and treatment supplying public area j[4]
us	0.344 \$dayft^{-3}year^{-1} (Lake Griffin) 0.53 \$dayft^{-3}year^{-1} (Sanford, DeLand, Titusville, Cocoa)	unit cost of surface water source supplying public area j
uwa	0.1229 \$dayft^{-3}year^{-1}	unit cost of agricultural well
data		
cv	0.00000748 MG/cf	converts cf to MG

[1] Capacities were hydraulic capacities (where availaible) reported by LAW Engineering, but some data were estimated

[2]Costs for new well development require refinement. Individual well depths were unknown, standard depths of 200 ft for Volusia wells, 500 ft for east-central Upper Floridan wells, and 1400 ft for east-central Lower Floridan wells were used. Capacities were hydraulic capacities (where availaible) reported by LAW Engineering, but some data were estimated

[3]Straight-line distances were used

[4]These costs do not consider macro- and microdistribution and are otherwise in need of refinement to reflect individual public supply utility area costs

DECISION MODEL VARIABLES

Decision model continuous variables include the hydrogeologic and water management variables of the deficit model as well as the use rates, fixed costs, and unit costs of alternative water supply strategies. Decision model binary variables include those for new public interconnects and surface water transport to public demand areas.

Table 16. Decision model variables

variable	*units*	*definition*
binary variables		
$Y2_{j,q}$		interconnect: public area j supplies area q
$YSP_{p,j}$		surface source p serves public area j
use rates		
QP_i	cfd	total pump rate of public well cell i
$Q1_{i,j}$	cfd	pump rate of public well cell i supplying demand area j
$Q2_{j,q}$	cfd	public interconnect use rate from source area j to destination area q
QA_m	cfd	pump rate of agricultural well m
$QRA_{n,k}$	cfd	reuse rate from reclaimed water site n to agricultural area k
$QRP_{n,j}$	cfd	reuse rate from reclaimed water site n to public area j
variable	*units*	*definition*
QR_n	cfd	total reuse rate from reclaimed water site n
QS_p	cfd	use rate of surface water source p
$QQS_{p,j}$	cfd	use rate of surface source p to public area j
hydrogeologic		
D_h	ft	drawdown at control point h
HS_l	ft	spring head at spring l
SD_l	cfd	spring discharge at spring l
PS_l		fraction of simulation year 1988 discharge at spring l
accounting		
$QR2_n$	MGD	public use of reclaimed water from source n
$QRA2_{n,k}$	MGD	agricultural use of reclaimed water from source n to area k
RTP	MGD	total use of reclaimed water
FNT	MGD	total use of interconnect
$Q22_{j,q}$	MGD	potential interconnect from public area j to public area q
$Q23_{j,q}$	MGD	existing interconnect from public area j to public area q
RTI_j	MGD	total use of interconnects from source public area j
RTQ_q	MGD	total use of interconnects to public destination area j
RTW_j	MGD	total use of wells at public demand area j
$QQS2_{p,j}$	MGD	use rate of surface source p to public area j
$QS2_p$	MGD	use rate of surface source p
annual costs		
$FP1_j$	$/year	fixed cost of surface water site serving public area j
$FP2_j$	$/year	fixed cost of surface water transport to public area j
FW_j	$/year	fixed cost of new wells and treatment in public area j
FIC_q	$/year	fixed cost of interconnect to public area q
FRA_k	$/year	fixed cost of reclaimed water serving agricultural area k
FRP_j	$/year	fixed cost of reclaimed water serving public area j
UP_j	$/year	unit cost of supplies serving public area j (less interconnects/transport)
UST_j	$/year	unit cost of surface water transport to public area j
UI_q	$/year	unit cost of interconnects serving public area q
UA_k	$/year	unit cost of supplies serving agricultural area k
Z	$/year	total costs

DECISION MODEL OBJECTIVE FUNCTION

The optimization model formulation was created with the assumption that groundwater allocation strategies could be found which minimized costs of meeting projected year 2010 water demands. In the model, the objective functions appears as a statement specifying that the value of decision variable Z be minimized. The objective function,

minimize

$$Z = \sum_j [FW_j + FRP_j + FP1_j + FP2_j + UP_j + UST_j] + \sum_q [FIC_q + UI_q] + \sum_k [FRA_k + UA_k] \tag{66}$$

minimizes total annualized fixed and unit costs where Z is the sum of all fixed and unit costs for meeting public and agricultural demands with existing and potential sources.

DECISION MODEL CONSTRAINTS

The model formulation includes hydrogeologic constraints, water management constraints, and cost constraints.

Hydrogeologic Constraints

Hydrogeologic constraints calculating the drawdown at control points were developed from influence coefficients that describe pressure changes at each control point due to pumping at each well grid cell. These constraints limit the drawdown to specifications based on the control point's potential for vegetative harm,

$$D_h = ho_h - hno_h + \sum_i \alpha_{i,h}[QP_i - qno_i] + \sum_m \beta_{m,h}[QA_m - qna_m] \tag{67}$$

For the east-central region, a drawdown limit is specified at each point. Currently this limit is from 0.8 to 0.9 of the simulated year 1988 head.

$$D_h \le dl_h \tag{68}$$

Constrains drawdowns based on the area's potential for vegetative harm,

$$D_h \le ml \ \ if\ med(h) = 1 \tag{69}$$

$$D_h \le hl \ \ if\ high(h) = 1 \tag{70}$$

with moderate and high harm areas presently tolerating 0%-2% reduction from simulated year 1988 Upper Floridan head in the east-central region and surficial head in the Volusia region.

Spring head is defined in the model similar to aquifer head above.

$$HS_l = hsno_l - \sum_i \gamma_{i,l}[QP_i - qno_i] - \sum_m \varsigma_{m,l}[QA_m - qna_m] \qquad (71)$$

Spring discharge losses are constrained by

$$HS_l \geq sp_l(hso_l - el_l) + el_l \qquad (72)$$

where sp_l is currently 0.85.

The spring's fraction of simulation year 1988 discharge is given by

$$Ps_l = \frac{Hs_l - el_l}{hso_l - el_l} \qquad (73)$$

The spring discharge (not currently used) may be defined by

$$SD_l = cd_l(Hs_l - el_l) \qquad (74)$$

If the critical identified minimum discharge (not currently used) for a spring is available, spring discharge must exceed this critical minimum so that

$$SD_l \geq scrit_l \qquad (75)$$

Public Water Management Constraints
The model uses constraints for public needs and sources to ensure that capacities of wells are not exceeded and to meet demands of public supply demand areas.

The total withdrawal rate of a public well consists of the sum of withdrawal rates serving all public areas

$$QP_i = \sum_j Q1_{i,j} \qquad (76)$$

Well withdrawal must not exceed capacities:

$$QP_i \leq mcap_i \qquad (77)$$

The next three constraints define area-to-area transfers between public supply utility areas.

The binary for a public interconnect $Y2_{j,q}$ must go to the '1' position when that interconnect has a nonzero use rate:

$$Q2_{j,q} \leq dm_q Y2_{j,q} \qquad if\ exist_{j,q} = 0 \tag{78}$$

$$Q2_{j,q} \leq qmx Y2_{j,q} \qquad if\ exist_{j,q} = 1 \tag{79}$$

where the projected year 2010 demand of the source area is the upper limit of the flow rate for $Q2_{j,q}$ if the interconnect is potential, and 5 MGD if the interconnect is existing.

A potential public interconnect is not considered unless its use rate greater than some specified minimum flow rate. Lower limits are employed to ensure that the approximating linear equations that govern fixed charges are valid:

$$qmn Y2_{j,q} \leq Q2_{j,q} \qquad if\ exist_{j,q} = 0 \tag{80}$$

The flow in each interconnect is limited to one direction:

$$Y2_{j,q} + Y2_{q,j} \leq 1 \ \ if\ at_{j,q} = 1\ or\ at_{q,j} = 1 \tag{81}$$

The sum of flows in to public destination area q may not exceed the projected year 2010 demand of public area j:

$$\sum_j Q2_{j,q} at_{j,q} \leq dm_q \tag{82}$$

No more than 20 interconnects are currently used:

$$\sum_{j,q} Y2_{j,q} at_{j,q} \leq 20 \tag{83}$$

The next two constraints define surface water quantities for public use.

Surface water use may not exceed the recommended maximum:

$$QS_p \leq scap_p \tag{84}$$

The binary for surface water use at public area j, $YSP_{p,j}$, must go to the '1' position when the decision model selects for its creation and use:

$$QQS_{p,j} \leq dm_j YSP_{p,j} \tag{85}$$

where the upper limit of the flow rate of surface water to public demand area j is taken as the projected year 2010 demand of the receiving area, though other values could be used.

The total use rate from a surface water source consists of the sum of its supplies to all public areas

$$QS_p = \sum_j QQS_{p,j} \tag{86}$$

The total use rate of all surface water sources cannot exceed the projected year 2010 of the receiving public area:

$$\sum_p QQS_{p,j} servs_{p,j} \leq dm_j \tag{87}$$

Reclaimed use for public supply irrigation cannot exceed the availability from the reclaimed site:

$$QRP_{n,j} \leq rcap_n \tag{88}$$

The total quantity of reclaimed water from all reclaimed sites for public irrigation is given by

$$RTP = \sum_{n,j} QRP_{n,j} servrm_{n,j} \tag{89}$$

The following restricts the amount of reclaimed water for irrigation that can be used to satisfy a public demand. (Here, irrigation use of public supply water is estimated as 25% of the public demand.)

$$\sum_n QRP_{n,j} servrm_{n,j} \leq 0.25 dm_j \tag{90}$$

The demand constraint for public supply areas is:

$$\begin{aligned} &\sum_i Q1_{i,j} servm_{i,j} + \sum_n QRP_{n,j} servm_{n,j} + \sum_p QQS_{p,j} servs_{p,j} \\ &+ \sum_q Q2_{q,j} at_{q,j} \geq dm_j + \sum_q Q2_{j,q} at_{j,q} \end{aligned} \tag{91}$$

Note that Q2 appears on both sides of the equation above. On the left side of the inequality, when summed over its first index it refers to the total quantity of water received from other public areas. On the right side of the inequality, $Q2$ is summed over its second index referring to total the amount of water serving other public areas.

Agricultural Water Management Constraints
Water Managment constraints for agricultural areas include limiting use or withdrawal rates to specified capacities, satisfying water demands with available sources, and switching on binary variables when potential sources are used:

The following constraint precludes operating agricultural wells beyond capacities:

$$QA_m serva_{m,k} \leq acap_m \tag{92}$$

Constraint (93) insures agricultural areas are satisfied with agricultural wells and reclaimed water use:

$$\sum_m QA_m serva_{m,k} + \sum_n QRA_{n,k} servra_{n,k} \geq da_k \tag{93}$$

Reclaimed Water Management Constraints
Water management constraints for reclaimed water use include agricultural and public uses:

The total amount of reuse from a reclaimed water site is the sum of all its supplies to agricultural and public demand areas,

$$\sum_k QRA_{n,k} servra_{n,k} + \sum_j QRP_{n,j} servrm_{n,j} = QR_n \tag{94}$$

Total reuse must not exceed the available capacity of reclaimed water from the site:

$$QR_n \leq rcap_n \tag{95}$$

Fixed charges of new alternatives
The next group of equations are equality constraints that define the fixed charge components of the objective function. Fixed charges are incurred when alternatives to existing water supplies are selected by the decision

model. Alternatives to existing supplies include new wells, new water treatment plants, new interconnects, surface water sources, and reclaimed water sources. Fixed charges are defined as follows:

New wells and treatment plants:
For Volusia:

$$FW_j = \sum_i servm_{i,j} QP_i[0.0164 + ful_i + ftp_i] \quad \textit{if } ul_i = 1 \tag{96}$$

For east-central:

$$FW_j = \sum_i servm_{i,j} QP_i[0.0164 + ful_i + fll_i + ftp_i] \quad \textit{if } ul_i = 1 \textit{ or } ll_i = 1 \tag{97}$$

New public interconnects

$$FIC_q = \sum_q (icept_{j,q} Y2_{j,q} + slope_{j,q} Q2_{j,q}) \textit{ if } at_{j,q} = 1 \textit{ and } exist_{j,q} = 0 \tag{98}$$

New surface water sources:

$$FP1_j = \sum_p fsu_p QQS_{p,j} \tag{99}$$

Connections from surface water sources to public demand areas:

$$FP2_j = \sum_p (icepts_{p,j} YSP_{p,j} + slopes_{p,j}\ QQS_{p,j}) \tag{100}$$

Reclaimed use for agricultural areas:

$$FRA_k = \sum_n QRA_{k,n} fia \tag{101}$$

Reclaimed use for public supply utility irrigation demands:

$$FRP_j = \sum_j QRP_{j,n} fip \tag{102}$$

Unit charges of all selections, existing or proposed
The following group of equality constraints calculates unit costs of all sources, both existing and potential, selected by the decision model.

For public supply demand areas (not considering interconnects)

$$UP_j = \sum_i QP_i servm_{i,j} uw_i + \sum_p QQS_{p,j} servs_{p,j} us_p + \sum_n QRP_{n,j} servrm_{n,j} rp_{n,j} \tag{103}$$

For public interconnects, which must be considered separately since the destination area pays,

$$UI_q = \sum_j 0.38Q2_{j,q} \;\; if\; dists_{j,q} \geq 5\; miles \tag{104}$$

The unit costs are similar for surface water transport, but indexed by public area j and summed over index p, the set of surface water sites:

$$UST_j = \sum_p 0.38QQS_{p,j} \;\; if\; distsm_{p,j} \geq 5\; miles \tag{105}$$

For agricultural areas,

$$UA_k = \sum_n QRA_{k,n} servra_{n,k} ra + \sum_m QA_m serva_{m,k} uwa \tag{106}$$

Non-binding constraints for data management include the following equations:

The total of all public interconnects in MGD is given by :

$$FNT = \sum_{j,q} cvQ2_{j,q} \tag{107}$$

Conversion of reclaimed water use to MGD is given by:

$$QR2_n = cvQR_n \tag{108}$$

$$QRA2_{n,k} = cvQRA_{n,k} \tag{109}$$

Total public use of reclaimed water in MGD is calculated in

$$RTP = \sum_{n,j} cv * servrm_{n,j} QRP_{n,j} \tag{110}$$

New interconnect use in MGD is defined by

$$Q22_{j,q} = cvQ2_{j,q} \qquad if\; at_{j,q} = 1\; and\; exist_{j,q} = 0 \tag{111}$$

Existing interconnect use in MGD is found by

$$Q23_{j,q} = cvQ2_{j,q} \;\; if\; at_{j,q} = 1\; and\; exist_{j,q} = 1 \tag{112}$$

The total use of interconnects from source public area j in MGD is

$$RTI_j = \sum_q cv * at_{j,q} Q2_{j,q} \tag{113}$$

The total use of interconnect to destination public area q in MGD is

$$RTQ_q = \sum_j cv * at_{j,q} Q2_{j,q} \tag{114}$$

The total use of wells at public area j in MGD is given by

$$RTW_j = \sum_i cv * servm_{j,i} Q1_{i,j} \tag{115}$$

Surface water use at each demand area in MGD is found by

$$QQS2_{p,j} = cvQQS_{p,j} \tag{116}$$

Total surface water use from each source p in MGD is

$$QS2_p = cvQS_p \tag{117}$$

Nonnegativity constraints
The following constraints specify nonnegativity:

$$Q1_{i,j} \geq 0.0 \tag{118}$$
$$Q2_{i,j} \geq 0.0 \tag{119}$$
$$QA_m \geq 0.0 \tag{120}$$
$$QRA_{n,k} \geq 0.0 \tag{121}$$
$$QRP_{n,j} \geq 0.0 \tag{122}$$
$$QQS_{p,j} \geq 0.0 \tag{123}$$

In summary,

minimize

$$Z = \sum_j [FW_j + FRP_j + FP1_j + FP2_j + UP_j + UST_j] + \sum_q [FIC_q + UI_q] + \sum_k [FRA_k + UA_k] \tag{124}$$

subject to
Hydrogeologic Constraints:

$$D_h = ho_h - hno_h + \sum_i \alpha_{i,h} [QP_i - qno_i] + \sum_m \beta_{m,h} [QA_m - qna_m] \tag{125}$$

$$D_h \leq dl_h \tag{126}$$

$$D_h \le ml \quad if\; med(h) = 1$$
$$D_h \le hl \quad if\; high(h) = 1 \tag{127}$$
$$HS_l = hsno_l - \sum_i \gamma_{i,l}[QP_i - qno_i] - \sum_m \varsigma_{m,l}[QA_m - qna_m] \tag{128}$$
$$HS_l \ge sp_l(hso_l - el_l) + el_l \tag{129}$$
$$PS_l = \frac{HS_l - el_l}{hso_l - el_l} \tag{130}$$
$$SD_l = cd_l(Hs_l - el_l) \tag{131}$$
$$SD_l \ge scrit_l \tag{132}$$

Public Water Management Constraints:

$$QP_i = \sum_j Q1_{i,j} \tag{133}$$
$$QP_i \le mcap_i \tag{134}$$
$$Q2_{j,q} \le dm_q Y2_{j,q} \quad if\; exist_{j,q} = 0 \tag{135}$$
$$Q2_{j,q} \le qmxY2_{j,q} \quad if\; exist_{j,q} = 1 \tag{136}$$
$$qmnY2_{j,q} \le Q2_{j,q} \quad if\; exist_{j,q} = 0 \tag{137}$$
$$Y2_{j,q} + Y2_{q,j} \le 1 \quad if\; at_{j,q} = 1 \; or \; at_{q,j} = 1 \tag{138}$$
$$\sum_j Q2_{j,q} at_{j,q} \le dm_q \tag{139}$$
$$\sum_{j,q} Y2_{j,q} at_{j,q} \le 20 \tag{140}$$
$$QS_p \le scap_p \tag{141}$$
$$QQS_{p,j} \le dm_j YSP_{p,j} \tag{142}$$
$$QS_p = \sum_j QQS_{p,j} \tag{143}$$
$$\sum_p QQS_{p,j} servs_{p,j} \le dm_j \tag{144}$$
$$QRP_{n,j} \le rcap_n \tag{145}$$
$$RTP = \sum_{n,j} QRP_{n,j} servrm_{n,j} \tag{146}$$
$$\sum_n QRP_{n,j} servrm_{n,j} \le 0.25 dm_j \tag{147}$$
$$\begin{aligned} &\sum_i Q1_{i,j} servm_{i,j} + \sum_n QRP_{n,j} servm_{n,j} + \sum_p QQS_{p,j} servs_{p,j} \\ &+ \sum_q Q2_{q,j} at_{q,j} \ge dm_j + \sum_q Q2_{j,q} at_{j,q} \end{aligned} \tag{148}$$

Agricultural Water Management Constraints

$$QA_m serva_{m,k} \le acap_m \qquad (149)$$

$$\sum_m QA_m serva_{m,k} + \sum_n QRA_{n,k} servra_{n,k} \ge da_k \qquad (150)$$

Reclaimed Water Management Constraints

$$\sum_k QRA_{n,k} servra_{n,k} + \sum_j QRP_{n,j} servrm_{n,j} = QR_n \qquad (151)$$

$$QR_n \le rcap_n \qquad (152)$$

Fixed charges of new alternatives

For Volusia:

$$FW_j = \sum_i servm_{i,j} QP_i [0.0164 + ful_i + ftp_i] \quad if\ ul_i = 1 \qquad (153)$$

For east-central:

$$FW_j = \sum_i servm_{i,j} QP_i [0.0164 + ful_i + fll_i + ftp_i] \qquad if\ ul_i = 1\ or\ ll_i = 1 \qquad (154)$$

$$FIC_q = \sum_q (icept_{j,q} Y2_{j,q} + slope_{j,q} Q2_{j,q})\ if\ at_{j,q} = 1\ and\ exist_{j,q} = 0 \qquad (155)$$

$$FP1_j = \sum_p fsu_p QQS_{p,j} \qquad (156)$$

$$FP2_j = \sum_p (icepts_{p,j} YSP_{p,j} + slopes_{p,j}\ QQS_{p,j}) \qquad (157)$$

$$FRA_k = \sum_n QRA_{k,n} fia \qquad (158)$$

$$FRP_j = \sum_j QRP_{j,n} fip \qquad (159)$$

Unit charges of all selections, existing or proposed

$$UP_j = \sum_i QP_i servm_{i,j} uw_i + \sum_p QQS_{p,j} servs_{p,j} us_p + \sum_n QRP_{n,j} servrm_{n,j} rp_{n,j} \qquad (160)$$

$$UI_q = \sum_j 0.38 Q2_{j,q} \quad if\ dists_{j,q} \ge 5\ miles \qquad (161)$$

$$UST_j = \sum_p 0.38 QQS_{p,j} \quad if\ distsm_{p,j} \ge 5\ miles \qquad (162)$$

$$UA_k = \sum_n QRA_{k,n} servra_{n,k} ra + \sum_m QA_m serva_{m,k} uwa \qquad (163)$$

Data management constraints:

$$FNT = \sum_{j,q} cvQ2_{j,q} \qquad (164)$$

$$QR2_n = cvQR_n \qquad (165)$$

$$QRA2_{n,k} = cvQRA_{n,k} \tag{166}$$

$$RTP = \sum_{n,j} cv * servrm_{n,j} QRP_{n,j} \tag{167}$$

$$Q22_{j,q} = cvQ2_{j,q} \; \text{if } at_{j,q} = 1 \text{ and } exist_{j,q} = 0 \tag{168}$$

$$Q23_{j,q} = cvQ2_{j,q} \; \text{if } at_{j,q} = 1 \text{ and } exist_{j,q} = 1 \tag{169}$$

$$RTI_j = \sum_{q} cv * at_{j,q} Q2_{j,q} \tag{170}$$

$$RTQ_q = \sum_{j} cv * at_{j,q} Q2_{j,q} \tag{171}$$

$$RTW_j = \sum_{i} cv * servm_{j,i} Q1_{i,j} \tag{172}$$

$$QQS2_{p,j} = cvQQS_{p,j} \tag{173}$$

$$QS2_p = cvQS_p \tag{174}$$

Nonnegativity constraints

$$Q1_{i,j} \geq 0.0 \tag{175}$$

$$Q2_{i,j} \geq 0.0 \tag{176}$$

$$QA_m \geq 0.0 \tag{177}$$

$$QRA_{n,k} \geq 0.0 \tag{178}$$

$$QRP_{n,j} \geq 0.0 \tag{179}$$

$$QQS_{p,j} \geq 0.0 \tag{180}$$

EAST-CENTRAL AND VOLUSIA MODEL COMPARISON

The east-central and Volusia GAMS MIP decision model formulations are summarized in Table 17 below:

Table 17. Decision model comparison

	east-central	*Volusia*
Public		
Well cells	332	177
Demand Areas	91	41
Projected 2010 demand	499 MGD	96 MGD
Agricultural		
Well cells	362	364
Demand Areas	69	59
Projected 2010 demand	99 MGD	26 MGD
Hydrogeologic		
Control points	157	177
Springs	17	3
Aquifer constrained	Upper Floridan	Surficial
Alternatives		
Interconnects	up to 16,380	up to 3280
Reclaimed Water Sites	up to 45	up to 20
Surface Water Sites	4	2

DECISION MODEL DISCUSSION

EAST-CENTRAL RESULTS

The decision model formulation was applied to the east-central Florida region for three cases having a 15% loss limit from simulated year 1988 conditions on Upper Floridan aquifer head control points with low potential for vegetative harm. Cases 1,2, and 3 differed with respect to an allowable specified limit of 2%,1%, or 0% loss at Upper Floridan control points with high or moderate potential for vegetative harm. All three examined cases employed 15% loss limit constraints on spring discharges. Vegetative harm data was included, though the data were not available throughout the entire active portion of the simulation model grid.

The results presented here are for illustrative purposes only and derived from estimated annualized costs and environmental constraints; they are not intended to reflect potential or final water supply alternatives. Tables 18-33 summarize east-central results while aquifer drawdowns are provided in Figures 28, 31 and 34 with the improvement from the nonoptimized projected year 2010 condition given in Figures 29, 32, and 35, for the cases of 2%, 1%, and 0% Upper Floridan Head loss at control points with high or moderate potential for vegetative harm, respectively.

Alternative sources selected by each case are provided in Figures 30, 33, and 36 with colored lines representing surface water use and transport, public supply utility interconnects, and reclaimed water use for public and agricultural areas. Red lines denote selections by all three examined cases, violet lines denote selections in two of the three examined cases, and blue lines represent selections in one case only.

The linearity of the aquifer response was demonstrated with the deficit model and is not repeated here. Optimized well withdrawal rates are given in appendix in Table A13 for public supply utility wells and Table A10 for agricultural wells.

Table 18 below provides model statistics. All three cases were given the same relative gap, or error, a measure of the difference between the current solution and the best integer solution possible. The final solution is the current solution at the time when the time (resolution) limit is exceeded. As the relative gap decreases, the quality of the solution increases. Choices of relative gap and resource limits (maximum CPU time) were dictated by hardware considerations, and better solutions could be obtained with more RAM than the currently available 256 MB.

All three models used approximately 1 hour of CPU time on a Sun UltraSparc provided by the Center for Applied Optimization at the Department of Industrial and Systems Engineering of the University of Florida.

The resulting system of equations was 17,877 rows (variables) by 61,923 columns (constraints) with 154,718 nonzeroes. The *CPLEX* presolve routine reduced this system to 1,374 rows by 1,777 columns with 80,459 nonzeroes. There were 21 binary variables for surface water transport and 309 binary variables for potential and existing interconnect use.

The total annual cost in the final solution increases as the allowable Upper Floridan head loss at control points with high or moderate potential for vegetative harm decreases.

Table 18. East-central model statistics

Loss limit at control points with high or moderate potential for vegetative harm	Case 3, 0%	Case 2, 1%	Case 1, 2%
CPU time required (hours)	1.42	1.29	0.8
Final solution ($/year)	159,500,000	143,200,000	132,300,000
Error	0.016	0.015	0.006

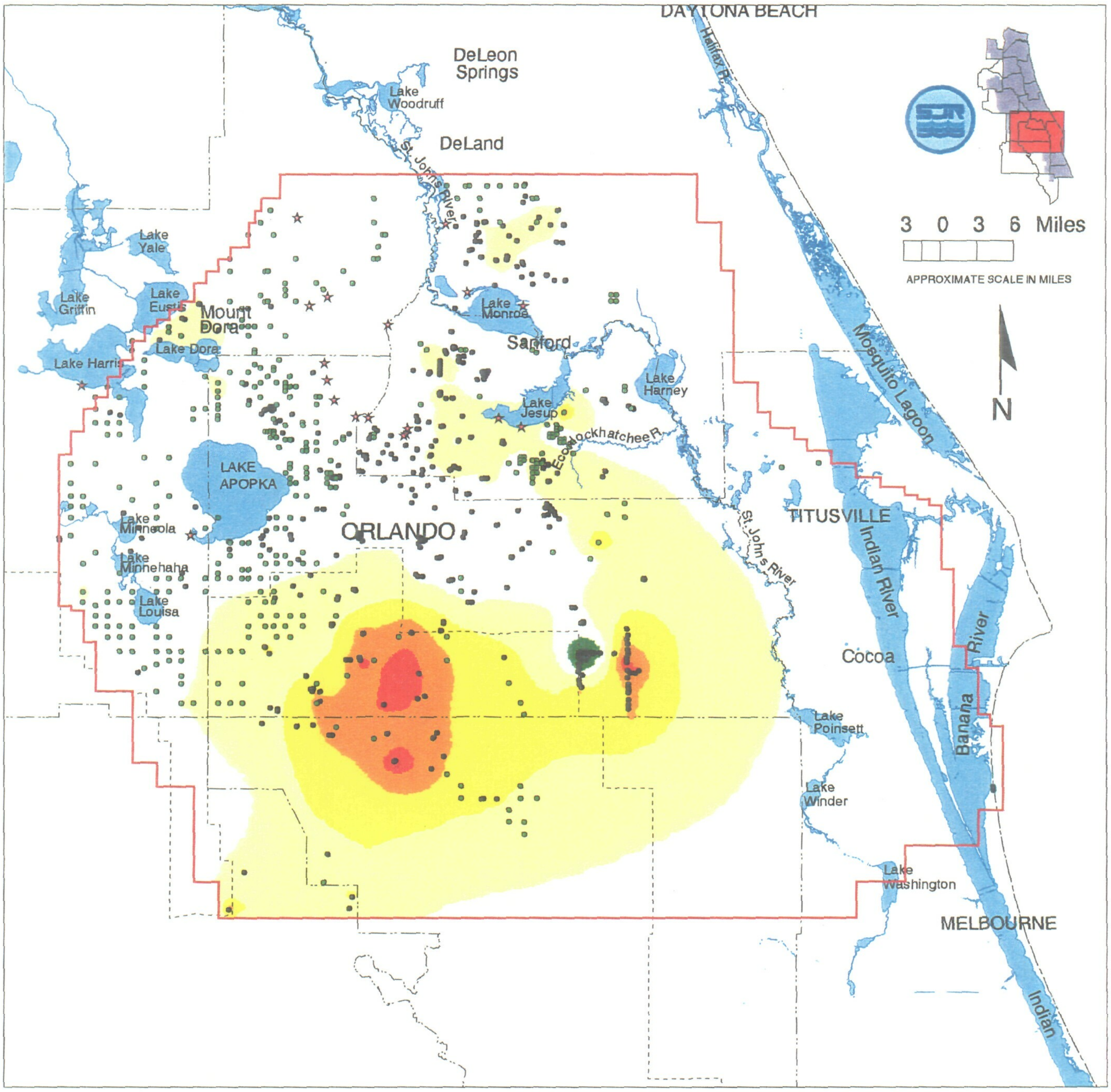


Figure 28

East-central projected year 2010 decision model optimized Upper Floridan drawdown allowing 2% head loss at control points with high or moderate potential for vegetative harm and 15% spring discharge loss and head loss at control points with low potential fo vegetative harm

Drawdown in Feet

- -11--9
- -9--7
- -7--5
- -5--3
- -3--1
- 1-3
- 3-5
- 5-7
- 7-9
- 9-11
- 11-13

- County Boundary
- SJRWMD Boundary
- ECF Active Edge
- Agricultural Wells
- Municipal Wells
- Springs
- General Water Bodies

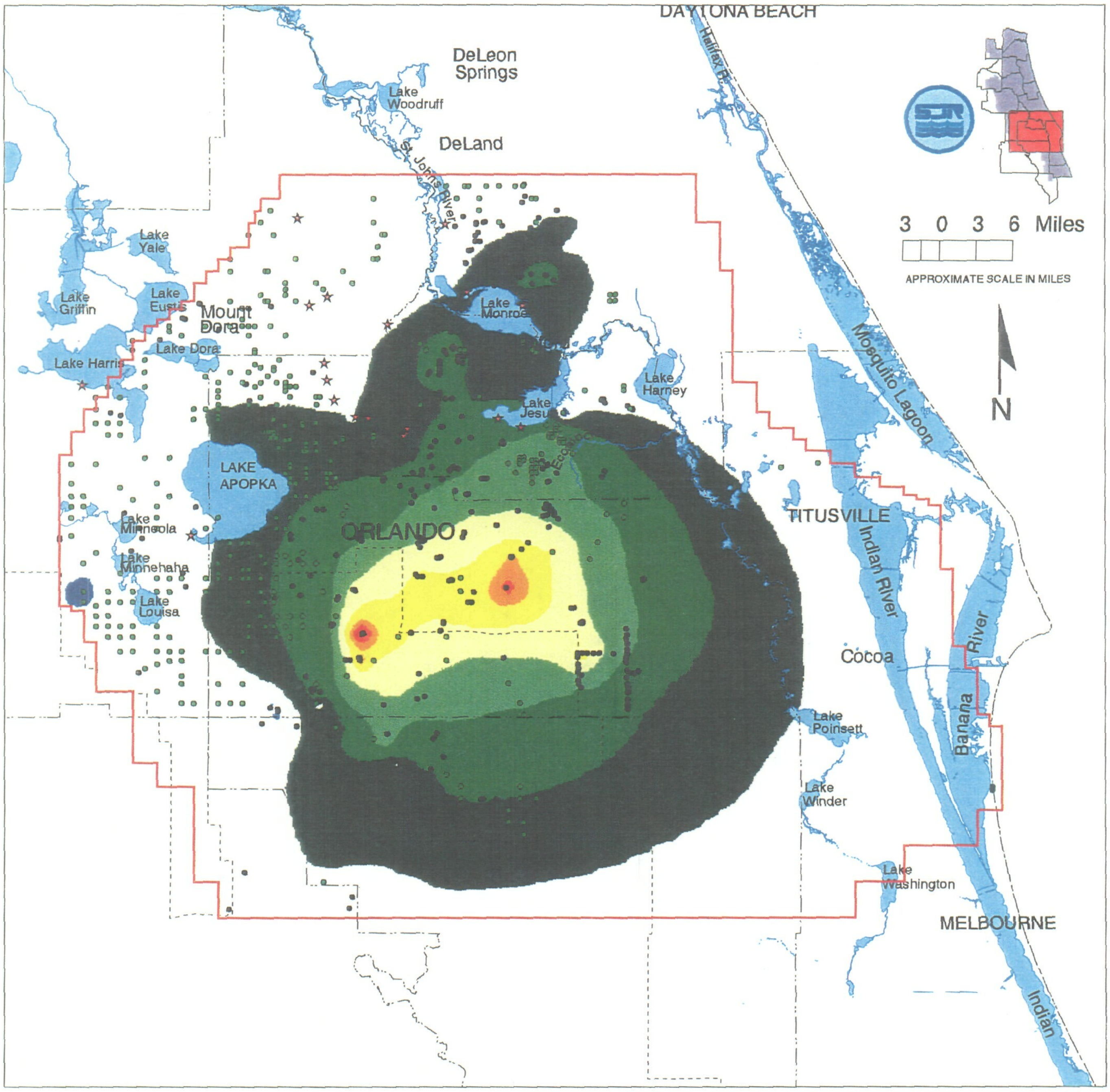
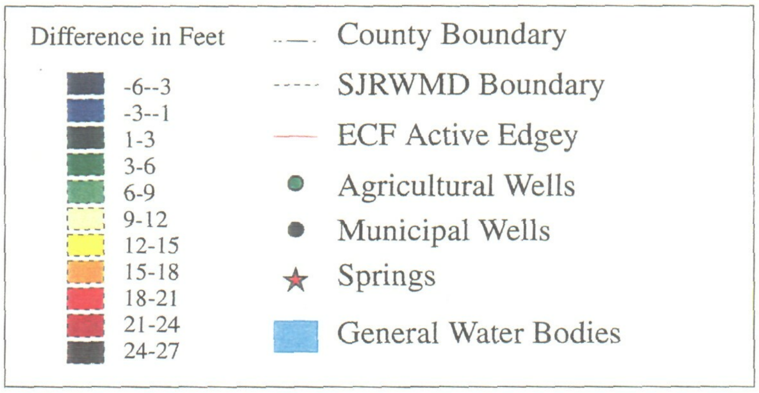


Figure 29

East-central projected year 2010 decision model Upper Floridan improvement over nonoptimized case allowing 2% head loss at control points with high or moderate potential for vegetative harm and 15% spring discharge loss and head loss at control points with low potential for vegetative harm



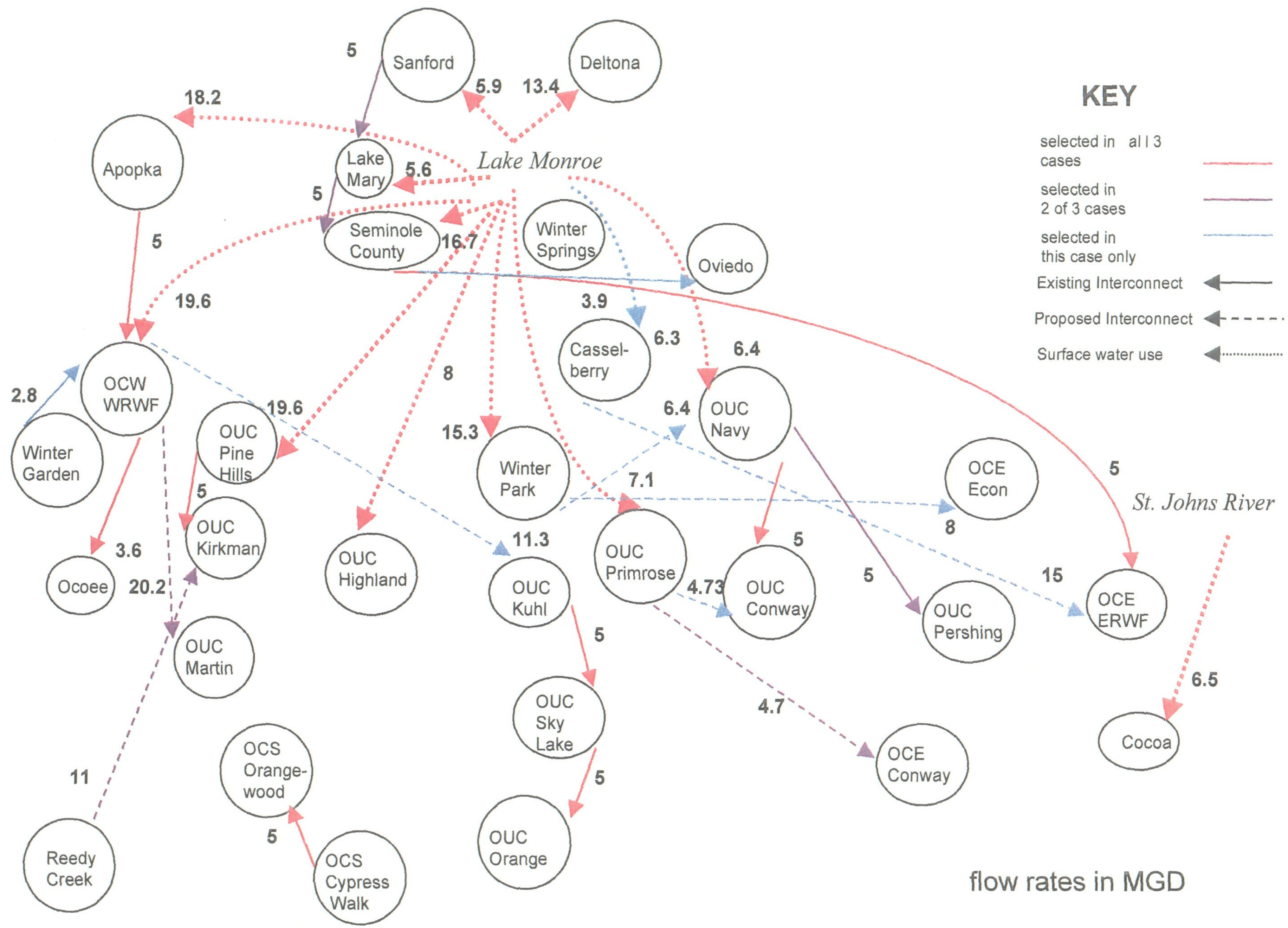


Figure 30. East-central alternative sources, decision model allowing 2% head loss at control points with high or moderate potential for vegetative harm, 15% discharge loss at springs, and 15% head loss at control points with low potential for vegetative harm.

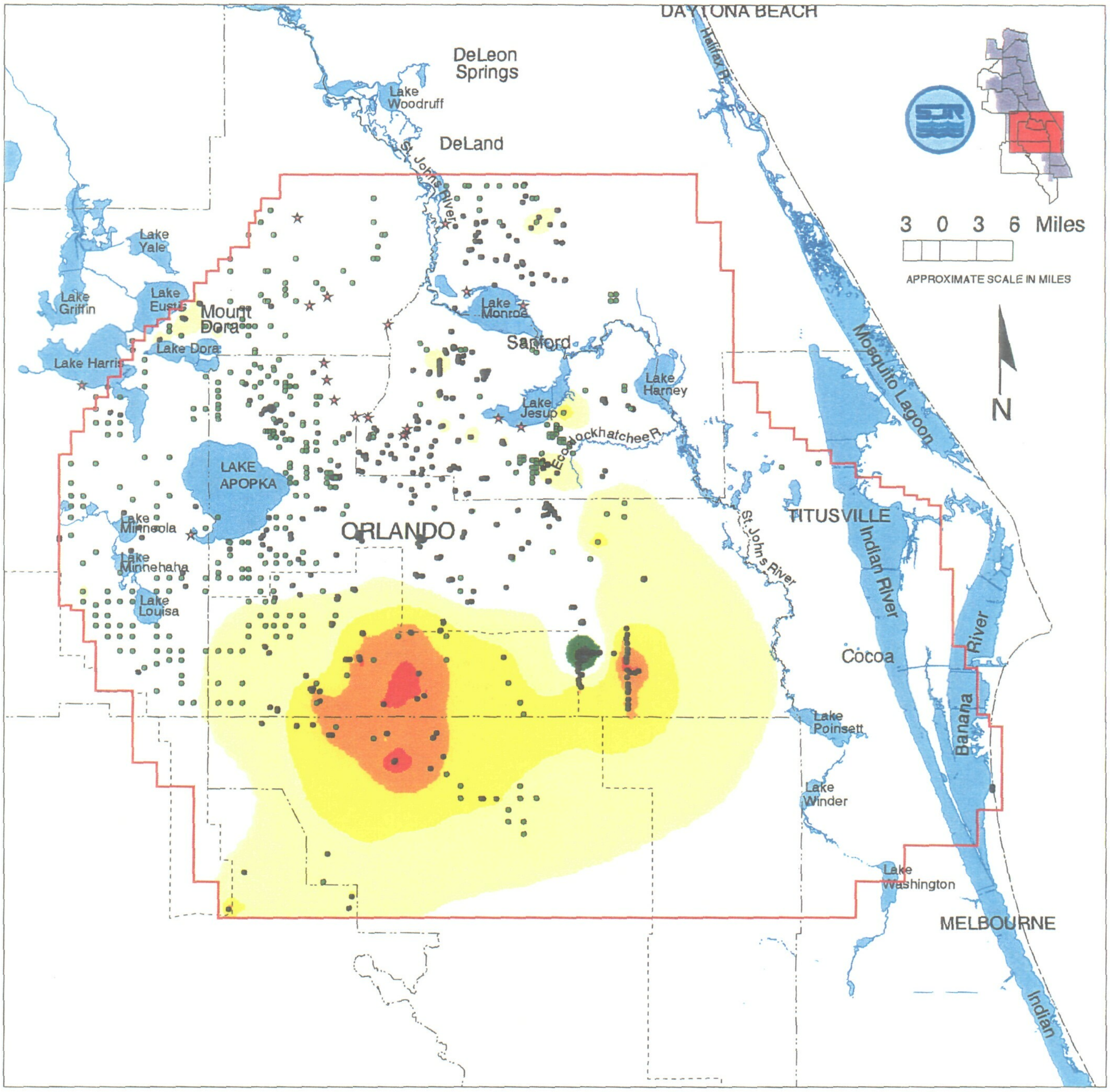


Figure 31

East-central projected year 2010 decision model optimized Upper Floridan drawdown allowing 1% head loss at control points with high or moderate potential for vegetative harm and 15% spring discharge loss and head loss at control points with low potential for vegetative harm

Drawdown in Feet
- -11--9
- -9--7
- -7--5
- -5--3
- -3--1
- 1-3
- 3-5
- 5-7
- 7-9
- 9-11
- 11-13

County Boundary
SJRWMD Boundary
ECF Active Edge
Agricultural Wells
Municipal Wells
Springs
General Water Bodies

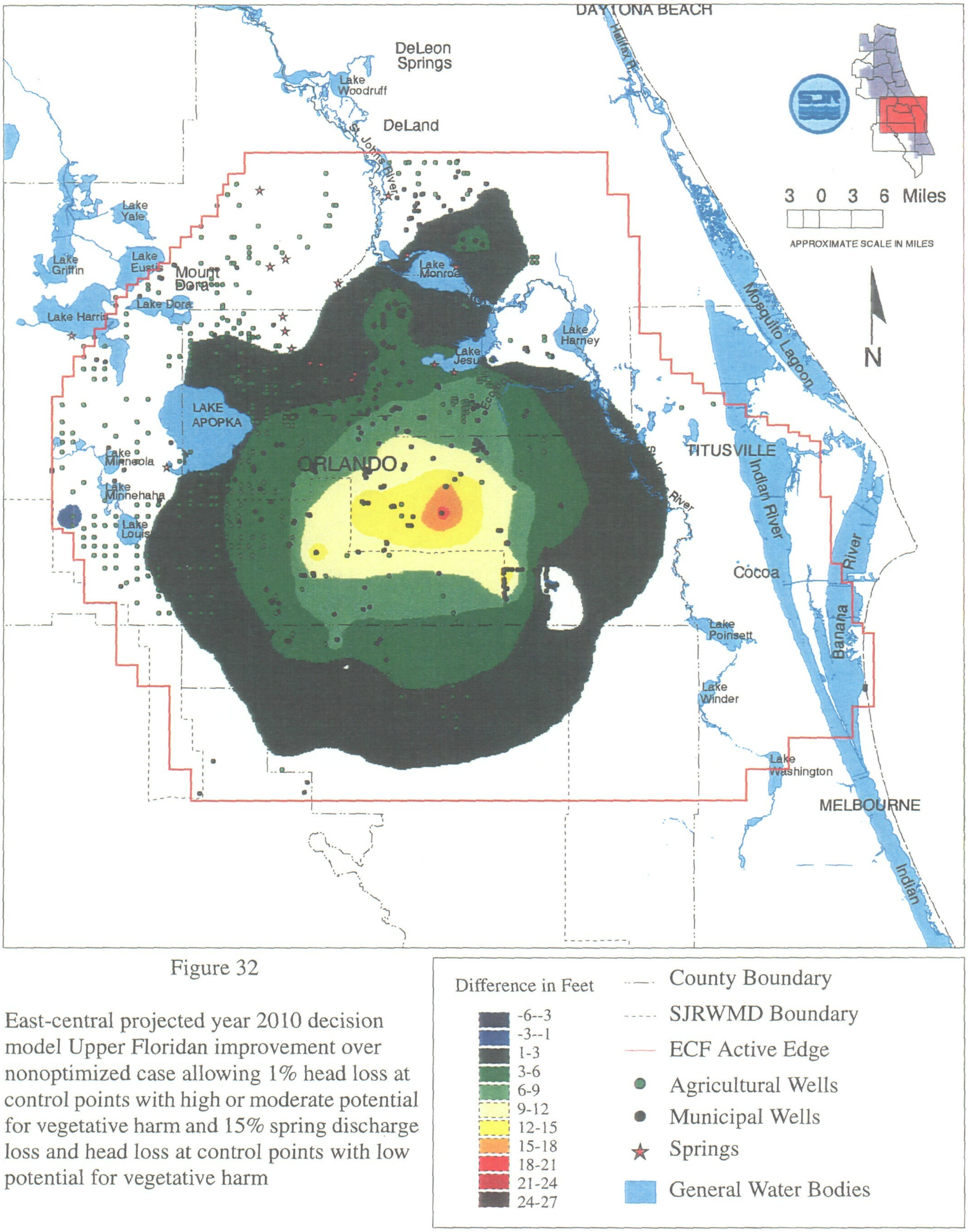


Figure 32

East-central projected year 2010 decision model Upper Floridan improvement over nonoptimized case allowing 1% head loss at control points with high or moderate potential for vegetative harm and 15% spring discharge loss and head loss at control points with low potential for vegetative harm

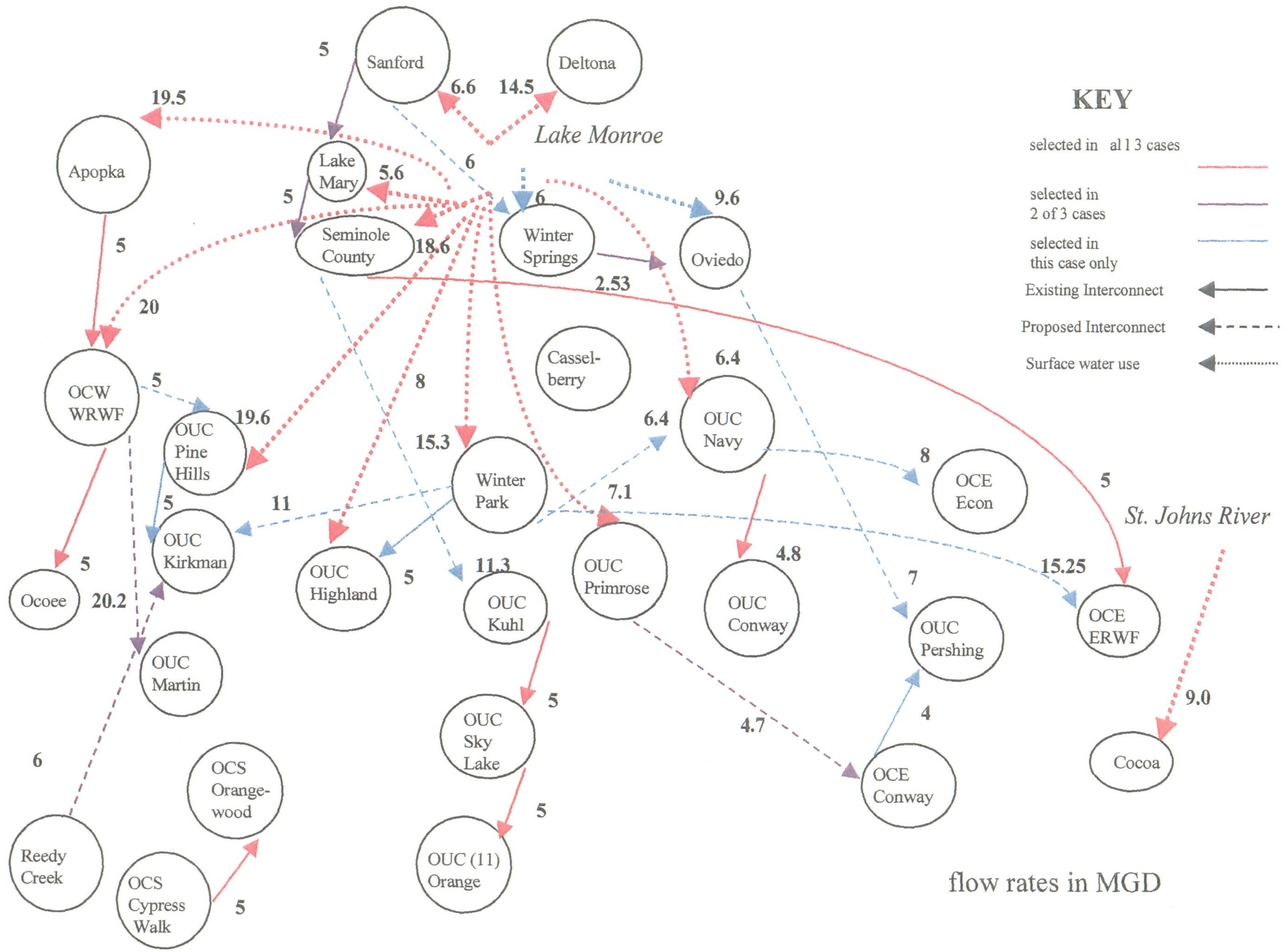


Figure 33. East-central alternative sources, decision model allowing 1% head loss at control points with high or moderate potential for vegetative harm, 15% discharge loss at springs, and 15% head loss at control points with low potential for vegetative harm.

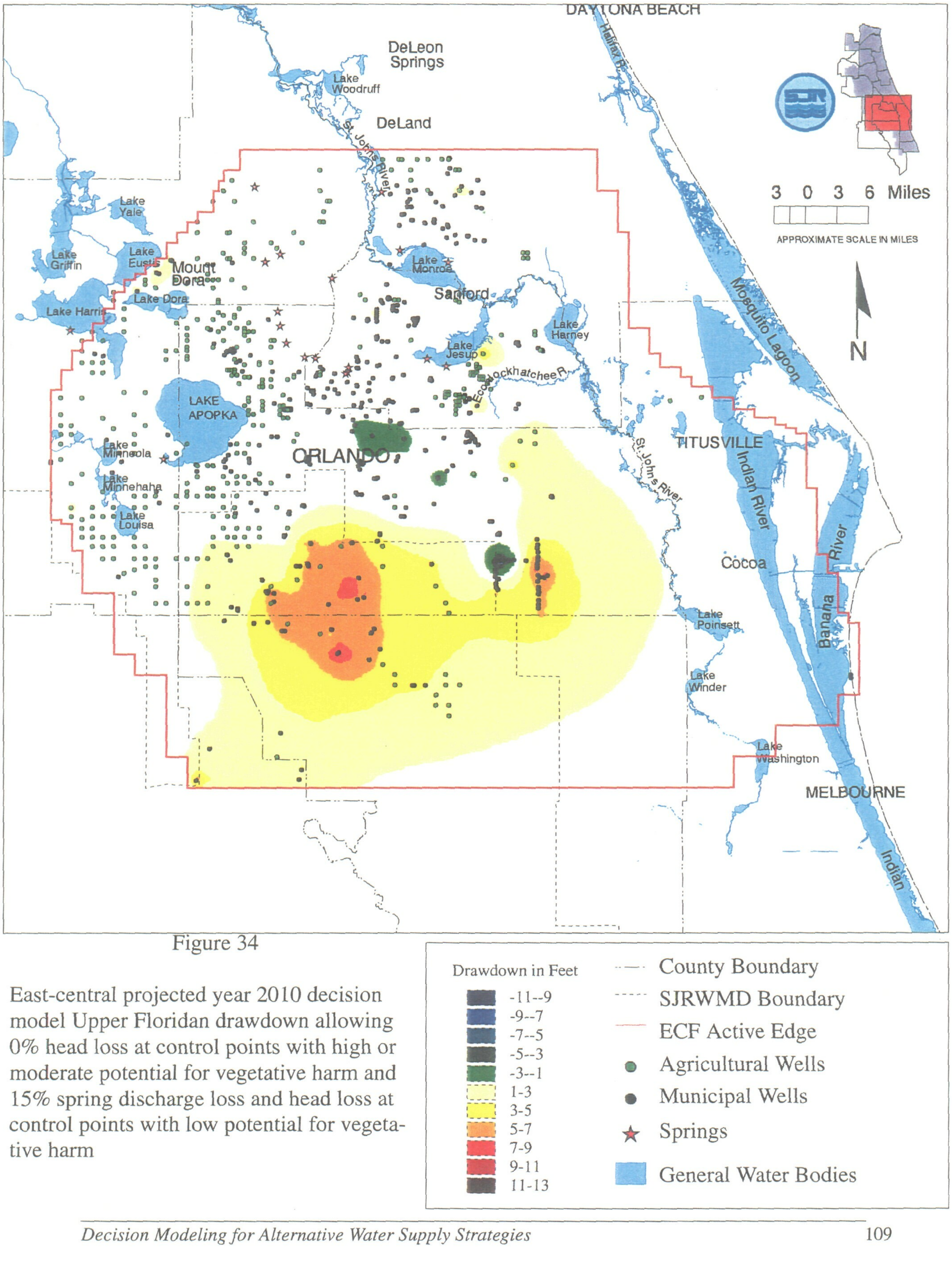


Figure 34

East-central projected year 2010 decision model Upper Floridan drawdown allowing 0% head loss at control points with high or moderate potential for vegetative harm and 15% spring discharge loss and head loss at control points with low potential for vegetative harm

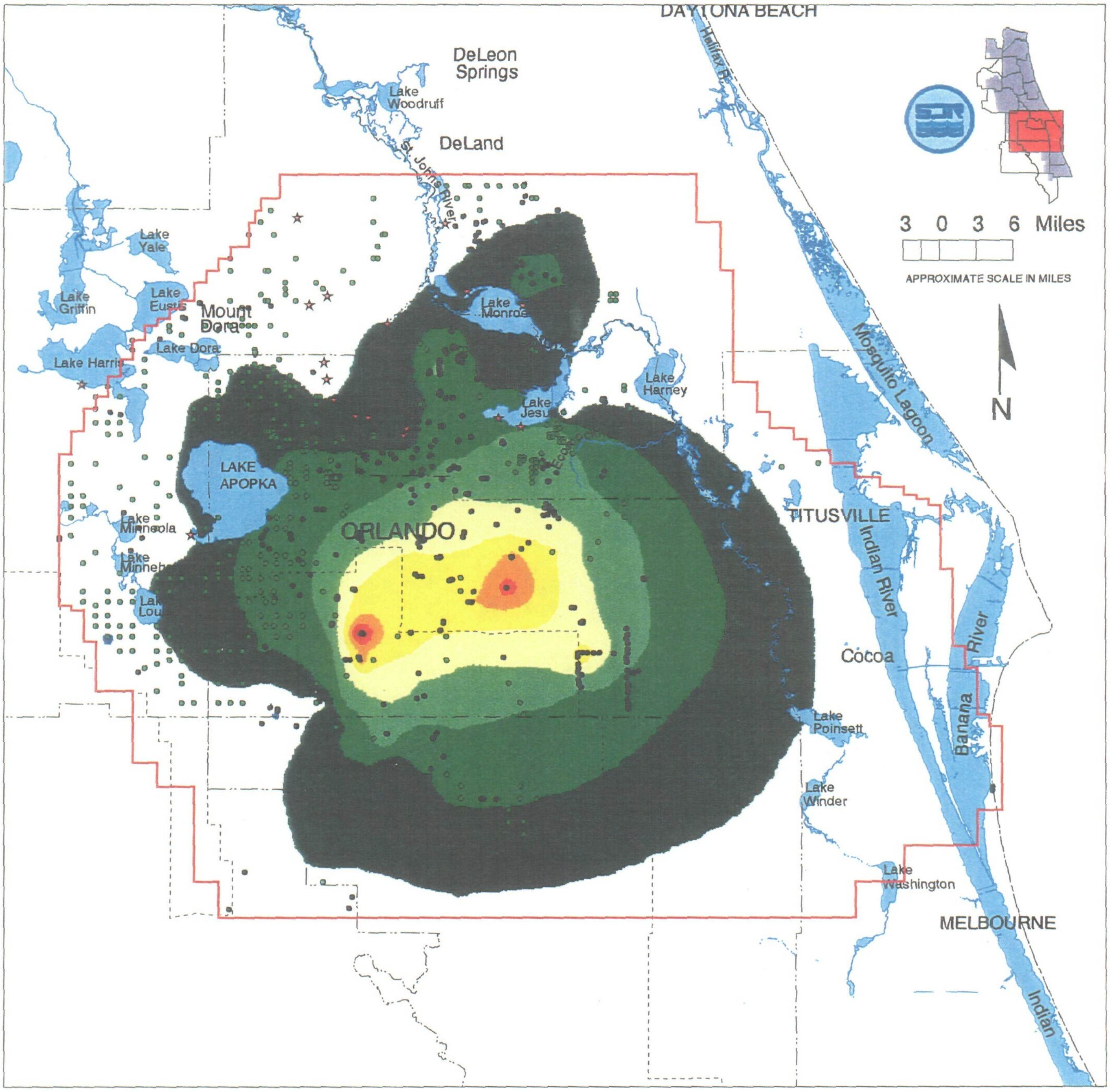


Figure 35

East-central projected year 2010 decision model Upper Floridan improvement over nonoptimized case allowing 0% head loss at control points with high or moderate potential for vegetative harm and 15% spring discharge loss and head loss at control points with low potential for vegetative harm

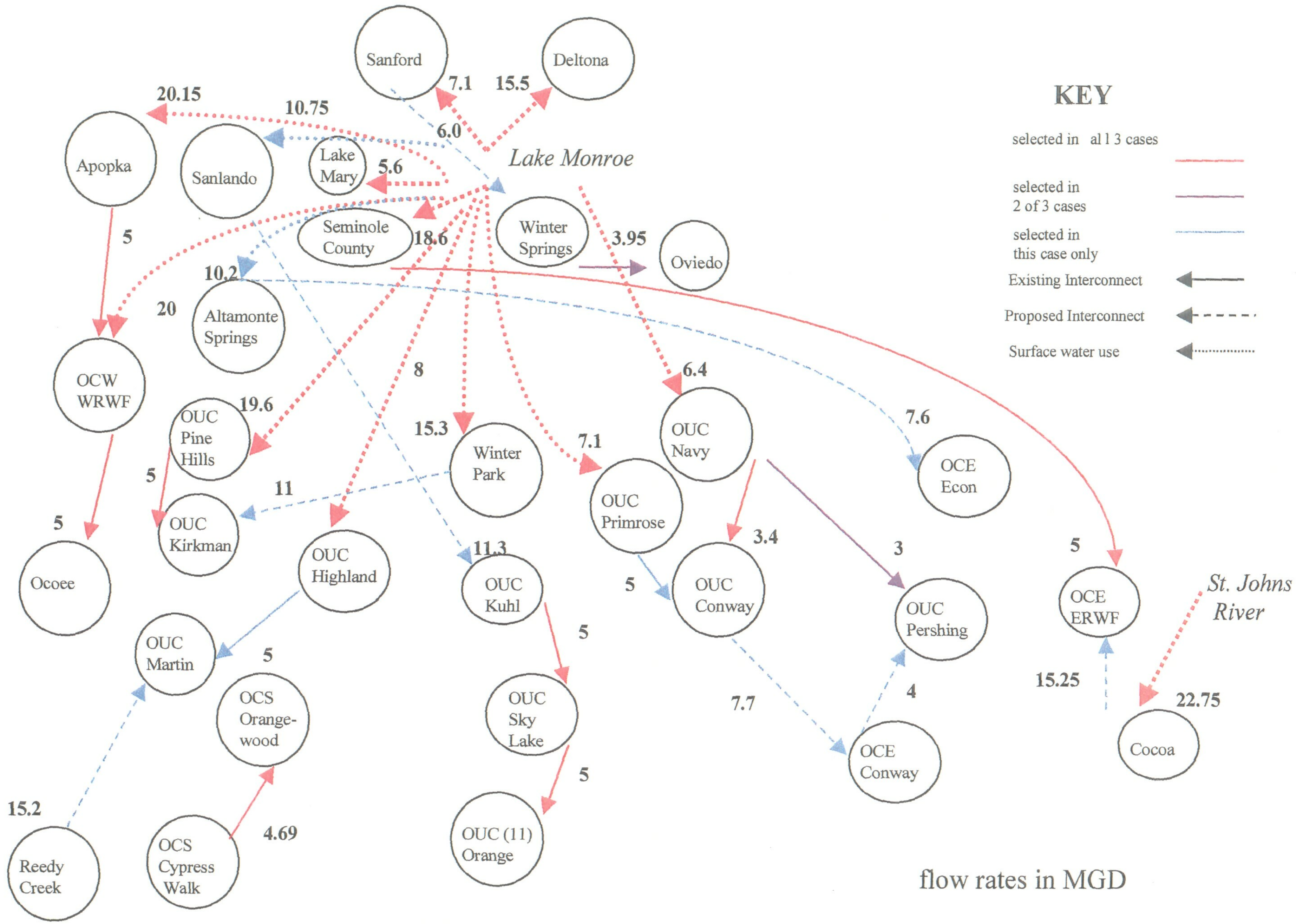


Figure 36. East-central alternative sources, decision model allowing 0% head loss at control points with high or moderate potential for vegetative harm, 15% discharge loss at springs, and 15% head loss at control points with low potential for vegetative harm.

Table 19 below provides total reuse selected in East-central Florida. Only Case 3 made agricultural use of reclaimed water No reuse for public areas was selected. The total amount of reuse was 5.12MGD from five wastewater treatment plants: Clermont, Ocoee, Orange County North, and Winter Garden.

Table 19. East-central total reuse

Reclaimed site	Case 3 only (0% losses at high harm areas) MGD
Clermont	0.78
Ocoee	0.39
Orange County North	2.82
Winter Garden1	0.4
Winter Garden2	0.74
Total	5.12

Table 20 provides the quantities of reuse to each citrus agricultural area. Areas C6 -C10 and C26, all near Lake Apopka and Apopka Spring.

Table 20. East-central reuse to agricultural areas

from		Citrus area	Case 3, 0% loss limit at high harm areas MGD
Clermont	to	C26	0.78
Ocoee	to	C6	0.07
Ocoee	to	C7	0.05
Ocoee	to	C10	0.27
Orange County North	to	C6	2.38
Orange County North	to	C26	0.44
Winter Garden1	to	C8	0.40
Winter Garden2	to	C8	0.1
Winter Garden2	to	C9	0.64
Total			5.12

New wells were selected in the Deltona, OUC Orange, and Orange County SRWF demand areas

Table 21. East-central new wells

Loss limit at control points with high or moderate potential for vegetative harm **Public Demand Area**	Case 3, 0%	Case 2, 1% **MGD**	Case 1, 2%
Deltona (Upper Floridan)	MW 62: 0.1 MW 64: 0.2 MW 65: 1.0	MW 62: 2.06 MW64: 1.03 MW65: 1.03 MW80: 0.1 5	MW 62: 2.06 MW64: 1.03 MW65: 1.03 MW80: 0.15
OUC Orange (Lower Floridan)	MW183: 2.2	MW183: 2.12	MW183: 2.12
OCPUD S SRWF (Lower Floridan)	MW131: 6.9	MW131: 7.17	MW131: 7.62
Total	10.4	13.56	14.01

All three cases made extensive use of surface water as displayed in Table 22. St. Johns River sites near Sanford and Cocoa were chosen in all three cases.

Table 22. East-central total surface water use

Loss limit at control points with high or moderate potential for vegetative harm	Case 3, 0%	Case 2, 1%	Case 1, 2%
Source		**MGD**	
From Sanford	164.2	156.8	142.0
From Cocoa	22.75	9.0	6.5
Total	186.95	165.8	148.5

Table 23 shows public use of surface water by public supply utility demand area. The public demand areas receiving the largest quantity of surface water were Apopka, Winter Springs, OUC, Seminole County, and Cocoa, in all three cases.

Table 23. East-central use rate of surface water to public area

Loss limit			**Case 3, 0%**	**Case 2, 1%**	**Case 1, 2%**
Source	**to**	**Destination**		**MGD**	
St. Johns River at Sanford		Altamonte Springs	10.19		
		Apopka	20.15	19.49	18.18
		Casselberry			6.33
		Deltona	15.51	14.46	13.39
		Lake Mary	5.62	5.62	5.62
		Orlando U. Highland	7.98	7.98	7.98
		Orlando U. Pine Hills	19.6	19.6	19.6
		Orlando U. Primrose	7.09	7.09	7.09
		Orlando U. Navy	6.4	6.4	6.4
		Sanford	7.07	6.62	5.90
		Seminole County	18.6	18.6	16.71
		Winter Park	15.28	15.28	15.28
		Sanlando	10.75		
		Oviedo		9.63	
		Winter Springs		6.01	
		Orange County W WRWF	20	20	19.56
St. Johns River near Cocoa	to	Cocoa	22.75	9.04	6.48
Total			186.95	165.82	148.53

Table 24 gives fixed charges for surface water use. Fixed charges for the surface water source were considerable in all three cases, totaling between $60 million/year and $80 million/year.

Table 24. East-central fixed costs of surface water sources

Loss limit			Case 3, 0%	Case 2, 1%	Case 1, 2%
Source	to	Destination		$ millions/year	
St. Johns River at Sanford		Altamonte Springs	4.239		
		Apopka	8.385	8.110	7.565
		Casselberry			2.634
		Deltona	6.453	6.016	5.518
		Lake Mary	2.339	2.339	2.339
		Orlando U. Highland	3.320	3.320	3.320
		Orlando U. Pine Hills	8.154	8.154	8.154
		Orlando U. Primrose	2.949	2.949	2.949
		Orlando U. Navy	2.663	2.663	2.663
		Sanford	2.943	2.753	2.456
		Seminole County	7.738	7.738	6.953
		Winter Park	6.257	6.357	6.357
		Sanlando	4.472		
		Oviedo		4.009	
		Winter Springs		2.501	6.357
		Orange County W WRWF	8.321		
St. Johns River near Cocoa	to	Cocoa	11.982	4.762	3.413
Total			80.215	61.670	60.678

The following table provides the transport costs for surface water, totaled for each receiving area. Actual costs for surface water transport are likely to be much lower than those reported here. The costs in Table 25 assume a different pipeline for each demand area. However, a more realistic scenario would involve a main pipe with branches to various demand areas. Fixed transport costs are not large compared to surface water fixed costs. However, the model formulation requires a separate physical pipeline for each public demand area supplied by surface water which results in an inefficient use of pipe. Future efforts will include a more efficient surface water transportation network which will consist of a main pipeline with branches to the appropriate public supply demand areas. This type of distribution system is likely incur lower fixed and unit charges, though an equitable distribution of costs may be difficult to define.

Table 25. East-central fixed costs of surface water transport

Loss limit			Case 3, 0%	Case 2, 1%	Case 1, 2%
Source	**to**	**Destination**		**$millions/year**	
St. Johns River at Sanford		Altamonte Springs	1.220		
		Apopka	1.939	1.908	1.847
		Casselberry			1.071
		Deltona	1.128	1.096	1.064
		Lake Mary	0.373	0.373	0.373
		Orlando U. Highland	1.372	1.372	1.372
		Orlando U. Pine Hills	1.913	1.913	1.913
		Orlando U. Primrose	1.331	1.331	1.331
		Orlando U. Navy	1.299	1.299	1.299
		Sanford	0.393	0.387	0.377
		Seminole County	1.095	1.095	1.044
		Winter Park	1.712	1.712	1.712
		Sanlando	0.983		
		Oviedo		1.449	
		Winter Springs		0.839	
		Orange County W WRWF	1.932		
St. Johns River near Cocoa	to	Cocoa	1.703	1.175	1.077
Total			15.234	15.950	14.480

Table 26 following displays the interconnects selected by each case sorted by destination area with Table 27 displaying interconnects sorted by source area. Orlando Utilities Commission had the largest number of interconnects, followed by Orange County East. The interconnects used are displayed in Figures 30,33, and 36 for each examined case in three colors: red if the interconnect is used by all three cases, violet, if chosen in two cases, and blue, if chosen by only one case. It must be noted that there were no constraints limiting the total quantity of interconnects to or from a given area, so some areas gave and received water via interconnects. Many of the areas that supply water via interconnects receive a large quantity of water from new surface sources. The minimum flow rate specified in the east-central region for interconnects is 4 MGD for new interconnects (1 MGD minimum in Volusia). Table 28 provides interconnect total fluxes for public demand areas. The sum of all interconnect fluxes should total to zero. Distances between source and destination areas were straight line distances.

Some public supply demand areas have multiple sources or multiple destinations, such as OUC Pine Hills or Navy. Political objections to such interconnect strategies, if any, may easily be taken into consideration to preclude their selection in future decision modeling efforts.

Table 26. East-central interconnects sorted by destination

Source	Destination	existing or potential	Loss at areas with high or moderate potential for vegetative harm Case 3, 0%	Case 2, 1%	Case 1, 2%	distance (miles)
				MGD		
Sanford	Lake Mary	e		5.00	5.00	2.3
Orange Cty. W WRWF	Ocoee	e	5.00	5.00	3.64	4.4
Orlando U. Conway	Orange Cty. E Conway	p	7.66			2.1
Orlando U. Primrose	Orange Cty. E Conway	p		4.73	4.73	5
Altamonte Springs	Orange Cty. E Econ	p	7.59			11.9
Orlando U. Navy	Orange Cty. E Econ	p		8.00		4.6
Winter Park	Orange Cty. E Econ	p			8.00	6.9
Casselberry	Orange Cty. E ERWF	p			15.04	10.8
Cocoa	Orange Cty. E ERWF	p	15.25			10.5
Seminole Cty.	Orange Cty. E ERWF	e	5.00	5.00	5.00	14.6
Winter Park	Orange Cty. E ERWF	p		15.25		14.6
Orange Cty. S Cypress	Orange Cty. S Orangewood	e	4.69	5.00	5.00	4.5
Apopka	Orange Cty. W WRWF	e	5.00	5.00	5.00	3.7
Winter Garden	Orange Cty. West WRWF	e			2.84	7.4
Orlando U. Navy	Orlando U. Conway	e	3.40	4.80	5.00	4.1
Orlando U. Primrose	Orlando U. Conway	e	5.00			2.3
Winter Park	Orlando U. Highland	p	5.00			3.8
Orlando U. Pine Hills	Orlando U. Kirkman	e		5.00		4.7
Reedy Creek	Orlando U. Kirkman	p		6.00	11.00	9
Winter Park	Orlando U. Kirkman	p	11.00			10.4
Orange Cty. W WRWF	Orlando U. Kuhl	p			11.31	10.5
Sanlando	Orlando U. Kuhl	p	11.28			12.2
Seminole Cty.	Orlando U. Kuhl	p		11.31		12.5
Orange Cty. W WRWF	Orlando U. Martin	p		20.19	20.19	13.1
Orlando U. Highland	Orlando U. Martin	e	5.00			9
Reedy Creek	Orlando U. Martin	p	15.19			7.3
Winter Park	Orlando U. Navy	p		6.40	6.40	2.8
Orlando U. Sky Lake	Orlando U. Orange	e	5.00	5.00		3.7
Orange Cty. E Conway	Orlando U. Pershing	p	4.00			1
Orlando U. Conway	Orlando U. Pershing	e			2.00	2
Orlando U. Navy	Orlando U. Pershing	e	3.00		5.00	4.9
Oviedo	Orlando U. Pershing	p		7.00		12.1
Orange Cty. W WRWF	Orlando U. Pine Hills	p		5.00		5.2
Orlando U. Kuhl	Orlando U. Sky Lake	e	5.00	5.00	5.00	4.9
Seminole Cty.	Oviedo	e			3.87	9.4
Winter Springs	Oviedo	e	5.00	2.53		6.3
Lake Mary	Seminole Cty.	e		5.00	5.00	4.8
Sanford	Winter Springs	p	6.01			6.6
Total			133.1	136.2	134.1	

Table 27. East-central interconnects sorted by source

			Loss at areas with high or moderate potential for vegetative harm			
Source	**Destination**	**existing or potential**	**Case 3, 0%**	**Case 2, 1% MGD**	**Case 1, 2%**	**distance (miles)**
Altamonte Springs	Orange Cty. E Econ	p	7.59			11.9
Apopka	Orange Cty. W WRWF	e	5.00	5.00	5.00	3.7
Casselberry	Orange Cty. E ERWF	p			15.04	10.8
Cocoa	Orange Cty. E ERWF	p	15.25			10.5
Lake Mary	Seminole Cty.	e		5.00	5.00	4.8
Orange Cty. E Conway	Orlando U. Pershing	p	4.00			1
Orange Cty. S Cypress	Orange Cty. S Orangewood	e	4.69	5.00	5.00	4.5
Orange Cty. W WRWF	Ocoee	e	5.00	5.00	3.64	4.4
Orange Cty. W WRWF	Orlando U. Kuhl	p			11.31	10.5
Orange Cty. W WRWF	Orlando U. Martin	p		20.19	20.19	13.1
Orange Cty. W WRWF	Orlando U. Pine Hills	p		5.00		5.2
Orlando U. Conway	Orlando U. Pershing	e			2.00	2
Orlando U. Conway	Orange Cty. E Conway	p	7.66			2.1
Orlando U. Highland	Orlando U. Martin	e	5.00			9
Orlando U. Kuhl	Orlando U. Sky Lake	e	5.00	5.00	5.00	4.9
Orlando U. Navy	Orlando U. Conway	e	3.40	4.80	5.00	4.1
Orlando U. Navy	Orange Cty. E Econ	p		8.00		4.6
Orlando U. Navy	Orlando U. Pershing	e	3.00		5.00	4.9
Orlando U. Pine Hills	Orlando U. Kirkman	e		5.00		4.7
Orlando U. Primrose	Orlando U. Conway	e	5.00			2.3
Orlando U. Primrose	Orange Cty. E Conway	p		4.73	4.73	5
Orlando U. Sky Lake	Orlando U. Orange	e	5.00	5.00		3.7
Oviedo	Orlando U. Pershing	p		7.00		12.1
Reedy Creek	Orlando U. Kirkman	p		6.00	11.00	9
Reedy Creek	Orlando U. Martin	p	15.19			7.3
Sanford	Lake Mary	e		5.00	5.00	2.3
Sanford	Winter Springs	p	6.01			6.6
Sanlando	Orlando U. Kuhl	p	11.28			12.2
Seminole Cty.	Oviedo	e			3.87	9.4
Seminole Cty.	Orange Cty. E ERWF	e	5.00	5.00	5.00	14.6
Seminole Cty.	Orlando U. Kuhl	p		11.31		12.5
Winter Garden	Orange Cty. West WRWF	e			2.84	7.4
Winter Park	Orlando U. Navy	p		6.40	6.40	2.8
Winter Park	Orange Cty. E Econ	p			8.00	6.9
Winter Park	Orlando U. Highland	p	5.00			3.8
Winter Park	Orange Cty. E ERWF	p		15.25		14.6
Winter Park	Orlando U. Kirkman	p	11.00			10.4
Winter Springs	Oviedo	e	5.00	2.53		6.3
Total			133.1	136.2	134.1	

Table 28. East-central total interconnects for public demand areas

Loss limit / Public demand area	Total of outflow from: Case 3, 0% (MGD)	Case 2, 1% (MGD)	Case 1, 2% (MGD)	Total of inflow to: Case 3, 0% (MGD)	Case 2, 1% (MGD)	Case 1, 2% (MGD)	net flux(inflow- outflow): Case 3, 0% (MGD)	Case 2, 1% (MGD)	Case 1, 2% (MGD)
Altamonte Springs	7.59						-7.59	0	0
Apopka	5	5	5				-5	-5	-5
Casselberry			15.04				0	0	-15
Cocoa	15.25						-15.25	0	0
Lake Mary		5	5		5	5	0	0	0
Ocoee				5	5	3.64	5	5	3.64
OCPUD E Conway	4			7.66	4.73	4.73	3.66	4.73	4.73
OCPUD E Econ				7.59	8	8	7.59	8	8
OCPUD E ERWF				20.25	20.25	20.04	20.25	20.25	20.04
OCPUD S Cypress Walk	4.69	5	5				-4.69	-5	-5
OCPUD S Orangewood				4.69	5	5	4.69	5	5
OCPUD W WRWF	5	30.19	35.14	5	5	7.84	0	-25.19	-27.3
OUC Conway	7.66		2	8.4	4.8	5	0.74	4.8	3
OUC Highland	5			5			0	0	0
OUC Kirkman				11	11	11	11	11	11
OUC Kuhl	5	5	5	11.28	11.31	11.31	6.28	6.31	6.31
OUC Martin				20.19	20.19	20.19	20.19	20.19	20.19
OUC Navy	6.4	12.8	10		6.4	6.4	-6.4	-6.4	-3.6
OUC Orange				5	5	5	5	5	5
OUC Pershing				7	7	7	7	7	7
OUC Pine Hills		5			5		0	0	0
OUC Primrose	5	4.73	4.73			0	-5	-4.73	-4.73
OUC Sky Lake	5	5	5	5	5	5	0	0	0
Oviedo		7		3.95	2.5	3.9	3.95	-4.5	3.9
Reedy Creek Utilities	15.19	6	11				-15.19	-6	-11
Sanford	6.01	5	5				-6.01	-5	-5
Sanlando	11.28						-11.28	0	0
Seminole County	5	16.31	8.9		5	5	-5	-11.31	-3.9
Winter Garden			2.84				0	0	-2.84
Winter Park	16	21.65	14.4				-16	-21.65	-14.4
Winter Springs	3.95	2.53		6.01			2.06	-2.53	0
Total	133.02	136.2	134.05	133	136.18	134.05	0.00	-0.03	0.00

Table 29 provides fixed charges for interconnects as calculated by the model for all three cases. The model used linear approximations of the nonlinear equations of CH2M-Hill (1997) as discussed in the Methods section. The linearized estimated cost of the interconnects are provided along with the error in each case, which is generally within 7% of the CH2M-Hill nonlinear cost. Costs are listed by destination area, and contain the sum of all new interconnects supplying that destination area.

Table 29. East-central interconnect fixed costs

	Annual fixed charges, $millions/year								
Public supply area loss limit model	Linear approximation			CH2M-Hill			Error		
	Case 3, 0%	Case 2, 1%	Case 1, 2%	Case 3, 0%	Case 2, 1%	Case 1, 2%	Case 3, 0%	Case 2, 1%	Case 1, 2%
OUC Martin	0.771	1.604	1.604	0.845	1.764	1.764	-0.074	-0.160	-0.160
OUC Highland	0.365			0.232			0.133		
OUC Pine Hills		0.365			0.364			0.001	
OUC Kuhl	1.261	1.263	1.000	1.267	1.247	1.085	-0.006	0.016	-0.085
OUC Kirkman	0.991	0.751	0.888	1.061	0.699	0.912	-0.070	0.052	-0.024
OUC Navy		0.124	0.124		0.177	0.177		-0.053	-0.053
OUC Pershing	0.048	1.097		0.041	1.019		0.007	0.078	
OCPUD E Conway	0.130	0.362	0.362	0.134	0.318	0.318	-0.004	0.044	0.044
OCPUD E Econ	1.120	0.405	0.620	1.037	0.360	0.601	0.083	0.045	0.019
OCPUD E ERWF	1.120	1.004	1.114	1.237	1.004	1.266	-0.117	0.000	-0.152
Winter Springs	0.578			0.506			0.072		
Total	6.384	6.974	5.711	6.361	7.693	6.286	0.023	-0.719	-0.575

Table 30 provides a well withdrawal summary while Table 31 provides the summary of alternative sources used in each case of the decision model for selected public supply utility demand areas. Table 32 gives totals for alternative water supply strategies selected by the decision model. Twenty public supply utility interconnects were selected to transport water, the bulk of which was comprised of surface water from the St. Johns River near Sanford. Relatively little use of reclaimed water was made in any of the examined cases.

Table 30. Well withdrawal summary for selected areas

Demand area	Well withdrawal rates (MGD) Simulation Year 2010	Decision model loss limit Case 3, 0%	Case 2, 1%	Case 1, 2%	Total of well withdrawal - projected year 2010 demand (MGD) Decision model loss limit Case 3, 0%	Case 2, 1%	Case 1, 2%
Altamonte Springs	10.2	7.6	10.2	10.2	-2.6	0	0
Apopka	21.1	6	6.7	8	-15.1	-14.4	-13.1
Casselberry	6.3	6.3	6.3	15	0	0	8.7
Cocoa	27.1	19.6	18	20.6	-7.5	-9.1	-6.5
Ocoee	5.5	0.5	0.5	1.8	-5	-5	-3.7
OCS Cypress	6.5	11.2	11.5	11.5	4.7	5	5
OCS Orangewood	6.5	1.8	1.5	1.5	-4.7	-5	-5
OCE Conway	7.7	4	2.9	2.9	-3.7	-4.8	-4.8
OCE Econ	8	0.4			-7.6	-8	-8
OCE ERWF	20.25			0.2	-20.25	-20.25	-20.05
OCW WRWF	20		25.2	27.7	-20	5.2	7.7
Oviedo	9.6	5.7	4.5	5.7	-3.9	-5.1	-3.9
Reedy Creek	29	44.2	35	40	15.2	6	11
Sanford	7.5	6.5	5.9	6.6	-1	-1.6	-0.9
Sanlando	10.75	11.3	10.7	10.7	0.55	-0.05	-0.05
Seminole Cty	18.6	5	11.3	5.8	-13.6	-7.3	-12.8
Winter Park	15.3	16	21.7	14.4	0.7	6.4	-0.9
Winter Springs	6	4	2.5	6	-2	-3.5	0
OUC::					0	0	0
Martin	20.2				-20.2	-20.2	-20.2
Orange	7.2	2.2	2.2	2.2	-5	-5	-5
Pershing	7				-7	-7	-7
Conway	9.2	8.5	4.4	6.2	-0.7	-4.8	-3
Highland	8				-8	-8	-8
Kirkman	11				-11	-11	-11
Kuhl	11.3	5	5	5	-6.3	-6.3	-6.3
Navy	6.4	6.4	6.4	3.6	0	0	-2.8
Primrose	7.1	5	4.7	4.7	-2.1	-2.4	-2.4
Pine Hills	19.6				-19.6	-19.6	-19.6
Sky Lake	15.3	15.3	15.3	15.3	0	0	0

Table 31. East-central alternative water supply strategies for selected demand areas

Demand area	Sum of well withdrawal - 2010 demand (MGD)			Interconnect flux (MGD)			Surface Water Use (MGD)			Sum of inflow -outflow (MGD)		
	Case 3, 0%	Case 2, 1%	Case 1, 2%	Case 3, 0%	Case 2, 1%	Case 1, 2%	Case 3, 0%	Case 2, 1%	Case 1, 2%	Case 3, 0%	Case 2, 1%	Case 1, 2%
Altamonte Springs	-2.6			-7.59			10.2			0.01		
Apopka	-15.1	-14.4	-13.1	-5	-5	-5	20.2	19.5	18.2	0.1	0.1	0.1
Casselberry			8.7			-15			6.3			
Cocoa	-7.5	-9.1	-6.5	-15.25			22.75	9	6.5		-0.1	
OCE Conway	-3.7	-4.8	-4.8	3.7	4.7	4.7					-0.1	-0.1
OCE Econ	-7.6	-8	-8	7.6	8	8						
OCE ERWF	-20.25	-20.25	-20.05	20.25	20.25	20.05						
Ocoee	-5	-5	-3.7	5	5	3.6						-0.1
OCS Cypress	4.7	5	5	-4.7	-5	-5						
OCS Orangewood	-4.7	-5	-5	4.7	5	5						
OCW WRWF	-20	5.2	7.7		-25.2	-27.3	20	20	19.6			
OUC Pine Hills	-19.6	-19.6	-19.6				19.6	19.6	19.6			
OUC Primrose	-2.1	-2.4	-2.4	-5	-4.7	-4.7	7.1	7.1	7.1			
OUC Conway	-0.7	-4.8	-3	0.7	4.8	3						
OUC Highland	-8	-8	-8				8	8	8			
OUC Kirkman	-11	-11	-11	11	11	11						
OUC Kuhl	-6.3	-6.3	-6.3	6.3	6.3	6.3						
OUC Martin	-20.2	-20.2	-20.2	20.2	20.2	20.2						
OUC Navy			-2.8	-6.4	-6.4	-3.6	6.4	6.4	6.4			
OUC Orange	-5	-5	-5	5	5	5						
OUC Pershing	-7	-7	-7	7	7	7						
Oviedo	-3.9	-5.1	-3.9	4	-4.5	4		9.6		0.1		0.1
Reedy Creek	15.2	6	11	-15.2	-6	-11						
Sanford	-1	-1.6	-0.9	-6	-5	-5	7.1	6.6	5.9	0.1		
Sanlando	0.55	-0.05	-0.05	-11.3			10.75					-0.05
Seminole Cty	-13.6	-7.3	-12.8	-5	-11.3	-3.9	18.6	18.6	16.7			
Winter Park	0.7	6.4	-0.9	-16	-21.7	-14.4	15.3	15.3	15.3			
Winter Springs	-2	-3.5		2.1	-2.5			6.1		0.1	0.1	

Table 32. East-central total alternative water supply strategy

loss limit	Case 3, 0%	Case 2, 1%	Case 1, 2%
		MGD	
Surface water	187	166	134
Reclaimed Water	5		
Total alternative use	192	166	134
Total projected year 2010 demand	567	567	567
Number of new interconnects used	9	9	7
Number of existing interconnects used	11	11	13
% of 2010 demand met by alternatives to groundwater	34%	29%	24%

Table 33 provides the fraction of simulated year 1988 spring discharge attained for each loss limit case. The aquifer response was verified to be linear in the deficit model cases discussed previously.

Table 33. East-central spring discharges and fractions of simulated 1988 discharge

	Simulation Model Spring Discharges, cfs				Fraction of year 1988 spring discharge attained		
	Decision Model Loss Limit				Decision Model Loss Limit		
Spring	Case 3, 0%	Case 2, 1%	Case 1, 2%	1988	Case 3, 0%	Case 2, 1%	Case 1, 2%
Messant	12.60	12.55	12.48	12.48	1.01	1.01	1.00
Seminole	26.63	26.40	26.07	27.37	0.97	0.96	0.95
Rock	53.61	52.85	51.31	53.73	1.00	0.98	0.95
Wekiva	70.01	69.08	68.37	70.02	1.00	0.99	0.98
Miami	4.57	4.51	4.45	4.56	1.00	0.99	0.98
Starbuck	14.36	13.99	13.66	14.30	1.00	0.98	0.95
Palm	6.19	6.03	5.89	6.18	1.00	0.97	0.95
Sanlando	16.12	15.66	15.26	16.17	1.00	0.97	0.94
Camp La No Che	0.32	0.32	0.32	0.34	0.94	0.95	0.94
Blue	106.39	106.86	106.58	109.92	0.97	0.97	0.97
Gemini	7.45	7.47	7.42	7.67	0.97	0.97	0.97
Island	7.48	7.47	7.43	6.78	1.10	1.10	1.10
Witherington	3.78	3.71	3.65	3.78	1.00	0.98	0.96
Lake Jessup	0.75	0.75	0.74	0.71	1.06	1.06	1.05
Clifton	1.52	1.51	1.50	1.40	1.08	1.08	1.07
Apopka	49.96	48.51	46.66	53.68	0.93	0.90	0.87
Sulphur	0.96	0.96	0.94	0.97	0.99	0.99	0.97

Finally, a display of the total annual costs as a function of environmental costs is provided in Figure 37 below. These costs are compared to an estimate of the projected year 2010 nonoptimized total annual cost. The general trend of costs increasing as environmental losses decrease is evident.

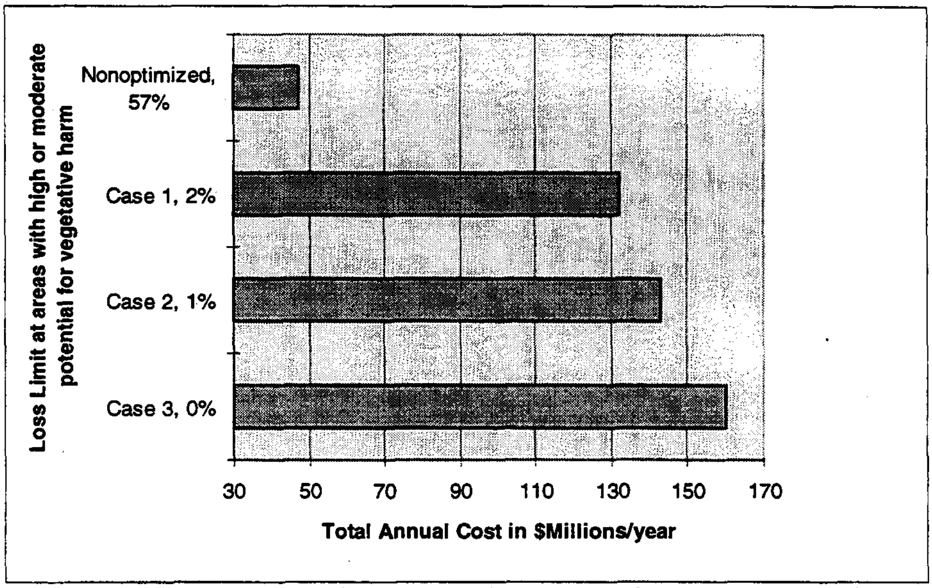


Figure 37. Total annual cost as a function of environmental constraints

EAST-CENTRAL SUMMARY

Several general trends were evident. The decision models made extensive use of surface water as an alternative source in all examined cases. Total surface water use was 134, 166, and 187 MGD for cases with environmental loss limits of 2%, 1%, and 0% at areas with high or moderate potential for vegetative harm, respectively. Most surface water use was at the Apopka, Deltona, OUC, and Orange County WRWF public supply demand areas.

Reclaimed water for agricultural use was selected by only those citrus demand areas near Lake Apopka. This reclaimed use is due to the demand areas' proximity to Apopka Spring, which has displayed high variability in its flow measurements, ranging from a low of 28.4 cfs to a high of 70.4 cfs (Rao and Clapp, 1995). Decisions regarding model results in the vicinity of Apopka Spring should not overlook this uncertainty.

The east-central model also made considerable use of interconnects. Generally, the receivers of large quantities of surface water passed much of it on to demand areas in the central and eastern portions of the simulation model area. Existing (11-13 selected) and potential (7-9 selected) interconnects were selected, with flow rates of up to 5 MGD in existing interconnects. Potential interconnects generally supported higher flow rates. The model may not capture sufficient detail with regard to interconnects in all areas. OUC, in particular, deserves additional attention as to potential interconnects, as a decision model with more detail at OUC may help to ascertain the lowest cost interconnect options. The precise scheme of existing interconnects within OUC, to OUC, and from OUC was not available for this study.

The alternative sources selected by each case are strongly dependent upon environmental constraints. The east-central model uses a 15% allowable decrease in Upper Floridan head at control points with low potential for vegetative harm, and a 15% allowable reduction in spring discharge. The model required that a 2%,1% or 0% loss limit be specified at Upper Floridan control points having high or moderate potential for vegetative harm. Environmental loss constraints could be revised to reflect potential for vegetative harm throughout the entire active portion of the east-central study area. Though the vegetative harm analysis was available for the portion of the east-central region within SJRWMD boundaries, better results would be obtained with a complete analysis throughout the entire active portion of the region. In addition, constraints to preclude saltwater intrusion should be incorporated in future decision model efforts and may significantly alter the resulting optimal solution.

Agricultural demands are not projected to increase from 1988. In addition, agricultural use comprises only a small fraction of the total projected water demand in the study areas. For these reasons, agricultural demands do not play a large part in the decision model. Thus, future modeling efforts may benefit from 1)eliminating the optimization of agricultural well withdrawals and 2)eliminating alternative sources for agricultural use such as reclaimed water. This would allow for a corresponding increase in detail and available alternatives at public supply demand areas.

The results presented in this report provide a general overview of how the models work in their specific areas. A number of alternative sources remain to be incorporated including lower quality sources, artificial recharge, and aquifer mitigation/avoidance of impacts.

VOLUSIA

The decision model formulation was applied to the Volusia region for three cases using 15% loss limits on spring discharges and surficial aquifer head at control points with low potential for vegetative harm, and the following loss limits at control points with moderate or high potential for vegetative harm: case 1-- 2% losses, case 2-- 1% losses, and case 3-- 0% losses. These cases were investigated based on the previously discussed deficit model results.

The results presented here are for illustrative purposes only and derived from estimated annualized costs; they are not intended to reflect final or proposed water supply alternatives. Tables 34-49 list Volusia results. Surficial aquifer drawdown plots are provided in Figures 38, 41, and 44 with improvement from the nonoptimized projected year 2010 condition shown in Figures 39, 42, and 45 for cases 1-3, respectively. Alternative sources selected by each case are provided in Figures 40,43, and 46 with colored lines representing surface water use and transport, public supply utility interconnects, and reclaimed water use for public and agricultural areas. Red lines denote decision model selections in all three examined cases, violet lines denote selections in two of the three examined cases, and blue lines represent selections in one case only.

Table 34 provides Volusia decision model statistics. All three cases were given the same relative gap, a measure of the difference between the current solution and the best integer solution possible. The final solution is the current solution at the time when the resolution limit is exceeded. As the relative gap decreases, the quality of the solution increases. Choices of relative gap (error) and resource limits (maximum CPU time) were dictated by hardware considerations, as in the east-central model, and better solutions could be obtained with more RAM than the currently available 256 MB. The total annual cost in the final solution increases as the environmental loss limits decrease. The decision model as written has 8,384 rows (constraints), 8,257 columns (variables), and 401,980 nonzeroes, which the CPLEX presolve routine reduces to 450 rows, 985 columns, and 96,003 nonzeroes.

Table 34. Volusia decision model statistics

	Case 3	Case 2	Case 1
loss limit in high harm area	0%	1%	2%
CPU time (hours)	0.4	0.4	0.2
Final solution ($)	46,140,000	29,740,000	20,490,000
Error	0.009	0.006	0.002

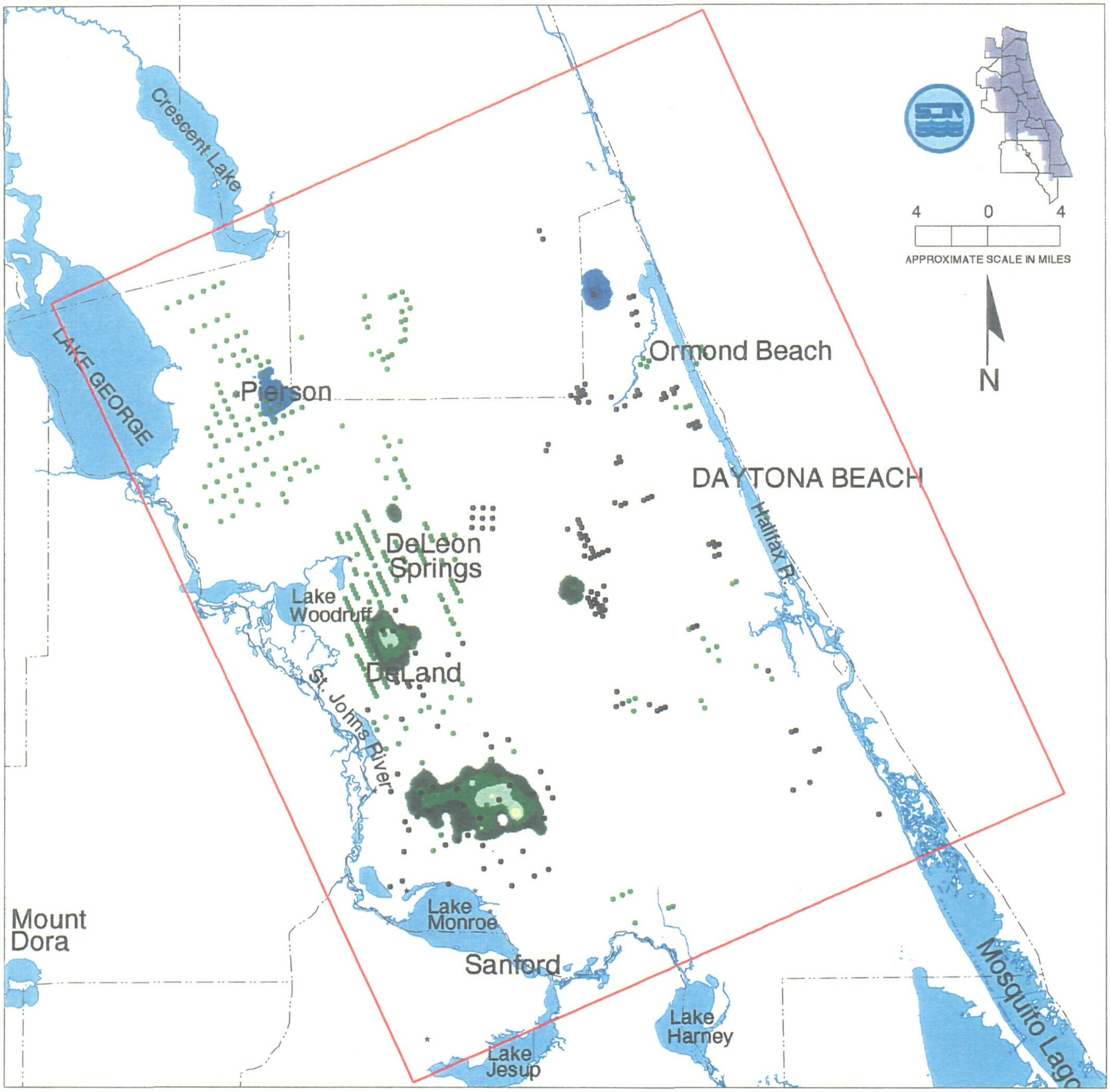


Figure 38

Volusia projected year 2010 decision model optimized surficial drawdown allowing 2% head loss at control points with high or moderate potential for vegetative harm and 15% discharge loss at springs and head loss at control points with low potential for vegetative harm

Drawdown in Feet

- -4--3
- -3--2
- -2--1
- 1-2
- 2-3
- 3-4
- 4-5
- 5-6
- 6-7
- 7-8
- 8-9

- County Boundaries
- Volusia Model Edge
- Agricultural Wells
- Municipal Wells
- Springs
- General Water Bodies

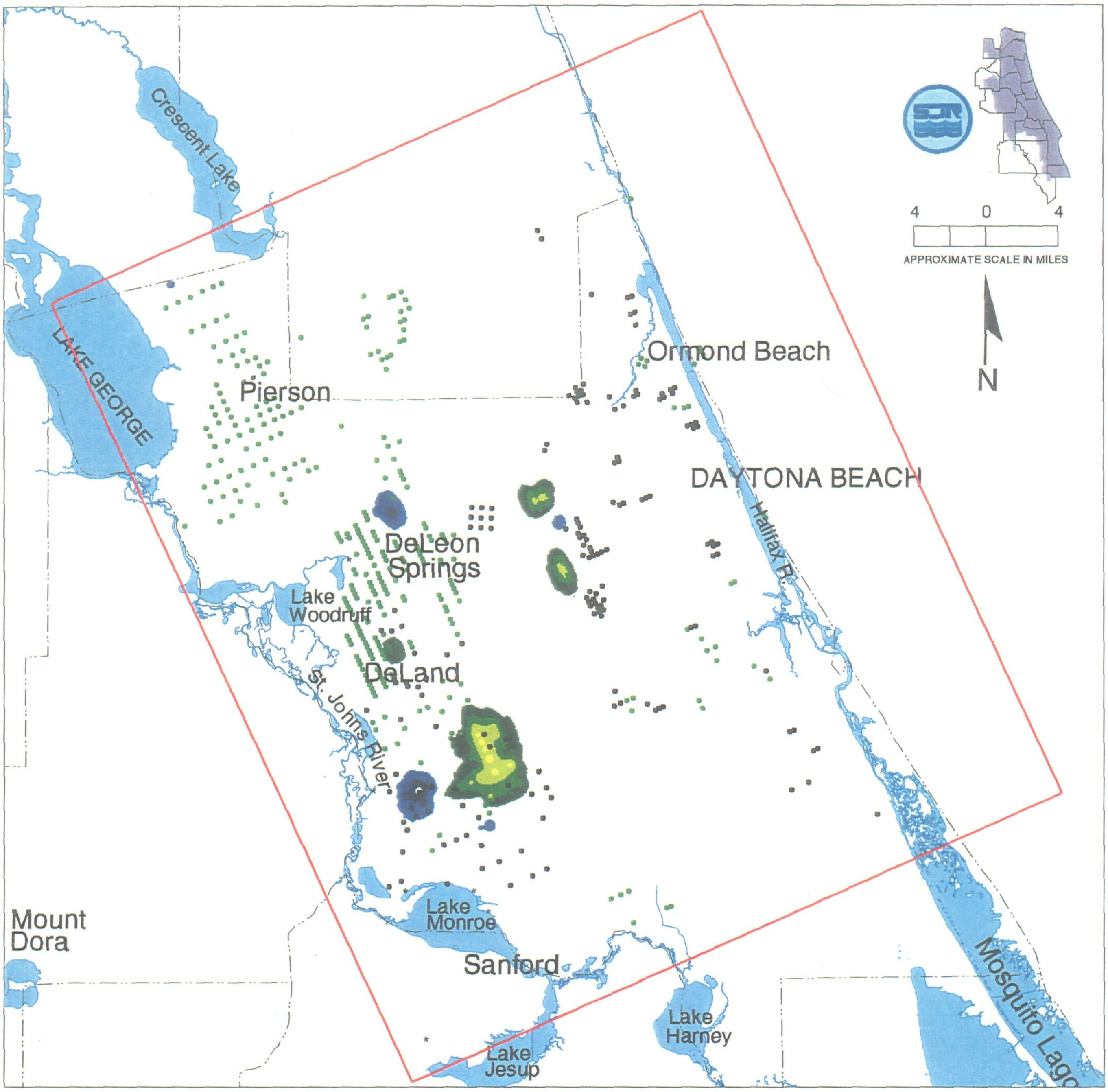
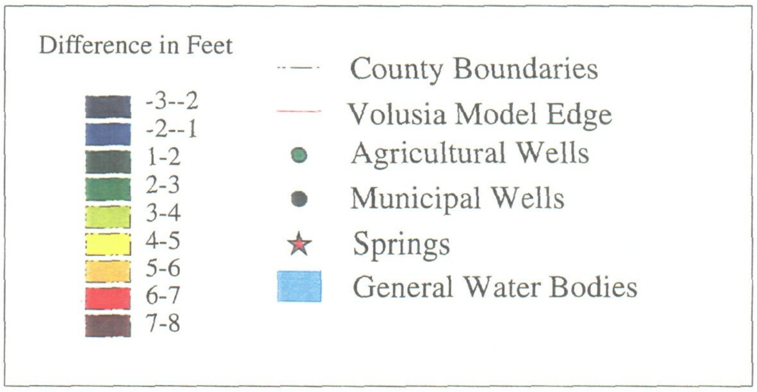


Figure 39

Volusia projected year 2010 decision model surficial improvement over nonoptimized case, allowing 2% head loss at control points with high or moderate potential for vegetative harm and 15% discharge loss at springs and head loss at control points with low potential for vegetative harm



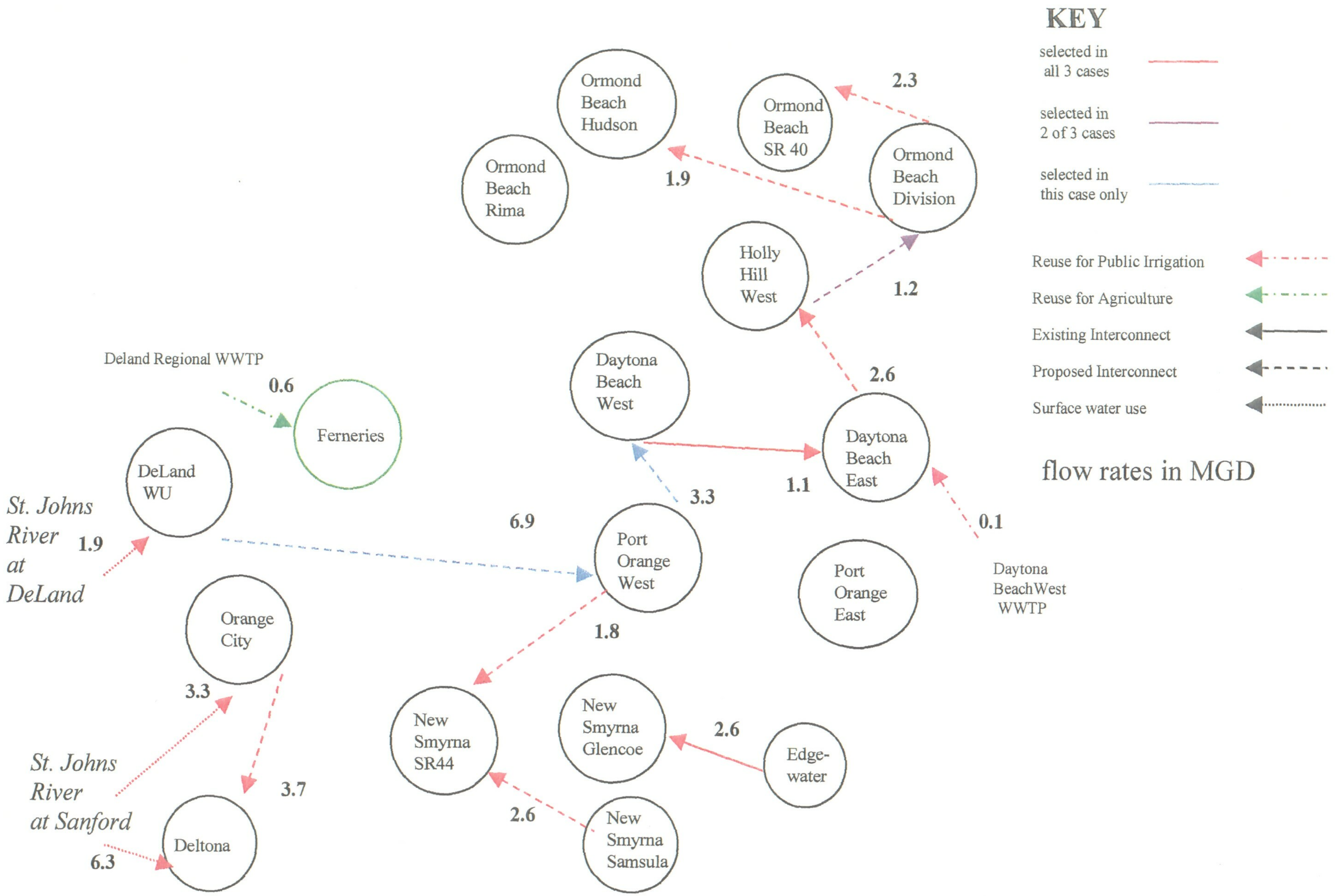


Figure 40. Volusia Alternative Sources, decision model allowing 2% head loss at control points with high or moderate potential for vegetative harm and 15% discharge loss at springs and head loss at control points with low potential for vegetative harm.

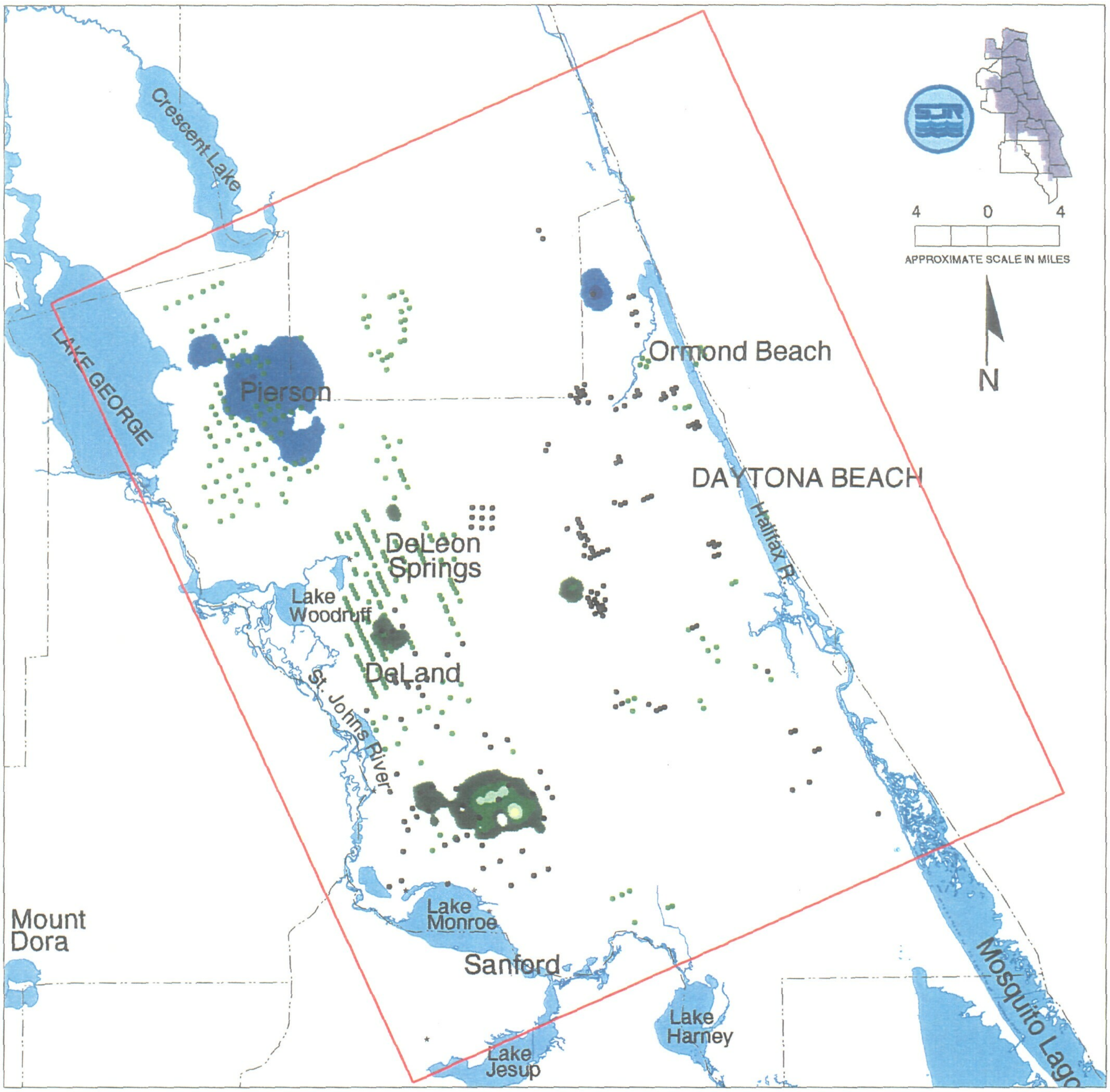


Figure 41

Volusia projected year 2010 decision model optimized surficial drawdown allowing 1% head loss at control points with high or moderate potential for vegetative harm and 15% discharge loss at springs and head loss at control points with low potential for vegetative harm

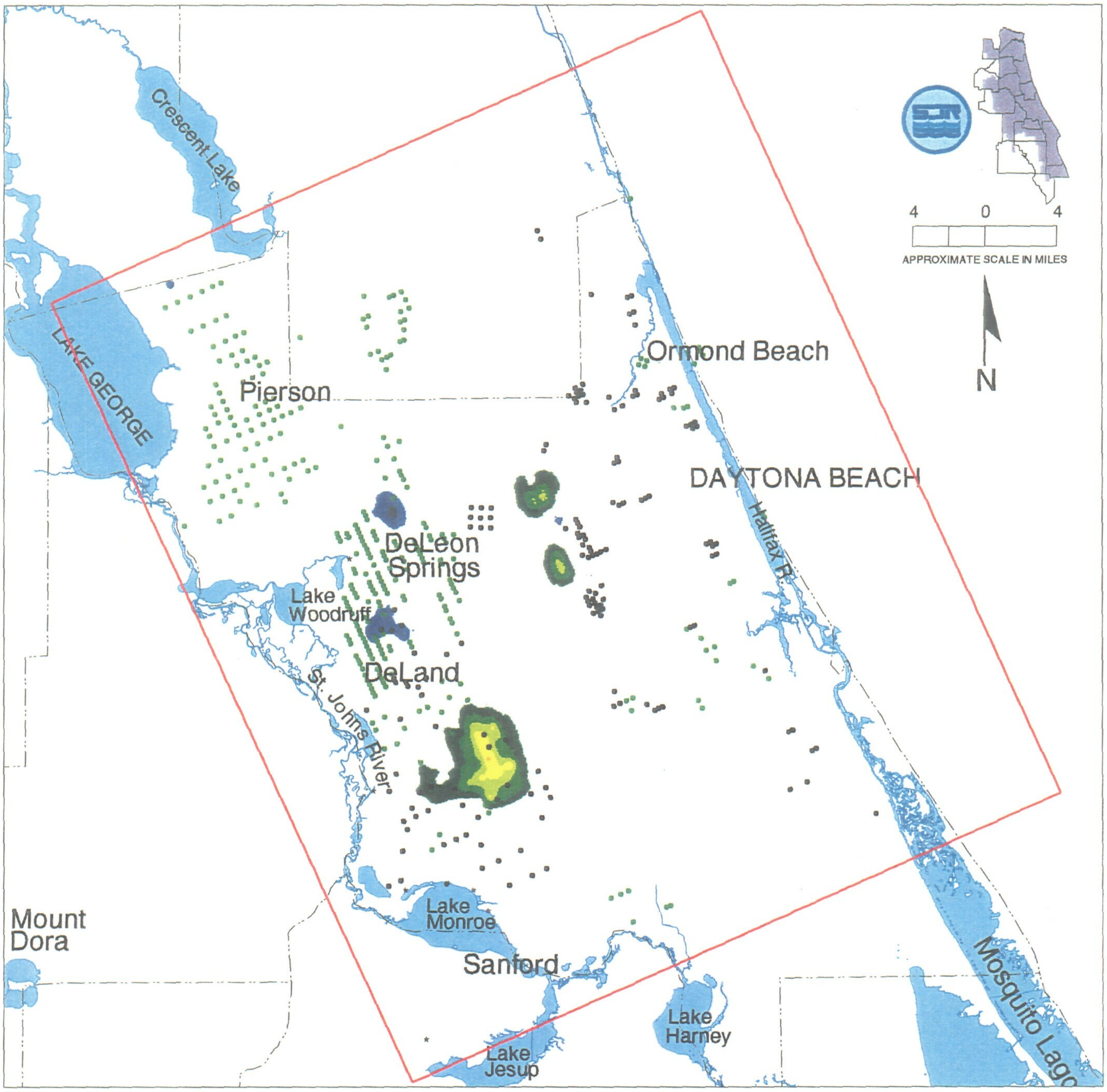
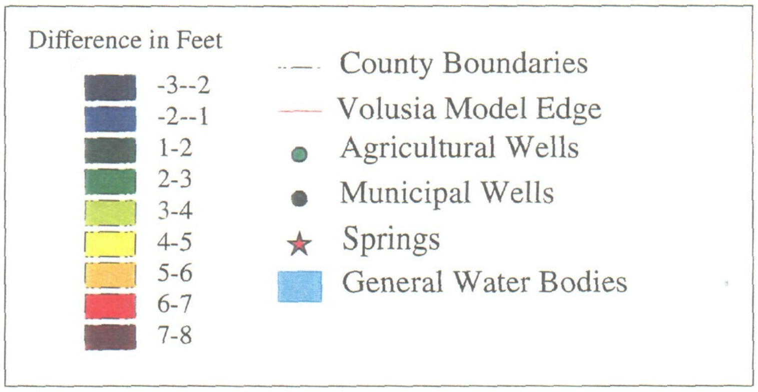


Figure 42

Volusia projected year 2010 decision model surficial improvement over nonoptimized case allowing 1% head loss at control point with high or moderate potential for vegetative harm and 15% discharge loss at springs and head loss at control points with low potential for vegetative harm



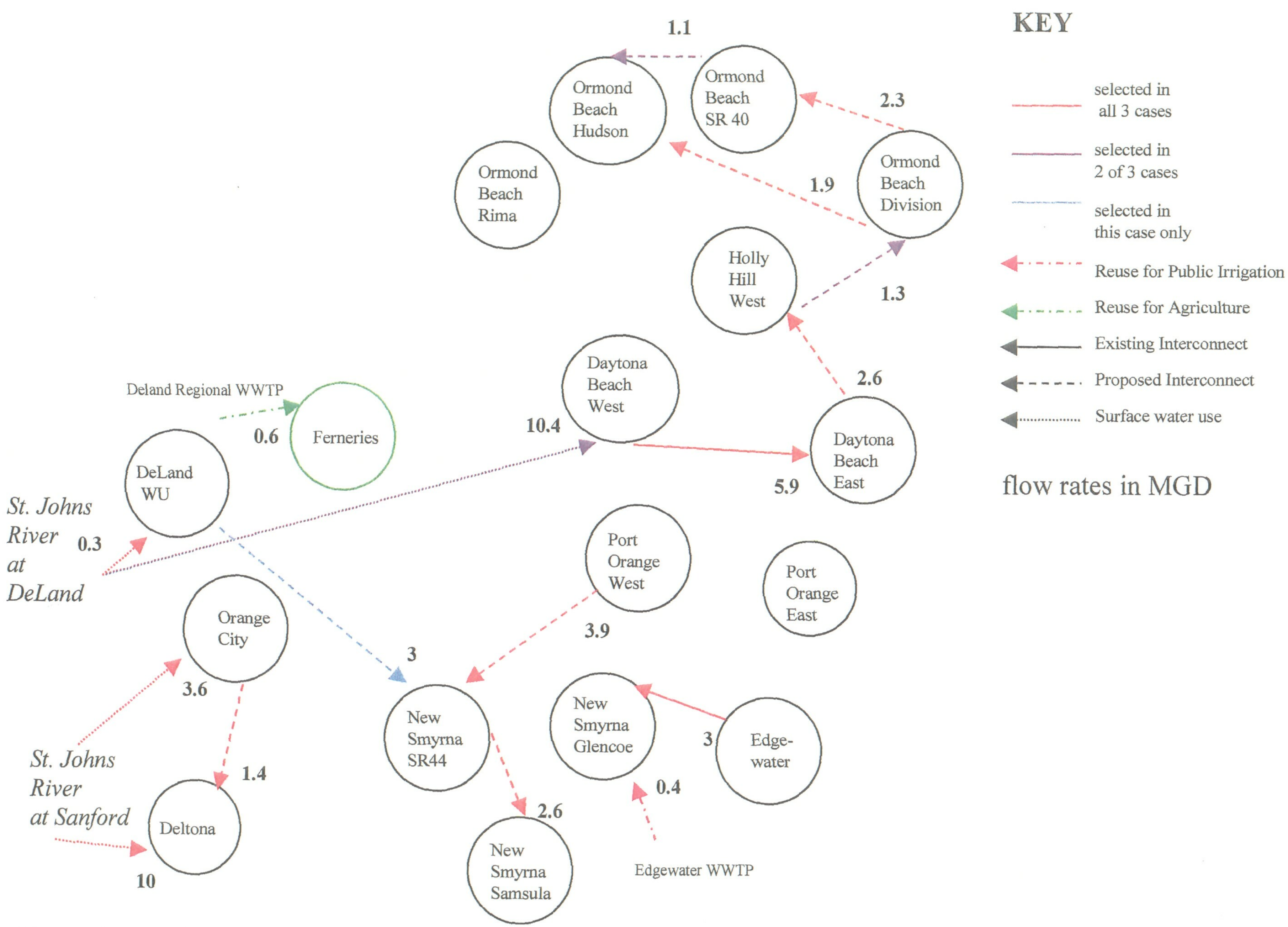


Figure 43. Volusia alternative sources, decision model allowing 1% head loss at control points with high or moderate potential for vegetative harm and 15% discharge loss at springs and head loss at control points with low potential for vegetative harm

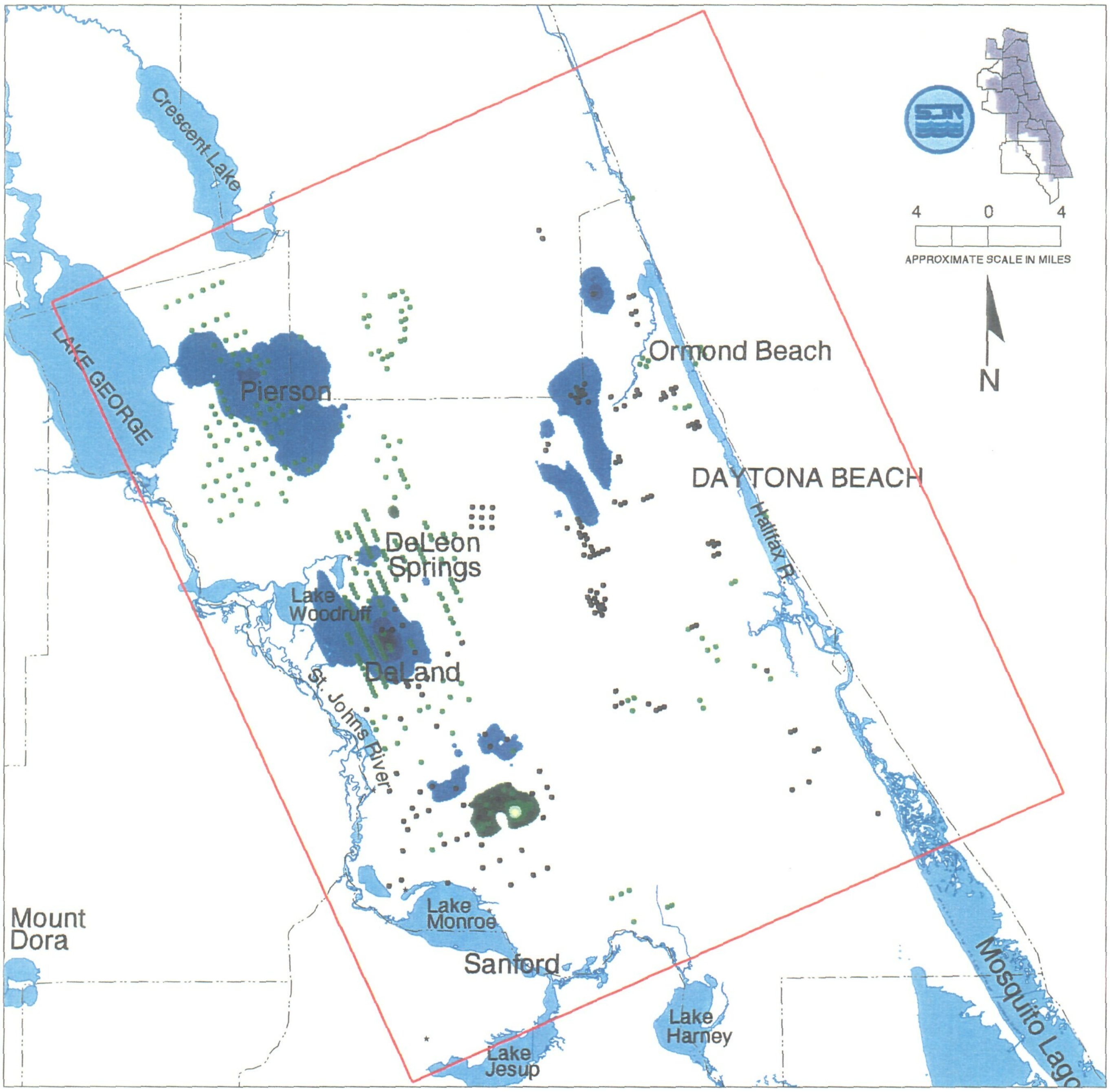


Figure 44

Volusia alternative sources, decision model with 1% head loss at control points with high or moderate potential for vegetative harm and 15% discharge loss at springs and head loss at control points with low potential for vegetative harm.

Drawdown in Feet

- -4--3
- -3--2
- -2--1
- 1-2
- 2-3
- 3-4
- 4-5
- 5-6
- 6-7
- 7-8
- 8-9

- County Boundaries
- Volusia Model Edge
- Agricultural Wells
- Municipal Wells
- Springs
- General Water Bodies

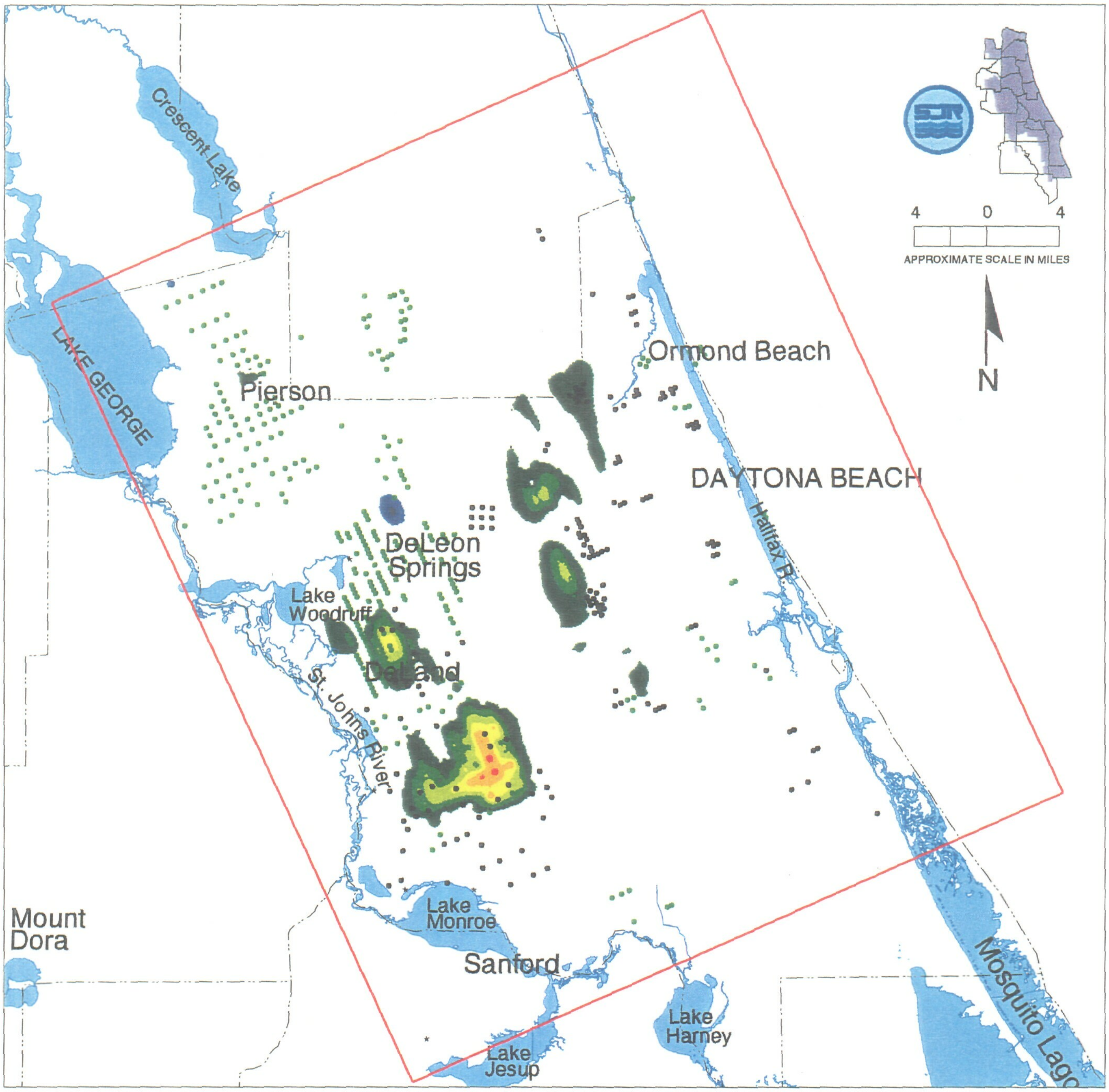
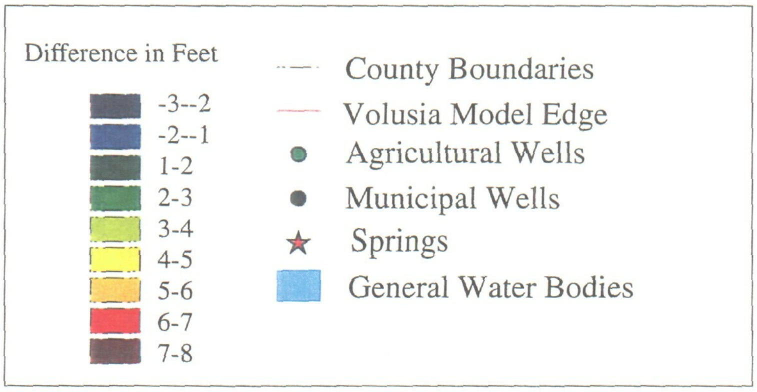


Figure 45

Volusia projected year 2010 decision model surficial improvement over nonoptimized case allowing 0% head loss at control points with high or moderate potential for vegetative harm and 15% discharge loss at springs and head loss at control points with low potential for vegetative harm.



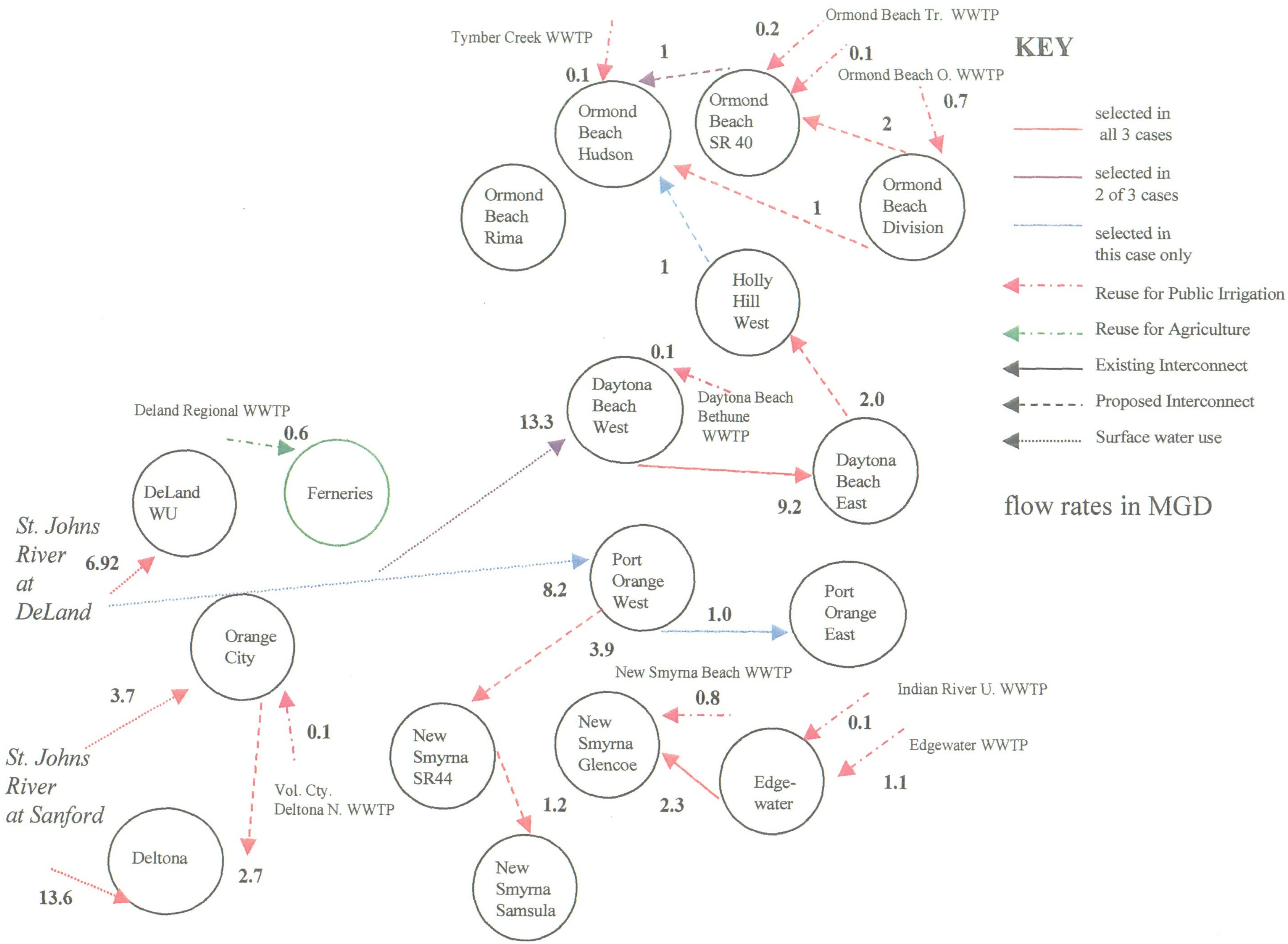


Figure 46. Volusia alternative sources, decision model allowing 0% head loss at control points with high or moderate potential for vegetative harm and 15% discharge loss at springs and head loss at control points with low potential for vegetative harm

The linearity of the surficial aquifer response was demonstrated with the deficit model and is not repeated here. Optimized well withdrawal rates are given in Table A14 of the appendix for public supply utility wells, and Table A11 for agricultural wells.

Table 35 below provides reuse results for public areas. Very little use of reclaimed water was selected in any case. Edgewater, Ormond Beach Hudson, and New Smyrna Glencoe received reclaimed water, along with National Gardens. The Case 1 (2% loss) solution made no use of reclaimed water for public demand areas.

Table 35. Volusia reuse to public demand areas

		MGD		
Reclaimed site	Public demand area	Case 3	Case 2	Case 1
Daytona Beach Regional	Holly Hill West	0.345		
Daytona Beach Bethune	Daytona Beach West	0.068		
Daytona Beach West	Daytona Beach East			0.083
New Smyrna Beach	New Smyrna Glencoe	0.769		
Ormond Beach Br. Tr.	Ormond Beach Sr 40	0.231		
Ormond Beach O	Ormond Beach Sr 40	0.058		
Ormond Beach O	Ormond Beach Division	0.664		
V. Cty Deltona North	Orange City C.	0.097		
Tymber Creek	Ormond Beach Hudson	0.006		
Edgewater	Edgewater	1.052		
Edgewater	New Smyrna Glencoe		0.384	
Indian River Utilities	Edgewater	0.112	0	
Ormond Beach Br. Tr.	Tymber Creek	0.045	0.045	
Ormond Beach Br. Tr.	The Trails	0.023	0.018	
Tymber Creek	The Trails	0.121	0.127	
Sugar Mill	National Gardens	0.097	0.097	0.097
Total		3.688	0.671	0.18

Table 36 below displays reuse for agricultural need areas. In the three cases, very little use of reclaimed water was selected. Only three fern growing areas, all near DeLand, used reclaimed water. The decision model formulation did not use binary variables for reclaimed water use to agricultural and public areas. The main consequence of this formulation is that no minimum use rate is specified and thus selected quantities may be small.

Table 36. Volusia reuse to agricultural demand areas

		Case 3	Case 2	Case 1
			MGD	
DeLand Regional	Fern 11	0.08	0.08	0.08
DeLand Regional	Fern 12	0.19	0.19	0.19
DeLand Regional	Fern 13	0.36	0.36	0.36
Total		0.633	0.633	0.633

New wells selected by the decision model are provided in Table 37. All three examined cases select new wells at Deltona and Ormond Beach Rima. Cases 1 and 2 also select new wells at Port Orange West.

Table 37. Volusia new wells

Public demand area	Case 3	Case2	Case1
(public supply utility well)		MGD	
Deltona (70)		1.5	1.5
Deltona (72)	1.5	1.5	1.5
Deltona (73)	1.5	1.5	1.5
Deltona (74)	2.25	1.9	1.84
Port Orange West (41)		1	1
Port Orange West (42)		0.4	1
Port Orange West (43)		1	1
Ormond Beach Rima (133)	0.2	0.25	0.35
Ormond Beach Rima (134)	0.3	0.21	0.11
Total	5.75	9.26	9.8

Table 38 below shows that all three models made extensive use of surface water at both available sites. The amount of surface water used increases by 111% from case 1 to case 2, and by an additional 88% from case 2 to case 3. The Sanford site is used heavily in all three cases.

Table 38. Volusia total surface water use

	Case 3	Case 2	Case 1
		MGD	
Sanford	17.25	13.7	9.6
DeLand	28.5	10.6	1.9
Total	45.75	24.31	11.52

The use rates of surface water to public demand areas are provided in Table 39 below. The surface water users with highest use rates are Deltona, Port Orange West, Daytona Beach West, and DeLand. All three cases used surface water to satisfy a large part of Deltona's projected year 2010 demand.

Table 39. Volusia use rate of surface water to public demand areas

Surface source		Public demand destination area	Case 3	Case 2 (MGD)	Case 1
DeLand	to	DeLand Water U.	6.9	0.3	1.9
DeLand	to	Port Orange West	8.2	0	0
DeLand	to	Daytona Beach West	13.3	10.4	0
Sanford	to	Deltona	13.6	11.3	6.3
Sanford	to	Orange City	3.7	2.4	3.3
Total			45.7	24.3	11.5

Annual fixed costs of surface water sources and surface water transport are provided in Tables 40 and 41 below. Deltona and Port Orange West, and Daytona Beach West have large fixed charges associated with surface water use. Fixed transport costs are not large compared to surface water fixed costs. However, the model formulation requires a separate physical pipeline for each public demand area supplied by surface water which results in an inefficient use of pipe. Future efforts will include a more efficient surface water transportation network which will consist of a main pipeline with branches to the appropriate public supply demand areas. This type of distribution system is likely incur lower fixed and unit charges, though an equitable distribution of costs may be difficult to define.

Table 40. Volusia fixed costs of surface water sources

Surface source		Public demand destination area	Case 3	Case 2 ($/year)	Case 1
DeLand	to	DeLand Water U.	3,831,400	145,900	1,034,900
DeLand	to	Port Orange West	4,547,100		
DeLand	to	Daytona Beach West	2,341,500	5,738,100	
Sanford	to	Deltona	7,528,800	6,227,200	3,485,000
Sanford	to	Orange City	2,021,200	1,335,300	1,837,700
Total			20,270,000	13,446,500	6,357,600

Table 41. Volusia fixed costs of surface water transport

Surface source		Public demand destination area	Case 3	Case 2 ($/year)	Case 1
DeLand	to	DeLand Water U.	118,400	50,000	67,000
DeLand	to	Port Orange West	1,612,800		
DeLand	to	Daytona Beach West	2,314,500	1,919,300	
Sanford	to	Deltona	1,514,100	1,301,000	852,000
Sanford	to	Orange City	262,400	223,000	252,000
Total			5,822,200	3,493,300	1,171,000

The following set of tables display the interconnects selected by each of the three Cases. Tables 42 and 43 display individual interconnects sorted by source and destination area. Table 44 gives the total inflows, total outflows, and the net flux of inflows minus outflows for each public area. It must be noted that the interconnect results may be examined on an individual basis, but their selection by the decision model becomes more apparent when surface water use, well use, and environmental restrictions are also considered. Some existing emergency interconnects that were selected by the decision model are noted (LAW Engineering, 1997).

Table 42 displays individual interconnects sorted by the destination area. The largest individual interconnect flows are observed at Daytona Beach and Port Orange, and Deltona. Table 43 displays individual interconnects listed by the source area. Table 44 provides the net flux (sum of inflows - sum of outflows) for all demand areas.

Table 42. Volusia interconnects sorted by destination

source	existing or proposed pipeline	destination	Case 3	Case 2	Case 1	distance
				MGD		miles
Daytona Beach West	e	Daytona Beach East	9.21	5.76	1.14	3.60
Port Orange West	p	Daytona Beach West			3.30	1.71
Orange City	p	Deltona	2.70		3.65	3.60
Daytona Beach East	p	Holly Hill West	2.04	2.61		2.27
New Smyrna Samsula	p	New Smyrna SR 44		2.64		1.71
Edgewater	e	New Smyrna Glencoe	2.31	2.57	2.57	1.71
DeLand Water Utilities	p	New Smyrna Samsula		3.05		14.02
New Smyrna SR 44	p	New Smyrna Samsula	1.22			1.71
Port Orange West	p	New Smyrna SR 44	3.86		1.83	5.30
Holly Hill West	p	Ormond Beach Division		1.23		3.41
Holly Hill West	p	Ormond Beach Hudson	1.00			4.36
Ormond Beach Division	p	Ormond Beach Hudson	1.00	1.85	1.85	5.30
Ormond Beach SR 40	p	Ormond Beach Hudson	1.00	1.16	1.16	3.41
Ormond Beach Division	p	Ormond Beach SR 40	1.87	2.31	2.31	2.65
Port Orange West	e	Port Orange East	1.00			7.01
Daytona Beach West	p	Port Orange West		2.10		1.71
DeLand Water Utilities	p	Port Orange West			6.92	11.36
			27.21	25.38	24.714	

Table 43. Volusia interconnects sorted by source

source	existing or proposed pipeline	destination	Case 3	Case 2	Case 1	distance
				MGD		miles
Daytona Beach East	p	Holly Hill West	2.04	2.61		2.27
Daytona Beach West	e	Daytona Beach East	9.21	5.76	1.14	3.60
Daytona Beach West	p	Port Orange West		2.10		1.71
DeLand Water Utilities	p	New Smyrna Samsula		3.05		14.02
DeLand Water Utilities	p	Port Orange West			6.92	11.36
Edgewater	e	New Smyrna Glencoe	2.31	2.57	2.57	1.71
Holly Hill West	p	Ormond Beach Division		1.23		3.41
Holly Hill West	p	Ormond Beach Hudson	1.00			4.36
New Smyrna Samsula	p	New Smyrna SR 44		2.64		1.71
New Smyrna SR 44	p	New Smyrna Samsula	1.22			1.71
Orange City	p	Deltona	2.70		3.65	3.60
Ormond Beach Division	p	Ormond Beach Hudson	1.00	1.85	1.85	5.30
Ormond Beach Division	p	Ormond Beach SR 40	1.87	2.31	2.31	2.65
Ormond Beach SR 40	p	Ormond Beach Hudson	1.00	1.16	1.16	3.41
Port Orange West	p	Daytona Beach West			3.30	1.71
Port Orange West	p	New Smyrna SR 44	3.86		1.83	5.30
Port Orange West	e	Port Orange East	1.00			7.01
			27.21	25.38	24.714	

Table 44. Volusia interconnect summary for public areas

Public supply utility area	sum of outflow from			sum of inflow to			net flux (inflow -outflow)		
	Case 3	Case 2	Case 1	Case 3	Case 2	Case 1	Case 3	Case 2	Case 1
	MGD			MGD			MGD		
Daytona Beach East	2.035	2.614		9.208	5.859	1.136	7.173	3.245	1.136
Daytona Beach West	9.208	7.961	1.136			3.295	-9.208	-7.961	2.159
DeLand WU		3.051	6.919				0	-3.051	-6.919
Edgewater	2.307	2.569	2.569				-2.307	-2.569	-2.569
Holly Hill West	1	1.234		2.035	2.614		1.035	1.38	
New Smyrna Glencoe				2.307	2.569	2.569	2.307	2.569	2.569
New Smyrna SR44	1.22			3.857	2.637	1.827	2.637	2.637	1.827
Orange City	2.701		3.650				-2.701		-3.65
Ormond Beach Division	2.867	4.162	4.162		1.234		-2.867	-2.928	-4.162
Ormond Beach SR40	1	1.156	1.156	1.867	2.312	2.312	0.867	1.156	1.156
Port Orange East				1			1		
Port Orange West	4.857		5.122		2.102	6.919	-4.857	2.102	1.797
Deltona				2.7		3.65	2.7		3.65
New Smyrna Samsula		2.637		1.22	3.051		1.22	0.414	
Ormond Beach Hudson				3	3.006	3.006	3	3.006	3.006
Total	27.195	25.384	24.714	27.194	25.384	24.714	-0.001	0.0	0.0

Table 45 displays the annualized fixed charges for interconnects as calculated by the decision model for all three cases. The model used linear approximations of the nonlinear equations provided by CH2M Hill (1997) as discussed in the Methods section. The actual cost of the interconnects are provided with the error associated with each case. The sum of the errors associated with each approximation is within 19% of the sum of true cost for all interconnects. The errors associated with the approximations for Volusia are slightly larger than in the east-central model results due to the extended range of possible flow rates in the Volusia model, i.e.; Volusia interconnect use rates may be much smaller than the minimums specified in the east-central model.

Table 45. Volusia interconnect fixed costs

	cost, linear approximation, $/year			Actual cost (CH2M Hill), $/year			Error, $/year		
Destination area	Case 3	Case 2	Case 1	Case 3	Case 2	Case 1	Case 3	Case 2	Case 1
New Smyrna SR44	269,000	74,400	204,400	331,300	65,800	238,400	-62,300	8,600	-34,000
Ormond Beach Division		60,000			111,400			-51,400	
Ormond Beach Hudson	413,800	264,300	264,300	422,300	348,000	347,000	-8,500	-83,700	-82,700
Port Orange West		68,900	1,428,600		59,700	949,000		9,200	479,600
Deltona	232,200		262,400	166,700		190,000	65,500		72,400
Holly Hill West	68,200	74,200		83,900	93,400		-15,700	-19,200	
New Smyrna Samsula	59,900	1,011,900		47,300	824,100		12,600	187,800	
Ormond Beach SR40	66,500	71,100	71,700	97,800	107,100	107,100	-31,300	-36,000	-35,400
Total ($/year)	1,109,600	1,624,800	2,231,400	1,149,300	1,609,500	1,831,500	-39,700	15,300	399,900

Table 46 below provides a summary of well withdrawal for selected public supply utility demand areas. This table provides some insight into why surface water or interconnects are selected by the model as alternatives to wells for supplying a demand area's projected year 2010 water needs. For example, Deltona has a projected water demand of over 24.9 MGD; while case 1 and case 2 supply approximately half of this amount from wells, the remainder comes from surface water and interconnects. Port Orange West also utilizes less water from its wells in all three cases than in the nonoptimized case, but receives the difference from surface water. The sum of Volusia Four Townes, Orange City, and Holly Hill West wells, which are located in areas of low potential for vegetative harm, all withdraw greater quantities of water in decision model cases 1-3 than in the nonoptimized case.

Table 46. Volusia well withdrawal summary for selected public areas

projected year 2010 demand (mgd)	sum of well withdrawal ((mgd) Case 3	Case 2	Case 1	Public demand area	model ID	Potential for vegetative harm	sum of well withdrawal -projected year 2010 demand (mgd) Case 3	Case 2	Case 1
24.9	8.6	13.64	14.96	Deltona	DEL	LOW TO MODERATE	16.3	11.26	9.94
13.33	9.14	10.92	11.17	Daytona Beach West	DBW	MODERATE	4.19	2.41	2.16
8.57	5.22	6.47	6.78	Port Orange West	POW	MODERATE	3.35	2.1	1.79
7.17.		3.93	5.95	Daytona Beach East	DBE	MODERATE	7.17	3.24	1.22
6.92		9.71	11.97	DeLand WU	DWU	LOW	6.92	-2.79	-5.05
4.66	5.8	7.23	7.23	Edgewater	EDG	LOW	-1.14	-2.57	-2.57
3.65	2.7	1.24	3.98	Orange City	OCY	LOW	0.95	2.41	-0.33
3.08		0.12	0.51	New Smyrna Glencoe	NSG	LOW	3.08	2.96	2.57
3.01				Ormond Beach Hudson	OBH	LOW	3.01	3.01	3.01
2.77	4.98	5.70	6.94	Ormond Beach Division	OBD	LOW	-2.21	-2.93	-4.17
1.16				Ormond Beach SR 40	OB4	LOW	1.16	1.16	1.16
2.64	1.42	2.22	2.64	New Smyrna Samsula	NSS	LOW	1.22	0.42	0
1.38			1.38	Holly Hill West	HHW	LOW	1.38	1.38	0
0.86		0.86	0.86	Port Orange East	POE	LOW	0.86	0	0
2.64			0.81	New Smyrna SR 44	NS4	LOW	2.64	2.64	1.83

Table 47 below displays the alternative supply strategies for selected public demand areas. The rightmost columns should total to zero in all three cases unless reclaimed water is used.

Table 47. Volusia alternative supply strategies for selected public areas

Public demand area	projected year 2010 demand -sum of well withdrawal (MGD) Case 3	Case 2	Case 1	sum of interconnect flux (inflow -outflow, MGD) Case 3	Case 2	Case 1	sum of surface water inflow (MGD) Case 3	Case 2	Case 1	total inflow -2010 demand (MGD) Case 3	Case 2	Case 1
Deltona	16.3	11.26	9.93	2.7	0	3.65	13.6	11.3	6.3	0.00	-0.04	-0.01
Daytona Beach West	4.19	2.41	2.16	-9.21	-7.96	2.16	13.3	10.4	0	0.10	-0.03	0.00
Port Orange West	3.35	2.1	1.79	-4.86	2.1	1.8	8.2	0	0	0.01	0.00	-0.01
Daytona Beach East	7.17	3.24	1.22	7.17	3.25	1.14				0.00	-0.01	0.08
DeLand WU	6.92	-2.79	-5.05	0	-3.05	-6.92	6.9	0.3	1.9	0.02	-0.04	-0.03
Edgewater	-1.14	-2.57	-2.57	-2.31	-2.57	-2.57				1.17	0.00	0.00
Orange City	0.95	2.41	-0.33	-2.7	0	-3.65	3.7	2.4	3.3	-0.05	0.01	0.02
New Smyrna Glencoe	3.08	2.96	2.57	2.31	2.57	2.57				0.77	0.39	0.00
Ormond Beach Hudson	3.01	3.01	3.01	3	3	3				0.01	0.01	0.01
Ormond Beach Division	-2.21	-2.93	-4.17	-2.87	-2.93	-4.16				0.66	0.00	-0.01
Ormond Beach SR 40	1.16	1.16	1.16	0.87	1.16	1.16				0.29	0.00	0.00
New Smyrna Samsula	1.22	0.42	0	1.22	0.41	0				0.00	0.01	0.00
Holly Hill West	1.38	1.38	0	1.04	1.38	0				0.34	0.00	0.00
Port Orange East	0.86	0	0	1	0	0				-0.14	0.00	0.00
New Smyrna SR 44	2.64	2.64	1.83	2.64	2.64	1.83				0.00	0.00	0.00

Table 48 below provides the summary of alternative water supply strategies used in each case, excluding new well development. Surface water and interconnects were used extensively in every case. Relatively little reclaimed water was used. The sum of surface water and reclaimed water use is approximately equivalent to the deficits reported in the previous section (19%, 26%, and 35% of projected year 2010 demand in deficit for cases 1-3, respectively).

Table 48. Volusia total alternative water strategies

Alternative	Case 3	Case 2	Case 1
Surface water (mgd)	45.7	24.3	11.5
Reclaimed water for ferneries (mgd)	0.6	0.6	0.6
Reclaimed water for public irrigation (mgd)	3.7	0.7	0.2
Total (mgd)	50	25.6	12.3
% of 2010 demand satisfied by alternatives to groundwater	41.3%	21.2%	10.2%
Existing interconnects	3	2	2
Potential interconnects	8	8	7

Spring responses are provided in Table 49 below, and previously verified to be linear in the Volusia deficit model.

Table 49. Volusia simulation model spring discharges

	Ponce De leon	Blue	Gemini
Conductance (ft2/second)	6.94	104.17	0.74
Elevation (ft)	1	1	1
Simulation Model	cfs		
1988 discharge	27.01	147.92	8.16
2010 nonoptimized discharge	26.53	132.29	7.68
Case 1 discharge	26.11	147.92	7.90
Case 2 discharge	25.49	140.63	7.35
Case 3 discharge	25.14	135.42	7.13
	Fraction of simulated year 1988 discharge		
2010 nonoptimized	0.98	0.89	0.94
Case 1	0.97	1.00	0.97
Case 2	0.94	0.95	0.90
Case 3	0.93	0.92	0.87

Finally, a display of the total annual costs as a function of environmental constraints is provided in Figure 47 below. These costs are compared to an estimate of the nonoptimzed projected year 2010 total annual cost. The case 1 solution has a total annual cost of $6.8 million/year more the nonoptimized case. The case 2 solution costs and additional $9.2 million/year over the case 1 solution. Case 3 costs an additional $16.4 million/year over case 2. The nonoptimized projected year 2010 solution is relatively inexpensive because many wells which did not exist in 1988 have since been drilled, and there are few wells and treatment plants yet to be constructed.

The trend of costs increasing as environmental restrictions increase is evident.

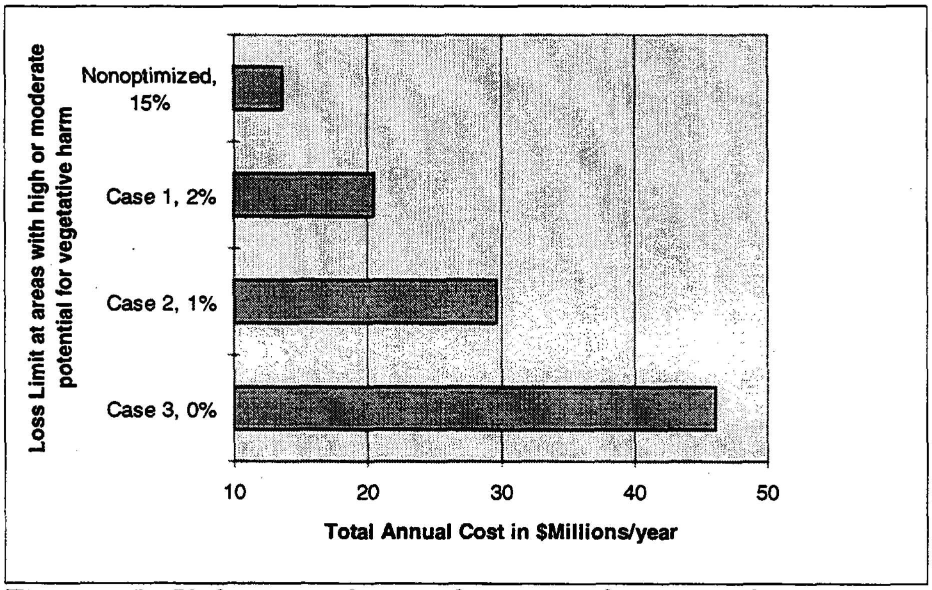


Figure 47. Volusia total annual cost as a function of environmental constraints

VOLUSIA SUMMARY

Preliminary results show that the primary alternative source in Volusia County could be surface water from the St. Johns River near Sanford and DeLand with some use of interconnects and reclaimed water.

Total surface water use was 12, 24, and 46 MGD for the examined cases having 2%, 1%, and 0% surficial head loss limits from 1988 at areas with high or moderate potential for vegetative harm. Very little reclaimed water was used, either for fern growing agricultural areas or public supply demand area irrigation. From 2-3 new interconnects were selected, while 7-8 existing interconnects were selected in the three examined cases.

The public supply demand areas making the greatest use of surface water were Daytona Beach West, Port Orange West, Deltona, DeLand, and Orange City. Generally, the large receivers of surface water passed on this water to demand areas in the central portions of the simulation model area which has a high potential for vegetative harm, such as the Port Orange West and Daytona Beach West demand areas.

These results would be expected to change considerably when further analysis regarding potential for vegetative harm and saltwater intrusion are considered.

As with the east-central area model, results were highly sensitive to environmental constraints. It is notable that the optimum alternative water supply strategies for Deltona were similar in both the east-central and Volusia applications.

CONCLUSIONS

The decision models provide insight as to the potential tradeoffs associated with the use of alternative sources, though results are strongly dependent on environmental restrictions and may change considerably. Using the mixed-integer models developed herein, a sensitivity analysis may be performed by making slight changes in allowable limits for environmental impact and/or the specification of high, moderate, or low potential for vegetative harm, and comparing the overall solutions. In changing the model to include a new objective function of minimizing both costs and drawdowns, one can develop a chart of minimal cost vs. minimal environmental impact solutions. With the data from several runs of varying environmental restrictions or cost criteria, water resources managers may assess the impacts and tradeoffs associated with competing schemes in order to evaluate which tradeoffs are acceptable.

The University will continue incorporating consultant and SJRWMD data into the decision model as it is made available. Alternative sources including lower quality sources, artificial recharge, and avoidance of impacts/mitigation have yet to be incorporated.

RECOMMENDATIONS

The specification of a particular control point's potential for vegetative harm is critical. Specifying high or low sensitivity at a particular point may result in a different optimal solution, as the decision model seeks alternative sources rather than depressing water levels at a highly sensitive control point. A number of different runs with varying environmental sensitivities should be pursued before making definitive statements about alternative source use in the study areas.

A decision model run without well capacities should be performed to determine the best current and proposed well sites. A number of alternative sources remain to be incorporated including lower quality sources, artificial recharge, and aquifer mitigation/avoidance of impacts. The use of alternative sources would decrease if well capacities were increased at certain locations.

Constraints precluding saltwater intrusion should be incorporated and are certain to yield different results.

Additional new well development should be included in future models as new wells may provide a considerably lower-cost option to the alternatives heretofore considered.

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APPENDIX A TABLES

Table A1. East-central public supply utility demand areas

Model ID	Rank By Projected Year 2010 Demand	Public Supply Demand Area	Year 1988 Demand (MGD)	Projected Year 2010 Demand (MGD)	Demand Increase (MGD)	% of Total Increase	Demand % Increase	% of Total Public Demand
AF1	67	USAF BAS Civil Engineer	0.80	0.80	0.00	0.00%	0.00%	0.16%
ALT	16	Altamonte Springs	7.95	10.19	2.24	0.84%	28.12%	2.04%
APO	4	Apopka	4.15	21.15	17.00	6.42%	409.71%	4.24%
CAS	30	Casselberry	4.83	6.33	1.50	0.57%	31.13%	1.27%
CFR	65	Cent. Fla. Res. Park	1.00	1.00	0.00	0.00%	0.00%	0.20%
CFU	43	Central Florida Utilities	1.27	3.03	1.76	0.66%	138.00%	0.61%
CHU	83	Chuluota	0.39	0.25	-0.14	-0.05%	-36.09%	0.05%
CLE	47	Clermont	1.43	2.47	1.04	0.39%	72.90%	0.49%
COC	2	Cocoa	20.10	27.07	6.98	2.63%	34.71%	5.42%
CON	88	Conway	0.08	0.10	0.02	0.01%	27.27%	0.02%
DAV	60	Davenport	0.53	1.27	0.73	0.28%	138.00%	0.25%
DEL	3	Deltona	7.26	24.90	17.64	6.66%	243.11%	4.99%
EAT	58	Eatonville	0.61	1.41	0.81	0.31%	133.71%	0.28%
ECU	87	Econ Utilities	0.13	0.15	0.02	0.01%	15.39%	0.03%
EUS	33	Eustis	2.91	5.79	2.88	1.09%	98.85%	1.16%
FDC	86	Florida Dept. of Corrections	0.22	0.16	-0.05	-0.02%	-25.00%	0.03%
FPL	70	Florida Power and Light	0.41	0.75	0.33	0.13%	81.16%	0.15%
GRO	68	Groveland Park	0.29	0.79	0.50	0.19%	176.18%	0.16%
HAI	44	Haines City	1.18	2.80	1.63	0.61%	138.00%	0.56%
HHO	71	Hyatt House Orlando	0.30	0.73	0.42	0.16%	138.00%	0.15%
HOH	75	Howey in the Hills	0.31	0.45	0.13	0.05%	42.36%	0.09%
IN1	63	B & W Canning	0.97	1.11	0.14	0.05%	14.34%	0.22%
IN2	50	Florida Crushed Stone	2.18	2.18	0.00	0.00%	0.00%	0.44%
IN3	66	Florida Rock (Lake Sand)	0.87	0.87	0.00	0.00%	0.00%	0.17%
IN4	55	Floribra USA, Inc.	1.58	1.58	0.00	0.00%	0.00%	0.32%
IN5	61	Silver Sand (Clermont Mine)	1.24	1.24	0.00	0.00%	0.00%	0.25%
IN6	72	Silver Springs Citrus	0.71	0.71	0.00	0.00%	0.00%	0.14%
JKV	80	John Knox Village	0.05	0.35	0.30	0.11%	640.54%	0.07%
KIS	19	Kissimmee	3.83	9.11	5.28	1.99%	138.00%	1.82%
LHE	73	Lake Helen	0.22	0.58	0.36	0.13%	159.72%	0.12%
LHY	91	Lake Harney	0.03	0.03	0.00	0.00%	16.66%	0.01%
LMY	34	Lake Mary	0.50	5.62	5.12	1.93%	1024.28%	1.13%
LON	42	Longwood	2.03	3.15	1.12	0.42%	55.22%	0.63%
MAI	40	Maitland	2.90	3.53	0.64	0.24%	21.99%	0.71%
MHN	51	City of Minne	1.28	2.01	0.73	0.27%	56.43%	0.40%
MIN	76	Minneola	0.19	0.45	0.26	0.10%	134.41%	0.09%
MON	85	Montverde	0.12	0.22	0.09	0.03%	74.11%	0.04%
MTD	36	Mt. Dora	2.35	4.45	2.11	0.80%	89.89%	0.89%
OAK	82	Oakland	0.29	0.28	-0.01	-0.01%	-4.89%	0.06%
OCO	35	Ocoee	2.13	5.47	3.34	1.26%	157.07%	1.10%
OCY	38	Orange City	0.65	4.04	3.40	1.28%	524.91%	0.81%
OE1	92	OCPUD E Bonneville/Corrine Terr.	0.94	0.00	-0.94	-0.36%	-100.00%	0.00%
OE2	22	OCPUD E Conway	2.50	7.66	5.16	1.95%	206.59%	1.53%
OE3	20	OCPUD E Econ	3.57	8.00	4.43	1.67%	123.84%	1.60%
OE4	52	OCPUD E Lake Nona	0.03	2.00	1.97	0.74%	5796.79%	0.40%
OE5	5	OCPUD E ERWF	0.00	20.25	20.25	7.65%	New	4.05%
ORO	39	Orange/Osceola Management	1.53	3.64	2.11	0.80%	138.01%	0.73%
OS1	27	OCPUD S Cypress Walk/Vistana	1.62	6.50	4.88	1.84%	301.52%	1.30%
OS2	74	OCPUD S Hunter's Creek	0.12	0.50	0.38	0.14%	319.17%	0.10%

Table A1--*Continued*

Model ID	Rank By Projected Year 2010 Demand	Public Supply Demand Area	Year 1988 Demand (MGD)	Projected Year 2010 Demand (MGD)	Demand Increase (MGD)	% of Total Increase	Demand % Increase	% of Total Public Demand
OS4	28	OCPUD S Orange Wood	2.36	6.48	4.12	1.56%	174.47%	1.30%
OSC	49	Osceola Service	0.96	2.28	1.32	0.50%	138.00%	0.46%
OU1	31	OUC Dr. Phillips	5.33	6.20	0.87	0.33%	16.38%	1.24%
OU2	6	OUC Martin	9.17	20.19	11.01	4.16%	120.06%	4.04%
OU3	18	OUC Conway	9.99	9.20	-0.79	-0.30%	-7.88%	1.84%
OU4	21	OUC Highland	8.07	7.98	-0.10	-0.04%	-1.18%	1.60%
OU5	8	OUC Pine Hills	11.19	19.60	8.40	3.17%	75.07%	3.92%
OU6	12	OUC Kuhl	8.40	11.31	2.91	1.10%	34.71%	2.26%
OU7	13	OUC Kirkman	6.26	11.00	4.74	1.79%	75.68%	2.20%
OU8	25	OUC Primrose	8.03	7.09	-0.94	-0.36%	-11.73%	1.42%
OU9	10	OUC Sky Lake	0.00	15.30	15.30	5.78%		3.06%
O10	29	OUC Navy	1.39	6.40	5.01	1.89%	359.08%	1.28%
O11	24	OUC Orange	0.00	7.20	7.20	2.72%		1.44%
O12	26	OUC Pershing	0.00	7.00	7.00	2.64%		1.40%
O13	78	OUC Stanton Energy Ctr	0.40	0.40	0.00	0.00%	0.00%	0.08%
		OUC Total	68.24	128.86	60.62	22.89%	88.84%	25.80%
OVI	17	Oviedo	1.16	9.63	8.48	3.20%	733.45%	1.93%
OW1	48	OCPUD W Bent Oaks/Plymouth	1.63	2.43	0.80	0.30%	48.85%	0.49%
OW2	93	OCPUD W Hidden Springs/Kelso/Windmere	1.93	0.00	-1.93	-0.73%	-100.00%	0.00%
OW3	94	OCPUD W Oak Meadow	1.93	0.00	-1.93	-0.73%	-100.00%	0.00%
OW4	95	OCPUD W Riverside	2.90	0.00	-2.90	-1.10%	-100.00%	0.00%
OW5	7	OCPUD W WRWF	0.00	20.00	20.00	7.55%		4.00%
OW6	90	OCPUD W Magnolia/Lake John	0.04	0.07	0.03	0.01%	71.14%	0.01%
PAM	77	Park Manor	0.45	0.41	-0.04	-0.02%	-9.37%	0.08%
POI	57	Poinciana	0.61	1.44	0.84	0.32%	138.00%	0.29%
RAV	84	Ravenna Park	0.18	0.24	0.05	0.02%	28.20%	0.05%
RCU	1	Reedy Creek Utilities	12.46	29.00	16.54	6.25%	132.83%	5.81%
SAF	23	Sanford	5.03	7.52	2.49	0.94%	49.53%	1.51%
SAN	14	Sanlando Utilities	9.03	10.75	1.72	0.65%	19.03%	2.15%
SCL	37	St. Cloud	1.80	4.29	2.49	0.94%	138.00%	0.86%
SEM	9	Seminole County	6.55	18.60	12.05	4.55%	183.86%	3.72%
SSS	56	SSU-Univ. Shores	0.66	1.55	0.90	0.34%	136.47%	0.31%
SSU	62	Southern St. Util	1.00	1.22	0.23	0.09%	22.85%	0.24%
SWA	89	Seminole Woods Assn.	0.06	0.08	0.03	0.01%	46.32%	0.02%
SWF	59	Sea World of Florida	1.30	1.30	0.00	0.00%	0.00%	0.26%
TAV	41	Tavares	1.16	3.36	2.20	0.83%	190.07%	0.67%
UCF	64	Univ. Central Fla	0.74	1.03	0.29	0.11%	39.84%	0.21%
VOL	45	Volusia County	1.19	2.52	1.33	0.50%	111.97%	0.50%
WEK	69	Wekiva	0.70	0.77	0.06	0.02%	9.21%	0.15%
WGA	46	Winter Garden	1.44	2.52	1.08	0.41%	74.64%	0.50%
WGC	54	Winter Garden Citrus Products	1.87	1.87	0.00	0.00%	0.00%	0.37%
WPK	11	Winter Park	12.34	15.28	2.94	1.11%	23.83%	3.06%
WSP	32	Winter Springs	2.97	6.01	3.04	1.15%	102.51%	1.20%
ZSU	53	Zellwood Station Utilities	0.95	1.89	0.93	0.35%	97.56%	0.38%
ZWF	81	Zellwood Farms	0.13	0.32	0.19	0.07%	148.69%	0.06%
ZWU	79	Zellwood Water Users	0.17	0.37	0.19	0.07%	112.12%	0.07%
		Total	234.59	499.41	264.81	100.00%	112.88%	100.00%

Table A2. Volusia public supply utility demand areas

Public Supply Utility Need Area	Model ID	1988 Withdrawal Rate (mgd)	Projected 2010 Withdrawal Rate (mgd)	Projected Increase from 1988 to 2010(mgd)	% of Total Increase from 1988	Projected % Increase in Withdrawal Rate
DELTONA	DEL	7.28	24.90	17.62	35.44%	242%
DAYTONA BEACH WESTERN WF	DBW	10.27	13.33	3.06	6.15%	30%
PORT ORANGE WEST PROP	POW	3.98	8.57	4.59	9.24%	115%
DAYTONA BEACH EASTERN WF	DBE	2.94	7.17	4.24	8.52%	144%
DELAND	DWU	4.33	6.92	2.59	5.21%	60%
CITY OF EDGEWATER	EDG	1.54	4.66	3.12	6.27%	202%
ORANGE CITY	OCY	0.51	3.65	3.14	6.32%	618%
NEW SMYRNA GLENCOE WF	NSG	2.08	3.08	1.00	2.01%	48%
ORMOND BEACH HUDSON	OBH	0.00	3.01	3.01	6.05%	New
ORMOND BEACH DIVISION	OBD	2.71	2.77	0.07	0.14%	2%
NEW SMYRNA SAMSULA WF	NSS	1.78	2.64	0.85	1.72%	48%
NEW SMYRNA SR 44	NS4	0.00	2.64	2.64	5.30%	New
HOLLY HILL WESTERN WF	HHW	1.02	1.38	0.36	0.72%	35%
ORMOND BEACH SR 40	OB4	1.90	1.16	-0.75	-1.51%	-39%
DELAND - BRANDYWINE	DEB	0.50	0.90	0.40	0.79%	79%
PORT ORANGE EASTERN WF	POE	0.40	0.86	0.46	0.92%	115%
V CTY - FOUR TOWNS	VFT	0.54	0.79	0.25	0.51%	47%
THE TRAILS INC.	TTI	0.32	0.58	0.26	0.52%	81%
LAKE HELEN	LHE	0.22	0.58	0.36	0.71%	160%
V CTY - TERRA ALTA	VTA	0.10	0.53	0.43	0.87%	453%
ORMOND BEACH RIMA PROP	OBR	0.00	0.46	0.46	0.93%	New
SPRUCE CREEK	SPC	0.32	0.40	0.08	0.16%	24%
OR. CITY CTRY VILLAGE	OCC	0.13	0.39	0.25	0.51%	189%
NATIONAL GARDENS	NGA	0.21	0.39	0.17	0.35%	81%
DELAND - HOLIDAY HILLS	DHH	0.17	0.36	0.19	0.39%	115%
L BERESFORD WATER ASSN	LBW	0.16	0.33	0.17	0.34%	105%
FPL - SANFORD PWR PLNT	FPS	0.32	0.32	0.00	0.00%	0%
V CTY - LAKE MARIE	VLM	0.14	0.25	0.11	0.23%	81%
TOMOKA CORR. FACILITY	TCF	0.23	0.23	0.00	0.00%	0%
SSU SUGAR MILL 1990	SME	0.10	0.22	0.12	0.24%	125%
V CTY GOVT COMPLEX	VGC	0.20	0.20	0.00	0.00%	0%
TYMBER CREEK UTIL.	TCU	0.09	0.18	0.09	0.18%	96%
DELAND - WOODLAND MANOR	DWW	0.06	0.16	0.10	0.21%	178%
SHERWOOD MEDICAL CO.	SMC	0.16	0.16	0.00	0.00%	0%
JOHN KNOX VILL.	JKV	0.05	0.14	0.09	0.19%	200%
HOLLY HILL EASTERN WF	HHE	0.10	0.14	0.04	0.07%	35%
SUNSHINE HOLIDAY PK	SHP	0.07	0.13	0.06	0.11%	81%
PLANTATION BAY	PTB	0.06	0.12	0.07	0.13%	117%
HACIENDA DEL RIO	HDR	0.06	0.10	0.05	0.09%	81%
FPL - TURNER POWER PLNT	FPT	0.10	0.10	0.00	0.00%	0%
ELLWOOD TITCOMB	ETI	0.05	0.09	0.05	0.09%	100%
Total		45.84	96.20	49.78	100.00%	210%

Table A3. East-central public supply utility wells

Model Row	Model Column	Well ID Number	Public Supply Demand Area	Well or Treatment Plant	Model Layer	Year 1988 Withdrawal Rate (MGD)	Projected Year 2010 Withdrawal Rate (MGD)	Well Application Number	Well Capacity (MGD)
46	58	1	ALT	ALTAMONTE SPR.(NEW CHARLOTTE ST W	1	0.65	4.15		4.49
48	54	2	ALT	ALTAMONTE SPR. (PLANT #3)	1	0.01	0.00	2-117-0139ANMG	1.50
49	57	3	ALT	ALTAMONTE SPR. (PLANT #1)	1	0.32	0.00	2-117-0130AN	1.50
49	48	4	ALT	ALTAMONTE SPR. (PLANT #4)	1	0.08	3.02	2-117-0139ANMG	3.74
50	57	5	ALT	ALTAMONTE SPR. (PLANT #1)	1	3.80	0.00	2-117-0130AN	1.50
52	45	6	ALT	ALTAMONTE SPR. (PLANT #5)	1	1.08	0.00	2-117-0139ANMG	4.49
53	55	7	ALT	ALTAMONTE SPR. (PLANT #2)	1	0.02	1.07	2-117-0130AN	3.46
52	45	8	ALT	ALTAMONTE SPRINGS (PLANT #5)	2	1.98	0.00		4.49
54	55	9	ALT	ALTAMONTE SPRINGS (PLANT #2)	2	1.04	1.95		3.46
43	31	10	APO	APOPKA - GROSSENBACHER WF.	1	0.00	3.38	2-095-0097ANGM	5.98
37	27	11	APO	APOPKA - PROPOSED NORTHWEST WF	2	1.04	4.44		5.98
43	31	12	APO	APOPKA - GROSSENBACHER WF.	2	0.00	3.38	2-095-0097ANGM	5.98
45	27	13	APO	APOPKA - PROPOSED SOUTHWEST WF	2	2.07	6.77		7.11
53	36	14	APO	APOPKA - SHEELOR OAKS WF.	2	2.03	3.17	2-095-0097ANGM	3.61
45	63	15	CAS	CASSELBERRY (NORTH WTP; WELL N-1)	1	0.31	0.48	2-117-0055ANG	0.90
53	63	16	CAS	CASSELBERRY (HOWELL PARK; CANON W	1	0.39	0.41	2-117-0055ANG	0.90
53	62	17	CAS	CASSELBERRY (HOWELL PARK; HP-1 WE	1	0.89	0.61		1.20
59	65	18	CAS	CASSELBERRY (SOUTH PLANT; WELL S-	1	0.15	0.51	2-117-0055ANG	1.05
46	63	19	CAS	CASSELBERRY (NORTH WTP; WELL N240	2	0.07	1.01	2-117-0055ANG	1.50
53	64	20	CAS	CASSELBERRY (HOWELL PARK WTP; WEL	2	0.90	1.40		1.50
59	65	21	CAS	CASSELBERRY (SOUTH PLANT; WELL S-	2	0.08	0.51		0.75
59	66	22	CAS	CASSELBERRY (SOUTH WTP; WELL S360	2	0.99	1.40		1.50
104	35	23	CFU	CENTRAL FLA UTIL (CAMELOT, CD 1&2	1	0.10	2.35	49-00076-W SFWMD	4.49
105	60	24	CFU	CENTRAL FLA UTIL (C. FL. PKWY. CD	1	0.19	0.23	49-00076-W SFWMD	0.45
107	57	25	CFU	CENTRAL FLA UTIL (C. FL. PKWY. CD	1	0.00	0.45	49-00076-W SFWMD	1.35
54	97	26	CHU	SOUTHERN ST. UTIL (CHULUOTA)	1	0.39	0.09	2-117-0132ANMR	0.43
55	96	27	CHU	SOUTHERN ST. UTIL (CHULUOTA)	1	0.91	0.16	2-117-0132ANMR	0.73
68	8	28	CLE	CLERMONT (GRAND)	1	0.52	1.57	2-069-0175AN	3.37
71	7	29	CLE	CLERMONT (4TH STREET)	1	0.19	0.90	2-069-0175AN	1.80
87	100	30	COC	COCOA (WELL #10)	1	0.15	0.15	2-095-0005	1.65
89	100	31	COC	COCOA (WELL #9)	1	0.24	0.24	2-095-0005	1.65
90	100	32	COC	COCOA (WELL #8)	1	1.53	0.48	2-095-0005	1.65
92	95	33	COC	COCOA (WELL #13 & 13R)	1	2.42	0.60	2-095-0005	1.65
92	94	34	COC	COCOA (WELL #14)	1	0.13	1.66	2-095-0005	3.02
92	100	35	COC	COCOA (WELL #3)	1	5.83	0.00	2-095-0005	0.82
93	93	36	COC	COCOA (WELL #16)	1	2.70	3.53	2-095-0005	4.49
93	92	37	COC	COCOA (WELL #17)	1	0.40	1.74	2-095-0005	3.02
93	100	38	COC	COCOA (WELL #7) <PHASE I CORRECTI	1	0.22	0.24	2-095-0005	1.65
93	99	39	COC	COCOA (WELL #7A)	1	0.00	0.26	2-095-0005	1.65
94	100	40	COC	COCOA (WELL # 1)	1	2.34	0.15	2-095-0005	1.65
94	92	41	COC	COCOA (WELL #18)	1	0.00	1.86	2-095-0005	3.02
95	100	42	COC	COCOA (WELL #6) <PHASE I CORRECTI	1	1.30	0.00	2-095-0005	0.82
96	92	43	COC	COCOA (WELL #19)	1	0.42	1.86	2-095-0005	3.02
96	100	44	COC	COCOA (WELL #5)	1	0.26	0.24	2-095-0005	1.65
97	102	45	COC	COCOA (WELL #12A)	1	0.28	0.24	2-095-0005	1.65
97	100	46	COC	COCOA (WELL #4)	1	0.00	0.24	2-095-0005	1.65
97	92	47	COC	COCOA PROP. WELL 20	1	0.74	1.86	2-095-0005	3.02
98	100	48	COC	COCOA (WELL #11)	1	0.54	0.24	2-095-0005	1.65
98	102	49	COC	COCOA (WELL #12B)	1	0.42	0.24	2-095-0005	1.65

Table A3. East-central public supply utility wells

Model Row	Model Column	Well ID Number	Public Supply Demand Area	Well or Treatment Plant	Model Layer	Year 1988 Withdrawal Rate (MGD)	Projected Year 2010 Withdrawal Rate (MGD)	Well Application Number	Well Capacity (MGD)
46	58	1	ALT	ALTAMONTE SPR.(NEW CHARLOTTE ST W	1	0.65	4.15		4.49
48	54	2	ALT	ALTAMONTE SPR. (PLANT #3)	1	0.01	0.00	2-117-0139ANMG	1.50
49	57	3	ALT	ALTAMONTE SPR. (PLANT #1)	1	0.32	0.00	2-117-0130AN	1.50
49	48	4	ALT	ALTAMONTE SPR. (PLANT #4)	1	0.08	3.02	2-117-0139ANMG	3.74
50	57	5	ALT	ALTAMONTE SPR. (PLANT #1)	1	3.80	0.00	2-117-0130AN	1.50
52	45	6	ALT	ALTAMONTE SPR. (PLANT #5)	1	1.08	0.00	2-117-0139ANMG	4.49
53	55	7	ALT	ALTAMONTE SPR. (PLANT #2)	1	0.02	1.07	2-117-0130AN	3.46
52	45	8	ALT	ALTAMONTE SPRINGS (PLANT #5)	2	1.98	0.00		4.49
54	55	9	ALT	ALTAMONTE SPRINGS (PLANT #2)	2	1.04	1.95		3.46
43	31	10	APO	APOPKA - GROSSENBACHER WF.	1	0.00	3.38	2-095-0097ANGM	5.98
37	27	11	APO	APOPKA - PROPOSED NORTHWEST WF	2	1.04	4.44		5.98
43	31	12	APO	APOPKA - GROSSENBACHER WF.	2	0.00	3.38	2-095-0097ANGM	5.98
45	27	13	APO	APOPKA - PROPOSED SOUTHWEST WF	2	2.07	6.77		7.11
53	36	14	APO	APOPKA - SHEELOR OAKS WF.	2	2.03	3.17	2-095-0097ANGM	3.61
45	63	15	CAS	CASSELBERRY (NORTH WTP; WELL N-1)	1	0.31	0.48	2-117-0055ANG	0.90
53	63	16	CAS	CASSELBERRY (HOWELL PARK; CANON W	1	0.39	0.41	2-117-0055ANG	0.90
53	62	17	CAS	CASSELBERRY (HOWELL PARK; HP-1 WE	1	0.89	0.61		1.20
59	65	18	CAS	CASSELBERRY (SOUTH PLANT; WELL S-	1	0.15	0.51	2-117-0055ANG	1.05
46	63	19	CAS	CASSELBERRY (NORTH WTP; WELL N240	2	0.07	1.01	2-117-0055ANG	1.50
53	64	20	CAS	CASSELBERRY (HOWELL PARK WTP; WEL	2	0.90	1.40		1.50
59	65	21	CAS	CASSELBERRY (SOUTH PLANT; WELL S-	2	0.08	0.51		0.75
59	66	22	CAS	CASSELBERRY (SOUTH WTP; WELL S360	2	0.99	1.40		1.50
104	35	23	CFU	CENTRAL FLA UTIL (CAMELOT, CD 1&2	1	0.10	2.35	49-00076-W SFWMD	4.49
105	60	24	CFU	CENTRAL FLA UTIL (C. FL. PKWY. CD	1	0.19	0.23	49-00076-W SFWMD	0.45
107	57	25	CFU	CENTRAL FLA UTIL (C. FL. PKWY. CD	1	0.00	0.45	49-00076-W SFWMD	1.35
54	97	26	CHU	SOUTHERN ST. UTIL (CHULUOTA)	1	0.39	0.09	2-117-0132ANMR	0.43
55	96	27	CHU	SOUTHERN ST. UTIL (CHULUOTA)	1	0.91	0.16	2-117-0132ANMR	0.73
68	8	28	CLE	CLERMONT (GRAND)	1	0.52	1.57	2-069-0175AN	3.37
71	7	29	CLE	CLERMONT (4TH STREET)	1	0.19	0.90	2-069-0175AN	1.80
87	100	30	COC	COCOA (WELL #10)	1	0.15	0.15	2-095-0005	1.65
89	100	31	COC	COCOA (WELL #9)	1	0.24	0.24	2-095-0005	1.65
90	100	32	COC	COCOA (WELL #8)	1	1.53	0.48	2-095-0005	1.65
92	95	33	COC	COCOA (WELL #13 & 13R)	1	2.42	0.60	2-095-0005	1.65
92	94	34	COC	COCOA (WELL #14)	1	0.13	1.66	2-095-0005	3.02
92	100	35	COC	COCOA (WELL #3)	1	5.83	0.00	2-095-0005	0.82
93	93	36	COC	COCOA (WELL #16)	1	2.70	3.53	2-095-0005	4.49
93	92	37	COC	COCOA (WELL #17)	1	0.40	1.74	2-095-0005	3.02
93	100	38	COC	COCOA (WELL #7) <PHASE I CORRECTI	1	0.22	0.24	2-095-0005	1.65
93	99	39	COC	COCOA (WELL #7A)	1	0.00	0.26	2-095-0005	1.65
94	100	40	COC	COCOA (WELL # 1)	1	2.34	0.15	2-095-0005	1.65
94	92	41	COC	COCOA (WELL #18)	1	0.00	1.86	2-095-0005	3.02
95	100	42	COC	COCOA (WELL #6) <PHASE I CORRECTI	1	1.30	0.00	2-095-0005	0.82
96	92	43	COC	COCOA (WELL #19)	1	0.42	1.86	2-095-0005	3.02
96	100	44	COC	COCOA (WELL #5)	1	0.26	0.24	2-095-0005	1.65
97	102	45	COC	COCOA (WELL #12A)	1	0.28	0.24	2-095-0005	1.65
97	100	46	COC	COCOA (WELL #4)	1	0.00	0.24	2-095-0005	1.65
97	92	47	COC	COCOA PROP. WELL 20	1	0.74	1.86	2-095-0005	3.02
98	100	48	COC	COCOA (WELL #11)	1	0.54	0.24	2-095-0005	1.65
98	102	49	COC	COCOA (WELL #12B)	1	0.42	0.24	2-095-0005	1.65

Table A3--*Continued*

Model Row	Model Column	Well ID Number	Public Supply Demand Area	Well or Treatment Plant	Model Layer	Year 1988 Withdrawal Rate (MGD)	Projected Year 2010 Withdrawal Rate (MGD)	Well Application Number	Well Capacity (MGD)
98	101	50	COC	COCOA (WELL #4A1)	1	0.00	0.24	2-095-0005	1.65
98	92	51	COC	COCOA PROP. WELL 22	1	0.00	3.73	2-095-0005	7.48
99	92	52	COC	COCOA PROP. WELL 32	1	0.00	3.73	2-095-0005	7.48
99	101	53	COC	COCOA PROP. WELL 39	1	0.00	0.48	2-095-0005	7.48
100	92	54	COC	COCOA PROP. WELL 33	1	0.00	1.86	2-095-0005	7.48
100	101	55	COC	COCOA PROP. WELL 41	1	0.00	0.48	2-095-0005	7.48
101	101	56	COC	COCOA PROP. WELL 43	1	0.00	0.48	2-095-0005	7.48
102	101	57	COC	COCOA PROP. WELL 44	1	0.01	0.24	2-095-0005	7.48
86	60	58	CON	SO. STATES UTIL (LAKE CONWAY PARK	1	0.01	0.01	2-095-0214AN	0.11
87	60	59	CON	SO. STATES UTIL (LAKE CONWAY PARK	1	0.03	0.01	2-095-0214AN	0.11
88	59	60	CON	SO. STATES UTIL (DAETWYLER SHORES	1	0.03	0.04	2-095-0215AN	0.11
88	60	61	CON	SO. STATES UTIL (DAETWYLER SHORES	1	0.00	0.04	2-095-0215AN	0.11
3	86	62	DEL	DELTONA-PROPOSED	1	1.45	1.61	2-127-0093AUNM	1.87
4	88	63	DEL	DELTONA	1	0.00	2.41	2-127-0093AN	3.74
4	80	64	DEL	DELTONA-PROPOSED	1	0.00	0.80	2-127-0093AUNM	1.87
4	82	65	DEL	DELTONA-PROPOSED	1	0.00	0.80	2-127-0093AUNM	1.87
4	84	66	DEL	DELTONA-PROPOSED	1	0.48	0.80	2-127-0093AUNM	1.87
5	74	67	DEL	DELTONA	1	0.48	0.80	2-127-0093AN	1.87
6	76	68	DEL	DELTONA	1	0.48	0.80	2-127-0093AN	1.87
6	88	69	DEL	DELTONA	1	0.00	0.00	2-127-0093AN	1.87
6	86	70	DEL	DELTONA-PROPOSED	1	0.48	0.80	2-127-0093AUNM	1.87
7	71	71	DEL	DELTONA	1	1.94	1.61	2-127-0093AN	1.87
7	78	72	DEL	DELTONA	1	1.45	3.21	2-127-0093AN	3.74
7	74	73	DEL	DELTONA-PROPOSED	1	0.48	3.21	2-127-0093AUNM	3.74
8	80	74	DEL	DELTONA	1	0.00	0.80	2-127-0093AN	1.87
8	76	75	DEL	DELTONA-PROPOSED	1	0.00	0.80	2-127-0093AUNM	1.87
8	83	76	DEL	DELTONA-PROPOSED	1	0.00	2.41	2-127-0093AUNM	3.74
9	77	77	DEL	DELTONA-PROPOSED	1	0.00	0.80	2-127-0093AUNM	1.87
9	80	78	DEL	DELTONA-PROPOSED	1	0.00	0.80	2-127-0093AUNM	1.87
9	85	79	DEL	DELTONA-PROPOSED	1	0.00	0.80	2-127-0093AUNM	1.87
9	88	80	DEL	DELTONA-PROPOSED	1	0.10	1.61	2-127-0093AUNM	1.87
77	103	81	ECU	ECON UTIL (WEDGEFIELD)	1	0.03	0.12	2-095-0278AUM	0.16
77	104	82	ECU	ECON UTIL (WEDGEFIELD)	1	0.17	0.04	2-095-0278AUM	0.16
12	12	83	EUS	EUSTIS (C R 44A ?)	1	0.17	1.36	2-069-0539ANGM	2.69
12	13	84	EUS	EUSTIS (C R 44A ?)	1	1.33	1.36	2-069-0539ANGM	2.69
13	22	85	EUS	EUSTIS (HAZELTON AVE.)	1	1.23	0.54	2-069-0539ANGM	1.12
15	11	86	EUS	EUSTIS (ARDICE PLACE)	1	0.05	2.53	2-069-0539ANGM	4.86
86	93	87	FDC	FL DEPT OF CORR	1	0.11	0.05	2-095-0190ANGM2	0.22
87	92	88	FDC	FL DEPT OF CORR	1	0.05	0.11	2-095-0190ANGM2	0.22
87	93	89	FDC	FL DEPT OF CORR	1	2.05	0.05	2-095-0190ANGM2	0.22
104	47	90	KIS	CITY OF KISSIMMEE (NORTH BERMUDA)	1	1.77	4.89	49-00162-W SFWMD	8.98
106	49	91	KIS	CITY OF KISSIMMEE (RUBY ST.)	1	0.09	4.22	49-00103-W SFWMD	8.98
1	78	92	LHE	LAKE HELEN - PLANT #2	1	0.13	0.29	2-127-0646AN	0.75
2	78	93	LHE	LAKE HELEN - PLANT #1	1	0.01	0.29	2-127-0646AN	0.75
34	101	94	LHY	LAKE HARNEY WATER ASSOC	1	0.02	0.03	2-117-0022ANM2	0.29
35	101	95	LHY	LAKE HARNEY WATER ASSOC	1	0.00	0.00	2-117-0022ANM2	0.29
24	59	96	LMY	LAKE MARY (NEW PUBLIC SUPPLY)	1	0.00	0.80	2-117-0053ANGM	2.30
25	59	97	LMY	LAKE MARY (NEW PUBLIC SUPPLY)	1	0.00	0.80	2-117-0053ANGM	2.30
26	59	98	LMY	LAKE MARY (NEW PUBLIC SUPPLY)	1	0.00	1.61	2-117-0053ANGM	2.30

Table A3--*Continued*

Model Row	Model Column	Well ID Number	Public Supply Demand Area	Well or Treatment Plant	Model Layer	Year 1988 Withdrawal Rate (MGD)	Projected Year 2010 Withdrawal Rate (MGD)	Well Application Number	Well Capacity (MGD)
27	59	99	LMY	LAKE MARY (NEW PUBLIC SUPPLY)	1	0.25	0.80	2-117-0053ANGM	2.30
28	59	100	LMY	LAKE MARY (NEW PUBLIC SUPPLY)	1	0.25	0.80	2-117-0053ANGM	2.30
29	59	101	LMY	LAKE MARY (NEW PUBLIC SUPPLY)	1	1.25	0.80	2-117-0053ANGM	2.30
39	57	102	LON	LONGWOOD	1	0.78	2.28	2-117-0046AUG	3.37
40	60	103	LON	LONGWOOD	1	0.57	0.87	2-117-0046AUG	3.37
55	60	104	MAI	MAITLAND - THISTLE LANE	1	0.09	0.69	2-095-0090ANGF	2.54
57	56	105	MAI	MAITLAND - MINNEHAHA CIRCLE	1	0.19	0.11	2-095-0090ANGF	1.08
58	53	106	MAI	MAITLAND - WELL NO. 5A	1	1.46	0.24	2-095-0090ANGF	2.24
57	50	107	MAI	MAITLAND - KELLER	2	0.58	1.79	2-095-0090ANGF	6.43
58	53	108	MAI	MAITLAND - WELL NO. 5A	2	0.74	0.71	2-095-0090ANGF	2.24
65	87	109	OE1	OCPUD EAST REG: (BONNEVILLE)	1	0.20	0.00	2-095-0060AUMG	7.48
68	65	110	OE1	OCPUD EAST REG: (CORRINE TERRACE)	1	1.79	0.00	2-095-0060AUMG	0.22
72	75	111	OE3	OCPUD EAST REG: (ECON)	1	1.79	4.00	2-095-0060AUMG	4.19
73	75	112	OE3	OCPUD EAST REG: (ECON)	1	0.00	4.00	2-095-0060AUMG	4.19
79	74	113	OE5	OCPUD EAST REG: ERWF	1	0.74	20.25	2-095-0060AUMG	20.94
82	66	114	OE2	OCPUD EAST REG: (CONWAY)	1	0.74	2.09	2-095-0060AUMG	4.49
82	67	115	OE2	OCPUD EAST REG: (CONWAY)	1	0.03	2.09	2-095-0060AUMG	4.49
94	73	116	OE4	OCPUD EAST REG: (LAKE NONA)	1	1.01	2.00	48-00276-W SFWMD	2.99
82	67	117	OE2	OCPUD EAST REG: (CONWAY)	2	0.57	3.47	2-095-0060AUMG	4.49
63	33	118	OCO	OCOEE (HACKNEY PRAIRIE)	1	0.00	0.68	2-095-0092AUGM2R	3.74
63	31	119	OCO	OCOEE (JAMELA & WURST ROAD)	1	0.89	0.00	2-095-0092AUGM2R	1.50
65	29	120	OCO	OCOEE (JAMELA & WURST ROAD)	1	0.67	0.93	2-095-0092AUGM2R	1.50
68	27	121	OCO	OCOEE (KISSIMEE AVE)	1	0.00	0.93	2-095-0092AUGM2R	4.32
73	28	122	OCO	OCOEE (SOUTH PLANT)	2	0.89	2.94	2-095-0092AUGM2R	2.99
94	41	123	OS4	OCPUD SOUTH REG: (ORANGE WOOD)	1	0.89	2.40	48-0005?? SFWMD	3.61
95	41	124	OS4	OCPUD SOUTH REG: (ORANGE WOOD)	1	0.28	2.40	48-0005?? SFWMD	3.61
100	30	125	OS1	OCPUD SOUTH REG: (CYPRESS WALK)	1	0.28	1.25	48-00134 SFWMD	1.35
100	31	126	OS1	OCPUD SOUTH REG: (CYPRESS WALK)	1	0.08	1.25	48-00134 SFWMD	1.35
100	56	127	OS3	OCPUD SOUTH REG: (MEADOW WOODS)	1	0.12	0.20	48-00185-W SFWMD	5.39
101	46	128	OS2	OCPUD SOUTH REG: (HUNTERS CREEK)	1	1.05	0.50	48-00231-W SFWMD	8.98
101	32	129	OS1	OCPUD SOUTH REG: (VISTANA)	1	0.59	4.00	48-0005?? SFWMD	4.19
94	41	130	OS4	OCPUD SOUTH REG: (ORANGE WOOD)	2	0.00	1.68	48-0005?? SFWMD	3.61
101	54	131	OS3	OCPUD SOUTH REG: SOUTH REG. WELL	2	0.19	10.00		10.47
28	31	132	OW1	OCPUD WEST REG: (MT. PLYMOUTH LAK	1	0.00	0.90	2-095-0049ANGM	1.44
38	25	133	OW1	OCPUD WEST REG: (PLYMOUTH)	1	0.03	1.50	2-095-0283ANM2G	1.80
39	24	134	OW1	OCPUD WEST REG: (PLYMOUTH HILLS)	1	1.32	0.00	2-095-0283ANM2G	0.16
43	38	135	OW1	OCPUD WEST REG: (BENT OAKS)	1	0.08	0.00	2-095-0272AN	5.24
43	26	136	OW1	OCPUD WEST REG: (PLYMOUTH CENTRAL	1	0.02	0.00		0.16
54	32	137	OW1	OCPUD WEST REG: (ORANGE VILLAGE)	1	0.48	0.03	2-095-0282AU	0.09
55	46	138	OW4	OCPUD - RIVERSIDE	1	0.48	0.00	2-095-031OUM2GF	1.50
55	47	139	OW4	OCPUD - RIVERSIDE	1	0.48	0.00	2-095-031OUM2GF	1.50
56	46	140	OW4	OCPUD - RIVERSIDE	1	0.04	0.00	2-095-031OUM2GF	1.50
65	21	141	OW6	OCPUD WEST REG: (MAGNOLIA WOODS)	1	0.00	0.03	2-095-0281AUM	1.50
70	15	142	OW6	OCPUD WEST REG: LAKE JOHN SHORES	1	0.39	0.03	2-095-0280U	0.34
72	36	143	OW3	OCPUD WEST REGIONAL (OAK MEADOWS)	1	0.22	0.00	2-095-031OUM2GF	4.49
76	30	144	OW2	OCPUD WEST REG: (WINDERMERE DOWNS	1	0.03	0.00		0.30
79	27	145	OW2	OCPUD WEST REG: (WAUSEON RIDGE)	1	0.18	0.00		0.04
81	36	146	OW2	OCPUD WEST REG: (HIDDEN SPRINGS)	1	0.02	0.00	48-00059-W SFWMD	5.24
81	23	147	OW2	OCPUD WEST REG: (KELSO)	1	0.01	0.00		0.58

Table A3--*Continued*

Model Row	Model Column	Well ID Number	Public Supply Demand Area	Well or Treatment Plant	Model Layer	Year 1988 Withdrawal Rate (MGD)	Projected Year 2010 Withdrawal Rate (MGD)	Well Application Number	Well Capacity (MGD)
81	29	148	OW2	OCPUD WEST REG: (WINDERMERE)	1	0.06	0.00		0.01
82	36	149	OW2	OCPUD WEST REG: (HIDDEN SPRINGS)	1	0.48	0.00	48-00059-W SFWMD	5.24
55	46	150	OW4	OCPUD - RIVERSIDE	2	0.48	0.00	2-095-0310UM2GF	1.50
55	47	151	OW4	OCPUD - RIVERSIDE	2	0.00	0.00	2-095-0310UM2GF	1.50
55	35	152	OW5	OCPUD WEST REG: WRWF WELL # 1	2	0.00	6.00	2-095-0310UM2GF	7.48
55	36	153	OW5	OCPUD WEST REG: WRWF WELL # 1	2	0.48	14.00	2-095-0310UM2GF	14.96
56	46	154	OW4	OCPUD - RIVERSIDE	2	1.55	0.00	2-095-0310UM2GF	1.50
72	36	155	OW3	OCPUD WEST REGIONAL (OAK MEADOWS)	2	1.42	0.00	2-095-0310UM2GF	4.49
82	36	156	OW2	OCPUD WEST REG: (HIDDEN SPRINGS)	2	0.14	0.00	48-00059-W SFWMD	5.24
4	73	157	OCY	Or. City Ctry V	1	0.17	0.39	2-127-0044AU	0.75
4	67	158	OCY	ORANGE CITY	1	0.34	0.91	2-127-0674ANV	1.87
4	68	159	OCY	ORANGE CITY	1	1.14	2.74	2-127-0674ANV	5.39
104	59	160	ORO	ORANGE/OSCEOLA (BEUNAVENTURA LAKE	1	0.39	2.72	49-00002-W SFWMD	5.39
104	58	161	ORO	ORANGE/OSCEOLA MGMENT	1	0.40	0.93		1.87
83	90	162	OU13	OUC-STANTON ENERGY CTR.	1	0.40	0.40		0.45
87	35	163	OU1	OUC (DR. PHILLIPS)	1	5.33	6.20	2-095-0002AUMGR	13.46
88	41	164	OU2	OUC (MARTIN)	1	9.17	20.19	2-095-0002AUMGR	20.94
68	55	165	OU4	OUC - HIGHLAND	2	2.31	2.42	2-095-0002AUMGR	8.98
68	64	166	OU10	OUC - NAVY	2	1.39	6.40	2-095-0002AUMGR	6.73
68	40	167	OU5	OUC - PINE HILLS	2	5.60	7.84	2-095-0002AUMGR	8.23
68	41	168	OU5	OUC - PINE HILLS	2	2.80	7.84	2-095-0002AUMGR	8.23
69	55	169	OU4	OUC - HIGHLAND	2	3.46	3.63	2-095-0002AUMGR	8.98
69	56	170	OU4	OUC - HIGHLAND	2	2.31	0.72	2-095-0002AUMGR	8.98
69	41	171	OU5	OUC - PINE HILLS	2	2.80	3.92	2-095-0002AUMGR	8.23
70	55	172	OU4	OUC - HIGHLAND	2	2.30	1.21	2-095-0002AUMGR	8.98
72	60	173	OU8	OUC - PRIMROSE	2	2.68	2.36	2-095-0002AUMGR	8.23
73	59	174	OU8	OUC - PRIMROSE SFWMD?	2	5.35	4.73	2-095-0002AUMGR	8.23
76	54	175	OU6	OUC - KUHL	2	2.80	3.77	2-095-0002AUMGR	8.23
77	62	176	OU3	OUC - CONWAY	2	3.33	6.13	2-095-0002AUMGR	8.23
77	55	177	OU6	OUC - KUHL	2	5.60	7.54	2-095-0002AUMGR	8.23
78	62	178	OU3	OUC - CONWAY	2	6.66	3.07	2-095-0002AUMGR	8.23
80	67	179	OU12	OUC (PERSHING)	2	0.00	7.00		7.48
80	39	180	OU7	OUC - KIRKMAN	2	2.09	3.67	2-095-0002AUMGR	8.23
80	40	181	OU7	OUC - KIRKMAN	2	4.17	7.33	2-095-0002AUMGR	8.23
88	53	182	OU9	OUC - SKY LAKE	2	0.00	15.30	2-095-0002AUMGR	15.71
98	55	183	OU11	OUC (ORANGE)	2	0.00	7.20		7.48
51	82	184	OVI	OVIEDO (PLNT #1)	1	0.37	3.02	2-117-0035ANGMR	5.98
52	83	185	OVI	OVIEDO (ALAFAYA WOODS - PLNT #2)	1	0.00	3.68	2-117-0035ANGMR	5.98
53	82	186	OVI	OVIEDO-PROP. WELL LAKE GEM	1	0.00	1.47		2.99
54	86	187	OVI	OVIEDO (ALAFAYA WOODS - PLNT #2)	1	0.22	1.47	2-117-0035ANGMR	2.99
69	79	188	PAM	PARK MANOR WATER WORKS	1	0.22	0.20	2-095-0470AUV	0.75
70	77	189	PAM	PARK MANOR WATER WORKS	1	0.41	0.20	2-095-0470AUV	0.75
114	34	190	POI	POINCIANA UTIL (IP-1&2)	1	0.06	0.98	49-00069-W SFWMD	1.12
117	39	191	POI	POINCIANA (CORES-1,2&3 89-90)	1	0.13	0.15	49-00069-W SFWMD	0.75
118	38	192	POI	POINCIANA (CORES-1,2&3 89-90)	1	0.12	0.31	49-00069-W SFWMD	0.75
22	67	193	RAV	UTILITIES OF FLA (RAVENNA PARK)	1	0.03	0.12	2-117-0120AN	0.37
23	65	194	RAV	UTILITIES OF FLA (CRYSTAL LAKE)	1	0.03	0.07	2-117-0118AN	0.37
25	65	195	RAV	UTILITIES OF FLA (PHILLIPS)	1	0.00	0.02	2-117-0118AN	0.37
30	68	196	RAV	UTILITIES OF FLA (PARK RIDGE)	1	3.65	0.02		0.45

Table A3--*Continued*

Model Row	Model Column	Well ID Number	Public Supply Demand Area	Well or Treatment Plant	Model Layer	Year 1988 Withdrawal Rate (MGD)	Projected Year 2010 Withdrawal Rate (MGD)	Well Application Number	Well Capacity (MGD)
91	20	197	RCU	REEDY CREEK UTIL (PUMP STN A; 89-	1	1.82	8.89	48-00009 SFWMD	8.98
92	22	198	RCU	REEDY CREEK UTIL (PUMP STN A; 89-	1	1.29	4.45	48-00009 SFWMD	4.49
98	30	199	RCU	REEDY CREEK UTIL (PUMP STATION C)	1	0.64	3.19	48-00009 SFWMD	3.37
100	31	200	RCU	REEDY CREEK UTIL (PUMP STATION C)	1	0.64	1.59	48-00009 SFWMD	3.37
100	32	201	RCU	REEDY CREEK UTIL (PUMP STATION C)	1	3.96	1.59	48-00009 SFWMD	3.37
101	22	202	RCU	REEDY CREEK UTIL (PMP STN B)	1	7.93	3.09	48-00009 SFWMD	4.11
102	24	203	RCU	REEDY CREEK UTIL (PMP STN B)	1	0.00	6.19	48-00009 SFWMD	8.98
21	61	204	SAF	SANFORD (WELLFIELD # 4) (PROP)	1	1.29	0.55	2-117-0026ANGM3	3.37
21	62	205	SAF	SANFORD (WELLFIELD #3)	1	0.86	2.07	2-117-0026ANGM3	3.74
21	63	206	SAF	SANFORD (WELLFIELD #3)	1	0.00	1.18	2-117-0026ANGM3	1.50
22	61	207	SAF	SANFORD (WELLFIELD # 4)	1	0.35	1.11	2-117-0026ANGM3	3.37
23	63	208	SAF	SANFORD (WELLFIELD #2)	1	0.71	0.00	2-117-0026ANGM3	2.92
24	63	209	SAF	SANFORD (WELLFIELD #2)	1	0.00	1.66	2-117-0026ANGM3	2.92
27	69	210	SAF	SANFORD (WELLFIELD #1)	1	0.61	0.00	2-117-0026ANGM3	1.50
28	68	211	SAF	SANFORD (WELLFIELD #1)	1	0.61	0.32	2-117-0026ANGM3	1.50
28	69	212	SAF	SANFORD (WELLFIELD #1)	1	0.30	0.30	2-117-0026ANGM3	1.50
29	68	213	SAF	SANFORD (WELLFIELD #1)	1	0.30	0.21	2-117-0026ANGM3	1.50
29	69	214	SAF	SANFORD (WELLFIELD #1)	1	0.00	0.11	2-117-0026ANGM3	1.50
37	54	215	SAN	SANLANDO UTIL CORP (DES PINAR)	1	0.57	0.53	2-117-0006AUR	2.62
38	55	216	SAN	SANLANDO UTIL CORP (DES PINAR)	1	1.70	1.06	2-117-0006AUR	2.62
39	55	217	SAN	SANLANDO UTIL CORP (DES PINAR)	1	1.13	1.93	2-117-0006AUR	2.62
41	44	218	SAN	SANLANDO (WEKIVA HUNT CLUB)	1	0.57	0.99	2-117-0006AUR	1.80
41	54	219	SAN	SANLANDO UTIL CORP (OVERSTREET)	1	0.57	0.00	2-117-0006AUR	0.75
41	55	220	SAN	SANLANDO UTIL CORP (OVERSTREET)	1	1.13	0.09	2-117-0006AUR	0.75
43	43	221	SAN	SANLANDO (WEKIVA HUNT CLUB)	1	1.13	2.29	2-117-0006AUR	2.39
43	44	222	SAN	SANLANDO (WEKIVA HUNT CLUB)	1	1.13	0.65	2-117-0006AUR	1.80
44	43	223	SAN	SANLANDO (WEKIVA HUNT CLUB)	1	1.13	1.32	2-117-0006AUR	1.80
45	43	224	SAN	SANLANDO (WEKIVA HUNT CLUB)	1	1.20	1.90	2-117-0006AUR	1.94
109	68	225	SCL	CITY OF ST. CLOUD	1	0.60	2.86	49-00084-W SFWMD	4.49
109	71	226	SCL	CITY OF ST. CLOUD	1	0.13	1.43	49-00084-W SFWMD	1.87
17	62	227	SEM	SEM CTY LAKE MONROE (I-4 IND. PAR	1	0.15	0.29		2.47
27	54	228	SEM	SEM. COUNTY (HANOVER WOODS)	1	0.31	0.60	2-117-0023ANGR2	2.24
28	57	229	SEM	SEM. COUNTY (HEATHROW)	1	0.31	1.87	2-117-0037ANF	3.59
32	59	230	SEM	SEM. COUNTY (GREENWOOD LAKES)	1	0.31	0.50	2-117-0008AUGM	1.05
32	60	231	SEM	SEM. COUNTY (GREENWOOD LAKES)	1	0.01	0.67	2-117-0008AUGM	1.05
33	62	232	SEM	SEM. COUNTY (COUNTRY CLUB)	1	0.00	1.33	2-117-0008AUGM	2.99
33	59	233	SEM	SEM. COUNTY (GREENWOOD LAKES)	1	0.31	0.90	2-117-0008AUGM	1.05
33	60	234	SEM	SEM. COUNTY (GREENWOOD LAKES)	1	0.31	0.30	2-117-0008AUGM	1.05
33	61	235	SEM	SEM. COUNTY (GREENWOOD LAKES)	1	0.10	1.14	2-117-0008AUGM	1.20
48	41	236	SEM	SEM. COUNTY (BELAIRE)	1	0.20	0.10	2-117-0031ANMGR	1.20
49	42	237	SEM	SEM. COUNTY (LYNWOOD)	1	0.20	0.49		3.44
50	42	238	SEM	SEM. COUNTY (LYNWOOD)	1	1.30	0.49		3.44
53	62	239	SEM	SEM. COUNTY (INDIAN HILLS)	1	0.67	3.09	2-117-0031ANMGR	4.49
55	68	240	SEM	SEM CTY (CONSUMER)	1	2.00	1.80	2-117-0031ANMGR	4.49
55	69	241	SEM	SEM CTY (CONSUMER)	1	0.21	4.04	2-117-0031ANMGR	4.49
56	84	242	SEM	SEM CTY (LAKE HAYES)	1	0.52	0.97	2-117-0043ANMG	4.49
63	76	243	SSS	SO. STATES UTIL (UNIV. SHORES/SUN	1	0.07	0.85	2-095-0019ANFM	1.50
66	71	244	SSS	SO. STATES UTIL (UNIV. SHORES)	1	0.07	0.35	2-095-0216AN	0.75
66	72	245	SSS	SO. STATES UTIL (UNIV. SHORES)	1	0.02	0.35	2-095-0216AN	0.75

Table A3--*Continued*

Model Row	Model Column	Well ID Number	Public Supply Demand Area	Well or Treatment Plant	Model Layer	Year 1988 Withdrawal Rate (MGD)	Projected Year 2010 Withdrawal Rate (MGD)	Well Application Number	Well Capacity (MGD)
42	45	246	SSU	SOUTHERN ST. UTIL (LAKE BRANTLEY)	1	0.12	0.02	2-117-0131AN	0.15
43	48	247	SSU	SOUTHERN ST. UTIL (MEREDITH MANOR	1	0.12	0.09	2-117-0128AN& 012	0.37
44	48	248	SSU	SOUTHERN ST. UTIL (MEREDITH MANOR	1	0.01	0.18	2-117-0128AN& 012	0.37
47	57	249	SSU	STATES UTIL (HARMONY HOMES)	1	0.44	0.05	2-117-0124AN & 01	0.45
47	52	250	SSU	SOUTHERN ST. UTIL (APPLE VALLEY)	1	0.08	0.51	2-117-0121AN	1.50
49	46	251	SSU	SOUTHERN ST. UTIL (LAKE HARRIET)	1	0.04	0.09	2-117-0126AN	0.90
50	54	252	SSU	SOUTHERN ST. UTIL (DOL RAY MANOR)	1	0.01	0.04		0.82
53	58	253	SSU	SO. STATES UTIL (FERN PARK)	1	0.14	0.05	2-117-0124AN & 01	0.37
54	54	254	SSU	SOUTHERN ST. UTIL (D. HILLS\BRETT	1	0.01	0.18	2-117-0125AN	0.60
33	96	255	SWA	SEMINOLE WOODS ASSOC, INC	1	0.01	0.02	2-117-0202ANR	0.12
33	97	256	SWA	SEMINOLE WOODS ASSOC, INC	1	0.01	0.02	2-117-0202ANR	0.12
34	96	257	SWA	SEMINOLE WOODS ASSOC, INC	1	0.01	0.02	2-117-0202ANR	0.12
34	97	258	SWA	SEMINOLE WOODS ASSOC, INC	1	0.40	0.02	2-117-0202ANR	0.12
95	38	259	SWF	SEA WORLD OF FLA.	1	0.90	0.40	48-00404-W SFWMD	1.35
95	39	260	SWF	SEA WORLD OF FLA.	1	0.06	0.90	48-00058-W SFWMD	1.35
61	83	261	UCF	UCF	1	0.06	0.09	2-095-0067ANGM2	0.37
62	84	262	UCF	UCF	1	0.12	0.09	2-095-0067ANGM2	0.37
63	83	263	UCF	UCF	1	0.06	0.17	2-095-0067ANGM2	0.75
63	84	264	UCF	UCF	1	0.18	0.09	2-095-0067ANGM2	0.37
63	85	265	UCF	UCF	1	0.06	0.26	2-095-0067ANGM2	1.12
64	83	266	UCF	UCF	1	0.06	0.09	2-095-0067ANGM2	0.37
64	85	267	UCF	UCF	1	0.06	0.09	2-095-0067ANGM2	0.37
64	86	268	UCF	UCF	1	0.06	0.09	2-095-0067ANGM2	0.37
65	82	269	UCF	UCF	1	0.02	0.09	2-095-0067ANGM2	0.37
2	78	270	VOL	VOL COUNTY - CASSADAGA	1	0.07	0.04	2-127-0420ANG	0.15
4	65	271	VOL	VOL COUNTY - ?	1	0.00	0.10	2-127-0420ANG	0.22
4	63	272	VOL	VOL CTY - WEST ORANGE CITY	1	0.20	0.01	2-127-0420AN	0.15
5	67	273	VOL	VOL COUNTY - FOUR TOWNS	1	0.04	0.32	2-127-0420AN	0.75
5	68	274	VOL	VOL COUNTY-ORANGE CITY INDUS PARK	1	0.14	0.04	2-127-0420AN	0.15
6	68	275	VOL	VOL COUNTY - BREEZEWOOD	1	0.23	0.16	2-127-0420AN	0.75
6	67	276	VOL	VOL COUNTY - FOUR TOWNS	1	0.11	0.37	2-127-0420AN	0.75
6	66	277	VOL	VOL COUNTY HIGHLAND CTRY EST	1	0.24	0.46	2-127-0420ANG	0.90
7	68	278	VOL	VOL COUNTY - GLEN ABBEY OR SWALLO	1	0.14	0.77	2-127-0420AN	1.87
7	65	279	VOL	VOL COUNTY - LAKE MARIE	1	0.02	0.25	2-127-0420AN	0.75
47	48	280	WEK	UTILITIES OF FLA (LITTLE WEKIVA)	1	0.06	0.03	2-117-0117AN	0.45
51	42	281	WEK	UTILITIES OF FLA (BEAR LAKE)	1	0.41	0.08	2-117-0116AN	0.60
51	49	282	WEK	UTILITIES OF FLA (WEATHERSFIELD)	1	0.07	0.42	2-117-0114AN	1.50
54	41	283	WEK	UTILITIES OF FLA (JANSEN)	1	0.14	0.08	2-117-0115AN	0.60
54	55	284	WEK	UTILITIES OF FLA (OAKLAND SHORES)	1	0.88	0.16	2-117-0113AN	0.60
67	20	285	WGA	WINTER GARDEN (PALMETTO STREET)	1	0.28	0.63	2-095-0430AUVG	2.54
68	19	286	WGA	WINTER GARDEN (FULLER CROSS)	1	0.28	0.63	2-095-0430AUVG	0.75
69	19	287	WGA	WINTER GARDEN (BOYD STREET)	1	0.00	0.63	2-095-0430AUVG	1.73
68	20	288	WGA	WINTER GARDEN PROPOSED PLANT #4	2	1.87	1.87	2-095-0430AUVG	0.75
70	22	289	WGC	WINTER GARDEN CITRUS PRODUCTS	1	2.47	0.63	2-095-0045AU	1.88
63	58	290	WPK	WINTER PARK - PLANT #1 (SWOOPE)	1	2.42	2.26	2-095-0391ANVG	4.49
63	67	291	WPK	WINTER PARK PLANT #5 (UNIV.)	1	1.97	2.02	2-095-0391ANVG	6.73
58	63	292	WPK	WINTER PARK - PLANT #4 (MAGNOLIA)	2	2.94	3.24	2-095-0391ANVG	5.46
61	53	293	WPK	WINTER PARK - PLANT #3 (Wymore)	2	0.00	3.12	2-095-0391ANVG	4.49
63	58	294	WPK	WINTER PARK - PLANT #1 (SWOOPE)	2	2.54	1.44	2-095-0391ANVG	4.49

Table A3--*Continued*

Model Row	Model Column	Well ID Number	Public Supply Demand Area	Well or Treatment Plant	Model Layer	Year 1988 Withdrawal Rate (MGD)	Projected Year 2010 Withdrawal Rate (MGD)	*Well Application Number	Well Capacity (MGD)
63	67	295	WPK	WINTER PARK - PLANT #5 (UNIV.)	2	0.59	3.20	2-095-0391ANVG	6.73
37	64	296	WSP	WINTER SPRINGS (WTP #2)	1	0.31	0.71	2-117-0029ANGM	1.65
44	66	297	WSP	WINTER SPRINGS (WTP #3)	1	0.31	0.36	2-117-0029ANGM	1.65
44	67	298	WSP	WINTER SPRINGS (WTP #3)	1	1.76	1.56	2-117-0029ANGM	3.46
46	73	299	WSP	WINTER SPRNGS EAST 2	1	0.07	3.38	2-117-0214AUV	3.74
30	16	300	ZWF	ZELLWOOD FARMS	1	0.07	0.16	2-095-0251AU	0.37
30	17	301	ZWF	ZELLWOOD FARMS	1	0.17	0.16	2-095-0251AU	0.37
34	17	302	ZWU	ZELLWOOD WATER USERS	1	0.12	0.37	2-095-0276AU	0.75
35	20	303	ZSU	ZELLWOOD STATION UTIL.	1	0.06	0.31	2-095-0231AN	0.75
35	21	304	ZSU	ZELLWOOD STATION UTIL.	1	0.54	0.16	2-095-0231AN	0.75
35	22	305	ZSU	ZELLWOOD STATION UTIL.	1	0.12	0.80	2-095-0231AN	1.50
35	23	306	ZSU	ZELLWOOD STATION UTIL.	1	0.06	0.31	2-095-0231AN	0.75
36	19	307	ZSU	ZELLWOOD STATION UTIL.	1	0.06	0.16	2-095-0231AN	0.37
36	23	308	ZSU	ZELLWOOD STATION UTIL.	1	2.35	0.16	2-095-0231AN	0.37
17	14	309	MTD	CITY OF MT. DORA	1	1.16	4.45	2-069-0897AUVG	4.49
19	9	310	TAV	CITY OF TAVARES	1	0.09	3.36	2-069-0816ANV	3.74
9	71	311	FPL	FPL LAKE MONROE	1	0.32	0.15	2-127-0515AU	0.30
13	63	312	FPL	FLORIDA POWER & LIGHT-SANFORD POW	1	0.97	0.60	2-127-0545AU	1.20
68	1	313	IN1	B & W CANNING	1	2.18	1.11	2-069-0001AU	1.12
76	11	314	IN2	FLORIDA CRUSHED STONE	1	0.87	2.18	2-069-0004ANR	2.24
98	8	315	IN3	FLA. ROCK (LAKE SAND PLANT)	1	1.58	0.87		0.90
103	31	316	IN4	FLORIBRA USA, INC	1	0.71	1.58	49-00117&118 SFWM	1.65
36	5	317	IN6	SILVER SPRINGS CITRUS	1	0.31	0.71	2-069-0063AU	0.75
37	6	318	HOH	HOWEY-IN-THE-HILLS	1	0.61	0.45	2-069-0431AUNGM	0.45
59	54	319	EAT	EATONVILLE	1	0.12	1.41		1.50
62	12	320	MON	MONTEVERDE	1	1.28	0.22	2-069-0625AUMG	0.22
64	6	321	MHN	MINNEOLA HARBOR HILLS/12/13/88- P	1	1.00	2.01	2-069-0917ANM	2.02
67	84	322	CFR	CENT. FLA RES. PARK	1	0.19	1.00	2-095-0274ANGM	1.05
67	8	323	MIN	CITY OF MINNEOLA	1	0.29	0.45	2-069-1086AUVG	0.45
69	15	324	OAK	CITY OF OAKLAND	1	0.29	0.28	2-095-0366ANV	1.44
69	1	325	GRO	TOWN OF GROVELAND	1	1.24	0.79	2-069-0890ANVG	0.90
79	11	326	IN5	SILVER SAND (CLERMONT MINE)	1	0.30	1.24	2-069-0023AU	1.35
103	28	327	HHO	HYATT HOUSE ORLANDO	1	0.96	0.73	49-00021-W SFWMD	0.75
103	19	328	OSC	OSCEOLA SERVICE	1	0.80	2.28		2.39
108	133	329	AF1	USAF BAS CIVIL ENGINEER/8/12/86	1	0.53	0.80	2-009-0075AUGF	0.90
115	16	330	DAV	DAVENPORT (1987)	1	1.18	1.27	POLK COUNTY	1.35
118	15	331	HAI	HAINES CITY	1	0.05	2.80		2.99
4	69	332	JKV	JOHN KNOX VILL.	1	0.05	0.35	2-127-0387AN	0.37

Table A4. Volusia Public Supply Utility Wells

Public Supply Utility Well or Control Point Number	Simulation Model Row Number	Simulation Model Column Number	1988 Well Withdrawal Rate (MGD)	Projected Year 2010 Well Withdrawal Rate (MGD)	Hydraulic Capacity (MGD, LAW B.3.a)	Well Description	Public Supply Utility Need Area	Potential for Vegetative Harm
1	68	13	0.54	0.00	2.40	DELAND WATER UTIL	DWU	LOW
2	67	12	0.54	0.77	2.40	DELAND WATER UTIL	DWU	LOW
3	66	12	1.08	1.54	2.40	DELAND WATER UTIL	DWU	LOW
4	64	11	0.54	0.77	2.40	DELAND WATER UTIL	DWU	LOW
5	67	14	0.54	0.77	2.40	DELAND WATER UTIL	DWU	LOW
6	61	14	0.54	0.77	2.40	DELAND WATER UTIL	DWU	LOW
7	65	11	0.54	0.77	2.40	DELAND WATER UTIL	DWU	LOW
8	70	13	0.00	1.54	2.40	DELAND WU 1990	DWU	LOW
9	41	73	0.03	0.05	0.26	HOLLY HILL EASTERN WF	HHE	LOW
10	41	74	0.02	0.02	0.26	HOLLY HILL EASTERN WF	HHE	LOW
11	40	74	0.02	0.02	0.26	HOLLY HILL EASTERN WF	HHE	LOW
12	40	73	0.02	0.02	0.26	HOLLY HILL EASTERN WF	HHE	LOW
13	40	72	0.02	0.02	0.26	HOLLY HILL EASTERN WF	HHE	LOW
14	41	54	0.29	0.35	0.69	HOLLY HILL WESTERN WF	HHW	LOW
15	41	55	0.44	0.52	1.03	HOLLY HILL WESTERN WF	HHW	LOW
16	40	55	0.29	0.35	0.69	HOLLY HILL WESTERN WF	HHW	LOW
17	40	55	0.00	0.17	0.26	HOLLY HIIL PROPOSED	HHW	LOW
18	79	12	0.13	0.39	0.00	OR. CITY CTRY VILLAGE	OCC	LOW
19	81	65	0.10	0.22	0.00	SSU SUGAR MILL EST	SME	HIGH
20	64	42	0.27	0.29	0.33	PORT ORANGE WESTERN WF	POW	MODERATE
21	67	41	0.27	0.29	0.33	PORT ORANGE WESTERN WF	POW	MODERATE
22	68	40	0.53	0.57	0.33	PORT ORANGE WESTERN WF	POW	MODERATE
23	69	39	0.27	0.29	0.33	PORT ORANGE WESTERN WF	POW	MODERATE
24	70	39	0.27	0.29	0.33	PORT ORANGE WESTERN WF	POW	MODERATE
25	65	40	0.27	0.29	0.33	PORT ORANGE WESTERN WF	POW	MODERATE
26	66	39	0.27	0.29	0.33	PORT ORANGE WESTERN WF	POW	MODERATE
27	67	39	0.27	0.29	0.33	PORT ORANGE WESTERN WF	POW	MODERATE
28	68	39	0.27	0.29	0.33	PORT ORANGE WESTERN WF	POW	MODERATE
29	65	38	0.27	0.29	0.33	PORT ORANGE WESTERN WF	POW	MODERATE
30	66	38	0.53	0.57	0.33	PORT ORANGE WESTERN WF	POW	MODERATE
31	69	40	0.27	0.29	0.33	PORT ORANGE WESTERN WF	POW	MODERATE
32	67	38	0.27	0.29	0.33	PORT ORANGE WESTERN WF	POW	MODERATE
33	64	39	0.00	0.86	0.33	PORT ORANGE WEST PROP	POW	MODERATE
34	69	38	0.00	0.86	0.33	PORT ORANGE WEST PROP	POW	MODERATE
35	40	26	0.00	0.29	0.33	PORT ORANGE WEST PROP	POW	MODERATE
36	39	24	0.00	0.29	0.33	PORT ORANGE WEST PROP	POW	MODERATE
37	41	28	0.00	0.29	0.33	PORT ORANGE WEST PROP	POW	MODERATE
38	38	27	0.00	0.29	0.33	PORT ORANGE WEST PROP	POW	MODERATE
39	37	25	0.00	0.29	0.33	PORT ORANGE WEST PROP	POW	MODERATE
40	39	29	0.00	0.29	0.33	PORT ORANGE WEST PROP	POW	MODERATE
41	42	25	0.00	0.29	0.33	PORT ORANGE WEST PROP	POW	MODERATE
42	41	23	0.00	0.29	0.33	PORT ORANGE WEST PROP	POW	MODERATE
43	43	27	0.00	0.29	0.33	PORT ORANGE WEST PROP	POW	MODERATE
44	68	66	0.12	0.26	0.33	PORT ORANGE EASTERN WF	POE	LOW
45	68	65	0.03	0.07	0.33	PORT ORANGE EASTERN WF	POE	LOW

Table A4--*Continued*

Public Supply Utility Well or Control Point Number	Simulation Model Row Number	Simulation Model Column Number	1988 Well Withdrawal Rate (MGD)	Projected Year 2010 Well Withdrawal Rate (MGD)	Hydraulic Capacity (MGD, LAW B.3.a)	Well Description	Public Supply Utility Need Area	Potential for Vegetative Harm
46	66	66	0.03	0.07	0.33	PORT ORANGE EASTERN WF	POE	LOW
47	66	67	0.10	0.20	0.33	PORT ORANGE EASTERN WF	POE	LOW
48	65	66	0.06	0.13	0.33	PORT ORANGE EASTERN WF	POE	LOW
49	65	65	0.06	0.13	0.33	PORT ORANGE EASTERN WF	POE	LOW
50	84	11	0.49	0.75	1.03	DELTONA	DEL	LOW
51	84	9	0.49	0.75	1.03	DELTONA	DEL	LOW
52	83	13	0.49	0.75	1.03	DELTONA	DEL	LOW
53	86	13	0.49	0.75	1.03	DELTONA	DEL	LOW
54	84	10	0.97	1.51	2.06	DELTONA	DEL	LOW
55	85	12	1.46	2.26	3.10	DELTONA	DEL	LOW
56	84	18	0.49	0.75	1.03	DELTONA	DEL	LOW
57	85	12	0.49	0.75	1.03	DELTONA	DEL	LOW
58	83	18	0.49	0.75	1.03	DELTONA	DEL	LOW
59	84	18	0.49	0.75	1.03	DELTONA	DEL	LOW
60	81	12	0.49	0.75	1.03	DELTONA	DEL	LOW
61	85	17	0.49	0.75	1.03	DELTONA	DEL	LOW
62	81	16	0.00	0.75	1.03	DELT - PROPOSED	DEL	MODERATE
63	81	18	0.00	1.51	2.06	DELT - PROPOSED	DEL	LOW
64	82	15	0.00	0.75	1.03	DELT - PROPOSED	DEL	LOW
65	83	17	0.00	0.75	1.03	DELT - PROPOSED	DEL	LOW
66	84	9	0.00	0.75	1.03	DELT - PROPOSED	DEL	LOW
67	84	10	0.00	0.75	1.03	DELT - PROPOSED	DEL	LOW
68	84	11	0.00	1.51	2.06	DELT - PROPOSED	DEL	LOW
69	85	17	0.00	0.75	1.03	DELT - PROPOSED	DEL	LOW
70	86	11	0.00	0.75	1.03	DELT - PROPOSED	DEL	LOW
71	86	15	0.00	2.26	3.10	DELT - PROPOSED	DEL	LOW
72	87	13	0.00	0.75	1.03	DELT - PROPOSED	DEL	LOW
73	87	15	0.00	0.75	1.03	DELT - PROPOSED	DEL	LOW
74	87	16	0.00	1.51	2.06	DELT - PROPOSED	DEL	LOW
75	75	54	0.16	0.08	0.00	SPRUCE CREEK	SPC	LOW
76	75	55	0.16	0.08	0.00	SPRUCE CREEK	SPC	LOW
77	75	54	0.00	0.16	0.22	SPRUCE CREEK PROP	SPC	LOW
78	75	55	0.00	0.08	0.22	SPRUCE CREEK PROP	SPC	LOW
79	79	40	0.59	0.88	1.15	NEW SMYRNA SAMSULA WF	NSS	LOW
80	80	41	0.59	0.88	1.15	NEW SMYRNA SAMSULA WF	NSS	LOW
81	80	42	0.30	0.44	1.15	NEW SMYRNA SAMSULA WF	NSS	MODERATE
82	80	43	0.30	0.44	1.15	NEW SMYRNA SAMSULA WF	NSS	MODERATE
83	86	64	1.19	1.76	2.29	NEW SMYRNA GLENCOE WF	NSG	MODERATE
84	86	65	0.89	1.32	1.15	NEW SMYRNA GLENCOE WF	NSG	MODERATE
85	78	36	0.00	0.44	1.15	NSB - PROPOSED	NS4	MODERATE
86	78	35	0.00	0.44	1.15	NEW SMYRNA SR 44	NS4	MODERATE
87	77	36	0.00	1.76	2.29	NEW SMYRNA SR 44	NS4	MODERATE
88	51	58	0.59	1.51	2.18	DAYTONA BEACH EASTERN WF	DBE	MODERATE
89	51	57	0.59	1.21	1.09	DAYTONA BEACH EASTERN WF	DBE	MODERATE
90	51	56	0.59	1.21	1.09	DAYTONA BEACH EASTERN WF	DBE	MODERATE

Table A4--*Continued*

Public Supply Utility Well or Control Point Number	Simulation Model Row Number	Simulation Model Column Number	1988 Well Withdrawal Rate (MGD)	Projected Year 2010 Well Withdrawal Rate (MGD)	Hydraulic Capacity (MGD, LAW B.3.a)	Well Description	Public Supply Utility Need Area	Potential for Vegetative Harm
91	50	52	1.17	3.25	3.27	DAYTONA BEACH EASTERN WF	DBE	MODERATE
92	50	51	0.93	1.47	2.18	DAYTONA BEACH WESTERN WF	DBW	MODERATE
93	49	50	0.93	1.76	2.18	DAYTONA BEACH WESTERN WF	DBW	MODERATE
94	58	46	0.93	0.27	1.09	DAYTONA BEACH WESTERN WF	DBW	MODERATE
95	58	45	1.87	0.94	1.09	DAYTONA BEACH WESTERN WF	DBW	MODERATE
96	58	44	0.93	0.49	1.09	DAYTONA BEACH WESTERN WF	DBW	MODERATE
97	58	43	0.93	0.21	1.09	DAYTONA BEACH WESTERN WF	DBW	MODERATE
98	58	42	0.93	0.41	1.09	DAYTONA BEACH WESTERN WF	DBW	MODERATE
99	57	43	0.93	0.33	1.09	DAYTONA BEACH WESTERN WF	DBW	MODERATE
100	56	43	0.93	0.32	1.09	DAYTONA BEACH WESTERN WF	DBW	LOW
101	55	42	0.93	0.63	1.09	DAYTONA BEACH WESTERN WF	DBW	LOW
102	53	42	0.00	0.31	1.09	DAYTONA WEST. 1988	DBW	LOW
103	52	42	0.00	2.32	3.27	DAYTONA WEST. 1988	DBW	LOW
104	51	43	0.00	0.40	1.09	DAYTONA WEST. 1988	DBW	LOW
105	50	43	0.00	1.63	2.18	DAYTONA WEST. 1988	DBW	LOW
106	49	43	0.00	0.48	1.09	DAYTONA WEST. 1988	DBW	MODERATE
107	57	41	0.00	0.55	1.09	DAYTONA WEST. 1988	DBW	MODERATE
108	54	43	0.00	0.53	1.09	DAYTONA WEST. 1988	DBW	LOW
109	53	43	0.00	0.27	1.09	DAYTONA WEST. 1988	DBW	MODERATE
110	31	73	0.45	0.46	0.32	ORMOND BEACH DIVISION	OBD	LOW
111	32	72	0.90	0.92	0.96	ORMOND BEACH DIVISION	OBD	LOW
112	31	70	0.23	0.23	0.32	ORMOND BEACH DIVISION	OBD	LOW
113	32	70	0.23	0.23	0.32	ORMOND BEACH DIVISION	OBD	LOW
114	32	69	0.23	0.23	0.32	ORMOND BEACH DIVISION	OBD	LOW
115	31	73	0.23	0.23	0.32	ORMOND BEACH DIVISION	OBD	LOW
116	31	72	0.23	0.23	0.32	ORMOND BEACH DIVISION	OBD	LOW
117	31	70	0.23	0.23	0.32	ORMOND BEACH DIVISION	OBD	LOW
118	29	64	0.63	0.23	0.32	ORMOND BEACH SR 40	OB4	LOW
119	30	61	0.63	0.23	0.32	ORMOND BEACH SR 40	OB4	LOW
120	28	65	0.00	0.23	0.32	ORMOND BEACH SR 40	OB4	MODERATE
121	29	65	0.00	0.23	0.32	ORMOND BEACH SR 40	OB4	MODERATE
122	30	59	0.63	0.23	0.32	ORMOND BEACH SR 40	OB4	LOW
123	25	52	0.00	0.46	0.64	ORMOND BEACH HUDSON	OBH	LOW
124	24	52	0.00	0.23	0.32	ORMOND BEACH HUDSON	OBH	LOW
125	23	53	0.00	0.46	0.64	ORMOND BEACH HUDSON	OBH	LOW
126	22	53	0.00	0.46	0.64	ORMOND BEACH HUDSON	OBH	LOW
127	24	53	0.00	0.23	0.32	ORMOND BEACH HUDSON	OBH	LOW
128	24	54	0.00	0.23	0.32	ORMOND BEACH HUDSON	OBH	LOW
129	23	54	0.00	0.23	0.32	ORMOND BEACH HUDSON	OBH	LOW
130	22	55	0.00	0.23	0.32	ORMOND BEACH HUDSON	OBH	LOW
131	24	52	0.00	0.23	0.32	ORMOND BEACH HUDSON	OBH	LOW
132	23	51	0.00	0.23	0.32	ORMOND BEACH HUDSON	OBH	LOW
133	32	43	0.00	0.23	0.32	ORMOND BEACH RIMA PROP	OBR	LOW
134	31	44	0.00	0.23	0.32	ORMOND BEACH RIMA PROP	OBR	LOW
135	78	10	0.05	0.14	0.00	JOHN KNOX VILL.	JKV	LOW

Table A4--*Continued*

Public Supply Utility Well or Control Point Number	Simulation Model Row Number	Simulation Model Column Number	1988 Well Withdrawal Rate (MGD)	Projected Year 2010 Well Withdrawal Rate (MGD)	Hydraulic Capacity (MGD, LAW B.3.a)	Well Description	Public Supply Utility Need Area	Potential for Vegetative Harm
136	80	8	0.20	0.32	0.00	V CTY - FOUR TOWNS	VFT	LOW
137	79	8	0.20	0.32	0.00	V CTY - FOUR TOWNS	VFT	LOW
138	80	9	0.14	0.16	0.00	V CTY - BREEZEWOOD	VFT	LOW
139	83	6	0.14	0.25	0.00	V CTY - LAKE MARIE	VLM	LOW
140	81	7	0.09	0.52	0.00	V CTY - TERRA ALTA	VTA	LOW
141	77	7	0.01	0.01	0.00	V CTY - W ORANGE CITY	VTA	LOW
142	55	14	0.46	0.82	0.00	DELAND - BRANDYWINE	DEB	MODERATE
143	55	13	0.01	0.02	0.00	DELAND - SPRING GARDEN	DEB	MODERATE
143	55	13	0.01	0.02	0.00	DELAND - SPRING GARDEN	DEB	LOW
144	54	12	0.02	0.03	0.00	DELAND - GLENWOOD EST	DEB	LOW
145	51	14	0.06	0.16	0.00	DELAND - WOODLAND MANOR	DWW	MODERATE
146	74	13	0.12	0.26	0.00	DELAND - LONGLEAF PLANT.	DHH	LOW
147	72	10	0.05	0.10	0.00	DELAND - HOLIDAY HILLS	DHH	LOW
148	77	17	0.05	0.09	0.00	ELLWOOD TITCOMB	ETI	MODERATE
149	87	68	0.28	0.85	0.00	CITY OF EDGEWATER	EDG	MODERATE
150	87	67	0.42	1.27	0.00	CITY OF EDGEWATER	EDG	MODERATE
152	88	59	0.42	1.27	0.00	CITY OF EDGEWATER	EDG	LOW
153	88	63	0.28	0.85	0.00	CITY OF EDGEWATER	EDG	LOW
154	27	59	0.09	0.18	0.00	TYMBER CREEK UTIL.	TCU	LOW
155	26	54	0.32	0.58	0.00	THE TRAILS INC.	TTI	LOW
156	77	16	0.11	0.29	0.00	LAKE HELEN	LHE	LOW
157	76	16	0.11	0.29	0.00	LAKE HELEN	LHE	LOW
158	90	74	0.06	0.10	0.00	HACIENDA DEL RIO	HDR	LOW
159	15	72	0.03	0.06	0.00	NATIONAL GARDENS	NGA	LOW
160	15	73	0.03	0.06	0.00	NATIONAL GARDENS	NGA	LOW
161	16	71	0.10	0.17	0.00	NATIONAL GARDENS	NGA	LOW
162	16	72	0.02	0.04	0.00	NATIONAL GARDENS	NGA	LOW
163	17	71	0.03	0.06	0.00	NATIONAL GARDENS	NGA	LOW
164	78	9	0.51	3.65	0.00	ORANGE CITY	OCY	LOW
165	14	65	0.07	0.13	0.00	SUNSHINE HOLIDAY PK	SHP	LOW
166	6	60	0.04	0.08	0.00	PLANTATION BAY	PTB	MODERATE
167	7	60	0.02	0.04	0.00	PLANTATION BAY	PTB	LOW
168	68	8	0.16	0.33	0.00	L BERESFORD WATER ASSN	LBW	LOW
169	86	8	0.10	0.10	0.00	FPL - TURNER POWER PLNT	FPT	HIGH
170	64	16	0.10	0.10	0.00	SHERWOOD MEDICAL CO.	SMC	LOW
171	63	17	0.05	0.05	0.00	SHERWOOD MEDICAL CO.	SMC	LOW
172	85	4	0.08	0.08	0.00	FPL - SANFORD PWR PLNT	FPS	LOW
173	85	5	0.08	0.08	0.00	FPL - SANFORD PWR PLNT	FPS	LOW
174	80	7	0.08	0.08	0.00	FPL - SANFORD PWR PLNT	FPS	LOW
175	81	7	0.08	0.08	0.00	FPL - SANFORD PWR PLNT	FPS	LOW
176	50	40	0.23	0.23	0.00	TOMOKA CORR. FACILITY	TCF	MODERATE
177	76	8	0.20	0.20	0.00	V CTY GOVT COMPLEX	VGC	LOW

Table A5. Reclaimed water sites for east-central and Volusia regions

County	Reference Number, PBSJ	WWTP Name	Decision Model	Decision Model Identifier	Disinfection Level	Filters	Reclaimed Water Availability, MGD
Brevard	8	Brevard County North			basic	N	0.27
Brevard	9	Brevard County Port St. John		psj	intermediate	N	0.24
Brevard	11	Brevard County South Beaches			basic	N	5.92
Brevard	12	Brevard County South Central			high	Y	0.83
Brevard	13	Cape Canaveral			basic	N	1.16
Brevard	14	Cocoa Beach			high	Y	0
Brevard	15	Cocoa	ECF	coc	high	Y	1.67
Brevard	16	Snug Harbor			basic	N	0
Brevard	17	Florida Cities Water, Inc.			basic	N	0.6
Brevard	18	Kennedy Space Center			basic	N	0
Brevard	19	Melbourne			high	N	2.32
Brevard	20	Melbourne			high	Y	3.53
Brevard	21	Palm Bay Utilities Commision			high	Y	1.67
Brevard	22	Rockledge			basic	N	1
Brevard	23	The Lakes of Melbourne			basic	N	0.06
Brevard	24	Titusville		tin	high	N	0.06
Brevard	25	Titusville			basic	N	1.8
Brevard	26	USAF			basic	N	0
Brevard	27	USAF			basic	N	0.13
Brevard	28	Walter T. Murphy NASA			basic	N	0.18
Brevard	29	Walter T. Murphy NASA			basic	N	0.04
Brevard	30	Walter T. Murphy NASA			basic	N	0.11
Brevard	31	West Melbourne			basic	N	1.06
Lake	88	John Boll	ECF	oak	basic	N	0
Lake	89	Clerbook RV Resorts	ECF		basic	N	0.05
Lake	90	Clermont	ECF	cle	basic	N	0.77
Lake	91	Eustis	ECF	eus	intermediate	N	0
Lake	92	Florida Dept. of Corrections	ECF	fdc	basic	N	0
Lake	93	Groveland	ECF	gro	basic	N	0.04
Lake	94	Lakewood Dev.	ECF		basic	N	0
Lake	95	Leesburg	ECF		intermediate	N	0
Lake	96	MHC Corp.	ECF		basic	N	0.13
Lake	97	Mount Dora	ECF	mtd	basic	N	0
Lake	98	Florida Water Services	ECF		basic	N	0.09
Lake	99	Southlake Utils.	ECF	slu	basic	N	0
Lake	100	Sunbelt Utils.	ECF		basic	N	0
Lake	101	Tavares	ECF	tvc	basic	N	0.54
Lake	102	Tavares	ECF	tvw	basic	N	0.38
Lake	103	Thousand Trails, Inc.	ECF	tht	basic	N	0.03
Lake	104	Umatilla	ECF	uma	basic	N	0
Lake	105	Village Center Comm. Dev. Distr.	ECF		basic	Y	0.68
Lake	106	Wilder Corporation	ECF		basic	N	0.02
Orange	124	Apopka	ECF	apo	high	Y	0.4
Orange	125	Dale Whittington	ECF		basic	N	0
Orange	126	Econ Utilites/Wedgefield	ECF	ecu	high	N	0
Orange	127	Fairways MHP	ECF	fmh	high	N	0
Orange	128	Ocoee	ECF	oco	basic	N	0.8
Orange	129	OCPUD East	ECF	oce	high	Y	5.12
Orange	130	OCPUD Meadow Woods	ECF	ocm	high	Y	0.1
Orange	131	OCPUD South	ECF	ocs	high	N	0

Table A5--*Continued*

County	Reference Number, PBSJ	WWTP Name	Decision Model	Decision Model Identifier	Disinfection Level	Filters	Reclaimed Water Availability, MGD
Orange	132	OCPUD Cypress Walk	ECF	occ	high	Y	0.1
Orange	133	OCPUD Northwest	ECF	ocn	basic	N	2.82
Orange	134	Orlando Fl Hotel Limited	ECF	hoj	basic	N	0.09
Orange	135	OUC Lake Nona	ECF	lan	high	Y	0
Orange	136	OUC Conserv I	ECF	or1	high	Y	1.41
Orange	137	OUC Conserv II	ECF	or2	high	Y	4.7
Orange	138	Park Manor Water Works	ECF	pam	basic	Y	0.28
Orange	139	Reeco Properties	ECF	rsm	basic	N	0.12
Orange	140	Reedy Creek Imp. Distr.	ECF	rcu	high	Y	6.73
Orange	141	Florida Water Service U. Shores #1	ECF		basic	Y	0.17
Orange	142	Florida Water Service U. Shores #2	ECF		basic	N	0
Orange	143	Starlight Ranch MHP	ECF	str	basic	N	0
Orange	144	UCF	ECF	ucf	basic	N	0
Orange	145	Winter Garden	ECF	wg1/wg2	basic	Y	1.37
Orange	146	Winter Park	ECF	wpk	high	N	0.1
Orange	147	Zellwood Station Coop.	ECF	zsc	basic	N	0.1
Seminole	166	Alafaya Utilities	ECF	alu	high	Y	0.18
Seminole	167	Altamonte Springs	ECF	alt	high	Y	3.74
Seminole	168	Casselberry	ECF	cas	high	N	0.41
Seminole	169	Longwood	ECF	lon	basic	N	0.43
Seminole	170	Orlando Iron Bridge	ECF	orf	basic	Y	27.16
Seminole	171	Palm Valley Assoc.	ECF	pvm	basic	N	0.11
Seminole	172	Sanford	ECF	saf	high	Y	0
Seminole	173	Sanlando Des Pinar/Woodlands	ECF	woo	basic	N	0.48
Seminole	174	Sanlando Wekiva Hunt Club	ECF	whc	basic	N	2.25
Seminole	175	Seminole County Greewood	ECF	gwl	high	Y	1.37
Seminole	176	Seminole County Northwest	ECF	sen	high	Y	0
Seminole	177	Florida Water Services Chuluota	ECF	chu	basic	N	0
Seminole	178	Utils. Inc--Lincoln Heights	ECF	lih	basic	N	0.08
Seminole	179	Utils Inc--Wethersfield	ECF		basic	N	0.11
Seminole	180	Winter Springs	ECF	wse	high	Y	0.5
Seminole	181	Winter Springs	ECF	wsw	high	Y	0.88
Volusia	182	Daytona Beach Bethune	VOL	dbb	high	Y	6.33
Volusia	183	Daytona Beach Regional	VOL	dbw	high	Y	1.5
Volusia	184	Deland Brandy Trails	VOL	deb	basic	N	0
Volusia	185	Deland Regional	VOL	der	high	Y	2.39
Volusia	186	Edgewater	VOL	edg	high	Y	0.87
Volusia	187	Holly Hill	VOL	hhc	low	Y	0.28
Volusia	188	Indian River Utilites	VOL	irh	basic	N	0
Volusia	190	New Smyrna Beach Utilites Comm.	VOL	nsb	high	N	1.74
Volusia	191	Ormond Beach Breakaway Trails	VOL	obb	high	N	0
Volusia	192	Ormond Beach	VOL	obo	high	Y	3.35
Volusia	193	Port Orange	VOL	por	high	Y	4.04
Volusia	194	Florida Water Service Deltona	ECF,VOL		basic	N	0
Volusia	195	Tymber Creek	VOL	tcs	basic	N	0
Volusia	196	Vol. County Deltona North	ECF,VOL	vod/vdn	basic	N	0.31
Volusia	197	Vol County Four Towns	ECF,VOL	vof/vft	basic	N	0.2
Volusia	198	Vol County SW Regional	ECF,VOL	vsr	high	Y	0.3
Volusia	199	Vol. County Spruce Creek	ECF,VOL	vsc	basic	N	0.17
		Total					108.97

Table A6. East-central LP optimization model results for control points

		Simulation Model			Drawdowns (ft)								
					Case 3			Case 2			Case 1		
Control Point Number	High or moderate potential for vegetative harm	Row	Column	Public Supply Utility Demand Area	Modflow	Gams	Error	Modflow	Gams	Error	Modflow	Gams	Error
1	yes	46	58	ALTAMONTE SPR. (NEW CHARLOTTE)	0.9	0.0	0.9	1.2	0.4	0.8	1.5	0.8	0.7
2	yes	49	48	ALTAMONTE SPR. (PLANT #4)	0.5	0.0	0.5	0.8	0.4	0.4	1.2	0.8	0.3
3	yes	52	45	ALTAMONTE SPR. (PLANT #5)	-0.6	-1.0	0.4	-0.1	-0.5	0.4	0.3	0.0	0.3
4		53	55	ALTAMONTE SPR. (PLANT #2)	-0.3	-1.1	0.7	0.1	-0.6	0.7	0.9	0.3	0.6
5		54	55	ALTAMONTE SPRINGS (PLANT #2)	-0.3	-1.0	0.7	0.1	-0.6	0.7	0.8	0.3	0.6
6	yes	43	31	APOPKA - GROSSENBACHER WF.	0.0	-0.2	0.2	0.7	0.5	0.2	1.1	0.9	0.2
7	yes	37	27	APOPKA - PROPOSED NORTHWEST WF	0.1	0.0	0.2	0.6	0.5	0.1	1.0	0.9	0.1
8	yes	45	27	APOPKA - PROPOSED SOUTHWEST WF	0.2	0.0	0.2	0.6	0.4	0.2	0.9	0.8	0.1
9	yes	46	63	CASSELBERRY (NORTH WTP; WELL N240	0.7	-0.6	1.3	1.0	-0.2	1.2	1.4	0.4	1.0
10	yes	53	64	CASSELBERRY (HOWELL PARK WTP; WEL	0.4	-0.9	1.3	0.8	-0.4	1.2	1.8	0.7	1.0
11	yes	59	66	CASSELBERRY (SOUTH WTP; WELL S360	-0.5	-1.4	1.0	-0.1	-1.0	0.9	0.5	-0.3	0.8
12		68	8	CLERMONT (GRAND)	0.3	0.3	0.0	0.4	0.4	0.0	0.5	0.5	0.0
13		92	94	COCOA (WELL #14)	-3.7	-4.0	0.2	-3.5	-3.7	0.2	-3.3	-3.5	0.2
14		93	93	COCOA (WELL #16)	-6.8	-7.0	0.2	-6.6	-6.8	0.2	-6.4	-6.6	0.2
15		93	92	COCOA (WELL #17)	-5.5	-5.8	0.2	-5.3	-5.6	0.2	-5.1	-5.3	0.2
16		94	92	COCOA (WELL #18)	-5.0	-5.3	0.2	-4.8	-5.1	0.2	-4.6	-4.8	0.2
17		96	92	COCOA (WELL #19)	-2.7	-3.0	0.2	-2.5	-2.8	0.2	-2.4	-2.6	0.2
18		97	92	COCOA PROP. WELL 20	-0.9	-1.1	0.2	-0.7	-1.0	0.2	-0.6	-0.8	0.2
19		98	92	COCOA PROP. WELL 22	1.1	0.9	0.2	1.3	1.1	0.2	1.4	1.2	0.2
20		99	92	COCOA PROP. WELL 32	3.3	3.1	0.2	3.4	3.2	0.2	3.4	3.3	0.2
21		99	101	COCOA PROP. WELL 39	5.8	5.6	0.2	5.8	5.6	0.2	5.8	5.6	0.1
22		100	92	COCOA PROP. WELL 33	6.2	6.1	0.2	6.2	6.1	0.2	6.2	6.1	0.1
23		100	101	COCOA PROP. WELL 41	5.6	5.5	0.2	5.7	5.5	0.1	5.6	5.5	0.1
24		101	101	COCOA PROP. WELL 43	6.0	5.9	0.1	6.0	5.9	0.1	6.0	5.9	0.1
25		102	101	COCOA PROP. WELL 44	6.1	6.0	0.1	6.1	6.0	0.1	6.1	6.0	0.1
26		88	60	SO. STATES UTIL (DAETWYLER SHORES	4.1	3.8	0.3	4.5	4.2	0.3	4.8	4.6	0.3
27	yes	4	88	DELTONA	0.1	0.0	0.1	0.3	0.3	0.0	0.5	0.5	0.0
28		7	78	DELTONA	0.1	-0.1	0.1	0.5	0.4	0.1	0.9	0.9	0.1
29		7	74	DELTONA-PROPOSED	0.6	0.5	0.1	1.2	1.1	0.1	1.8	1.8	0.1
30	yes	8	83	DELTONA-PROPOSED	0.1	0.0	0.1	0.3	0.2	0.1	0.5	0.5	0.1
31	yes	9	88	DELTONA-PROPOSED	0.0	0.0	0.1	0.2	0.1	0.1	0.3	0.2	0.1
32		77	104	ECON UTIL (WEDGEFIELD)	2.2	1.9	0.3	2.5	2.2	0.3	2.8	2.6	0.3
33		12	12	EUSTIS (C R 44A ?)	2.0	2.0	0.0	2.0	2.0	0.0	2.1	2.1	0.0
34		12	13	EUSTIS (C R 44A ?)	1.3	1.2	0.0	1.3	1.3	0.0	1.4	1.4	0.0
35		15	11	EUSTIS (ARDICE PLACE)	1.8	1.8	0.0	1.9	1.9	0.0	2.0	2.0	0.0
36		104	47	CITY OF KISSIMMEE (NORTH BERMUDA)	5.2	5.0	0.1	5.3	5.2	0.1	5.5	5.3	0.1
37	yes	28	59	LAKE MARY (NEW PUBLIC SUPPLY)	1.0	0.0	1.0	1.2	0.4	0.9	1.5	0.7	0.8
38	yes	29	59	LAKE MARY (NEW PUBLIC SUPPLY)	0.8	-0.1	1.0	1.1	0.3	0.9	1.4	0.6	0.8
39	yes	39	57	LONGWOOD	0.0	-0.7	0.7	0.4	-0.3	0.7	1.3	0.8	0.6
40	yes	55	60	MAITLAND - THISTLE LANE	-0.3	-1.3	0.9	0.1	-0.8	0.9	1.3	0.6	0.7
41	yes	57	50	MAITLAND - KELLER	-0.3	-0.8	0.5	0.1	-0.4	0.5	0.6	0.3	0.4
42	yes	65	87	OCPUD EAST REG: (BONNEVILLE)	0.6	-0.4	1.0	0.9	0.0	0.9	1.2	0.4	0.8

Table A6--*Continued*

		Simulation Model			Drawdowns (ft)								
						Case 3			Case 2			Case 1	
Control Point Number	High or moderate potential for vegetative harm	Row	Column	Public Supply Utility Demand Area	Modflow	Gams	Error	Modflow	Gams	Error	Modflow	Gams	Error
43	yes	72	75	OCPUD EAST REG: (ECON)	-1.2	-1.9	0.7	-0.8	-1.5	0.7	-0.4	-1.0	0.6
44	yes	79	74	OCPUD EAST REG: ERWF	0.4	-0.2	0.6	0.7	0.2	0.5	1.1	0.7	0.5
45	yes	82	66	OCPUD EAST REG: (CONWAY)	0.5	0.0	0.5	0.9	0.4	0.5	1.3	0.9	0.4
46		94	73	OCPUD EAST REG: (LAKE NONA)	4.2	3.9	0.3	4.4	4.2	0.3	4.6	4.4	0.2
47	yes	63	33	OCOEE (HACKNEY PRAIRIE)	-0.1	-0.4	0.3	0.4	0.2	0.3	0.8	0.6	0.2
48	yes	65	29	OCOEE (JAMELA & WURST ROAD)	-0.1	-0.4	0.3	0.4	0.2	0.2	0.8	0.6	0.2
49	yes	68	27	OCOEE (KISSIMEE AVE)	0.0	-0.3	0.2	0.6	0.3	0.2	0.9	0.7	0.2
50		73	28	OCOEE (SOUTH PLANT)	0.3	0.0	0.2	0.9	0.7	0.2	1.3	1.1	0.2
51		94	41	OCPUD SOUTH REG: (ORANGE WOOD)	6.7	6.5	0.2	6.9	6.7	0.2	7.4	7.2	0.2
52		100	30	OCPUD SOUTH REG: (CYPRESS WALK)	5.3	5.2	0.2	5.0	4.9	0.2	5.0	4.9	0.1
53		100	56	OCPUD SOUTH REG: (MEADOW WOODS)	7.7	7.4	0.2	7.7	7.4	0.2	7.5	7.3	0.2
54		101	46	OCPUD SOUTH REG: (HUNTERS CREEK)	7.6	7.4	0.2	7.8	7.6	0.2	8.1	8.0	0.2
55		101	32	OCPUD SOUTH REG: (VISTANA)	7.6	7.4	0.2	6.9	6.8	0.2	6.9	6.8	0.1
56		101	54	OCPUD SOUTH REG: SOUTH REG. WELL	6.9	6.7	0.2	7.1	6.9	0.2	7.2	7.1	0.2
57		28	31	OCPUD WEST REG: (MT. PLYMOUTH LAK	0.5	0.5	0.1	0.7	0.6	0.1	0.8	0.8	0.1
58	yes	38	25	OCPUD WEST REG: (PLYMOUTH)	0.1	0.0	0.1	0.6	0.5	0.1	1.1	1.0	0.1
59	yes	43	38	OCPUD WEST REG: (BENT OAKS)	0.2	-0.1	0.3	0.5	0.3	0.2	0.7	0.5	0.2
60	yes	56	46	OCPUD - RIVERSIDE	-0.4	-0.8	0.4	0.1	-0.3	0.4	0.5	0.2	0.3
61	yes	65	21	OCPUD WEST REG: (MAGNOLIA WOODS)	0.1	-0.1	0.2	0.6	0.4	0.2	0.9	0.7	0.2
62	yes	72	36	OCPUD WEST REGIONAL (OAK MEADOWS)	0.3	0.0	0.3	0.9	0.6	0.3	1.4	1.2	0.2
63		81	36	OCPUD WEST REG: (HIDDEN SPRINGS)	0.8	0.5	0.3	1.6	1.3	0.2	2.1	1.9	0.2
64		82	36	OCPUD WEST REG: (HIDDEN SPRINGS)	0.9	0.7	0.3	1.8	1.6	0.3	2.3	2.1	0.2
65	yes	55	35	OCPUD WEST REG: WRWF WELL # 1	0.0	-0.3	0.3	0.4	0.2	0.3	0.8	0.6	0.2
66	yes	55	36	OCPUD WEST REG: WRWF WELL # 1	0.0	-0.3	0.3	0.5	0.2	0.3	0.8	0.6	0.2
67		82	36	OCPUD WEST REG: (HIDDEN SPRINGS)	0.9	0.7	0.3	1.8	1.6	0.3	2.3	2.1	0.2
68		4	68	ORANGE CITY	1.3	1.3	0.1	1.5	1.5	0.0	1.6	1.6	0.0
69		104	59	ORANGE/OSCEOLA (BEUNAVENTURA LAKE	6.6	6.5	0.2	6.8	6.6	0.2	6.9	6.8	0.1
70		83	90	OUC-STANTON ENERGY CTR.	0.7	0.2	0.4	1.0	0.5	0.4	1.3	1.0	0.4
71		87	35	OUC (DR. PHILLIPS)	0.5	0.3	0.2	2.7	2.5	0.2	3.1	2.9	0.2
72		88	41	OUC (MARTIN)	7.6	7.4	0.3	6.0	5.8	0.3	7.6	7.4	0.2
73		68	55	OUC - HIGHLAND	-0.4	-0.9	0.6	0.1	-0.5	0.5	0.7	0.3	0.4
74	yes	68	64	OUC - NAVY	-0.4	-1.1	0.7	0.0	-0.6	0.7	0.6	0.0	0.6
75	yes	68	40	OUC - PINE HILLS	0.2	-0.2	0.4	0.7	0.3	0.3	1.2	1.0	0.3
76		69	55	OUC - HIGHLAND	-0.3	-0.9	0.6	0.1	-0.4	0.5	0.8	0.3	0.5
77		69	41	OUC - PINE HILLS	0.3	-0.1	0.4	0.8	0.4	0.3	1.3	1.1	0.3
78	yes	70	55	OUC - HIGHLAND	-0.3	-0.9	0.5	0.1	-0.4	0.5	0.8	0.4	0.5
79	yes	72	60	OUC - PRIMROSE	-0.1	-0.7	0.6	0.3	-0.3	0.6	0.9	0.4	0.5
80		73	59	OUC - PRIMROSE SFWMD?	-0.1	-0.7	0.6	0.3	-0.2	0.6	0.9	0.4	0.5
81	yes	76	54	OUC - KUHL	0.2	-0.3	0.4	0.7	0.3	0.4	1.3	0.9	0.4
82	yes	77	62	OUC - CONWAY	0.3	-0.2	0.6	0.8	0.2	0.5	1.2	0.7	0.5
83		78	62	OUC - CONWAY	0.4	-0.2	0.6	0.9	0.3	0.5	1.3	0.8	0.5
84	yes	80	67	OUC (PERSHING)	0.5	-0.1	0.6	0.9	0.3	0.5	1.3	0.8	0.5

Table A6--*Continued*

		Simulation Model			Drawdowns (ft)								
						Case 3			Case 2			Case 1	
Control Point Number	High or moderate potential for vegetative harm	Row	Column	Public Supply Utility Demand Area	Modflow	Gams	Error	Modflow	Gams	Error	Modflow	Gams	Error
85		80	40	OUC - KIRKMAN	1.1	0.8	0.3	1.7	1.4	0.3	2.3	2.1	0.2
86		88	53	OUC - SKY LAKE	6.3	6.0	0.3	6.6	6.3	0.3	7.1	6.8	0.3
87		98	55	OUC (ORANGE)	7.3	7.1	0.3	7.5	7.3	0.2	7.7	7.5	0.2
88	yes	51	82	OVIEDO (PLNT #1)	1.5	0.0	1.5	1.8	0.4	1.4	2.1	0.8	1.3
89	yes	52	83	OVIEDO (ALAFAYA WOODS - PLNT #2)	1.4	0.0	1.4	1.7	0.4	1.3	2.0	0.8	1.2
90	yes	70	77	PARK MANOR WATER WORKS	-0.4	-1.2	0.8	-0.1	-0.8	0.7	0.4	-0.3	0.6
91		114	34	POINCIANA UTIL (IP-1&2)	2.2	2.2	0.1	2.3	2.2	0.0	2.3	2.3	0.0
92		117	39	POINCIANA (CORES-1,2&3 89-90)	3.7	3.7	0.0	3.8	3.7	0.0	3.8	3.8	0.0
93		91	20	REEDY CREEK UTIL (PUMP STN A; 89-	2.2	2.0	0.2	3.5	3.4	0.2	4.0	3.9	0.1
94		100	32	REEDY CREEK UTIL (PUMP STATION C)	8.0	7.8	0.2	5.7	5.6	0.2	5.5	5.4	0.1
95		102	24	REEDY CREEK UTIL (PMP STN B)	2.9	2.8	0.2	3.2	3.1	0.2	3.4	3.2	0.1
96	yes	21	61	SANFORD (WELLFIELD # 4) (PROP)	0.8	-0.2	1.0	0.9	0.0	0.9	1.1	0.3	0.8
97	yes	21	62	SANFORD (WELLFIELD #3)	0.4	-0.6	1.0	0.3	-0.7	1.0	0.5	-0.4	0.9
98	yes	22	61	SANFORD (WELLFIELD # 4)	1.0	0.0	1.0	1.3	0.3	1.0	1.5	0.7	0.8
99	yes	24	63	SANFORD (WELLFIELD #2)	1.0	0.0	1.0	1.3	0.3	1.0	1.5	0.7	0.8
100	yes	27	69	SANFORD (WELLFIELD #1)	0.8	0.0	0.8	1.1	0.3	0.7	1.3	0.7	0.6
101	yes	29	69	SANFORD (WELLFIELD #1)	0.8	0.0	0.8	1.1	0.3	0.7	1.3	0.7	0.7
102	yes	37	54	SANLANDO UTIL CORP (DES PINAR)	0.5	0.0	0.5	0.8	0.4	0.4	1.1	0.8	0.4
103	yes	39	55	SANLANDO UTIL CORP (DES PINAR)	0.4	-0.2	0.6	0.7	0.2	0.5	0.8	0.4	0.4
104	yes	41	44	SANLANDO (WEKIVA HUNT CLUB)	0.3	0.0	0.3	0.7	0.4	0.3	1.0	0.8	0.2
105	yes	41	55	SANLANDO UTIL CORP (OVERSTREET)	0.6	0.0	0.6	0.9	0.4	0.5	1.2	0.7	0.4
106	yes	43	43	SANLANDO (WEKIVA HUNT CLUB)	0.3	0.0	0.3	0.7	0.4	0.3	1.0	0.8	0.2
107		109	68	CITY OF ST. CLOUD	3.8	3.7	0.1	3.9	3.8	0.1	4.0	3.9	0.1
108	yes	17	62	SEM CTY LAKE MONROE (I-4 IND. PAR	0.7	0.0	0.7	0.9	0.3	0.6	1.1	0.6	0.6
109	yes	27	54	SEM. COUNTY (HANOVER WOODS)	0.6	0.0	0.6	0.9	0.4	0.5	1.2	0.7	0.5
110	yes	28	57	SEM. COUNTY (HEATHROW)	0.8	0.0	0.8	1.1	0.4	0.8	1.4	0.7	0.7
111	yes	32	60	SEM. COUNTY (GREENWOOD LAKES)	1.0	0.0	1.0	1.3	0.4	1.0	1.6	0.7	0.8
112	yes	33	62	SEM. COUNTY (COUNTRY CLUB)	1.1	0.0	1.1	1.3	0.4	1.0	1.6	0.8	0.8
113	yes	33	61	SEM. COUNTY (GREENWOOD LAKES)	1.1	0.0	1.1	1.3	0.4	1.0	1.6	0.8	0.8
114	yes	48	41	SEM. COUNTY (BELAIRE)	0.3	0.0	0.3	0.7	0.4	0.3	1.1	0.9	0.2
115	yes	50	42	SEM. COUNTY (LYNWOOD)	0.1	-0.3	0.4	0.7	0.4	0.3	1.2	0.9	0.3
116	yes	55	69	SEM CTY (CONSUMER)	1.4	0.0	1.4	1.8	0.5	1.3	2.1	0.9	1.2
117	yes	56	84	SEM CTY (LAKE HAYES)	1.2	0.0	1.2	1.6	0.4	1.2	1.9	0.8	1.1
118	yes	63	76	SO. STATES UTIL (UNIV. SHORES/SUN	0.7	-0.4	1.1	1.1	0.0	1.1	1.5	0.5	1.0
119	yes	47	52	SOUTHERN ST. UTIL (APPLE VALLEY)	0.5	0.0	0.5	0.8	0.3	0.4	1.1	0.7	0.4
120	yes	49	46	SOUTHERN ST. UTIL (LAKE HARRIET)	0.1	-0.3	0.4	0.6	0.2	0.4	0.9	0.6	0.3
121	yes	50	54	SOUTHERN ST. UTIL (DOL RAY MANOR)	0.4	-0.2	0.6	0.8	0.2	0.6	1.2	0.7	0.5
122	yes	54	54	SOUTHERN ST. UTIL (D. HILLS\BRETT	-0.2	-0.8	0.7	0.2	-0.4	0.6	0.8	0.3	0.5
123		95	38	SEA WORLD OF FLA.	5.6	5.3	0.2	5.9	5.6	0.2	6.3	6.1	0.2
124	yes	63	83	UCF	0.7	-0.3	1.1	1.0	0.0	1.0	1.4	0.5	0.9
125		63	85	UCF	0.9	-0.2	1.0	1.2	0.2	1.0	1.5	0.6	0.9
126		6	68	VOL COUNTY - BREEZEWOOD	1.0	0.9	0.1	1.2	1.1	0.1	1.4	1.4	0.1

Table A6--*Continued*

Control Point Number	High or moderate potential for vegetative harm	Simulation Model Row	Simulation Model Column	Public Supply Utility Demand Area	Drawdowns (ft) Case 3 Modflow	Case 3 Gams	Case 3 Error	Case 2 Modflow	Case 2 Gams	Case 2 Error	Case 1 Modflow	Case 1 Gams	Case 1 Error
127		6	66	VOL COUNTY HIGHLAND CTRY EST	1.0	0.9	0.1	1.2	1.1	0.1	1.4	1.4	0.1
128		7	68	VOL COUNTY - GLEN ABBEY OR SWALLO	0.9	0.8	0.1	1.1	1.1	0.1	1.4	1.4	0.1
129		7	65	VOL COUNTY - LAKE MARIE	0.8	0.7	0.1	1.0	1.0	0.1	1.2	1.2	0.1
130		51	49	UTILITIES OF FLA (WEATHERSFIELD)	0.2	-0.3	0.5	0.6	0.2	0.4	0.9	0.6	0.4
131		67	20	WINTER GARDEN (PALMETTO STREET)	-0.1	-0.3	0.2	0.6	0.4	0.2	0.9	0.7	0.2
132		69	19	WINTER GARDEN (BOYD STREET)	0.1	-0.1	0.2	0.9	0.8	0.2	1.2	1.1	0.2
133		70	22	WINTER GARDEN CITRUS PRODUCTS	-0.1	-0.4	0.2	0.5	0.4	0.2	0.8	0.7	0.2
134		63	58	WINTER PARK PLANT #1 (SWOOPE)	-0.9	-1.6	0.7	-0.5	-1.1	0.6	0.1	-0.4	0.5
135	yes	63	67	WINTER PARK PLANT #5 (UNIVERSITY)	-1.1	-1.9	0.9	-0.7	-1.5	0.8	-0.2	-0.9	0.7
136	yes	58	63	WINTER PARK - PLANT #4 (MAGNOLIA)	-0.4	-1.3	0.9	0.0	-0.9	0.9	0.7	0.0	0.7
137		61	53	WINTER PARK - PLANT #3 (Wymore)	-0.4	-1.0	0.6	0.0	-0.5	0.5	0.6	0.2	0.4
138	yes	37	64	WINTER SPRINGS (WTP #2)	1.1	0.0	1.1	1.4	0.4	1.0	1.6	0.8	0.9
139	yes	44	67	WINTER SPRINGS (WTP #3)	1.4	0.0	1.4	1.7	0.4	1.3	2.0	0.8	1.2
140	yes	46	73	WINTER SPRNGS EAST 2	1.5	0.0	1.5	1.8	0.4	1.4	2.1	0.8	1.3
141		35	22	ZELLWOOD STATION UTIL.	0.0	-0.1	0.1	0.7	0.6	0.1	1.2	1.1	0.1
142		35	23	ZELLWOOD STATION UTIL.	0.1	-0.1	0.1	0.7	0.6	0.1	1.2	1.1	0.1
143		17	14	CITY OF MT. DORA	1.8	1.7	0.0	1.9	1.9	0.0	2.1	2.0	0.0
144		19	9	CITY OF TAVARES	1.9	1.8	0.0	1.9	1.9	0.0	2.0	2.0	0.0
145		76	11	FLORIDA CRUSHED STONE	0.5	0.4	0.1	0.7	0.7	0.1	0.9	0.8	0.1
146		98	8	FLA. ROCK (LAKE SAND PLANT)	0.5	0.4	0.1	0.7	0.6	0.1	0.8	0.7	0.1
147		103	31	FLORIBRA USA, INC	5.3	5.1	0.2	5.2	5.1	0.1	5.3	5.2	0.1
148		36	5	SILVER SPRINGS CITRUS	0.1	0.1	0.0	0.1	0.1	0.0	0.2	0.2	0.0
149		59	54	EATONVILLE	-0.6	-1.2	0.6	-0.2	-0.7	0.6	0.5	0.0	0.5
150		64	6	MINNEOLA HARBOR HILLS/12/13/88- P	0.6	0.5	0.0	0.6	0.6	0.0	0.7	0.6	0.0
151		67	84	CENT. FLA RES. PARK	0.5	-0.4	0.9	0.8	0.0	0.9	1.2	0.4	0.8
152	yes	69	15	CITY OF OAKLAND	0.2	0.0	0.2	0.8	0.6	0.2	1.0	0.8	0.1
153		79	11	SILVER SAND (CLERMONT MINE)	0.6	0.5	0.1	0.8	0.7	0.1	1.0	0.9	0.1
154		103	28	HYATT HOUSE ORLANDO	4.2	4.0	0.2	4.3	4.1	0.2	4.4	4.3	0.1
155		103	19	OSCEOLA SERVICE	2.6	2.4	0.2	2.8	2.7	0.2	3.0	2.8	0.1
156		108	133	USAF BAS CIVIL ENGINEER/8/12/86	0.2	0.2	0.0	0.2	0.2	0.0	0.2	0.2	0.0
157		115	16	DAVENPORT (1987)	3.7	3.7	0.0	3.7	3.7	0.0	3.8	3.8	0.0
				Total	187.5	117.6	69.9	234.4	169.0	65.3	285.1	229.2	56.0
				Minimum	-6.8	-7.0	0.0	-6.6	-6.8	0.0	-6.4	-6.6	0.0
				Maximum	8.0	7.8	1.5	7.8	7.6	1.4	8.1	8.0	1.3
				Average	1.2	1.2	0.4	1.5	1.1	0.4	1.8	1.5	0.4

Table A7. Volusia linear programming model results for control points

				Drawdowns (ft)								
				Case 3			Case 2			Case 1		
Public well or control point number	Well Description	Public Supply Utility Need Area	Potential for Vegetative Harm	Modflow	Gams	Error	Modflow	Gams	Error	Modflow	Gams	Error
1	DELAND WATER UTIL	DWU	LOW	0.10	0.07	0.03	0.38	0.36	0.02	-0.08	-0.15	0.07
2	DELAND WATER UTIL	DWU	LOW	-0.36	-0.39	0.03	-0.11	-0.13	0.02	0.25	0.23	0.02
3	DELAND WATER UTIL	DWU	LOW	-0.24	-0.26	0.02	-0.01	-0.02	0.01	0.50	0.49	0.01
4	DELAND WATER UTIL	DWU	LOW	0.33	0.33	0.00	0.43	0.43	0.00	1.13	1.12	0.01
5	DELAND WATER UTIL	DWU	LOW	1.24	1.21	0.03	1.41	1.38	0.03	-0.07	-0.15	0.08
6	DELAND WATER UTIL	DWU	LOW	0.58	0.57	0.01	0.71	0.71	0.00	0.70	0.70	0.00
7	DELAND WATER UTIL	DWU	LOW	0.14	0.14	0.00	0.25	0.25	0.00	1.10	1.10	0.00
8	DELAND WU 1990	DWU	LOW	0.04	-0.01	0.05	0.33	0.30	0.03	0.03	-0.03	0.06
9	HOLLY HILL EASTERN WF	HHE	LOW	0.01	-0.01	0.02	0.19	0.18	0.01	0.32	0.32	0.00
10	HOLLY HILL EASTERN WF	HHE	LOW	0.01	-0.01	0.02	0.15	0.15	0.00	0.26	0.26	0.00
11	HOLLY HILL EASTERN WF	HHE	LOW	0.01	-0.01	0.02	0.15	0.15	0.00	0.26	0.26	0.00
12	HOLLY HILL EASTERN WF	HHE	LOW	0.01	-0.01	0.02	0.19	0.19	0.00	0.32	0.32	0.00
13	HOLLY HILL EASTERN WF	HHE	LOW	0.01	-0.01	0.02	0.20	0.20	0.00	0.35	0.34	0.01
14	HOLLY HILL WESTERN WF	HHW	LOW	-0.01	0.01	0.02	0.20	0.20	0.00	0.37	0.37	0.00
15	HOLLY HILL WESTERN WF	HHW	LOW	0.00	0.02	0.02	0.34	0.35	0.01	0.61	0.61	0.00
16	HOLLY HILL WESTERN WF	HHW	LOW	-0.03	0.00	0.03	0.33	0.33	0.00	0.64	0.64	0.00
17	HOLLY HIIL PROPOSED	HHW	LOW	-0.03	0.00	0.03	0.33	0.33	0.00	0.64	0.64	0.00
18	OR. CITY CTRY VILLAGE	OCC	LOW	0.01	0.05	0.04	0.30	0.32	0.02	0.53	0.53	0.00
19	SSU SUGAR MILL EST	SME	HIGH	-0.01	0.00	0.01	0.13	0.13	0.00	0.20	0.20	0.00
20	PORT ORANGE WESTERN WF	POW	MODERATE	0.16	0.00	0.16	0.46	0.35	0.11	0.77	0.70	0.07
21	PORT ORANGE WESTERN WF	POW	MODERATE	0.01	-0.33	0.34	0.51	0.26	0.25	0.67	0.47	0.20
22	PORT ORANGE WESTERN WF	POW	MODERATE	-0.38	-1.39	1.01	0.54	-0.21	0.75	0.60	-0.04	0.64
23	PORT ORANGE WESTERN WF	POW	MODERATE	0.17	-1.61	1.78	0.60	-0.84	1.44	0.78	-0.47	1.25
24	PORT ORANGE WESTERN WF	POW	MODERATE	0.42	-1.55	1.97	0.73	-0.95	1.68	0.98	-0.47	1.45
25	PORT ORANGE WESTERN WF	POW	MODERATE	0.16	-0.49	0.65	0.58	0.09	0.49	0.87	0.49	0.38
26	PORT ORANGE WESTERN WF	POW	MODERATE	0.01	-1.23	1.24	0.43	-0.51	0.94	0.63	-0.15	0.78
27	PORT ORANGE WESTERN WF	POW	MODERATE	-0.14	-1.51	1.37	0.41	-0.61	1.02	0.56	-0.30	0.86
28	PORT ORANGE WESTERN WF	POW	MODERATE	-0.13	-1.78	1.65	0.46	-0.81	1.27	0.58	-0.53	1.11
29	PORT ORANGE WESTERN WF	POW	MODERATE	0.55	0.00	0.55	0.76	0.32	0.44	1.01	0.65	0.36
30	PORT ORANGE WESTERN WF	POW	MODERATE	0.46	-0.75	1.21	0.74	-0.23	0.97	0.96	0.15	0.81
31	PORT ORANGE WESTERN WF	POW	MODERATE	-0.03	-1.30	1.27	0.55	-0.41	0.96	0.73	-0.07	0.80
32	PORT ORANGE WESTERN WF	POW	MODERATE	0.54	-0.76	1.30	0.85	-0.18	1.03	1.03	0.17	0.86
33	PORT ORANGE WEST PROP	POW	MODERATE	0.78	0.00	0.78	0.93	0.33	0.60	1.12	0.67	0.45
34	PORT ORANGE WEST PROP	POW	MODERATE	1.07	0.00	1.07	1.23	0.33	0.90	1.43	0.66	0.77
35	PORT ORANGE WEST PROP	POW	MODERATE	0.42	-1.45	1.87	0.73	-0.92	1.65	0.98	-0.43	1.41
36	PORT ORANGE WEST PROP	POW	MODERATE	0.41	-0.92	1.33	0.79	-0.32	1.11	1.07	0.16	0.91
37	PORT ORANGE WEST PROP	POW	MODERATE	0.46	-0.05	0.51	0.78	0.35	0.43	1.05	0.70	0.35
38	PORT ORANGE WEST PROP	POW	MODERATE	0.69	-1.02	1.71	0.91	-0.63	1.54	1.20	-0.11	1.31
39	PORT ORANGE WEST PROP	POW	MODERATE	0.63	-0.61	1.24	0.93	-0.15	1.08	1.25	0.36	0.89
40	PORT ORANGE WEST PROP	POW	MODERATE	0.50	0.00	0.50	0.80	0.36	0.44	1.08	0.72	0.36
41	PORT ORANGE WEST PROP	POW	MODERATE	0.87	-0.05	0.92	0.98	0.12	0.86	1.22	0.52	0.70
42	PORT ORANGE WEST PROP	POW	MODERATE	0.73	0.00	0.73	1.02	0.37	0.65	1.24	0.74	0.50
43	PORT ORANGE WEST PROP	POW	MODERATE	0.51	0.20	0.31	0.86	0.57	0.29	1.04	0.81	0.23
44	PORT ORANGE EASTERN WF	POE	LOW	0.05	0.04	0.01	0.15	0.15	0.00	0.20	0.20	0.00
45	PORT ORANGE EASTERN WF	POE	LOW	0.04	0.04	0.00	0.13	0.13	0.00	0.17	0.17	0.00
46	PORT ORANGE EASTERN WF	POE	LOW	0.05	0.05	0.00	0.13	0.13	0.00	0.20	0.20	0.00

Table A7--*Continued*

				Drawdowns (ft)								
				Case 3			Case 2			Case 1		
Public well or control point number	Well Description	Public Supply Utility Need Area	Potential for Vegetative Harm	Modflow	Gams	Error	Modflow	Gams	Error	Modflow	Gams	Error
47	PORT ORANGE EASTERN WF	POE	LOW	0.07	0.07	0.00	0.16	0.16	0.00	0.25	0.25	0.00
48	PORT ORANGE EASTERN WF	POE	LOW	0.05	0.05	0.00	0.12	0.12	0.00	0.20	0.20	0.00
49	PORT ORANGE EASTERN WF	POE	LOW	0.04	0.05	0.01	0.12	0.12	0.00	0.19	0.19	0.00
50	DELTONA	DEL	LOW	0.38	0.26	0.12	1.12	1.09	0.03	1.60	1.61	0.01
51	DELTONA	DEL	LOW	4.35	4.33	0.02	9.89	9.44	0.45	8.06	7.85	0.21
52	DELTONA	DEL	LOW	0.02	0.10	0.08	0.37	0.45	0.08	0.66	0.73	0.07
53	DELTONA	DEL	LOW	2.57	2.62	0.05	1.52	1.89	0.37	2.42	2.45	0.03
54	DELTONA	DEL	LOW	1.64	1.59	0.05	4.87	4.89	0.03	6.26	6.20	0.06
55	DELTONA	DEL	LOW	0.42	0.50	0.08	0.30	0.42	0.12	1.04	1.12	0.08
56	DELTONA	DEL	LOW	-0.51	-0.45	0.06	-0.37	-0.34	0.03	-0.27	-0.26	0.01
57	DELTONA	DEL	LOW	0.42	0.50	0.08	0.30	0.42	0.12	1.04	1.12	0.08
58	DELTONA	DEL	LOW	-0.43	-0.40	0.03	-0.29	-0.27	0.02	-0.20	-0.19	0.01
59	DELTONA	DEL	LOW	-0.51	-0.45	0.06	-0.37	-0.34	0.03	-0.27	-0.26	0.01
60	DELTONA	DEL	LOW	0.03	0.07	0.04	0.39	0.42	0.03	0.60	0.62	0.02
61	DELTONA	DEL	LOW	-0.12	0.00	0.12	0.39	0.44	0.05	0.83	0.80	0.03
62	DELT - PROPOSED	DEL	MODERATE	-0.01	-0.20	0.19	0.65	0.48	0.17	1.11	0.97	0.14
63	DELT - PROPOSED	DEL	LOW	-0.13	-0.05	0.08	0.03	0.09	0.06	0.13	0.17	0.04
64	DELT - PROPOSED	DEL	LOW	0.00	-1.33	1.33	0.37	-0.75	1.12	0.68	-0.28	0.96
65	DELT - PROPOSED	DEL	LOW	-0.23	-0.06	0.17	0.04	0.14	0.10	0.24	0.29	0.05
66	DELT - PROPOSED	DEL	LOW	4.35	4.33	0.02	9.89	9.44	0.45	8.06	7.85	0.21
67	DELT - PROPOSED	DEL	LOW	1.64	1.59	0.05	4.87	4.89	0.03	6.26	6.20	0.06
68	DELT - PROPOSED	DEL	LOW	0.38	0.26	0.12	1.12	1.09	0.03	1.60	1.61	0.01
69	DELT - PROPOSED	DEL	LOW	-0.12	0.00	0.12	0.39	0.44	0.05	0.83	0.80	0.03
70	DELT - PROPOSED	DEL	LOW	3.66	3.65	0.01	0.66	0.71	0.05	1.14	1.16	0.02
71	DELT - PROPOSED	DEL	LOW	3.61	4.07	0.46	3.88	4.33	0.45	4.98	5.21	0.23
72	DELT - PROPOSED	DEL	LOW	3.95	4.87	0.92	3.94	4.87	0.93	3.95	4.87	0.92
73	DELT - PROPOSED	DEL	LOW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
74	DELT - PROPOSED	DEL	LOW	3.74	4.05	0.31	5.53	5.69	0.16	5.59	5.69	0.10
75	SPRUCE CREEK	SPC	LOW	0.09	0.16	0.07	0.34	0.36	0.02	0.51	0.50	0.01
76	SPRUCE CREEK	SPC	LOW	0.07	0.15	0.08	0.27	0.30	0.03	0.41	0.41	0.00
77	SPRUCE CREEK PROP	SPC	LOW	0.09	0.16	0.07	0.34	0.36	0.02	0.51	0.50	0.01
78	SPRUCE CREEK PROP	SPC	LOW	0.07	0.15	0.08	0.27	0.30	0.03	0.41	0.41	0.00
79	NEW SMYRNA SAMSULA WF	NSS	LOW	-0.03	-0.02	0.01	0.64	0.64	0.00	0.90	0.90	0.00
80	NEW SMYRNA SAMSULA WF	NSS	LOW	0.04	0.06	0.02	0.39	0.40	0.01	0.79	0.80	0.01
81	NEW SMYRNA SAMSULA WF	NSS	MODERATE	-0.02	0.01	0.03	0.33	0.34	0.01	0.71	0.71	0.00
82	NEW SMYRNA SAMSULA WF	NSS	MODERATE	-0.06	0.00	0.06	0.31	0.34	0.03	0.67	0.68	0.01
83	NEW SMYRNA GLENCOE WF	NSG	MODERATE	0.00	0.00	0.00	0.24	0.23	0.01	0.47	0.46	0.01
84	NEW SMYRNA GLENCOE WF	NSG	MODERATE	0.01	0.00	0.01	0.29	0.28	0.01	0.58	0.57	0.01
85	NSB - PROPOSED	NS4	MODERATE	-0.03	-0.03	0.00	0.37	0.37	0.00	0.75	0.74	0.01
86	NEW SMYRNA SR 44	NS4	MODERATE	0.00	0.00	0.00	0.37	0.37	0.00	0.74	0.73	0.01
87	NEW SMYRNA SR 44	NS4	MODERATE	0.01	0.00	0.01	0.38	0.37	0.01	0.75	0.75	0.00
88	DAYTONA BEACH EASTERN WF	DBE	MODERATE	-0.03	0.00	0.03	0.19	0.20	0.01	0.28	0.28	0.00
89	DAYTONA BEACH EASTERN WF	DBE	MODERATE	-0.04	-0.01	0.03	0.19	0.19	0.00	0.33	0.33	0.00
90	DAYTONA BEACH EASTERN WF	DBE	MODERATE	-0.04	0.00	0.04	0.25	0.25	0.00	0.51	0.51	0.00
91	DAYTONA BEACH EASTERN WF	DBE	MODERATE	-0.02	0.00	0.02	0.17	0.17	0.00	0.47	0.47	0.00
92	DAYTONA BEACH WESTERN WF	DBW	MODERATE	-0.03	0.00	0.03	0.20	0.21	0.01	0.47	0.47	0.00

Table A7--*Continued*

				Drawdowns (ft)								
				Case 3			Case 2			Case 1		
Public well or control point number	Well Description	Public Supply Utility Need Area	Potential for Vegetative Harm	Modflow	Gams	Error	Modflow	Gams	Error	Modflow	Gams	Error
93	DAYTONA BEACH WESTERN WF	DBW	MODERATE	-0.05	0.00	0.05	0.22	0.24	0.02	0.45	0.46	0.01
94	DAYTONA BEACH WESTERN WF	DBW	MODERATE	-0.01	0.00	0.01	0.17	0.17	0.00	0.30	0.30	0.00
95	DAYTONA BEACH WESTERN WF	DBW	MODERATE	-0.03	-0.03	0.00	0.20	0.19	0.01	0.36	0.34	0.02
96	DAYTONA BEACH WESTERN WF	DBW	MODERATE	-0.05	-0.06	0.01	0.36	0.34	0.02	0.63	0.58	0.05
97	DAYTONA BEACH WESTERN WF	DBW	MODERATE	-0.13	-0.15	0.02	0.37	0.34	0.03	0.74	0.63	0.11
98	DAYTONA BEACH WESTERN WF	DBW	MODERATE	-0.05	-0.07	0.02	0.35	0.33	0.02	0.71	0.66	0.05
99	DAYTONA BEACH WESTERN WF	DBW	MODERATE	-0.31	-0.34	0.03	0.29	0.26	0.03	0.57	0.51	0.06
100	DAYTONA BEACH WESTERN WF	DBW	LOW	-0.08	-0.14	0.06	0.08	0.05	0.03	0.16	0.14	0.02
101	DAYTONA BEACH WESTERN WF	DBW	LOW	0.21	0.19	0.02	0.33	0.32	0.01	-0.07	-0.09	0.02
102	DAYTONA WEST. 1988	DBW	LOW	0.18	0.07	0.11	0.32	0.22	0.10	0.26	0.16	0.10
103	DAYTONA WEST. 1988	DBW	LOW	0.17	-0.07	0.24	0.30	0.09	0.21	0.38	0.19	0.19
104	DAYTONA WEST. 1988	DBW	LOW	0.08	-0.56	0.64	0.34	-0.23	0.57	0.57	0.05	0.52
105	DAYTONA WEST. 1988	DBW	LOW	0.05	-0.13	0.18	0.36	0.18	0.18	0.66	0.49	0.17
106	DAYTONA WEST. 1988	DBW	MODERATE	0.02	0.00	0.02	0.38	0.33	0.05	0.71	0.66	0.05
107	DAYTONA WEST. 1988	DBW	MODERATE	0.01	0.00	0.01	0.33	0.32	0.01	0.66	0.64	0.02
108	DAYTONA WEST. 1988	DBW	LOW	0.12	0.08	0.04	0.28	0.24	0.04	0.20	0.17	0.03
109	DAYTONA WEST. 1988	DBW	MODERATE	0.12	0.00	0.12	0.32	0.21	0.11	0.35	0.26	0.09
110	ORMOND BEACH DIVISION	OBD	LOW	0.09	0.07	0.02	0.31	0.31	0.00	0.49	0.48	0.01
111	ORMOND BEACH DIVISION	OBD	LOW	0.04	0.02	0.02	0.27	0.26	0.01	0.45	0.45	0.00
112	ORMOND BEACH DIVISION	OBD	LOW	-0.01	-0.02	0.01	0.20	0.20	0.00	0.37	0.36	0.01
113	ORMOND BEACH DIVISION	OBD	LOW	-0.02	-0.02	0.00	0.19	0.19	0.00	0.35	0.34	0.01
114	ORMOND BEACH DIVISION	OBD	LOW	-0.03	-0.03	0.00	0.14	0.14	0.00	0.27	0.27	0.00
115	ORMOND BEACH DIVISION	OBD	LOW	0.09	0.07	0.02	0.31	0.31	0.00	0.49	0.48	0.01
116	ORMOND BEACH DIVISION	OBD	LOW	0.05	0.04	0.01	0.29	0.28	0.01	0.48	0.47	0.01
117	ORMOND BEACH DIVISION	OBD	LOW	-0.01	-0.02	0.01	0.20	0.20	0.00	0.37	0.36	0.01
118	ORMOND BEACH SR 40	OB4	LOW	-0.10	-0.02	0.08	0.28	0.30	0.02	0.56	0.56	0.00
119	ORMOND BEACH SR 40	OB4	LOW	-0.24	-0.12	0.12	0.33	0.35	0.02	0.75	0.74	0.01
120	ORMOND BEACH SR 40	OB4	MODERATE	-0.04	0.00	0.04	0.27	0.27	0.00	0.52	0.51	0.01
121	ORMOND BEACH SR 40	OB4	MODERATE	-0.05	0.00	0.05	0.24	0.25	0.01	0.44	0.44	0.00
122	ORMOND BEACH SR 40	OB4	LOW	-0.27	-0.18	0.09	0.38	0.38	0.00	0.87	0.86	0.01
123	ORMOND BEACH HUDSON	OBH	LOW	-0.04	0.17	0.21	0.42	0.44	0.02	0.65	0.65	0.00
124	ORMOND BEACH HUDSON	OBH	LOW	-0.02	0.13	0.15	0.35	0.36	0.01	0.53	0.54	0.01
125	ORMOND BEACH HUDSON	OBH	LOW	0.00	0.12	0.12	0.37	0.39	0.02	0.56	0.56	0.00
126	ORMOND BEACH HUDSON	OBH	LOW	0.01	0.08	0.07	0.28	0.29	0.01	0.41	0.41	0.00
127	ORMOND BEACH HUDSON	OBH	LOW	-0.02	0.14	0.16	0.42	0.45	0.03	0.67	0.67	0.00
128	ORMOND BEACH HUDSON	OBH	LOW	-0.02	0.19	0.21	0.45	0.49	0.04	0.71	0.71	0.00
129	ORMOND BEACH HUDSON	OBH	LOW	0.01	0.15	0.14	0.39	0.41	0.02	0.60	0.60	0.00
130	ORMOND BEACH HUDSON	OBH	LOW	0.03	0.12	0.09	0.29	0.31	0.02	0.44	0.44	0.00
131	ORMOND BEACH HUDSON	OBH	LOW	-0.02	0.13	0.15	0.35	0.36	0.01	0.53	0.54	0.01
132	ORMOND BEACH HUDSON	OBH	LOW	0.00	0.12	0.12	0.32	0.34	0.02	0.49	0.49	0.00
133	ORMOND BEACH RIMA PROP	OBR	LOW	-0.02	0.00	0.02	0.32	0.33	0.01	0.69	0.70	0.01
134	ORMOND BEACH RIMA PROP	OBR	LOW	-0.02	0.00	0.02	0.37	0.37	0.00	0.73	0.73	0.00
135	JOHN KNOX VILL.	JKV	LOW	0.06	0.07	0.01	0.65	0.66	0.01	1.21	1.21	0.01
136	V CTY - FOUR TOWNS	VFT	LOW	0.11	0.12	0.01	0.35	0.35	0.00	0.40	0.41	0.01
137	V CTY - FOUR TOWNS	VFT	LOW	0.06	0.06	0.00	0.26	0.26	0.00	0.39	0.39	0.00
138	V CTY - BREEZEWOOD	VFT	LOW	0.24	0.26	0.02	0.64	0.65	0.01	0.81	0.81	0.00

Table A7--*Continued*

				Drawdowns (ft)								
				Case 3			Case 2			Case 1		
Public well or control point number	Well Description	Public Supply Utility Need Area	Potential for Vegetative Harm	Modflow	Gams	Error	Modflow	Gams	Error	Modflow	Gams	Error
139	V CTY - LAKE MARIE	VLM	LOW	0.57	0.57	0.00	1.09	1.10	0.01	1.10	1.10	0.00
140	V CTY - TERRA ALTA	VTA	LOW	0.23	0.23	0.00	0.54	0.54	0.00	0.57	0.57	0.00
141	V CTY - W ORANGE CITY	VTA	LOW	0.06	0.06	0.00	0.33	0.34	0.01	0.59	0.59	0.00
142	DELAND - BRANDYWINE	DEB	MODERATE	0.00	0.00	0.00	0.28	0.28	0.00	0.31	0.31	0.00
143	DELAND - SPRING GARDEN	DEB	MODERATE	0.00	0.00	0.00	0.34	0.34	0.00	0.40	0.41	0.01
144	DELAND - SPRING GARDEN	DEB	LOW	0.00	0.00	0.00	0.34	0.34	0.00	0.40	0.41	0.01
145	DELAND - GLENWOOD EST	DEB	LOW	-0.06	-0.05	0.01	0.15	0.16	0.01	0.22	0.22	0.00
146	DELAND - WOODLAND MANOR	DWW	MODERATE	-0.10	-0.09	0.01	0.18	0.18	0.00	0.22	0.22	0.00
147	DELAND - LONGLEAF PLANT.	DHH	LOW	0.00	-0.21	0.21	0.30	0.19	0.11	0.45	0.38	0.07
148	DELAND - HOLIDAY HILLS	DHH	LOW	-0.08	-0.10	0.02	0.26	0.25	0.01	0.53	0.52	0.01
149	ELLWOOD TITCOMB	ETI	MODERATE	-0.02	0.00	0.02	0.22	0.24	0.02	0.17	0.18	0.01
150	CITY OF EDGEWATER	EDG	MODERATE	0.30	0.29	0.01	0.57	0.55	0.02	0.81	0.80	0.01
151	CITY OF EDGEWATER	EDG	MODERATE	0.29	0.28	0.01	0.55	0.54	0.01	0.79	0.78	0.01
152	CITY OF EDGEWATER	EDG	LOW	0.18	0.18	0.00	0.23	0.23	0.00	0.27	0.27	0.00
153	CITY OF EDGEWATER	EDG	LOW	0.42	0.40	0.02	0.56	0.55	0.01	0.69	0.68	0.01
154	TYMBER CREEK UTIL.	TCU	LOW	-0.17	-0.08	0.09	0.43	0.44	0.01	0.88	0.88	0.00
155	THE TRAILS INC.	TTI	LOW	-0.09	0.09	0.18	0.50	0.52	0.02	0.89	0.89	0.00
156	LAKE HELEN	LHE	LOW	-0.03	-0.01	0.02	0.27	0.28	0.01	0.39	0.40	0.01
157	LAKE HELEN	LHE	LOW	0.01	0.00	0.01	0.61	0.60	0.01	0.92	0.92	0.00
158	HACIENDA DEL RIO	HDR	LOW	0.07	0.07	0.00	0.11	0.11	0.00	0.15	0.14	0.01
159	NATIONAL GARDENS	NGA	LOW	-1.58	-1.59	0.01	-1.52	-1.53	0.01	-1.44	-1.44	0.00
160	NATIONAL GARDENS	NGA	LOW	-1.61	-1.61	0.00	-1.55	-1.55	0.00	-1.47	-1.47	0.00
161	NATIONAL GARDENS	NGA	LOW	-3.10	-3.10	0.00	-3.03	-3.03	0.00	-2.93	-2.93	0.00
162	NATIONAL GARDENS	NGA	LOW	-2.66	-2.67	0.01	-2.59	-2.59	0.00	-2.47	-2.48	0.01
163	NATIONAL GARDENS	NGA	LOW	-1.36	-1.35	0.01	-1.26	-1.26	0.00	-1.15	-1.15	0.00
164	ORANGE CITY	OCY	LOW	0.05	0.06	0.01	0.54	0.54	0.00	1.10	1.10	0.00
165	SUNSHINE HOLIDAY PK	SHP	LOW	-0.01	0.00	0.01	0.02	0.02	0.00	0.05	0.05	0.00
166	PLANTATION BAY	PTB	MODERATE	0.00	0.00	0.00	0.17	0.17	0.00	0.35	0.35	0.00
167	PLANTATION BAY	PTB	LOW	0.01	0.01	0.00	0.20	0.21	0.01	0.40	0.40	0.00
168	L BERESFORD WATER ASSN	LBW	LOW	-0.04	-0.04	0.01	0.19	0.19	0.00	0.50	0.49	0.01
169	FPL - TURNER POWER PLNT	FPT	HIGH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
170	SHERWOOD MEDICAL CO.	SMC	LOW	0.27	0.27	0.00	0.39	0.39	0.00	0.27	0.27	0.00
171	SHERWOOD MEDICAL CO.	SMC	LOW	0.19	0.19	0.00	0.29	0.29	0.00	0.27	0.27	0.00
172	FPL - SANFORD PWR PLNT	FPS	LOW	0.26	0.26	0.00	0.32	0.32	0.00	0.32	0.32	0.00
173	FPL - SANFORD PWR PLNT	FPS	LOW	0.33	0.33	0.00	0.41	0.41	0.00	0.40	0.40	0.00
174	FPL - SANFORD PWR PLNT	FPS	LOW	0.13	0.12	0.01	0.35	0.35	0.00	0.41	0.40	0.01
175	FPL - SANFORD PWR PLNT	FPS	LOW	0.23	0.23	0.00	0.54	0.54	0.00	0.57	0.57	0.00
176	TOMOKA CORR. FACILITY	TCF	MODERATE	0.10	-0.14	0.24	0.11	-0.13	0.24	0.33	0.12	0.21
177	V CTY GOVT COMPLEX	VGC	LOW	0.01	0.00	0.01	0.31	0.31	0.00	0.62	0.62	0.00
			Total	33.06	8.91	35.57	95.67	73.84	28.51	129.48	109.85	23.29
			Avg	0.19	0.05	0.20	0.54	0.42	0.16	0.73	0.62	0.13
			Min	-3.10	-3.10	0.00	-3.03	-3.03	0.00	-2.93	-2.93	0.00
			Max	4.35	4.87	1.97	9.89	9.44	1.68	8.06	7.85	1.45

Table A8. East-central optimization model public supply well withdrawal rates

Model Row	Model Column	Well ID Number	Public Supply Demand Area	Well or Treatment Plant	Model Layer (1= Upper, 2= Lower Floridan)	Well withdrawal rates (MGD) Year 1988	Projected Year 2010	Case 3	Case 2	Case 1	Estimated Well Capacity (MGD)
46	58	1	ALT	ALTAMONTE SPR.(NEW CHARLOTTE ST W	1	0.00	4.15	0.00	0.00	0.00	4.49
48	54	2	ALT	ALTAMONTE SPR. (PLANT #3)	1	0.65	0.00	1.50	1.50	1.50	3.00
49	57	3	ALT	ALTAMONTE SPR. (PLANT #1)	1	0.01	0.00	1.50	1.50	0.11	1.50
49	48	4	ALT	ALTAMONTE SPR. (PLANT #4)	1	0.32	3.02	2.17	2.06	2.07	3.74
50	57	5	ALT	ALTAMONTE SPR. (PLANT #1)	1	0.08	0.00	1.04	1.34	1.50	1.50
52	45	6	ALT	ALTAMONTE SPR. (PLANT #5)	1	3.80	0.00	0.00	0.00	0.00	4.49
53	55	7	ALT	ALTAMONTE SPR. (PLANT #2)	1	1.08	1.07	0.00	0.00	0.53	3.46
52	45	8	ALT	ALTAMONTE SPRINGS (PLANT #5)	2	0.02	0.00	3.99	3.79	4.49	4.49
54	55	9	ALT	ALTAMONTE SPRINGS (PLANT #2)	2	1.98	1.95	0.00	0.00	0.00	3.46
43	31	10	APO	APOPKA - GROSSENBACHER WF.	1	1.04	3.38	0.25	1.50	2.11	5.98
37	27	11	APO	APOPKA - PROPOSED NORTHWEST WF	2	0.00	4.44	5.98	5.98	5.98	5.98
43	31	12	APO	APOPKA - GROSSENBACHER WF.	2	1.04	3.38	5.98	5.98	5.98	5.98
45	27	13	APO	APOPKA - PROPOSED SOUTHWEST WF	2	0.00	6.77	7.11	7.11	7.07	7.11
53	36	14	APO	APOPKA - SHEELOR OAKS WF.	2	2.07	3.17	0.00	0.00	0.00	3.61
45	63	15	CAS	CASSELBERRY (NORTH WTP; WELL N-1)	1	2.03	0.48	0.90	0.90	0.90	3.50
53	63	16	CAS	CASSELBERRY (HOWELL PARK; CANON W	1	0.31	0.41	0.90	0.90	0.20	2.11
53	62	17	CAS	CASSELBERRY (HOWELL PARK; HP-1 WE	1	0.39	0.61	0.79	0.79	0.00	2.11
59	65	18	CAS	CASSELBERRY (SOUTH PLANT; WELL S-	1	0.89	0.51	0.00	0.00	0.00	2.88
46	63	19	CAS	CASSELBERRY (NORTH WTP; WELL N240	2	0.15	1.01	1.50	1.50	1.50	3.45
53	64	20	CAS	CASSELBERRY (HOWELL PARK WTP; WEL	2	0.07	1.40	0.00	0.00	1.50	1.50
59	65	21	CAS	CASSELBERRY (SOUTH PLANT; WELL S-	2	0.90	0.51	0.75	0.75	0.75	0.75
59	66	22	CAS	CASSELBERRY (SOUTH WTP; WELL S360	2	0.08	1.40	1.50	1.50	1.50	2.88
104	35	23	CFU	CENTRAL FLA UTIL (CAMELOT, CD 1&2	1	0.99	2.35	1.24	1.24	1.24	4.49
105	60	24	CFU	CENTRAL FLA UTIL (C. FL. PKWY. CD	1	0.10	0.23	0.45	0.45	0.45	0.45
107	57	25	CFU	CENTRAL FLA UTIL (C. FL. PKWY. CD	1	0.19	0.45	1.35	1.35	1.35	1.35
54	97	26	CHU	SOUTHERN ST. UTIL (CHULUOTA)	1	0.00	0.09	0.25	0.25	0.25	0.43
55	96	27	CHU	SOUTHERN ST. UTIL (CHULUOTA)	1	0.39	0.16	0.00	0.00	0.00	0.73
68	8	28	CLE	CLERMONT (GRAND)	1	0.91	1.57	0.67	0.67	0.67	3.37
71	7	29	CLE	CLERMONT (4TH STREET)	1	0.52	0.90	1.80	1.80	1.80	2.36
87	100	30	COC	COCOA (WELL #10)	1	0.19	0.15	0.00	0.13	0.93	1.65
89	100	31	COC	COCOA (WELL #9)	1	0.15	0.24	1.40	1.65	1.65	1.65
90	100	32	COC	COCOA (WELL #8)	1	0.24	0.48	1.65	1.65	1.65	1.65
92	95	33	COC	COCOA (WELL #13 & 13R)	1	1.53	0.60	0.00	0.00	0.00	1.65
92	94	34	COC	COCOA (WELL #14)	1	2.42	1.66	0.00	0.00	0.00	3.02
92	100	35	COC	COCOA (WELL #3)	1	0.13	0.00	0.82	0.82	0.82	0.82
93	93	36	COC	COCOA (WELL #16)	1	5.83	3.53	0.00	0.00	0.00	4.49
93	92	37	COC	COCOA (WELL #17)	1	2.70	1.74	0.00	0.00	0.00	3.02
93	100	38	COC	COCOA (WELL #7) <PHASE I CORRECTI	1	0.40	0.24	1.65	1.65	1.65	1.65
93	99	39	COC	COCOA (WELL #7A)	1	0.22	0.26	0.00	0.00	0.00	1.65
94	100	40	COC	COCOA (WELL # 1)	1	0.00	0.15	1.65	1.65	1.65	1.65
94	92	41	COC	COCOA (WELL #18)	1	2.34	1.86	0.00	0.00	0.00	3.02
95	100	42	COC	COCOA (WELL #6) <PHASE I CORRECTI	1	0.00	0.00	0.82	0.82	0.82	0.82
96	92	43	COC	COCOA (WELL #19)	1	1.30	1.86	0.00	0.00	0.00	3.02
96	100	44	COC	COCOA (WELL #5)	1	0.42	0.24	1.65	1.65	1.65	1.65
97	102	45	COC	COCOA (WELL #12A)	1	0.26	0.24	1.65	1.65	1.65	1.65
97	100	46	COC	COCOA (WELL #4)	1	0.28	0.24	1.65	1.65	1.65	1.65
97	92	47	COC	COCOA PROP. WELL 20	1	0.00	1.86	0.00	0.00	0.00	3.02
98	100	48	COC	COCOA (WELL #11)	1	0.74	0.24	0.00	1.26	0.83	1.65

Table A8--*Continued*

Model Row	Model Column	Well ID Number	Public Supply Demand Area	Well or Treatment Plant	Model Layer (1= Upper, 2= Lower Floridan)	Year 1988	Projected Year 2010	Case 3	Case 2	Case 1	Estimated Well Capacity (MGD)
98	102	49	COC	COCOA (WELL #12B)	1	0.54	0.24	1.65	1.65	1.65	1.65
98	101	50	COC	COCOA (WELL #4A1)	1	0.42	0.24	1.20	0.00	0.00	1.65
98	92	51	COC	COCOA PROP. WELL 22	1	0.00	3.73	0.00	0.00	0.00	7.48
99	92	52	COC	COCOA PROP. WELL 32	1	0.00	3.73	0.00	0.00	0.00	7.48
99	101	53	COC	COCOA PROP. WELL 39	1	0.00	0.48	0.00	0.00	0.00	7.48
100	92	54	COC	COCOA PROP. WELL 33	1	0.00	1.86	5.39	5.18	4.99	7.48
100	101	55	COC	COCOA PROP. WELL 41	1	0.00	0.48	0.00	0.00	0.00	7.48
101	101	56	COC	COCOA PROP. WELL 43	1	0.00	0.48	1.99	1.87	1.80	7.48
102	101	57	COC	COCOA PROP. WELL 44	1	0.00	0.24	3.93	3.82	3.71	7.48
86	60	58	CON	SO. STATES UTIL (LAKE CONWAY PARK	1	0.01	0.01	0.00	0.00	0.00	0.11
87	60	59	CON	SO. STATES UTIL (LAKE CONWAY PARK	1	0.01	0.01	0.00	0.00	0.00	0.11
88	59	60	CON	SO. STATES UTIL (DAETWYLER SHORES	1	0.03	0.04	0.00	0.00	0.00	0.11
88	60	61	CON	SO. STATES UTIL (DAETWYLER SHORES	1	0.03	0.04	0.00	0.00	0.00	0.11
3	86	62	DEL	DELTONA-PROPOSED	1	0.00	1.61	1.87	1.87	1.87	2.06
4	88	63	DEL	DELTONA	1	1.45	2.41	0.00	0.00	0.00	3.74
4	80	64	DEL	DELTONA-PROPOSED	1	0.00	0.80	1.87	1.87	1.87	1.87
4	82	65	DEL	DELTONA-PROPOSED	1	0.00	0.80	1.44	1.87	1.87	1.87
4	84	66	DEL	DELTONA-PROPOSED	1	0.00	0.80	0.00	0.17	0.63	1.87
5	74	67	DEL	DELTONA	1	0.48	0.80	1.87	1.87	1.87	1.87
6	76	68	DEL	DELTONA	1	0.48	0.80	1.87	1.87	1.87	1.87
6	88	69	DEL	DELTONA	1	0.48	0.00	0.00	0.00	0.00	1.87
6	86	70	DEL	DELTONA-PROPOSED	1	0.00	0.80	0.00	0.00	0.00	1.87
7	71	71	DEL	DELTONA	1	0.48	1.61	1.87	1.87	1.87	2.06
7	78	72	DEL	DELTONA	1	1.94	3.21	0.00	0.00	0.00	3.74
7	74	73	DEL	DELTONA-PROPOSED	1	1.45	3.21	0.43	1.92	3.38	3.74
8	80	74	DEL	DELTONA	1	0.48	0.80	0.00	0.00	0.00	1.87
8	76	75	DEL	DELTONA-PROPOSED	1	0.00	0.80	0.00	0.00	0.00	1.87
8	83	76	DEL	DELTONA-PROPOSED	1	0.00	2.41	0.00	0.00	0.00	3.74
9	77	77	DEL	DELTONA-PROPOSED	1	0.00	0.80	0.00	0.00	0.00	1.87
9	80	78	DEL	DELTONA-PROPOSED	1	0.00	0.80	0.00	0.00	0.00	1.87
9	85	79	DEL	DELTONA-PROPOSED	1	0.00	0.80	0.00	0.00	0.00	1.87
9	88	80	DEL	DELTONA-PROPOSED	1	0.00	1.61	0.00	0.00	0.00	1.87
77	103	81	ECU	ECON UTIL (WEDGEFIELD)	1	0.10	0.12	0.00	0.00	0.00	0.16
77	104	82	ECU	ECON UTIL (WEDGEFIELD)	1	0.03	0.04	0.15	0.15	0.15	0.16
12	12	83	EUS	EUSTIS (C R 44A ?)	1	0.17	1.36	2.69	2.69	2.69	2.69
12	13	84	EUS	EUSTIS (C R 44A ?)	1	0.17	1.36	0.00	0.00	0.00	2.69
13	22	85	EUS	EUSTIS (HAZELTON AVE.)	1	1.33	0.54	0.00	0.00	0.00	1.12
15	11	86	EUS	EUSTIS (ARDICE PLACE)	1	1.23	2.53	3.09	3.09	3.09	4.86
86	93	87	FDC	FL DEPT OF CORR	1	0.05	0.05	0.00	0.00	0.00	0.22
87	92	88	FDC	FL DEPT OF CORR	1	0.11	0.11	0.00	0.00	0.00	0.22
87	93	89	FDC	FL DEPT OF CORR	1	0.05	0.05	0.16	0.16	0.16	0.22
104	47	90	KIS	CITY OF KISSIMMEE (NORTH BERMUDA)	1	2.05	4.89	0.13	0.13	0.13	8.98
106	49	91	KIS	CITY OF KISSIMMEE (RUBY ST.)	1	1.77	4.22	8.98	8.98	8.98	8.98
1	78	92	LHE	LAKE HELEN - PLANT #2	1	0.09	0.29	0.58	0.58	0.58	0.75
2	78	93	LHE	LAKE HELEN - PLANT #1	1	0.13	0.29	0.00	0.00	0.00	0.75
34	101	94	LHY	LAKE HARNEY WATER ASSOC	1	0.01	0.03	0.03	0.03	0.03	0.29
35	101	95	LHY	LAKE HARNEY WATER ASSOC	1	0.02	0.00	0.00	0.00	0.00	0.29
24	59	96	LMY	LAKE MARY (NEW PUBLIC SUPPLY)	1	0.00	0.80	0.00	2.21	2.30	2.30
25	59	97	LMY	LAKE MARY (NEW PUBLIC SUPPLY)	1	0.00	0.80	1.79	1.20	1.34	2.30

Table A8--*Continued*

Model Row	Model Column	Well ID Number	Public Supply Demand Area	Well or Treatment Plant	Model Layer (1= Upper, 2= Lower Floridan)	Year 1988	Projected Year 2010	Case 3	Case 2	Case 1	Estimated Well Capacity (MGD)
26	59	98	LMY	LAKE MARY (NEW PUBLIC SUPPLY)	1	0.00	1.61	0.38	0.00	0.00	2.30
27	59	99	LMY	LAKE MARY (NEW PUBLIC SUPPLY)	1	0.00	0.80	0.00	0.00	0.00	2.30
28	59	100	LMY	LAKE MARY (NEW PUBLIC SUPPLY)	1	0.25	0.80	0.00	0.00	0.00	2.30
29	59	101	LMY	LAKE MARY (NEW PUBLIC SUPPLY)	1	0.25	0.80	0.00	0.00	0.00	2.30
39	57	102	LON	LONGWOOD	1	1.25	2.28	0.00	0.00	1.15	3.37
40	60	103	LON	LONGWOOD	1	0.78	0.87	3.15	3.15	2.00	3.37
55	60	104	MAI	MAITLAND - THISTLE LANE	1	0.57	0.69	0.00	0.00	0.55	2.54
57	56	105	MAI	MAITLAND - MINNEHAHA CIRCLE	1	0.09	0.11	0.00	0.00	0.00	1.08
58	53	106	MAI	MAITLAND - WELL NO. 5A	1	0.19	0.24	0.00	0.00	0.00	2.24
57	50	107	MAI	MAITLAND - KELLER	2	1.46	1.79	0.00	0.00	2.99	6.43
58	53	108	MAI	MAITLAND - WELL NO. 5A	2	0.58	0.71	0.00	0.00	0.00	2.24
65	87	109	OE1	OCPUD EAST REG: (BONNEVILLE)	1	0.74	0.00	0.00	0.00	0.00	7.48
68	65	110	OE1	OCPUD EAST REG: (CORRINE TERRACE)	1	0.20	0.00	0.00	0.00	0.00	0.22
72	75	111	OE3	OCPUD EAST REG: (ECON)	1	1.79	4.00	0.00	0.00	0.00	4.19
73	75	112	OE3	OCPUD EAST REG: (ECON)	1	1.79	4.00	0.00	0.00	0.00	4.19
79	74	113	OE5	OCPUD EAST REG: ERWF	1	0.00	20.25	0.00	0.00	0.00	20.94
82	66	114	OE2	OCPUD EAST REG: (CONWAY)	1	0.74	2.09	0.00	0.00	0.00	4.49
82	67	115	OE2	OCPUD EAST REG: (CONWAY)	1	0.74	2.09	0.00	0.00	0.00	4.49
94	73	116	OE4	OCPUD EAST REG: (LAKE NONA)	1	0.03	2.00	2.00	2.00	2.00	2.99
82	67	117	OE2	OCPUD EAST REG: (CONWAY)	2	1.01	3.47	0.00	0.00	0.00	4.49
63	33	118	OCO	OCOEE (HACKNEY PRAIRIE)	1	0.57	0.68	0.00	0.00	0.00	3.74
63	31	119	OCO	OCOEE (JAMELA & WURST ROAD)	1	0.00	0.00	0.00	0.00	0.00	1.50
65	29	120	OCO	OCOEE (JAMELA & WURST ROAD)	1	0.89	0.93	0.00	0.00	0.00	1.50
68	27	121	OCO	OCOEE (KISSIMEE AVE)	1	0.67	0.93	0.00	0.00	0.00	4.32
73	28	122	OCO	OCOEE (SOUTH PLANT)	2	0.00	2.94	0.00	0.00	1.51	2.99
94	41	123	OS4	OCPUD SOUTH REG: (ORANGE WOOD)	1	0.89	2.40	0.00	0.00	0.00	3.61
95	41	124	OS4	OCPUD SOUTH REG: (ORANGE WOOD)	1	0.89	2.40	3.61	3.61	3.61	3.61
100	30	125	OS1	OCPUD SOUTH REG: (CYPRESS WALK)	1	0.28	1.25	1.35	1.35	1.35	1.35
100	31	126	OS1	OCPUD SOUTH REG: (CYPRESS WALK)	1	0.28	1.25	0.96	0.96	0.96	1.35
100	56	127	OS3	OCPUD SOUTH REG: (MEADOW WOODS)	1	0.08	0.20	1.65	1.37	0.83	5.39
101	46	128	OS2	OCPUD SOUTH REG: (HUNTERS CREEK)	1	0.12	0.50	0.50	0.50	0.50	8.98
101	32	129	OS1	OCPUD SOUTH REG: (VISTANA)	1	1.05	4.00	4.19	4.19	4.19	4.19
94	41	130	OS4	OCPUD SOUTH REG: (ORANGE WOOD)	2	0.59	1.68	2.87	2.87	2.87	3.61
101	54	131	OS3	OCPUD SOUTH REG: SOUTH REG. WELL	2	0.00	10.00	8.55	8.83	9.37	10.47
28	31	132	OW1	OCPUD WEST REG: (MT. PLYMOUTH LAK	1	0.19	0.90	1.44	1.44	1.44	1.44
38	25	133	OW1	OCPUD WEST REG: (PLYMOUTH)	1	0.00	1.50	0.00	0.00	0.42	1.80
39	24	134	OW1	OCPUD WEST REG: (PLYMOUTH HILLS)	1	0.03	0.00	0.00	0.00	0.16	0.16
43	38	135	OW1	OCPUD WEST REG: (BENT OAKS)	1	1.32	0.00	1.00	1.00	0.26	5.24
43	26	136	OW1	OCPUD WEST REG: (PLYMOUTH CENTRAL	1	0.08	0.00	0.00	0.00	0.16	0.16
54	32	137	OW1	OCPUD WEST REG: (ORANGE VILLAGE)	1	0.02	0.03	0.00	0.00	0.00	0.09
55	46	138	OW4	OCPUD - RIVERSIDE	1	0.48	0.00	0.00	0.00	0.00	1.50
55	47	139	OW4	OCPUD - RIVERSIDE	1	0.48	0.00	0.00	0.00	0.00	1.50
56	46	140	OW4	OCPUD - RIVERSIDE	1	0.48	0.00	0.00	0.00	0.00	1.50
65	21	141	OW6	OCPUD WEST REG: (MAGNOLIA WOODS)	1	0.04	0.03	0.05	0.00	0.00	1.50
70	15	142	OW6	OCPUD WEST REG: LAKE JOHN SHORES	1	0.00	0.03	0.00	0.07	0.07	0.34
72	36	143	OW3	OCPUD WEST REGIONAL (OAK MEADOWS)	1	0.39	0.00	0.00	0.00	0.00	4.49
76	30	144	OW2	OCPUD WEST REG: (WINDERMERE DOWNS	1	0.22	0.00	0.00	0.00	0.00	0.30
79	27	145	OW2	OCPUD WEST REG: (WAUSEON RIDGE)	1	0.03	0.00	0.00	0.00	0.00	0.04
81	36	146	OW2	OCPUD WEST REG: (HIDDEN SPRINGS)	1	0.18	0.00	0.00	0.00	0.00	5.24

Table A8--*Continued*

Model Row	Model Column	Well ID Number	Public Supply Demand Area	Well or Treatment Plant	Model Layer (1= Upper, 2= Lower Floridan)	Year 1988	Projected Year 2010	Case 3	Case 2	Case 1	Estimated Well Capacity (MGD)
81	23	147	OW2	OCPUD WEST REG: (KELSO)	1	0.02	0.00	0.00	0.00	0.00	0.58
81	29	148	OW2	OCPUD WEST REG: (WINDERMERE)	1	0.01	0.00	0.00	0.00	0.00	0.01
82	36	149	OW2	OCPUD WEST REG: (HIDDEN SPRINGS)	1	0.06	0.00	0.00	0.00	0.00	5.24
55	46	150	OW4	OCPUD - RIVERSIDE	2	0.48	0.00	0.00	0.00	0.00	1.50
55	47	151	OW4	OCPUD - RIVERSIDE	2	0.48	0.00	0.00	0.00	0.00	1.50
55	35	152	OW5	OCPUD WEST REG: WRWF WELL # 1	2	0.00	6.00	5.04	5.04	5.04	7.48
55	36	153	OW5	OCPUD WEST REG: WRWF WELL # 1	2	0.00	14.00	14.96	14.96	14.96	14.96
56	46	154	OW4	OCPUD - RIVERSIDE	2	0.48	0.00	0.00	0.00	0.00	1.50
72	36	155	OW3	OCPUD WEST REGIONAL (OAK MEADOWS)	2	1.55	0.00	0.00	0.00	0.00	4.49
82	36	156	OW2	OCPUD WEST REG: (HIDDEN SPRINGS)	2	1.42	0.00	0.00	0.00	0.00	5.24
4	73	157	OCY	Or. City Ctry V	1	0.14	0.39	0.00	0.00	0.00	0.75
4	67	158	OCY	ORANGE CITY	1	0.17	0.91	1.87	1.87	1.87	1.87
4	68	159	OCY	ORANGE CITY	1	0.34	2.74	2.17	2.17	2.17	5.39
104	59	160	ORO	ORANGE/OSCEOLA (BEUNAVENTURA LAKE	1	1.14	2.72	1.77	1.77	1.77	5.39
104	58	161	ORO	ORANGE/OSCEOLA MGMENT	1	0.39	0.93	1.87	1.87	1.87	1.87
83	90	162	OU13	OUC-STANTON ENERGY CTR.	1	0.40	0.40	0.40	0.40	0.40	0.45
87	35	163	OU1	OUC (DR. PHILLIPS)	1	5.33	6.20	0.37	6.20	6.20	13.46
88	41	164	OU2	OUC (MARTIN)	1	9.17	20.19	12.92	10.88	11.85	20.94
68	55	165	OU4	OUC - HIGHLAND	2	2.31	2.42	0.00	0.00	0.00	8.98
68	64	166	OU10	OUC - NAVY	2	1.39	6.40	0.00	0.00	6.40	6.73
68	40	167	OU5	OUC - PINE HILLS	2	5.60	7.84	0.00	0.00	0.00	8.23
68	41	168	OU5	OUC - PINE HILLS	2	2.80	7.84	0.00	0.00	0.00	8.23
69	55	169	OU4	OUC - HIGHLAND	2	3.46	3.63	0.00	0.00	0.00	8.98
69	56	170	OU4	OUC - HIGHLAND	2	1.15	0.72	0.00	0.00	0.00	8.98
69	41	171	OU5	OUC - PINE HILLS	2	2.80	3.92	0.00	0.00	0.00	8.23
70	55	172	OU4	OUC - HIGHLAND	2	1.15	1.21	0.00	0.00	0.00	8.98
72	60	173	OU8	OUC - PRIMROSE	2	2.68	2.36	0.00	0.00	0.00	8.23
73	59	174	OU8	OUC - PRIMROSE SFWMD?	2	5.35	4.73	7.09	7.09	6.79	8.23
76	54	175	OU6	OUC - KUHL	2	2.80	3.77	0.00	0.00	0.00	8.23
77	62	176	OU3	OUC - CONWAY	2	6.66	6.13	3.15	5.43	0.00	8.23
77	55	177	OU6	OUC - KUHL	2	5.60	7.54	0.00	0.00	0.00	8.23
78	62	178	OU3	OUC - CONWAY	2	3.33	3.07	0.00	0.00	0.00	8.23
80	67	179	OU12	OUC (PERSHING)	2	0.00	7.00	0.00	0.00	0.00	7.48
80	39	180	OU7	OUC - KIRKMAN	2	2.09	3.67	0.00	0.00	0.00	8.23
80	40	181	OU7	OUC - KIRKMAN	2	4.17	7.33	0.00	0.00	0.00	8.23
88	53	182	OU9	OUC - SKY LAKE	2	0.00	15.30	15.30	15.30	15.30	15.71
98	55	183	OU11	OUC (ORANGE)	2	0.00	7.20	7.20	7.20	7.20	7.48
51	82	184	OVI	OVIEDO (PLNT #1)	1	0.78	3.02	1.68	1.55	1.54	5.98
52	83	185	OVI	OVIEDO (ALAFAYA WOODS - PLNT #2)	1	0.37	3.68	0.13	0.00	0.00	5.98
53	82	186	OVI	OVIEDO-PROP. WELL LAKE GEM	1	0.00	1.47	0.36	0.92	0.85	2.99
54	86	187	OVI	OVIEDO (ALAFAYA WOODS - PLNT #2)	1	0.00	1.47	2.99	2.99	2.99	2.99
69	79	188	PAM	PARK MANOR WATER WORKS	1	0.22	0.20	0.41	0.41	0.41	0.75
70	77	189	PAM	PARK MANOR WATER WORKS	1	0.22	0.20	0.00	0.00	0.00	0.75
114	34	190	POI	POINCIANA UTIL (IP-1&2)	1	0.41	0.98	0.00	0.00	0.00	1.12
117	39	191	POI	POINCIANA (CORES-1,2&3 89-90)	1	0.06	0.15	0.69	0.69	0.69	0.75
118	38	192	POI	POINCIANA (CORES-1,2&3 89-90)	1	0.13	0.31	0.75	0.75	0.75	0.75
22	67	193	RAV	UTILITIES OF FLA (RAVENNA PARK)	1	0.12	0.12	0.24	0.24	0.24	0.37
23	65	194	RAV	UTILITIES OF FLA (CRYSTAL LAKE)	1	0.03	0.07	0.00	0.00	0.00	0.37
25	65	195	RAV	UTILITIES OF FLA (PHILLIPS)	1	0.03	0.02	0.00	0.00	0.00	0.37

Table A8--*Continued*

Model Row	Model Column	Well ID Number	Public Supply Demand Area	Well or Treatment Plant	Model Layer (1= Upper, 2= Lower Floridan)	Year 1988	Projected Year 2010	Case 3	Case 2	Case 1	Estimated Well Capacity (MGD)
30	68	196	RAV	UTILITIES OF FLA (PARK RIDGE)	1	0.00	0.02	0.00	0.00	0.00	0.45
91	20	197	RCU	REEDY CREEK UTIL (PUMP STN A; 89-	1	3.65	8.89	4.69	8.05	8.98	8.98
92	22	198	RCU	REEDY CREEK UTIL (PUMP STN A; 89-	1	1.82	4.45	4.49	4.49	4.49	4.49
98	30	199	RCU	REEDY CREEK UTIL (PUMP STATION C)	1	1.29	3.19	0.00	0.00	0.00	3.37
100	31	200	RCU	REEDY CREEK UTIL (PUMP STATION C)	1	0.64	1.59	3.37	3.37	2.44	3.37
100	32	201	RCU	REEDY CREEK UTIL (PUMP STATION C)	1	0.64	1.59	3.37	0.00	0.00	3.37
101	22	202	RCU	REEDY CREEK UTIL (PMP STN B)	1	3.96	3.09	4.11	4.11	4.11	4.11
102	24	203	RCU	REEDY CREEK UTIL (PMP STN B)	1	7.93	6.19	8.98	8.98	8.98	8.98
21	61	204	SAF	SANFORD (WELLFIELD # 4) (PROP)	1	0.00	0.55	0.00	0.00	0.00	3.37
21	62	205	SAF	SANFORD (WELLFIELD #3)	1	1.29	2.07	0.00	0.00	0.00	3.74
21	63	206	SAF	SANFORD (WELLFIELD #3)	1	0.86	1.18	1.50	1.16	1.09	1.50
22	61	207	SAF	SANFORD (WELLFIELD # 4)	1	0.00	1.11	0.00	0.00	0.00	3.37
23	63	208	SAF	SANFORD (WELLFIELD #2)	1	0.35	0.00	1.81	0.00	0.00	2.92
24	63	209	SAF	SANFORD (WELLFIELD #2)	1	0.71	1.66	0.00	1.03	1.05	2.92
27	69	210	SAF	SANFORD (WELLFIELD #1)	1	0.00	0.00	0.00	0.00	0.00	1.50
28	68	211	SAF	SANFORD (WELLFIELD #1)	1	0.61	0.32	0.44	0.75	0.96	1.50
28	69	212	SAF	SANFORD (WELLFIELD #1)	1	0.61	0.30	0.00	0.00	0.00	1.50
29	68	213	SAF	SANFORD (WELLFIELD #1)	1	0.30	0.21	1.30	1.35	1.28	1.50
29	69	214	SAF	SANFORD (WELLFIELD #1)	1	0.30	0.11	0.00	0.00	0.00	1.50
37	54	215	SAN	SANLANDO UTIL CORP (DES PINAR)	1	0.00	0.53	0.00	0.00	0.00	2.62
38	55	216	SAN	SANLANDO UTIL CORP (DES PINAR)	1	0.57	1.06	0.64	1.17	2.29	2.62
39	55	217	SAN	SANLANDO UTIL CORP (DES PINAR)	1	1.70	1.93	1.40	1.29	0.00	2.62
41	44	218	SAN	SANLANDO (WEKIVA HUNT CLUB)	1	1.13	0.99	0.93	1.09	1.46	1.80
41	54	219	SAN	SANLANDO UTIL CORP (OVERSTREET)	1	0.57	0.00	0.75	0.75	0.75	0.75
41	55	220	SAN	SANLANDO UTIL CORP (OVERSTREET)	1	0.57	0.09	0.75	0.75	0.75	0.75
43	43	221	SAN	SANLANDO (WEKIVA HUNT CLUB)	1	1.13	2.29	0.56	0.86	1.80	2.39
43	44	222	SAN	SANLANDO (WEKIVA HUNT CLUB)	1	1.13	0.65	1.80	1.80	1.80	1.80
44	43	223	SAN	SANLANDO (WEKIVA HUNT CLUB)	1	1.13	1.32	1.80	1.11	0.00	1.80
45	43	224	SAN	SANLANDO (WEKIVA HUNT CLUB)	1	1.13	1.90	1.94	1.94	1.91	1.94
109	68	225	SCL	CITY OF ST. CLOUD	1	1.20	2.86	2.42	2.42	2.42	4.49
109	71	226	SCL	CITY OF ST. CLOUD	1	0.60	1.43	1.87	1.87	1.87	1.87
17	62	227	SEM	SEM CTY LAKE MONROE (I-4 IND. PAR	1	0.13	0.29	0.05	0.10	0.11	2.47
27	54	228	SEM	SEM. COUNTY (HANOVER WOODS)	1	0.15	0.60	0.00	0.00	0.09	2.24
28	57	229	SEM	SEM. COUNTY (HEATHROW)	1	0.31	1.87	0.10	0.05	0.08	3.59
32	59	230	SEM	SEM. COUNTY (GREENWOOD LAKES)	1	0.31	0.50	0.43	0.98	0.46	1.05
32	60	231	SEM	SEM. COUNTY (GREENWOOD LAKES)	1	0.31	0.67	0.00	0.00	0.00	1.05
33	62	232	SEM	SEM. COUNTY (COUNTRY CLUB)	1	0.01	1.33	0.10	0.22	0.24	2.99
33	59	233	SEM	SEM. COUNTY (GREENWOOD LAKES)	1	0.00	0.90	1.05	1.05	1.05	1.05
33	60	234	SEM	SEM. COUNTY (GREENWOOD LAKES)	1	0.31	0.30	0.91	0.00	1.00	1.05
33	61	235	SEM	SEM. COUNTY (GREENWOOD LAKES)	1	0.31	1.14	0.00	0.30	0.00	1.20
48	41	236	SEM	SEM. COUNTY (BELAIRE)	1	0.10	0.10	1.20	0.00	0.25	1.20
49	42	237	SEM	SEM. COUNTY (LYNWOOD)	1	0.20	0.49	0.57	3.38	3.44	3.44
50	42	238	SEM	SEM. COUNTY (LYNWOOD)	1	0.20	0.49	0.00	0.00	0.39	3.44
53	62	239	SEM	SEM. COUNTY (INDIAN HILLS)	1	1.30	3.09	0.00	0.00	4.49	4.49
55	68	240	SEM	SEM CTY (CONSUMER)	1	0.67	1.80	0.17	0.39	0.00	4.49
55	69	241	SEM	SEM CTY (CONSUMER)	1	2.00	4.04	4.49	4.49	4.35	4.49
56	84	242	SEM	SEM CTY (LAKE HAYES)	1	0.21	0.97	0.00	0.04	0.01	4.49
63	76	243	SSS	SO. STATES UTIL (UNIV. SHORES/SUN	1	0.52	0.85	1.50	1.50	1.50	1.50
66	71	244	SSS	SO. STATES UTIL (UNIV. SHORES)	1	0.07	0.35	0.00	0.00	0.00	0.75

Table A8--*Continued*

Model Row	Model Column	Well ID Number	Public Supply Demand Area	Well or Treatment Plant	Model Layer (1= Upper, 2= Lower Floridan)	Year 1988	Projected Year 2010	Case 3	Case 2	Case 1	Estimated Well Capacity (MGD)
66	72	245	SSS	SO. STATES UTIL (UNIV. SHORES)	1	0.07	0.35	0.00	0.06	0.06	0.75
42	45	246	SSU	SOUTHERN ST. UTIL (LAKE BRANTLEY)	1	0.02	0.02	0.00	0.00	0.00	0.15
43	48	247	SSU	SOUTHERN ST. UTIL (MEREDITH MANOR	1	0.12	0.09	0.37	0.37	0.37	0.37
44	48	248	SSU	SOUTHERN ST. UTIL (MEREDITH MANOR	1	0.12	0.18	0.10	0.37	0.37	0.37
47	57	249	SSU	STATES UTIL (HARMONY HOMES)	1	0.01	0.05	0.00	0.00	0.00	0.45
47	52	250	SSU	SOUTHERN ST. UTIL (APPLE VALLEY)	1	0.44	0.51	0.75	0.47	0.47	1.50
49	46	251	SSU	SOUTHERN ST. UTIL (LAKE HARRIET)	1	0.08	0.09	0.00	0.00	0.00	0.90
50	54	252	SSU	SOUTHERN ST. UTIL (DOL RAY MANOR)	1	0.04	0.04	0.00	0.00	0.00	0.82
53	58	253	SSU	SO. STATES UTIL (FERN PARK)	1	0.01	0.05	0.00	0.00	0.00	0.37
54	54	254	SSU	SOUTHERN ST. UTIL (D. HILLS\BRETT	1	0.14	0.18	0.00	0.00	0.00	0.60
33	96	255	SWA	SEMINOLE WOODS ASSOC, INC	1	0.01	0.02	0.00	0.00	0.00	0.12
33	97	256	SWA	SEMINOLE WOODS ASSOC, INC	1	0.01	0.02	0.08	0.08	0.08	0.12
34	96	257	SWA	SEMINOLE WOODS ASSOC, INC	1	0.01	0.02	0.00	0.00	0.00	0.12
34	97	258	SWA	SEMINOLE WOODS ASSOC, INC	1	0.01	0.02	0.00	0.00	0.00	0.12
95	38	259	SWF	SEA WORLD OF FLA.	1	0.40	0.40	1.30	1.30	1.30	1.35
95	39	260	SWF	SEA WORLD OF FLA.	1	0.90	0.90	0.00	0.00	0.00	1.35
61	83	261	UCF	UCF	1	0.06	0.09	0.00	0.00	0.00	0.37
62	84	262	UCF	UCF	1	0.06	0.09	0.00	0.00	0.00	0.37
63	83	263	UCF	UCF	1	0.12	0.17	0.00	0.00	0.00	0.75
63	84	264	UCF	UCF	1	0.06	0.09	0.00	0.00	0.00	0.37
63	85	265	UCF	UCF	1	0.18	0.26	0.28	0.28	0.28	1.12
64	83	266	UCF	UCF	1	0.06	0.09	0.00	0.00	0.00	0.37
64	85	267	UCF	UCF	1	0.06	0.09	0.37	0.37	0.37	0.37
64	86	268	UCF	UCF	1	0.06	0.09	0.37	0.37	0.37	0.37
65	82	269	UCF	UCF	1	0.06	0.09	0.00	0.00	0.00	0.37
2	78	270	VOL	VOL COUNTY - CASSADAGA	1	0.02	0.04	0.15	0.15	0.15	0.15
4	65	271	VOL	VOL COUNTY - ?	1	0.07	0.10	0.22	0.22	0.22	0.22
4	63	272	VOL	VOL CTY - WEST ORANGE CITY	1	0.00	0.01	0.15	0.15	0.15	0.15
5	67	273	VOL	VOL COUNTY - FOUR TOWNS	1	0.20	0.32	0.75	0.75	0.75	0.75
5	68	274	VOL	VOL COUNTY-ORANGE CITY INDUS PARK	1	0.04	0.04	0.15	0.15	0.15	0.15
6	68	275	VOL	VOL COUNTY - BREEZEWOOD	1	0.14	0.16	0.00	0.00	0.00	0.75
6	67	276	VOL	VOL COUNTY - FOUR TOWNS	1	0.23	0.37	0.00	0.00	0.00	0.75
6	66	277	VOL	VOL COUNTY HIGHLAND CTRY EST	1	0.11	0.46	0.90	0.90	0.90	0.90
7	68	278	VOL	VOL COUNTY - GLEN ABBEY OR SWALLO	1	0.24	0.77	0.00	0.00	0.00	1.87
7	65	279	VOL	VOL COUNTY - LAKE MARIE	1	0.14	0.25	0.20	0.20	0.20	0.75
47	48	280	WEK	UTILITIES OF FLA (LITTLE WEKIVA)	1	0.02	0.03	0.45	0.45	0.45	0.45
51	42	281	WEK	UTILITIES OF FLA (BEAR LAKE)	1	0.06	0.08	0.00	0.00	0.00	0.60
51	49	282	WEK	UTILITIES OF FLA (WEATHERSFIELD)	1	0.41	0.42	0.32	0.32	0.32	1.50
54	41	283	WEK	UTILITIES OF FLA (JANSEN)	1	0.07	0.08	0.00	0.00	0.00	0.60
54	55	284	WEK	UTILITIES OF FLA (OAKLAND SHORES)	1	0.14	0.16	0.00	0.00	0.00	0.60
67	20	285	WGA	WINTER GARDEN (PALMETTO STREET)	1	0.88	0.63	0.00	0.04	0.04	2.54
68	19	286	WGA	WINTER GARDEN (FULLER CROSS)	1	0.28	0.63	0.00	0.75	0.75	0.75
69	19	287	WGA	WINTER GARDEN (BOYD STREET)	1	0.28	0.63	0.00	1.73	1.73	1.73
68	20	288	WGA	WINTER GARDEN PROPOSED PLANT #4	2	0.00	0.63	0.00	0.00	0.00	0.75
70	22	289	WGC	WINTER GARDEN CITRUS PRODUCTS	1	1.87	1.87	1.87	1.87	1.87	1.88
63	58	290	WPK	WINTER PARK - PLANT #1 (SWOOPE)	1	2.47	2.26	0.00	0.00	0.00	4.49
63	67	291	WPK	WINTER PARK PLANT #5 (UNIV.)	1	2.42	2.02	0.00	0.00	0.00	6.73
58	63	292	WPK	WINTER PARK - PLANT #4 (MAGNOLIA)	2	1.97	3.24	5.46	5.46	5.46	5.46
61	53	293	WPK	WINTER PARK - PLANT #3 (Wymore)	2	2.94	3.12	4.49	4.49	4.49	4.49

Table A8--*Continued*

Model Row	Model Column	Well ID Number	Public Supply Demand Area	Well or Treatment Plant	Model Layer (1= Upper, 2= Lower Floridan)	Year 1988	Projected Year 2010	Case 3	Case 2	Case 1	Estimated Well Capacity (MGD)
63	58	294	WPK	WINTER PARK - PLANT #1 (SWOOPE)	2	0.00	1.44	0.00	0.00	0.00	4.49
63	67	295	WPK	WINTER PARK - PLANT #5 (UNIV.)	2	2.54	3.20	5.33	5.33	5.33	6.73
37	64	296	WSP	WINTER SPRINGS (WTP #2)	1	0.59	0.71	0.49	0.58	0.66	1.65
44	66	297	WSP	WINTER SPRINGS (WTP #3)	1	0.31	0.36	1.65	1.65	1.65	1.65
44	67	298	WSP	WINTER SPRINGS (WTP #3)	1	0.31	1.56	0.77	0.84	0.62	3.46
46	73	299	WSP	WINTER SPRNGS EAST 2	1	1.76	3.38	2.37	2.40	2.35	3.74
30	16	300	ZWF	ZELLWOOD FARMS	1	0.07	0.16	0.32	0.32	0.32	0.37
30	17	301	ZWF	ZELLWOOD FARMS	1	0.07	0.16	0.00	0.00	0.00	0.37
34	17	302	ZWU	ZELLWOOD WATER USERS	1	0.17	0.37	0.37	0.37	0.37	0.75
35	20	303	ZSU	ZELLWOOD STATION UTIL.	1	0.12	0.31	0.00	0.75	0.75	0.75
35	21	304	ZSU	ZELLWOOD STATION UTIL.	1	0.06	0.16	0.00	0.24	0.75	0.75
35	22	305	ZSU	ZELLWOOD STATION UTIL.	1	0.54	0.80	0.00	0.00	0.02	1.50
35	23	306	ZSU	ZELLWOOD STATION UTIL.	1	0.12	0.31	0.00	0.00	0.00	0.75
36	19	307	ZSU	ZELLWOOD STATION UTIL.	1	0.06	0.16	0.00	0.37	0.37	0.37
36	23	308	ZSU	ZELLWOOD STATION UTIL.	1	0.06	0.16	0.00	0.00	0.00	0.37
17	14	309	MTD	CITY OF MT. DORA	1	2.35	4.45	4.45	4.45	4.45	4.49
19	9	310	TAV	CITY OF TAVARES	1	1.16	3.36	3.36	3.36	3.36	3.74
9	71	311	FPL	FPL LAKE MONROE	1	0.09	0.15	0.00	0.00	0.00	0.30
13	63	312	FPL	FLORIDA POWER & LIGHT-SANFORD POW	1	0.32	0.60	0.75	0.75	0.75	1.20
68	1	313	IN1	B & W CANNING	1	0.97	1.11	1.11	1.11	1.11	1.12
76	11	314	IN2	FLORIDA CRUSHED STONE	1	2.18	2.18	2.18	2.18	2.18	2.24
98	8	315	IN3	FLA. ROCK (LAKE SAND PLANT)	1	0.87	0.87	0.87	0.87	0.87	0.90
103	31	316	IN4	FLORIBRA USA, INC	1	1.58	1.58	1.58	1.58	1.58	1.65
36	5	317	IN6	SILVER SPRINGS CITRUS	1	0.71	0.71	0.71	0.71	0.71	0.75
37	6	318	HOH	HOWEY-IN-THE-HILLS	1	0.31	0.45	0.45	0.45	0.45	0.45
59	54	319	EAT	EATONVILLE	1	0.61	1.41	0.00	0.00	0.00	1.50
62	12	320	MON	MONTEVERDE	1	0.12	0.22	0.22	0.22	0.22	0.22
64	6	321	MHN	MINNEOLA HARBOR HILLS/12/13/88- P	1	1.28	2.01	2.01	2.01	2.01	2.02
67	84	322	CFR	CENT. FLA RES. PARK	1	1.00	1.00	1.00	1.00	1.00	1.05
67	8	323	MIN	CITY OF MINNEOLA	1	0.19	0.45	0.45	0.45	0.45	0.45
69	15	324	OAK	CITY OF OAKLAND	1	0.29	0.28	0.00	0.28	0.28	1.44
69	1	325	GRO	TOWN OF GROVELAND	1	0.29	0.79	0.79	0.79	0.79	0.90
79	11	326	IN5	SILVER SAND (CLERMONT MINE)	1	1.24	1.24	1.24	1.24	1.24	1.35
103	28	327	HHO	HYATT HOUSE ORLANDO	1	0.30	0.73	0.73	0.73	0.73	0.75
103	19	328	OSC	OSCEOLA SERVICE	1	0.96	2.28	2.28	2.28	2.28	2.39
108	133	329	AF1	USAF BAS CIVIL ENGINEER/8/12/86	1	0.80	0.80	0.80	0.80	0.80	0.90
115	16	330	DAV	DAVENPORT (1987)	1	0.53	1.27	1.27	1.27	1.27	1.35
118	15	331	HAI	HAINES CITY	1	1.18	2.80	2.80	2.80	2.80	2.99
4	69	332	JKV	JOHN KNOX VILL.	1	0.05	0.35	0.00	0.35	0.35	0.37

Table A9. Volusia LP optimization model public supply utility well withdrawal rates

Public well or Control Point Number	Well Description	Public Utility Need Area	Simulation Model Row	Simulation Model Column	Well withdrawal rates (MGD) 1988	Non-optimized projected year 2010	Case 3	Case 2	Case 1	Potential for Vegetative Harm
1	DELAND WATER UTIL	DWU	68	13	0.54	0.00	0.00	0.00	0.00	LOW
2	DELAND WATER UTIL	DWU	67	12	0.54	0.77	0.00	0.00	0.00	LOW
3	DELAND WATER UTIL	DWU	66	12	1.08	1.54	0.00	0.00	0.00	LOW
4	DELAND WATER UTIL	DWU	64	11	0.54	0.77	2.26	2.26	2.26	LOW
5	DELAND WATER UTIL	DWU	67	14	0.54	0.77	2.26	2.26	0.12	LOW
6	DELAND WATER UTIL	DWU	61	14	0.54	0.77	2.26	2.26	2.26	LOW
7	DELAND WATER UTIL	DWU	65	11	0.54	0.77	0.12	0.12	2.26	LOW
8	DELAND WU 1990	DWU	70	13	0.00	1.54	0.00	0.00	0.00	LOW
9	HOLLY HILL EASTERN WF	HHE	41	73	0.03	0.05	0.14	0.14	0.14	LOW
10	HOLLY HILL EASTERN WF	HHE	41	74	0.02	0.02	0.00	0.00	0.00	LOW
11	HOLLY HILL EASTERN WF	HHE	40	74	0.02	0.02	0.00	0.00	0.00	LOW
12	HOLLY HILL EASTERN WF	HHE	40	73	0.02	0.02	0.00	0.00	0.00	LOW
13	HOLLY HILL EASTERN WF	HHE	40	72	0.02	0.02	0.00	0.00	0.00	LOW
14	HOLLY HILL WESTERN WF	HHW	41	54	0.29	0.35	0.00	0.00	0.00	LOW
15	HOLLY HILL WESTERN WF	HHW	41	55	0.44	0.52	1.27	1.27	0.00	LOW
16	HOLLY HILL WESTERN WF	HHW	40	55	0.29	0.35	0.05	0.11	1.09	LOW
17	HOLLY HIIL PROPOSED	HHW	40	55	0.00	0.17	0.00	0.00	0.29	LOW
18	OR. CITY CTRY VILLAGE	OCC	79	12	0.13	0.39	0.00	0.00	0.39	LOW
19	SSU SUGAR MILL EST	SME	81	65	0.10	0.22	0.00	0.22	0.22	HIGH
20	PORT ORANGE WESTERN WF	POW	64	42	0.27	0.29	0.27	0.32	0.51	MODERATE
21	PORT ORANGE WESTERN WF	POW	67	41	0.27	0.29	0.51	0.51	0.51	MODERATE
22	PORT ORANGE WESTERN WF	POW	68	40	0.53	0.57	0.00	0.52	0.25	MODERATE
23	PORT ORANGE WESTERN WF	POW	69	39	0.27	0.29	0.00	0.00	0.00	MODERATE
24	PORT ORANGE WESTERN WF	POW	70	39	0.27	0.29	0.00	0.00	0.00	MODERATE
25	PORT ORANGE WESTERN WF	POW	65	40	0.27	0.29	0.00	0.00	0.00	MODERATE
26	PORT ORANGE WESTERN WF	POW	66	39	0.27	0.29	0.00	0.00	0.00	MODERATE
27	PORT ORANGE WESTERN WF	POW	67	39	0.27	0.29	0.00	0.00	0.00	MODERATE
28	PORT ORANGE WESTERN WF	POW	68	39	0.27	0.29	0.00	0.00	0.00	MODERATE
29	PORT ORANGE WESTERN WF	POW	65	38	0.27	0.29	0.33	0.32	0.40	MODERATE
30	PORT ORANGE WESTERN WF	POW	66	38	0.53	0.57	0.57	0.57	0.57	MODERATE
31	PORT ORANGE WESTERN WF	POW	69	40	0.27	0.29	0.00	0.00	0.00	MODERATE
32	PORT ORANGE WESTERN WF	POW	67	38	0.27	0.29	0.51	0.51	0.51	MODERATE
33	PORT ORANGE WEST PROP	POW	64	39	0.00	0.86	0.65	0.43	0.29	MODERATE
34	PORT ORANGE WEST PROP	POW	69	38	0.00	0.86	1.05	0.83	0.84	MODERATE
35	PORT ORANGE WEST PROP	POW	40	26	0.00	0.29	0.00	0.00	0.00	MODERATE
36	PORT ORANGE WEST PROP	POW	39	24	0.00	0.29	0.00	0.00	0.00	MODERATE
37	PORT ORANGE WEST PROP	POW	41	28	0.00	0.29	0.81	0.64	0.82	MODERATE
38	PORT ORANGE WEST PROP	POW	38	27	0.00	0.29	0.00	0.00	0.00	MODERATE
39	PORT ORANGE WEST PROP	POW	37	25	0.00	0.29	0.00	0.00	0.00	MODERATE
40	PORT ORANGE WEST PROP	POW	39	29	0.00	0.29	0.00	0.00	0.23	MODERATE
41	PORT ORANGE WEST PROP	POW	42	25	0.00	0.29	0.66	0.00	0.00	MODERATE
42	PORT ORANGE WEST PROP	POW	41	23	0.00	0.29	0.00	0.00	0.00	MODERATE
43	PORT ORANGE WEST PROP	POW	43	27	0.00	0.29	0.00	0.74	0.54	MODERATE
44	PORT ORANGE EASTERN WF	POE	68	66	0.12	0.26	0.00	0.86	0.00	LOW
45	PORT ORANGE EASTERN WF	POE	68	65	0.03	0.07	0.00	0.00	0.00	LOW
46	PORT ORANGE EASTERN WF	POE	66	66	0.03	0.07	0.00	0.00	0.00	LOW
47	PORT ORANGE EASTERN WF	POE	66	67	0.10	0.20	0.86	0.00	0.86	LOW

Table A9--*Continued*

Public well or Control Point Number	Well Description	Public Utility Need Area	Simulation Model Row	Simulation Model Column	Well withdrawal rates (MGD) 1988	Non-optimized projected year 2010	Case 3	Case 2	Case 1	Potential for Vegetative Harm
48	PORT ORANGE EASTERN WF	POE	65	66	0.06	0.13	0.00	0.00	0.00	LOW
49	PORT ORANGE EASTERN WF	POE	65	65	0.06	0.13	0.00	0.00	0.00	LOW
50	DELTONA	DEL	84	11	0.49	0.75	0.00	0.00	0.00	LOW
51	DELTONA	DEL	84	9	0.49	0.75	1.50	1.50	1.50	LOW
52	DELTONA	DEL	83	13	0.49	0.75	0.00	0.00	0.00	LOW
53	DELTONA	DEL	86	13	0.49	0.75	0.00	0.00	1.50	LOW
54	DELTONA	DEL	84	10	0.97	1.51	0.00	2.04	2.26	LOW
55	DELTONA	DEL	85	12	1.46	2.26	0.00	0.00	0.00	LOW
56	DELTONA	DEL	84	18	0.49	0.75	0.00	0.00	0.00	MODERATE
57	DELTONA	DEL	85	12	0.49	0.75	0.00	0.00	0.00	LOW
58	DELTONA	DEL	83	18	0.49	0.75	0.00	0.00	0.00	LOW
59	DELTONA	DEL	84	18	0.49	0.75	0.00	0.00	0.00	MODERATE
60	DELTONA	DEL	81	12	0.49	0.75	0.00	0.00	0.00	LOW
61	DELTONA	DEL	85	17	0.49	0.75	0.00	0.00	0.00	MODERATE
62	DELT - PROPOSED	DEL	81	16	0.00	0.75	0.00	0.00	0.00	MODERATE
63	DELT - PROPOSED	DEL	81	18	0.00	1.51	0.00	0.00	0.00	MODERATE
64	DELT - PROPOSED	DEL	82	15	0.00	0.75	0.00	0.00	0.00	LOW
65	DELT - PROPOSED	DEL	83	17	0.00	0.75	0.00	0.00	0.00	MODERATE
66	DELT - PROPOSED	DEL	84	9	0.00	0.75	3.58	8.04	4.13	LOW
67	DELT - PROPOSED	DEL	84	10	0.00	0.75	0.00	0.00	3.43	LOW
68	DELT - PROPOSED	DEL	84	11	0.00	1.51	0.00	0.00	0.00	LOW
69	DELT - PROPOSED	DEL	85	17	0.00	0.75	0.00	0.00	0.00	MODERATE
70	DELT - PROPOSED	DEL	86	11	0.00	0.75	5.59	0.00	0.00	LOW
71	DELT - PROPOSED	DEL	86	15	0.00	2.26	0.00	0.00	0.00	LOW
72	DELT - PROPOSED	DEL	87	13	0.00	0.75	2.01	1.82	1.55	LOW
73	DELT - PROPOSED	DEL	87	15	0.00	0.75	3.33	6.03	5.56	LOW
74	DELT - PROPOSED	DEL	87	16	0.00	1.51	0.00	0.00	0.00	LOW
75	SPRUCE CREEK	SPC	75	54	0.16	0.08	0.00	0.00	0.00	LOW
76	SPRUCE CREEK	SPC	75	55	0.16	0.08	0.00	0.00	0.00	LOW
77	SPRUCE CREEK PROP	SPC	75	54	0.00	0.16	0.40	0.40	0.40	LOW
78	SPRUCE CREEK PROP	SPC	75	55	0.00	0.08	0.00	0.00	0.00	LOW
79	NEW SMYRNA SAMSULA WF	NSS	79	40	0.59	0.88	0.43	1.63	1.37	LOW
80	NEW SMYRNA SAMSULA WF	NSS	80	41	0.59	0.88	1.14	0.62	1.27	LOW
81	NEW SMYRNA SAMSULA WF	NSS	80	42	0.30	0.44	0.00	0.00	0.00	LOW
82	NEW SMYRNA SAMSULA WF	NSS	80	43	0.30	0.44	0.00	0.00	0.00	MODERATE
83	NEW SMYRNA GLENCOE WF	NSG	86	64	1.19	1.76	0.84	1.73	2.51	MODERATE
84	NEW SMYRNA GLENCOE WF	NSG	86	65	0.89	1.32	0.00	0.00	0.37	LOW
85	NSB - PROPOSED	NS4	78	36	0.00	0.44	0.00	0.01	0.18	MODERATE
86	NEW SMYRNA SR 44	NS4	78	35	0.00	0.44	0.00	0.11	0.35	MODERATE
87	NEW SMYRNA SR 44	NS4	77	36	0.00	1.76	0.00	0.19	0.53	MODERATE
88	DAYTONA BEACH EASTERN WF	DBE	51	58	0.59	1.51	0.44	2.26	1.37	MODERATE
89	DAYTONA BEACH EASTERN WF	DBE	51	57	0.59	1.21	0.00	0.00	0.00	MODERATE
90	DAYTONA BEACH EASTERN WF	DBE	51	56	0.59	1.21	1.01	0.00	0.00	MODERATE
91	DAYTONA BEACH EASTERN WF	DBE	50	52	1.17	3.25	1.40	0.57	3.99	MODERATE
92	DAYTONA BEACH WESTERN WF	DBW	50	51	0.93	1.47	1.11	2.22	2.22	MODERATE
93	DAYTONA BEACH WESTERN WF	DBW	49	50	0.93	1.76	0.02	2.11	2.51	MODERATE
94	DAYTONA BEACH WESTERN WF	DBW	58	46	0.93	0.27	1.02	1.02	1.02	MODERATE

Table A9--*Continued*

Public well or Control Point Number	Well Description	Public Utility Need Area	Simulation Model		Well withdrawal rates (MGD)					Potential for Vegetative Harm
			Row	Column	1988	Non -optimized projected year 2010	Case 3	Case 2	Case 1	
95	DAYTONA BEACH WESTERN WF	DBW	58	45	1.87	0.94	1.69	1.69	1.69	MODERATE
96	DAYTONA BEACH WESTERN WF	DBW	58	44	0.93	0.49	1.24	1.24	1.24	MODERATE
97	DAYTONA BEACH WESTERN WF	DBW	58	43	0.93	0.21	0.96	0.96	0.96	MODERATE
98	DAYTONA BEACH WESTERN WF	DBW	58	42	0.93	0.41	1.04	0.96	1.09	MODERATE
99	DAYTONA BEACH WESTERN WF	DBW	57	43	0.93	0.33	0.00	1.08	1.08	MODERATE
100	DAYTONA BEACH WESTERN WF	DBW	56	43	0.93	0.32	1.03	0.07	0.28	LOW
101	DAYTONA BEACH WESTERN WF	DBW	55	42	0.93	0.63	1.38	1.31	0.00	LOW
102	DAYTONA WEST. 1988	DBW	53	42	0.00	0.31	0.02	0.00	0.00	LOW
103	DAYTONA WEST. 1988	DBW	52	42	0.00	2.32	0.13	0.00	0.00	LOW
104	DAYTONA WEST. 1988	DBW	51	43	0.00	0.40	0.00	0.00	0.00	LOW
105	DAYTONA WEST. 1988	DBW	50	43	0.00	1.63	0.00	0.00	0.00	LOW
106	DAYTONA WEST. 1988	DBW	49	43	0.00	0.48	0.00	0.00	0.00	MODERATE
107	DAYTONA WEST. 1988	DBW	57	41	0.00	0.55	0.00	0.00	0.46	MODERATE
108	DAYTONA WEST. 1988	DBW	54	43	0.00	0.53	0.00	0.00	0.00	LOW
109	DAYTONA WEST. 1988	DBW	53	43	0.00	0.27	0.00	0.00	0.00	MODERATE
110	ORMOND BEACH DIVISION	OBD	31	73	0.45	0.46	1.21	1.21	1.21	LOW
111	ORMOND BEACH DIVISION	OBD	32	72	0.90	0.92	0.58	0.58	0.58	LOW
112	ORMOND BEACH DIVISION	OBD	31	70	0.23	0.23	0.00	0.00	0.00	LOW
113	ORMOND BEACH DIVISION	OBD	32	70	0.23	0.23	0.00	0.00	0.00	LOW
114	ORMOND BEACH DIVISION	OBD	32	69	0.23	0.23	0.00	0.00	0.00	LOW
115	ORMOND BEACH DIVISION	OBD	31	73	0.23	0.23	0.98	0.98	0.98	LOW
116	ORMOND BEACH DIVISION	OBD	31	72	0.23	0.23	0.00	0.00	0.00	LOW
117	ORMOND BEACH DIVISION	OBD	31	70	0.23	0.23	0.00	0.00	0.00	LOW
118	ORMOND BEACH SR 40	OB4	29	64	0.63	0.23	0.00	0.00	0.00	LOW
119	ORMOND BEACH SR 40	OB4	30	61	0.63	0.23	0.00	0.00	0.00	LOW
120	ORMOND BEACH SR 40	OB4	28	65	0.00	0.23	0.21	0.00	1.16	MODERATE
121	ORMOND BEACH SR 40	OB4	29	65	0.00	0.23	0.95	1.16	0.00	MODERATE
122	ORMOND BEACH SR 40	OB4	30	59	0.63	0.23	0.00	0.00	0.00	LOW
123	ORMOND BEACH HUDSON	OBH	25	52	0.00	0.46	0.00	0.00	0.00	LOW
124	ORMOND BEACH HUDSON	OBH	24	52	0.00	0.23	0.00	0.00	0.00	LOW
125	ORMOND BEACH HUDSON	OBH	23	53	0.00	0.46	0.00	0.00	0.00	LOW
126	ORMOND BEACH HUDSON	OBH	22	53	0.00	0.46	0.00	1.66	1.83	LOW
127	ORMOND BEACH HUDSON	OBH	24	53	0.00	0.23	0.00	0.00	0.00	LOW
128	ORMOND BEACH HUDSON	OBH	24	54	0.00	0.23	0.00	0.00	0.00	LOW
129	ORMOND BEACH HUDSON	OBH	23	54	0.00	0.23	0.00	0.00	0.00	LOW
130	ORMOND BEACH HUDSON	OBH	22	55	0.00	0.23	0.86	0.93	1.18	LOW
131	ORMOND BEACH HUDSON	OBH	24	52	0.00	0.23	0.00	0.00	0.00	LOW
132	ORMOND BEACH HUDSON	OBH	23	51	0.00	0.23	0.00	0.00	0.00	LOW
133	ORMOND BEACH RIMA PROP	OBR	32	43	0.00	0.23	0.00	0.00	0.11	MODERATE
134	ORMOND BEACH RIMA PROP	OBR	31	44	0.00	0.23	0.00	0.00	0.00	MODERATE
135	JOHN KNOX VILL.	JKV	78	10	0.05	0.14	0.00	0.00	0.14	LOW
136	V CTY - FOUR TOWNS	VFT	80	8	0.20	0.32	0.00	0.79	0.00	LOW
137	V CTY - FOUR TOWNS	VFT	79	8	0.20	0.32	0.00	0.00	0.79	LOW
138	V CTY - BREEZEWOOD	VFT	80	9	0.14	0.16	0.00	0.00	0.00	LOW
139	V CTY - LAKE MARIE	VLM	83	6	0.14	0.25	0.25	0.25	0.25	LOW
140	V CTY - TERRA ALTA	VTA	81	7	0.09	0.52	0.53	0.53	0.36	LOW
141	V CTY - W ORANGE CITY	VTA	77	7	0.01	0.01	0.00	0.00	0.16	LOW

Table A9--*Continued*

Public well or Control Point Number	Well Description	Public Utility Need Area	Simulation Model Row	Column	Well withdrawal rates (MGD) 1988	Non -optimized projected year 2010	Case 3	Case 2	Case 1	Potential for Vegetative Harm
142	DELAND - BRANDYWINE	DEB	55	14	0.46	0.82	0.07	0.82	0.82	MODERATE
143	DELAND - SPRING GARDEN	DEB	55	13	0.01	0.02	0.00	0.00	0.00	MODERATE
143	DELAND - SPRING GARDEN	DEB	55	13	0.01	0.02	0.00	0.00	0.00	LOW
144	DELAND - GLENWOOD EST	DEB	54	12	0.02	0.03	0.18	0.08	0.08	MODERATE
145	DELAND - WOODLAND MANOR	DWW	51	14	0.06	0.16	0.16	0.16	0.16	LOW
146	DELAND - LONGLEAF PLANT.	DHH	74	13	0.12	0.26	0.00	0.00	0.00	LOW
147	DELAND - HOLIDAY HILLS	DHH	72	10	0.05	0.10	0.00	0.36	0.36	MODERATE
148	ELLWOOD TITCOMB	ETI	77	17	0.05	0.09	0.02	0.09	0.00	MODERATE
149	CITY OF EDGEWATER	EDG	87	68	0.28	0.85	1.04	1.04	1.04	LOW
150	CITY OF EDGEWATER	EDG	87	67	0.42	1.27	0.00	0.00	0.00	LOW
152	CITY OF EDGEWATER	EDG	88	59	0.42	1.27	2.02	2.02	2.02	LOW
153	CITY OF EDGEWATER	EDG	88	63	0.28	0.85	1.59	1.59	1.59	LOW
154	TYMBER CREEK UTIL.	TCU	27	59	0.09	0.18	0.13	0.18	0.18	LOW
155	THE TRAILS INC.	TTI	26	54	0.32	0.58	0.00	0.00	0.58	LOW
156	LAKE HELEN	LHE	77	16	0.11	0.29	0.00	0.00	0.00	MODERATE
157	LAKE HELEN	LHE	76	16	0.11	0.29	0.15	0.36	0.58	MODERATE
158	HACIENDA DEL RIO	HDR	90	74	0.06	0.10	0.10	0.10	0.10	LOW
159	NATIONAL GARDENS	NGA	15	72	0.03	0.06	0.00	0.00	0.00	LOW
160	NATIONAL GARDENS	NGA	15	73	0.03	0.06	0.00	0.00	0.00	LOW
161	NATIONAL GARDENS	NGA	16	71	0.10	0.17	0.25	0.08	0.25	LOW
162	NATIONAL GARDENS	NGA	16	72	0.02	0.04	0.00	0.00	0.00	LOW
163	NATIONAL GARDENS	NGA	17	71	0.03	0.06	0.13	0.13	0.13	LOW
164	ORANGE CITY	OCY	78	9	0.51	3.65	0.00	0.33	3.65	LOW
165	SUNSHINE HOLIDAY PK	SHP	14	65	0.07	0.13	0.00	0.00	0.13	LOW
166	PLANTATION BAY	PTB	6	60	0.04	0.08	0.00	0.00	0.00	MODERATE
167	PLANTATION BAY	PTB	7	60	0.02	0.04	0.00	0.00	0.00	LOW
168	L BERESFORD WATER ASSN	LBW	68	8	0.16	0.33	0.33	0.33	0.33	LOW
169	FPL - TURNER POWER PLNT	FPT	86	8	0.10	0.10	0.00	0.00	0.00	LOW
170	SHERWOOD MEDICAL CO.	SMC	64	16	0.10	0.10	0.03	0.03	0.03	LOW
171	SHERWOOD MEDICAL CO.	SMC	63	17	0.05	0.05	0.13	0.13	0.13	LOW
172	FPL - SANFORD PWR PLNT	FPS	85	4	0.08	0.08	0.08	0.05	0.00	LOW
173	FPL - SANFORD PWR PLNT	FPS	85	5	0.08	0.08	0.08	0.00	0.00	LOW
174	FPL - SANFORD PWR PLNT	FPS	80	7	0.08	0.08	0.08	0.08	0.08	LOW
175	FPL - SANFORD PWR PLNT	FPS	81	7	0.08	0.08	0.08	0.08	0.08	LOW
176	TOMOKA CORR. FACILITY	TCF	50	40	0.23	0.23	0.23	0.00	0.00	HIGH
177	V CTY GOVT COMPLEX	VGC	76	8	0.20	0.20	0.00	0.00	0.00	LOW

Table A10. East-central LP optimization and MIP decision model agricultural well withdrawal rates

					Well withdrawal rates (cfd)						
					MIP Decision Model			LP Optimization Model			
Model number	Simulation model row	Simulation model column	Type	Agricultural demand area	Case 3	Case 2	Case 1	Case 3	Case 2	Case 1	1988 and projected year 2010
1	56	2	Citrus	C1	0.94	0.94	0.94	0.94	0.94	0.94	0.16
2	59	2	Citrus	C1	0.00	0.00	0.00	0.00	0.00	0.00	0.13
3	62	2	Citrus	C1	0.00	0.00	0.00	0.00	0.00	0.00	0.15
4	65	2	Citrus	C1	0.00	0.00	0.00	0.00	0.00	0.00	0.21
5	59	3	Citrus	C1	0.00	0.00	0.00	0.00	0.00	0.00	0.12
6	62	3	Citrus	C1	0.00	0.00	0.00	0.00	0.00	0.00	0.17
7	98	11	Citrus	C2	0.00	0.00	0.00	0.00	0.00	0.00	0.23
8	99	11	Citrus	C2	0.00	0.00	0.00	0.00	0.00	0.00	0.20
9	101	11	Citrus	C2	1.80	1.80	1.80	1.80	1.80	1.80	0.13
10	101	12	Citrus	C2	0.00	0.00	0.00	0.00	0.00	0.00	0.16
11	99	14	Citrus	C2	0.00	0.00	0.00	0.00	0.00	0.00	0.19
12	101	14	Citrus	C2	0.00	0.00	0.00	0.00	0.00	0.00	0.17
13	101	15	Citrus	C2	0.00	0.00	0.00	0.00	0.00	0.00	0.13
14	99	16	Citrus	C2	0.00	0.00	0.00	0.00	0.00	0.00	0.24
15	101	16	Citrus	C2	0.00	0.00	0.00	0.00	0.00	0.00	0.35
16	92	13	Citrus	C3	0.00	0.68	0.68	0.68	0.68	0.68	0.24
17	92	14	Citrus	C3	0.00	0.00	0.00	0.00	0.00	0.00	0.09
18	92	15	Citrus	C3	0.68	0.00	0.00	0.00	0.00	0.00	0.17
19	92	16	Citrus	C3	0.00	0.00	0.00	0.00	0.00	0.00	0.18
20	87	17	Citrus	C4	0.00	0.00	0.00	0.00	0.00	0.00	0.25
21	89	17	Citrus	C4	2.68	2.68	2.68	2.68	2.68	2.68	0.15
22	85	19	Citrus	C4	0.00	0.00	0.00	0.00	0.00	0.00	0.27
23	87	20	Citrus	C4	0.00	0.00	0.00	0.00	0.00	0.00	0.15
24	87	23	Citrus	C4	0.00	0.00	0.00	0.00	0.00	0.00	0.37
25	85	24	Citrus	C4	0.00	0.00	0.00	0.00	0.00	0.00	0.22
26	89	24	Citrus	C4	0.00	0.00	0.00	0.00	0.00	0.00	0.25
27	87	26	Citrus	C4	0.00	0.00	0.00	0.00	0.00	0.00	0.30
28	85	27	Citrus	C4	0.00	0.00	0.00	0.00	0.00	0.00	0.13
29	89	27	Citrus	C4	0.00	0.00	0.00	0.00	0.00	0.00	0.13
30	85	29	Citrus	C4	0.00	0.00	0.00	0.00	0.00	0.00	0.23
31	87	29	Citrus	C4	0.00	0.00	0.00	0.00	0.00	0.00	0.23
32	82	17	Citrus	C5	0.00	1.00	1.00	1.00	1.00	1.00	0.14
33	80	19	Citrus	C5	0.00	0.00	0.00	0.00	0.00	0.00	0.19
34	82	20	Citrus	C5	1.00	0.00	0.00	0.00	0.00	0.00	0.44
35	80	23	Citrus	C5	0.00	0.00	0.00	0.00	0.00	0.00	0.11
36	82	23	Citrus	C5	0.00	0.00	0.00	0.00	0.00	0.00	0.11
37	77	13	Citrus	C6	0.00	2.53	2.53	0.00	2.53	2.53	0.25
38	80	13	Citrus	C6	0.00	0.00	0.00	2.53	0.00	0.00	0.12
39	74	14	Citrus	C6	0.00	0.00	0.00	0.00	0.00	0.00	0.14
40	77	14	Citrus	C6	0.00	0.00	0.00	0.00	0.00	0.00	0.20
41	72	15	Citrus	C6	0.00	0.00	0.00	0.00	0.00	0.00	0.10
42	77	15	Citrus	C6	0.00	0.00	0.00	0.00	0.00	0.00	0.25
43	75	16	Citrus	C6	0.00	0.00	0.00	0.00	0.00	0.00	0.28
44	77	16	Citrus	C6	0.00	0.00	0.00	0.00	0.00	0.00	0.40
45	75	17	Citrus	C6	0.00	0.00	0.00	0.00	0.00	0.00	0.20
46	77	17	Citrus	C6	0.00	0.00	0.00	0.00	0.00	0.00	0.18
47	77	19	Citrus	C6	0.09	0.00	0.00	0.00	0.00	0.00	0.30

Table A10--*Continued*

					Well withdrawal rates (cfd)						
					MIP Decision Model			LP Optimization Model			
Model number	Simulation model row	Simulation model column	Type	Agricultural demand area	Case 3	Case 2	Case 1	Case 3	Case 2	Case 1	1988 and projected year 2010
48	77	24	Citrus	C6	0.00	0.00	0.00	0.00	0.00	0.00	0.12
49	67	13	Citrus	C7	0.00	0.46	0.46	0.46	0.46	0.46	0.31
50	65	14	Citrus	C7	0.00	0.00	0.00	0.00	0.00	0.00	0.15
51	69	15	Citrus	C8	0.00	0.50	0.50	0.00	0.50	0.50	0.11
52	69	16	Citrus	C8	0.00	0.00	0.00	0.00	0.00	0.00	0.27
53	69	17	Citrus	C8	0.00	0.00	0.00	0.50	0.00	0.00	0.11
54	72	19	Citrus	C9	0.00	1.84	1.84	1.84	1.84	1.84	0.16
55	74	20	Citrus	C9	0.00	0.00	0.00	0.00	0.00	0.00	0.51
56	72	24	Citrus	C9	0.00	0.00	0.00	0.00	0.00	0.00	0.19
57	74	24	Citrus	C9	0.00	0.00	0.00	0.00	0.00	0.00	0.25
58	72	26	Citrus	C9	0.00	0.00	0.00	0.00	0.00	0.00	0.23
59	74	27	Citrus	C9	0.00	0.00	0.00	0.00	0.00	0.00	0.10
60	71	29	Citrus	C9	1.20	0.00	0.00	0.00	0.00	0.00	0.13
61	74	29	Citrus	C9	0.00	0.00	0.00	0.00	0.00	0.00	0.15
62	74	31	Citrus	C9	0.00	0.00	0.00	0.00	0.00	0.00	0.12
63	74	3	Citrus	C10	0.00	0.27	0.27	0.27	0.27	0.27	0.10
64	71	4	Citrus	C10	0.00	0.00	0.00	0.00	0.00	0.00	0.17
65	65	24	Citrus	C11	0.43	0.43	0.43	0.43	0.43	0.43	0.12
66	67	24	Citrus	C11	0.00	0.00	0.00	0.00	0.00	0.00	0.15
67	67	26	Citrus	C11	0.00	0.00	0.00	0.00	0.00	0.00	0.16
68	29	13	Citrus	C12	0.56	0.56	0.56	0.56	0.56	0.56	0.16
69	30	14	Citrus	C12	0.00	0.00	0.00	0.00	0.00	0.00	0.30
70	28	15	Citrus	C12	0.00	0.00	0.00	0.00	0.00	0.00	0.10
71	16	10	Citrus	C13	0.00	0.49	0.00	0.00	0.00	0.49	0.10
72	13	11	Citrus	C13	0.49	0.00	0.49	0.49	0.49	0.00	0.15
73	18	11	Citrus	C13	0.00	0.00	0.00	0.00	0.00	0.00	0.11
74	16	13	Citrus	C13	0.00	0.00	0.00	0.00	0.00	0.00	0.13
75	16	15	Citrus	C14	0.00	0.00	0.00	0.00	0.00	0.00	0.20
76	13	16	Citrus	C14	0.63	0.63	0.63	0.63	0.63	0.63	0.11
77	18	17	Citrus	C14	0.00	0.00	0.00	0.00	0.00	0.00	0.17
78	16	18	Citrus	C14	0.00	0.00	0.00	0.00	0.00	0.00	0.15
79	107	61	Citrus	C15	0.00	0.00	0.00	0.00	0.00	0.00	0.10
80	108	64	Citrus	C15	0.00	0.00	0.00	0.00	0.00	0.00	0.10
81	109	64	Citrus	C15	0.31	0.31	0.31	0.31	0.31	0.31	0.10
82	99	74	Citrus	C16	0.00	0.00	0.00	0.00	0.00	0.00	0.24
83	101	77	Citrus	C16	0.00	0.00	0.00	0.00	0.00	0.00	0.30
84	102	78	Citrus	C16	0.87	0.87	0.87	0.87	0.87	0.87	0.33
85	108	77	Citrus	C17	0.00	0.00	0.00	0.00	0.00	0.00	0.13
86	109	77	Citrus	C17	0.00	0.00	0.00	0.00	0.00	0.00	0.34
87	109	81	Citrus	C17	0.57	0.57	0.57	0.57	0.57	0.57	0.10
88	110	74	Citrus	C18	0.00	0.00	0.00	0.00	0.00	0.00	0.12
89	111	74	Citrus	C18	0.00	0.00	0.00	0.00	0.00	0.00	0.11
90	111	78	Citrus	C18	0.00	0.00	0.00	0.00	0.00	0.00	0.35
91	112	78	Citrus	C18	0.82	0.82	0.82	0.82	0.82	0.82	0.23
92	80	3	Citrus	C19	0.00	3.05	3.05	3.05	3.05	3.05	0.10
93	82	3	Citrus	C19	0.00	0.00	0.00	0.00	0.00	0.00	0.12
94	85	4	Citrus	C19	0.00	0.00	0.00	0.00	0.00	0.00	0.20

Table A10--*Continued*

					Well withdrawal rates (cfd)						
					MIP Decision Model			LP Optimization Model			
Model number	Simulation model row	Simulation model column	Type	Agricultural demand area	Case 3	Case 2	Case 1	Case 3	Case 2	Case 1	1988 and projected year 2010
95	87	4	Citrus	C19	0.00	0.00	0.00	0.00	0.00	0.00	0.11
96	80	5	Citrus	C19	0.00	0.00	0.00	0.00	0.00	0.00	0.13
97	82	5	Citrus	C19	0.00	0.00	0.00	0.00	0.00	0.00	0.13
98	85	5	Citrus	C19	0.00	0.00	0.00	0.00	0.00	0.00	0.10
99	87	5	Citrus	C19	0.00	0.00	0.00	0.00	0.00	0.00	0.12
100	89	5	Citrus	C19	3.05	0.00	0.00	0.00	0.00	0.00	0.16
101	82	6	Citrus	C19	0.00	0.00	0.00	0.00	0.00	0.00	0.18
102	87	6	Citrus	C19	0.00	0.00	0.00	0.00	0.00	0.00	0.23
103	89	6	Citrus	C19	0.00	0.00	0.00	0.00	0.00	0.00	0.13
104	92	6	Citrus	C19	0.00	0.00	0.00	0.00	0.00	0.00	0.21
105	80	7	Citrus	C19	0.00	0.00	0.00	0.00	0.00	0.00	0.20
106	82	7	Citrus	C19	0.00	0.00	0.00	0.00	0.00	0.00	0.13
107	87	7	Citrus	C19	0.00	0.00	0.00	0.00	0.00	0.00	0.25
108	89	7	Citrus	C19	0.00	0.00	0.00	0.00	0.00	0.00	0.29
109	92	7	Citrus	C19	0.00	0.00	0.00	0.00	0.00	0.00	0.27
110	64	97	Citrus	C20	0.00	0.00	0.00	0.00	0.00	0.00	0.27
111	61	100	Citrus	C20	0.68	0.68	0.68	0.68	0.68	0.68	0.18
112	65	100	Citrus	C20	0.00	0.00	0.00	0.00	0.00	0.00	0.23
113	53	116	Citrus	C21	0.00	0.00	0.00	0.00	0.00	0.00	0.12
114	52	119	Citrus	C21	0.24	0.24	0.24	0.24	0.24	0.24	0.12
115	39	5	Citrus	C22	0.00	0.79	0.79	0.79	0.00	0.79	0.19
116	43	5	Citrus	C22	0.79	0.00	0.00	0.00	0.79	0.00	0.20
117	39	6	Citrus	C22	0.00	0.00	0.00	0.00	0.00	0.00	0.28
118	43	6	Citrus	C22	0.00	0.00	0.00	0.00	0.00	0.00	0.12
119	31	5	Citrus	C23	0.35	0.35	0.35	0.35	0.35	0.35	0.20
120	33	6	Citrus	C23	0.00	0.00	0.00	0.00	0.00	0.00	0.15
121	21	7	Citrus	C24	0.54	0.54	0.54	0.54	0.54	0.54	0.17
122	24	8	Citrus	C24	0.00	0.00	0.00	0.00	0.00	0.00	0.12
123	28	8	Citrus	C24	0.00	0.00	0.00	0.00	0.00	0.00	0.13
124	31	8	Citrus	C24	0.00	0.00	0.00	0.00	0.00	0.00	0.12
125	50	8	Citrus	C25	1.11	1.11	1.11	1.11	1.11	1.11	0.11
126	56	9	Citrus	C25	0.00	0.00	0.00	0.00	0.00	0.00	0.15
127	62	9	Citrus	C25	0.00	0.00	0.00	0.00	0.00	0.00	0.15
128	65	9	Citrus	C25	0.00	0.00	0.00	0.00	0.00	0.00	0.11
129	67	9	Citrus	C25	0.00	0.00	0.00	0.00	0.00	0.00	0.26
130	50	10	Citrus	C25	0.00	0.00	0.00	0.00	0.00	0.00	0.11
131	59	10	Citrus	C25	0.00	0.00	0.00	0.00	0.00	0.00	0.20
132	77	9	Citrus	C26	0.00	1.22	1.22	1.22	1.22	1.22	0.13
133	80	9	Citrus	C26	0.00	0.00	0.00	0.00	0.00	0.00	0.15
134	77	10	Citrus	C26	0.00	0.00	0.00	0.00	0.00	0.00	0.45
135	80	10	Citrus	C26	0.00	0.00	0.00	0.00	0.00	0.00	0.23
136	77	11	Citrus	C26	0.00	0.00	0.00	0.00	0.00	0.00	0.26
137	87	9	Citrus	C27	0.00	0.00	0.00	0.00	0.00	0.00	0.16
138	89	9	Citrus	C27	0.00	0.00	0.00	0.00	0.00	0.00	0.17
139	92	9	Citrus	C27	0.00	0.00	0.00	0.00	0.00	0.00	0.28
140	96	9	Citrus	C27	1.72	1.72	1.72	1.72	1.72	1.72	0.11
141	89	10	Citrus	C27	0.00	0.00	0.00	0.00	0.00	0.00	0.14

Table A10--*Continued*

					Well withdrawal rates (cfd)						
					MIP Decision Model			LP Optimization Model			
Model number	Simulation model row	Simulation model column	Type	Agricultural demand area	Case 3	Case 2	Case 1	Case 3	Case 2	Case 1	1988 and projected year 2010
142	92	10	Citrus	C27	0.00	0.00	0.00	0.00	0.00	0.00	0.18
143	95	10	Citrus	C27	0.00	0.00	0.00	0.00	0.00	0.00	0.26
144	92	11	Citrus	C27	0.00	0.00	0.00	0.00	0.00	0.00	0.15
145	95	11	Citrus	C27	0.00	0.00	0.00	0.00	0.00	0.00	0.26
146	77	64	SFWMD nc	F1	0.80	0.80	0.80	0.80	0.80	0.80	0.40
147	80	64	SFWMD nc	F1	0.00	0.00	0.00	0.00	0.00	0.00	0.40
148	104	44	SFWMD nc	F2	0.51	0.51	0.51	0.51	0.51	0.51	0.33
149	89	61	SFWMD nc	F2	0.00	0.00	0.00	0.00	0.00	0.00	0.05
150	95	61	SFWMD nc	F2	0.00	0.00	0.00	0.00	0.00	0.00	0.13
151	80	33	SFWMD nc	F3	0.00	0.00	0.00	0.00	0.00	0.00	0.50
152	116	33	SFWMD nc	F3	0.83	0.83	0.83	0.83	0.83	0.83	0.11
153	85	36	SFWMD nc	F3	0.00	0.00	0.00	0.00	0.00	0.00	0.21
154	99	31	SFWMD nc	F4	0.00	0.00	0.00	0.00	0.00	0.00	1.07
155	103	36	SFWMD nc	F4	1.55	1.55	1.55	1.55	1.55	1.55	0.01
156	98	38	SFWMD nc	F4	0.00	0.00	0.00	0.00	0.00	0.00	0.25
157	101	31	SFWMD nc	F4	0.00	0.00	0.00	0.00	0.00	0.00	0.21
158	62	38	SFWMD nc	F5	0.40	0.40	0.40	0.40	0.40	0.40	0.40
159	95	44	SFWMD nc	F6	0.31	0.31	0.31	0.31	0.31	0.31	0.31
160	89	50	SFWMD nc	F7	0.03	0.03	0.03	0.03	0.03	0.03	0.03
161	35	12	Lake nc	L1	0.14	0.14	0.14	0.14	0.14	0.14	0.08
162	38	12	Lake nc	L1	0.00	0.00	0.00	0.00	0.00	0.00	0.06
163	19	7	Lake nc	L2	0.20	0.20	0.20	0.20	0.20	0.20	0.17
164	17	10	Lake nc	L2	0.00	0.00	0.00	0.00	0.00	0.00	0.03
165	33	4	Lake nc	L3	0.79	0.79	0.79	0.79	0.79	0.79	0.08
166	35	4	Lake nc	L3	0.00	0.00	0.00	0.00	0.00	0.00	0.46
167	39	4	Lake nc	L3	0.00	0.00	0.00	0.00	0.00	0.00	0.26
168	52	2	Lake nc	L4	0.45	0.45	0.45	0.45	0.45	0.45	0.42
169	52	4	Lake nc	L4	0.00	0.00	0.00	0.00	0.00	0.00	0.03
170	65	2	Lake nc	L5	0.15	0.15	0.15	0.15	0.15	0.15	0.01
171	68	2	Lake nc	L5	0.00	0.00	0.00	0.00	0.00	0.00	0.15
172	83	4	Lake nc	L6	0.00	0.00	0.00	0.03	0.03	0.03	0.02
173	76	6	Lake nc	L6	0.03	0.03	0.03	0.00	0.00	0.00	0.01
174	97	8	Lake nc	L7	0.00	0.00	0.00	0.00	0.00	0.00	1.17
175	100	9	Lake nc	L7	1.64	1.64	1.64	1.64	1.64	1.64	0.47
176	57	6	Lake nc	L8	0.09	0.09	0.09	0.09	0.09	0.09	0.06
177	60	7	Lake nc	L8	0.00	0.00	0.00	0.00	0.00	0.00	0.03
178	5	17	Lake nc	L9	0.00	0.00	0.00	0.00	0.00	0.00	0.21
179	4	19	Lake nc	L9	0.47	0.47	0.47	0.00	0.00	0.00	0.05
180	3	22	Lake nc	L9	0.00	0.00	0.00	0.47	0.47	0.47	0.04
181	5	23	Lake nc	L9	0.00	0.00	0.00	0.00	0.00	0.00	0.08
182	7	15	Lake nc	L10	0.07	0.07	0.07	0.07	0.07	0.07	0.06
183	8	15	Lake nc	L10	0.00	0.00	0.00	0.00	0.00	0.00	0.01
184	2	44	Lake nc	L12	0.47	0.47	0.47	0.47	0.47	0.47	0.00
185	4	44	Lake nc	L12	0.00	0.00	0.00	0.00	0.00	0.00	0.04
186	7	44	Lake nc	L12	0.00	0.00	0.00	0.00	0.00	0.00	0.13
187	6	45	Lake nc	L12	0.00	0.00	0.00	0.00	0.00	0.00	0.01
188	7	45	Lake nc	L12	0.00	0.00	0.00	0.00	0.00	0.00	0.06

Table A10--*Continued*

					Well withdrawal rates (cfd)						
					MIP Decision Model			LP Optimization Model			
Model number	Simulation model row	Simulation model column	Type	Agricultural demand area	Case 3	Case 2	Case 1	Case 3	Case 2	Case 1	1988 and projected year 2010
189	5	46	Lake nc	L12	0.00	0.00	0.00	0.00	0.00	0.00	0.14
190	5	47	Lake nc	L12	0.00	0.00	0.00	0.00	0.00	0.00	0.06
191	8	37	Lake nc	L13	0.28	0.28	0.28	0.28	0.28	0.28	0.02
192	9	39	Lake nc	L13	0.00	0.00	0.00	0.00	0.00	0.00	0.20
193	7	28	Lake nc	L14	0.00	0.00	0.00	0.54	0.54	0.54	0.11
194	9	31	Lake nc	L14	0.54	0.54	0.54	0.00	0.00	0.00	0.04
195	10	33	Lake nc	L14	0.00	0.00	0.00	0.00	0.00	0.00	0.39
196	12	15	Lake nc	L15	0.00	0.00	0.00	0.00	0.00	0.00	0.01
197	11	19	Lake nc	L15	0.00	0.00	0.00	0.00	0.00	0.00	0.15
198	8	20	Lake nc	L15	1.39	1.39	1.39	1.39	1.39	1.39	0.04
199	12	20	Lake nc	L15	0.00	0.00	0.00	0.00	0.00	0.00	0.34
200	8	21	Lake nc	L15	0.00	0.00	0.00	0.00	0.00	0.00	0.04
201	12	21	Lake nc	L15	0.00	0.00	0.00	0.00	0.00	0.00	0.17
202	9	26	Lake nc	L15	0.00	0.00	0.00	0.00	0.00	0.00	0.15
203	10	26	Lake nc	L15	0.00	0.00	0.00	0.00	0.00	0.00	0.15
204	11	26	Lake nc	L15	0.00	0.00	0.00	0.00	0.00	0.00	0.15
205	12	28	Lake nc	L15	2.13	2.13	2.13	2.13	2.13	2.13	0.30
206	15	16	Lake nc	L16	0.00	0.00	0.00	0.00	0.00	0.00	0.09
207	16	16	Lake nc	L16	0.00	0.00	0.00	0.00	0.00	0.00	0.14
208	13	17	Lake nc	L16	0.00	0.00	0.00	0.00	0.00	0.00	0.40
209	16	17	Lake nc	L16	0.00	0.00	0.00	0.00	0.00	0.00	0.47
210	21	18	Lake nc	L16	0.00	0.00	0.00	0.00	0.00	0.00	0.30
211	22	18	Lake nc	L16	0.00	0.00	0.00	0.00	0.00	0.00	0.38
212	16	22	Lake nc	L16	0.00	0.00	0.00	0.00	0.00	0.00	0.03
213	18	26	Lake nc	L16	0.00	0.00	0.00	0.00	0.00	0.00	0.01
214	35	13	Orange nc	O1	0.00	0.00	0.00	3.52	3.52	0.00	0.50
215	32	14	Orange nc	O1	3.52	3.52	3.52	0.00	0.00	3.52	0.34
216	33	14	Orange nc	O1	0.00	0.00	0.00	0.00	0.00	0.00	0.31
217	34	14	Orange nc	O1	0.00	0.00	0.00	0.00	0.00	0.00	0.53
218	35	14	Orange nc	O1	0.00	0.00	0.00	0.00	0.00	0.00	0.78
219	37	14	Orange nc	O1	0.00	0.00	0.00	0.00	0.00	0.00	0.76
220	38	14	Orange nc	O1	0.00	0.00	0.00	0.00	0.00	0.00	0.31
221	76	14	Orange nc	O11	2.68	2.68	2.68	2.68	2.68	2.68	2.68
222	30	16	Orange nc	O2	0.00	0.00	0.00	0.00	0.00	0.00	0.04
223	28	17	Orange nc	O2	0.00	0.00	0.00	0.00	0.00	0.00	0.02
224	34	17	Orange nc	O2	0.00	0.00	0.00	0.00	0.00	0.00	0.10
225	25	18	Orange nc	O2	0.54	0.54	0.54	0.54	0.54	0.54	0.11
226	31	18	Orange nc	O2	0.00	0.00	0.00	0.00	0.00	0.00	0.01
227	26	19	Orange nc	O2	0.00	0.00	0.00	0.00	0.00	0.00	0.02
228	30	19	Orange nc	O2	0.00	0.00	0.00	0.00	0.00	0.00	0.10
229	33	19	Orange nc	O2	0.00	0.00	0.00	0.00	0.00	0.00	0.07
230	29	21	Orange nc	O2	0.00	0.00	0.00	0.00	0.00	0.00	0.01
231	42	20	Orange nc	O6	0.00	0.00	0.00	0.00	0.00	0.00	0.05
232	42	21	Orange nc	O6	0.00	0.00	0.00	0.00	0.00	0.00	0.13
233	42	22	Orange nc	O6	0.00	0.00	0.00	0.00	0.00	0.00	0.19
234	44	22	Orange nc	O6	0.00	0.00	0.00	0.00	0.00	0.00	0.03
235	26	23	Orange nc	O3	0.00	0.00	0.00	0.00	0.00	0.00	0.11

Table A10--*Continued*

					Well withdrawal rates (cfd)						
					MIP Decision Model			LP Optimization Model			
Model number	Simulation model row	Simulation model column	Type	Agricultural demand area	Case 3	Case 2	Case 1	Case 3	Case 2	Case 1	1988 and projected year 2010
236	27	23	Orange nc	O3	0.00	0.00	0.00	0.00	0.00	0.00	0.11
237	38	23	Orange nc	O6	0.00	0.00	0.00	0.00	0.00	0.00	0.04
238	42	23	Orange nc	O6	0.00	0.00	0.00	0.00	0.00	0.00	0.07
239	43	23	Orange nc	O6	0.00	0.00	0.00	0.00	0.00	0.00	0.15
240	30	24	Orange nc	O3	0.00	0.00	0.00	0.00	0.00	0.00	0.01
241	34	24	Orange nc	O6	1.51	1.51	1.51	0.13	1.51	1.51	0.02
242	44	24	Orange nc	O6	0.00	0.00	0.00	0.00	0.00	0.00	0.02
243	24	25	Orange nc	O3	1.18	1.18	1.18	1.18	1.18	1.18	0.08
244	47	25	Orange nc	O6	0.00	0.00	0.00	1.38	0.00	0.00	0.74
245	30	26	Orange nc	O3	0.00	0.00	0.00	0.00	0.00	0.00	0.04
246	31	26	Orange nc	O3	0.00	0.00	0.00	0.00	0.00	0.00	0.02
247	32	26	Orange nc	O3	0.00	0.00	0.00	0.00	0.00	0.00	0.12
248	40	26	Orange nc	O6	0.00	0.00	0.00	0.00	0.00	0.00	0.02
249	45	26	Orange nc	O6	0.00	0.00	0.00	0.00	0.00	0.00	0.02
250	54	26	Orange nc	O9	0.00	0.00	0.00	2.30	2.30	2.30	0.50
251	29	27	Orange nc	O3	0.00	0.00	0.00	0.00	0.00	0.00	0.07
252	31	27	Orange nc	O3	0.00	0.00	0.00	0.00	0.00	0.00	0.15
253	33	27	Orange nc	O3	0.00	0.00	0.00	0.00	0.00	0.00	0.32
254	45	27	Orange nc	O6	0.00	0.00	0.00	0.00	0.00	0.00	0.02
255	52	27	Orange nc	O9	0.00	0.00	0.00	0.00	0.00	0.00	0.06
256	53	27	Orange nc	O9	0.00	0.00	0.00	0.00	0.00	0.00	0.12
257	55	27	Orange nc	O9	0.00	0.00	0.00	0.00	0.00	0.00	0.02
258	56	27	Orange nc	O9	0.00	0.00	0.00	0.00	0.00	0.00	0.15
259	65	27	Orange nc	O9	0.00	0.00	0.00	0.00	0.00	0.00	0.02
260	31	28	Orange nc	O3	0.00	0.00	0.00	0.00	0.00	0.00	0.15
261	56	28	Orange nc	O9	0.00	0.00	0.00	0.00	0.00	0.00	0.25
262	59	28	Orange nc	O9	0.00	0.00	0.00	0.00	0.00	0.00	0.35
263	39	29	Orange nc	O7	0.00	0.00	0.00	0.00	0.00	0.00	0.45
264	40	29	Orange nc	O7	0.00	0.00	0.00	0.00	0.00	0.00	0.02
265	48	29	Orange nc	O8	0.00	0.00	0.00	0.00	0.00	0.00	0.07
266	46	30	Orange nc	O8	0.00	0.00	0.00	0.00	0.00	0.61	0.01
267	47	30	Orange nc	O8	0.00	0.00	0.00	0.00	0.00	0.00	0.32
268	48	30	Orange nc	O8	0.00	0.00	0.00	0.00	0.00	0.00	0.07
269	53	30	Orange nc	O9	2.30	2.30	2.30	0.00	0.00	0.00	0.36
270	54	30	Orange nc	O9	0.00	0.00	0.00	0.00	0.00	0.00	0.15
271	59	30	Orange nc	O9	0.00	0.00	0.00	0.00	0.00	0.00	0.32
272	33	31	Orange nc	O7	1.10	1.10	1.10	0.00	0.00	0.00	0.33
273	34	31	Orange nc	O7	0.00	0.00	0.00	0.00	0.00	0.00	0.14
274	39	31	Orange nc	O7	0.00	0.00	0.00	0.00	0.00	0.00	0.13
275	46	31	Orange nc	O8	0.61	0.61	0.61	0.61	0.61	0.00	0.04
276	48	31	Orange nc	O8	0.00	0.00	0.00	0.00	0.00	0.00	0.10
277	33	32	Orange nc	O7	0.00	0.00	0.00	1.10	1.10	1.10	0.03
278	54	34	Orange nc	O10	0.00	0.00	0.00	0.00	0.00	0.00	0.19
279	55	34	Orange nc	O10	0.00	0.00	0.00	0.00	0.00	0.00	0.48
280	56	34	Orange nc	O10	0.00	0.00	0.00	0.00	0.00	0.00	0.14
281	51	35	Orange nc	O10	1.34	1.34	1.34	1.34	1.34	1.34	0.05
282	54	35	Orange nc	O10	0.00	0.00	0.00	0.00	0.00	0.00	0.28

Table A10--*Continued*

					Well withdrawal rates (cfd)						
					MIP Decision Model			LP Optimization Model			
Model number	Simulation model row	Simulation model column	Type	Agricultural demand area	Case 3	Case 2	Case 1	Case 3	Case 2	Case 1	1988 and projected year 2010
283	57	35	Orange nc	O10	0.00	0.00	0.00	0.00	0.00	0.00	0.05
284	46	36	Orange nc	O4	0.00	0.00	0.00	0.00	0.00	0.00	0.13
285	55	36	Orange nc	O10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
286	57	36	Orange nc	O10	0.00	0.00	0.00	0.00	0.00	0.00	0.01
287	44	37	Orange nc	O4	0.17	0.17	0.17	0.17	0.17	0.17	0.02
288	45	37	Orange nc	O4	0.00	0.00	0.00	0.00	0.00	0.00	0.01
289	64	37	Orange nc	O10	0.00	0.00	0.00	0.00	0.00	0.00	0.08
290	71	85	Orange nc	O5	0.00	0.00	0.00	0.00	0.00	0.00	2.70
291	73	94	Orange nc	O5	5.93	5.93	5.93	0.00	0.00	0.00	3.07
292	69	95	Orange nc	O5	0.00	0.00	0.00	5.93	5.93	5.93	0.16
293	19	78	Seminole nc	S1	0.00	0.00	0.00	0.00	0.00	0.00	0.08
294	20	78	Seminole nc	S1	0.00	0.00	0.00	0.00	0.00	0.00	0.09
295	21	80	Seminole nc	S1	0.00	0.00	0.00	0.00	0.00	0.00	0.01
296	20	81	Seminole nc	S1	0.23	0.23	0.23	0.00	0.00	0.00	0.02
297	22	81	Seminole nc	S1	0.00	0.00	0.00	0.23	0.23	0.23	0.01
298	20	55	Seminole nc	S2	0.23	0.23	0.23	0.23	0.23	0.23	0.08
299	21	56	Seminole nc	S2	0.00	0.00	0.00	0.00	0.00	0.00	0.06
300	21	65	Seminole nc	S2	0.00	0.00	0.00	0.00	0.00	0.00	0.06
301	33	68	Seminole nc	S6	0.53	0.53	0.53	0.53	0.53	0.53	0.00
302	32	93	Seminole nc	S3	0.32	0.32	0.32	0.32	0.32	0.32	0.51
303	31	100	Seminole nc	S3	0.00	0.00	0.00	0.00	0.00	0.00	0.09
304	32	100	Seminole nc	S3	0.00	0.00	0.00	0.00	0.00	0.00	0.09
305	35	101	Seminole nc	S3	0.00	0.00	0.00	0.00	0.00	0.00	0.10
306	40	83	Seminole nc	S4	0.00	0.00	0.00	0.00	0.00	0.00	0.05
307	43	84	Seminole nc	S4	0.00	0.00	0.00	0.00	0.00	0.00	0.05
308	44	84	Seminole nc	S4	0.00	0.00	0.00	0.00	0.00	0.00	0.07
309	43	85	Seminole nc	S4	0.00	0.00	0.00	0.00	0.00	0.00	0.10
310	44	85	Seminole nc	S4	0.00	0.00	0.00	0.00	0.00	0.00	0.07
311	40	86	Seminole nc	S4	0.00	0.00	0.00	0.00	0.00	0.00	0.04
312	41	86	Seminole nc	S4	0.00	0.00	0.00	0.00	0.00	0.00	0.32
313	42	86	Seminole nc	S4	0.00	0.00	0.00	0.00	0.00	0.00	0.10
314	43	86	Seminole nc	S4	0.00	0.00	0.00	0.00	0.00	0.00	0.01
315	41	87	Seminole nc	S4	0.00	0.00	0.00	0.00	0.00	0.00	0.05
316	45	87	Seminole nc	S4	0.00	0.00	0.00	0.00	0.00	0.00	0.48
317	46	87	Seminole nc	S4	1.76	1.76	1.76	1.76	1.76	1.76	0.05
318	36	88	Seminole nc	S4	0.00	0.00	0.00	0.00	0.00	0.00	0.11
319	45	88	Seminole nc	S4	0.00	0.00	0.00	0.00	0.00	0.00	0.10
320	46	88	Seminole nc	S4	0.00	0.00	0.00	0.00	0.00	0.00	0.05
321	47	89	Seminole nc	S4	0.00	0.00	0.00	0.00	0.00	0.00	0.02
322	46	90	Seminole nc	S4	0.00	0.00	0.00	0.00	0.00	0.00	0.03
323	49	90	Seminole nc	S4	0.00	0.00	0.00	0.00	0.00	0.00	0.02
324	55	30	Seminole nc	S5	0.00	0.00	0.00	0.00	0.00	0.00	0.02
325	43	44	Seminole nc	S7	0.00	0.00	0.00	0.00	0.00	0.00	0.09
326	44	44	Seminole nc	S7	0.38	0.38	0.38	0.38	0.38	0.38	0.04
327	34	55	Seminole nc	S6	0.00	0.00	0.00	0.00	0.00	0.00	0.34
328	21	64	Seminole nc	S2	0.00	0.00	0.00	0.00	0.00	0.00	0.02
329	52	74	Seminole nc	S5	0.00	0.00	0.00	0.00	0.00	0.00	0.04

Table A10--*Continued*

					Well withdrawal rates (cfd)						
					MIP Decision Model			LP Optimization Model			
Model number	Simulation model row	Simulation model column	Type	Agricultural demand area	Case 3	Case 2	Case 1	Case 3	Case 2	Case 1	1988 and projected year 2010
330	54	76	Seminole nc	S5	0.00	0.00	0.00	0.00	0.00	0.00	0.16
331	50	77	Seminole nc	S5	0.00	0.00	0.00	0.00	0.00	0.00	0.20
332	51	77	Seminole nc	S5	0.00	0.00	0.00	0.00	0.00	0.00	0.14
333	52	77	Seminole nc	S5	0.00	0.00	0.00	0.00	0.00	0.00	0.10
334	50	78	Seminole nc	S5	0.00	0.00	0.00	0.00	0.00	0.00	0.13
335	51	78	Seminole nc	S5	0.00	0.00	0.00	0.00	0.00	0.00	0.03
336	51	80	Seminole nc	S5	0.00	0.00	0.00	0.00	0.00	0.00	0.02
337	53	80	Seminole nc	S5	0.00	0.00	0.00	0.00	0.00	0.00	0.02
338	54	80	Seminole nc	S5	0.00	0.00	0.00	0.00	0.00	0.00	0.07
339	55	80	Seminole nc	S5	0.00	0.00	0.00	0.00	0.00	0.00	0.13
340	56	80	Seminole nc	S5	0.00	0.00	0.00	0.00	0.00	0.00	0.05
341	51	81	Seminole nc	S5	0.00	0.00	0.00	0.00	0.00	0.00	0.07
342	52	81	Seminole nc	S5	0.00	0.00	0.00	0.00	0.00	0.00	0.04
343	53	81	Seminole nc	S5	0.00	0.00	0.00	0.00	0.00	0.00	0.04
344	54	81	Seminole nc	S5	0.00	0.00	0.00	0.00	0.00	0.00	0.03
345	49	82	Seminole nc	S5	0.00	0.00	0.00	0.00	0.00	0.00	0.01
346	52	82	Seminole nc	S5	1.44	1.44	1.44	1.44	1.44	1.44	0.01
347	1	61	Volusia nc	V1	0.00	0.00	0.00	0.00	0.00	0.00	0.01
348	2	63	Volusia nc	V1	0.00	0.00	0.00	0.73	0.73	0.73	0.03
349	1	65	Volusia nc	V1	0.73	0.73	0.73	0.00	0.00	0.00	0.07
350	1	66	Volusia nc	V1	0.00	0.00	0.00	0.00	0.00	0.00	0.20
351	2	68	Volusia nc	V1	0.00	0.00	0.00	0.00	0.00	0.00	0.05
352	3	68	Volusia nc	V1	0.00	0.00	0.00	0.00	0.00	0.00	0.02
353	1	69	Volusia nc	V1	0.00	0.00	0.00	0.00	0.00	0.00	0.02
354	1	72	Volusia nc	V1	0.00	0.00	0.00	0.00	0.00	0.00	0.01
355	4	72	Volusia nc	V1	0.00	0.00	0.00	0.00	0.00	0.00	0.03
356	1	76	Volusia nc	V1	0.00	0.00	0.00	0.00	0.00	0.00	0.01
357	1	78	Volusia nc	V1	0.00	0.00	0.00	0.00	0.00	0.00	0.05
358	2	80	Volusia nc	V1	0.00	0.00	0.00	0.00	0.00	0.00	0.08
359	2	81	Volusia nc	V1	0.00	0.00	0.00	0.00	0.00	0.00	0.03
360	4	81	Volusia nc	V1	0.00	0.00	0.00	0.00	0.00	0.00	0.03
361	11	98	Volusia nc	V2	0.00	0.00	0.00	0.00	0.00	0.00	0.12
362	12	98	Volusia nc	V2	0.46	0.46	0.46	0.00	0.00	0.00	0.10
363	11	99	Volusia nc	V2	0.00	0.00	0.00	0.00	0.00	0.00	0.12
364	12	99	Volusia nc	V2	0.00	0.00	0.00	0.46	0.46	0.46	0.22

Table A11. Volusia LP optimization and MIP decision model agricultural well withdrawal rates

Simulation Model Row	Simulation Model Column	Model Well Number	Well type	Agricultural Area	Well withdrawal rates (MGD)						
					1988 and Nonoptimized Projected Year 2010	MIP decision model			LP optimization model		
						case 3	case 2	case 1	case 3	case 2	case 1
36	18	1	CITRUS	C1	0.05	0.09	0.09	0.09	0.09	0.09	0.09
37	18	2	CITRUS	C1	0.01	0.00	0.00	0.00	0.00	0.00	0.00
52	17	3	CITRUS	C2	0.01	0.00	0.00	0.00	0.00	0.00	0.00
52	18	4	CITRUS	C2	0.02	0.00	0.00	0.00	0.00	0.00	0.00
53	17	5	CITRUS	C2	0.01	0.07	0.07	0.07	0.07	0.07	0.07
55	17	6	CITRUS	C2	0.01	0.00	0.00	0.00	0.00	0.00	0.00
55	18	7	CITRUS	C2	0.01	0.00	0.00	0.00	0.00	0.00	0.00
56	17	8	CITRUS	C2	0.07	0.00	0.00	0.00	0.00	0.00	0.00
71	16	9	CITRUS	C3	0.02	0.11	0.11	0.11	0.11	0.11	0.11
77	17	10	CITRUS	C3	0.02	0.00	0.00	0.00	0.00	0.00	0.00
78	17	11	CITRUS	C3	0.02	0.00	0.00	0.00	0.00	0.00	0.00
46	13	12	CITRUS	C4	0.21	0.00	0.00	0.00	0.00	0.00	0.00
47	14	13	CITRUS	C4	0.39	0.22	0.22	0.22	0.22	0.22	0.22
2	8	14	FERN	F1	0.13	1.54	1.54	1.54	1.54	1.54	1.54
2	9	15	FERN	F1	0.02	0.00	0.00	0.00	0.00	0.00	0.00
2	10	16	FERN	F1	0.26	0.00	0.00	0.00	0.00	0.00	0.00
2	11	17	FERN	F1	0.20	0.00	0.00	0.00	0.00	0.00	0.00
2	12	18	FERN	F1	0.09	0.00	0.00	0.00	0.00	0.00	0.00
3	8	19	FERN	F1	0.21	0.00	0.00	0.00	0.00	0.00	0.00
3	9	20	FERN	F1	0.25	0.00	0.00	0.00	0.00	0.00	0.00
3	10	21	FERN	F1	0.01	0.00	0.00	0.00	0.00	0.00	0.00
4	9	22	FERN	F1A	0.05	0.00	0.00	0.00	0.00	0.00	0.00
4	10	23	FERN	F1A	0.21	0.00	0.00	0.00	0.00	0.00	0.00
4	11	24	FERN	F1A	0.39	0.92	0.92	0.92	0.92	0.92	0.00
4	12	25	FERN	F1A	0.04	0.00	0.00	0.00	0.00	0.00	0.92
5	9	26	FERN	F1A	0.04	0.00	0.00	0.00	0.00	0.00	0.00
5	11	27	FERN	F1A	0.07	0.00	0.00	0.00	0.00	0.00	0.00
6	10	28	FERN	F1A	0.08	0.00	0.00	0.00	0.00	0.00	0.00
6	11	29	FERN	F1A	0.01	0.00	0.00	0.00	0.00	0.00	0.00
6	12	30	FERN	F1A	0.01	0.00	0.00	0.00	0.00	0.00	0.00
7	12	32	FERN	F1A	0.02	0.00	0.00	0.00	0.00	0.00	0.00
8	12	34	FERN	F1A	0.01	0.00	0.00	0.00	0.00	0.00	0.00
7	8	31	FERN	F2	0.04	0.00	0.00	0.00	0.00	0.00	0.00
8	8	33	FERN	F2	0.03	0.00	0.00	0.00	0.00	0.00	0.00
9	7	35	FERN	F2	0.07	0.00	0.00	0.00	0.00	0.00	0.00
9	8	36	FERN	F2	0.10	0.00	0.00	0.00	0.00	0.00	0.00
10	7	37	FERN	F2	0.03	0.00	0.00	0.00	0.00	0.00	0.00
11	6	38	FERN	F2	0.24	0.00	0.00	0.00	0.00	0.00	0.00
11	7	39	FERN	F2	0.05	0.91	0.91	0.91	0.91	0.91	0.91
11	8	40	FERN	F2	0.08	0.00	0.00	0.00	0.00	0.00	0.00
12	8	44	FERN	F2	0.03	0.00	0.00	0.00	0.00	0.00	0.00
13	6	49	FERN	F2	0.03	2.59	2.59	2.59	2.59	2.59	2.59
13	7	50	FERN	F2	0.03	0.00	0.00	0.00	0.00	0.00	0.00
13	8	51	FERN	F2	0.17	0.00	0.00	0.00	0.00	0.00	0.00
14	8	60	FERN	F2	0.07	0.00	0.00	0.00	0.00	0.00	0.00
11	10	41	FERN	F3	0.11	0.00	0.00	0.00	0.00	0.00	0.00

Table A11--*Continued*

Simulation Model Row	Simulation Model Column	Model Well Number	Well type	Agricultural Area	Well withdrawal rates (MGD): 1988 and Nonoptimized Projected Year 2010	MIP decision model: case 3	MIP decision model: case 2	MIP decision model: case 1	LP optimization model: case 3	LP optimization model: case 2	LP optimization model: case 1
11	0	42	FERN	F3	0.04	0.00	0.00	0.00	0.00	0.00	0.00
11	12	43	FERN	F3	0.17	0.00	0.00	0.00	0.00	0.00	0.00
12	9	45	FERN	F3	0.21	0.00	0.00	0.00	0.00	0.00	0.00
12	10	46	FERN	F3	0.26	0.00	0.00	0.00	0.00	0.00	0.00
12	11	47	FERN	F3	0.08	0.00	0.00	0.00	0.00	0.00	0.00
12	12	48	FERN	F3	0.09	0.00	0.00	0.00	0.00	0.00	0.00
13	9	52	FERN	F3	0.35	0.00	0.00	0.00	0.00	0.00	0.00
13	10	53	FERN	F3	0.26	0.00	0.00	0.00	0.00	0.00	0.00
13	11	54	FERN	F3	0.12	0.00	0.00	0.00	0.00	0.00	0.00
13	12	55	FERN	F3	0.07	0.00	0.00	0.00	0.00	0.00	0.00
13	13	56	FERN	F3	0.10	0.00	0.00	0.00	0.00	0.00	0.00
13	14	57	FERN	F3	0.04	0.00	0.00	0.00	0.00	0.00	0.00
14	9	61	FERN	F3	0.26	0.00	0.00	0.00	0.00	0.00	0.00
14	10	62	FERN	F3	0.37	0.00	0.00	0.00	0.00	0.00	0.00
14	11	63	FERN	F3	0.10	0.00	0.00	0.00	0.00	0.00	0.00
14	5	58	FERN	F4	0.02	0.00	0.00	0.00	0.00	0.00	0.00
14	6	59	FERN	F4	0.04	0.00	0.00	0.00	0.00	0.00	0.00
15	4	64	FERN	F4	0.23	0.00	0.00	0.00	0.00	0.00	0.00
15	5	65	FERN	F4	0.21	1.03	1.03	1.03	1.03	1.03	1.03
15	6	66	FERN	F4	0.15	0.00	0.00	0.00	0.00	0.00	0.00
15	7	67	FERN	F4	0.02	0.00	0.00	0.00	0.00	0.00	0.00
16	4	70	FERN	F4	0.13	0.00	0.00	0.00	0.00	0.00	0.00
16	5	71	FERN	F4	0.04	0.84	0.00	0.60	0.84	0.84	0.84
16	6	72	FERN	F4	0.07	0.00	0.00	0.00	0.00	0.00	0.00
17	2	75	FERN	F4	0.02	0.00	0.00	0.00	0.00	0.00	0.00
18	4	76	FERN	F4	0.01	0.00	0.00	0.00	0.00	0.00	0.00
18	7	79	FERN	F4	0.05	0.00	0.84	0.23	0.00	0.00	0.00
15	8	68	FERN	F4A	0.14	0.00	0.00	0.00	0.00	0.00	0.00
15	9	69	FERN	F4A	0.15	0.00	0.00	0.00	0.00	0.00	0.00
16	9	73	FERN	F4A	0.26	0.00	0.00	0.00	0.00	0.00	0.00
16	10	74	FERN	F4A	0.21	0.00	0.00	0.00	0.00	0.00	0.00
17	12	77	FERN	F4A	0.12	0.00	0.00	0.00	0.00	0.00	0.00
17	13	78	FERN	F4A	0.04	0.00	0.00	0.00	0.00	0.00	0.00
18	9	80	FERN	F4A	0.02	0.00	0.00	0.00	0.00	0.00	0.00
19	9	81	FERN	F4A	0.06	0.00	0.00	0.00	0.00	0.00	0.00
18	19	82	FERN	F5	0.07	0.00	0.00	0.00	0.00	0.00	0.00
20	18	83	FERN	F5	0.07	0.00	0.00	0.00	0.00	0.00	0.00
23	17	84	FERN	F5	0.11	0.53	0.53	0.53	0.53	0.53	0.53
23	18	85	FERN	F5	0.21	0.00	0.00	0.00	0.00	0.00	0.00
24	18	86	FERN	F5	0.02	0.00	0.00	0.00	0.00	0.00	0.00
25	18	87	FERN	F5	0.01	0.00	0.00	0.00	0.00	0.00	0.00
28	15	88	FERN	F6	0.05	0.00	0.00	0.00	0.00	0.00	0.00
29	15	89	FERN	F6	0.01	0.00	0.00	0.00	0.00	0.00	0.00
30	14	90	FERN	F6	0.05	0.00	0.00	0.00	0.00	0.00	0.00
30	15	91	FERN	F6	0.06	0.00	0.00	0.00	0.00	0.00	0.00
31	14	92	FERN	F6	0.05	0.00	0.00	0.00	0.00	0.00	0.00

Table A11--*Continued*

Simulation Model Row	Simulation Model Column	Model Well Number	Well type	Agricultural Area	Well withdrawal rates (MGD)						
						MIP decision model			LP optimization model		
					1988 and Nonoptimized Projected Year 2010	case 3	case 2	case 1	case 3	case 2	case 1
32	14	93	FERN	F6	0.06	0.00	0.00	0.00	0.00	0.00	0.00
33	14	94	FERN	F6	0.12	0.00	0.00	0.00	0.00	0.00	0.00
33	15	95	FERN	F6	1.65	0.00	0.00	0.00	0.00	0.00	0.00
34	14	96	FERN	F6	0.06	2.72	2.72	2.72	2.72	2.72	2.72
34	15	97	FERN	F6	0.05	0.00	0.00	0.00	0.00	0.00	0.00
35	14	98	FERN	F6	0.10	0.00	0.00	0.00	0.00	0.00	0.00
35	15	99	FERN	F6	0.01	0.00	0.00	0.00	0.00	0.00	0.00
36	13	100	FERN	F6	0.07	0.00	0.00	0.00	0.00	0.00	0.00
36	14	101	FERN	F6	0.03	0.00	0.00	0.00	0.00	0.00	0.00
37	14	102	FERN	F6	0.07	0.00	0.00	0.00	0.00	0.00	0.00
37	16	103	FERN	F6	0.08	0.00	0.00	0.00	0.00	0.00	0.00
38	14	104	FERN	F6	0.03	0.00	0.00	0.00	0.00	0.00	0.00
38	15	105	FERN	F6	0.01	0.00	0.00	0.00	0.00	0.00	0.00
38	16	106	FERN	F6	0.01	0.00	0.00	0.00	0.00	0.00	0.00
39	12	107	FERN	F6	0.03	0.00	0.00	0.00	0.00	0.00	0.00
40	12	111	FERN	F6	0.08	0.00	0.00	0.00	0.00	0.00	0.00
40	14	112	FERN	F6	0.02	1.52	1.52	1.52	1.52	1.52	1.52
40	15	113	FERN	F6	0.04	0.00	0.00	0.00	0.00	0.00	0.00
39	15	108	FERN	F7	0.19	0.00	0.00	0.00	0.00	0.00	0.00
39	18	110	FERN	F7	0.06	0.00	0.00	0.00	0.00	0.00	0.00
40	17	114	FERN	F7	0.04	0.00	0.00	0.00	0.00	0.00	0.00
40	18	115	FERN	F7	0.06	0.98	0.98	0.98	0.98	0.98	0.98
40	19	116	FERN	F7	0.03	0.00	0.00	0.00	0.00	0.00	0.00
41	17	119	FERN	F7	0.03	0.00	0.00	0.00	0.00	0.00	0.00
41	19	120	FERN	F7	0.06	1.41	1.41	1.41	1.41	1.41	1.41
41	20	121	FERN	F7	0.04	0.00	0.00	0.00	0.00	0.00	0.00
42	17	126	FERN	F7	0.04	0.00	0.00	0.00	0.00	0.00	0.00
42	19	127	FERN	F7	0.15	0.00	0.00	0.00	0.00	0.00	0.00
43	17	131	FERN	F7	0.06	0.00	0.00	0.00	0.00	0.00	0.00
44	17	136	FERN	F7	0.11	0.00	0.00	0.00	0.00	0.00	0.00
45	18	142	FERN	F7	0.09	0.00	0.00	0.00	0.00	0.00	0.00
46	18	145	FERN	F7	0.03	0.00	0.00	0.00	0.00	0.00	0.00
46	19	146	FERN	F7	0.04	0.00	0.00	0.00	0.00	0.00	0.00
41	13	117	FERN	F8	0.03	0.00	0.00	0.00	0.00	0.00	0.00
41	16	118	FERN	F8	0.04	0.00	0.00	0.00	0.00	0.00	0.00
42	11	122	FERN	F8	0.08	0.00	0.00	0.00	0.00	0.00	0.00
42	14	123	FERN	F8	0.04	0.00	0.00	0.00	0.00	0.00	0.00
42	15	124	FERN	F8	0.05	0.00	0.00	0.00	0.00	0.00	0.00
42	16	125	FERN	F8	0.01	0.00	0.00	0.00	0.00	0.00	0.00
43	11	128	FERN	F8	0.04	0.00	0.00	0.00	0.00	0.00	0.00
43	13	129	FERN	F8	0.06	0.00	0.00	0.00	0.00	0.00	0.00
43	14	130	FERN	F8	0.02	0.00	0.00	0.00	0.00	0.00	0.00
44	10	132	FERN	F8	0.07	0.00	0.00	0.00	0.00	0.00	0.00
44	11	133	FERN	F8	0.02	0.00	0.00	0.00	0.00	0.00	0.00
44	13	134	FERN	F8	0.02	0.00	0.00	0.00	0.00	0.00	0.00
44	14	135	FERN	F8	0.01	0.00	0.00	0.00	0.00	0.00	0.00

Table A11--*Continued*

					Well withdrawal rates (MGD)						
						MIP decision model			LP optimization model		
Simulation Model Row	Simulation Model Column	Model Well Number	Well type	Agricultural Area	1988 and Nonoptimized Projected Year 2010	case 3	case 2	case 1	case 3	case 2	case 1
45	10	137	FERN	F8	0.09	0.00	0.00	0.00	0.00	0.00	0.00
45	11	138	FERN	F8	0.20	0.00	0.00	0.00	0.00	0.00	0.00
45	13	139	FERN	F8	0.08	0.00	0.00	0.00	0.00	0.00	0.00
45	14	140	FERN	F8	0.10	0.00	0.00	0.00	0.00	0.00	0.00
45	15	141	FERN	F8	0.06	0.00	0.00	0.00	0.00	0.00	0.00
46	10	143	FERN	F8	0.06	0.00	0.00	0.00	0.00	0.00	0.00
46	14	144	FERN	F8	0.05	0.00	0.00	0.00	0.00	0.00	0.00
47	10	147	FERN	F8	0.05	0.00	0.00	0.00	0.00	0.00	0.00
47	12	148	FERN	F8	0.02	0.00	0.00	0.00	0.00	0.00	0.00
48	10	149	FERN	F8	0.02	0.00	0.00	0.00	0.00	0.00	0.00
48	13	150	FERN	F8	0.04	0.00	0.00	0.00	0.00	0.00	0.00
49	13	151	FERN	F8	0.03	0.00	0.00	0.00	0.00	0.00	0.00
49	15	152	FERN	F8	0.06	0.00	0.00	0.00	0.00	0.00	0.00
50	15	155	FERN	F8	0.02	0.00	0.00	0.00	0.00	0.00	0.00
51	13	159	FERN	F8	0.04	0.00	0.00	0.00	0.00	0.00	0.00
39	17	109	FERN	F9	0.03	0.00	0.00	0.00	0.00	0.00	0.00
50	10	153	FERN	F9	0.02	0.00	0.00	0.00	0.00	0.00	0.00
50	11	154	FERN	F9	0.02	0.37	0.37	0.37	0.37	0.37	0.37
51	10	157	FERN	F9	0.03	0.00	0.00	0.00	0.00	0.00	0.00
51	11	158	FERN	F9	0.02	0.00	0.00	0.00	0.00	0.00	0.00
52	9	161	FERN	F9	0.01	0.00	0.00	0.00	0.00	0.00	0.00
52	10	162	FERN	F9	0.03	0.00	0.00	0.00	0.00	0.00	0.00
53	9	163	FERN	F9	0.07	0.00	0.00	0.00	0.00	0.00	0.00
53	10	164	FERN	F9	0.04	0.00	0.00	0.00	0.00	0.00	0.00
54	9	166	FERN	F9	0.03	0.00	0.00	0.00	0.00	0.00	0.00
54	10	167	FERN	F9	0.03	0.00	0.00	0.00	0.00	0.00	0.00
55	10	168	FERN	F9	0.05	0.00	0.00	0.00	0.00	0.00	0.00
55	11	169	FERN	F9	0.01	0.00	0.00	0.00	0.00	0.00	0.00
55	12	170	FERN	F9	0.03	0.00	0.00	0.00	0.00	0.00	0.00
56	10	171	FERN	F9	0.04	0.00	0.00	0.00	0.00	0.00	0.00
56	11	172	FERN	F9	0.01	0.00	0.00	0.00	0.00	0.00	0.00
57	9	173	FERN	F9	0.11	0.00	0.00	0.00	0.00	0.00	0.00
57	10	174	FERN	F9	0.02	0.00	0.00	0.00	0.00	0.00	0.00
57	11	175	FERN	F9	0.09	0.00	0.00	0.00	0.00	0.00	0.00
58	9	176	FERN	F9	0.10	0.00	0.00	0.00	0.00	0.00	0.00
58	10	177	FERN	F9	0.00	0.00	0.00	0.00	0.00	0.00	0.00
58	11	178	FERN	F9	0.01	0.00	0.00	0.00	0.00	0.00	0.00
58	12	179	FERN	F9	0.07	0.00	0.00	0.00	0.00	0.00	0.00
59	9	180	FERN	F9	0.03	0.00	0.00	0.00	0.00	0.00	0.00
59	10	181	FERN	F9	0.07	0.00	0.00	0.00	0.00	0.00	0.00
61	9	182	FERN	F9	0.16	0.00	0.00	0.00	0.00	0.00	0.00
61	10	183	FERN	F9	0.02	0.00	0.00	0.00	0.00	0.00	0.00
62	9	184	FERN	F9	0.03	0.00	0.00	0.00	0.00	0.00	0.00
62	10	185	FERN	F9	0.10	0.00	0.00	0.00	0.00	0.00	0.00
63	9	186	FERN	F9	0.07	0.00	0.00	0.00	0.00	0.00	0.00
63	10	187	FERN	F9	0.01	0.00	0.00	0.00	0.00	0.00	0.00

Table A11--*Continued*

					Well withdrawal rates (MGD)						
						MIP decision model			LP optimization model		
Simulation Model Row	Simulation Model Column	Model Well Number	Well type	Agricultural Area	1988 and Nonoptimized Projected Year 2010	case 3	case 2	case 1	case 3	case 2	case 1
63	11	188	FERN	F9	0.03	0.00	0.00	0.00	0.00	0.00	0.00
64	9	189	FERN	F9	0.01	0.00	0.00	0.00	0.00	0.00	0.00
64	10	190	FERN	F9	0.01	0.00	0.00	0.00	0.00	0.00	0.00
64	11	191	FERN	F9	0.02	0.00	0.00	0.00	0.00	0.00	0.00
65	9	192	FERN	F9	0.01	0.00	0.00	0.00	0.00	0.00	0.00
65	10	193	FERN	F9	0.01	0.00	0.00	0.00	0.00	0.00	0.00
66	9	194	FERN	F9	0.04	0.00	0.00	0.00	0.00	0.00	0.00
68	8	195	FERN	F9	0.01	0.00	0.00	0.00	0.00	0.00	0.00
59	12	197	FERN	F9	0.16	0.00	0.00	0.00	0.00	0.00	0.00
50	18	156	FERN	F10	0.02	0.00	0.00	0.00	0.00	0.00	0.00
51	18	160	FERN	F10	0.09	0.00	0.00	0.00	0.00	0.00	0.00
53	18	165	FERN	F10	0.01	0.00	0.00	0.00	0.00	0.00	0.00
58	17	196	FERN	F10	0.02	0.00	0.00	0.00	0.00	0.00	0.00
59	14	198	FERN	F10	0.03	0.00	0.00	0.00	0.00	0.00	0.00
59	17	199	FERN	F10	0.03	0.00	0.00	0.00	0.00	0.00	0.00
60	14	200	FERN	F10	0.01	0.00	0.00	0.00	0.00	0.00	0.00
61	17	201	FERN	F10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
69	15	202	FERN	F11	0.04	0.00	0.00	0.00	0.00	0.00	0.00
72	15	203	FERN	F11	0.03	0.00	0.00	0.00	0.08	0.08	0.08
73	14	204	FERN	F11	0.01	0.00	0.00	0.00	0.00	0.00	0.00
73	16	205	FERN	F11	0.01	0.00	0.00	0.00	0.00	0.00	0.00
71	8	206	FERN	F12	0.01	0.00	0.00	0.00	0.00	0.19	0.19
71	9	207	FERN	F12	0.06	0.00	0.00	0.00	0.00	0.00	0.00
72	10	208	FERN	F12	0.11	0.00	0.00	0.00	0.00	0.00	0.00
73	10	209	FERN	F12	0.02	0.00	0.00	0.00	0.00	0.00	0.00
74	8	210	FERN	F13	0.04	0.00	0.00	0.00	0.00	0.25	0.36
74	9	211	FERN	F13	0.02	0.00	0.00	0.00	0.00	0.00	0.00
74	13	212	FERN	F13	0.02	0.00	0.00	0.00	0.00	0.00	0.00
75	14	213	FERN	F13	0.05	0.00	0.00	0.00	0.00	0.00	0.00
76	10	214	FERN	F13	0.07	0.00	0.00	0.00	0.00	0.00	0.00
76	16	215	FERN	F13	0.03	0.00	0.00	0.00	0.00	0.00	0.00
77	17	216	FERN	F13	0.02	0.00	0.00	0.00	0.00	0.11	0.00
78	9	217	FERN	F13	0.04	0.00	0.00	0.00	0.00	0.00	0.00
79	12	218	FERN	F13	0.03	0.00	0.00	0.00	0.00	0.00	0.00
82	16	219	FERN	F13	0.02	0.00	0.00	0.00	0.00	0.00	0.00
4	11	220	FOLIAGE 2	L1	0.04	0.06	0.00	0.00	0.00	0.00	0.00
16	12	221	FOLIAGE 2	L1	0.03	0.00	0.06	0.06	0.06	0.06	0.06
60	9	222	FOLIAGE 2	L2	0.04	0.06	0.06	0.06	0.06	0.00	0.00
60	14	223	FOLIAGE 2	L2	0.05	0.00	0.00	0.00	0.00	0.06	0.06
61	9	224	FOLIAGE 2	L3	0.05	0.10	0.10	0.10	0.10	0.10	0.10
62	9	225	FOLIAGE 2	L3	0.02	0.00	0.00	0.00	0.00	0.00	0.00
25	78	226	GOLF	G1	0.02	0.00	0.00	0.00	0.00	0.00	0.00
25	79	227	GOLF	G1	0.02	0.00	0.00	0.00	0.00	0.00	0.00
26	79	228	GOLF	G1	0.07	0.00	0.00	0.00	0.00	0.00	0.00
27	79	229	GOLF	G1	0.02	0.16	0.16	0.16	0.16	0.16	0.16
28	78	230	GOLF	G1	0.04	0.00	0.00	0.00	0.00	0.00	0.00

Table A11--*Continued*

					Well withdrawal rates (MGD)						
						MIP decision model			LP optimization model		
Simulation Model Row	Simulation Model Column	Model Well Number	Well type	Agricultural Area	1988 and Nonoptimized Projected Year 2010	case 3	case 2	case 1	case 3	case 2	case 1
64	78	231	GOLF	G2	0.05	0.09	0.00	0.00	0.09	0.00	0.00
65	78	232	GOLF	G2	0.07	0.00	0.09	0.09	0.00	0.09	0.09
75	53	233	GOLF	G3	0.22	0.30	0.00	0.00	0.30	0.00	0.00
75	55	234	GOLF	G3	0.11	0.00	0.30	0.30	0.00	0.30	0.30
80	63	235	GOLF	G4	0.05	0.16	0.16	0.00	0.00	0.16	0.16
82	65	236	GOLF	G4	0.09	0.00	0.00	0.16	0.00	0.00	0.00
84	8	237	GOLF	G5	0.07	0.09	0.09	0.09	0.09	0.00	0.00
2	7	238	LIVESTOCK	P1	0.22	0.00	0.00	0.00	0.00	0.00	0.00
2	8	239	LIVESTOCK	P1	0.02	0.57	0.57	0.57	0.57	0.57	0.57
3	9	240	LIVESTOCK	P1	0.03	0.00	0.00	0.00	0.00	0.00	0.00
3	10	241	LIVESTOCK	P1	0.07	0.00	0.00	0.00	0.00	0.00	0.00
3	11	242	LIVESTOCK	P1	0.02	0.00	0.00	0.00	0.00	0.00	0.00
4	11	243	LIVESTOCK	P1	0.03	0.00	0.00	0.00	0.00	0.00	0.00
5	9	244	LIVESTOCK	P1	0.10	0.00	0.00	0.00	0.00	0.00	0.00
5	10	245	LIVESTOCK	P1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	4	246	LIVESTOCK	P1	0.04	0.00	0.00	0.00	0.00	0.00	0.00
10	7	247	LIVESTOCK	P2	0.04	0.00	0.00	0.00	0.00	0.00	0.00
14	5	248	LIVESTOCK	P2	0.06	0.43	0.43	0.43	0.00	0.00	0.00
9	8	249	LIVESTOCK	P2	0.01	0.00	0.00	0.00	0.00	0.00	0.00
12	6	250	LIVESTOCK	P2	0.02	0.00	0.00	0.00	0.00	0.00	0.00
11	7	251	LIVESTOCK	P2	0.01	0.00	0.00	0.00	0.00	0.00	0.00
13	6	252	LIVESTOCK	P2	0.08	0.00	0.00	0.00	0.00	0.00	0.00
10	8	253	LIVESTOCK	P2	0.02	0.00	0.00	0.00	0.43	0.43	0.43
16	5	254	LIVESTOCK	P2	0.14	0.00	0.00	0.00	0.00	0.00	0.00
5	23	255	LIVESTOCK	P2	0.05	0.00	0.00	0.00	0.00	0.00	0.00
6	16	256	LIVESTOCK	P3	0.08	0.00	0.00	0.00	0.00	0.00	0.00
7	12	257	LIVESTOCK	P3	0.04	0.17	0.17	0.17	0.17	0.17	0.17
7	13	258	LIVESTOCK	P3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	8	259	LIVESTOCK	P4	0.04	0.00	0.00	0.00	0.00	0.00	0.00
13	7	260	LIVESTOCK	P4	0.05	0.00	0.00	0.00	0.00	0.00	0.00
14	6	261	LIVESTOCK	P4	0.01	0.00	0.00	0.00	0.00	0.00	0.00
15	6	262	LIVESTOCK	P4	0.01	0.00	0.00	0.00	0.00	0.00	0.00
16	6	263	LIVESTOCK	P4	0.15	0.00	0.00	0.00	0.00	0.00	0.00
17	6	264	LIVESTOCK	P4	0.05	0.32	0.32	0.32	0.32	0.32	0.32
18	5	265	LIVESTOCK	P4	0.04	0.00	0.00	0.00	0.00	0.00	0.00
11	10	266	LIVESTOCK	P5	0.02	0.00	0.00	0.00	0.00	0.00	0.00
12	9	267	LIVESTOCK	P5	0.01	0.00	0.00	0.00	0.00	0.00	0.00
13	8	268	LIVESTOCK	P5	0.12	0.00	0.00	0.00	0.00	0.00	0.00
14	8	269	LIVESTOCK	P5	0.01	0.21	0.21	0.21	0.21	0.21	0.21
16	7	270	LIVESTOCK	P5	0.13	0.00	0.00	0.00	0.00	0.00	0.00
12	10	271	LIVESTOCK	P6	0.13	0.00	0.00	0.00	0.00	0.00	0.00
15	8	272	LIVESTOCK	P6	0.05	0.46	0.46	0.46	0.46	0.46	0.46
14	9	273	LIVESTOCK	P6	0.03	0.00	0.00	0.00	0.00	0.00	0.00
13	10	274	LIVESTOCK	P6	0.03	0.00	0.00	0.00	0.00	0.00	0.00
15	9	275	LIVESTOCK	P6	0.03	0.00	0.00	0.00	0.00	0.00	0.00
14	10	276	LIVESTOCK	P6	0.04	0.00	0.00	0.00	0.00	0.00	0.00

Table A11--*Continued*

					Well withdrawal rates (MGD)						
						MIP decision model			LP optimization model		
Simulation Model Row	Simulation Model Column	Model Well Number	Well type	Agricultural Area	1988 and Nonoptimized Projected Year 2010	case 3	case 2	case 1	case 3	case 2	case 1
13	11	277	LIVESTOCK	P6	0.03	0.00	0.00	0.00	0.00	0.00	0.00
12	12	278	LIVESTOCK	P6	0.11	0.00	0.00	0.00	0.00	0.00	0.00
7	21	279	LIVESTOCK	P7	0.05	0.21	0.21	0.21	0.21	0.21	0.21
7	22	280	LIVESTOCK	P7	0.05	0.00	0.00	0.00	0.00	0.00	0.00
8	21	281	LIVESTOCK	P7	0.04	0.00	0.00	0.00	0.00	0.00	0.00
6	28	282	LIVESTOCK	P8	0.04	0.00	0.00	0.00	0.00	0.00	0.00
6	29	283	LIVESTOCK	P8	0.04	0.00	0.00	0.00	0.00	0.00	0.00
6	31	284	LIVESTOCK	P8	0.04	0.00	0.00	0.00	0.00	0.00	0.00
7	31	285	LIVESTOCK	P8	0.04	0.00	0.00	0.00	0.00	0.00	0.00
8	29	286	LIVESTOCK	P8	0.04	0.00	0.00	0.00	0.00	0.00	0.00
8	31	287	LIVESTOCK	P8	0.05	0.00	0.00	0.00	0.00	0.00	0.00
9	28	288	LIVESTOCK	P8	0.09	0.00	0.00	0.00	0.00	0.00	0.00
9	29	289	LIVESTOCK	P8	0.10	0.00	0.00	0.00	0.00	0.00	0.00
10	28	290	LIVESTOCK	P8	0.05	0.00	0.00	0.00	0.00	0.00	0.00
11	26	291	LIVESTOCK	P8	0.05	0.58	0.58	0.58	0.58	0.58	0.58
11	27	292	LIVESTOCK	P8	0.02	0.00	0.00	0.00	0.00	0.00	0.00
16	11	293	LIVESTOCK	P9	0.07	0.00	0.00	0.00	0.00	0.00	0.00
17	10	294	LIVESTOCK	P9	0.08	0.09	0.09	0.09	0.09	0.09	0.09
11	20	295	LIVESTOCK	P10	0.08	0.55	0.55	0.55	0.55	0.55	0.55
11	21	296	LIVESTOCK	P10	0.08	0.00	0.00	0.00	0.00	0.00	0.00
12	21	297	LIVESTOCK	P10	0.16	0.00	0.00	0.00	0.00	0.00	0.00
12	22	298	LIVESTOCK	P10	0.08	0.00	0.00	0.00	0.00	0.00	0.00
12	23	299	LIVESTOCK	P10	0.08	0.00	0.00	0.00	0.00	0.00	0.00
13	21	300	LIVESTOCK	P10	0.61	0.00	0.00	0.00	0.00	0.00	0.00
15	16	301	LIVESTOCK	P11	0.04	0.79	0.79	0.79	0.79	0.79	0.79
17	18	302	LIVESTOCK	P11	0.10	0.00	0.00	0.00	0.00	0.00	0.00
19	17	303	LIVESTOCK	P11	0.02	0.00	0.00	0.00	0.00	0.00	0.00
18	18	304	LIVESTOCK	P11	0.03	0.00	0.00	0.00	0.00	0.00	0.00
18	19	305	LIVESTOCK	P11	0.02	0.00	0.00	0.00	0.00	0.00	0.00
30	12	306	LIVESTOCK	P12	0.02	0.00	0.00	0.00	0.00	0.00	0.00
31	12	307	LIVESTOCK	P12	0.02	0.00	0.00	0.00	0.00	0.00	0.00
32	12	308	LIVESTOCK	P12	0.02	0.00	0.00	0.00	0.00	0.00	0.00
31	13	309	LIVESTOCK	P12	0.08	0.00	0.00	0.00	0.00	0.00	0.00
32	13	310	LIVESTOCK	P12	0.11	0.15	0.15	0.15	0.15	0.15	0.15
29	15	311	LIVESTOCK	P13	0.03	0.11	0.11	0.11	0.11	0.11	0.11
44	10	312	LIVESTOCK	P14	0.08	0.18	0.18	0.18	0.18	0.18	0.18
48	10	313	LIVESTOCK	P14	0.02	0.00	0.00	0.00	0.00	0.00	0.00
50	10	314	LIVESTOCK	P14	0.04	0.00	0.00	0.00	0.00	0.00	0.00
51	11	315	LIVESTOCK	P14	0.02	0.00	0.00	0.00	0.00	0.00	0.00
27	18	316	LIVESTOCK	P15	0.08	0.00	0.00	0.00	0.00	0.00	0.00
28	17	317	LIVESTOCK	P15	0.06	0.11	0.11	0.11	0.11	0.11	0.11
7	79	318	LIVESTOCK	P16	0.01	0.00	0.00	0.00	0.11	0.11	0.11
72	8	319	LIVESTOCK	P16	0.04	0.11	0.11	0.11	0.00	0.00	0.00
78	9	320	LIVESTOCK	P16	0.01	0.00	0.00	0.00	0.00	0.00	0.00
43	14	321	LIVESTOCK	P17	0.04	0.00	0.00	0.00	0.00	0.00	0.00
44	13	322	LIVESTOCK	P17	0.03	0.16	0.16	0.16	0.00	0.16	0.16

Table A11--*Continued*

					Well withdrawal rates (MGD)						
						MIP decision model			LP optimization model		
Simulation Model Row	Simulation Model Column	Model Well Number	Well type	Agricultural Area	1988 and Nonoptimized Projected Year 2010	case 3	case 2	case 1	case 3	case 2	case 1
44	16	323	LIVESTOCK	P17	0.04	0.00	0.00	0.00	0.16	0.00	0.00
45	13	324	LIVESTOCK	P17	0.03	0.00	0.00	0.00	0.00	0.00	0.00
45	14	325	LIVESTOCK	P17	0.09	0.00	0.00	0.00	0.00	0.00	0.00
59	11	326	LIVESTOCK	P18	0.03	0.14	0.14	0.14	0.14	0.14	0.14
60	11	327	LIVESTOCK	P18	0.03	0.00	0.00	0.00	0.00	0.00	0.00
63	11	328	LIVESTOCK	P18	0.12	0.00	0.00	0.00	0.00	0.00	0.00
77	17	329	LIVESTOCK	P19	0.05	0.12	0.12	0.12	0.12	0.12	0.00
35	71	330	LIVESTOCK	P20	0.05	0.00	0.00	0.00	0.00	0.00	0.00
36	73	331	LIVESTOCK	P20	0.05	0.00	0.00	0.00	0.00	0.00	0.00
36	74	332	LIVESTOCK	P20	0.21	0.14	0.14	0.14	0.14	0.14	0.14
78	37	333	LIVESTOCK	P21	0.21	0.32	0.45	0.08	0.00	0.00	0.00
79	37	334	LIVESTOCK	P21	0.21	0.31	0.18	0.56	0.39	0.63	0.63
78	38	335	LIVESTOCK	P21	0.03	0.00	0.00	0.00	0.00	0.00	0.00
11	8	336	NURSERY	N1	0.05	0.00	0.00	0.00	0.00	0.00	0.00
12	8	337	NURSERY	N1	0.01	0.15	0.15	0.15	0.15	0.15	0.00
13	9	338	NURSERY	N1	0.06	0.00	0.00	0.00	0.00	0.00	0.00
14	10	339	NURSERY	N1	0.04	0.00	0.00	0.00	0.00	0.00	0.15
73	66	340	NURSERY	N2	0.03	0.07	0.07	0.00	0.07	0.07	0.07
73	67	341	NURSERY	N2	0.08	0.00	0.00	0.07	0.00	0.00	0.00
81	49	342	NURSERY	N3	0.04	0.00	0.00	0.00	0.12	0.12	0.12
82	49	343	NURSERY	N3	0.05	0.12	0.12	0.12	0.00	0.00	0.00
22	69	344	TURF	T1	0.05	0.00	0.00	0.00	0.00	0.00	0.00
23	68	345	TURF	T1	0.05	0.00	0.00	0.00	0.00	0.00	0.00
23	70	346	TURF	T1	0.05	0.19	0.00	0.00	0.19	0.19	0.19
24	69	347	TURF	T1	0.03	0.00	0.19	0.19	0.00	0.00	0.00
72	12	348	TURF	T2	0.03	0.07	0.00	0.00	0.00	0.00	0.00
72	13	349	TURF	T2	0.03	0.00	0.07	0.07	0.00	0.07	0.07
76	55	350	TURF	T3	0.21	0.76	0.00	0.00	0.40	0.00	0.00
77	55	351	TURF	T3	0.03	0.00	0.00	0.00	0.00	0.00	0.00
77	57	352	TURF	T3	0.49	0.00	0.00	0.00	0.00	0.00	0.00
78	56	353	TURF	T3	0.13	0.00	0.76	0.76	0.00	0.76	0.76
82	14	354	TURF	T4	0.03	0.00	0.00	0.00	0.00	0.00	0.00
83	9	355	TURF	T4	0.13	0.28	0.28	0.28	0.00	0.28	0.28
83	14	356	TURF	T4	0.17	0.00	0.00	0.00	0.00	0.00	0.00
90	27	357	TURF	T5	0.17	0.33	0.33	0.33	0.33	0.33	0.33
90	28	358	TURF	T5	0.07	0.00	0.00	0.00	0.00	0.00	0.00
89	19	359	VEGETABLE	V1	0.19	0.00	0.00	0.00	0.00	0.00	0.00
89	20	360	VEGETABLE	V1	0.07	0.00	0.00	0.00	0.00	0.00	0.00
89	21	361	VEGETABLE	V1	0.04	0.00	0.00	0.00	0.00	0.00	0.00
90	20	362	VEGETABLE	V1	4.992	0.37	0.37	0.37	0.37	0.37	0.37

Table A12. Linear approximations for transport costs

Annualized fixed cost estimates to approximate the following equations:

Less than 5 miles long:

$[22460(Length in miles)^1.232 *(ADF in MGD)^0.43]/year (a)

More than 5 miles long:

1 pump station: $[32040(Length in miles)^1.044 *(ADF in MGD)^0.44] /year (b)

2 pump stations: $[43180(Length in miles)^0.935 *(ADF in MGD)^0.448] /year (c)

Annualized unit charges are approximated as

Less than 5 miles long: $0/year

1 or 2 pump stations: $[51420(ADF in MGD)]/year (d)

Each segment below has a slope and an intercept for a straight line approximation

linear approximation = intercept + slope*(ADF in cfd)

length in miles	adf (mgd)	adf (cfd)	CH2M Hill (eqn a, b, or c) $/year	Linear approximation $/year	Error $/year	% error
1	5	668,449	44,871	50272.7513	5,402	12.04%
1	7.5	1,002,674	53,418	54851.62695	1,434	2.68%
1	10	1,336,898	60,452	59430.5026	-1,021	-1.69%
1	15	2,005,347	71,966	68588.2539	-3,378	-4.69%
1	20	2,673,796	81,443	77746.0052	-3,697	-4.54%
1	25	3,342,245	89,645	86903.7565	-2,741	-3.06%
1	30	4,010,694	96,955	96061.5078	-894	-0.92%
1	40	5,347,592	109,723	114377.0104	4,655	4.24%
	intercept	41,115				
	slope	0.0137				

length in miles	adf (mgd)	adf (cfd)	CH2M Hill (eqn a, b, or c) $/year	Linear approximation $/year	Error $/year	
2	5	668,449	105,399	118,100	12,701	12.05%
2	7.5	1,002,674	125,474	128,862	3,388	2.70%
2	10	1,336,898	141,997	139,624	-2,373	-1.67%
2	15	2,005,347	169,043	161,148	-7,895	-4.67%
2	20	2,673,796	191,303	182,672	-8,631	-4.51%
2	25	3,342,245	210,568	204,196	-6,372	-3.03%
2	30	4,010,694	227,741	225,720	-2,020	-0.89%
2	40	5,347,592	257,730	268,768	11,039	4.28%
	intercept	96,576				
	slope	0.0322				

Table A12--*Continued*

			CH2M Hill (eqn a, b, or c)	Linear approximation	Error	
length in miles	adf (mgd)	adf (cfd)	$/year			
5	5	668,449	325,910	365,206	39,295	12.06%
5	7.5	1,002,674	387,987	398,494	10,507	2.71%
5	10	1,336,898	439,077	431,783	-7,294	-1.66%
5	15	2,005,347	522,709	498,361	-24,349	-4.66%
5	20	2,673,796	591,539	564,938	-26,601	-4.50%
5	25	3,342,245	651,111	631,516	-19,595	-3.01%
5	30	4,010,694	704,211	698,093	-6,118	-0.87%
5	40	5,347,592	796,942	831,248	34,306	4.30%
	intercept	298,628				
	slope	0.0996				
			CH2M Hill (eqn a, b, or c)	Linear approximation	Error	
length in miles	adf (mgd)	adf (cfd)	$/year			
6	5	668,449	422,308	473,996	51,688	12.24%
6	7.5	1,002,674	504,788	518,681	13,893	2.75%
6	10	1,336,898	572,905	563,367	-9,538	-1.66%
6	15	2,005,347	684,798	652,739	-32,059	-4.68%
6	20	2,673,796	777,205	742,111	-35,095	-4.52%
6	25	3,342,245	857,385	831,482	-25,903	-3.02%
6	30	4,010,694	929,000	920,854	-8,146	-0.88%
6	40	5,347,592	1,054,360	1,099,597	45,237	4.29%
	intercept	384,624				
	slope	0.1337				
			CH2M Hill (eqn a, b, or c)	Linear approximation	Error	
length in miles	adf (mgd)	adf (cfd)	$/year			
7	5	668,449	496,046	556,728	60,683	12.23%
7	7.5	1,002,674	592,928	609,202	16,274	2.74%
7	10	1,336,898	672,938	661,675	-11,263	-1.67%
7	15	2,005,347	804,368	766,621	-37,747	-4.69%
7	20	2,673,796	912,910	871,568	-41,342	-4.53%
7	25	3,342,245	1,007,090	976,514	-30,576	-3.04%
7	30	4,010,694	1,091,210	1,081,461	-9,749	-0.89%
7	40	5,347,592	1,238,458	1,291,354	52,896	4.27%
	intercept	451,782				
	slope	0.1570				
			CH2M Hill (eqn a, b, or c)	Linear approximation	Error	
length in miles	adf (mgd)	adf (cfd)	$/year			
8	5	668,449	570,250	640,020	69,770	12.23%
8	7.5	1,002,674	681,625	700,348	18,723	2.75%
8	10	1,336,898	773,604	760,675	-12,929	-1.67%
8	15	2,005,347	924,695	881,330	-43,365	-4.69%
8	20	2,673,796	1,049,474	1,001,985	-47,489	-4.53%
8	25	3,342,245	1,157,743	1,122,640	-35,103	-3.03%
8	30	4,010,694	1,254,446	1,243,295	-11,150	-0.89%
8	40	5,347,592	1,423,721	1,484,605	60,884	4.28%
	intercept	519,365				
	slope	0.1805				

Table A12--*Continued*

				CH2M Hill (eqn a, b, or c)	Linear approximation	Error				
	length in miles	adf (mgd)	adf (cfd)		$/year					
	9	5	668,449	644,865	723,819	78,955	12.24%			
	9	7.5	1,002,674	770,812	792,068	21,256	2.76%			
	9	10	1,336,898	874,826	860,317	-14,510	-1.66%			
	9	15	2,005,347	1,045,687	996,814	-48,874	-4.67%			
	9	20	2,673,796	1,186,793	1,133,311	-53,482	-4.51%			
	9	25	3,342,245	1,309,228	1,269,808	-39,420	-3.01%			
	9	30	4,010,694	1,418,584	1,406,306	-12,278	-0.87%			
	9	40	5,347,592	1,610,008	1,679,300	69,292	4.30%			
		intercept	587,322							
		slope	0.2042							
				CH2M Hill (eqn a, b, or c)	Linear approximation	Error				
	length in miles	adf (mgd)	adf (cfd)		$/year					
	10	5	668,449	719,846	807,952	88,106	12.24%			
	10	7.5	1,002,674	860,438	884,121	23,683	2.75%			
	10	10	1,336,898	976,546	960,291	-16,255	-1.66%			
	10	15	2,005,347	1,167,274	1,112,631	-54,643	-4.68%			
	10	20	2,673,796	1,324,786	1,264,970	-59,816	-4.52%			
	10	25	3,342,245	1,461,457	1,417,310	-44,148	-3.02%			
	10	30	4,010,694	1,583,528	1,569,649	-13,879	-0.88%			
	10	40	5,347,592	1,797,210	1,874,328	77,118	4.29%			
		intercept	655,612							
		slope	0.2279							
				CH2M Hill (eqn a, b, or c)	Linear approximation	Error				
	length in miles	adf (mgd)	adf (cfd)		$/year					
	12.5	5	668,449	908,685	1,019,914	111,229	12.24%			
	12.5	7.5	1,002,674	1,086,159	1,116,070	29,911	2.75%			
	12.5	10	1,336,898	1,232,726	1,212,227	-20,500	-1.66%			
	12.5	15	2,005,347	1,473,489	1,404,539	-68,949	-4.68%			
	12.5	20	2,673,796	1,672,322	1,596,852	-75,469	-4.51%			
	12.5	25	3,342,245	1,844,846	1,789,165	-55,682	-3.02%			
	12.5	30	4,010,694	1,998,941	1,981,478	-17,463	-0.87%			
	12.5	40	5,347,592	2,268,679	2,366,103	97,424	4.29%			
		intercept	827,601							
		slope	0.2877							
				CH2M Hill (eqn a, b, or c)	Linear approximation	Error				
	length in miles	adf (mgd)	adf (cfd)		$/year					
	15	5	668,449	1,099,205	1,233,740	134,536	12.24%			
	15	7.5	1,002,674	1,313,889	1,350,050	36,161	2.75%			
	15	10	1,336,898	1,491,186	1,466,361	-24,825	-1.66%			
	15	15	2,005,347	1,782,428	1,698,981	-83,447	-4.68%			
	15	20	2,673,796	2,022,949	1,931,601	-91,348	-4.52%			
	15	25	3,342,245	2,231,647	2,164,221	-67,425	-3.02%			
	15	30	4,010,694	2,418,049	2,396,842	-21,208	-0.88%			
	15	40	5,347,592	2,744,342	2,862,082	117,741	4.29%			
		intercept	1,001,120							
		slope	0.3480							

Table A13. East-central MIP decision model public supply well withdrawal rates

Model Row	Model Column	Well ID Number	Public Supply Demand Area	Well or Treatment Plant	Model Layer (1=Upper 2=Lower Floridan	Well withdrawal rates (MGD)					Estimated Well Capacity (MGD)
						Year 1988	Projected Year 2010	Case 3	Case 2	Case 1	
46	58	1	ALT	ALTAMONTE SPR.(NEW CHARLOTTE ST W	1	0.00	4.15	0.00	0.00	0.00	4.49
48	54	2	ALT	ALTAMONTE SPR. (PLANT #3)	1	0.65	0.00	2.56	2.46	2.72	3.00
49	57	3	ALT	ALTAMONTE SPR. (PLANT #1)	1	0.01	0.00	0.00	1.13	0.00	1.50
49	48	4	ALT	ALTAMONTE SPR. (PLANT #4)	1	0.32	3.02	1.95	1.05	0.81	3.74
50	57	5	ALT	ALTAMONTE SPR. (PLANT #1)	1	0.08	0.00	1.21	0.17	0.00	1.50
52	45	6	ALT	ALTAMONTE SPR. (PLANT #5)	1	3.80	0.00	0.90	1.92	3.20	4.49
53	55	7	ALT	ALTAMONTE SPR. (PLANT #2)	1	1.08	1.07	0.35	0.00	0.00	3.46
52	45	8	ALT	ALTAMONTE SPRINGS (PLANT #5)	2	0.02	0.00	0.63	3.46	3.46	4.49
54	55	9	ALT	ALTAMONTE SPRINGS (PLANT #2)	2	1.98	1.95	0.00	0.00	0.00	3.46
43	31	10	APO	APOPKA - GROSSENBACHER WF.	1	1.04	3.38	0.25	0.91	1.84	5.98
37	27	11	APO	APOPKA - PROPOSED NORTHWEST WF	2	0.00	4.44	0.00	0.00	0.00	5.98
43	31	12	APO	APOPKA - GROSSENBACHER WF.	2	1.04	3.38	5.75	5.75	5.75	5.98
45	27	13	APO	APOPKA - PROPOSED SOUTHWEST WF	2	0.00	6.77	0.00	0.00	0.00	7.11
53	36	14	APO	APOPKA - SHEELOR OAKS WF.	2	2.07	3.17	0.00	0.00	0.38	3.61
45	63	15	CAS	CASSELBERRY (NORTH WTP; WELL N-1)	1	2.03	0.48	3.18	3.45	1.61	3.50
53	63	16	CAS	CASSELBERRY (HOWELL PARK; CANON W	1	0.31	0.41	2.11	0.00	2.11	0.90
53	62	17	CAS	CASSELBERRY (HOWELL PARK; HP-1 WE	1	0.39	0.61	0.00	0.00	2.11	1.20
59	65	18	CAS	CASSELBERRY (SOUTH PLANT; WELL S-	1	0.89	0.51	0.00	0.00	2.88	1.05
46	63	19	CAS	CASSELBERRY (NORTH WTP; WELL N240	2	0.15	1.01	0.00	2.88	3.45	1.50
53	64	20	CAS	CASSELBERRY (HOWELL PARK WTP; WEL	2	0.07	1.40	0.00	0.00	0.00	1.50
59	65	21	CAS	CASSELBERRY (SOUTH PLANT; WELL S-	2	0.90	0.51	0.00	0.00	0.00	0.75
59	66	22	CAS	CASSELBERRY (SOUTH WTP; WELL S360	2	0.08	1.40	1.04	0.00	2.88	1.50
104	35	23	CFU	CENTRAL FLA UTIL (CAMELOT, CD 1&2	1	0.99	2.35	1.24	1.24	1.24	4.49
105	60	24	CFU	CENTRAL FLA UTIL (C. FL. PKWY. CD	1	0.10	0.23	0.45	0.45	0.45	0.45
107	57	25	CFU	CENTRAL FLA UTIL (C. FL. PKWY. CD	1	0.19	0.45	1.35	1.35	1.35	1.35
54	97	26	CHU	SOUTHERN ST. UTIL (CHULUOTA)	1	0.00	0.09	0.25	0.25	0.25	0.43
55	96	27	CHU	SOUTHERN ST. UTIL (CHULUOTA)	1	0.39	0.16	0.00	0.00	0.00	0.73
68	8	28	CLE	CLERMONT (GRAND)	1	0.91	1.57	0.11	0.11	0.11	3.37
71	7	29	CLE	CLERMONT (4TH STREET)	1	0.52	0.90	2.36	2.36	2.36	1.80
87	100	30	COC	COCOA (WELL #10)	1	0.19	0.15	0.00	0.00	0.00	1.65
89	100	31	COC	COCOA (WELL #9)	1	0.15	0.24	0.00	0.00	0.00	1.65
90	100	32	COC	COCOA (WELL #8)	1	0.24	0.48	0.00	0.00	0.00	1.65
92	95	33	COC	COCOA (WELL #13 & 13R)	1	1.53	0.60	0.00	0.00	0.00	1.65
92	94	34	COC	COCOA (WELL #14)	1	2.42	1.66	0.00	0.00	0.00	3.02
92	100	35	COC	COCOA (WELL #3)	1	0.13	0.00	0.00	0.00	0.00	0.82
93	93	36	COC	COCOA (WELL #16)	1	5.83	3.53	0.00	0.00	0.00	4.49
93	92	37	COC	COCOA (WELL #17)	1	2.70	1.74	0.00	0.00	0.00	3.02
93	100	38	COC	COCOA (WELL #7) <PHASE I CORRECTI	1	0.40	0.24	0.00	0.00	0.00	1.65
93	99	39	COC	COCOA (WELL #7A)	1	0.22	0.26	0.00	0.00	0.00	1.65
94	100	40	COC	COCOA (WELL # 1)	1	0.00	0.15	0.00	0.00	0.00	1.65
94	92	41	COC	COCOA (WELL #18)	1	2.34	1.86	0.00	0.00	0.00	3.02
95	100	42	COC	COCOA (WELL #6) <PHASE I CORRECTI	1	0.00	0.00	0.00	0.00	0.00	0.82
96	92	43	COC	COCOA (WELL #19)	1	1.30	1.86	0.00	0.00	0.24	3.02
96	100	44	COC	COCOA (WELL #5)	1	0.42	0.24	0.00	0.00	0.00	1.65
97	102	45	COC	COCOA (WELL #12A)	1	0.26	0.24	0.00	0.70	0.57	1.65
97	100	46	COC	COCOA (WELL #4)	1	0.28	0.24	0.00	0.00	0.82	1.65
97	92	47	COC	COCOA PROP. WELL 20	1	0.00	1.86	2.18	0.00	3.02	3.02
98	100	48	COC	COCOA (WELL #11)	1	0.74	0.24	0.82	0.82	0.82	1.65
98	102	49	COC	COCOA (WELL #12B)	1	0.54	0.24	0.82	0.82	0.82	1.65

Table A13--*Continued*

Model Row	Model Column	Well ID Number	Public Supply Demand Area	Well or Treatment Plant	Model Layer (1=Upper 2=Lower Floridan	Year 1988	Projected Year 2010	Case 3	Case 2	Case 1	Estimated Well Capacity (MGD)
98	101	50	COC	COCOA (WELL #4A1)	1	0.42	0.24	0.82	0.82	0.82	1.65
98	92	51	COC	COCOA PROP. WELL 22	1	0.00	3.73	4.49	2.73	4.49	7.48
99	92	52	COC	COCOA PROP. WELL 32	1	0.00	3.73	3.00	4.49	2.14	7.48
99	101	53	COC	COCOA PROP. WELL 39	1	0.00	0.48	0.82	0.82	0.82	7.48
100	92	54	COC	COCOA PROP. WELL 33	1	0.00	1.86	4.14	4.35	3.56	7.48
100	101	55	COC	COCOA PROP. WELL 41	1	0.00	0.48	0.82	0.82	0.82	7.48
101	101	56	COC	COCOA PROP. WELL 43	1	0.00	0.48	0.82	0.82	0.82	7.48
102	101	57	COC	COCOA PROP. WELL 44	1	0.00	0.24	0.82	0.82	0.82	7.48
86	60	58	CON	SO. STATES UTIL (LAKE CONWAY PARK	1	0.01	0.01	0.00	0.00	0.00	0.11
87	60	59	CON	SO. STATES UTIL (LAKE CONWAY PARK	1	0.01	0.01	0.00	0.00	0.00	0.11
88	59	60	CON	SO. STATES UTIL (DAETWYLER SHORES	1	0.03	0.04	0.00	0.10	0.00	0.11
88	60	61	CON	SO. STATES UTIL (DAETWYLER SHORES	1	0.03	0.04	0.10	0.00	0.10	0.11
3	86	62	DEL	DELTONA-PROPOSED	1	0.00	1.61	2.06	2.06	2.06	2.06
4	88	63	DEL	DELTONA	1	1.45	2.41	0.17	0.25	0.48	3.74
4	80	64	DEL	DELTONA-PROPOSED	1	0.00	0.80	1.03	1.03	1.03	1.87
4	82	65	DEL	DELTONA-PROPOSED	1	0.00	0.80	1.03	1.03	1.03	1.87
4	84	66	DEL	DELTONA-PROPOSED	1	0.00	0.80	0.00	0.00	0.00	1.87
5	74	67	DEL	DELTONA	1	0.48	0.80	1.03	1.03	1.03	1.87
6	76	68	DEL	DELTONA	1	0.48	0.80	1.03	1.03	1.03	1.87
6	88	69	DEL	DELTONA	1	0.48	0.00	0.49	1.03	1.03	1.87
6	86	70	DEL	DELTONA-PROPOSED	1	0.00	0.80	0.00	0.00	0.00	1.87
7	71	71	DEL	DELTONA	1	0.48	1.61	2.06	2.06	2.06	2.06
7	78	72	DEL	DELTONA	1	1.94	3.21	0.48	0.47	1.00	3.74
7	74	73	DEL	DELTONA-PROPOSED	1	1.45	3.21	0.00	0.00	0.00	3.74
8	80	74	DEL	DELTONA	1	0.48	0.80	0.00	0.41	0.60	1.87
8	76	75	DEL	DELTONA-PROPOSED	1	0.00	0.80	0.00	0.00	0.00	1.87
8	83	76	DEL	DELTONA-PROPOSED	1	0.00	2.41	0.00	0.00	0.00	3.74
9	77	77	DEL	DELTONA-PROPOSED	1	0.00	0.80	0.00	0.00	0.00	1.87
9	80	78	DEL	DELTONA-PROPOSED	1	0.00	0.80	0.00	0.00	0.00	1.87
9	85	79	DEL	DELTONA-PROPOSED	1	0.00	0.80	0.00	0.00	0.00	1.87
9	88	80	DEL	DELTONA-PROPOSED	1	0.00	1.61	0.00	0.02	0.15	1.87
77	103	81	ECU	ECON UTIL (WEDGEFIELD)	1	0.10	0.12	0.15	0.15	0.15	0.16
77	104	82	ECU	ECON UTIL (WEDGEFIELD)	1	0.03	0.04	0.00	0.00	0.00	0.16
12	12	83	EUS	EUSTIS (C R 44A ?)	1	0.17	1.36	2.05	2.05	2.05	2.69
12	13	84	EUS	EUSTIS (C R 44A ?)	1	0.17	1.36	2.05	0.14	0.14	2.69
13	22	85	EUS	EUSTIS (HAZELTON AVE.)	1	1.33	0.54	0.00	0.00	0.00	1.12
15	11	86	EUS	EUSTIS (ARDICE PLACE)	1	1.23	2.53	1.69	3.60	3.60	4.86
86	93	87	FDC	FL DEPT OF CORR	1	0.05	0.05	0.00	0.00	0.00	0.22
87	92	88	FDC	FL DEPT OF CORR	1	0.11	0.11	0.00	0.16	0.16	0.22
87	93	89	FDC	FL DEPT OF CORR	1	0.05	0.05	0.16	0.00	0.00	0.22
104	47	90	KIS	CITY OF KISSIMMEE (NORTH BERMUDA)	1	2.05	4.89	0.13	0.13	0.13	8.98
106	49	91	KIS	CITY OF KISSIMMEE (RUBY ST.)	1	1.77	4.22	8.98	8.98	8.98	8.98
1	78	92	LHE	LAKE HELEN - PLANT #2	1	0.09	0.29	0.58	0.58	0.58	0.75
2	78	93	LHE	LAKE HELEN - PLANT #1	1	0.13	0.29	0.00	0.00	0.00	0.75
34	101	94	LHY	LAKE HARNEY WATER ASSOC	1	0.01	0.03	0.03	0.03	0.03	0.29
35	101	95	LHY	LAKE HARNEY WATER ASSOC	1	0.02	0.00	0.00	0.00	0.00	0.29
24	59	96	LMY	LAKE MARY (NEW PUBLIC SUPPLY)	1	0.00	0.80	0.00	0.00	0.00	2.30
25	59	97	LMY	LAKE MARY (NEW PUBLIC SUPPLY)	1	0.00	0.80	0.00	0.00	0.00	2.30
26	59	98	LMY	LAKE MARY (NEW PUBLIC SUPPLY)	1	0.00	1.61	0.00	0.00	0.00	2.30
27	59	99	LMY	LAKE MARY (NEW PUBLIC SUPPLY)	1	0.00	0.80	0.00	0.00	0.00	2.30

Table A13--*Continued*

Model Row	Model Column	Well ID Number	Public Supply Demand Area	Well or Treatment Plant	Model Layer (1=Upper 2=Lower Floridan	Year 1988	Projected Year 2010	Case 3	Case 2	Case 1	Estimated Well Capacity (MGD)
28	59	100	LMY	LAKE MARY (NEW PUBLIC SUPPLY)	1	0.25	0.80	0.00	0.00	0.00	2.30
29	59	101	LMY	LAKE MARY (NEW PUBLIC SUPPLY)	1	0.25	0.80	0.00	0.00	0.00	2.30
39	57	102	LON	LONGWOOD	1	1.25	2.28	0.00	0.00	1.17	3.37
40	60	103	LON	LONGWOOD	1	0.78	0.87	3.15	3.15	1.98	3.37
55	60	104	MAI	MAITLAND - THISTLE LANE	1	0.57	0.69	1.88	1.88	0.92	2.54
57	56	105	MAI	MAITLAND - MINNEHAHA CIRCLE	1	0.09	0.11	1.08	1.08	1.08	1.08
58	53	106	MAI	MAITLAND - WELL NO. 5A	1	0.19	0.24	0.57	0.57	1.53	2.24
57	50	107	MAI	MAITLAND - KELLER	2	1.46	1.79	0.00	0.00	0.00	6.43
58	53	108	MAI	MAITLAND - WELL NO. 5A	2	0.58	0.71	0.00	0.00	0.00	2.24
65	87	109	OE1	OCPUD EAST REG: (BONNEVILLE)	1	0.74	0.00	0.00	0.00	0.00	7.48
68	65	110	OE1	OCPUD EAST REG: (CORRINE TERRACE)	1	0.20	0.00	0.00	0.00	0.00	0.22
72	75	111	OE3	OCPUD EAST REG: (ECON)	1	1.79	4.00	0.41	0.00	0.00	4.19
73	75	112	OE3	OCPUD EAST REG: (ECON)	1	1.79	4.00	0.00	0.00	0.00	4.19
79	74	113	OE5	OCPUD EAST REG: ERWF	1	0.00	20.25	0.00	0.00	0.20	20.94
82	66	114	OE2	OCPUD EAST REG: (CONWAY)	1	0.74	2.09	0.00	0.00	0.00	4.49
82	67	115	OE2	OCPUD EAST REG: (CONWAY)	1	0.74	2.09	0.43	0.00	0.00	4.49
94	73	116	OE4	OCPUD EAST REG: (LAKE NONA)	1	0.03	2.00	2.00	2.00	2.00	2.99
82	67	117	OE2	OCPUD EAST REG: (CONWAY)	2	1.01	3.47	3.57	2.93	2.93	4.49
63	33	118	OCO	OCOEE (HACKNEY PRAIRIE)	1	0.57	0.68	0.47	0.47	1.83	3.74
63	31	119	OCO	OCOEE (JAMELA & WURST ROAD)	1	0.00	0.00	0.00	0.00	0.00	1.50
65	29	120	OCO	OCOEE (JAMELA & WURST ROAD)	1	0.89	0.93	0.00	0.00	0.00	1.50
68	27	121	OCO	OCOEE (KISSIMEE AVE)	1	0.67	0.93	0.00	0.00	0.00	4.32
73	28	122	OCO	OCOEE (SOUTH PLANT)	2	0.00	2.94	0.00	0.00	0.00	2.99
94	41	123	OS4	OCPUD SOUTH REG: (ORANGE WOOD)	1	0.89	2.40	0.00	0.00	0.00	3.61
95	41	124	OS4	OCPUD SOUTH REG: (ORANGE WOOD)	1	0.89	2.40	0.00	0.00	0.00	3.61
100	30	125	OS1	OCPUD SOUTH REG: (CYPRESS WALK)	1	0.28	1.25	1.73	1.08	1.36	1.36
100	31	126	OS1	OCPUD SOUTH REG: (CYPRESS WALK)	1	0.28	1.25	1.73	0.00	0.00	1.35
100	56	127	OS3	OCPUD SOUTH REG: (MEADOW WOODS)	1	0.08	0.20	3.30	3.00	2.58	5.39
101	46	128	OS2	OCPUD SOUTH REG: (HUNTERS CREEK)	1	0.12	0.50	0.50	0.50	0.50	8.98
101	32	129	OS1	OCPUD SOUTH REG: (VISTANA)	1	1.05	4.00	7.72	10.42	10.14	10.41
94	41	130	OS4	OCPUD SOUTH REG: (ORANGE WOOD)	2	0.59	1.68	1.79	1.48	1.48	3.61
101	54	131	OS3	OCPUD SOUTH REG: SOUTH REG. WELL	2	0.00	10.00	6.90	7.20	7.62	10.47
28	31	132	OW1	OCPUD WEST REG: (MT. PLYMOUTH LAK	1	0.19	0.90	0.00	0.59	1.44	1.44
38	25	133	OW1	OCPUD WEST REG: (PLYMOUTH)	1	0.00	1.50	0.00	0.00	0.00	1.80
39	24	134	OW1	OCPUD WEST REG: (PLYMOUTH HILLS)	1	0.03	0.00	0.16	0.12	0.16	0.16
43	38	135	OW1	OCPUD WEST REG: (BENT OAKS)	1	1.32	0.00	2.03	1.48	0.68	5.24
43	26	136	OW1	OCPUD WEST REG: (PLYMOUTH CENTRAL	1	0.08	0.00	0.16	0.16	0.16	0.16
54	32	137	OW1	OCPUD WEST REG: (ORANGE VILLAGE)	1	0.02	0.03	0.09	0.09	0.00	0.09
55	46	138	OW4	OCPUD - RIVERSIDE	1	0.48	0.00	0.00	0.00	0.00	1.50
55	47	139	OW4	OCPUD - RIVERSIDE	1	0.48	0.00	0.00	0.00	0.00	1.50
56	46	140	OW4	OCPUD - RIVERSIDE	1	0.48	0.00	0.00	0.00	0.00	1.50
65	21	141	OW6	OCPUD WEST REG: (MAGNOLIA WOODS)	1	0.04	0.03	0.07	0.07	0.07	1.50
70	15	142	OW6	OCPUD WEST REG: LAKE JOHN SHORES	1	0.00	0.03	0.00	0.00	0.00	0.34
72	36	143	OW3	OCPUD WEST REGIONAL (OAK MEADOWS)	1	0.39	0.00	0.00	0.00	0.00	4.49
76	30	144	OW2	OCPUD WEST REG: (WINDERMERE DOWNS	1	0.22	0.00	0.00	0.00	0.00	0.30
79	27	145	OW2	OCPUD WEST REG: (WAUSEON RIDGE)	1	0.03	0.00	0.00	0.00	0.00	0.04
81	36	146	OW2	OCPUD WEST REG: (HIDDEN SPRINGS)	1	0.18	0.00	0.00	0.00	0.00	5.24
81	23	147	OW2	OCPUD WEST REG: (KELSO)	1	0.02	0.00	0.00	0.00	0.00	0.58
81	29	148	OW2	OCPUD WEST REG: (WINDERMERE)	1	0.01	0.00	0.00	0.00	0.00	0.01
82	36	149	OW2	OCPUD WEST REG: (HIDDEN SPRINGS)	1	0.06	0.00	0.00	0.00	0.00	5.24

Table A13--*Continued*

Model Row	Model Column	Well ID Number	Public Supply Demand Area	Well or Treatment Plant	Model Layer (1=Upper 2=Lower Floridan	Year 1988	Projected Year 2010	Case 3	Case 2	Case 1	Estimated Well Capacity (MGD)
55	46	150	OW4	OCPUD - RIVERSIDE	2	0.48	0.00	0.00	0.00	0.00	1.50
55	47	151	OW4	OCPUD - RIVERSIDE	2	0.48	0.00	0.00	0.00	0.00	1.50
55	35	152	OW5	OCPUD WEST REG: WRWF WELL # 1	2	0.00	6.00	0.00	13.73	13.73	13.73
55	36	153	OW5	OCPUD WEST REG: WRWF WELL # 1	2	0.00	14.00	0.00	11.46	14.00	14.96
56	46	154	OW4	OCPUD - RIVERSIDE	2	0.48	0.00	0.00	0.00	0.00	1.50
72	36	155	OW3	OCPUD WEST REGIONAL (OAK MEADOWS)	2	1.55	0.00	0.00	0.00	0.00	4.49
82	36	156	OW2	OCPUD WEST REG: (HIDDEN SPRINGS)	2	1.42	0.00	0.00	0.00	0.00	5.24
4	73	157	OCY	Or. City Ctry V	1	0.14	0.39	0.00	0.00	0.00	0.75
4	67	158	OCY	ORANGE CITY	1	0.17	0.91	1.87	1.87	1.87	1.87
4	68	159	OCY	ORANGE CITY	1	0.34	2.74	2.17	2.17	2.17	5.39
104	59	160	ORO	ORANGE/OSCEOLA (BEUNAVENTURA LAKE	1	1.14	2.72	1.77	1.77	1.77	5.39
104	58	161	ORO	ORANGE/OSCEOLA MGMENT	1	0.39	0.93	1.87	1.87	1.87	1.87
83	90	162	OU13	OUC-STANTON ENERGY CTR.	1	0.40	0.40	0.40	0.40	0.40	0.45
87	35	163	OU1	OUC (DR. PHILLIPS)	1	5.33	6.20	6.20	6.20	6.20	13.46
88	41	164	OU2	OUC (MARTIN)	1	9.17	20.19	0.00	0.00	0.00	20.94
98	55	183	OU11	OUC (ORANGE)	2	2.31	2.42	0.00	0.00	0.00	8.98
80	67	179	OU12	OUC (PERSHING)	2	1.39	6.40	6.40	6.40	3.60	6.73
77	62	176	OU3	OUC - CONWAY	2	5.60	7.84	0.00	0.00	0.00	8.23
78	62	178	OU3	OUC - CONWAY	2	2.80	7.84	0.00	0.00	0.00	8.23
68	55	165	OU4	OUC - HIGHLAND	2	3.46	3.63	0.00	0.00	0.00	8.98
69	55	169	OU4	OUC - HIGHLAND	2	1.15	0.72	0.00	0.00	0.00	8.98
69	56	170	OU4	OUC - HIGHLAND	2	2.80	3.92	0.00	0.00	0.00	8.23
70	55	172	OU4	OUC - HIGHLAND	2	1.15	1.21	0.00	0.00	0.00	8.98
80	39	180	OU7	OUC - KIRKMAN	2	2.68	2.36	0.27	0.00	0.00	8.23
80	40	181	OU7	OUC - KIRKMAN	2	5.35	4.73	4.73	4.73	4.73	8.23
76	54	175	OU6	OUC - KUHL	2	2.80	3.77	3.79	3.79	3.79	8.23
77	55	177	OU6	OUC - KUHL	2	6.66	6.13	4.73	4.40	4.73	8.23
68	64	166	OU10	OUC - NAVY	2	5.60	7.54	1.24	1.21	1.21	8.23
68	40	167	OU5	OUC - PINE HILLS	2	3.33	3.07	3.73	0.00	1.47	8.23
68	41	168	OU5	OUC - PINE HILLS	2	0.00	7.00	0.00	0.00	0.00	7.48
69	41	171	OU5	OUC - PINE HILLS	2	2.09	3.67	0.00	0.00	0.00	8.23
72	60	173	OU8	OUC - PRIMROSE	2	4.17	7.33	0.00	0.00	0.00	8.23
73	59	174	OU8	OUC - PRIMROSE SFWMD?	2	0.00	15.30	15.30	15.30	15.30	15.71
88	53	182	OU9	OUC - SKY LAKE	2	0.00	7.20	2.20	2.20	2.20	7.48
51	82	184	OVI	OVIEDO (PLNT #1)	1	0.78	3.02	2.60	2.11	2.62	5.98
52	83	185	OVI	OVIEDO (ALAFAYA WOODS - PLNT #2)	1	0.37	3.68	1.12	0.71	1.15	5.98
53	82	186	OVI	OVIEDO-PROP. WELL LAKE GEM	1	0.00	1.47	0.00	0.00	0.00	2.99
54	86	187	OVI	OVIEDO (ALAFAYA WOODS - PLNT #2)	1	0.00	1.47	1.97	1.65	1.97	2.99
69	79	188	PAM	PARK MANOR WATER WORKS	1	0.22	0.20	0.41	0.41	0.41	0.75
70	77	189	PAM	PARK MANOR WATER WORKS	1	0.22	0.20	0.00	0.00	0.00	0.75
114	34	190	POI	POINCIANA UTIL (IP-1&2)	1	0.41	0.98	0.00	0.00	0.00	1.12
117	39	191	POI	POINCIANA (CORES-1,2&3 89-90)	1	0.06	0.15	0.69	0.69	0.69	0.75
118	38	192	POI	POINCIANA (CORES-1,2&3 89-90)	1	0.13	0.31	0.75	0.75	0.75	0.75
22	67	193	RAV	UTILITIES OF FLA (RAVENNA PARK)	1	0.12	0.12	0.24	0.24	0.24	0.37
23	65	194	RAV	UTILITIES OF FLA (CRYSTAL LAKE)	1	0.03	0.07	0.00	0.00	0.00	0.37
25	65	195	RAV	UTILITIES OF FLA (PHILLIPS)	1	0.03	0.02	0.00	0.00	0.00	0.37
30	68	196	RAV	UTILITIES OF FLA (PARK RIDGE)	1	0.00	0.02	0.00	0.00	0.00	0.45
91	20	197	RCU	REEDY CREEK UTIL (PUMP STN A; 89-	1	3.65	8.89	0.00	11.38	11.81	11.81
92	22	198	RCU	REEDY CREEK UTIL (PUMP STN A; 89-	1	1.82	4.45	8.71	0.00	4.57	8.71
98	30	199	RCU	REEDY CREEK UTIL (PUMP STATION C)	1	1.29	3.19	7.87	0.00	0.00	3.37

Table A13--*Continued*

Model Row	Model Column	Well ID Number	Public Supply Demand Area	Well or Treatment Plant	Model Layer (1=Upper 2=Lower Floridan	Year 1988	Projected Year 2010	Case 3	Case 2	Case 1	Estimated Well Capacity (MGD)
100	31	200	RCU	REEDY CREEK UTIL (PUMP STATION C)	1	0.64	1.59	3.99	0.00	0.00	3.37
100	32	201	RCU	REEDY CREEK UTIL (PUMP STATION C)	1	0.64	1.59	0.00	0.00	0.00	3.37
101	22	202	RCU	REEDY CREEK UTIL (PMP STN B)	1	3.96	3.09	11.81	11.81	11.81	11.81
102	24	203	RCU	REEDY CREEK UTIL (PMP STN B)	1	7.93	6.19	11.81	11.81	11.81	11.81
21	61	204	SAF	SANFORD (WELLFIELD # 4) (PROP)	1	0.00	0.55	0.00	0.00	0.00	3.37
21	62	205	SAF	SANFORD (WELLFIELD #3)	1	1.29	2.07	0.57	0.00	0.58	3.74
21	63	206	SAF	SANFORD (WELLFIELD #3)	1	0.86	1.18	2.16	2.16	2.16	2.16
22	61	207	SAF	SANFORD (WELLFIELD # 4)	1	0.00	1.11	0.00	0.00	0.00	3.37
23	63	208	SAF	SANFORD (WELLFIELD #2)	1	0.35	0.00	1.78	2.07	1.95	2.92
24	63	209	SAF	SANFORD (WELLFIELD #2)	1	0.71	1.66	0.00	0.00	0.00	2.92
27	69	210	SAF	SANFORD (WELLFIELD #1)	1	0.00	0.00	0.00	0.00	0.00	1.50
28	68	211	SAF	SANFORD (WELLFIELD #1)	1	0.61	0.32	1.59	0.00	0.00	1.50
28	69	212	SAF	SANFORD (WELLFIELD #1)	1	0.61	0.30	0.00	1.67	1.42	1.50
29	68	213	SAF	SANFORD (WELLFIELD #1)	1	0.30	0.21	0.00	0.00	0.00	1.50
29	69	214	SAF	SANFORD (WELLFIELD #1)	1	0.30	0.11	0.36	0.00	0.49	1.50
37	54	215	SAN	SANLANDO UTIL CORP (DES PINAR)	1	0.00	0.53	0.00	0.00	0.00	2.62
38	55	216	SAN	SANLANDO UTIL CORP (DES PINAR)	1	0.57	1.06	0.85	1.13	2.25	2.62
39	55	217	SAN	SANLANDO UTIL CORP (DES PINAR)	1	1.70	1.93	1.93	1.80	0.59	2.62
41	44	218	SAN	SANLANDO (WEKIVA HUNT CLUB)	1	1.13	0.99	0.66	0.68	0.94	1.80
41	54	219	SAN	SANLANDO UTIL CORP (OVERSTREET)	1	0.57	0.00	0.30	0.30	0.30	0.75
41	55	220	SAN	SANLANDO UTIL CORP (OVERSTREET)	1	0.57	0.09	0.30	0.30	0.30	0.75
43	43	221	SAN	SANLANDO (WEKIVA HUNT CLUB)	1	1.13	2.29	0.00	0.00	0.60	2.39
43	44	222	SAN	SANLANDO (WEKIVA HUNT CLUB)	1	1.13	0.65	2.70	2.70	2.70	2.70
44	43	223	SAN	SANLANDO (WEKIVA HUNT CLUB)	1	1.13	1.32	1.84	1.14	0.37	1.80
45	43	224	SAN	SANLANDO (WEKIVA HUNT CLUB)	1	1.13	1.90	2.70	2.70	2.70	2.70
109	68	225	SCL	CITY OF ST. CLOUD	1	1.20	2.86	2.42	2.42	2.42	4.49
109	71	226	SCL	CITY OF ST. CLOUD	1	0.60	1.43	1.87	1.87	1.87	1.87
17	62	227	SEM	SEM CTY LAKE MONROE (I-4 IND. PAR	1	0.13	0.29	0.06	0.11	0.07	2.47
27	54	228	SEM	SEM. COUNTY (HANOVER WOODS)	1	0.15	0.60	0.24	0.31	0.39	2.24
28	57	229	SEM	SEM. COUNTY (HEATHROW)	1	0.31	1.87	0.54	0.61	0.62	3.59
32	59	230	SEM	SEM. COUNTY (GREENWOOD LAKES)	1	0.31	0.50	1.66	0.95	1.23	1.66
32	60	231	SEM	SEM. COUNTY (GREENWOOD LAKES)	1	0.31	0.67	0.00	0.00	0.00	1.05
33	62	232	SEM	SEM. COUNTY (COUNTRY CLUB)	1	0.01	1.33	0.61	0.62	0.00	2.99
33	59	233	SEM	SEM. COUNTY (GREENWOOD LAKES)	1	0.00	0.90	0.32	1.66	1.66	1.66
33	60	234	SEM	SEM. COUNTY (GREENWOOD LAKES)	1	0.31	0.30	0.00	0.00	0.00	1.05
33	61	235	SEM	SEM. COUNTY (GREENWOOD LAKES)	1	0.31	1.14	0.00	0.25	0.00	1.20
48	41	236	SEM	SEM. COUNTY (BELAIRE)	1	0.10	0.10	0.00	0.09	0.00	1.20
49	42	237	SEM	SEM. COUNTY (LYNWOOD)	1	0.20	0.49	0.00	0.62	1.47	3.44
50	42	238	SEM	SEM. COUNTY (LYNWOOD)	1	0.20	0.49	0.00	0.71	0.03	3.44
53	62	239	SEM	SEM. COUNTY (INDIAN HILLS)	1	1.30	3.09	0.00	0.00	0.00	4.49
55	68	240	SEM	SEM CTY (CONSUMER)	1	0.67	1.80	0.00	0.00	0.00	4.49
55	69	241	SEM	SEM CTY (CONSUMER)	1	2.00	4.04	1.57	4.52	0.31	4.49
56	84	242	SEM	SEM CTY (LAKE HAYES)	1	0.21	0.97	0.00	0.85	0.00	4.49
63	76	243	SSS	SO. STATES UTIL (UNIV. SHORES/SUN	1	0.52	0.85	0.50	1.55	0.00	1.50
66	71	244	SSS	SO. STATES UTIL (UNIV. SHORES)	1	0.07	0.35	0.00	0.00	0.50	0.75
66	72	245	SSS	SO. STATES UTIL (UNIV. SHORES)	1	0.07	0.35	1.05	0.00	1.05	1.05
42	45	246	SSU	SOUTHERN ST. UTIL (LAKE BRANTLEY)	1	0.02	0.02	0.15	0.00	0.15	0.15
43	48	247	SSU	SOUTHERN ST. UTIL (MEREDITH MANOR	1	0.12	0.09	0.37	0.37	0.37	0.37
44	48	248	SSU	SOUTHERN ST. UTIL (MEREDITH MANOR	1	0.12	0.18	0.37	0.37	0.37	0.37
47	57	249	SSU	STATES UTIL (HARMONY HOMES)	1	0.01	0.05	0.00	0.00	0.00	0.45

Table A13–*Continued*

Model Row	Model Column	Well ID Number	Public Supply Demand Area	Well or Treatment Plant	Model Layer (1=Upper 2=Lower Floridan	Year 1988	Projected Year 2010	Case 3	Case 2	Case 1	Estimated Well Capacity (MGD)
47	52	250	SSU	SOUTHERN ST. UTIL (APPLE VALLEY)	1	0.44	0.51	0.32	0.32	0.32	1.50
49	46	251	SSU	SOUTHERN ST. UTIL (LAKE HARRIET)	1	0.08	0.09	0.00	0.16	0.00	0.90
50	54	252	SSU	SOUTHERN ST. UTIL (DOL RAY MANOR)	1	0.04	0.04	0.00	0.00	0.00	0.82
53	58	253	SSU	SO. STATES UTIL (FERN PARK)	1	0.01	0.05	0.00	0.00	0.00	0.37
54	54	254	SSU	SOUTHERN ST. UTIL (D. HILLS\BRETT	1	0.14	0.18	0.00	0.00	0.00	0.60
33	96	255	SWA	SEMINOLE WOODS ASSOC, INC	1	0.01	0.02	0.00	0.00	0.00	0.12
33	97	256	SWA	SEMINOLE WOODS ASSOC, INC	1	0.01	0.02	0.08	0.08	0.08	0.12
34	96	257	SWA	SEMINOLE WOODS ASSOC, INC	1	0.01	0.02	0.00	0.00	0.00	0.12
34	97	258	SWA	SEMINOLE WOODS ASSOC, INC	1	0.01	0.02	0.00	0.00	0.00	0.12
95	38	259	SWF	SEA WORLD OF FLA.	1	0.40	0.40	1.30	1.30	1.30	1.35
95	39	260	SWF	SEA WORLD OF FLA.	1	0.90	0.90	0.00	0.00	0.00	1.35
61	83	261	UCF	UCF	1	0.06	0.09	0.09	0.09	0.09	0.37
62	84	262	UCF	UCF	1	0.06	0.09	0.09	0.09	0.09	0.37
63	83	263	UCF	UCF	1	0.12	0.17	0.17	0.17	0.17	0.75
63	84	264	UCF	UCF	1	0.06	0.09	0.09	0.09	0.09	0.37
63	85	265	UCF	UCF	1	0.18	0.26	0.26	0.26	0.26	1.12
64	83	266	UCF	UCF	1	0.06	0.09	0.09	0.09	0.09	0.37
64	85	267	UCF	UCF	1	0.06	0.09	0.09	0.09	0.09	0.37
64	86	268	UCF	UCF	1	0.06	0.09	0.09	0.09	0.09	0.37
65	82	269	UCF	UCF	1	0.06	0.09	0.09	0.09	0.09	0.37
2	78	270	VOL	VOL COUNTY - CASSADAGA	1	0.02	0.04	0.15	0.15	0.15	0.15
4	65	271	VOL	VOL COUNTY - ?	1	0.07	0.10	0.22	0.22	0.22	0.22
4	63	272	VOL	VOL CTY - WEST ORANGE CITY	1	0.00	0.01	0.00	0.00	0.00	0.15
5	67	273	VOL	VOL COUNTY - FOUR TOWNS	1	0.20	0.32	0.75	0.75	0.75	0.75
5	68	274	VOL	VOL COUNTY-ORANGE CITY INDUS PARK	1	0.04	0.04	0.15	0.15	0.15	0.15
6	68	275	VOL	VOL COUNTY - BREEZEWOOD	1	0.14	0.16	0.00	0.00	0.00	0.75
6	67	276	VOL	VOL COUNTY - FOUR TOWNS	1	0.23	0.37	0.00	0.00	0.00	0.75
6	66	277	VOL	VOL COUNTY HIGHLAND CTRY EST	1	0.11	0.46	0.90	0.90	0.90	0.90
7	68	278	VOL	VOL COUNTY - GLEN ABBEY OR SWALLO	1	0.24	0.77	0.00	0.00	0.00	1.87
7	65	279	VOL	VOL COUNTY - LAKE MARIE	1	0.14	0.25	0.35	0.35	0.35	0.75
47	48	280	WEK	UTILITIES OF FLA (LITTLE WEKIVA)	1	0.02	0.03	0.45	0.45	0.45	0.45
51	42	281	WEK	UTILITIES OF FLA (BEAR LAKE)	1	0.06	0.08	0.32	0.00	0.00	0.60
51	49	282	WEK	UTILITIES OF FLA (WEATHERSFIELD)	1	0.41	0.42	0.00	0.00	0.00	1.50
54	41	283	WEK	UTILITIES OF FLA (JANSEN)	1	0.07	0.08	0.00	0.32	0.32	0.60
54	55	284	WEK	UTILITIES OF FLA (OAKLAND SHORES)	1	0.14	0.16	0.00	0.00	0.00	0.60
67	20	285	WGA	WINTER GARDEN (PALMETTO STREET)	1	0.88	0.63	2.00	0.52	1.98	2.54
68	19	286	WGA	WINTER GARDEN (FULLER CROSS)	1	0.28	0.63	0.52	2.00	2.00	2.00
69	19	287	WGA	WINTER GARDEN (BOYD STREET)	1	0.28	0.63	0.00	0.00	1.38	1.73
68	20	288	WGA	WINTER GARDEN PROPOSED PLANT #4	2	0.00	0.63	0.00	0.00	0.00	0.75
70	22	289	WGC	WINTER GARDEN CITRUS PRODUCTS	1	1.87	1.87	1.87	1.87	1.87	1.88
63	58	290	WPK	WINTER PARK - PLANT #1 (SWOOPE)	1	2.47	2.26	0.00	0.00	0.00	4.49
63	67	291	WPK	WINTER PARK PLANT #5 (UNIV.)	1	2.42	2.02	2.85	2.31	1.25	6.73
58	63	292	WPK	WINTER PARK - PLANT #4 (MAGNOLIA)	2	1.97	3.24	7.06	7.06	7.06	5.46
61	53	293	WPK	WINTER PARK - PLANT #3 (Wymore)	2	2.94	3.12	6.09	6.09	6.09	4.49
63	58	294	WPK	WINTER PARK - PLANT #1 (SWOOPE)	2	0.00	1.44	0.00	0.00	0.00	4.49
63	67	295	WPK	WINTER PARK - PLANT #5 (UNIV.)	2	2.54	3.20	0.00	6.18	0.00	6.73
37	64	296	WSP	WINTER SPRINGS (WTP #2)	1	0.59	0.71	0.70	0.00	1.01	1.65
44	66	297	WSP	WINTER SPRINGS (WTP #3)	1	0.31	0.36	0.49	0.00	1.15	1.65
44	67	298	WSP	WINTER SPRINGS (WTP #3)	1	0.31	1.56	0.00	0.00	1.17	3.46
46	73	299	WSP	WINTER SPRNGS EAST 2	1	1.76	3.38	2.76	2.53	2.68	3.74

Table A13--*Continued*

Model Row	Model Column	Well ID Number	Public Supply Demand Area	Well or Treatment Plant	Model Layer (1=Upper 2=Lower Floridan	Year 1988	Projected Year 2010	Case 3	Case 2	Case 1	Estimated Well Capacity (MGD)
30	16	300	ZWF	ZELLWOOD FARMS	1	0.07	0.16	0.32	0.32	0.32	0.37
30	17	301	ZWF	ZELLWOOD FARMS	1	0.07	0.16	0.00	0.00	0.00	0.37
34	17	302	ZWU	ZELLWOOD WATER USERS	1	0.17	0.37	0.37	0.37	0.37	0.75
35	20	303	ZSU	ZELLWOOD STATION UTIL.	1	0.12	0.31	0.00	0.75	0.75	0.75
35	21	304	ZSU	ZELLWOOD STATION UTIL.	1	0.06	0.16	0.75	0.75	0.75	0.75
35	22	305	ZSU	ZELLWOOD STATION UTIL.	1	0.54	0.80	0.39	0.02	0.02	1.50
35	23	306	ZSU	ZELLWOOD STATION UTIL.	1	0.12	0.31	0.75	0.00	0.00	0.75
36	19	307	ZSU	ZELLWOOD STATION UTIL.	1	0.06	0.16	0.00	0.37	0.37	0.37
36	23	308	ZSU	ZELLWOOD STATION UTIL.	1	0.06	0.16	0.00	0.00	0.00	0.37
17	14	309	MTD	CITY OF MT. DORA	1	2.35	4.45	4.45	4.45	4.45	4.49
19	9	310	TAV	CITY OF TAVARES	1	1.16	3.36	3.36	3.36	3.36	3.74
9	71	311	FPL	FPL LAKE MONROE	1	0.09	0.15	0.00	0.00	0.00	0.30
13	63	312	FPL	FLORIDA POWER & LIGHT-SANFORD POW	1	0.32	0.60	0.75	0.75	0.75	1.20
68	1	313	IN1	B & W CANNING	1	0.97	1.11	1.11	1.11	1.11	1.12
76	11	314	IN2	FLORIDA CRUSHED STONE	1	2.18	2.18	2.18	2.18	2.18	2.24
98	8	315	IN3	FLA. ROCK (LAKE SAND PLANT)	1	0.87	0.87	0.87	0.87	0.87	0.90
103	31	316	IN4	FLORIBRA USA, INC	1	1.58	1.58	1.58	1.58	1.58	1.65
36	5	317	IN6	SILVER SPRINGS CITRUS	1	0.71	0.71	0.71	0.71	0.71	0.75
37	6	318	HOH	HOWEY-IN-THE-HILLS	1	0.31	0.45	0.45	0.45	0.45	0.45
59	54	319	EAT	EATONVILLE	1	0.61	1.41	1.41	1.41	1.41	1.50
62	12	320	MON	MONTEVERDE	1	0.12	0.22	0.22	0.22	0.22	0.22
64	6	321	MHN	MINNEOLA HARBOR HILLS/12/13/88- P	1	1.28	2.01	2.01	2.01	2.01	2.02
67	84	322	CFR	CENT. FLA RES. PARK	1	1.00	1.00	1.00	1.00	1.00	1.05
67	8	323	MIN	CITY OF MINNEOLA	1	0.19	0.45	0.45	0.45	0.45	0.45
69	15	324	OAK	CITY OF OAKLAND	1	0.29	0.28	0.28	0.28	0.28	1.44
69	1	325	GRO	TOWN OF GROVELAND	1	0.29	0.79	0.79	0.79	0.79	0.90
79	11	326	IN5	SILVER SAND (CLERMONT MINE)	1	1.24	1.24	1.24	1.24	1.24	1.35
103	28	327	HHO	HYATT HOUSE ORLANDO	1	0.30	0.73	0.73	0.73	0.73	0.75
103	19	328	OSC	OSCEOLA SERVICE	1	0.96	2.28	2.28	2.28	2.28	2.39
108	133	329	AF1	USAF BAS CIVIL ENGINEER/8/12/86	1	0.80	0.80	0.80	0.80	0.80	0.90
115	16	330	DAV	DAVENPORT (1987)	1	0.53	1.27	1.27	1.27	1.27	1.35
118	15	331	HAI	HAINES CITY	1	1.18	2.80	2.80	2.80	2.80	2.99
4	69	332	JKV	JOHN KNOX VILL.	1	0.05	0.35	0.35	0.35	0.35	0.37

Table A14. Volusia MIP decision model public supply utility area well withdrawal rates

Well or Control Point Number	Simulation model row	Simulation model column	Withdrawal rates (MGD) 1988	Non-optimized projected year 2010	Case 3	Case 2	Case 1	Well Description	Public Utility Need Area	Potential for Vegetative Harm
1	68	13	0.54	0.00	0.00	0.00	0.62	DELAND WATER UTIL	DWU	LOW
2	67	12	0.54	0.77	0.00	0.00	0.00	DELAND WATER UTIL	DWU	LOW
3	66	12	1.08	1.54	0.00	0.65	2.29	DELAND WATER UTIL	DWU	LOW
4	64	11	0.54	0.77	0.00	2.26	2.26	DELAND WATER UTIL	DWU	LOW
5	67	14	0.54	0.77	0.00	2.26	2.26	DELAND WATER UTIL	DWU	LOW
6	61	14	0.54	0.77	0.00	2.26	2.26	DELAND WATER UTIL	DWU	LOW
7	65	11	0.54	0.77	0.00	2.26	2.26	DELAND WATER UTIL	DWU	LOW
8	70	13	0.00	1.54	0.00	0.00	0.00	DELAND WU 1990	DWU	LOW
9	41	73	0.03	0.05	0.00	0.14	0.00	HOLLY HILL EASTERN WF	HHE	LOW
10	41	74	0.02	0.02	0.14	0.00	0.14	HOLLY HILL EASTERN WF	HHE	LOW
11	40	74	0.02	0.02	0.00	0.00	0.00	HOLLY HILL EASTERN WF	HHE	LOW
12	40	73	0.02	0.02	0.00	0.00	0.00	HOLLY HILL EASTERN WF	HHE	LOW
13	40	72	0.02	0.02	0.00	0.00	0.00	HOLLY HILL EASTERN WF	HHE	LOW
14	41	54	0.29	0.35	0.00	0.00	0.00	HOLLY HILL WESTERN WF	HHW	LOW
15	41	55	0.44	0.52	0.00	0.00	0.00	HOLLY HILL WESTERN WF	HHW	LOW
16	40	55	0.29	0.35	0.00	0.00	1.09	HOLLY HILL WESTERN WF	HHW	LOW
17	40	55	0.00	0.17	0.00	0.00	0.29	HOLLY HIIL PROPOSED	HHW	LOW
18	79	12	0.13	0.39	0.29	0.39	0.39	OR. CITY CTRY VILLAGE	OCC	LOW
19	81	65	0.10	0.22	0.22	0.22	0.22	SSU SUGAR MILL EST	SME	HIGH
20	64	42	0.27	0.29	0.48	0.47	0.51	PORT ORANGE WESTERN WF	POW	MODERATE
21	67	41	0.27	0.29	0.00	0.51	0.51	PORT ORANGE WESTERN WF	POW	MODERATE
22	68	40	0.53	0.57	0.32	0.27	0.57	PORT ORANGE WESTERN WF	POW	MODERATE
23	69	39	0.27	0.29	0.51	0.00	0.00	PORT ORANGE WESTERN WF	POW	MODERATE
24	70	39	0.27	0.29	0.51	0.51	0.28	PORT ORANGE WESTERN WF	POW	MODERATE
25	65	40	0.27	0.29	0.51	0.00	0.00	PORT ORANGE WESTERN WF	POW	MODERATE
26	66	39	0.27	0.29	0.00	0.00	0.00	PORT ORANGE WESTERN WF	POW	MODERATE
27	67	39	0.27	0.29	0.51	0.01	0.06	PORT ORANGE WESTERN WF	POW	MODERATE
28	68	39	0.27	0.29	0.51	0.32	0.00	PORT ORANGE WESTERN WF	POW	MODERATE
29	65	38	0.27	0.29	0.28	0.51	0.49	PORT ORANGE WESTERN WF	POW	MODERATE
30	66	38	0.53	0.57	0.57	0.57	0.57	PORT ORANGE WESTERN WF	POW	MODERATE
31	69	40	0.27	0.29	0.51	0.33	0.17	PORT ORANGE WESTERN WF	POW	MODERATE
32	67	38	0.27	0.29	0.51	0.51	0.51	PORT ORANGE WESTERN WF	POW	MODERATE
33	64	39	0.00	0.86	0.00	0.00	0.00	PORT ORANGE WEST PROP	POW	MODERATE
34	69	38	0.00	0.86	0.00	0.00	0.00	PORT ORANGE WEST PROP	POW	MODERATE
35	40	26	0.00	0.29	0.00	0.00	0.00	PORT ORANGE WEST PROP	POW	MODERATE
36	39	24	0.00	0.29	0.00	0.00	0.00	PORT ORANGE WEST PROP	POW	MODERATE
37	41	28	0.00	0.29	0.00	0.00	0.00	PORT ORANGE WEST PROP	POW	MODERATE
38	38	27	0.00	0.29	0.00	0.00	0.00	PORT ORANGE WEST PROP	POW	MODERATE
39	37	25	0.00	0.29	0.00	0.00	0.00	PORT ORANGE WEST PROP	POW	MODERATE
40	39	29	0.00	0.29	0.00	0.00	0.00	PORT ORANGE WEST PROP	POW	MODERATE
41	42	25	0.00	0.29	0.00	1.03	1.03	PORT ORANGE WEST PROP	POW	MODERATE
42	41	23	0.00	0.29	0.00	0.39	1.03	PORT ORANGE WEST PROP	POW	MODERATE
43	43	27	0.00	0.29	0.00	1.03	1.03	PORT ORANGE WEST PROP	POW	MODERATE
44	68	66	0.12	0.26	0.00	0.86	0.86	PORT ORANGE EASTERN WF	POE	LOW
45	68	65	0.03	0.07	0.00	0.00	0.00	PORT ORANGE EASTERN WF	POE	LOW
46	66	66	0.03	0.07	0.00	0.00	0.00	PORT ORANGE EASTERN WF	POE	LOW
47	66	67	0.10	0.20	0.00	0.00	0.00	PORT ORANGE EASTERN WF	POE	LOW
48	65	66	0.06	0.13	0.00	0.00	0.00	PORT ORANGE EASTERN WF	POE	LOW
49	65	65	0.06	0.13	0.00	0.00	0.00	PORT ORANGE EASTERN WF	POE	LOW

Table A14--*Continued*

Well or Control Point Number	Simulation model row	Simulation model column	Withdrawal rates (MGD) 1988	Non-optimized projected year 2010	Case 3	Case 2	Case 1	Well Description	Public Utility Need Area	Potential for Vegetative Harm
50	84	11	0.49	0.75	0.00	0.00	0.00	DELTONA	DEL	LOW
51	84	9	0.49	0.75	1.50	1.50	1.50	DELTONA	DEL	LOW
52	83	13	0.49	0.75	0.00	0.00	0.00	DELTONA	DEL	LOW
53	86	13	0.49	0.75	1.50	1.50	1.50	DELTONA	DEL	LOW
54	84	10	0.97	1.51	0.00	2.26	2.26	DELTONA	DEL	LOW
55	85	12	1.46	2.26	0.00	0.44	1.85	DELTONA	DEL	LOW
56	84	18	0.49	0.75	0.00	0.00	0.00	DELTONA	DEL	MODERATE
57	85	12	0.49	0.75	0.34	1.50	1.50	DELTONA	DEL	LOW
58	83	18	0.49	0.75	0.00	0.00	0.00	DELTONA	DEL	LOW
59	84	18	0.49	0.75	0.00	0.00	0.00	DELTONA	DEL	MODERATE
60	81	12	0.49	0.75	0.00	0.00	0.00	DELTONA	DEL	LOW
61	85	17	0.49	0.75	0.00	0.00	0.00	DELTONA	DEL	MODERATE
62	81	16	0.00	0.75	0.00	0.00	0.00	DELT - PROPOSED	DEL	MODERATE
63	81	18	0.00	1.51	0.00	0.00	0.00	DELT - PROPOSED	DEL	MODERATE
64	82	15	0.00	0.75	0.00	0.00	0.00	DELT - PROPOSED	DEL	LOW
65	83	17	0.00	0.75	0.00	0.00	0.00	DELT - PROPOSED	DEL	MODERATE
66	84	9	0.00	0.75	0.00	0.00	0.00	DELT - PROPOSED	DEL	LOW
67	84	10	0.00	0.75	0.00	0.00	0.00	DELT - PROPOSED	DEL	LOW
68	84	11	0.00	1.51	0.00	0.00	0.00	DELT - PROPOSED	DEL	LOW
69	85	17	0.00	0.75	0.00	0.00	0.00	DELT - PROPOSED	DEL	MODERATE
70	86	11	0.00	0.75	0.00	1.50	1.50	DELT - PROPOSED	DEL	LOW
71	86	15	0.00	2.26	0.00	0.00	0.00	DELT - PROPOSED	DEL	LOW
72	87	13	0.00	0.75	1.50	1.50	1.50	DELT - PROPOSED	DEL	LOW
73	87	15	0.00	0.75	1.50	1.50	1.50	DELT - PROPOSED	DEL	LOW
74	87	16	0.00	1.51	2.26	1.94	1.83	DELT - PROPOSED	DEL	LOW
75	75	54	0.16	0.08	0.40	0.00	0.00	SPRUCE CREEK	SPC	LOW
76	75	55	0.16	0.08	0.00	0.40	0.40	SPRUCE CREEK	SPC	LOW
77	75	54	0.00	0.16	0.00	0.00	0.00	SPRUCE CREEK PROP	SPC	LOW
78	75	55	0.00	0.08	0.00	0.00	0.00	SPRUCE CREEK PROP	SPC	LOW
79	79	40	0.59	0.88	1.42	1.63	1.63	NEW SMYRNA SAMSULA WF	NSS	LOW
80	80	41	0.59	0.88	0.00	0.60	1.01	NEW SMYRNA SAMSULA WF	NSS	LOW
81	80	42	0.30	0.44	0.00	0.00	0.00	NEW SMYRNA SAMSULA WF	NSS	LOW
82	80	43	0.30	0.44	0.00	0.00	0.00	NEW SMYRNA SAMSULA WF	NSS	MODERATE
83	86	64	1.19	1.76	0.00	0.12	0.00	NEW SMYRNA GLENCOE WF	NSG	MODERATE
84	86	65	0.89	1.32	0.00	0.00	0.51	NEW SMYRNA GLENCOE WF	NSG	LOW
85	78	36	0.00	0.44	0.00	0.00	0.10	NSB - PROPOSED	NS4	MODERATE
86	78	35	0.00	0.44	0.00	0.00	0.33	NEW SMYRNA SR 44	NS4	MODERATE
87	77	36	0.00	1.76	0.00	0.00	0.39	NEW SMYRNA SR 44	NS4	MODERATE
88	51	58	0.59	1.51	0.00	2.26	2.26	DAYTONA BEACH EASTERN WF	DBE	MODERATE
89	51	57	0.59	1.21	0.00	1.67	0.00	DAYTONA BEACH EASTERN WF	DBE	MODERATE
90	51	56	0.59	1.21	0.00	0.00	0.00	DAYTONA BEACH EASTERN WF	DBE	MODERATE
91	50	52	1.17	3.25	0.00	0.00	3.70	DAYTONA BEACH EASTERN WF	DBE	MODERATE
92	50	51	0.93	1.47	0.00	1.94	2.22	DAYTONA BEACH WESTERN WF	DBW	MODERATE
93	49	50	0.93	1.76	0.00	0.00	0.64	DAYTONA BEACH WESTERN WF	DBW	MODERATE
94	58	46	0.93	0.27	0.04	1.02	1.02	DAYTONA BEACH WESTERN WF	DBW	MODERATE
95	58	45	1.87	0.94	1.69	1.69	1.69	DAYTONA BEACH WESTERN WF	DBW	MODERATE
96	58	44	0.93	0.49	1.24	1.24	1.24	DAYTONA BEACH WESTERN WF	DBW	MODERATE
97	58	43	0.93	0.21	0.96	0.96	0.96	DAYTONA BEACH WESTERN WF	DBW	MODERATE
98	58	42	0.93	0.41	1.16	0.97	1.01	DAYTONA BEACH WESTERN WF	DBW	MODERATE

Table A14–*Continued*

Well or Control Point Number	Simulation model row	Simulation model column	Withdrawal rates (MGD) 1988	Non-optimized projected year 2010	Case 3	Case 2	Case 1	Well Description	Public Utility Need Area	Potential for Vegetative Harm
99	57	43	0.93	0.33	1.08	1.08	0.80	DAYTONA BEACH WESTERN WF	DBW	MODERATE
100	56	43	0.93	0.32	0.00	0.37	0.91	DAYTONA BEACH WESTERN WF	DBW	LOW
101	55	42	0.93	0.63	1.38	0.98	0.59	DAYTONA BEACH WESTERN WF	DBW	LOW
102	53	42	0.00	0.31	0.00	0.00	0.00	DAYTONA WEST. 1988	DBW	LOW
103	52	42	0.00	2.32	1.12	0.59	0.00	DAYTONA WEST. 1988	DBW	LOW
104	51	43	0.00	0.40	0.00	0.00	0.00	DAYTONA WEST. 1988	DBW	LOW
105	50	43	0.00	1.63	0.00	0.08	0.00	DAYTONA WEST. 1988	DBW	LOW
106	49	43	0.00	0.48	0.30	0.00	0.00	DAYTONA WEST. 1988	DBW	MODERATE
107	57	41	0.00	0.55	0.18	0.00	0.09	DAYTONA WEST. 1988	DBW	MODERATE
108	54	43	0.00	0.53	0.00	0.00	0.00	DAYTONA WEST. 1988	DBW	LOW
109	53	43	0.00	0.27	0.00	0.00	0.00	DAYTONA WEST. 1988	DBW	MODERATE
110	31	73	0.45	0.46	1.21	1.21	1.21	ORMOND BEACH DIVISION	OBD	LOW
111	32	72	0.90	0.92	1.67	1.67	1.67	ORMOND BEACH DIVISION	OBD	LOW
112	31	70	0.23	0.23	0.00	0.00	0.98	ORMOND BEACH DIVISION	OBD	LOW
113	32	70	0.23	0.23	0.14	0.86	0.98	ORMOND BEACH DIVISION	OBD	LOW
114	32	69	0.23	0.23	0.00	0.00	0.00	ORMOND BEACH DIVISION	OBD	LOW
115	31	73	0.23	0.23	0.98	0.98	0.98	ORMOND BEACH DIVISION	OBD	LOW
116	31	72	0.23	0.23	0.98	0.98	0.98	ORMOND BEACH DIVISION	OBD	LOW
117	31	70	0.23	0.23	0.00	0.00	0.14	ORMOND BEACH DIVISION	OBD	LOW
118	29	64	0.63	0.23	0.00	0.00	0.00	ORMOND BEACH SR 40	OB4	LOW
119	30	61	0.63	0.23	0.00	0.00	0.00	ORMOND BEACH SR 40	OB4	LOW
120	28	65	0.00	0.23	0.00	0.00	0.00	ORMOND BEACH SR 40	OB4	MODERATE
121	29	65	0.00	0.23	0.00	0.00	0.00	ORMOND BEACH SR 40	OB4	MODERATE
122	30	59	0.63	0.23	0.00	0.00	0.00	ORMOND BEACH SR 40	OB4	LOW
123	25	52	0.00	0.46	0.00	0.00	0.00	ORMOND BEACH HUDSON	OBH	LOW
124	24	52	0.00	0.23	0.00	0.00	0.00	ORMOND BEACH HUDSON	OBH	LOW
125	23	53	0.00	0.46	0.00	0.00	0.00	ORMOND BEACH HUDSON	OBH	LOW
126	22	53	0.00	0.46	0.00	0.00	0.00	ORMOND BEACH HUDSON	OBH	LOW
127	24	53	0.00	0.23	0.00	0.00	0.00	ORMOND BEACH HUDSON	OBH	LOW
128	24	54	0.00	0.23	0.00	0.00	0.00	ORMOND BEACH HUDSON	OBH	LOW
129	23	54	0.00	0.23	0.00	0.00	0.00	ORMOND BEACH HUDSON	OBH	LOW
130	22	55	0.00	0.23	0.00	0.00	0.00	ORMOND BEACH HUDSON	OBH	LOW
131	24	52	0.00	0.23	0.00	0.00	0.00	ORMOND BEACH HUDSON	OBH	LOW
132	23	51	0.00	0.23	0.00	0.00	0.00	ORMOND BEACH HUDSON	OBH	LOW
133	32	43	0.00	0.23	0.17	0.26	0.35	ORMOND BEACH RIMA PROP	OBR	MODERATE
134	31	44	0.00	0.23	0.29	0.21	0.12	ORMOND BEACH RIMA PROP	OBR	MODERATE
135	78	10	0.05	0.14	0.14	0.14	0.14	JOHN KNOX VILL.	JKV	LOW
136	80	8	0.20	0.32	0.00	0.00	0.00	V CTY - FOUR TOWNS	VFT	LOW
137	79	8	0.20	0.32	0.79	0.79	0.79	V CTY - FOUR TOWNS	VFT	LOW
138	80	9	0.14	0.16	0.00	0.00	0.00	V CTY - BREEZEWOOD	VFT	LOW
139	83	6	0.14	0.25	0.25	0.25	0.25	V CTY - LAKE MARIE	VLM	LOW
140	81	7	0.09	0.52	0.53	0.53	0.53	V CTY - TERRA ALTA	VTA	LOW
141	77	7	0.01	0.01	0.00	0.00	0.00	V CTY - W ORANGE CITY	VTA	LOW
142	55	14	0.46	0.82	0.04	0.82	0.04	DELAND - BRANDYWINE	DEB	MODERATE
143	55	13	0.01	0.02	0.00	0.00	0.00	DELAND - SPRING GARDEN	DEB	MODERATE
143	55	13	0.01	0.02	0.00	0.00	0.00	DELAND - SPRING GARDEN	DEB	LOW
144	54	12	0.02	0.03	0.86	0.08	0.86	DELAND - GLENWOOD EST	DEB	MODERATE
145	51	14	0.06	0.16	0.16	0.16	0.16	DELAND - WOODLAND MANOR	DWW	LOW
146	74	13	0.12	0.26	0.00	0.36	0.36	DELAND - LONGLEAF PLANT.	DHH	LOW

Table A14--*Continued*

Well or Control Point Number	Simulation model row	Simulation model column	Withdrawal rates (MGD) 1988	Non -optimized projected year 2010	Case 3	Case 2	Case 1	Well Description	Public Utility Need Area	Potential for Vegetative Harm
147	72	10	0.05	0.10	0.36	0.00	0.00	DELAND - HOLIDAY HILLS	DHH	MODERATE
148	77	17	0.05	0.09	0.09	0.09	0.09	ELLWOOD TITCOMB	ETI	MODERATE
149	87	68	0.28	0.85	1.59	1.59	1.59	CITY OF EDGEWATER	EDG	LOW
150	87	67	0.42	1.27	0.59	2.02	2.02	CITY OF EDGEWATER	EDG	LOW
152	88	59	0.42	1.27	2.02	2.02	2.02	CITY OF EDGEWATER	EDG	LOW
153	88	63	0.28	0.85	1.59	1.59	1.59	CITY OF EDGEWATER	EDG	LOW
154	27	59	0.09	0.18	0.13	0.13	0.18	TYMBER CREEK UTIL.	TCU	LOW
155	26	54	0.32	0.58	0.43	0.43	0.58	THE TRAILS INC.	TTI	LOW
156	77	16	0.11	0.29	0.17	0.49	0.00	LAKE HELEN	LHE	MODERATE
157	76	16	0.11	0.29	0.40	0.09	0.58	LAKE HELEN	LHE	MODERATE
158	90	74	0.06	0.10	0.10	0.10	0.10	HACIENDA DEL RIO	HDR	LOW
159	15	72	0.03	0.06	0.00	0.00	0.00	NATIONAL GARDENS	NGA	LOW
160	15	73	0.03	0.06	0.00	0.00	0.00	NATIONAL GARDENS	NGA	LOW
161	16	71	0.10	0.17	0.04	0.04	0.04	NATIONAL GARDENS	NGA	LOW
162	16	72	0.02	0.04	0.11	0.11	0.11	NATIONAL GARDENS	NGA	LOW
163	17	71	0.03	0.06	0.13	0.13	0.13	NATIONAL GARDENS	NGA	LOW
164	78	9	0.51	3.65	2.70	1.24	3.98	ORANGE CITY	OCY	LOW
165	14	65	0.07	0.13	0.13	0.13	0.13	SUNSHINE HOLIDAY PK	SHP	LOW
166	6	60	0.04	0.08	0.01	0.01	0.01	PLANTATION BAY	PTB	MODERATE
167	7	60	0.02	0.04	0.12	0.12	0.12	PLANTATION BAY	PTB	LOW
168	68	8	0.16	0.33	0.33	0.33	0.33	L BERESFORD WATER ASSN	LBW	LOW
169	86	8	0.10	0.10	0.10	0.10	0.10	FPL - TURNER POWER PLNT	FPT	LOW
170	64	16	0.10	0.10	0.03	0.03	0.03	SHERWOOD MEDICAL CO.	SMC	LOW
171	63	17	0.05	0.05	0.13	0.13	0.13	SHERWOOD MEDICAL CO.	SMC	LOW
172	85	4	0.08	0.08	0.08	0.08	0.08	FPL - SANFORD PWR PLNT	FPS	LOW
173	85	5	0.08	0.08	0.08	0.08	0.08	FPL - SANFORD PWR PLNT	FPS	LOW
174	80	7	0.08	0.08	0.08	0.08	0.08	FPL - SANFORD PWR PLNT	FPS	LOW
175	81	7	0.08	0.08	0.08	0.08	0.08	FPL - SANFORD PWR PLNT	FPS	LOW
176	50	40	0.23	0.23	0.23	0.23	0.23	TOMOKA CORR. FACILITY	TCF	HIGH
177	76	8	0.20	0.20	0.20	0.20	0.20	V CTY GOVT COMPLEX	VGC	LOW

Table A15. East-central MIP decision model annualized public supply utility area fixed costs

Model ID	Public supply demand area	Fixed cost less interconnects Case 3	Case 2	Case 1	Fixed cost of interconnects Case 3	Case 2	Case 1	Total fixed costs Case 3	Case 2	Case 1	Nonoptimized fixed costs
AF1	USAF BAS Civil Engineer										
ALT	Altamonte Springs	5,458,900	5,458,900	9,211,600				5,458,900	5,458,900	9,211,600	1,051,703
APO	Apopka	10,324,000	10,684,000					10,324,000	10,684,000		2,873,947
CAS	Casselberry			3,704,600						3,704,600	
CFR	Cent. Fla. Res. Park										
CFU	Central Florida Utilities										
CHU	Chuluota										
CLE	Clermont										
COC	Cocoa	13,685,000						13,685,000			
CON	Conway										
DAV	Davenport										
DEL	Deltona	8,401,400	7,937,000	7,485,200				8,401,400	7,937,000	7,485,200	2,398,476
EAT	Eatonville										
ECU	Econ Utilities										
EUS	Eustis										
FDC	Florida Dept. of Corrections										
FPL	Florida Power and Light										
GRO	Groveland Park										
HAI	Haines City										
HHO	Hyatt House Orlando										
HOH	Howey in the Hills										
IN1	B & W Canning										
IN2	Florida Crushed Stone										
IN3	Florida Rock (Lake Sand)										
IN4	Floribra USA, Inc.										
IN5	Silver Sand (Clermont Mine)										
IN6	Silver Springs Citrus										
JKV	John Knox Village										
KIS	Kissimmee										
LHE	Lake Helen										
LHY	Lake Harney										
LMY	Lake Mary	2,712,300	2,712,300	2,712,300				2,712,300	2,712,300	2,712,300	1,053,655
LON	Longwood										
MAI	Maitland										
MHN	City of Minne										
MIN	Minneola										
MON	Montverde										
MTD	Mt. Dora										
O10	OUC Navy	3,961,500	3,961,500	3,961,500		124,120	124,120	3,961,500	4,085,620	4,085,620	
O11	OUC Orange	560,720	560,720	560,720				560,720	560,720	560,720	1,835,432
O12	OUC Pershing				48,441			48,441			
O13	OUC Stanton Energy Ctr.										
OAK	Oakland										
OCO	Ocoee										
OCY	Orange City										
OE1	OCPUD E Bonneville/Corrine Terr.										
OE2	OCPUD E Conway				129,539	398,820	361,550	129,539	398,820	361,550	
OE3	OCPUD E Econ				1,119,622	1,135,300	619,680	1,119,622	1,135,300	619,680	
OE4	OCPUD E Lake Nona										

Table A15--*Continued*

Model ID	Public supply demand area	Fixed cost less interconnects Case 3	Fixed cost less interconnects Case 2	Fixed cost less interconnects Case 1	Fixed cost of interconnects Case 3	Fixed cost of interconnects Case 2	Fixed cost of interconnects Case 1	Total fixed costs Case 3	Total fixed costs Case 2	Total fixed costs Case 1	Nonoptimized fixed costs
OE5	OCPUD E ERWF				1,120,202	1,120,200	1,114,000	1,120,202	1,120,200	1,114,000	
ORO	Orange/Osceola Management										
OS1	OCPUD S Cypress Walk/Vistana										
OS2	OCPUD S Hunter's Creek										
OS3	OCPUD S Meadow Woods/SRWF	1,550,000	1,609,500	1,711,800				1,550,000	1,609,500	1,711,800	2,245,557
OS4	OCPUD S Orange Wood										
OSC	Osceola Service										
OU1	OUC Dr. Phillips										
OU2	OUC Martin				770,578	1,604,100	1,604,100	770,578	1,604,100	1,604,100	
OU3	OUC Conway										
OU4	OUC Highland	4,691,900	4,691,900	4,691,900	365,206			5,057,106	4,691,900	4,691,900	
OU5	OUC Pine Hills	10,067,000	10,067,000	10,067,000				10,067,000	10,067,000	10,067,000	
OU6	OUC Kuhl				1,261,370	586,770	1,000,200	1,261,370	586,770	1,000,200	
OU7	OUC Kirkman				990,764	1,790,800	887,620	990,764	1,790,800	887,620	
OU8	OUC Primrose	4,280,200	4,280,200	4,280,200				4,280,200	4,280,200	4,280,200	
OU9	OUC Sky Lake										
OVI	Oviedo										655,481
OW1	OCPUD W Bent Oaks/Plymouth										672,594
OW2	OCPUD W Hidden Springs/Kelso/Windmere										
OW3	OCPUD W Oak Meadow										
OW4	OCPUD W Riverside										
OW5	OCPUD W WRWF	10,252,000	10,252,000	10,252,000				10,252,000	10,252,000	10,252,000	
OW6	OCPUD W Magnolia/Lake John										15,042
PAM	Park Manor										
POI	Poinciana										
RAV	Ravenna										10,483
RCU	Reedy Creek										
SAF	Sanford	3,335,600	2,857,700	2,833,600				3,335,600	2,857,700	2,833,600	742,435
SAN	Sanlando	5,454,600						5,454,600			234,545
SCL	St. Cloud										
SEM	Seminole County	8,832,900	8,832,900	7,996,900				8,832,900	8,832,900	7,996,900	
SSS	Southern States U. Shores										
SSU	Southern States U.										
SWA	Seminole Woods Association										
SWF	Sea World of Florida										
TAV	Tavares										
UCF	Univ. Central Fla.										
VOL	Volusia County										4,293
WEK	Wekiva										
WGA	Winter Garden										892,909
WGC	Winter										
WPK	Winter Park	8,069,000	8,069,000	8,069,000				8,069,000	8,069,000	8,069,000	
WSP	Winter Springs		3,339,700		577,944			577,944	3,339,700		
ZSU	Zellwood Station										
ZWF	Zellwood Farms										
ZWU	Zellwood Water Users										
	Total	101,637,020	85,314,320	77,538,320	6,383,666	6,760,110	5,711,270	108,020,686	92,074,430	83,249,590	14,686,552

Table A16. East-central MIP decision model annual public supply utility area unit costs

		Unit cost less interconnect			Unit cost of interconnect			Total unit cost			Nonoptimized unit costs
	Public demand area	Case 3	Case 2	Case 1	Case 3	Case 2	Case 1	Case 3	Case 2	Case 1	
AF1	USAF BAS Civil Engineer	50,309	50,309	50,309				50,309	50,309	50,309	50,309
ALT	Altamonte Springs	1,717,100	1,742,700	640,810				1,717,100	1,742,700	640,810	640,805
APO	Apopka	2,829,100	2,986,100	2,660,500				2,829,100	2,986,100	2,660,500	1,330,285
CAS	Casselberry	398,070	1,042,600	1,716,100				398,070	1,042,600	1,716,100	398,065
CFR	Cent. Fla. Res. Park	62,879	62,879	62,879				62,879	62,879	62,879	62,879
CFU	Central Florida Utilities	190,630	190,630	190,630				190,630	190,630	190,630	190,631
CHU	Chuluota	15,721	15,721	15,721				15,721	15,721	15,721	15,721
CLE	Clermont	155,160	155,160	155,160				155,160	155,160	155,160	155,155
COC	Cocoa	3,998,900	2,162,500	2,083,600				3,998,900	2,162,500	2,083,600	1,702,710
CON	Conway	6,357	6,357	6,357				6,357	6,357	6,357	6,357
DAV	Davenport	79,599	79,599	79,599				79,599	79,599	79,599	79,599
DEL	Deltona	2,477,300	2,415,600	2,352,900				2,477,300	2,415,600	2,352,900	1,565,903
EAT	Eatonville	88,936	88,936	88,936				88,936	88,936	88,936	88,936
ECU	Econ Utilities	9,680	9,680	9,680				9,680	9,680	9,680	9,680
EUS	Eustis	363,890	363,890	363,890				363,890	363,890	363,890	363,892
FDC	Florida Dept. of Corrections	10,375	10,375	10,375				10,375	10,375	10,375	13,833
FPL	Florida Power and Light	46,856	46,856	46,856				46,856	46,856	46,856	46,856
GRO	Groveland Park	49,528	49,528	49,528				49,528	49,528	49,528	49,528
HAI	Haines City	176,390	176,390	176,390				176,390	176,390	176,390	176,394
HHO	Hyatt House Orlando	45,650	45,650	45,650				45,650	45,650	45,650	45,651
HOH	Howey in the Hills	28,106	28,106	28,106				28,106	28,106	28,106	28,106
IN1	B & W Canning	69,803	69,803	69,803				69,803	69,803	69,803	69,803
IN2	Florida Crushed Stone	137,350	137,350	137,350				137,350	137,350	137,350	137,352
IN3	Florida Rock (Lake Sand)	54,638	54,638	54,638				54,638	54,638	54,638	54,638
IN4	Floribra USA, Inc.	99,349	99,349	99,349				99,349	99,349	99,349	99,349
IN5	Silver Sand (Clermont Mine)	77,798	77,798	77,798				77,798	77,798	77,798	77,798
IN6	Silver Springs Citrus	44,394	44,394	44,394				44,394	44,394	44,394	44,394
JKV	John Knox Village	22016.597	22016.597	22016.597				22,017	22,017	22,017	22016.6
KIS	Kissimmee	572,900	572,900	572,900				572,900	572,900	572,900	572,896
LHE	Lake Helen	36,315	36,315	36,315				36,315	36,315	36,315	36,315
LHY	Lake Harney	2,201	2,201	2,201				2,201	2,201	2,201	2,201
LMY	Lake Mary	398,300	398,300	398,300				398,300	398,300	398,300	353,528
LON	Longwood	198,090	198,090	198,090				198,090	198,090	198,090	198,090
MAI	Maitland	222,140	222,140	222,140				222,140	222,140	222,140	222,140
MHN	City of Minne	126,400	126,400	126,400				126,400	126,400	126,400	126,400
MIN	Minneola	28,106	28,106	28,106				28,106	28,106	28,106	28,106
MON	Montverde	13,587	13,587	13,587				13,587	13,587	13,587	13,587
MTD	Mt. Dora	280,150	280,150	280,150				280,150	280,150	280,150	280,154
O10	OUC Navy	1,181,000	1,181,000	1,005,000				1,181,000	1,181,000	1,005,000	402,469
O11	OUC Orange	138,320	138,320	138,320				138,320	138,320	138,320	452,777
O12	OUC Pershing							0	0	0	440,200
O13	OUC Stanton Energy Ctr.	25,272	25,272	25,272				25,272	25,272	25,272	25,272
OAK	Oakland	17,640	17,640	17,640				17,640	17,640	17,640	17,640
OCO	Ocoee	29,799	344,250	115,320				29,799	344,250	115,320	344,251
OCY	Orange City	254,270	254,270	254,270				254,270	254,270	254,270	254,270
OE1	OCPUD E Bonneville/Corrine Terr.	5	5	5				5	5	5	0
OE2	OCPUD E Conway	251,560	8,346	184,380				251,560	8,346	184,380	481,578
OE3	OCPUD E Econ	25,599			385,710	406,390	406,390	411,309	406,390	406,390	503,086
OE4	OCPUD E Lake Nona	125,770	125,770	125,770				125,770	125,770	125,770	125,771

Table A16--*Continued*

		Unit cost less interconnect			Unit cost of interconnect			Total unit cost			Nonoptimized unit costs
	Public demand area	Case 3	Case 2	Case 1	Case 3	Case 2	Case 1	Case 3	Case 2	Case 1	
OE5	OCPUD E ERWF			12,888	1,028,700	1,028,700	1,018,300	1,028,700	1,028,700	1,031,188	1,273,436
ORO	Orange/Osceola Management	229,130	229,130	229,130				229,130	229,130	229,130	229,132
OS1	OCPUD S Cypress Walk/Vistana	703,520	723,210	723,210				703,520	723,210	723,210	408,757
OS2	OCPUD S Hunter's Creek	31,443	31,443	31,443				31,443	31,443	31,443	31,443
OS3	OCPUD S Meadow Woods/SRWF	641,430	641,430	641,430				641,430	641,430	641,430	641,435
OS4	OCPUD S Orange Wood	112,730	93,047	93,047				112,730	93,047	93,047	407,499
OSC	Osceola Service	143,510	143,510	143,510				143,510	143,510	143,510	143,510
OU1	OUC Dr. Phillips	389,890	389,890	389,890				389,890	389,890	389,890	389,892
OU2	OUC Martin				1,025,600	1,025,600	1,025,600	1,025,600	1,025,600	1,025,600	1,269,663
OU3	OUC Conway	531,910	389,910	389,910				531,910	389,910	389,910	578,611
OU4	OUC Highland	970,640	970,640	970,640				970,640	970,640	970,640	501,765
OU5	OUC Pine Hills	2,384,300	2,384,300	2,384,300				2,384,300	2,384,300	2,384,300	1,232,560
OU6	OUC Kuhl	316,430	314,450	314,450	572,930	574,530	574,530	889,360	888,980	888,980	711,237
OU7	OUC Kirkman				558,830	558,830	558,830	558,830	558,830	558,830	691,806
OU8	OUC Primrose	1,176,800	1,159,600	1,159,600				1,176,800	1,159,600	1,159,600	445,797
OU9	OUC Sky Lake	962,150	962,150	962,150				962,150	962,150	962,150	962,152
OVI	Oviedo	357,600	342,310	360,800	200,580	212,930	197,990	558,180	555,240	558,790	605,904
OW1	OCPUD W Bent Oaks/Plymouth	153,000	153,000	153,000				153,000	153,000	153,000	153,001
OW2	OCPUD W Hidden Springs/Kelso/Windmere	5	5	5				5	5	5	0
OW3	OCPUD W Oak Meadow	5	5	5				5	5	5	0
OW4	OCPUD W Riverside	5	5	5				5	5	5	0
OW5	OCPUD W WRWF	2,433,000	3,702,600	4,176,900			144,440	2,433,000	3,702,600	4,321,340	1,257,715
OW6	OCPUD W Magnolia/Lake John	4,150	4,150	4,150				4,150	4,150	4,150	4,150
PAM	Park Manor	25,608	25,608	25,608				25,608	25,608	25,608	25,608
POI	Poinciana	90,641	90,641	90,641				90,641	90,641	90,641	90,641
RAV	Ravenna	14,840	14,840	14,840				14,840	14,840	14,840	14,840
RCU	Reedy Creek	2,778,900	2,089,800	2,515,500				2,778,900	2,089,800	2,515,500	1,823,686
SAF	Sanford	907,390	834,950	834,500				907,390	834,950	834,500	473,026
SAN	Sanlando	2,016,700	675,900	675,900				2,016,700	675,900	675,900	675,894
SCL	St. Cloud	269,710	269,710	269,710				269,710	269,710	269,710	269,711
SEM	Seminole County	2,577,000	2,577,000	2,396,800				2,577,000	2,577,000	2,396,800	1,169,610
SSS	Southern States U. Shores	97,767	97,767	97,767				97,767	97,767	97,767	97,766
SSU	Southern States U.	76,886	76,886	76,886				76,886	76,886	76,886	76,885
SWA	Seminole Woods Association	5,344	5,344	5,344				5,344	5,344	5,344	5,344
SWF	Sea World of Florida	81,743	81,743	81,743				81,743	81,743	81,743	81,743
TAV	Tavares	211,230	211,230	211,230				211,230	211,230	211,230	211,230
UCF	Univ. Central Fla.	64,709	64,709	64,709				64,709	64,709	64,709	64,709
VOL	Volusia County	158,550	158,550	158,550				158,550	158,550	158,550	158,546
WEK	Wekiva	48,240	48,240	48,240				48,240	48,240	48,240	48,239
WGA	Winter Garden	158,220	158,220	337,030				158,220	158,220	337,030	236,429
WGC	Winter	117,760	117,760	117,760				117,760	117,760	117,760	39,555
WPK	Winter Park	2,865,100	2,972,500	2,764,400				2,865,100	2,972,500	2,764,400	960,896
WSP	Winter Springs	248,300	994,860	378,020	305,360			553,660	994,860	378,020	378,021
ZSU	Zellwood Station	118,580	118,580	118,580				118,580	118,580	118,580	118,578
ZWF	Zellwood Farms	20,394	20,394	20,394				20,394	20,394	20,394	20,394
ZWU	Zellwood Water Users	23,022	23,022	23,022				23,022	23,022	23,022	23,022
	Total	41,751,591	40,571,016	39,551,127	4,077,710	3,806,980	3,926,080	45,829,301	44,377,996	43,477,207	31,411,215

Table A17. East-central MIP decision model total annual costs for public supply utility areas

Model ID	Public supply demand area	Total optimized costs			Total nonoptimized costs	Difference between optimized and nonoptimized total costs		
		Case 3	Case 2	Case 1		Case 3	Case 2	Case 1
AF1	USAF BAS Civil Engineer	50,309	50,309	50,309	50,309	50,309	50,309	50,309
ALT	Altamonte Springs	7,176,000	7,201,600	9,852,410	1,692,509	7,200,591	7,251,791	8,800,711
APO	Apopka	13,153,100	13,670,100	2,660,500	4,204,231	11,777,969	12,451,969	1,116,769
CAS	Casselberry	398,070	1,042,600	5,420,700	398,065	398,075	1,687,135	6,738,735
CFR	Cent. Fla. Res. Park	62,879	62,879	62,879	62,879	62,879	62,879	62,879
CFU	Central Florida Utilities	190,630	190,630	190,630	190,631	190,629	190,629	190,629
CHU	Chuluota	15,721	15,721	15,721	15,721	15,721	15,721	15,721
CLE	Clermont	155,160	155,160	155,160	155,155	155,165	155,165	155,165
COC	Cocoa	17,683,900	2,162,500	2,083,600	1,702,710	19,980,090	2,622,290	2,464,490
CON	Conway	6,357	6,357	6,357	6,357	6,357	6,357	6,357
DAV	Davenport	79,599	79,599	79,599	79,599	79,599	79,599	79,599
DEL	Deltona	10,878,700	10,352,600	9,838,100	3,964,379	9,391,621	8,803,821	8,226,621
EAT	Eatonville	88,936	88,936	88,936	88,936	88,936	88,936	88,936
ECU	Econ Utilities	9,680	9,680	9,680	9,680	9,680	9,680	9,680
EUS	Eustis	363,890	363,890	363,890	363,892	363,888	363,888	363,888
FDC	Florida Dept. of Corrections	10,375	10,375	10,375	13,833	6,917	6,917	6,917
FPL	Florida Power and Light	46,856	46,856	46,856	46,856	46,856	46,856	46,856
GRO	Groveland Park	49,528	49,528	49,528	49,528	49,528	49,528	49,528
HAI	Haines City	176,390	176,390	176,390	176,394	176,386	176,386	176,386
HHO	Hyatt House Orlando	45,650	45,650	45,650	45,651	45,650	45,650	45,650
HOH	Howey in the Hills	28,106	28,106	28,106	28,106	28,106	28,106	28,106
IN1	B & W Canning	69,803	69,803	69,803	69,803	69,803	69,803	69,803
IN2	Florida Crushed Stone	137,350	137,350	137,350	137,352	137,348	137,348	137,348
IN3	Florida Rock (Lake Sand)	54,638	54,638	54,638	54,638	54,638	54,638	54,638
IN4	Floribra USA, Inc.	99,349	99,349	99,349	99,349	99,349	99,349	99,349
IN5	Silver Sand (Clermont Mine)	77,798	77,798	77,798	77,798	77,798	77,798	77,798
IN6	Silver Springs Citrus	44,394	44,394	44,394	44,394	44,394	44,394	44,394
JKV	John Knox Village	22016.597	22016.597	22016.597	22016.6	22016.594	22016.594	22016.594
KIS	Kissimmee	572,900	572,900	572,900	572,896	572,904	572,904	572,904
LHE	Lake Helen	36,315	36,315	36,315	36,315	36,315	36,315	36,315
LHY	Lake Harney	2,201	2,201	2,201	2,201	2,201	2,201	2,201
LMY	Lake Mary	3,110,600	3,110,600	3,110,600	1,407,183	2,101,717	2,101,717	2,101,717
LON	Longwood	198,090	198,090	198,090	198,090	198,090	198,090	198,090
MAI	Maitland	222,140	222,140	222,140	222,140	222,140	222,140	222,140
MHN	City of Minne	126,400	126,400	126,400	126,400	126,400	126,400	126,400
MIN	Minneola	28,106	28,106	28,106	28,106	28,106	28,106	28,106
MON	Montverde	13,587	13,587	13,587	13,587	13,587	13,587	13,587
MTD	Mt. Dora	280,150	280,150	280,150	280,154	280,146	280,146	280,146
O10	OUC Navy	5,142,500	5,266,620	5,090,620	402,469	5,921,031	6,169,271	5,817,271
O11	OUC Orange	699,040	699,040	699,040	2,288,209	-1,450,849	-1,450,849	-1,450,849
O12	OUC Pershing	48,441	0	0	440,200	-343,318	-440,200	-440,200
O13	OUC Stanton Energy Ctr.	25,272	25,272	25,272	25,272	25,272	25,272	25,272
OAK	Oakland	17,640	17,640	17,640	17,640	17,640	17,640	17,640
OCO	Ocoee	29,799	344,250	115,320	344,251	-284,653	344,249	-113,611
OCY	Orange City	254,270	254,270	254,270	254,270	254,270	254,270	254,270
OE1	OCPUD E Bonneville/Corrine Terr.	5	5	5	0	9	9	9
OE2	OCPUD E Conway	381,099	407,166	545,930	481,578	280,620	332,754	610,282
OE3	OCPUD E Econ	1,530,931	1,541,690	1,026,070	503,086	2,558,777	2,580,294	1,549,054
OE4	OCPUD E Lake Nona	125,770	125,770	125,770	125,771	125,769	-1	-1

Table A17–*Continued*

Model ID	Public supply demand area	Total optimized costs			Total nonoptimized costs	Difference between optimized and nonoptimized total costs		
		Case 3	Case 2	Case 1		Case 3	Case 2	Case 1
OE5	OCPUD E ERWF	2,148,902	2,148,900	2,145,188	1,273,436	3,024,368	3,024,364	3,016,939
ORO	Orange/Osceola Management	229,130	229,130	229,130	229,132	229,128	229,128	229,128
OS1	OCPUD S Cypress Walk/Vistana	703,520	723,210	723,210	408,757	998,283	1,037,663	1,037,663
OS2	OCPUD S Hunter's Creek	31,443	31,443	31,443	31,443	31,443	31,443	31,443
OS3	OCPUD S Meadow Woods/SRWF	2,191,430	2,250,930	2,353,230	2,886,991	-54,131	5,369	107,669
OS4	OCPUD S Orange Wood	112,730	93,047	93,047	407,499	-182,039	-221,405	-221,405
OSC	Osceola Service	143,510	143,510	143,510	143,510	143,510	143,510	143,510
OU1	OUC Dr. Phillips	389,890	389,890	389,890	389,892	389,888	389,888	389,888
OU2	OUC Martin	1,796,178	2,629,700	2,629,700	1,269,663	2,322,693	3,989,737	3,989,737
OU3	OUC Conway	531,910	389,910	389,910	578,611	485,209	201,209	201,209
OU4	OUC Highland	6,027,746	5,662,540	5,662,540	501,765	6,861,826	6,131,415	6,131,415
OU5	OUC Pine Hills	12,451,300	12,451,300	12,451,300	1,232,560	13,603,040	13,603,040	13,603,040
OU6	OUC Kuhl	2,150,730	1,475,750	1,889,180	711,237	3,590,223	2,240,263	3,067,123
OU7	OUC Kirkman	1,549,594	2,349,630	1,446,450	691,806	2,407,382	4,007,454	2,201,094
OU8	OUC Primrose	5,457,000	5,439,800	5,439,800	445,797	6,188,003	6,153,603	6,153,603
OU9	OUC Sky Lake	962,150	962,150	962,150	962,152	962,148	962,148	962,148
OVI	Oviedo	558,180	555,240	558,790	1,261,385	-145,025	-150,905	-143,805
OW1	OCPUD W Bent Oaks/Plymouth	153,000	153,000	153,000	825,595	-519,595	-519,595	-519,595
OW2	OCPUD W Hidden Springs/Kelso/Windmere	5	5	5	0	9	9	9
OW3	OCPUD W Oak Meadow	5	5	5	0	9	9	9
OW4	OCPUD W Riverside	5	5	5	0	9	9	9
OW5	OCPUD W WRWF	12,685,000	13,954,600	14,573,340	1,257,715	13,860,285	16,399,485	17,636,965
OW6	OCPUD W Magnolia/Lake John	4,150	4,150	4,150	19,192	-10,892	-10,892	-10,892
PAM	Park Manor	25,608	25,608	25,608	25,608	25,608	25,608	25,608
POI	Poinciana	90,641	90,641	90,641	90,641	90,641	90,641	90,641
RAV	Ravenna	14,840	14,840	14,840	25,323	4,358	4,358	4,358
RCU	Reedy Creek	2,778,900	2,089,800	2,515,500	1,823,686	3,734,114	2,355,914	3,207,314
SAF	Sanford	4,242,990	3,692,650	3,668,100	1,215,460	3,934,920	3,312,140	3,287,140
SAN	Sanlando	7,471,300	675,900	675,900	910,439	8,577,561	441,361	441,361
SCL	St. Cloud	269,710	269,710	269,710	269,711	269,709	269,709	269,709
SEM	Seminole County	11,409,900	11,409,900	10,393,700	1,169,610	12,817,290	12,817,290	11,620,890
SSS	Southern States U. Shores	97,767	97,767	97,767	97,766	97,768	97,768	97,768
SSU	Southern States U.	76,886	76,886	76,886	76,885	76,888	76,888	76,888
SWA	Seminole Woods Association	5,344	5,344	5,344	5,344	5,344	5,344	5,344
SWF	Sea World of Florida	81,743	81,743	81,743	81,743	81,743	81,743	81,743
TAV	Tavares	211,230	211,230	211,230	211,230	211,230	211,230	211,230
UCF	Univ. Central Fla.	64,709	64,709	64,709	64,709	64,709	64,709	64,709
VOL	Volusia County	158,550	158,550	158,550	162,839	154,261	154,261	154,261
WEK	Wekiva	48,240	48,240	48,240	48,239	48,241	48,241	48,241
WGA	Winter Garden	158,220	158,220	337,030	1,129,338	-812,898	-812,898	-455,278
WGC	Winter	117,760	117,760	117,760	39,555	195,965	195,965	195,965
WPK	Winter Park	10,934,100	11,041,500	10,833,400	960,896	12,838,304	13,053,104	12,636,904
WSP	Winter Springs	1,131,604	4,334,560	378,020	378,021	1,885,187	4,951,399	378,019
ZSU	Zellwood Station	118,580	118,580	118,580	118,578	118,582	118,582	118,582
ZWF	Zellwood Farms	20,394	20,394	20,394	20,394	20,394	20,394	20,394
ZWU	Zellwood Water Users	23,022	23,022	23,022	23,022	23,022	23,022	23,022
	Total	153,849,987	136,452,426	126,726,797	46,097,768	159,965,186	141,366,994	129,691,737

Table A18. Volusia MIP decision model public supply utility area annual fixed costs

Model ID	Public Supply Utility Area	Fixed cost less interconnects			Fixed cost of interconnects			Total fixed costs			Nonoptimized Fixed costs
		Case 3	Case 2	Case 1	Case 3	Case 2	Case 1	Case 3	Case 2	Case 1	
DBE	DAYTONA BEACH EASTERN WF			65,156						65,156	
DBW	DAYTONA BEACH WESTERN WF	9,720,100	7,657,400		62,377		81,186	9,782,477	7,657,400	81,186	
DEB	DELAND - BRANDYWINE										
DEL	DELTONA	10,266,000	9,005,500	5,790,100	230,380		262,373	10,496,380	9,005,500	6,052,473	3,113,285
DHH	DELAND - HOLIDAY HILLS										
DWU	DELAND	3,949,900	195,880	1,101,400				3,949,900	195,880	1,101,400	
DWW	DELAND - WOODLAND MANOR										
EDG	CITY OF EDGEWATER	910,550	300,200					910,550	300,200		
ETI	ELLWOOD TITCOMB										
FPS	FPL - SANFORD PWR PLNT										
FPT	FPL - TURNER POWER PLNT										
HDR	HACIENDA DEL RIO	19,900						19,900			
HHE	HOLLY HILL EASTERN WF										
HHW	HOLLY HILL WESTERN WF	23,891			71,462	229,415		95,353	229,415		
JKV	JOHN KNOX VILL.										
LBW	L BERESFORD WATER ASSN										
LHE	LAKE HELEN										
NGA	NATIONAL GARDENS	75,728	75,728	75,728				75,728	75,728	75,728	
NS4	NEW SMYRNA SR 44			363,710	266,600	74,416	204,378	266,600	74,416	568,088	1,183,614
NSG	NEW SMYRNA GLENCOE WF	601,480						601,480			
NSS	NEW SMYRNA SAMSULA WF				59,091	1,011,854		59,091	1,011,854		
OB4	ORMOND BEACH SR 40	226,040			66,503	71,079	71,079	292,543	71,079	71,079	207,574
OBD	ORMOND BEACH DIVISION	503,000				59,992		503,000	59,992		
OBH	ORMOND BEACH HUDSON	4,522			413,770	24,308	264,308	418,292	24,308	264,308	1,349,228
OBR	ORMOND BEACH RIMA PROP	207,570	207,570	207,570				207,570	207,570	207,570	207,574
OCC	OR. CITY CTRY VILLAGE	75,736						75,736			
OCY	ORANGE CITY	2,283,500	1,558,300	2,089,500				2,283,500	1,558,300	2,089,500	
POE	PORT ORANGE EASTERN WF										
POW	PORT ORANGE WEST PROP	6,411,300	635,980	801,270		68,920	1,428,584	6,411,300	704,900	2,229,854	1,107,467
PTB	PLANTATION BAY										
SHP	SUNSHINE HOLIDAY PK										
SMC	SHERWOOD MEDICAL CO.										
SME	SSU SUGAR MILL 1990										
SPC	SPRUCE CREEK										108,162
TCF	TOMOKA CORR. FACILITY										
TCU	TYMBER CREEK UTIL.	35,046	35,046					35,046	35,046		
TTI	THE TRAILS INC.	113,230	113,230					113,230	113,230		
VFT	V CTY - FOUR TOWNS										
VGC	V CTY GOVT COMPLEX										
VLM	V CTY - LAKE MARIE										
VTA	V CTY - TERRA ALTA										
	Total	35,427,493	19,784,834	10,494,434	1,170,182	1,539,984	2,311,908	36,597,675	21,324,818	12,806,342	7,276,903

Table A19. Volusia MIP decision model public supply utility area annual unit costs

Model ID	Public Supply Utility Area	Unit cost less interconnects			Unit cost of interconnects			Total unit costs			Nonoptimized Unit costs
		Case 3	Case 2	Case 1	Case 3	Case 2	Case 1	Case 3	Case 2	Case 1	
DBE	DAYTONA BEACH EASTERN WF		247,030	388,810				0	247,030	388,810	451,113
DBW	DAYTONA BEACH WESTERN WF	2,190,700	1,947,600	702,160				2,190,700	1,947,600	702,160	838,015
DEB	DELAND - BRANDYWINE	56,429	56,429	56,429				56,429	56,429	56,429	56,432
DEL	DELTONA	2,200,200	2,226,800	1,706,200				2,200,200	2,226,800	1,706,200	1,565,969
DHH	DELAND - HOLIDAY HILLS	22,794	22,794	22,794				22,794	22,794	22,794	22,795
DWU	DELAND	490,260	629,070	885,150				490,260	629,070	885,150	435,148
DWW	DELAND - WOODLAND MANOR	10,211	10,211	10,211				10,211	10,211	10,211	10,211
EDG	CITY OF EDGEWATER	565,540	520,600	454,410				565,540	520,600	454,410	266,258
ETI	ELLWOOD TITCOMB	5,741	5,741	5,741				5,741	5,741	5,741	5,741
FPS	FPL - SANFORD PWR PLNT	19,898	19,898	19,898				19,898	19,898	19,898	19,899
FPT	FPL - TURNER POWER PLNT	5,978	5,978	5,978				5,978	5,978	5,978	5,978
HDR	HACIENDA DEL RIO	9,189	6,401	6,401				9,189	6,401	6,401	6,401
HHE	HOLLY HILL EASTERN WF	8,690	8,690	8,690				8,690	8,690	8,690	8,691
HHW	HOLLY HILL WESTERN WF	5,268		86,787				5,268		86,787	86,792
JKV	JOHN KNOX VILL.	8,931	8,931	8,931				8,931	8,931	8,931	8,932
LBW	L BERESFORD WATER ASSN	20,639	20,639	20,639				20,639	20,639	20,639	20,640
LHE	LAKE HELEN	36,316	36,316	36,316				36,316	36,316	36,316	36,317
NGA	NATIONAL GARDENS	34,967	34,967	34,967				34,967	34,967	34,967	24,358
NS4	NEW SMYRNA SR 44			50,956	192,000		92,794	192,000	0	143,750	165,832
NSG	NEW SMYRNA GLENCOE WF	132,630	7,787	31,927				132,630	7,787	31,927	193,470
NSS	NEW SMYRNA SAMSULA WF	93,750	139,810	165,820		155,000		93,750	294,810	165,820	165,832
OB4	ORMOND BEACH SR 40	49,844						49,844	0	0	72,706
OBD	ORMOND BEACH DIVISION	425,260	358,630	436,220				425,260	358,630	436,220	174,494
OBH	ORMOND BEACH HUDSON	997			50,802	93,969	93,969	51,799	93,969	93,969	189,035
OBR	ORMOND BEACH RIMA PROP	29,081	29,081	29,081				29,081	29,081	29,081	29,082
OCC	OR. CITY CTRY VILLAGE	34,970	24,360	24,360				34,970	24,360	24,360	24,361
OCY	ORANGE CITY	424,910	248,750	485,520				424,910	248,750	485,520	229,550
POE	PORT ORANGE EASTERN WF		53,893	53,893				0	53,893	53,893	53,896
POW	PORT ORANGE WEST PROP	1,373,000	406,920	426,090			351,510	1,373,000	406,920	777,600	539,144
PTB	PLANTATION BAY	7,684	7,684	7,684				7,684	7,684	7,684	7,684
SHP	SUNSHINE HOLIDAY PK	7,941	7,941	7,941				7,941	7,941	7,941	7,942
SMC	SHERWOOD MEDICAL CO.	9,890	9,890	9,890				9,890	9,890	9,890	9,889
SME	SSU SUGAR MILL 1990	13,581	13,581	13,581				13,581	13,581	13,581	13,582
SPC	SPRUCE CREEK	25,256	25,256	25,256				25,256	25,256	25,256	25,257
TCF	TOMOKA CORR. FACILITY	14,316	14,316	14,316				14,316	14,316	14,316	14,317
TCU	TYMBER CREEK UTIL.	16,182	16,182	11,272				16,182	16,182	11,272	11,273
TTI	THE TRAILS INC.	52,284	52,284	36,420				52,284	52,284	36,420	36,422
VFT	V CTY - FOUR TOWNS	49,898	49,898	49,898				49,898	49,898	49,898	49,900
VGC	V CTY GOVT COMPLEX	12,456	12,456	12,456				12,456	12,456	12,456	12,456
VLM	V CTY - LAKE MARIE	15,956	15,956	15,956				15,956	15,956	15,956	15,957
VTA	V CTY - TERRA ALTA	33,136	33,136	33,136				33,136	33,136	33,136	33,137
	Total	8,514,775	7,335,907	6,402,185	242,802	248,969	538,273	8,757,577	7,584,876	6,940,459	5,944,905

Table A20. Volusia MIP decision model public supply utility area annual total costs

Model ID	Public Supply Utility Area	Total costs			Total nonoptimized costs	Difference between optimized and nonoptimized total costs		
		Case 3	Case 2	Case 1		Case 3	Case 2	Case 1
DBE	DAYTONA BEACH EASTERN WF	0	247,030	453,966	451,113	-451,113	-204,083	2,853
DBW	DAYTONA BEACH WESTERN WF	11,973,177	9,605,000	783,346	838,015	11,135,161	8,766,985	-54,669
DEB	DELAND - BRANDYWINE	56,429	56,429	56,429	56,432	-2	-2	-2
DEL	DELTONA	12,696,580	11,232,300	7,758,673	4,679,254	8,017,326	6,553,046	3,079,419
DHH	DELAND - HOLIDAY HILLS	22,794	22,794	22,794	22,795	-1	-1	-1
DWU	DELAND	4,440,160	824,950	1,986,550	435,148	4,005,012	389,802	1,551,402
DWW	DELAND - WOODLAND MANOR	10,211	10,211	10,211	10,211	0	0	0
EDG	CITY OF EDGEWATER	1,476,090	820,800	454,410	266,258	1,209,832	554,542	188,152
ETI	ELLWOOD TITCOMB	5,741	5,741	5,741	5,741	0	0	0
FPS	FPL - SANFORD PWR PLNT	19,898	19,898	19,898	19,899	-1	-1	-1
FPT	FPL - TURNER POWER PLNT	5,978	5,978	5,978	5,978	0	0	0
HDR	HACIENDA DEL RIO	29,089	6,401	6,401	6,401	22,688	0	0
HHE	HOLLY HILL EASTERN WF	8,690	8,690	8,690	8,691	0	0	0
HHW	HOLLY HILL WESTERN WF	100,622	229,415	86,787	86,792	13,829	142,623	-6
JKV	JOHN KNOX VILL.	8,931	8,931	8,931	8,932	0	0	0
LBW	L BERESFORD WATER ASSN	20,639	20,639	20,639	20,640	-1	-1	-1
LHE	LAKE HELEN	36,316	36,316	36,316	36,317	-2	-2	-2
NGA	NATIONAL GARDENS	110,695	110,695	110,695	24,358	86,337	86,337	86,337
NS4	NEW SMYRNA SR 44	458,600	74,416	711,838	1,349,446	-890,846	-1,275,030	-637,608
NSG	NEW SMYRNA GLENCOE WF	734,110	7,787	31,927	193,470	540,640	-185,683	-161,544
NSS	NEW SMYRNA SAMSULA WF	152,841	1,306,664	165,820	165,832	-12,991	1,140,832	-12
OB4	ORMOND BEACH SR 40	342,387	71,079	71,079	280,279	62,107	-209,200	-209,200
OBD	ORMOND BEACH DIVISION	928,260	418,622	436,220	174,494	753,766	244,128	261,726
OBH	ORMOND BEACH HUDSON	470,091	118,277	358,277	1,538,263	-1,068,172	-1,419,986	-1,179,986
OBR	ORMOND BEACH RIMA PROP	236,651	236,651	236,651	236,656	-5	-5	-5
OCC	OR. CITY CTRY VILLAGE	110,706	24,360	24,360	24,361	86,345	-1	-1
OCY	ORANGE CITY	2,708,410	1,807,050	2,575,020	229,550	2,478,860	1,577,500	2,345,470
POE	PORT ORANGE EASTERN WF	0	53,893	53,893	53,896	-53,896	-2	-2
POW	PORT ORANGE WEST PROP	7,784,300	1,111,820	3,007,454	1,646,610	6,137,690	-534,790	1,360,844
PTB	PLANTATION BAY	7,684	7,684	7,684	7,684	0	0	0
SHP	SUNSHINE HOLIDAY PK	7,941	7,941	7,941	7,942	0	0	0
SMC	SHERWOOD MEDICAL CO.	9,890	9,890	9,890	9,889	1	1	1
SME	SSU SUGAR MILL 1990	13,581	13,581	13,581	13,582	-1	-1	-1
SPC	SPRUCE CREEK	25,256	25,256	25,256	133,419	-108,163	-108,163	-108,163
TCF	TOMOKA CORR. FACILITY	14,316	14,316	14,316	14,317	-1	-1	-1
TCU	TYMBER CREEK UTIL.	51,228	51,228	11,272	11,273	39,955	39,955	0
TTI	THE TRAILS INC.	165,514	165,514	36,420	36,422	129,093	129,093	-2
VFT	V CTY - FOUR TOWNS	49,898	49,898	49,898	49,900	-2	-2	-2
VGC	V CTY GOVT COMPLEX	12,456	12,456	12,456	12,456	0	0	0
VLM	V CTY - LAKE MARIE	15,956	15,956	15,956	15,957	-1	-1	-1
VTA	V CTY - TERRA ALTA	33,136	33,136	33,136	33,137	-1	-1	-1
	Total	45,355,253	28,909,694	19,746,801	13,221,808	32,133,445	15,687,886	6,524,993

APPENDIX B: GAMS FILES

EAST-CENTRAL LP OPTIMIZATION MODEL
VOLUSIA LP OPTIMIZATION MODEL
EAST-CENTRAL MIP DECISION MODEL
VOLUSIA MIP DECISION MODEL

EAST-CENTRAL LP OPTIMIZATION MODEL GAMS FILE

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$title minimize deficits and drawdowns while meeting 2010 demands
*
* deficit optimization modeling for the east-central Florida region
*
* demand areas are wellfields
*
*  Units
*
* all flows, demands, spring discharge, and use rates are in cfd
* heads and drawdowns are in feet
* note that rcw, reclaimed water, and  reuse denote the same thing

   sets

      h  all control points / welpt1*welpt157 /

      i  public well cells / mw1*mw332 /

      j  public demand areas / alt, apo, cas, cfu, chu, cle, coc,
         con, del, ecu, eus, fdc, kis, lhe, lhy, lmy, lon, mai, oco,
         ocy, oro, ou1, ou2,ou3,ou4,ou5,ou6,ou7,ou8,ou9,o10,o11,o12,o13,
         os1,os2,os3,os4,oe1,oe2,oe3,oe4,oe5,ow1,ow2,ow3,ow4,ow5,ow6,
          ovi, pam, poi, rav, rcu, saf, san, scl, sem,
         sss, ssu, swa, swf, ucf, vol, wek, wga, wgc, wpk, wsp, zwf, zwu,
         zsu, mtd, tav, fpl, in1, in2, in3, in4, in6, hoh, eat, mon, mhn,
         cfr, min, oak, gro, in5, hho, osc, af1, dav, hai, jkv /
*     the following set is preliminary, areas were loosely defined by visual
*        inspection, County, and type
      k  agricultural areas / c1,c2,c3,c4,c5,c6,c7,c8,c9,c10,c11,c12,c13,
         c14,c15,c16,c17,c18,c19,c20,c21,c22,c23,c24,c25,c26,c27,f1,f2,f3
         f4,f5,f6,f7,l1,l2,l3,l4,l5,l6,l7,l8,l9,l10,l12,l13,l14,l15,l16,
         o1,o2,o3,o4,o5,o6,o7,o8,o9,o10,o11,s1,s2,s3,s4,s5,s6,s7,v1,v2 /

      l  springs / sprin1*sprin17 /

      m  agricultural wells / aw1*aw364 /


   table  alpha(i,h) public well influence coefficients for heads (ft squared per day)
        welpt1    welpt2    welpt3    welpt4    welpt5    welpt6    welpt7    welpt8    welpt9    welpt10

mw1   .542E-05 .578E-06 .442E-06 .105E-05 .955E-06 .172E-06 .110E-06 .132E-06 .148E-05 .102E-05
mw2   .112E-05 .893E-06 .636E-06 .119E-05 .103E-05 .223E-06 .139E-06 .167E-06 .634E-06 .571E-06
mw3   .216E-05 .658E-06 .506E-06 .148E-05 .132E-05 .189E-06 .119E-06 .145E-06 .120E-05 .105E-05
mw4   .578E-06 .211E-05 .994E-06 .731E-06 .679E-06 .294E-06 .178E-06 .218E-06 .379E

   table    gamma(i,l)  public well influence coefficients for springs (ft squared per day)
        sprin1   sprin2   sprin3   sprin4   sprin5   sprin6   sprin7   sprin8   sprin9   sprin10

mw1   .215E-07 .873E-08 .100E-07 .167E-06 .294E-06 .533E-06 .554E-06 .565E-06 .860E-08 .518E-09
mw2   .231E-07 .977E-08 .123E-07 .214E-06 .375E-06 .683E-06 .745E-06 .803E-06 .893E-08 .412E-09
mw3   .211E-07 .877E-08 .104E-07 .174E-06 .303E-06 .528E-06 .560E-06 .586E-06 .862E

   table    beta(m,h)    ag well influence coefficients for heads (ft squared per day)
        welpt1    welpt2    welpt3    welpt4    welpt5    welpt6    welpt7    welpt8    welpt9    welpt10

aw1   .276E-08 .355E-08 .473E-08 .395E-08 .395E-08 .671E-08 .789E-08 .907E-08 .237E-08 .276E-08
aw2   .294E-08 .401E-08 .508E-08 .401E-08 .428E-08 .669E-08 .749E-08 .910E-08 .268E-08 .321E-08
aw3   .323E-08 .420E-08 .549E-08 .452E-08 .452E-08 .711E-08 .775E-08 .937E-08 .291E
```

```
   table    zeta(m,l)   ag well influence coefficients for springs (ft squared per day)
       sprin1   sprin2   sprin3   sprin4   sprin5   sprin6   sprin7   sprin8   sprin9   sprin10

aw1    .118E-08  .395E-09  .395E-09  .237E-08  .316E-08  .237E-08  .237E-08  .237E-08  .789E-09  .247E-10
aw2    .107E-08  .535E-09  .401E-09  .241E-08  .321E-08  .241E-08  .241E-08  .241E-08  .535E-09  .167E-10
aw3    .969E-09  .323E-09  .485E-09  .258E-08  .323E-08  .258E-08  .258E-08  .258E-08  .646E

table dist(j,q) distance from public area j to area q in thousand feet

     alt apo cas cfu cle coc del eus kis lhe lhy lmy lon mai oe1 oe2 oe3 oe4 oe5 oco
alt    0.  43.  22. 128. 122. 126. 109. 103. 128. 131.  99.  42.  19.  14.  55.  69.  63.  98.  72.  53.
apo    43.  0.  65. 142.  87. 163. 129.  69. 141. 145. 140.  63.  54.  51.  96. 100. 102. 129. 108.  37.
cas    22.  65.  0. 126. 142. 108. 104. 123. 126. 128.  80.  45.  22.  20.  36.  59.  46.  87.  57.

table dists(i,p) distance from municipal well i to surface source p in thousand feet

     gri  xma   mon del
mw1   138. 118.  57. 114.
mw2   133. 125.  62. 118.
mw3   139. 119.  62. 119.

   parameters

 ho(h) 1988 head of control point in feet

/
welpt1  41.993435
welpt2  41.544031
welpt3  43.744708
welpt4  44.258228

   qo(i) 1988 withdrawal rate of public well in cfd

    / mw1            0
      mw2        86425
      mw3         1995
      mw4        43359
      mw5        10895

 parameter servm(j,i) service mapping   demand area j to public well i

 / alt. mw1*mw9 = 1
  apo. mw10*mw14 = 1
  cas. mw15*mw22  = 1
  cfu. mw23*mw25  = 1
parameter dm(j) demand of public area  j in cfd

 / alt  1362200
  apo  2827867
  cas  846194
  cfu  405236

     parameter mcap(i) capacity of public well i in cfd

    / mw1          600000
     mw2          200000
     mw3          200000
     mw4          500000

   parameter serva(k,m) maps ag area k to ag area m

   / c1.aw1*aw6 = 1
    c2.aw7*aw15 = 1
    c3.aw16*aw19 = 1
```

```
parameter qao(m)  1988 withdrawal rate of ag well m in cfd

 / aw1          21706
  aw2          17120
  aw3          19566

 parameter acap(k)  capacity of ag well in cfd;
 acap(k) = sum(m,serva(k,m)*qao(m)) ;

 parameter da(k)  demand of ag area in cfd;
 da(k) = sum(m,serva(k,m)*qao(m)) ;


parameter  qso(l) initial discharge rate of spring(l) cfd

/ sprin1  1.10898E+06
 sprin2  2.43490E+06
 sprin3  4.82220E+06

 parameter  cd(l) conductance of spring(l) cfd

/ sprin1  1.300E+05
 sprin2  1.300E+06
 sprin3  5.400E+06

parameter  el(l) elevation of spring(l) ft

/ sprin1  26.0
 sprin2  34.0
 sprin3  30.0
parameter  hso(l) 1988 potentiometric head of spring(l) ft

/ sprin1  34.295
 sprin2  35.819

parameter  hsno(l) nonoptimized 2010 head of spring(l) ft


/ sprin1  33.984
 sprin2  35.628


parameter qna(m) 2010 nonoptimized withdrawal rate of ag well m cfd
 /
  aw1        21706.
  aw2        17120.
  aw3        19566.
  aw4        27820.
  aw5        16203.

parameter qno(i) 2010 nonoptimized withdrawal rate of public well i (cfd)
/   mw1          554772.
  mw2            0.
  mw3            0.
  mw4          403714.


parameter harm(h) potential for vegetative harm
/
welpt1*welpt3 = 1
welpt6*welpt11 = 1
welpt27 = 1
```

```
welpt30*welpt31 = 1

parameter sm sum of public demands;
 sm=sum(j,dm(j))*0.00000748;
parameter sa sum of ag demands;
 sa=sum(k,da(k))*0.00000748;

 parameter hno(h) 2010 nonoptimized head  of control point h in ft

 /
welpt1   34.286378
welpt2   37.234242
welpt3   40.117960
welpt4   38.147063
welpt5   38.732193

parameter look(h) maximum head loss at harm areas;
look(h)$harm(h) = 100*(1 - hno(h)/ho(h));


  variables



*     withdrawal or use rates

      qp(i)    total pump rate of public well cell i
      q1(i,j)  pump rate of public well cell i
      qa(m)    pump rate of agricultural well cell m
      qd(j)    deficit for j cfd
      qd2(j)   deficit for j mgd
      qa(m)    pump rate of agricultural well cell m


*     hydrogeologic

      d(h)    drawdown at control point h
      hd(h)   head at control point h
      hs(l)   head at spring l
      ps(l)   percent of 1988 discharge at spring l

*   accounting
      fdt     sum of public deficits
      pct     percent in deficit
      Z     total drawdown plus deficits

 positive variables qp,q1,ps,qd,qa;

  equations

*
*   Hydrogeologic equations
*
      draw(h) calculate drawdown at control point h
      head(h) calculate head at control point h
      sph(l)  calculate head at spring l
      dis(l)  calculate percent of 1988 discharge at spring l
      spcap(l) lower limit of spring discharge
      ddp(h)  cap percent head loss at low harm area
      ddp2(h)  cap percent head loss  at high harm area


*
```

```
*   Municipal Water Management equations
*

    capm(i)  do not exceed capacity of municipal well i
    muntot(i) calc total pumping at mwell i
    md(j)  satisfy demand at public area j with interconnects
    md2(j)    convert deficit to mgd
    sumf     sum of  deficits
    sumf2     percent  deficits

*
*   Agricultural Water Management equations
*

    capa(m,k) do not exceed capacity of agricultural well m
    adem(k)   satisfy demand at agricultural area k
*
*


    ctot     sum of drawdowns and deficits ;


*********************************************************************
*
*   Hydrogeologic Constraints
*
*********************************************************************


*
*   Hydrogeologic Constraints on the Aquifer
*
    head(h) .. hd(h) =E=hno(h)
                      -sum(i,alpha(i,h)*(qp(i) -qno(i)))
                      -sum(m,beta(m,h)*(qa(m) -qna(m)));
    draw(h) .. d(h) =E= ho(h) -hd(h);
    ddp(h) .. d(h) =L= 0.15*ho(h) ;

    ddp2(h)$(harm(h) eq 1) .. d(h) =L= 0.00*ho(h) ;

*   Hydrogeologic Constraints on Springs

    sph(l)   .. hs(l) =E=-sum(i,gamma(i,l)*(qp(i) -qno(i))) -sum(m,zeta(m,l)*(qa(m) -qna(m)))
                  +hsno(l);
    dis(l)  ..  ps(l) =E= (hs(l) -el(l))/(hso(l) -el(l));
    spcap(l) .. hs(l) =G= 0.85*(hso(l) -el(l)) + el(l);

*********************************************************************
*
*   Water Management Constraints for Municipal Need Areas
*
*********************************************************************


* well
    capm(i)  .. qp(i) =L= mcap(i);

* total well withdrawal rate
    muntot(i) ..  qp(i) =E= sum(j,q1(i,j));

* satisfy demand at public area

 md(j) .. sum(i,q1(i,j)*servm(j,i))
          + qd(j) =G= dm(j) ;
  md2(j) .. qd2(j) =E= qd(j)*0.00000748;
```

```
* sum of public deficits
    sumf   .. fdt =E= sum(j,qd(j))*0.00000748;
    sumf2   .. pct =E= fdt/(sm+sa);

*********************************************************************
*
*   Water Management Constraints for Agricultural  Need Areas
*
*********************************************************************

    capa(m,k)$serva(k,m)  .. qa(m) =L= acap(k);

* note east-central model does not have agricultural deficits
    adem(k) .. sum(m,qa(m)$serva(k,m)) =G= da(k);

* total costs plus deficits
    ctot .. Z =E= sum(h,d(h)) +
         sum(j,qd(j)) ;

    model mincost /all/;
    option iterlim = 10000;
    option reslim = 10000;
*    option optcr = 0.001;
*   option lp=mpswrite;
    solve mincost using lp minimizing Z;

    display d.l,qd2.l,qp.l,qa.l,ps.l,fdt.l,pct.l,sa,sm,look;


   FILE F1 /op.efdd0/;
   PUT F1;
   LOOP(H, PUT hd.L(H)@15 /);
   LOOP(H, PUT d.L(H)@15 /);

   FILE F3 /op.w/;
   PUT F3;
   LOOP(I, PUT qp.L(I)@15 / );
   LOOP(m, PUT qa.L(m)@15 / );

   FILE F4 /op.s/;
   PUT F4;
   LOOP(l, PUT pS.L(l)@15 / );
   LOOP(l, PUT HS.L(l)@15 / );

   FILE F5 /op.def/;
   PUT F5;
   LOOP(j, PUT qd2.L(j)@15 / );
```

VOLUSIA LP OPTIMIZATION MODEL GAMS FILE

```
$title  minimize environmental impact, deficits and  meet 2010 demands
*
* volusia regional model
* service areas are wellfields
*
* Units
*
* all flows, demands, and use rates are in cfd
* all final costs are in dollars per year
* heads and drawdowns are in feet

        sets

         h  all control points / welpt1*welpt177 /
         i  public well cells / mw1*mw177 /
         j  public water service areas
              /dwu,hhe,hhw,occ,sme,pow,poe,del,spc,
              nss,nsg,ns4,dbe,dbw,obd,ob4,obh,obr,jkv,
              vft,vlm,vta,deb,dww,dhh,eti,edg,tcu,tti,lhe,
              hdr,nga,ocy,shp,ptb,lbw,fpt,smc,fps,tcf,vgc/
         k  agricultural areas / c1,c2,c3,c4,f1,f1a,f2,f4,f4a,f3,f5,f6,f7,f8
            f9,f10,f11,f12,f13,l1,l2,l3,g1,g2,g3,g4,g5,p1,p2,p3,
            p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,
            p19,p20,p21,n1,n2,n3,t1,t2,t3,t4,t5,v1/
         l  springs /ponce,blue,gemini/
         m  agricultural wells / aw1*aw362 /


table   alpha(i,h)    well influence coefficients for wells at control po
        welpt1   welpt2   welpt3   welpt4   welpt5   welpt6   welpt7   welpt8   welpt9   welpt10

mw1     .874E-05 .587E-05 .505E-05 .140E-05 .365E-05 .623E-06 .178E-05 .662E-05 .140E-08 .896E-09
mw2     .624E-05 .799E-05 .698E-05 .208E-05 .239E-05 .655E-06 .269E-05 .476E-05 .173E-08 .116E-08
mw3     .563E-05 .727E-05 .763E-05 .246E-05 .233E-05 .788E-06 .303E-05 .404E-05 .108E-08


  table    beta(m,h)    agricultural well influence coefficients for contro
        welpt1   welpt2   welpt3   welpt4   welpt5   welpt6   welpt7   welpt8   welpt9   welpt10

aw1    .818E-07 .756E-07 .768E-07 .396E-07 .558E-07 .483E-07 .384E-07 .694E-07 .796E-07 .606E-07
aw2    .880E-07 .818E-07 .830E-07 .421E-07 .607E-07 .520E-07 .421E-07 .750E-07 .794E-07 .604E-07
aw3    .327E-06 .296E-06 .301E-06 .150E-06 .233E-06 .213E-06 .146E-06 .274E-06 .343E-06 .263E-06

  table  gamma(i,l)    influence coeffs of public wells on springs heads
         ponce    blue     gemini

mw1     .440E-07 .441E-07 .981E-07
mw2     .480E-07 .466E-07 .951E-07
mw3     .540E-07 .443E-07 .916E-07
mw4     .655E-07 .431E-07 .835E-07

  table   zeta(m,l)    ag well influence coefficients for spring heads
        ponce    blue     gemini

aw1    .332E-06 .287E-08 .867E-08
aw2    .314E-06 .302E-08 .929E-08
aw3    .132E-06 .940E-08 .291E-07
aw4    .108E-06 .788E-08 .273E-07

Parameter
```

```
 ho(h) 1988 surficial head of control point (ft)

 /

welpt1  65.620004
welpt2  67.556763
welpt3  68.941133

high(h) control points with high potential for vegetative harm
/
 welpt19 1
 welpt176 1
/


 med(h) control points with moderate potential for vegetative harm
/

welpt20 1
welpt21 1
welpt22 1
welpt23 1
welpt24 1
     qmo(i) 1988 withdrawal rate of utility well (cfd)

/ mw1      72335.
 mw2     72335.
 mw3     144670.

   parameter servm(j,i) service mapping public i to demand area j

  / dwu. mw1*mw8 = 1
   hhe . mw9*mw13 = 1
   hhw . mw14*mw17  = 1
   occ . mw18  = 1
  parameter dm(j) demand of area j (cfd)

  / dwu 925020
   hhe 18474
   hhw 184496
   occ  51785
   sme 28872

     parameter serva(k,m) map ag well to ag area

     / c1.aw1*aw2 = 1
      c2.aw3*aw8 = 1


 parameter qna(m) 2010 nonoptimized withdrawal rate of ag well m (cfd)
       /
 aw1      6158.
 aw2      6158.
 aw3      1573.

       parameter acap(k)  capacity of ag well (cfd);
       acap(k) = sum(m,serva(k,m)*qna(m)) ;

       parameter da(k)  demand of ag area (cfd);
       da(k) = sum(m,serva(k,m)*qna(m)) ;


     parameter qno(i) 2010 nonoptimized withdrawal rate of public well i (cfd)
    /
```

```
mw1       0.
mw2    102780.
mw3    205560.
mw4    102780.
    parameter mcap(i) capacity of public well (cfd)
   /
mw1    300000.
mw2    302780.
mw3    305560.
mw4    302780.
mw5    302780.

  parameter hno(h) 2010 nonoptimized surficial head value of control point h (cfd)
 /
welpt1  63.467080
welpt2  65.509538
welpt3  67.034249
welpt4  72.771046
parameter sm sum of public demands;
 sm=sum(j,dm(j))*0.00000748;
parameter sa sum of ag demands;
 sa=sum(k,da(k))*0.00000748;


parameter hso(l) 1988 spring head
/ponce  4.890709
blue   2.42100
gemini  12.01101 /;

parameter hsno(l) 2010 nonopt spring head
/ponce   4.815960
blue   2.26777859
gemini  10.365401 /;

parameter el(l)  spring elevation
/ponce 1.0
blue   1.0
gemini 1.0 /;
dno(h) = ho(h)-hno(h);
parameter dnp(h) nonoptimized percent head loss;
dnp(h) = 100.*dno(h)/ho(h);


parameter look(h) maximum head loss at harm areas;
look(h)$(med(h) or high(h)) = 100*(1 - hno(h)/ho(h));
  variables


*    withdrawal or use rates
     qd(j)   deficit of public  area j cfd
     qd2(j)   deficit of public  area j mgd
     qad(k)  deficit of ag area k cfd
     qad2(k)   deficit of ag area k mgd
     q1(i,j) use rate of public supply well cell i for  need area j
     qp(i)   total pump rate of public  well  i
     qa(m)   pump rate of agricultural well cell m

*    hydrogeologic


     hd(h) drawdown at control point h
     d(h)  drawdown at control point h
     hs(l) head at spring l
     sd(l) discharge at spring l
```

```
*    qs(l) percent of 1988 discharge at spring l

*    accounting
     si   sum of interconnects
     sf   sum of public deficits
     td   total deficit
     sfa  sum of ag deficits
     pct  percent public in deficit
     pct2  percent ag in deficit
     pct3  percent total in deficit

      Z    total drawdown plus deficits

     positive variables  qp, qa,qd,qad,  q1;

  equations

*
*   Hydrogeologic equations
*
    draw(h)  calculate drawdown at control point h
    head(h)  calculate drawdown at control point h
    spring(l) calculate spring head at spring l
    sl(l) calculate discharge at spring l
    ddph(h)  cap head loss in high harm area
    ddpm(h)  cap head loss in moderate harm area
   ddpl(h)  cap head loss in low harm area

*   Municpal Water Management equations
*

     capm(i)     do not exceed capacity of municpal well i
     muntot(i,q)  calc total pumping at public i
     mdm(j)    satisfy demand at municpal area j
     md2(j)   satisfy demand at municpal area j
     sumf      sum of fake public sources in mgd
     sumt      sum of all deficits mgd


*    Agricultural Water Management equations

     capa(m,k)  do not exceed capacity of agricultural well m
     adem(k)  satisfy demand at agricultural area k
     md3(k)    satisfy demand at municpal area j
     sumfa   pct of ag deficit
     sumf2   pct of public deficit
     sumf3    pct of ag inf deficit
     sumf4   pct of total deficit


*    Average drawdown

     ctot    calculate total drawdown plus deficits;


*********************************************************************
*
*   Hydrogeologic Constraints
*
*********************************************************************


*
*   Hydrogeologic Constraints on the Aquifer
*
```

```
head(h) .. hd(h) =E= hno(h) -sum(i,alpha(i,h)*(qp(i) -qno(i))) -sum(m,beta(m,h)*(qa(m) -qna(m)));
spring(l) .. hs(l) =E= hsno(l) -sum(i,gamma(i,l)*(qp(i) -qno(i))) -sum(m,zeta(m,l)*(qa(m) -qna(m)));
draw(h) .. d(h) =E= ho(h) -hd(h);

sl(l) .. hs(l) =G= 0.85*(hso(l)-el(l)) + el(l);

ddpm(h)$(med(h) eq 1) .. d(h) =L= 0.02*ho(h);

ddph(h)$(high(h) eq 1) .. d(h) =L= 0.02*ho(h);

ddpl(h)$(med(h) eq 0 and high(h) eq 0) .. d(h) =L= 0.15*ho(h);

*******************************************************************
*
*  Water Management Constraints for Municipal Need Areas
*
*******************************************************************

  muntot(i,q) .. qp(i) =E= sum(j,q1(i,j));

  capm(i)$(ul(i) eq 0) .. qp(i) =L= mcap(i);

  mdm(j) .. sum(i,q1(i,j)$servm(j,i)) + qd(j) =G= dm(j);

*******************************************************************
*
*  Water Management Constraints for Agricultural  Need Areas
*
*******************************************************************

   capa(m,k)$(serva(k,m) eq 1) .. qa(m) =L= acap(k);

   adem(k) .. sum(m,qa(m)$serva(k,m)) +qad(k)  =G= da(k);

*******************************************************************
* Accounting
*******************************************************************

  md3(k) .. qad2(k) =E= qad(k)*0.00000748;
  md2(j) .. qd2(j) =E= qd(j)*0.00000748;
  sumf  .. sf =E= sum(j,qd(j)*0.00000748);
  sumfa  .. sfa =E= sum(k,qad(k)*0.00000748);
  sumt  .. td =E= sf + sfa;
  sumf2  .. pct =E= sf/(sm);
  sumf3  .. pct2 =E= sfa/(sa);
  sumf4  .. pct3 =E= (sf+sfa)/(sm+sa);

*******************************************************************
*  Objective function
*******************************************************************
    ctot .. Z =E= sum(h,d(h)) + sum(j,qd(j)) + sum(k,qad(k))

    model mincost /all/;
    option iterlim = 1000000;
    option reslim = 1000000;
    option optcr = 0.0001;
*   option lp=mpswrite;
    solve mincost using lp minimizing Z;
    display qd2.l,qad2.l,qp.l, q1.l, qa.l, d.l, dno, dnp,sm,sa,sfa.l,sf.l,td.l,pct.l,
     pct2.l,pct3.l,look ;

  FILE F1 /op.vfdd2/;
  PUT F1;
```

```
LOOP(H, PUT d.L(H)@15 /);

FILE F3 /op.w/;
PUT F3;
LOOP(I, PUT qp.L(I)@15 / );
LOOP(m, PUT qa.L(m)@15 / );
```

EAST-CENTRAL MIP DECISION MODEL GAMS FILE

```
$title minimize cost of meeting 2010 demands
*
* decision modeling for the east-central Florida region
*
* minimize cost of meeting 2010 demands
* demand areas are wellfields
*
*  Units
*
* all flows, demands, spring discharge, and use rates are in cfd
* all final costs are in dollars per year
* heads and drawdowns are in feet
* note that rcw, reclaimed water, and  reuse denote the same thing
* note that this model is for demonstration purposes only
*   many calculations that are performed herein may not be necessary
*   in future models, including intermediate calculations for distances
*   service maps, etc.

    sets

      h  all control points / welpt1*welpt157 /

      i  public well cells / mw1*mw332 /

      j  public demand areas / alt, apo, cas, cfu, chu, cle, coc,
         con, del, ecu, eus, fdc, kis, lhe, lhy, lmy, lon, mai, oco,
         ocy, oro, ou1, ou2,ou3,ou4,ou5,ou6,ou7,ou8,ou9,o10,o11,o12,o13,
         os1,os2,os3,os4,oe1,oe2,oe3,oe4,oe5,ow1,ow2,ow3,ow4,ow5,ow6,
          ovi, pam, poi, rav, rcu, saf, san, scl, sem,
         sss, ssu, swa, swf, ucf, vol, wek, wga, wgc, wpk, wsp, zwf, zwu,
         zsu, mtd, tav, fpl, in1, in2, in3, in4, in6, hoh, eat, mon, mhn,
         cfr, min, oak, gro, in5, hho, osc, af1, dav, hai, jkv /

*     the following set is preliminary, areas were loosely defined by visual
*        inspection, County, and type
      k  agricultural areas / c1,c2,c3,c4,c5,c6,c7,c8,c9,c10,c11,c12,c13,
         c14,c15,c16,c17,c18,c19,c20,c21,c22,c23,c24,c25,c26,c27,f1,f2,f3
         f4,f5,f6,f7,l1,l2,l3,l4,l5,l6,l7,l8,l9,l10,l12,l13,l14,l15,l16,
         o1,o2,o3,o4,o5,o6,o7,o8,o9,o10,o11,s1,s2,s3,s4,s5,s6,s7,v1,v2 /

      l  springs / sprin1*sprin17 /

      m  agricultural wells / aw1*aw364 /

*     the following set is very preliminary.  The actual sites and
*     quantities of available reclaimed water are not known

      n  reclaimed water sites /bti,bco,bro,bcn,bps,alt,
          alu, ams, apo, cle, eus, fmh, fdc, gro, gwl,
         kis, lan, lep, lon, mtd, oak,occ,oce, ocn, ocs, hoj, or1, orf, or2, pvm, pam,
         rsm, rcu, saf, scl, slu, whc, sen, chu, sup, str, tvc, tvw, tin,
         tht, uma, lih, vod, vof, wg1, wg2, wse, wsw, zsc,cmp,mfl,omw,oco,vls
         woo,cas,vsr,vft /

      p  surface water sources /gri, saf, tit, coc/

      alias(j,q)

   table  alpha(i,h) public well influence coefficients for heads (ft squared per day)
       welpt1   welpt2   welpt3   welpt4   welpt5   welpt6   welpt7   welpt8   welpt9   welpt10
```

```
mw1    .542E-05  .578E-06  .442E-06  .105E-05  .955E-06  .172E-06  .110E-06  .132E-06  .148E-05  .102E-05
mw2    .112E-05  .893E-06  .636E-06  .119E-05  .103E-05  .223E-06  .139E-06  .167E-06  .634E-06  .571E-06
mw3    .216E-05  .658E-06  .506E-06  .148E-05  .132E-05  .189E-06  .119E-06  .145E-06  .120E-05  .105E-05

  table    gamma(i,l)  public well influence coefficients for springs (ft squared per day)
       sprin1    sprin2    sprin3    sprin4    sprin5    sprin6    sprin7    sprin8    sprin9    sprin10

mw1    .215E-07  .873E-08  .100E-07  .167E-06  .294E-06  .533E-06  .554E-06  .565E-06  .860E-08  .518E-09
mw2    .231E-07  .977E-08  .123E-07  .214E-06  .375E-06  .683E-06  .745E-06  .803E-06  .893E-08  .412E-09

  table    beta(m,h)    ag well influence coefficients for heads (ft squared per day)
       welpt1    welpt2    welpt3    welpt4    welpt5    welpt6    welpt7    welpt8    welpt9    welpt10

aw1    .276E-08  .355E-08  .473E-08  .395E-08  .395E-08  .671E-08  .789E-08  .907E-08  .237E-08  .276E-08
aw2    .294E-08  .401E-08  .508E-08  .401E-08  .428E-08  .669E-08  .749E-08  .910E-08  .268E-08  .321E-08
aw3    .323E-08  .420E-08  .549E-08  .452E-08  .452E-08  .711E-08  .775E-08  .937E-08  .291E-08  .355E-08

  table    zeta(m,l)    ag well influence coefficients for springs (ft squared per day)
       sprin1    sprin2    sprin3    sprin4    sprin5    sprin6    sprin7    sprin8    sprin9    sprin10

aw1    .118E-08  .395E-09  .395E-09  .237E-08  .316E-08  .237E-08  .237E-08  .237E-08  .789E-09  .247E-10
aw2    .107E-08  .535E-09  .401E-09  .241E-08  .321E-08  .241E-08  .241E-08  .241E-08  .535E-09  .167E-10
aw3    .969E-09  .323E-09  .485E-09  .258E-08  .323E-08  .258E-08  .258E-08  .258E-08  .646E-09  .20

  table dist(j,q) distance from public area j to area q in miles

      alt  apo  cas  cfu  cle  coc  del  eus  kis  lhe  lhy  lmy  lon  mai  oe1  oe2  oe3  oe4  oe5  oco
alt   0.0  8.1  4.2 24.2 23.1 23.8 20.6 19.6 24.2 24.8 18.8  7.9  3.7  2.6 10.4 13.0 11.9 18.6 13.6 10.0
apo   8.1  0.0 12.3 26.8 16.5 30.9 24.4 13.0 26.6 27.5 26.4 12.0 10.3  9.6 18.2 18.9 19.3 24.3 20.5  7.0
cas   4.2 12.3  0.0 23.8 26.9 20.5 19.7 23.4 23.9 24.3 15.1  8.5  4.2  3.8  6.7 11.2  8.7 16.4 10.8 13.4
cfu  24.2 26.8 23.8  0.0 27.4 18.8 43.4 39.4  0.6 48.1 34.1 31.8 27.2 21.7 20.6 13.5 18.5 11.4 16.2 20.3


table dists(i,p) distance from municipal well i to surface source p in thousand feet

     gri  saf  tit  coc
mw1  168.  55. 153. 177.
mw2  162.  60. 159. 182.
mw3  168.  60. 153. 175.
mw4  152.  65. 169. 190.

  parameters

ho(h) 1988 head of control point in feet

/
welpt1  41.993435
welpt2  41.544031
welpt3  43.744708
welpt4  44.258228

  qo(i) 1988 withdrawal rate of public well in cfd

   / mw1        0
     mw2        86425
     mw3        1995
     mw4        43359

 parameter servm(j,i) service mapping  demand area j to public well i

 / alt. mw1*mw9 = 1
  apo. mw10*mw14 = 1
  cas. mw15*mw22  = 1
  cfu. mw23*mw25  = 1
```

```
 parameter dm(j) demand of public area  j in cfd

 / alt  1362200
  apo  2827867
  cas  846194
  cfu  405236

 parameter nmarea(j)  number of wells in public demand area

 / alt  9
  apo  5
  cas  8
  cfu  3
  chu  2
  cle  2
  coc  27
  con  4

  parameter scap(p) cfd capacity of alternate surface water source p
 /gri  4264679
  saf 41978346
  tit 22192374
  coc 16978503  /;

 parameter at3(q) potential receiver for area transfer
* these areas came up with deficits in the deficit model *
  /
con 3
del 2
lmy 2
mai 1


parameter  exist(j,q)  interconnects that already exist
 /ou5.ou7 = 1
  ou7.ou5 = 1
  ou7.ou2 = 1
  ou2.ou7 = 1
  ou2.ou4 = 1
  ou2.ou5 = 1
  ou5.ou2 = 1

   Parameter distsp(p,j) service mapping surface source p to municipal area j;
   distsp(p,j)$(nmarea(j) gt 0) = sum(i,dists(i,p)*servm(j,i))/nmarea(j);
  parameter distspm(p,j) distance in miles;
   distspm(p,j) = distsp(p,j)/5.28;
  parameter servs(p,j) service mapping surface source p to municipal area j;
   servs(p,j)$(distspm(p,j) lt 20  and dm(j) gt 668450 ) = 1;
  parameter at(j,q) denotes potential area to area transfer;
     at(j,q)$((ord(j) ne ord(q) and dm(j) gt 668450
       and dmm(q) gt 668450 and dist(j,q) lt 15  and  at3(q) gt 1)
         or (exist(j,q) eq 1) ) = 1;

   parameter atsum sum of all possible interconnects;
   atsum= sum((j,q),at(j,q)$(exist(j,q) eq 0));
   parameter stsum sum of all possible surface water transports;
   stsum= sum((p,j),servs(p,j));

      parameter mcap(i) capacity of public well i in cfd

    /
mw1  600000
mw2  385027
```

```
mw3 200000

   parameter serva(k,m) maps ag area k to ag area m

   / c1.aw1*aw6 = 1
    c2.aw7*aw15 = 1
    c3.aw16*aw19 = 1

    parameter qao(m)  1988 withdrawal rate of ag well m in cfd

    / aw1          21706
     aw2          17120
     aw3          19566

     parameter acap(k)  capacity of ag well in cfd;
     acap(k) = sum(m,serva(k,m)*qao(m)) ;

     parameter da(k)  demand of ag area in cfd;
     da(k) = sum(m,serva(k,m)*qao(m)) ;

  parameter rcap(n) capacity (cfd) of reclaimed water site
  /
* brevard county
  bti  240642
  bco  223262

  parameter  servra(n,k) service mapping rcw site n to ag area k
  /
  tvc.c12 = 1
  tvc.c13 = 1
  tvc.c14 = 1
  tvw.c22 = 1
  tvw.c24 = 1

parameter  servrm(n,j) service mapping rcw site n to  public area j

  / alt.alt = 1
  apo. apo = 1
  cle. cle = 1
  bti.coc = 1

  parameter nagarea(k) number of ag wells in the agarea
   /
 c1 6
 c2 9
 c3 4

   parameter  qso(l) initial discharge rate of spring(l) cfd

   / sprin1  1.10898E+06
    sprin2  2.43490E+06
    sprin3  4.82220E+06
    sprin4  6.11496E+06


    parameter  hso(l) 1988 potentiometric head of spring(l) ft

   / sprin1  34.295
    sprin2  35.819
    sprin3  30.860
    sprin4  29.806

    parameter  cd(l) conductance of spring(l) cfd
   / sprin1  1.300E+05
```

```
   sprin2  1.300E+06
   sprin3  5.400E+06
   sprin4  3.600E+05

  parameter  el(l) elevation of spring(l) ft

  / sprin1  26.0
   sprin2  34.0
   sprin3  30.0
   sprin4  13.0


  parameter  hsno(l) nonoptimized 2010 head of spring(l) ft
  / sprin1  33.984
   sprin2  35.628
   sprin3  30.727
   sprin4  28.251
   sprin5  33.534
   sprin6  32.898


 parameter ul(i) mgd capacities of twenty six upper layer proposed public wells
 / mw1 = 5
  mw62 = 2
  mw64 = 2
  mw65 = 2
  mw66 = 2
  mw70 = 2
  mw75 = 2
  mw76 = 4

parameter ftp(i) fixed cost of treatement plants dollardaypercfperyear
/ mw1 = 1.857
 mw11  = 1.857
  mw13  = 1.857
  mw62 = 1.415
  mw64 =  1.415

parameter ful(i) fixed cost of twenty six upper layer proposed public wells dollardaypercfperyear
 / mw1 =  0.02234
  mw62 = 0.05585
  mw64 =  0.05585
  mw65 =  0.05585
  mw66 =  0.05585
  mw70 =  0.05585

 parameter ll(i) mgd capacities of five lower layer proposed public wells
 / mw11  = 5
  mw13  = 7
  mw131 = 11

 parameter fll(i) fixed cost of  five lower layer proposed public wells dollardaypercfperyear
 / mw11  =  0.05368
  mw13  =  0.03834
  mw131 =  0.0244


    parameter qna(m) 2010 nonoptimized withdrawal rate of ag well m cfd
    /
     aw1        21706.
     aw2        17120.
     aw3        19566.
     aw4        27820.
```

```
parameter qno(i) 2010 nonoptimized withdrawal rate of public well i (cfd)
/ mw1        554772.
  mw2        0.
  mw3        0.
  mw4        403714.

parameter qai(m) initial guess for ag well withdrawal cfd
/
  aw1    125497
  aw2    0
  aw3    0
  aw4    0

parameter inter(j,q) total cost of interconnect in dollars;
inter(j,q)$(dist(j,q) le 1.5) =41115;
 inter(j,q)$(dist(j,q) gt 1.5 and dist(j,q) le 3.5) =96576;
 inter(j,q)$(dist(j,q) gt 3.5 and dist(j,q) le 5.5) =298628;
 inter(j,q)$(dist(j,q) gt 5.5 and dist(j,q) le 6.5) =384624;
parameter slope(j,q) total cost of interconnect in dollars;
 slope(j,q)$(dist(j,q) le 1.5) = 0.0137;
 slope(j,q)$(dist(j,q) gt 1.5 and dist(j,q) le 3.5) =0.0322;
 slope(j,q)$(dist(j,q) gt 3.5 and dist(j,q) le 5.5) =0.0996;
 slope(j,q)$(dist(j,q) gt 5.5 and dist(j,q) le 6.5) =0.1337;
parameter inters(p,j) total cost of interconnect in dollars;
 inters(p,j)$(distspm(p,j) le 1.5) =41115;
 inters(p,j)$(distspm(p,j) gt 1.5 and distspm(p,j) le 3.5) =96576;
 inters(p,j)$(distspm(p,j) gt 3.5 and distspm(p,j) le 5.5) =298628;
 inters(p,j)$(distspm(p,j) gt 5.5 and distspm(p,j) le 6.5) =384624;
 inters(p,j)$(distspm(p,j) gt 6.5 and distspm(p,j) le 7.5) =451782;
parameter slopes(p,j) total cost of interconnect in dollars;
 slopes(p,j)$(distspm(p,j) le 1.5) = 0.0137;
 slopes(p,j)$(distspm(p,j) gt 1.5 and distspm(p,j) le 3.5) =0.0322;
 slopes(p,j)$(distspm(p,j) gt 3.5 and distspm(p,j) le 5.5) =0.0996;
 slopes(p,j)$(distspm(p,j) gt 5.5 and distspm(p,j) le 6.5) =0.1337;

parameter sm sum of public demands;
sm = sum(j,dm(j)*0.00000748);
parameter sa sum of ag demands;
sa = sum(k,da(k)*0.00000748);


prameter fqs(p) annual fixed  cost per flow rate of surface source in dollars
 /gri 2.344
*  saf 4.142
*  saf 3.3606
  saf 3.1122
  tit 3.939
  coc 3.939 /;
 parameter uqs(p) annual unit  cost per flow rate of surface source in dollars
 /gri 0.344
  saf 0.53
  tit 0.53
  coc 0.53 /;

*nonoptimized costs for comparison
 parameter cno nonoptimized costs;
   cno = sum(i,0.47042*qno(i)) + sum(m,0.1229*qna(m))
                 + sum(i,(0.0164 + ful(i) + fll(i) +ftp(i))*qno(i)
                        $(ul(i) gt 0 or ll(i) gt 0));

 parameter hno(h) 2010 nonoptimized head  of control point h in ft
 /
welpt1   34.286378
```

```
welpt2   37.234242
welpt3   40.117960

 parameter harm(h) potential for vegetative harm
  /
 welpt1 1
 welpt2 1
 welpt3 1
 welpt4 1
 welpt5 1
 welpt6 1
 welpt7 1

   variables


*     binaries

      y2(j,q)  binary for an interconnect public area j supplies  area q
      ysp(p,j) binary for new connection (surface source p to public area j)

*     withdrawal or use rates

      qp(i)    total pump rate of public well cell i
      q1(i,j)  pump rate of public well cell i
      q2(j,q)  area to area transfer from area j to area q
      q22(j,q) new interconnect transfer (mgd)
      q23(j,q) existing transfer (mgd)
      qa(m)    pump rate of agricultural well cell m
      qr(n)    total reuse rate from rcw site n
      qr2(n)   total reuse rate mgd from rcw site n  to ag area
      qa(m)    pump rate of agricultural well cell m
      qra(n,k) reuse rate cfd from rcw site n to ag area k
      qra2(n,k) reuse rate mgd from rcw site n to ag area k
      qrp(n,j) reuse rate from rcw site n to public area j
      qr(n)    total reuse rate from rcw site n
      qs(p)    use rate of surface water source p cfd
      qs2(p)   use rate of surface water source p mgd
      qqs(p,j) use rate of surface source p to public area j
      qqs2(p,j) use rate of surface source p to public area j

*     hydrogeologic

      d(h)     drawdown at control point h
      hd(h)    head at control point h
      hs(l)    head at spring l
      ps(l)    percent of 1988 discharge at spring l

*    accounting
      sm       sum of public demands
      fdt      sum of public deficits
      fnt      sum of interconnects
      sa       sum of ag demands
      rt       total reuse rate from rcw
      rtp      total reuse use for public areas
      rtw(j)   total use of wells per demand area
      rti(j)   total use of interconnects area j out
      rtq(q)   total use of interconnects at area q in

* costs
      fp1(j)   fixed cost of new surface source
      fp2(j)   fixed cost of new surface source connections to public areas
      fw(j)    fixed cost of well
      fic(q)   fixed cost of new public interconnect
```

```
     ds(j,q) length of new public interconnect
     fra(k)  fixed cost of treatment and line for reclaimed to ag
     frp(j)  fixed cost of treatment and line for reclaimed to public
     up(j)   unit cost of public supply area
     ui(q)   unit cost of public supply area transport
     ua(k)   unit cost of ag area
     Z       total costs

 positive variables qp,q1,q2,qa,qr,ps,qqs,qs,qra,qrp;

 qa.l(m) = qai(m);
 binary variables Y2,YSP;

 equations

*
*  Hydrogeologic equations
*
     draw(h)  calculate drawdown at control point h
     head(h)  calculate head at control point h
     sph(l)   calculate head at spring l
     dis(l)   calculate percent of 1988 discharge at spring l
     spcap(l) lower limit of spring discharge
     ddp(h)   cap percent head loss
     ddp2(h)  cap percent head loss  high harm area

*
*  Municipal Water Management equations
*
     nsmax(p)  set max flow rate for large new surface source
     nsp(p,j)  turn on new surface source connection to public if utilized
     nsp2(p,j) convert surface source use to MGD
     nsp3(j)   convert surface source use to MGD
     ssum(p)   sum of surface sources
     ss(p)     convert surface source use to MGD

     capm(i)   do not exceed capacity of municipal well i
     muntot(i) calc total pumping at mwell i
     md(j)     satisfy demand at public area j with interconnects
     n1a       flow in one direction allowed
     n1o       Only 20 interconnects may be chosen
     n2a       convert flow rate to MGD
     n2b       convert flow rate to MGD
     mc1(j,q)  turn on proposed connect from municipal well to other municipal wsa
     mc1a(j,q) turn on proposed connect from municipal well to other municipal wsa
     mc2(j,q)  set minimum flow rate for new public interconnect
     mc3(q)    sum of flows in do not exceed demands
     rtwe(j)   total use of wells per demand area
     rtis(j)   total use of interconnects area j out
     rtis2(j)  total use of interconnects at area q in
     sumin     sum of interconnects

*
*  Agricultural Water Management equations
*

     capa(m,k) do not exceed capacity of agricultural well m
     adem(k)   satisfy demand at agricultural area k
*
*  Reclaimed Water Management  equations
*
     rtm       total reclaimed use for public areas
     cr1(n)    convert reclaimed to mgd
     cr2(n,k)  convert reclaimed to ag to mgd
```

```
    newcrm(j,n) turn on proposed connect from mun area j to rcw site n
    rtot       total reclaimed use
    capr(n)    do not exceed capacity of reclaimed water site n
    rlim(j)    limit fraction of total public demand for reclaimed use

    newcr(k,n) turn on proposed connect from ag area k to rcw site n
    nrcw(n)    calculate total reclaimed water use from source n

*   Costs

*  cost constraint equations

    ssp1(j)   fixed cost of surface water
    ssp2(j)   fixed cost of surface water
    suwe(j)   new well fixed cost
    snws(q)   new public to public interconnect fixed cost
    dst(j,q)  total distance of public interconnect fixed cost
    sconrag(k) fixed interconnect cost for reclaimed to ag
    sconrm(j) fixed interconnect cost for reclaimed to public
    upun(j)   unit costs for public supply utility area j
    ut(q)     unit costs for public transport to area q
    uag(k)    unit costs for ag area k

    ctot      sum of all costs;


**********************************************************************
*  Hydrogeologic Constraints
**********************************************************************
*
*  Hydrogeologic Constraints on the Aquifer
    head(h) .. hd(h) =E=hno(h)
                      -sum(i,alpha(i,h)*(qp(i) -qno(i)))
                      -sum(m,beta(m,h)*(qa(m)$(ord(m) le 145)
                          + qai(m)$(ord(m) gt 145) -qna(m)));
    draw(h) .. d(h) =E= ho(h) -hd(h);
    ddp(h)$(harm(h) ne 1) .. d(h) =L= 0.15*ho(h) ;
    ddp2(h)$(harm(h) eq 1) .. d(h) =L= 0.00*ho(h) ;

*  Hydrogeologic Constraints on Springs
    sph(l)  .. hs(l) =E=-sum(i,gamma(i,l)*(qp(i) -qno(i)))
             -sum(m,zeta(m,l)*(qa(m)$(ord(m) le 145)
                          +qai(m)$(ord(m) gt 145)    -qna(m)))
                 +hsno(l);
    dis(l) ..  ps(l) =E= (hs(l) -el(l))/(hso(l) -el(l));
    spcap(l) .. hs(l) =G= 0.85*(hso(l) -el(l)) + el(l);

**********************************************************************
*   Water Management Constraints for Public demand Areas
**********************************************************************

* surface water source  ( 20 MGD)
  nsmax(p) .. qs(p) =L= scap(p);

  nsp(p,j)$(servs(p,j) eq 1) ..  qqs(p,j) =L= dm(j)*ysp(p,j);
  nsp3(j) ..  sum(p,qqs(p,j)$servs(p,j)) =L= dm(j);

* well
  capm(i) .. qp(i) =L= mcap(i);

* total well withdrawal rate
  muntot(i) .. qp(i) =E= sum(j,q1(i,j));

* satisfy demand at public area
```

```
md(j) .. sum(i,q1(i,j)*servm(j,i)) + sum(q,q2(q,j)$at(q,j))
      +sum(p,servs(p,j)*qqs(p,j))  =G= dm(j) +sum(q,q2(j,q)$at(j,q));

* binary for public interconnect
  mc1(j,q)$(at(j,q) eq 1 and exist(j,q) eq 0) .. q2(j,q)$at(j,q) =L= dm(q)*Y2(j,q)$at(j,q);
  mc1a(j,q)$(at(j,q) and exist(j,q) eq 1) .. q2(j,q)$at(j,q) =L= 668450*Y2(j,q)$at(j,q);

* minimum flow rate for new public interconnect
  mc2(j,q)$(at(j,q) eq 1 and exist(j,q) eq 0) .. 534760*Y2(j,q)$at(j,q) =L= q2(j,q)$at(j,q);

* sum of flows in do not exceed demand
   mc3(q)  ..  sum(j,q2(j,q)$at(j,q)) =L= dmm(q);

* no more than 20 interconnects
  n1o .. sum((j,q),Y2(j,q)) =L= 20;

* one directional flow  public interconnect
  n1a(j,q)$(at(j,q) eq 1 ) .. Y2(j,q)$at(j,q) + Y2(q,j)$at(q,j) =L= 1;

* capacity limit public use of reclaimed water
  newcrm(j,n)$servrm(n,j)  .. qrp(n,j) =L=rcap(n);

*********************************************************************
*   Water Management Constraints for Agricultural  Need Areas
*********************************************************************

* capacity limit on wells
  capa(m,k)$(serva(k,m) and ord(m) le 145)  .. qa(m) =L= acap(k);

* satisfy ag demands
  adem(k)  ..  sum(m,(qa(m)$(serva(k,m) eq 1 and
               ord(m) le 145)
             +qai(m)$(serva(k,m) eq 1 and ord(m) gt 145))) + sum(n,qra(n,k)$servra(n,k)) =G= da(k);

* capacity limit for  ag use of reclaimed water
  newcr(k,n)$servra(n,k)  .. qra(n,k) =L=rcap(n) ;

*********************************************************************
*   Water Management Constraints for Reclaimed Water Sources
*********************************************************************

* total reclaimed water use at each reclaimed water site
    nrcw(n) .. sum(k,qra(n,k)$servra(n,k)) +sum(j,qrp(n,j)$servrm(n,j)) =E= qr(n);

* do not exceed capacity of reclaimed water site
    capr(n)  ..  qr(n) =L= rcap(n);

* total reclaimed water use from all reclaimed water sites
    rtot ..     rt =E= sum(n,qr(n));

* do not satisfy more than 0.25 of public area demand with reclaimed water
    rlim(j) ..     sum(n,qrp(n,j)$servrm(n,j)) =L= 0.25*dm(j);

*********************************************************************
*   fixed charges for new (alternative)  sources
*********************************************************************


* fixed charge of a new Upper or Lower Floridan high quality well and treatment
     suwe(j) ..  fw(j) =E= sum(i,servm(j,i)*(0.0164 + ful(i) + fll(i) +ftp(i))*qp(i)
                        $(ul(i) gt 0 or ll(i) gt 0));

* fixed cost of new connections from public wells to other water service areas
```

```
    snws(q) .. fic(q) =E= sum(j, (inter(j,q)*Y2(j,q)$(at(j,q) eq 1 and exist(j,q) eq 0)+ slope(j,q)*q2(j,q)
             $(at(j,q) eq 1 and exist(j,q) eq 0)));
    dst(j,q) .. ds(j,q) =E=  dist(j,q)*Y2(j,q)$at(j,q);

* fixed cost of a surface water source
    ssp1(j) .. fp1(j) =E= sum(p,qqs(p,j)*fqs(p)) ;

* fixed cost of lines from surface source to public demand area
    ssp2(j) .. fp2(j) =E= sum(p, (inters(p,j)*YSP(p,j) + slopes(p,j)*qqs(p,j)));

* fixed cost of reclaimed water for agricultural
    sconrag(k) .. fra(k) =E= sum(n,4.9*qra(n,k)$servra(n,k));

* fixed cost of public use of reclaimed water and lines
    sconrm(j) .. frp(j) =E= sum(n,5.85*qrp(n,j)$servrm(n,j));

*****************************************************************
* unit charges of  public area less transport
*****************************************************************

  upun(j) .. up(j) =E= sum(i,0.47042*qp(i)$servm(j,i))
             + sum(n,1.29*qrp(n,j)$servrm(n,j)) + sum(p,uqs(p)*qqs(p,j)$servs(p,j))
             + sum(p,0.38*qqs(p,j)$(distspm(p,j) gt 5));

*****************************************************************
* unit cost of  public area transport
*****************************************************************

  ut(q) ..  ui(q) =E=  sum(j, 0.38*q2(j,q)$(dist(j,q) gt 5 and at(j,q) eq 1));

*****************************************************************
* unit cost  agricultural area
*****************************************************************

   uag(k) .. ua(k) =E= sum(m,0.1229*(qa(m)$(serva(k,m) eq 1 and ord(m) le 145)
                 +qai(m)$(serva(k,m) eq 1 and ord(m) gt 145)))
                    + sum(n,1.36*qra(n,k)$servra(n,k));

*****************************************************************
* total costs
*****************************************************************

   ctot .. Z =E= sum(j,up(j)) + sum(j,fw(j)) +sum(j,frp(j))+ sum(j,fp1(j)) + sum(j,fp2(j))
       + sum(q,ui(q)) +  sum(q,fic(q)) +sum(k,fra(k)) + sum(k,ua(k)) ;

*****************************************************************
* equality constraints for accounting in mgd
*****************************************************************

* reclaimed water conversions to MGD
  cr1(n) ..     qr2(n) =E= qr(n)*0.00000748;
  cr2(n,k) ..     qra2(n,k) =E= qra(n,k)*0.00000748;
* total public use of reclaimed water

  rtm ..   rtp =E= sum((n,j),qrp(n,j)$servrm(n,j)*0.00000748) ;
* sum of public interconnects
  sumin    .. fnt =E= sum((j,q),q2(j,q)$at(j,q)*0.00000748);
* new interconnects
  n2a(j,q)$(at(j,q) eq 1 and exist(j,q) eq 0) .. q22(j,q) =E= q2(j,q)*0.00000748;
* existing interconnects
  n2b(j,q)$(at(j,q) eq 1 and exist(j,q) eq 1) .. q23(j,q) =E= q2(j,q)*0.00000748;
* total  use of interconnects from  source
  rtis(j) ..   rti(j) =E= sum(q,q2(j,q)$at(j,q)*0.00000748) ;
* total  use of interconnects to destination
```

```
rtis2(q) ..  rtq(q) =E= sum(j,q2(j,q)$at(j,q)*0.00000748) ;
* total public use of wells
 rtwe(j) ..  rtw(j) =E= sum(i,q1(i,j)$servm(j,i)*0.00000748) ;
* surface water use
 nsp2(p,j)$(servs(p,j) eq 1) ..  qqs2(p,j) =E= qqs(p,j)*0.00000748;
 ssum(p) .. qs(p) =E= sum(j,qqs(p,j)$servs(p,j));
 ss(p) .. qs2(p) =E= qs(p)*0.00000748;

   model mincost /all/;
   option iterlim = 10000;
   option reslim = 54000;
   option optcr = 0.016;
*  option lp=mpswrite;
   solve mincost using mip minimizing z;

   display d.l,qp.l,qa.l,up.l,qr2.l, qrp.l,qra2.l,
        y2.l,ysp.l,q22.l,q23.l,fic.l,qs2.l,qqs2.l,up.l,ui.l,
        ua.l,Z.l,fp1.l,fp2.l,ds.l,stsum,atsum, servs,
        rt.l,rtp.l,ps.l,fnt.l,rtw.l,rti.l,rtq.l,cno ;

  FILE F1 /op.dd/;
  PUT F1;
  LOOP(H, PUT hd.L(H)@15 /);
  LOOP(H, PUT d.L(H)@15 /);

  FILE F3 /op.w/;
  PUT F3;
  LOOP(I, PUT qp.L(I)@15 / );
  LOOP(m, PUT qa.L(m)@15 / );

  FILE F4 /op.s/;
  PUT F4;
  LOOP(l, PUT pS.L(l)@15 / );
  LOOP(l, PUT HS.L(l)@15 / );
```

VOLUSIA MIP DECISION MODEL GAMS FILE

```
$title minimize cost of meeting 2010 demands
*
* volusia regional model
* service areas are wellfields
*
* Units
*
* all flows, demands, and use rates are in cfd
* all final costs are in dollars per year
* heads and drawdowns are in feet

       sets

        h  all control points / welpt1*welpt177 /
        i  public well cells / mw1*mw177 /
        j  public water service areas
             /dwu,hhe,hhw,occ,sme,pow,poe,del,spc,
              nss,nsg,ns4,dbe,dbw,obd,ob4,obh,obr,jkv,
              vft,vlm,vta,deb,dww,dhh,eti,edg,tcu,tti,lhe,
              hdr,nga,ocy,shp,ptb,lbw,fpt,smc,fps,tcf,vgc/
        k  agricultural areas / c1,c2,c3,c4,f1,f1a,f2,f4,f4a,f3,f5,f6,f7,f8
           f9,f10,f11,f12,f13,l1,l2,l3,g1,g2,g3,g4,g5,p1,p2,p3,
           p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,
           p19,p20,p21,n1,n2,n3,t1,t2,t3,t4,t5,v1/
        l  springs /ponce,blue,gemini/
        m  agricultural wells / aw1*aw362 /
        n  reclaimed water sites /dbb,dbw,der,deb,del,edg,hhc,irh,sbs,nsb,
           obb,obo,por,sss,ssd,tmv,tcs,vdn,vft,vsc,vsr/
        p  surface water sources /saf,dld/
        alias(j,q);


table   alpha(i,h)     well influence coefficients for wells at control po
        welpt1    welpt2    welpt3    welpt4    welpt5    welpt6    welpt7    welpt8    welpt9    welpt10

mw1     .874E-05  .587E-05  .505E-05  .140E-05  .365E-05  .623E-06  .178E-05  .662E-05  .140E-08  .896E-09
mw2     .624E-05  .799E-05  .698E-05  .208E-05  .239E-05  .655E-06  .269E-05  .476E-05  .173E-08  .116E-08
mw3     .563E-05  .727E-05  .763E-05  .246E-05  .233E-05  .788E-06  .303E-05  .404E-05  .108E-08  .984E-09
mw4     .304E-05  .400E-05  .441E-05  .373E-05  .131E-05  .758E-06  .351E-05  .221E-05  .199


  table    beta(m,h)    agricultural well influence coefficients for contro
        welpt1    welpt2    welpt3    welpt4    welpt5    welpt6    welpt7    welpt8    welpt9    welpt10

aw1     .818E-07  .756E-07  .768E-07  .396E-07  .558E-07  .483E-07  .384E-07  .694E-07  .796E-07  .606E-07
aw2     .880E-07  .818E-07  .830E-07  .421E-07  .607E-07  .520E-07  .421E-07  .750E-07  .794E-07  .604E-07
aw3     .327E-06  .296E-06  .301E-06  .150E-06  .233E-06  .213E-06  .146E-06  .274E-06  .343E-06  .263E-06
aw4     .264E-06  .238E-06  .238E-06  .116E-06  .189E-06  .155E-06  .116E-06  .226E-06  .341E-06  .261E-06

  table   gamma(i,l)     influence coeffs of public wells on springs heads
        ponce     blue      gemini

mw1     .440E-07  .441E-07  .981E-07
mw2     .480E-07  .466E-07  .951E-07
mw3     .540E-07  .443E-07  .916E-07
mw4     .655E-07  .431E-07  .835E-07
```

```
   table    zeta(m,l)    ag well influence coefficients for spring heads
        ponce     blue     gemini

awl    .332E-06  .287E-08  .867E-08
aw2    .314E-06  .302E-08  .929E-08
aw3    .132E-06  .940E-08  .291E-07
aw4    .108E-06  .788E-08  .273E-07

table  dist(j,q) distance in thousand feet between demand areas

   del dbw pow dbe dwu edg ocy nsg obh obd nss ns4 hhw ob4 deb poe vft
del  0 101  83 120  46 110  19 101 138 145  74  65 124 148  69 115  27
dbw 101  0   9  19  69  92  92  83  46  50  51  46  25  46  60  37  97
pow  83  9   0  37  60  74  83  69  65  69  37  28  44  65  60  37  88
dbe 120 19  37   0  85  92 116  83  35  33  60  60  12  32  88  23 120
dwu  46 69  60  85   0 125  28 113 102 120  74  62  92 111  18 102  37

table  dists(p,j) distance in thousand feet between surface source to demand area
   del dbw pow dbe dwu edg ocy nsg obh obd nss ns4 hhw ob4 deb poe vft
saf  37 101  83 120  46 110  19 101 138 145  74  65 124 148  69 115  27
dld  46  69  60  85  10 125  28 113 102 120  74  62  92 111  18 102  37
;
    parameters



servs(p,j) map surface source to demand area
/saf.del 1
 saf.dbw 1
 saf.pow 1
 saf.dbe 1
 saf.dwu 1

 yy2(j) demand areas that have interconnect possiblities
 /dwu 1
 hhw 1
 pow 1

 y3(q) demand areas that have interconnect possiblities
 /dwu 1
 hhw 1
 pow 1

exist(j,q) existing interconnects
/obh.dbe = 1
deb.obh = 1
poe.dbe = 1
dbe.poe = 1
dbw.dbe = 1
dbe.dbw = 1
pow.poe = 1
poe.pow = 1
nsg.edg = 1
edg.nsg = 1/

 parameter at(j,q) potential for area to area transfer;
 at(j,q)$(yy2(j) eq 1 and y3(q) eq 1 and ord(j) ne ord(q) )=1;

parameters
rcap(n) mgd capacity of reclaimed water site
/
 dbb 1604000
 dbw 1336000
 del  534759
```

```
 scap(p,j) capacity for surface connection (mgd)
* this is the 2010 demand of the public area
/  saf.del 3328875
  saf.ocy 487968
  saf.edg 622600


servra(n,k) service map for  reclaimed water to agricultural area
/
  obo.f1 = 1
  deb.f1 = 1
  der.f1 = 1
  obb.f1 = 1

servrm(n,j) service map for  reclaimed water to public area
/
  dbb.dbe = 1
  dbb.dbw = 1
  dbb.hhw = 1
  dbw.dbe = 1

  ho(h) 1988 surficial head of control point (ft)

 /
welpt1   65.620004
welpt2   67.556763
welpt3   68.941133

high(h) control points with high potential for vegetative harm
/
 welpt19 1
 welpt176 1
/

 med(h) control points with moderate potential for vegetative harm
/

welpt20 1
welpt21 1
welpt22 1
welpt23 1

ul(i) new public supply utility well
/
mw33*mw43 = 1
mw62*mw74  = 1
mw77*mw78  = 1
mw85*mw87  = 1
mw120*mw121  = 1
mw123*mw134  = 1
/


     qo(i) 1988 withdrawal rate of utility well (cfd)

/ mw1     72335.
 mw2      72335.
 mw3     144670.
 mw4      72335.

  parameter servm(j,i) service mapping public i to demand area j

  / dwu. mw1*mw8 = 1
```

```
  hhe . mw9*mw13 = 1
  hhw . mw14*mw17  = 1
  occ . mw18  = 1

 parameter dm(j) demand of area j (cfd)

 / dwu 925020
  hhe 18474
  hhw 184496

parameter tp(i) fixed charge for treatment plant dollar day per cf per year
/
mw33*mw43 = 1.857
mw62*mw74  = 1.639
mw77*mw78  = 3.282
mw85*mw87  =  3.282
mw120*mw121  = 3.282
mw123*mw134  = 3.282
/;
    parameter serva(k,m) map ag well to ag area

    / c1.aw1*aw2 = 1
     c2.aw3*aw8 = 1
     c3.aw9*aw11 = 1
     c4.aw12*aw13 = 1
     f1.aw14*aw21 = 1

 parameter qna(m) 2010 nonoptimized withdrawal rate of ag well m (cfd)
     /
 aw1      6158.
 aw2      6158.
 aw3      1573.

       parameter acap(k)  capacity of ag well (cfd);
       acap(k) = sum(m,serva(k,m)*qna(m)) ;

       parameter da(k)  demand of ag area (cfd);
       da(k) = sum(m,serva(k,m)*qna(m)) ;


      parameter qno(i) 2010 nonoptimized withdrawal rate of public well i (cfd)
    /
 mw1        0.
 mw2      102780.
 mw3      205560.

 parameter qai(m)  initial guess for ag well withdrawal (cfd)
 /aw1  12316
aw2  0
aw3  9973
aw4  0

 parameter mcap(i) capacity of public well (cfd)
    /
 mw1      300000.
 mw2      302780.
 mw3      305560.


  parameter hno(h) 2010 nonoptimized surficial head value of control point h (cfd)
 /
 welpt1   63.467080
welpt2  65.509538
welpt3  67.034249
```

```
parameter distm(j,q) distance in miles between public demand areas;
distm(j,q)=dist(j,q)/5.28;
parameter distspm(p,j) distance in miles between public demand areas;
distspm(p,j)=dists(p,j)/5.28;
parameter sm sum of public demands;
sm = sum(j,dm(j)*0.00000748);
parameter sa sum of ag demands;
sa = sum(k,da(k)*0.00000748);

 parameter inter(j,q) total cost of interconnect in dollars;
  inter(j,q)$(distm(j,q) le 1.5) =20140;
  inter(j,q)$(distm(j,q) gt 1.5 and distm(j,q) le 3.5) =47308;
parameter slope(j,q) total cost of interconnect in dollars;
  slope(j,q)$(distm(j,q) le 1.5) = 0.0328;
  slope(j,q)$(distm(j,q) gt 1.5 and distm(j,q) le 3.5) =0.0769;
  slope(j,q)$(distm(j,q) gt 3.5 and distm(j,q) le 5.5) =0.2379;
  slope(j,q)$(distm(j,q) gt 5.5 and distm(j,q) le 6.5) =0.6013;
 parameter inters(p,j) total cost of interconnect in dollars;
  inters(p,j)$(distspm(p,j) le 1.5) =20140;
  inters(p,j)$(distspm(p,j) gt 1.5 and distspm(p,j) le 3.5) =47308;
  inters(p,j)$(distspm(p,j) gt 3.5 and distspm(p,j) le 5.5) =146285;
 parameter slopes(p,j) total cost of interconnect in dollars;
  slopes(p,j)$(distspm(p,j) le 1.5) = 0.0328;
  slopes(p,j)$(distspm(p,j) gt 1.5 and distspm(p,j) le 3.5) =0.0769;
  slopes(p,j)$(distspm(p,j) gt 3.5 and distspm(p,j) le 5.5) =0.2379;
parameter hso(l) 1988 spring head
/ponce  4.890709
blue  2.42100
gemini  12.01101 /;

parameter hsno(l) 2010 nonopt spring head
/ponce  4.815960
blue  2.26777859
gemini  10.365401 /;

parameter el(l)  spring elevation
/ponce 1.0
blue  1.0
gemini 1.0 /;
parameter icap(j,q) capacity of interconnect (cfd);

parameter dno(h) nonoptimized drawdowns (ft);
dno(h) = ho(h)-hno(h);
parameter dnp(h) nonoptimized percent head loss;
dnp(h) = 100.*dno(h)/ho(h);

  variables

*    binaries

     y2(j,q)  binary for an interconnect public area j supplies  area q
     ysp(p,j) binary for new connection (surface source p to public area j)

*    withdrawal or use rates
     rtw(j)   total use of wells in mgd at area j
     q2(j,q)   area to area transfer from j to q cfd
     q22(j,q)  new interconnect transfer from j to q mgd
     q23(j,q)  existing interconnect transfer from j to q mgd
     q1(i,j)  use rate of public supply well cell i for  need area j
     qp(i)    total pump rate of public  well  i
     qa(m)    pump rate of agricultural well cell m
     qra(n,k)  reuse rate from reclaimed site n to ag area k
     qra2(n,k) mgd reuse rate from reclaimed site n to ag area k
```

```
qrp(n,j) reuse rate from reclaimed site n to public area j
qrp2(n,j) mgd reuse rate from reclaimed site n to public area j
qr(n)    total reuse rate from reclaimed site n
qs(p)    use rate of surface water source p
qqs(p,j) use rate of surface source p to public area j cfd
qqs2(p,j) use rate of surface source p to public area j mgd

*   hydrogeologic

    hd(h) drawdown at control point h
    d(h) drawdown at control point h
    hs(l) head at spring l
    sd(l) discharge at spring l
*   qs(l) percent of 1988 discharge at spring l

*   accounting
    ds(j,q) length of selected interconnect
    si    sum of interconnects
    rt    total reuse rate from reclaimed
    rtp   total reuse rate for public areas

*   cost
    fp1(j)   fixed cost of new surface source
    fp2(j)   fixed cost of new surface source
    fw(j)    fixed cost of setup of well
    fic(q)   fixed cost of new public interconnect
    fra(k)   fixed cost of treatment and line for reclaimed to ag
    frm(j)   fixed cost of treatment and line for reclaimed to public
    up(j)    fixed cost of public supply area
    ua(k)    fixed cost of ag area
    fi(q)    unit cost of interconnect supplying area q
    sumin(q) sum of interconnect influx to area q

    sumout(j) sum of interonnect outflow for area j
    cno      sum of nonoptimized costs
    z       sum of costs
   positive variables  qp, qa,  q1 ,up, qs,qqs,
   qra,qrp,qr,ua,fw,ua,q2;
   binary variables y2,ysp;

 equations

*
*   Hydrogeologic equations
*
   draw(h)  calculate drawdown at control point h
   head(h)  calculate drawdown at control point h
   spring(l) calculate spring head at spring l
   sl(l)    calculate discharge at spring l
   ddph(h)  cap head loss in high harm area
   ddpm(h)  cap head loss in moderate harm area
   ddpl(h)  cap head loss in low harm area

*   Municpal Water Management equations
*
   nsmax(p)   set max flow rate for large new surface source
   nsp(p,j)   turn on new surface source connection to public if utilized
   mc1(j,q)   do not exceed capacity of interconnect
   mc2(j,q)   do not exceed capacity of interconnect
   capm(i)    do not exceed capacity of public well i
   muntot(i,q) calc total pumping at public i
   mdm(j)     satisfy demand at public demand area j
   n1(j,q)    limit flow to one direction
   rtm        total reclaimed use for public areas
```

```
    rlim(j)    limit reclaimed use at public area j

*   cost constraint equations

    ssp1(j)   fixed cost of surface water
    ssp2(j)   fixed cost of surface water
    suwe(j)   new well and treatment plant fixed cost
    snws(q)   new public to public nterconnect fixed
    sconrag(k) fixed interconnect cost for reclaimed to ag
    sconrm(j)  fixed interconnect cost for reclaimed to public
    upun(j)   unit costs for public supply utility area j
    uag(k)    unit costs for ag area k
    ut(q)     unit costs for interconnects supplying area q

*   Agricultural Water Management equations

    capa(m,k) do not exceed capacity of agricultural well m
    adem(k)   satisfy demand at agricultural area k

*   Reclaimed Water Management  equations

    capr(n)      do not exceed capacity of reclaimed water site n
    newcr(k,n)   turn on proposed connect from ag area k to reclaimed site n
    newcrm(j,n)  turn on proposed connect from public area j to reclaimed site n
    nrcw(n)      calculate total reclaimed water use from source n

* accounting

    newcr2(k,n)  MGD flow for connect from ag area k to reclaimed site n
    newcrm2(j,n) MGD flow for connect from public area j to reclaimed site n
    sq(q)        sum of interconnect influx to area q MGD
    sqi(j)       sum of interonnect outflow for area j MGD
    ssum(p)      sum of surface sources MGD
    sumi         sum of interconnects MGD
    mc1a(j,q)    convert new interconnect  to MGD
    mc1b(j,q)    convert existing interconnect  to MGD
    mc1c(j,q)    length of interconnect (for accounting)
    nsp2(p,j)    convert to MGD
    rtwe(j)      total use of wells at demand area j MGD
    rtot         total reclaimed use MGD


*    costs
     cnot    calc nonopt cost
     ctot    calculate total cost;

*******************************************************************
*
*   Hydrogeologic Constraints
*
*******************************************************************
*
*   Hydrogeologic Constraints on the Aquifer

  head(h) .. hd(h) =E= hno(h) -sum(i,alpha(i,h)*(qp(i) -qno(i))) -sum(m,beta(m,h)*(qa(m) -qna(m)));
  spring(l) .. hs(l) =E= hsno(l) -sum(i,gamma(i,l)*(qp(i) -qno(i))) -sum(m,zeta(m,l)*(qa(m) -qna(m)));
  draw(h) .. d(h) =E= ho(h) -hd(h);
  sl(l) .. hs(l) =G= 0.85*(hso(l)-el(l)) + el(l);

  ddpm(h)$(med(h) eq 1) .. d(h) =L= 0.02*ho(h);
  ddph(h)$(high(h) eq 1) .. d(h) =L= 0.02*ho(h);
  ddpl(h)$(med(h) eq 0 and high(h) eq 0) .. d(h) =L= 0.15*ho(h);

*******************************************************************
```

```
*   Water Management Constraints for public demand  areas
**********************************************************************

*  chose surface water source (20 MGD)

   nsmax(p) .. qs(p) =L= 5347600;

   nsp(p,j)$servs(p,j) ..  qqs(p,j) =L= dm(j)*ysp(p,j);

   muntot(i,q) ..  qp(i) =E= sum(j,q1(i,j));

   capm(i)  .. qp(i) =L= mcap(i);
*
* satisfy public demand
   mdm(j)  .. sum(i,q1(i,j)$servm(j,i))   + sum(q,q2(q,j)$at(q,j))
          + sum(n,servrm(n,j)*qrp(n,j)) + sum(p,servs(p,j)*qqs(p,j))
            =G= dm(j)  + sum(q,q2(j,q)$at(j,q));
*
* do not exceed demand of area to area interconnect
*
   mc1(j,q)$at(j,q) .. q2(j,q) =L= dm(j)*Y2(j,q);
   mc2(j,q)$(at(j,q) eq 1)  .. 133690*Y2(j,q) =L= q2(j,q);


*  flow is in only one direction

   n1(j,q)$at(j,q) .. Y2(j,q) + Y2(q,j) =L= 1;

   newcrm(j,n)$servrm(n,j).. qrp(n,j) =L=rcap(n);

**********************************************************************
*   Water Management Constraints for Agricultural  Need Areas
**********************************************************************

   rlim(j) ..    sum(n,qrp(n,j)$servrm(n,j)) =L= 0.25*dm(j);

   capa(m,k)$(serva(k,m) eq 1)  .. qa(m) =L= acap(k);

   adem(k)  .. sum(m,qa(m)$serva(k,m)) + sum(n,qra(n,k)$servra(n,k))   =G= da(k);

   newcr(k,n)$servra(n,k)  .. qra(n,k) =L=rcap(n);

**********************************************************************
*   Water Management Constraints for Reclaimed Water Sources
**********************************************************************

     nrcw(n) .. sum(k,qra(n,k)$servra(n,k)) +sum(j,qrp(n,j)$servrm(n,j))  =E= qr(n);

     capr(n)  ..  qr(n) =L= rcap(n);

*************************************************
* fixed charges for new sources
*************************************************
*   fixed cost of a new Upper or Lower Floridan high quality well including treatment

     suwe(j) ..  fw(j) =E= sum(i,servm(j,i)*(qp(i)*(0.0756+ tp(i)) )$ul(i)) ;

*   fixed cost of new public interconnect

     snws(q) .. fic(q) =E= sum(j, (inter(j,q)*Y2(j,q) $(at(j,q) eq 1 and exist(j,q) eq 0)
                        + slope(j,q)*q2(j,q))$(at(j,q) eq 1 and exist(j,q) eq 0));

* fixed  cost of surface source and transport to public area
     ssp1(j) .. fp1(j) =E= sum(p, 4.142*qqs(p,j));
```

```
    ssp2(j) .. fp2(j) =E= sum(p, (inters(p,j)*YSP(p,j) + slopes(p,j)*qqs(p,j)));

* fixed cost of reclaimed water for agricultural
    sconrag(k) .. fra(k) =E= sum(n,2.681*qra(n,k)$servra(n,k));

* fixed cost of reclaimed water for public
    sconrm(j) .. frm(j) =E=  sum(n,5.85*qrp(n,j)*servrm(n,j));

*************************************************
* unit charges for all sources (existing and new
*************************************************
* all public less interconnect
    upun(j) .. up(j) =E=
                  + sum(i,.4704*qp(i)$servm(j,i))
                  + sum(n,1.29*qrp(n,j)$servrm(n,j))
                  + sum(p,.53*qqs(p,j)$servs(p,j))
                  + sum(p, 0.38*qqs(p,j)$(distspm(p,j) gt 5));
* unit cost of public area interconnect

    ut(q) ..  fi(q) =E= sum(j, 0.38*q2(j,q)$(distm(j,q) gt 5));

* all agricultural
    uag(k) .. ua(k) =E=
                  + sum(m,0.1229*qa(m)$serva(k,m))
                  + sum(n,1.175*qra(n,k)$servra(n,k));

*************************************************
* all costs
*************************************************

    ctot .. Z =E= sum(j,up(j)) + sum(j,fw(j)) + sum(j,frm(j)) + sum(j,fp1(j)) + sum(j,fp2(j))
            + sum(q,fic(q))  + sum(q,fi(q)) +sum(k,fra(k))+ sum(k,ua(k))  ;

************************************************************
* equality constraints for accounting
************************************************************

*total interconnect flux to area q
   sq(q) .. sumin(q) =E= sum(j,q2(j,q)*0.00000748$at(j,q));
*total interconnect flux from area j
   sqi(j) .. sumout(j) =E= sum(q,q2(j,q)*0.00000748$at(j,q));
*sum of public reclaimed water use
   rtm ..   rtp =E= sum((n,j), 0.00000748*qrp(n,j)$servrm(n,j)) ;
* total public use of  wells
   rtwe(j) ..   rtw(j) =E= sum(i,q1(i,j)$servm(j,i)*0.00000748) ;
* total public use of  surface water
   ssum(p) ..  qs(p) =E= sum(j,qqs(p,j)$servs(p,j)*0.00000748);
* total public use of interconnects
   sumi    .. si =E= sum((j,q),q2(j,q)*0.00000748);
* public use of reclaimed water
   newcrm2(j,n)$servrm(n,j).. qrp2(n,j) =E=qrp(n,j)*0.00000748;
* agricultural use of reclaimed water
   newcr2(k,n)$servra(n,k)  .. qra2(n,k) =E=qra(n,k)*0.00000748;
* public use of surface water
   nsp2(p,j)$servs(p,j)  ..  qqs2(p,j) =E= qqs(p,j)*0.00000748;
* total use of reclaimed water
   rtot ..     rt =e= sum(n,qr(n)*0.00000748);
* new interconnect
   mc1a(j,q)$(at(j,q) and exist(j,q) eq 0).. q22(j,q) =E= q2(j,q)*0.00000748;
* existing interconnect
   mc1b(j,q)$(at(j,q) and exist(j,q) eq 1).. q23(j,q) =E= q2(j,q)*0.00000748;
* length of  interconnect
   mc1c(j,q)$at(j,q) .. ds(j,q) =E= Y2(j,q)*distm(j,q);
* nonoptimized costs
```

```
cnot .. cno =E= sum(i,.4704*qno(i)) + sum(i,(qno(i)*(0.0756+ tp(i)) )$ul(i))
          + sum(m,0.1229*qna(m));


  model mincost /all/;
  option iterlim = 10000;
  option reslim = 39000;
  option optcr = 0.01;
*  option lp=mpswrite;
  solve mincost using mip minimizing Z;
  display qp.l, q1.l, qa.l, d.l, dno, dnp, rtw.l,
       y2.l,q22.l,q23.l,ds.l,up.l,fic.l,si.l,qs.l,qqs2.l,ysp.l,qr.l,

      qra2.l,qrp2.l,rt.l,rtp.l,fi.l,z.l,fp1.l,fp2.l,sumin.l,sumout.l
       cno.l,sm,sa;


 FILE F1 /op.dd/;
 PUT F1;
 LOOP(H, PUT d.L(H)@15 /);

 FILE F3 /op.w/;
 PUT F3;
 LOOP(I, PUT qp.L(I)@15 / );
 LOOP(m, PUT qa.L(m)@15 / );
```

APPENDIX C: SUPPORTING FORTRAN AND UNIX SCRIPT CODES

RUNNING THE MODELS

SUPPORTING PROGRAMS

The following program perturbs a 'nonoptimized well withdrawal scheme' (vnew.wel) to generate perturbed well withdrawal rates (pumpinc) along with the differences between the nonoptimized and perturbed rates (wel. inc). These well files will be used to generate influence coefficients. First note that the simulation model well input files are arranged thusly:

public supply utility wells to be optimized
agricultural wells to be optimized
background wells that are not optimized

For the following codes, there are 177 public wells, 362 agricultural wells, and 852 background (nonoptimized) wells in the simulation model well input file. There are 177 control points where aquifer head is constrained.

```
*Program prw2.f

      dimension dmk(696),pcap(696)
      OPEN (UNIT=1,FILE='vnew.wel')
      OPEN (UNIT=2,FILE='wel.inc')
      OPEN (UNIT=3,FILE='pumpinc')
      OPEN (UNIT=4,FILE='mlim')
      OPEN (UNIT=41,FILE='aglim')
      OPEN (UNIT=5,FILE='mcap')
       do I=1,177  * number of public supply utility wells in the optimization process*
        read(4,*)dmk(i)
        read(5,*)pcap(i)
       enddo
       do I=1,362 * number of agricultural wells in the optimization process*
         ii=i+177
        read(41,*)dmk(ii)
       enddo
        READ(1,*)ia,ib
        read(1,*)ic
       write(2,6)ia,ib
        write(2,5)ic
       do i=1,1391
        read(1,*)il,ir,ic,po
            ppo = abs(po)
            if(pcap(i).gt.0.)ulim=pcap(i)
            if(dmk(i).lt. pcap(i))ulim= dmk(i)
             if(pcap(i).eq.0.)ulim=dmk(i)
             write(*,*)i,pcap(i),ulim
*   Perturbation scheme
            if(ppo.lt.0.25*ulim) pr =  -ulim
            if(ppo.ge.0.25*ulim.and.
     $         ppo.lt.0.5*ulim) pr =  -ulim
            if(ppo.ge.0.5*ulim.and.
     $         ppo.lt.0.75*ulim) pr = -ulim
             if(ppo.ge.0.75*ulim) pr = 0.9*po
        del=(pr)-(po)
        if(i.gt.539)pr=po
        if(i.gt.539)del=0.
```

```
    write(2,4)il,ir,ic,pr
    write(3,4)il,ir,ic,del
   enddo

4  FORMAT(3i10,f10.0)
5  FORMAT(i10)
6  FORMAT(2i10)

   STOP
   END
```

With perturbed pumping rates generated, a simulation model run must be performed for each perturbed well in the well file, or each well that will be represented the optimization model. The following UNIX script file is used to generate 539 runs of the simulation model, one for each well that is optimized. Each run uses a different well file. The first run uses a perturbed withdrawal rate for well 1 and nonperturbed well withdrawal rates for wells 2-539. The second run uses a nonperturbed well withdrawal rate for wells 1 and 3-539 and a perturbed pumping rate for well 2, and so on. All output is concatenated for later use in generating influence coefficients. Program DRUNX requires about 24 hours to run using an IBM PowerParallel SP2 computer.

```
*Program DRUNX

#!/bin/sh


PROG=drunx
WE=./wk
WELL=./new.delta
OUTPUT1=./hdout
OUTPUT2=./drain
HEAD=./ho
DR=./do

RERUN=1
 while [ $RERUN -lt 540 ]  *number of wells in the optimization process*
do
 echo "Iteration ... $RERUN"
  echo "$RERUN" > $WE
  incwe                          **executable code to  generate a new well input file for each run
 #---run modflow here
  modflow  < files10              *simulation model executable with input file list

 #---rename output file with unique names---
 cat $OUTPUT1 >>  $HEAD
 cat $OUTPUT2 >>  $DR
 rm $WE

 RERUN=`expr $RERUN + 1`

done
```

The following program is used to generate a new well file for running the simulation model, one new well file for each well to be optimized. The nonoptimized well withdrawal scheme (vnew.wel) is used with a different withdrawal rate for the particular well being perturbed at the time.

*Program incwe.f

```
   OPEN (UNIT=1,FILE='vnew.wel')
   OPEN (UNIT=2,FILE='wel.inc')
   OPEN (UNIT=20,FILE='wk')
   OPEN (UNIT=3,FILE='new.delta')
C  ------------------------------------------
    read(1,6)ia,ib
    read(1,5)ia
    read(2,6)ia,ib
    read(2,5)ia
    read(20,*)kkk
    write(3,6)ia,ib
    write(3,5)ia
    do I=1,1391 *number of wells in the simulation model well input file*
     read(1,4)il,ir,ic,po
     read(2,4)il,ir,ic,poi
     if(kkk.eq.i)write(3,4)il,ir,ic,poi
     if(kkk.ne.i)write(3,4)il,ir,ic,po
   enddo
C  ------------------------------------------
c------------------------------------------
4  FORMAT(3i10,f10.0)
5  FORMAT(i10)
6  FORMAT(2i10)
20  FORMAT(t19,g9.3)
   STOP
   END
```

Now that all of the wells have been perturbed and aquifer response generated for each perturbed well, the influence coefficients may be generated. The following program generates the change in head at a particular control point due to a change in pumping at a particular well. The following equation is used:

$$\alpha_{i,j} = [h'_j - h_j] / [Q'_i - Q_i]$$

where h′ and Q′ represent the perturbed aquifer head and perturbed well withdrawal rates while the unprimed quantities refer to the nonoptimized original aquifer head and well withdrawal rate. In the program below, the influence coefficients are given by the cfw matrix for aquifer heads and cfs for aquifer springs.

*Program inf2.f

```
C  determination of influence coefficients
C  ------------------------------------------
    Dimension pump(539),cfw(539,177),cfs(539,3)
    Dimension hin(177),din(3),hout(177)
    OPEN (UNIT=1,FILE='hno')
    OPEN (UNIT=2,FILE='dno')
    OPEN (UNIT=3,FILE='ho')
    OPEN (UNIT=4,FILE='do')
    OPEN (UNIT=5,FILE='pumpinc')
```

```
      OPEN (UNIT=7,FILE='wifm')
      OPEN (UNIT=71,FILE='wifa')
      OPEN (UNIT=8,FILE='difm')
      OPEN (UNIT=10,FILE='difa')

C  -----------------------------------------
       do i=1,539
        read(5,*)il,ir,ic,pump(i)
       enddo
        do j=1,177                              *number of control points*
        read(1,*)hin(j)
       enddo
       do i=1,539
        do j=1,177
        read(3,*)hout(j)
            cfw(i,j)=-(hin(j)-hout(j))/(pump(i))
            cfw(i,j)=abs(cfw(i,j))
        if(i.le.177)write(7,*)cfw(i,j), i, j
        if(i.gt.177)write(71,*)cfw(i,j)
       enddo
       enddo
       do i=1,3
        read(2,*)din(i)
       enddo
       do i=1,539
        do j=1,3
        read(4,*)dout
          cfs(i,j)=-(din(j) -dout)/(pump(i))
          cfs(i,j)=abs(cfs(i,j))
        if(i.le.177)write(8,*)cfs(i,j)
        if(i.gt.177)write(10,*)cfs(i,j)
       enddo
       enddo
30     continue
c-------------------------------------------
      STOP
      END
```

Now that the influence coefficients have been generated, they must be formatted so that they can be used in the GAMS for optimization. The following four programs are used to format influence coefficients. They are not completely automatic, and some formatting is still required after running the control point programs. Program zetaap.f creates the tables of agricultural well influence coefficients for control points:

```
* Program zetaap.f

C ***  PROGRAM CONVERTS FILE ***
C ***  CONTAINING THE INFLUENCE COEFFICIENTS TO A FORMAT WHICH THE  ***
C ***  GAMS PROGRAM CAN READ.  OUTPUT DATA TABLE HAS (10) COLUMNS &  ***
C ***  HAS CHARACTERS OUT TO A MAXIMUM OF 120 SPACES. ***
C
      CHARACTER*20 OLDFILE,NEWFILE
      CHARACTER*5 P(177),PT
      CHARACTER*6 W
      CHARACTER*10 A
      CHARACTER*24 Y,X
      CHARACTER*60 YY,XX
      DIMENSION V(362,177)
      open(unit=7,file='wifa')
      open(unit=8,file='paout')
```

```
   ntw=177
   nm=362
C
C
C
C
C *** DETERMINE # OF ROWS TO READ BASED ON # OF INTEREST POINTS ***
C
   ZNIP=NTW
   ZZ=AINT(ZNIP/15.01)+1.0
   NP=ZZ*15
   NIP=ZNIP
C
C *** SET UP INTEREST POINT LABELS TO BE PRINTED IN TABLE ***
C
   A='0123456789'
C
   DO 10 I=1,9
    P(I)=A(I+1:I+1)
10  CONTINUE
C
   IF (NIP.GT.9) THEN
    K=9
    DO 20 J=2,10
     DO 30 I=1,10
      K=K+1
      P(K)=A(J:J)//A(I:I)
30    CONTINUE
20   CONTINUE
C
    IF (NIP.GT.99) THEN
     K=99
     DO 40 J=2,10
      IF (K.GT.NIP) GOTO 40
      DO 45 I=1,10
       DO 50 L=1,10
        K=K+1
        P(K)=A(J:J)//A(I:I)//A(L:L)
50      CONTINUE
45     CONTINUE
40    CONTINUE
    ENDIF
   ENDIF
C
C *** WRITE HEADERS AND READ INFLUENCE CLOEFFICIENT INPUT DATA ***
C
   Y='table    beta(m,h)'
   YY='agricultural well influence coefficients for control points'
   X='TABLE     PHI(N,H)  '
   XX='WELL INFLUENCE COEFFICIENTS FOR AG WELLS-WRT DELTA QUALITY '
   PT='welpt'
C
*   OPEN (UNIT=7,FILE=OLDFILE,ACCESS='SEQUENTIAL')
*   OPEN (UNIT=8,FILE=NEWFILE,STATUS='NEW')
C
*   DO 100 II=1,2
*    IF (II.EQ.1) THEN
     WRITE (8,4000) Y,YY
     W='aw'
     NW=NM

     do I=1,362                    *number of agricultural  wells*
      do j=1,177                   * number of control points where head is constrained *
        read(7,*)v(i,j)
```

```
      enddo
      enddo
C
C *** DETERMINE # OF SETS REQUIRED BASED ON # OF INTEREST POINTS ***
C
   ZK= AINT(ZNIP/10.01)
   KZ= (ZK*10) + 1
C
C *** WRITE INFLUENCE COEFFICIENTS IN TABULAR FORM TO OUTPUT FILE. ***
C *** AMOUNT OF DATA DEPENDS ON WELL AND INTEREST POINT NUMBERS ***
C
   DO 90 L=1,KZ,10
C
C ***  WRITE WELPT# LABELS ***
C
    ASSIGN 7000 TO KK
    IF (L.EQ.1) ASSIGN 5000 TO KK
    LN=L+9
    IF (L.EQ.KZ) LN=NIP
    IF (LN.EQ.100) ASSIGN 7100 TO KK
    IF (LN.GT.100) ASSIGN 7200 TO KK
    WRITE (8,KK) (PT//P(I), I=L,LN)
    WRITE (8,*)
C
C *** WRITE WELL# LABELS AND DATA ***
C
    IF (NW.LE.9) THEN
     ASSIGN 6000 TO LL
     DO 60 I=1,NW
      IF ((LN.EQ.NIP).AND.(I.EQ.NW)) ASSIGN 6050 TO LL
      WRITE (8,LL) W,I,(V(I,J), J=L,LN)
 60   CONTINUE
    ELSE
C
     DO 65 I=1,9
      WRITE (8,6000) W,I,(V(I,J), J=L,LN)
 65   CONTINUE
C
     IF (NW.LE.99) THEN
      ASSIGN 6100 TO LL
      DO 70 I=10,NW
       IF ((LN.EQ.NIP).AND.(I.EQ.NW)) ASSIGN 6150 TO LL
       WRITE (8,LL) W,I,(V(I,J), J=L,LN)

 70    CONTINUE
     ELSE
C
      DO 75 I=10,99
       WRITE (8,6100) W,I,(V(I,J), J=L,LN)
 75    CONTINUE
C
      ASSIGN 6200 TO LL
       DO 80 I=100,NW
        IF ((LN.EQ.NIP).AND.(I.EQ.NW)) ASSIGN 8000 TO LL
        WRITE (8,LL) W,I,(V(I,J), J=L,LN)
 80     CONTINUE
C
     ENDIF
    ENDIF
C
    IF (L.EQ.KZ) WRITE (8,9000)
    WRITE (8,*)
C
 90 CONTINUE
```

```
C
   WRITE (8,*)
C
 100 CONTINUE
C
C *** CLOSE FILES ***
C
   CLOSE (UNIT=7)
   CLOSE (UNIT=8)
C
222  FORMAT (10F5.0)
500  FORMAT (F10.3,I10)
1000 FORMAT (A20)
1100 FORMAT (I10)
1150 FORMAT (F10.0)
1200 FORMAT (F10.0)
2000 FORMAT (A80)
3000 FORMAT (15E10.4)
4000 FORMAT (5X,A24,1X,A51)
5000 FORMAT (11X,10A11)
6000 FORMAT (1X,A2,I1,4X,10E11.3)
6050 FORMAT (1X,A2,I1,4X,10E11.3)
6100 FORMAT (1X,A2,I2,3X,10E11.3)
6150 FORMAT (1X,A2,I2,3X,10E11.3)
6200 FORMAT (1X,A2,I3,2X,10E11.3)
7000 FORMAT (2X,'+',8X,10A11)
7100 FORMAT (2X,'+',8X,10A11)
7200 FORMAT (2X,'+',7X,10A11)
8000 FORMAT (1x,A2,I3,2X,10E11.3)
9000 FORMAT (10X,';')
C
   END
```

Program zetamp.f generates public well influence coefficients for changes in aquifer head at control points:

```
*Program zetamp.f
C *** PROGRAM CONVERTS FILE ***
C *** CONTAINING THE INFLUENCE COEFFICIENTS TO A FORMAT WHICH THE ***
C *** GAMS PROGRAM CAN READ. OUTPUT DATA TABLE HAS (10) COLUMNS & ***
C *** HAS CHARACTERS OUT TO A MAXIMUM OF 120 SPACES. ***
C


C *** PROGRAM CONVERTS FILE CREATED BY THE SWIFT BATCH PROGRAM ***
C *** CONTAINING THE INFLUENCE COEFFICIENTS TO A FORMAT WHICH THE ***
C *** GAMS PROGRAM CAN READ. OUTPUT DATA TABLE HAS (10) COLUMNS & ***
C *** HAS CHARACTERS OUT TO A MAXIMUM OF 120 SPACES. ***
C *** THE WELL INFLUENCE COEFFICIENTS ARE CONVERTED BY PROGRAM ***
C
   CHARACTER*20 OLDFILE,NEWFILE
   CHARACTER*5 P(177),PT
   CHARACTER*6 W
   CHARACTER*10 A
   CHARACTER*24 Y,X
   CHARACTER*60 YY,XX
   DIMENSION V(177,177)
   open(unit=7,file='wifm')
   open(unit=8,file='pmout')
   ntw=177
```

```
   nm=177
C
   WRITE (6,*)
   WRITE (6,*)
   WRITE (6,*)
C
C
C *** DETERMINE # OF ROWS TO READ BASED ON # OF INTEREST POINTS ***
C
   ZNIP=NTW
   ZZ=AINT(ZNIP/15.01)+1.0
   NP=ZZ*15
   NIP=ZNIP
C
C *** SET UP INTEREST POINT LABELS TO BE PRINTED IN TABLE ***
C
   A='0123456789'
C
   DO 10 I=1,9
    P(I)=A(I+1:I+1)
 10 CONTINUE
C
   IF (NIP.GT.9) THEN
    K=9
    DO 20 J=2,10
     DO 30 I=1,10
      K=K+1
      P(K)=A(J:J)//A(I:I)
 30   CONTINUE
 20  CONTINUE
C
    IF (NIP.GT.99) THEN
     K=99
     DO 40 J=2,10
      IF (K.GT.NIP) GOTO 40
      DO 45 I=1,10
       DO 50 L=1,10
        K=K+1
        P(K)=A(J:J)//A(I:I)//A(L:L)
 50     CONTINUE
 45    CONTINUE
 40   CONTINUE
    ENDIF
   ENDIF
C
C *** WRITE HEADERS AND READ INFLUENCE CLOEFFICIENT INPUT DATA ***
C
   Y='table   alpha(i,h)'
   YY='well influence coefficients for wells at control points   '

   PT='welpt'
C
*   OPEN (UNIT=7,FILE=OLDFILE,ACCESS='SEQUENTIAL')
*   OPEN (UNIT=8,FILE=NEWFILE,STATUS='NEW')
C
*   DO 100 II=1,2
*    IF (II.EQ.1) THEN
     WRITE (8,4000) Y,YY
     W='mw'
     NW=NM

      do i=1,177
       do j=1,177
         read(7,*)v(i,j)
```

```
      enddo
     enddo
C
C *** DETERMINE # OF SETS REQUIRED BASED ON # OF INTEREST POINTS ***
C
   ZK= AINT(ZNIP/10.01)
   KZ= (ZK*10) + 1
C
C *** WRITE INFLUENCE COEFFICIENTS IN TABULAR FORM TO OUTPUT FILE. ***
C *** AMOUNT OF DATA DEPENDS ON WELL AND INTEREST POINT NUMBERS ***
C
   DO 90 L=1,KZ,10
C
C ***  WRITE WELPT# LABELS ***
C
    ASSIGN 7000 TO KK
    IF (L.EQ.1) ASSIGN 5000 TO KK
    LN=L+9
    IF (L.EQ.KZ) LN=NIP
    IF (LN.EQ.100) ASSIGN 7100 TO KK
    IF (LN.GT.100) ASSIGN 7200 TO KK
    WRITE (8,KK) (PT//P(I), I=L,LN)
    WRITE (8,*)
C
C *** WRITE WELL# LABELS AND DATA ***
C
    IF (NW.LE.9) THEN
     ASSIGN 6000 TO LL
     DO 60 I=1,NW
      IF ((LN.EQ.NIP).AND.(I.EQ.NW)) ASSIGN 6050 TO LL
      WRITE (8,LL) W,I,(V(I,J), J=L,LN)
 60   CONTINUE
    ELSE
C
     DO 65 I=1,9
      WRITE (8,6000) W,I,(V(I,J), J=L,LN)
 65   CONTINUE
C
     IF (NW.LE.99) THEN
      ASSIGN 6100 TO LL
      DO 70 I=10,NW
       IF ((LN.EQ.NIP).AND.(I.EQ.NW)) ASSIGN 6150 TO LL
       WRITE (8,LL) W,I,(V(I,J), J=L,LN)

 70    CONTINUE
     ELSE
C
      DO 75 I=10,99
       WRITE (8,6100) W,I,(V(I,J), J=L,LN)
 75    CONTINUE
C
      ASSIGN 6200 TO LL
       DO 80 I=100,NW
        IF ((LN.EQ.NIP).AND.(I.EQ.NW)) ASSIGN 8000 TO LL
        WRITE (8,LL) W,I,(V(I,J), J=L,LN)
 80     CONTINUE
C
     ENDIF
    ENDIF
C
    IF (L.EQ.KZ) WRITE (8,9000)
    WRITE (8,*)
C
 90 CONTINUE
```

```
C
   WRITE (8,*)
C
 100  CONTINUE
C
C *** CLOSE FILES ***
C
   CLOSE (UNIT=7)
   CLOSE (UNIT=8)
C
222  FORMAT (10F5.0)
500  FORMAT (F10.3,I10)
1000 FORMAT (A20)
1100 FORMAT (I10)
1150 FORMAT (F10.0)
1200 FORMAT (F10.0)
2000 FORMAT (A80)
3000 FORMAT (15E10.4)
4000 FORMAT (5X,A24,1X,A51)
5000 FORMAT (11X,10A11)
6000 FORMAT (1X,A2,I1,4X,10E11.3)
6050 FORMAT (1X,A2,I1,4X,10E11.3)
6100 FORMAT (1X,A2,I2,3X,10E11.3)
6150 FORMAT (1X,A2,I2,3X,10E11.3)
6200 FORMAT (1X,A2,I3,2X,10E11.3)
7000 FORMAT (2X,'+',8X,10A11)
7100 FORMAT (2X,'+',8X,10A11)
7200 FORMAT (2X,'+',7X,10A11)
8000 FORMAT (1x,A2,I3,2X,10E11.3)
9000 FORMAT (10X,';')
C
   END
```

Program zetams.f generates public well influence coefficients for changes in head at spring cells:

```
*Program zetams.f
C ***  PROGRAM CONVERTS FILE ***
C ***  CONTAINING THE INFLUENCE COEFFICIENTS TO A FORMAT WHICH THE  ***
C ***  GAMS PROGRAM CAN READ.  OUTPUT DATA TABLE HAS (10) COLUMNS &  ***
C ***  HAS CHARACTERS OUT TO A MAXIMUM OF 120 SPACES. ***
C


   CHARACTER*20 OLDFILE,NEWFILE
   CHARACTER*5 P(177),PT
   CHARACTER*6 W
   CHARACTER*10 A
   CHARACTER*24 Y,X
   CHARACTER*60 YY,XX
   DIMENSION V(177,3)
   open(unit=7,file='difm')
   open(unit=8,file='smout')
   ntw=3
   nm=177
C
C
C *** DETERMINE # OF ROWS TO READ BASED ON # OF INTEREST POINTS ***
C
   ZNIP=NTW
   ZZ=AINT(ZNIP/15.01)+1.0
```

```
   NP=ZZ*15
   NIP=ZNIP
C
C *** SET UP INTEREST POINT LABELS TO BE PRINTED IN TABLE ***
C
   A='0123456789'
C
   DO 10 I=1,9
    P(I)=A(I+1:I+1)
10  CONTINUE
C
   IF (NIP.GT.9) THEN
    K=9
    DO 20 J=2,10
     DO 30 I=1,10
      K=K+1
      P(K)=A(J:J)//A(I:I)
30    CONTINUE
20   CONTINUE
C
    IF (NIP.GT.99) THEN
     K=99
     DO 40 J=2,10
      IF (K.GT.NIP) GOTO 40
      DO 45 I=1,10
       DO 50 L=1,10
        K=K+1
        P(K)=A(J:J)//A(I:I)//A(L:L)
50      CONTINUE
45     CONTINUE
40    CONTINUE
    ENDIF
   ENDIF
C
C *** WRITE HEADERS AND READ INFLUENCE CLOEFFICIENT INPUT DATA ***
C
   Y='table  gamma(i,l)'
   YY='influence coeffs of public wells on springs heads'

   PT='welpt'
C
*   OPEN (UNIT=7,FILE=OLDFILE,ACCESS='SEQUENTIAL')
*   OPEN (UNIT=8,FILE=NEWFILE,STATUS='NEW')
C
*   DO 100 II=1,2
*    IF (II.EQ.1) THEN
     WRITE (8,4000) Y,YY
     W='mw'
     NW=NM

      do i=1,177
       do j=1,3
         read(7,*)v(i,j)
       enddo
      enddo
C
C *** DETERMINE # OF SETS REQUIRED BASED ON # OF INTEREST POINTS ***
C
   ZK= AINT(ZNIP/10.01)
   KZ= (ZK*10) + 1
C
C *** WRITE INFLUENCE COEFFICIENTS IN TABULAR FORM TO OUTPUT FILE. ***
C *** AMOUNT OF DATA DEPENDS ON WELL AND INTEREST POINT NUMBERS ***
C
```

```
   DO 90 L=1,KZ,10
C
C *** WRITE WELPT# LABELS ***
C
    ASSIGN 7000 TO KK
    IF (L.EQ.1) ASSIGN 5000 TO KK
    LN=L+9
    IF (L.EQ.KZ) LN=NIP
    IF (LN.EQ.100) ASSIGN 7100 TO KK
    IF (LN.GT.100) ASSIGN 7200 TO KK
    WRITE (8,KK) (PT//P(I), I=L,LN)
    WRITE (8,*)
C
C *** WRITE WELL# LABELS AND DATA ***
C
    IF (NW.LE.9) THEN
     ASSIGN 6000 TO LL
     DO 60 I=1,NW
      IF ((LN.EQ.NIP).AND.(I.EQ.NW)) ASSIGN 6050 TO LL
      WRITE (8,LL) W,I,(V(I,J), J=L,LN)
 60   CONTINUE
    ELSE
C
     DO 65 I=1,9
      WRITE (8,6000) W,I,(V(I,J), J=L,LN)
 65   CONTINUE
C
     IF (NW.LE.99) THEN
      ASSIGN 6100 TO LL
      DO 70 I=10,NW
       IF ((LN.EQ.NIP).AND.(I.EQ.NW)) ASSIGN 6150 TO LL
       WRITE (8,LL) W,I,(V(I,J), J=L,LN)

 70    CONTINUE
     ELSE
C
      DO 75 I=10,99
       WRITE (8,6100) W,I,(V(I,J), J=L,LN)
 75    CONTINUE
C
      ASSIGN 6200 TO LL
       DO 80 I=100,NW
        IF ((LN.EQ.NIP).AND.(I.EQ.NW)) ASSIGN 8000 TO LL
        WRITE (8,LL) W,I,(V(I,J), J=L,LN)
 80     CONTINUE
C
     ENDIF
    ENDIF
C
    IF (L.EQ.KZ) WRITE (8,9000)
    WRITE (8,*)
C
 90 CONTINUE
C
   WRITE (8,*)
C
 100 CONTINUE
C
C *** CLOSE FILES ***
C
   CLOSE (UNIT=7)
   CLOSE (UNIT=8)
C
222  FORMAT (10F5.0)
```

```
500  FORMAT (F10.3,I10)
1000 FORMAT (A20)
1100 FORMAT (I10)
1150 FORMAT (F10.0)
1200 FORMAT (F10.0)
2000 FORMAT (A80)
3000 FORMAT (15E10.4)
4000 FORMAT (5X,A24,1X,A51)
5000 FORMAT (11X,10A11)
6000 FORMAT (1X,A2,I1,4X,10E11.3)
6050 FORMAT (1X,A2,I1,4X,10E11.3)
6100 FORMAT (1X,A2,I2,3X,10E11.3)
6150 FORMAT (1X,A2,I2,3X,10E11.3)
6200 FORMAT (1X,A2,I3,2X,10E11.3)
7000 FORMAT (2X,'+',8X,10A11)
7100 FORMAT (2X,'+',8X,10A11)
7200 FORMAT (2X,'+',7X,10A11)
8000 FORMAT (1x,A2,I3,2X,10E11.3)
9000 FORMAT (10X,';')
C
   END
```

Program zetaas.f generates tables of influence coefficients for agricultural wells on spring heads:

```
*Program zetaas.f
C *** PROGRAM CONVERTS FILE ***
C *** CONTAINING THE INFLUENCE COEFFICIENTS TO A FORMAT WHICH THE  ***
C *** GAMS PROGRAM CAN READ. OUTPUT DATA TABLE HAS (10) COLUMNS &  ***
C *** HAS CHARACTERS OUT TO A MAXIMUM OF 120 SPACES. ***
C
   CHARACTER*5 P(362),PT
   CHARACTER*6 W
   CHARACTER*10 A
   CHARACTER*24 Y,X
   CHARACTER*60 YY,XX
   DIMENSION V(362,3)
   open(unit=7,file='difa')  *input file for influence coefficients*
   open(unit=8,file='saout')  *output file in GAMS tabular format*
   ntw=3
   nm=362
C
C *** DETERMINE # OF ROWS TO READ BASED ON # OF INTEREST POINTS ***
C
   ZNIP=NTW
   ZZ=AINT(ZNIP/15.01)+1.0
   NP=ZZ*15
   NIP=ZNIP
C
C *** SET UP INTEREST POINT LABELS TO BE PRINTED IN TABLE ***
C
   A='0123456789'
C
   DO 10 I=1,9
    P(I)=A(I+1:I+1)
 10  CONTINUE
C
   IF (NIP.GT.9) THEN
    K=9
    DO 20 J=2,10
     DO 30 I=1,10
      K=K+1
      P(K)=A(J:J)//A(I:I)
```

```
30     CONTINUE
20    CONTINUE
C
      IF (NIP.GT.99) THEN
       K=99
       DO 40 J=2,10
        IF (K.GT.NIP) GOTO 40
        DO 45 I=1,10
         DO 50 L=1,10
          K=K+1
          P(K)=A(J:J)//A(I:I)//A(L:L)
50        CONTINUE
45       CONTINUE
40     CONTINUE
      ENDIF
     ENDIF
C
C *** WRITE HEADERS AND READ INFLUENCE CLOEFFICIENT INPUT DATA ***
C
     Y='table    zeta(m,l)'
     YY='ag well influence coefficients for spring heads  '
     PT='welpt'
C
C
*     DO 100 II=1,2
*      IF (II.EQ.1) THEN
       WRITE (8,4000) Y,YY
       W='aw'
       NW=NM

        do i=1,362
         do j=1,3
           read(7,*)v(i,j)
         enddo
        enddo
C
C *** DETERMINE # OF SETS REQUIRED BASED ON # OF INTEREST POINTS ***
C
     ZK= AINT(ZNIP/10.01)
     KZ= (ZK*10) + 1
C
C *** WRITE INFLUENCE COEFFICIENTS IN TABULAR FORM TO OUTPUT FILE. ***
C *** AMOUNT OF DATA DEPENDS ON WELL AND INTEREST POINT NUMBERS ***
C
     DO 90 L=1,KZ,10
C
C ***  WRITE WELPT# LABELS ***
C
      ASSIGN 7000 TO KK
      IF (L.EQ.1) ASSIGN 5000 TO KK
      LN=L+9
      IF (L.EQ.KZ) LN=NIP
      IF (LN.EQ.100) ASSIGN 7100 TO KK
      IF (LN.GT.100) ASSIGN 7200 TO KK
      WRITE (8,KK) (PT//P(I), I=L,LN)
      WRITE (8,*)
C
C *** WRITE WELL# LABELS AND DATA ***
C
      IF (NW.LE.9) THEN
       ASSIGN 6000 TO LL
       DO 60 I=1,NW
        IF ((LN.EQ.NIP).AND.(I.EQ.NW)) ASSIGN 6050 TO LL
        WRITE (8,LL) W,I,(V(I,J), J=L,LN)
```

```
60    CONTINUE
     ELSE
C
      DO 65 I=1,9
       WRITE (8,6000) W,I,(V(I,J), J=L,LN)
65    CONTINUE
C
      IF (NW.LE.99) THEN
       ASSIGN 6100 TO LL
       DO 70 I=10,NW

        IF ((LN.EQ.NIP).AND.(I.EQ.NW)) ASSIGN 6150 TO LL
        WRITE (8,LL) W,I,(V(I,J), J=L,LN)
70      CONTINUE
      ELSE
C
       DO 75 I=10,99
        WRITE (8,6100) W,I,(V(I,J), J=L,LN)
75      CONTINUE
C
       ASSIGN 6200 TO LL
        DO 80 I=100,NW
         IF ((LN.EQ.NIP).AND.(I.EQ.NW)) ASSIGN 8000 TO LL
         WRITE (8,LL) W,I,(V(I,J), J=L,LN)
80       CONTINUE
C
      ENDIF
     ENDIF
C
     IF (L.EQ.KZ) WRITE (8,9000)
     WRITE (8,*)
C
90  CONTINUE
C
    WRITE (8,*)
C
100 CONTINUE
C
222  FORMAT (10F5.0)
500  FORMAT (F10.3,I10)
1000 FORMAT (A20)
1100 FORMAT (I10)
1150 FORMAT (F10.0)
1200 FORMAT (F10.0)
2000 FORMAT (A80)
3000 FORMAT (15E10.4)
4000 FORMAT (5X,A24,1X,A51)
5000 FORMAT (11X,10A11)
6000 FORMAT (1X,A2,I1,4X,10E11.3)
6050 FORMAT (1X,A2,I1,4X,10E11.3)
6100 FORMAT (1X,A2,I2,3X,10E11.3)
6150 FORMAT (1X,A2,I2,3X,10E11.3)
6200 FORMAT (1X,A2,I3,2X,10E11.3)
7000 FORMAT (2X,'+',8X,10A11)
7100 FORMAT (2X,'+',8X,10A11)
7200 FORMAT (2X,'+',7X,10A11)
8000 FORMAT (1x,A2,I3,2X,10E11.3)
9000 FORMAT (10X,';')
C
    END
```

Model output includes flow or use rates, costs and predictions for aquifer drawdown and spring heads. Because the unit response matrix is only an approximation, the true aquifer response to the optimal well withdrawal scheme is obtained using MODFLOW. Once the true response is obtained, comparisons may be made with a FORTRAN program.

The following program generates a comparision between the optimization model predictions and the simulation model results. Generally the predictions and true response agree within six inches except at control points where surficial heads are specified.

```
*Program compare.f
   OPEN (UNIT=1,FILE='h88') *1988 head*
   OPEN (UNIT=2,FILE='hno') * nonoptimized projected year 2010 head*
   OPEN (UNIT=3,FILE='opho') * simulation model output of heads at control points using the optimal well withdrawl
strategy*
   OPEN (UNIT=31,FILE='op.dd') *optimization model predictions for control point heads*
   OPEN (UNIT=32,FILE='op.d2') *optimization model predictions for control point drawdowns*
C  ------------------------------------------------
    write(8,*)"ddno,ddo"
    write(83,*)"h20,hop,hg"
   do i=1,177
    read(1,*)h88
    read(2,*)h20
    read(3,*)hop
    read(31,*)hg
    read(32,*)dg

 222  format(e15.5)
    read(11,*)il,ir,ic
    ddno=h88-h20
    ddo=h88-hop
    write(8,11)ddno,ddo
    write(810,11)ddno
    write(811,11)ddo
    pct=100*(ddo -dg)/ddo
    pct2=100*(hop -hg)/hop
    apct = apct + abs(pct)
    apct2 = apct2 + abs(pct2)
*    write(9,*)hop,hg,pct2
    write(9,*)hop,hg
    write(95,*)hop
    write(96,*)hg
    diff=ddo-dg
    diffi=diff*12.0
    dd2=h20-dnew
    write(100,*)dd2
    write(89,11)ddo,dg,diff,diffi,pct
     as = abs(ddo-dg)
    write(893,11)ddo,dg,as
c     write(892,19)diff,area
     write(892,19)diff
 write(82,11)ddo,dg
     write(83,11)h20,hop,hg
 11   format(5(f12.4,3x))
 19   format(f12.4,2x,e15.5) sumno+ddno
    enddo
     apct=apct/177.
     apct2=apct2/177.
     write(82,*)apct
```

```
    write(9,*)apct2
    write(*,*)sumno,sum
    write(8,*)sumno,sum
12   format(9(f9.4,3x))
   STOP
   END
```

The following section of code is from the SBAS1H subroutine of MODFLOW. It illustrates the modifications to the output that are used for all FORTRAN codes in the optimization process. In addition to compactly formatted output of pertinent head and spring data, several print statements throughout MODFLOW are commented out (though not shown) so as to save run time.

The code below is for the Volusia model.

```
*Program modflow.f
*Modifications to MODFLOW source code subroutine SBAS1H
C----VERSION 1653 15MAY1987 SBAS1H
C    ******************************************************
C    PRINT AND RECORD HEADS
C    ******************************************************
C
C      SPECIFICATIONS
C    ---------------------------------
     CHARACTER*4 TEXT
     DOUBLE PRECISION HNEW
C
     DIMENSION HNEW(NCOL,NROW,NLAY),IOFLG(NLAY,4),TEXT(4),
    1    BUFF(NCOL,NROW,NLAY), hnw(137,119,2),ibound(ncol,nrow,nlay)
C
ced
     DIMENSION xx(137),yy(119),left(119),iright(119)
     DIMENSION delr(91),delc(86),x(86),y(91),h88(86,91,3),dd(86,91)
ced
C
     DATA TEXT(1),TEXT(2),TEXT(3),TEXT(4) /'    ','    ','    ',
    1     'HEAD'/
C    ---------------------------------
C
ced

* various output files. Files Hdout and drain are required for generating the output files which are concattentated during
*the running of the unix script file which runs Modflow repeatedly, once for each well in the optimization model, they *c
*create the concatenated files ho and do which are eventually used to generate influence coefficients.

     OPEN(UNIT=422,FILE='hdout')
     OPEN(UNIT=425,FILE='drain')
     OPEN(UNIT=499,FILE='grid')
     OPEN(UNIT=423,FILE='points.prn')
     OPEN(UNIT=424,FILE='hform')

*the following lines write spring heads to a file named drain
       write(425,*)hnew(12,35,2)
       write(425,*)hnew(6,76,2)
       write(425,*)hnew(7,86,2)

*the following lines write the entire surficial head response to a file named grid
     do j=1,91
      do i=1,86
       write(499,987)j,i,hnew(i,j,1)
```

```
987  format(3x,2(i5,3x),f10.3)
    enddo
   enddo

* the following lines write the new heads at control points to a file named hdout
   do n=1,177
    read(423,*)nwr,nwc
     j=nwr
     i=nwc
     write(422,*)HNEW(i,j,1),j,i
     if(n.lt.10)write(424,223)n,HNEW(i,j,1)
     if(n.ge.10.and.n.lt.100)write(424,224)n,HNEW(i,j,1)
     if(n.ge.100)write(424,225)n,HNEW(i,j,1)
223  format('welpt',i1,2x,f11.6)
224  format('welpt',i2,2x,f11.6)
225  format('welpt',i3,2x,f11.6)
   enddo

* the following lines write the entire Upper Floridan response to file 444
   do j=1,119
     write(444,223)(hnew(i,j,1),i=1,137)
   enddo
* the following lines write the entire Lower Floridan response to file 445
   do j=1,119
     write(445,223)(hnew(i,j,2),i=1,137)
   enddo

*the following files write surficial aquifer response at control points to files 422 and 424
   do n=1,157
    read(423,*)il,nwr,nwc
     j=nwr
     i=nwc
     write(422,*)HNEW(i,j,1),j,i
     write(424,223)n,HNEW(i,j,1)
   enddo
10   format(i5, f9.2)
    sum=sum+ddo
```