Kissimmee Basin Water Supply Plan

Support Document

Volume 2

prepared by

South Florida Water Management District

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Water Supply Planning and
Development Department
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LIST OF ABBREVIATIONS AND ACRONYMS

AC-FT	acre-feet
ADAPS	Automated Data Processing System (USGS)
ADF	Average Daily Flow
AFSIRS	Agricultural Field Scale Irrigation Requirements Simulation
AGWQMN	Ambient Ground Water Quality Monitoring Network
ASR	Aquifer Storage and Recovery
ATRP	Abandoned Tank Restoration Program
AWWA	American Water Works Association
BMPs	Best Management Practices
BOD	Biochemical Oxygen Demand
BOR	Basis of Review
CARL	Conservation and Recreation Lands
C&SF Project	Central and Southern Florida Flood Control Project
CCMP	Comprehensive Conservation and Management Plan
CDF	Cumulative Distribution Function
CERP	Comprehensive Everglades Restoration Plan
COD	Chemical Oxygen Demand
CR	County Road
CUP	Consumptive Use Permit
DBP	Disinfection By-Product
D/DBPR	Disinfectant/Disinfection By-Product Rule
DEP	Florida Department of Environmental Protection
District	South Florida Water Management District
DWMP	District Water Management Plan
DWSA	District Water Supply Assessment
DWSRF	Drinking Water State Revolving Funds
DSS	Domestic Self-Supplied
EC	Electrical Conductivity
ED	Electrodialysis
EDI	Early Detection Incentive
EDR	Electrodialysis Reversal
EOC	Emergency Operations Center

ERP	Environmental Resource Permitting
ET	Evapotranspiration
F.A.C.	Florida Administrative Code
FAS	Floridan Aquifer System
FCD	Central and Southern Florida Flood Control District
FDACS	Florida Department of Agriculture and Consumer Services
FDEP	Florida Department of Environmental Protection
FDOH	Florida Department of Health
FDOT	Florida Department of Transportation
FEMA	Federal Emergency Management Agency
FFA	Florida Forever Act
FFWCC	Florida Fish and Wildlife Conservation Commission (*now known as FWC*)
FGFWFC	Florida Game and Freshwater Fish Commission
FGS	Florida Geological Survey
FDHRS	Florida Department of Health and Rehabilitative Services (*now known as FDOH*)
F.S.	Florida Statutes
FSRI	Florida Sinkhole Research Institute
FWC	Florida Wildlife Commission
FY	Fiscal Year
GAC	Granular Activated Carbon
GIS	Geographic Information System
GOH	Glades, Okeechobee, and Highlands
GPD	gallons per day
GPM	gallons per minute
IAS	Intermediate Aquifer System
IESWRT	Interim Enhanced Surface Water Treatment Rule
IFAS	Institute of Food and Agricultural Sciences
I/I	Infiltration and Inflow
KB	Kissimmee Basin
KBWSP	Kissimmee Basin Water Supply Plan
KOE	Kissimmee-Okeechobee-Everglades
LFA	Lower Floridan Aquifer
LWC	Lower West Coast

MCL	Maximum Contaminant Level
MFLs	Minimum Flows and Levels
mg/L	milligrams per liter
MGD	million gallons per day
MGY	million gallons per year
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MSE	Mean Square Error
MWC	Molecular Weight Cutoff
NGVD	National Geodetic Vertical Datum
NPDES	National Pollution Discharge Elimination System
NPL	National Priorities List
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NWI	National Wetland Inventory
OUC	Orlando Utilities Commission
O&M	Operations and Maintenance
OLS	Ordinary Least Squares
OPE	Lake Istokpoga Regulation Schedule
P2000	Preservation 2000
PACP	Pre-Approved Advanced Cleanup Program
PCPP	Petroleum Cleanup Participation Program
PDF	Probability Distribution Function
PIR	Project Implementation Report
PLRG	Pollution Loading Reduction Goals
PWS	Public Water Supply
RAA	Restricted Allocation Area
RCID	Reedy Creek Improvement District
Restudy	Central and Southern Florida Flood Control Project Comprehensive Review Study
RIB	Rapid Infiltration Basin
RO	Reverse Osmosis
RTA	Reduced Threshold Areas
RTE	Rare, Threatened, or Endangered Species
SAS	Surficial Aquifer System

SDWA	Safe Drinking Water Act
SFWMD	South Florida Water Management District
SFWMM	South Forida Water Management Model
SJRWMD	St. Johns River Water Management District
SOR	Save Our Rivers
SOW	Statement of Work
STA	Stormwater Treatment Area
SWCD	Soil and Water Conservation District
SWFWMD	Southwest Florida Water Management District
SWIM	Surface Water Improvement Management
SWTP	Surface Water Treatment Plant
TAZ	Traffic Analysis Zone
THM	Trihalomethane
TTHM	Total Trihalomethanes
TDS	Total Dissolved Solids
UFA	Upper Floridan Aquifer
UIC	Underground Injection Control
ULV	Ultra-Low Volume
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USDW	Underground Source of Drinking Water
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WCA	Water Conservation Area
WHPA	Wellhead Protection Area
WPCG	Water Planning Coordination Group
WRCA	Water Resource Caution Area
WVA	Wetlands Vulnerability Analysis
WWTP	Wastewater Treatment Plant

Chapter 1
INTRODUCTION

PURPOSE AND SCOPE

The South Florida Water Management District (SFWMD or District) has undertaken development of long-term comprehensive regional water supply plans to provide better management of South Florida's water resources. The purpose of the water supply plans is to develop strategies to meet the future water demands of urban areas and agriculture, while meeting the needs of the environment. This process identifies areas where historically used sources of water will not be adequate to meet future demands, and evaluates several water source options to meet the deficit.

The Kissimmee Basin (KB) Planning Area is one of four regional planning areas, as indicated in **Figure 1**. These regions are generally defined by hydrologic divides. Water supply plans for the planning regions have been sequenced based on their history of water shortage problems.

During the 1997 legislative session, significant amendments were made to the Florida Water Resources Act of 1972 (Chapter 373, Florida Statutes) regarding regional water supply planning. These changes required the District to prepare a Districtwide Water Supply Assessment (DWSA) by July 1, 1998, and to then prepare water supply plans for regions that are anticipated to have the potential of demand outstripping available supply by the year 2020. The District had already committed to preparing water supply plans for each of its planning regions, which cumulatively cover the entire District. The DWSA affirmed that commitment. The 1997 amendments also incorporated minimum requirements of water supply plans. In many respects, these amendments also dovetailed with an existing Executive Order, 96-297.

This document includes information, assumptions, and potential water source options to address new statutory requirements through the year 2020. Support Document information was used by the District, advisory committee, other agencies, counties, municipalities, utilities, and various interested parties in the development of the KB Water Supply Plan.

BASIS OF WATER SUPPLY PLANNING

Legal Authority and Requirements

In 1972 the Florida Legislature created the water management districts to manage the state's water resources for various purposes, including water supply. As mentioned above, the 1997 legislature adopted more specific legislation concerning the role of the water management districts in water supply planning and development. The legislative intent is to provide for human and environmental demands, thereby avoiding competition.

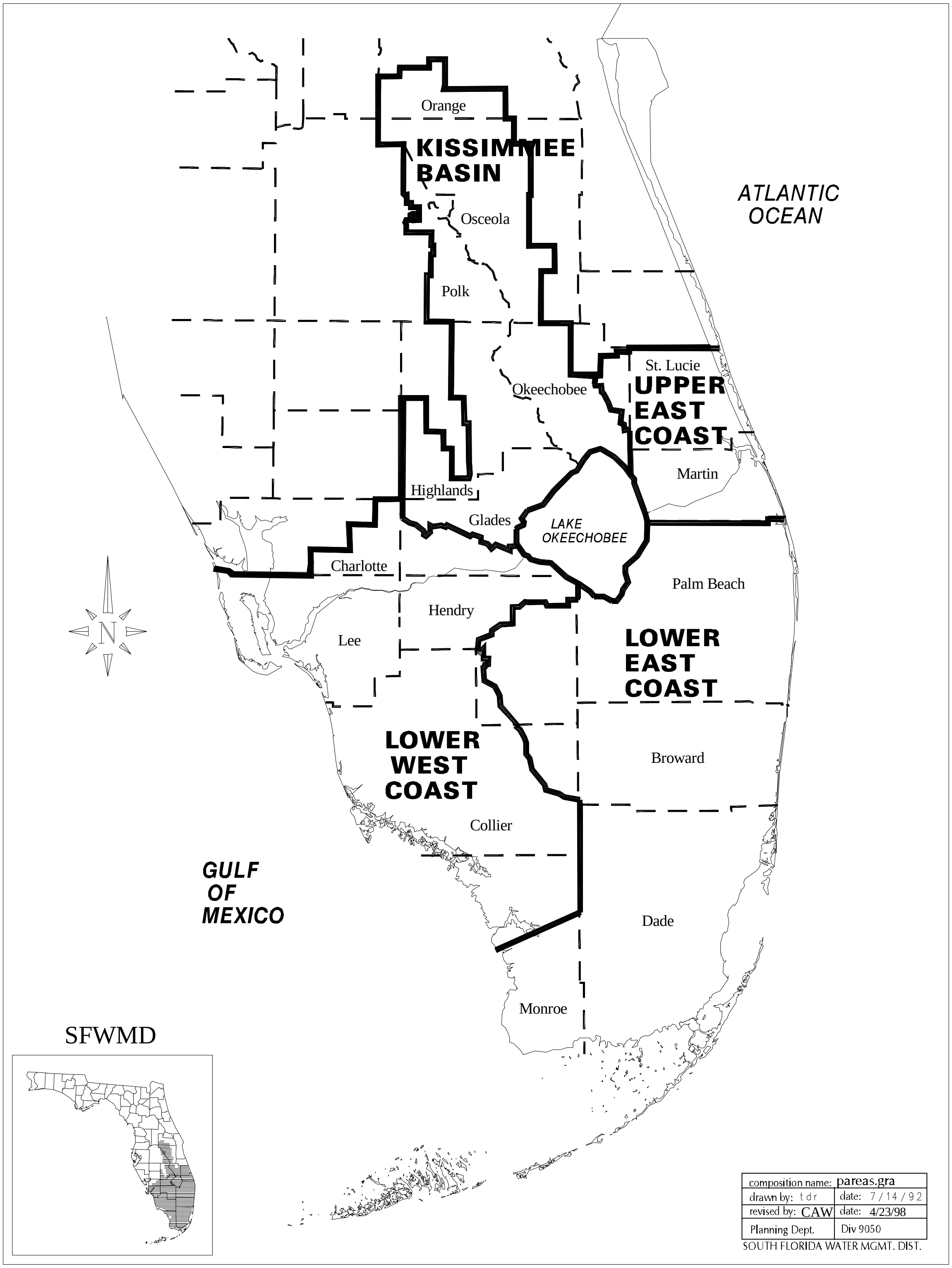

Figure 1. Regional Planning Areas.

The legal basis of the District's water supply planning program in the KB Planning Area is described in this section. Excerpts of specific Florida statutes and administrative codes cited in this section are provided in Appendix A.

Water supply planning activities were first required of the state's water management districts following adoption of the Florida Water Resources Act of 1972 (Chapter 373, Florida Statutes). The authors of “A Model Water Code” (Maloney et al., 1972), upon which much of Chapter 373 is based, theorized that proper water resource allocation could best be accomplished within a statewide, coordinated planning framework. The State Water Use Plan and the State Water Policy were the primary documents to meet this objective.

With the passage of the legislative amendments, the legislature eliminated the State Water Use Plan and provided for the development of the Florida Water Plan. The Florida Water Plan is required to include the Water Resource Implementation Rule and District Water Management Plans.

The Water Resource Implementation Rule is intended to guide the FDEP and the water management districts in implementing statutory directives. These directives are prescribed in the Water Resources Act (Chapter 373, F.S.), the Florida Air and Water Pollution Control Act (Chapter 403, F.S.), and, the State Comprehensive Plan (Chapter 187, F.S.). These statutes provide the basic authorities, directives, and policies for statewide water management, pollution control, and environmental protection. The current legal framework for water supply planning is shown in **Figure 2**.

District Water Management Plans are intended to provide comprehensive long-range guidance for the actions of the water management districts in implementing their water supply, water quality, flood protection, and natural system responsibilities under state and federal laws. In addition to other information, the water management plans are required to include a Districtwide water supply assessment. Where the assessment indicates that sources of water are not adequate to meet demands, the development of a regional water supply plan is required. The District preempted this requirement by committing to a water supply planning initiative in the early 1990s that included developing water supply plans encompassing the entire District.

Water Supply Planning Initiative

The District has undertaken a water supply planning initiative to ensure prudent management of South Florida's water resources. This initiative began with the development of a Water Supply Policy Document (1991), and continued with the District Water Management Plan (1995), Districtwide Water Supply Assessment (1998), and regional water supply plans (on going).

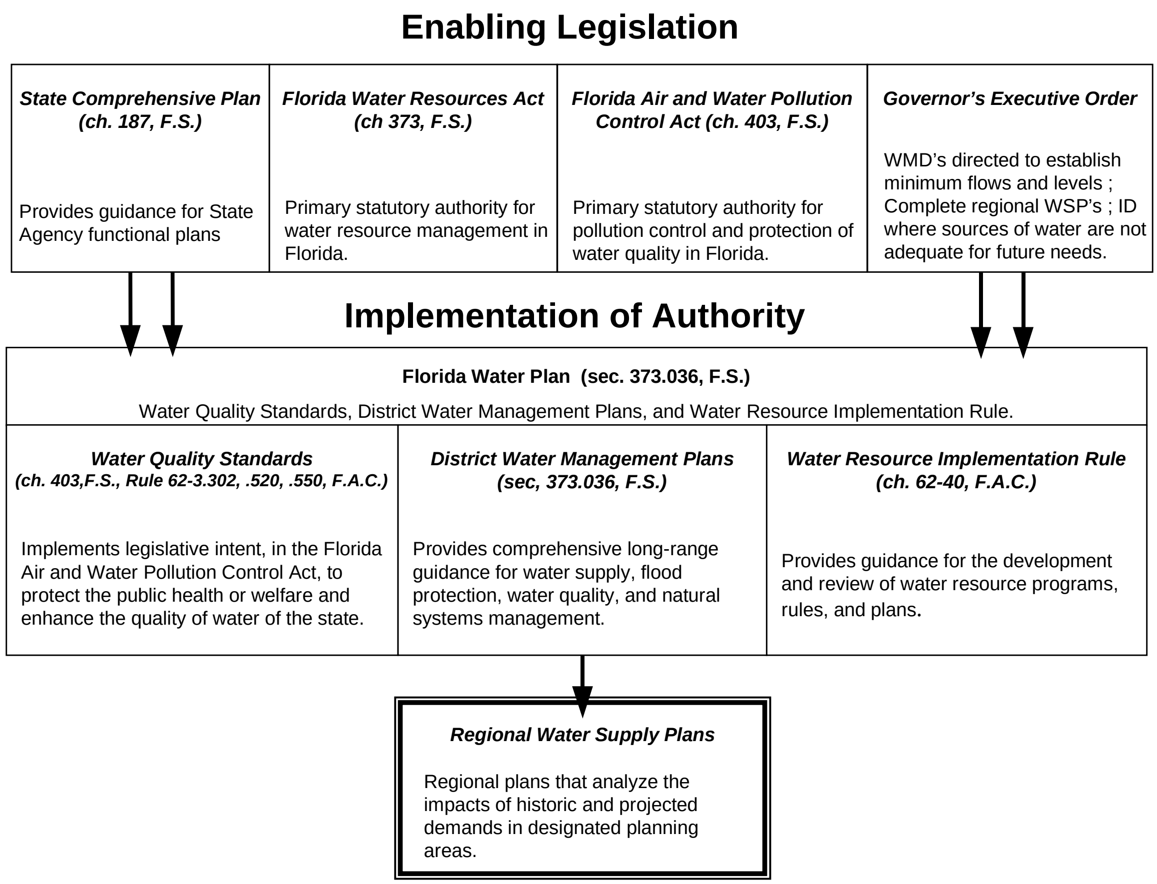

Figure 2. Legal Framework for Water Supply Planning.

Water Supply Policy Document

The District's interpretative summary of the many state statutes and rules governing the uses of surface and ground water in Florida are provided in the Water Supply Policy Document, approved in 1991. The six Water Use Directives, outlined in this document, guide the development of water supply plans:

1. Prevent wasteful, uneconomical, impractical, or unreasonable uses of the water resources.
2. Promote economic development of the water resources consistent with other directives and uses.
3. Protect and enhance environmental resources while providing appropriate levels of service for drainage, flood control, water storage, and water supply.
4. Maximize levels of service for legal users, consistent with other directives.

5. Preserve and enhance the quality of the state's ground and surface waters.
6. Develop and maintain resource monitoring networks and applied research programs (such as forecasting models) which are required to predict the quantity and quality of water available for reasonable-beneficial uses.

The KB Plan vision, goal and objectives conform to the principles established in these Directives.

District Water Management Plan

The District approved the initial District Water Management Plan (DWMP) in April 1995, which incorporated information from the Needs and Sources Document. One outcome of new legislative revisions of Section 373.036, F.S., in 1997 was that the District would be required to develop a district water management plan that is representative of an overall strategy for future planning and implementation activities. As mentioned above, the DWMP will provide a comprehensive examination of the complex issues of water supply, flood protection, water quality, and natural systems management in South Florida. Based on the 20-year planning period, the DWMP incorporates established schedules for future District planning activities.

The DWMP update (anticipated by mid-2000) includes: scientific methodologies used in the establishment of minimum flows and levels (Section 373.042, F.S.); planning region boundaries; and revised technical data and information (Section 373.0391 and Section 373.0395). Data and recommendations are included from both the KB Water Supply Plan and the Districtwide Water Supply Assessment (July 1998). The District compiles an annual DWMP progress report on project status, performance measures, and funding requirements.

Districtwide Water Supply Assessment

Section 373.036, F.S., requires water management districts to prepare assessments of water needs and supply sources. The District, through discussions with the FDEP, bifurcated this process, and prepared a Districtwide needs and sources analysis followed by regional water supply plans. The Water Supply Needs and Sources Document (July 1992) made a preliminary analysis of the District's water demand and available resources. The significant role of this initial document was to provide information to local governments pursuant to Section 373.0391 and Section 373.0395, F.S., and to facilitate the completion of the District Water Management Plan. As a current data source, the Districtwide Water Supply Assessment (July 1998) (DWSA) presents a composite of water demands for 1995, projections for 2020, and descriptions of surface water and ground water resources within each planning area. The water demands and projections within this KB Water Supply Plan Support Document were made in conjunction with the DWSA.

Regional Water Supply Plans

Regional water supply plans provide more detailed region-specific information than the water supply assessments. Water supply plans are based upon data that are related to the specific water needs, sources and environmental features of regional planning areas, and are updated every five years. Area-specific goals and objectives are developed for each region during the water supply planning process.

Incorporation of State Directives into District Water Supply Goals

The District is committed to an overall goal in water supply plans, that is derived from the State Comprehensive Plan:

> Florida shall assure the availability of an adequate supply of water for all competing uses deemed reasonable and beneficial and shall maintain the functions of natural systems and the overall present level of surface and ground water quality. Florida shall improve and restore the quality of waters not presently meeting water quality standards.

District water supply plans seek conformity to the six Water Use Directives from the Water Supply Policy Document (1991), referenced earlier in this chapter, to achieve the state's overall water supply goal. The state's policies endorse conservation of available supplies, diversification of potential supply sources, protection and enhancement of water quality, and protection of environmental resources. At the same time, the state and the District are required to meet the water resource needs of the region's population, and to provide clean water for drinking, other domestic uses, and agriculture. This goal is reflected in the planning process of the KB Water Supply Plan.

THE PLANNING PROCESS

The KB water supply planning process consists of three overlapping phases: (1) background work; (2) analysis/issue identification; and (3) solution development (**Figure 3**). Advisory committee meetings were held to facilitate the planning process. The advisory committee participated in various activities involving: initial information sharing; issue identification; vision, goal, and objective formulation; development of the plan's resource protection criteria; interpretation of modeling results; identification of possible solutions; strategy development; and, review of draft plan document.

Background Work

Background work included gathering information for the region describing water resources, rainfall patterns, natural resources, historical and projected water demands, water conservation programs, and land use coverage that could be useful in developing the plan. This information was compiled into this Support Document and Appendices. The background work also included use of three regional ground water models for the (1) Metro-Orlando Area, (2) Osceola County, and (3) Glades, Okeechobee, and Highlands

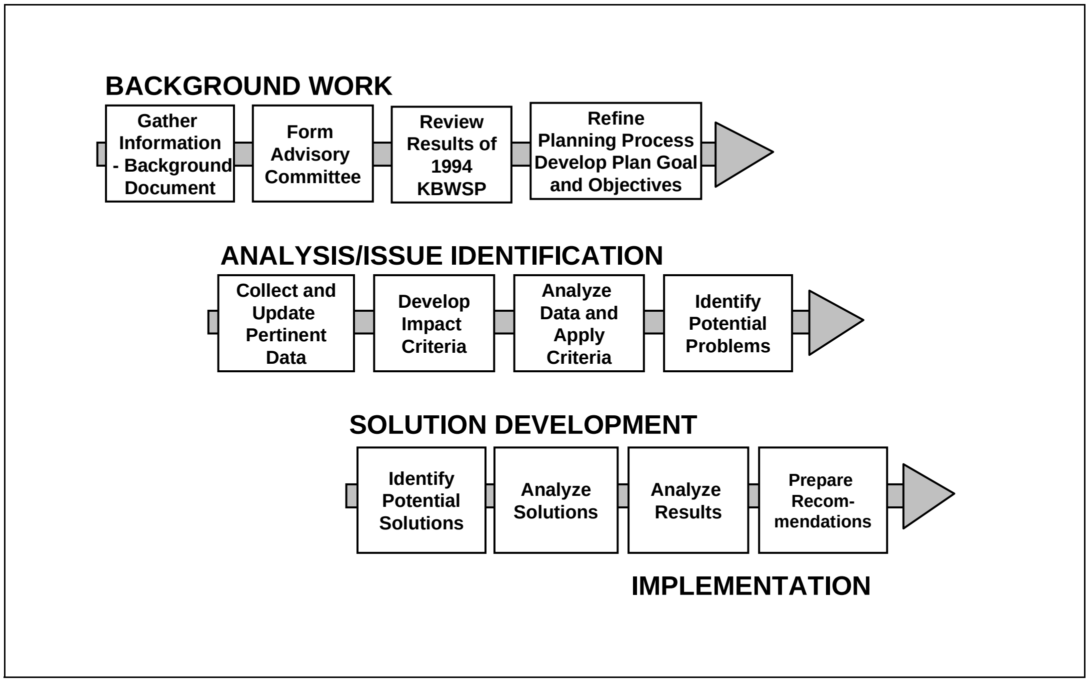

Figure 3. The Kissimmee Basin Planning Process.

counties. In addition, a surface water budget assessment was developed for the Lake Istokpoga-Indian Prairie Basin. Model preparation involved the assembly of substantial amounts of information, including statistical analyses of rainfall events in the region, and descriptive data pertaining to aquifer characteristics such as transmissivity.

An advisory committee was established to provide public input throughout the planning process. The primary function of the advisory committee was to provide assistance to the District in the identification and clarification of basin issues, development of acceptable impact criteria, solution identification, and preparation of the plan recommendations presented in this report. The role of the advisory committee is considered to be a key element in the development of this plan and through their assistance, it is hoped that the recommendations contained in this plan will be more agreeable by the public during implementation. The advisory committee is discussed in the Public and Agency Participation section, later in this chapter.

Plan Vision

The advisory committee adopted the water resource goal of the State Comprehensive Plan (Chapter 187, F.S.) as the overall vision for the KB Water Supply Plan:

> Florida shall assure the availability of an adequate supply of water for all competing uses deemed reasonable and beneficial and shall maintain the functions of natural systems and the overall present level of surface and ground water quality. Florida shall improve and restore the quality of waters not presently meeting water quality standards.

This vision advances the six principal Water Use Directives from the Water Supply Policy Document (1991), referenced earlier in this chapter.

Plan Goal

To ensure that the KB Water Supply Plan addresses the specific needs of the region, the committee developed the following goal:

> Identify sufficient sources of water and funding to meet the needs of all reasonable-beneficial uses within the KB Planning Area through the year 2020 during a drought event that has the probability of occurring no more frequently than once every ten years, while sustaining the water resources and related natural systems.

Plan Objectives

To ensure the Kissimmee Basin Water Supply Plan addresses the specific needs of the region, the advisory committee developed the following regional objectives (no implied priority):

- **Water Sources**: Optimize the use of all water sources
- **Natural System Protection**: Protect natural systems from harm due to water uses
- **Level of Certainty**: Identify options that will provide a 1-in-10 year level of certainty for all existing and projected reasonable-beneficial uses
- **Compatibility with Local Governments**: Promote compatibility of the Kissimmee Basin Water Supply Plan with tribal and local government land use decisions and policies
- **Linkage with Other Regional Planning Efforts**: Promote compatibility and integration with other related regional water resource planning efforts, including, but not limited to, Kissimmee River Restoration, Kissimmee Chain of Lakes, the Restudy, and Southwest Florida Water Management District and St. Johns River Water Management District water supply planning efforts without detriment to the Kissimmee Basin region
- **Conservation of Water Sources**: Promote water conservation and efficient use of water sources
- **Water Supply Demands**: Refine water supply demand projections for all reasonable-beneficial uses for average year and the 1-in-10 year level of certainty
- **Funding**: Identify adequate sources of funding to support water resource development and water supply development options identified in the plan

- **Water Resource Protection**: Protect water resources (aquifers, rivers, and lakes) from harm due to water uses, including preventing harmful movement of saline water within the Floridan Aquifer System as a result of water use

The goal and associated objectives captured the expectations and issues in the KB Planning Area, and in turn, provided direction for the planning process. Topics scheduled for committee discussion, research and analytical work, and the formulation of final recommendations centered on these objectives. Completion of the plan's initial goal and objectives marked the transition into the analytical phase of the process.

Analysis/Issue Identification

The identification of potential problem areas was accomplished by comparing the results of the 2020 water use ground water and surface water simulations, to the resource protection criteria that were developed. Where areas of possible concern were identified through this process, solutions were discussed and strategies were developed. Where necessary, the developed analytical tools were applied to test the effectiveness of the proposed solutions.

Solution Development

In areas where projected demands had the potential to exceed available supplies, there was a need to devise possible solutions. Potential solutions included increased use of water conservation and water source options which are described in Chapters 7 and 8. Each water source option was discussed and evaluated by the committee, including the identification of related local and regional responsibilities.

Implementation

Concepts resulting from the solution development phase will be translated into implementation and funding strategies through various functions within the District (**Figure 4**). Developing strategies, identifying funding sources and building partnerships for future implementation efforts will be emphasized.

COORDINATION

Development of the KB Water Supply Plan was coordinated with several other planning efforts in the region, as well as with many other entities, to ensure an integrated approach and compatibility with local and regional plans.

Related Planning Efforts

Water management planning efforts in the KB Planning Area include a variety of interrelated studies and activities, in both the public and private sectors. Each plan or

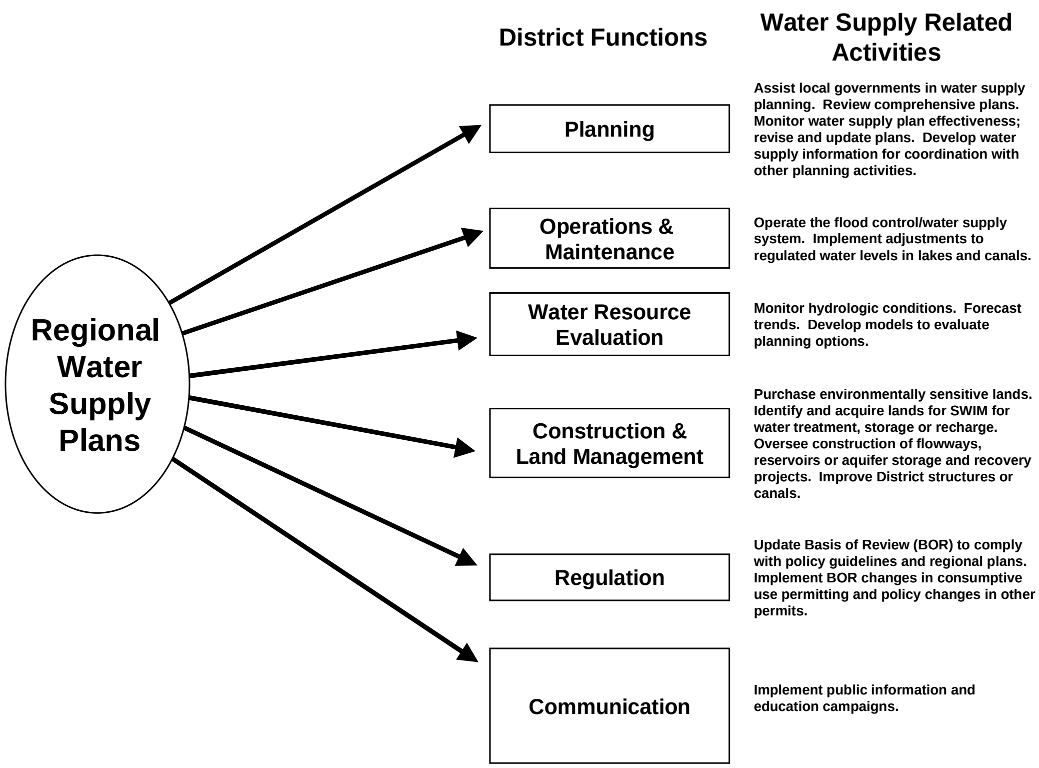

Figure 4. District Water Supply Implementation Activities.

study addresses unique water management issues while maintaining close relationships with water supply planning (**Table 1**).

The related efforts with the most significant influence on the implementation of the KB Water Supply Plan include the Comprehensive Everglades Restoration Plan (CERP) and the establishment of minimum flows and levels to several lakes in the Kissimmee Basin. The CERP will address the regulation schedule of Lake Istokpoga and the amount of water potentially available from the lake. This plan will also consider construction of storage (reservoirs and/or ASR) north of Lake Okeechobee, primarily for water quality purposes. These facilities will influence recommendations regarding the use of Lake Istokpoga and Lake Okeechobee as water sources in the Lake Istokpoga-Indian Prairie Basin. In addition, establishing minimum flows and levels for the 12 lakes will more clearly define the quantity of water available for consumptive uses (these recommendations are further described in Chapter 5 of the Planning Document).

Other water supply planning efforts within the SFWMD include the Upper East Coast, Lower West Coast, and Lower East Coast water supply plans. The Upper East Coast Water Supply Plan is in its third year of implementation while the remaining plans were approved by the Governing Board in April 2000. A common issue of the Kissimmee Basin and these other plans is the use of water from Lake Okeechobee as a water supply source.

Table 1. Kissimmee Basin Related Water Management Planning Efforts.

	Scope/Primary Goal	Relationship to KB Water Supply Plan	Timeframes
KB Water Supply Plan	Adequate and reliable water supply	N/A	2000
Kissimmee Chain of Lakes Water Management Plan	Environmental enhancement of Kissimmee Chain of Lakes	Changing lake regulation schedules	Final plan FY99
Kissimmee River Restoration	Environmental restoration of Kissimmee River floodplain. Improved surface water quality.	Changing deliveries to Lake Okeechobee	2015
Lake Okeechobee SWIM Plan	Protection and enhancement of Lake Okeechobee and its watershed (water quality)	Discharge water quality and nutrient loading from the Kissimmee River	Update completed 1997. Next update 2000.
Lake Okeechobee Regulation Schedule Environmental Impact Study	Evaluates environmental and economic impacts associated with proposed Lake Okeechobee Regulation Schedules (quantity)	Discharge quantity from the Kissimmee River	1999
C&SF Project Restudy	Comprehensive review of environmental impacts of C&SF project	Lake Okeechobee storage and treatment, including reservoirs and aquifer storage and recovery	1995-1999
Comprehensive Everglades Restoration Plan	Implementation of C&SF Project Restudy	Lake Istokpoga Regulation Schedule, potential construction of reservoirs and ASR system north of Lake Okeechobee	2000-2050
Kissimmee Basin Minimum Flows and Levels	Prevent significant harm to the water resources and ecology of surface water resources in the Kissimmee Basin	MFLs will more clearly define the quantity of water available for consumptive uses. Recovery or prevention strategy has potential to alter future water management activities, including use of water resources in the Kissimmee Basin	2004-2006

Intergovernmental Agreements

Two existing intergovernmental agreements in the KB Planning Area that facilitate coordination between the SFWMD and other entities are the Memorandum of Understanding between the SFWMD, SJRWMD, and SWFWMD; and the agreement between the SFWMD and Seminole Tribe.

The purpose of the Memorandum of Understanding is to establish processes by which water resource investigations, planning, regulation and water shortage efforts may be coordinated and consistently applied between the three districts. The agreement with the Seminole Tribe outlines surface water control strategies to the Brighton Reservation to assure maximum reliability of surface water deliveries to meet the Tribe's entitlement. These agreements are discussed in further detail in Chapter 5.

In addition, the District will coordinate the implementation of the Kissimmee Basin Water Supply Plan with local governments/utilities, the Lower East Coast Regional Water Supply Plan, the C&SF Comprehensive Review Study, the Comprehensive Everglades Restoration Plan (the implementation phase of the C&SF Restudy), and other related efforts to promote compatibility.

PUBLIC AND AGENCY PARTICIPATION

Public and agency involvement was critical in the preparation of the KB Plan. The steps listed below were taken by the District to ensure adequate public input.

Advisory Committee

A 24 member advisory committee, with approximately 17 alternate members, was created to obtain public participation in the planning process. Membership included representatives of federal, state and local agencies, planning officials, public water supply utilities, local business community, environmental interests, community leadership, and agricultural concerns. Each of the advisory committee meetings were advertised and open to the public.

The primary role of the committee, as well as the general public who attended these meetings, was to provide input at each stage of the water supply planning process, contribute local knowledge and expertise, and to reflect the collective concerns and interests of various stakeholders in the KB Planning Area. The role of District staff was to facilitate the planning process, provide professional and technical support and guidance, and prepare the planning document with committee input.

The advisory committee spent the initial monthly meetings listening to background presentations, sharing information and improving the District's understanding of the local issues, along with developing of the plan's goals and objectives. The goals and objectives established by the advisory committee served as a "road map" for the subsequent planning process. Topics scheduled for committee discussion, research and analytical work, and formulation of final recommendations all centered on these goals. Completion of the plan's initial goals marked the transition into the analytical phase of the process.

The advisory committee was instrumental in providing input on utility demands and identifying resource protection criteria. The advisory committee met a total of 17 times between November 1998 and April 2000. After plan approval, committee members will continue to be informed of the implementation activities through newsletters or periodic status meetings, and the Five Year Water Resource Development Work Program based on the KB Water Supply Plan.

In addition, a subcommittee or focus group to the advisory committee was formed to evaluate options and develop recommendations for issues associated with surface water availability in the Lake Istokpoga-Indian Prairie Basin. The focus group was composed of agricultural water users, the local government for Highlands County, local lake interest groups, representatives of the Seminole Tribe and members of the public. The focus group drew upon their local knowledge and experience with Lake Istokpoga and the Indian Prairie Canal system to formulate water supply strategies and recommendations. This focus group met four times during the period of May 1999 to January 2000.

The focus group was instrumental in providing input on projected agricultural water use and formulation of the water source options and strategies for the region. The group also provided critical review of the results of a surface water management analysis upon which the water source options were evaluated. The final water source options and associated recommendations were brought back to the full advisory committee prior to plan approval.

Data Confirmation

The technical information incorporated into this Support Document was the basis for discussions of water demand and availability in the KB Planning Area; it was also the key data for analysis (i.e., predictive modeling and analysis of water management alternatives) of the water resources. Therefore, it is important that this information is accurate so that the most appropriate solutions are presented.

As part of the data collection effort, many entities, such as local governments, state and federal agencies, environmental groups, agricultural interests, and utilities within the KB Planning Area, were contacted to gather initial input and information, and informal meetings were held with several of these groups. Two examples where public input was utilized to generate and/or confirm information were the utility information and the population and urban demand projections.

Utility Information

To accurately reflect historic, current and projected water supply practices by the utilities in the KB Planning Area, the District initiated an exhaustive survey of all regional public and private water and wastewater utilities in the study area in 1996. The utilities were sent a questionnaire addressing existing and future customers, service areas, treatment technologies, average daily flows, treatment plant locations, number of wells, interconnects with other utilities, and planned expansions for their respective utilities. Follow up telephone calls were made to those utilities who did not respond, or whose response was incomplete.

This information was tabulated in a computerized spreadsheet and checked against other District sources, such as permits and comprehensive planning documents, for accuracy. Where inaccuracies were found, additional follow up contacts were made.

Population and Urban Demand Projections

As part of the work completed under the Districtwide Water Supply Assessment (DWSA), U.S. Census data for 1995 and 1990 were used as the basis for 1995 total population and population distribution. Population was further broken down by utility service area and adjusted to account for estimates of self supply. Per captia water use estimates were determined by dividing utility raw water production by population. The District developed per capita water demand calculations were submitted to local governments and utilities for their review.

Population estimates published by the Bureau of Economic and Business Research (1998) were used for the estimate and distribution of 2020 projections. The per captia use rates determined for each utility for 1995 were multiplied 2020 population estimates to approximate future PWS demand. These estimates were again sent to the local government and utilities for conformation of the demand and distribution among their various water plants and wells. Appendix F provides a detailed description of the source and use of the population estimates.

Chapter 2
PLANNING AREA DESCRIPTION

PLAN BOUNDARIES

The Kissimmee Basin (KB) Planning Area encompasses that portion of the SFWMD extending from southern Orange County, through the Kissimmee Chain of Lakes and the Kissimmee River, to the north shore of Lake Okeechobee. The area includes parts of Orange, Osceola, Polk, Highlands, Okeechobee, and Glades counties. The portions of these counties within the KB Planning Area will be referred to as the Orange Area, Osceola Area, Polk Area, Highlands Area, Okeechobee Area, and Glades Area in this document. The boundary of the KB Planning Area generally reflects the drainage basin of the Kissimmee River. The northern and eastern portions of the boundary are adjacent to the St. Johns River Water Management District, while the western boundary is adjacent to the Southwest Florida Water Management District.

The KB Planning Area is divided at the outlet of Lake Kissimmee into upper and lower sections (**Figure 5**). The upper lake section (Upper Kissimmee Basin) has an area of 1,368 square miles, of which 176 square miles are lakes. The lower river system (Lower Kissimmee Basin) covers 2,109 square miles, of which 44 square miles are lakes (SFWMD GIS data). The Upper Kissimmee Basin includes a series of lakes linked by streams and canals referred to as the Kissimmee Chain of Lakes.

RELATED PLANNING AREAS

The District has established four water supply planning areas: (1) the Upper East Coast, (2) the Lower East Coast, (3) the Lower West Coast, and (4) the Kissimmee Basin. The planning areas are generally defined by the drainage divides of major surface water systems in South Florida. The major water bodies considered in establishing these boundaries include the Kissimmee River, Lake Okeechobee, the Everglades and the Big Cypress Swamp. The series of canals, levees, pump stations, and storage areas that comprise the Central and South Florida Flood Control Project were also considered because these structures have altered the hydrology of the natural water bodies (see Surface Water Resources discussion in Chapter 3).

Lake Okeechobee is considered part of each of the planning areas, which are connected to the lake through a regional surface water system. The Kissimmee River is the predominant surface water inflow into the lake, while the remaining three planning areas receive outflows from the lake. The major outflows are: (a) the Caloosahatchee River to the Lower West Coast; (b) the St. Lucie Canal to the Upper East Coast; and (c) the West Palm Beach, Hillsborough, North New River, and Miami canals to the Lower East Coast.

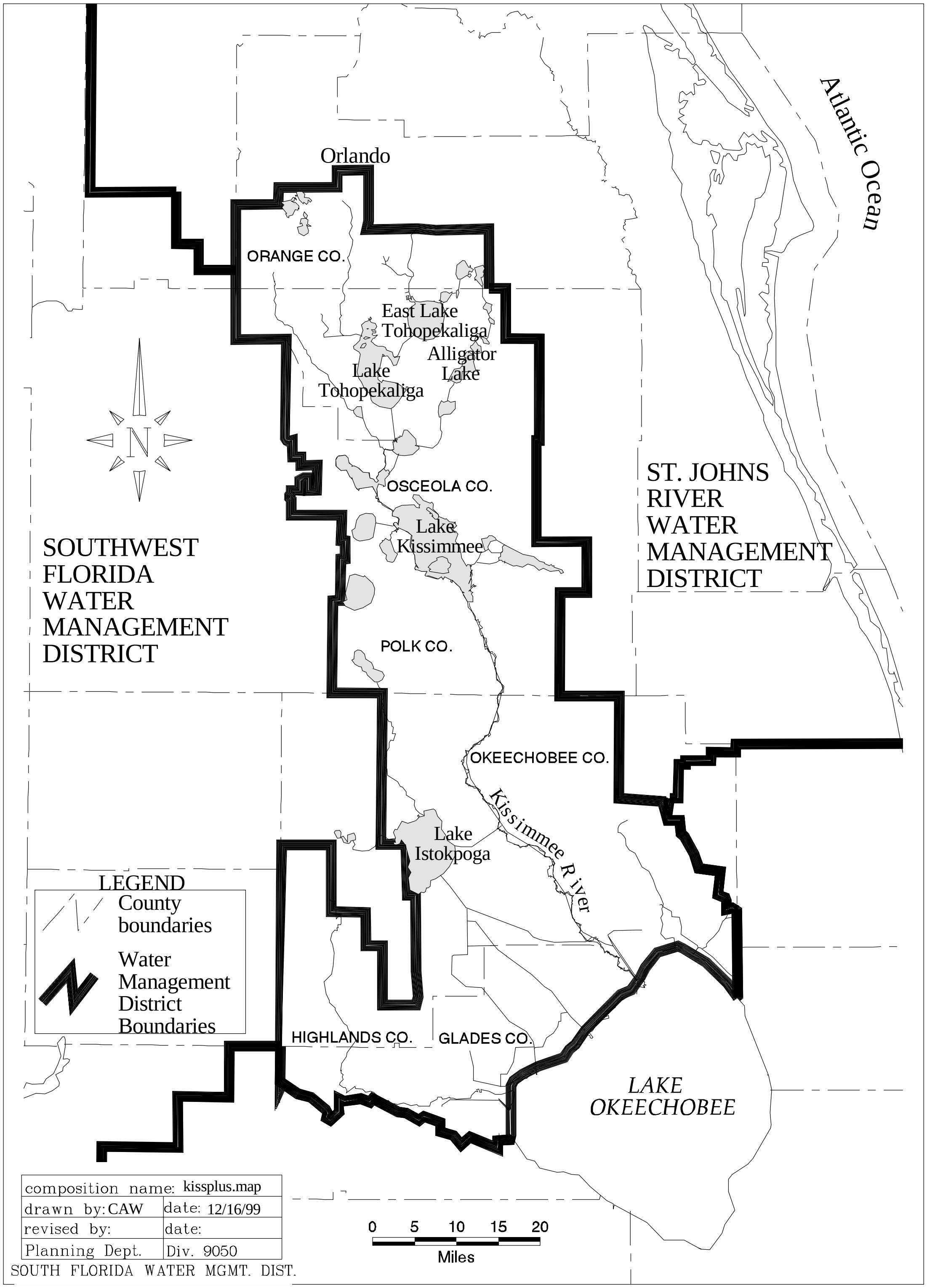

Figure 5. Kissimmee Basin Water Supply Planning Area.

PHYSICAL FEATURES

Geography and Climate

The KB Planning Area covers 3,477 square miles and has an average elevation of 63 feet. Average seasonal temperatures range from 60° F during the winter to 83° F during the summer (SFWMD DBHYDRO data). Annual average rainfall in the KB Planning Area is about 50 inches. Rainfall is further discussed in Chapter 3.

Physiography

The KB Planning Area has three major physiographic zones. These zones are identified by White (1970) as: (1) the Lake Wales Ridge, (2) the Osceola Plain, and (3) the Okeechobee Plain. The Lake Wales Ridge traverses the western edge of the KB Planning Area and is bounded on the east by the Osceola and Okeechobee plains. In general, the physiographic features in the region were formed as the land mass gradually emerged from a retreating sea.

The Lake Wales Ridge is a relict beach ridge with elevations exceeding 100 feet. The crest of the ridge forms the water divide between the South Florida Water Management District (SFWMD) and the Southwest Florida Water Management District (SWFWMD). Most of the surface waters to the east of the ridge are drained by the Kissimmee River.

Most of the KB Planning Area lies within the Osceola Plain, named after Osceola County which is almost wholly encompassed within it. The Osceola Plain is a broad flat area about 40 miles in width and 100 miles in length. The highest elevation of the Osceola Plain is between 90 and 95 feet near the southern part of Orlando. Elsewhere it is between 60 and 70 feet in elevation with small local relief. The Osceola Plain narrows toward the southeast where it meets the northeastern edge of the Okeechobee Plain.

The Osceola Plain has numerous lakes, including some of the largest lakes in Florida. These lakes are described in Chapter 3. Little research has been conducted on the geomorphology of the lakes. Most of the area’s natural lakes probably originated as sinkholes when sea level was much lower than it is today. Sinkholes are common in areas that are underlain by limestone, which is soluble in water. The larger lakes may have formed over a long period of time through the coalescence of a large number of sinkholes.

These lakes drain into the Kissimmee River, which begins at the southern end of Lake Hatchineha and flows southward through Lake Kissimmee, and then south through the Osceola and Okeechobee plains, before flowing into Lake Okeechobee. Where the Kissimmee River flows across the Osceola Plain, it occupies a floodplain valley about a mile and a half wide. However, where the river flows in the Okeechobee Plain, the distinction between the valley and upland surface is obscure.

The Okeechobee Plain, named after Okeechobee County and the adjacent Lake Okeechobee, gradually slopes southward from an elevation of 30 to 40 feet near the top of its boundary, to about 20 feet at the north shore of Lake Okeechobee. The plain is about 30 miles wide and 30 miles long, with less local relief than the Osceola Plain.

POPULATION

The driving force behind urban water demand is population. Population in the Kissimmee Basin planning region is projected to increase by 89 percent, from 362,837 in 1995 to 686,696 in 2020. Most of the population in the KB Planning Area resides in the northern urban areas, particularly southern Orange and western Osceola counties (**Table 2**). The northern urban areas also are expected to experience the most significant population increases. By contrast, the southern areas are expected to have minor increases of residents. The relationship between population and urban water demand is discussed in Chapter 6.

Table 2. Population 1995-2020.

Region	1995	2020	Increase	% Growth
Orange Area	186,131	349,453	163,322	88
Osceola Area	130,605	260,937	130,332	100
Polk Area	6,375	13,832	7,457	117
Highlands Area	7,700	11,590	3,890	51
Okeechobee Area	28,737	45,244	16,507	57
Glades Area	3,289	5,640	2,351	71
Total	362,837	686,696	323,859	89

MUNICIPALITIES

There are seven municipalities in the KB Planning Area. These are Bay Lake, Lake Buena Vista, Orlando, Windermere (Orange Area); Kissimmee and St. Cloud (Osceola Area); and Okeechobee (Okeechobee Area). There are no municipalities in the Highlands or Polk areas.

The Orange Area has the most municipalities. The largest of these, Orlando, is partially within the St. Johns River Water Management District.

AGRICULTURE

Agricultural activity represents the single largest water use type within the planning region. Citrus is the major irrigated agricultural crop in the KB Planning Area, and this trend is expected to continue over the next 20 years (**Table 3**). A major change in the geographic distribution of citrus production occurred in Central Florida following a series of severe freezes in the mid-1980s. Since then, a reduction in citrus acreage has taken place in the northern areas of the Kissimmee Basin. Conversely, to the south, significant increases in citrus acreage have been observed. These general trends in citrus acreage are projected to continue through 2020. The relationship between irrigated agricultural acreage and agricultural water demand is discussed in Chapter 6.

Table 3. Irrigated Citrus Acreage 1995-2020.

Region	1995	2020	Change in Citrus Acreage	% Change
Orange Area	6,210	3,275	-2,936	-47
Osceola Area	19,807	19,408	-399	-2
Polk Area	2,354	1,916	-438	-18
Highlands Area	39,324	61,037	21,713	55
Okeechobee Area	11,408	18,282	6,874	60
Glades Area	8,087	11,996	3,908	48
Total	87,190	115,914	28,722	33

Source: SFWMD Districtwide Water Supply Assessment, 1998.

LAND USE

The existing land use in the KB Planning Area is generally more urban in the north than in the south. Continued urbanization is anticipated in the north, while in the south, citrus acreage is projected to increase.

Existing Land Use

The KB Planning Area is predominantly agricultural, especially in the Glades, Highlands, and Okeechobee areas. The Orange Area is by far the most urbanized, and the Orange, Osceola, and Polk areas have the highest percentages of wetlands (**Table 4**). The majority of agricultural land (including rangeland) is used for pasture, which is rarely irrigated. A land use map for the KB Planning Area is shown on **Plate 1**.

Within Glades County is the Brighton Reservation, one of several Seminole Tribe reservations in Florida. The Brighton Reservation is located northwest of Lake Okeechobee within the Lake Istokpoga-Indian Prairie Basin. The Reservation was established in 1938 and currently has a population of about 500. The Reservation covers almost 36,000 acres, which is primarily agricultural, including improved pasture, citrus, sugarcane, and aquaculture.

Table 4. Acreage and Percentage of Land Use by County Area[a].

Land Use	Orange Area	Osceola Area	Polk Area	Highlands Area	Okeechobee Area	Glades Area	Kissimmee Basin Area
Agriculture	31,513 (17%)	218,656 (35%)	44,243 (16%)	259,362 (53%)	189,625 (52%)	139,470 (47%)	882,869 (40%)
Urban	60,243 (32%)	52,212 8%	51,449 (19%)	42,194 (9%)	21,928 (6%)	2,760 (1%)	230,786 (10%)
Wetlands	36,338 (20%)	164,355 (27%)	59,571 (22%)	76,821 (16%)	66,800 (18%)	59,678 (20%)	463,563 (21%)
Forest	30,264 (16%)	74,857 (12%)	65,136 (24%)	41,586 (9%)	32,591 (9%)	68,578 (23%)	313,012 (14%)
Rangeland	2,005 (1%)	26,012 (4%)	25,270 (9%)	33,489 (7%)	48,284 (13%)	20,223 (7%)	155,283 (7%)
Barren	3,419 (2%)	2,842 (1%)	1,420 (1%)	3,733 (0%)	3,588 (1%)	2,471 (1%)	17,473 (1%)
Water	21,796 12%	81,082 (13%)	23,885 (9%)	30,022 (6%)	4,299 (1%)	1,492 (1%)	162,576 (7%)
Total	185,578 (100%)	620,016 (100%)	270,974 (100%)	487,207 (100%)	367,115 (100%)	294,672 (100%)	2,225,562 (100%)

a. Data for the portion of county within the KB Planning Area only.
Source: SFWMD Florida Land Use/Land Cover Geographic Information System Database, 1995.

The Lake Istokpoga-Indian Prairie Basin has historically experienced water shortages. The Seminole Tribe of Florida, the State of Florida and the District executed a Water Rights Compact in 1987. The Compact establishes, among other things, the Tribe's water entitlement for the Brighton Reservation. A subsequent Agreement (Number C-4121) was executed in the early 1990s and further defines the Tribe's water rights. This Agreement is further discussed in Chapter 5.

Land Use Trends

The rapid conversion of rural land into urban land is expected to continue in southern Orange County and in northwestern Osceola County. Additionally, continued urban development is expected in Polk County along the I-4 Corridor. The remaining areas in the Kissimmee Basin are expected to remain largely rural.

Orange County

The Orlando Metropolitan Area has experienced a high rate of growth since the development of Disney World in 1971. The metropolitan area extends outward from Orlando along major transportation arteries, especially the I-4 Corridor.

Residential developments are the dominant urban land use and are expected to remain so through 2020. The growth in theme parks, associated hotel/motel and convention commercial land uses, and a burgeoning high tech industry have allowed the

Metro area to become a financial and business service center for Central Florida and portions of the southeastern U.S.

Many agricultural lands in the Metro area, especially orange groves affected by the freezes of the 1980s, have been converted into largely residential urban uses. This has caused Orange County to experience a substantial decline in agricultural acreage. Citrus remains the predominant irrigated crop in the county, but has declined dramatically since the 1980s. For example, in 1982 there were 48,527 acres of citrus countywide. This declined to 10,029 acres in 1996. Of these, 6,210 acres are in those portions of the county draining into the Kissimmee Basin. This number is expected to decrease to 3,275 acres by the year 2020 (SFWMD, 1998).

Osceola County

The northwestern portion of Osceola County is also experiencing a high rate of urban growth as the Orange County Metropolitan area expands to the south along the U.S. 17/92/441 Corridor, and to the southwest along the I-4 Corridor. This trend is expected to continue through the year 2020.

Despite Osceola County's high rate of urban development, the predominant land use remains agricultural, largely rangeland. The Osceola County Comprehensive Plan indicates that there were 701,883 acres of agriculture in 1990. The vast majority of this is unirrigated pasture. Citrus is the predominant irrigated agricultural crop within the county. Agricultural land use is expected to decline through 2020, as urbanization in the northern portion of the county continues.

Polk County

Urbanization in Polk County is occurring along the I-4 Corridor, where growth from Orlando and Tampa is spreading. It is estimated that three percent of the county population resided within the District's boundaries in 1990. This area is expected to remain largely rural through 2020.

Highlands, Glades, and Okeechobee Counties

Within Highlands County, urbanization is occurring on the Lake Wales Ridge along U.S. Highway 27, which is outside the jurisdiction of the SFWMD and does not drain into the Kissimmee Basin. It is estimated that 39,800 people resided in these counties and within the jurisdictional boundary of the SFWMD in 1995. This number is expected to increase to 62,475 by the year 2020 (SFWMD, 1998).

The majority of land use in Highlands, Glades, and Okeechobee counties is, and is expected to remain, agricultural. The acreage devoted to citrus production is projected to increase through 2020. This is reflective of the migration of the citrus industry to more southern locations in the state following severe freezes in the 1980s.

Sugarcane has seen a rise in production in Highlands and Glades counties in recent years due to regulatory changes. Sugarcane, which was nearly nonexistent in this basin 10 years ago, increased to roughly 3,300 acres in 1995. Production is projected to reach 15,300 acres by the year 2020.

The dairy industry is a major industry in Okeechobee County, but has undergone a significant decline in recent years as a result of land acquisitions and rule changes designed to improve water quality in Lake Okeechobee. Despite this reduction, Okeechobee County remains the state's leading producer of beef and dairy cattle, and has extensive acreage devoted to pasture and range.

Chapter 3
WATER RESOURCES AND SYSTEM OVERVIEW

REGIONAL HYDROLOGIC CYCLE

The main components of the hydrologic cycle for the Kissimmee Basin (KB) Planning Area include precipitation, evapotranspiration, and the resulting flow of surface water and ground water. The interaction between surface water and ground water is expressed as either recharge to or discharge from the aquifer system.

Precipitation and Evapotranspiration

The average rainfall in the KB Planning Area is about 50 inches per year. There is a wet season from June through October, and a dry season from November through May. The heaviest rainfall occurs in June or July, averaging 7.75 inches for the month; the lightest rainfall month is usually November or December, averaging 1.75 inches for the month (**Table 5**). On average, 64 percent of the annual rainfall occurs in the wet season. Historical rainfall data are presented in Appendix B.

Evapotranspiration (ET) is the sum of evaporation and transpiration. ET, like rainfall, is generally expressed in inches per year. Approximately 45 inches of water per year is returned to the atmosphere by evapotranspiration in South Florida. Precipitation minus ET is equal to the combined amounts of surface water runoff and average ground water recharge.

Surface Water Flow

Surface water flow includes inflow from areas adjacent to the planning basin and rainfall falling within the basin; storage; and outflow to Lake Okeechobee via the Kissimmee River.

There are several primary surface water features providing surface water drainage for the KB Planning Area. Reedy Creek, Shingle Creek and Boggy Creek, located in the northernmost section of the basin, are the primary drainage features for Orange and northern Osceola counties. The Alligator and Kissimmee Chain of Lakes act as the primary features in northern Osceola County. All of these features eventually connect to the Kissimmee River, which is the primary drainage feature of the basin.

Table 5. Mean Rainfall Data for Rainfall Stations in the Kissimmee Planning Area.

County	Rainfall Station	Average Annual Rainfall (inches)	Years and Period of Record	Maximum Monthly Rainfall		Minimum Monthly Rainfall		% Rain Falling in Wet Season	Primary DBKEY[a]
				inches	month	inches	month		
Glades	Moore Haven	48.72	56 1940-1995	7.69	Jun	1.60	Dec	65.8	06124
Highlands	Archbold	49.16	53 1929-1995	7.81	Jun	1.56	Dec	65.7	06205
	Avon Park	52.25	82 1902-1995	8.27	Jun	1.71	Nov	66.2	06136
	Lake Placid	49.73	50 1933-1995	8.05	Jun	1.47	Dec	65.8	06137
Okeechobee	Ft. Drum	50.96	40 1956-1995	7.61	Jun	1.72	Dec	63.8	06141
	Okeechobee	48.53	67 1922-1995	7.35	Jun	1.56	Dec	64.2	06196, 06152, 06070, 06020
Orange	Orlando	51.97	89 1900-1995	7.80	Jul	1.89	Nov	62.9	06185
Osceola	Kissimmee	49.63	81 1901-1995	7.46	Jul	1.95	Nov	62.7	06146, 06147
	Brooks Property	48.91	30 1963-1995	7.49	Jul	1.99	Apr	62.5	05813
	S-65	50.79	31 1965-1995	7.90	Jun	1.78	Dec	63.2	05940
Polk	Mountain Lake	50.95	61 1935-1995	7.82	Jul	1.96	Nov	62.5	06134
Overall average		50.14		7.75		1.75		64.1	

a. For those interested in accessing DBHYDRO. Missing data were replaced with data from nearby stations, when available. Some years were excluded when values were missing and no nearby stations were available.

In general, rainfall falling within the basin is directed to one of the hydrologic features mentioned above. There are, however, three sources of inflow from areas adjacent to the planning basin. These are Josephine and Arbuckle creeks, which flow into Lake Istokpoga, and surface water from the Horse Creek Basin which flows into Lake Hatchineha via Lake Marion Creek. All of these inflows primarily originate in areas located within the Southwest Florida Water Management District.

In some areas located in the Orlando metropolitan area, some surface water drainage is directed towards drainage wells, which discharge directly to the Floridan aquifer. These wells, constructed up until the 1970s, are generally limited to closed drainage basins in the Orlando area. There are about 400 drainage wells, which provide a significant portion of the aquifer recharge in the Orlando area. Most of these wells are in the SJRWMD, and are a potential water source option for the Orange-Osceola Area.

Ground Water Flow

The components which together comprise ground water flow in the KB Planning Area include: ground water inflow from the west; the difference between surface water inflow to and outflow from the KB Planning Area; and ground water discharge to the east and south.

Two aquifer systems underlie the KB Planning Area; the Surficial Aquifer System (SAS) and the Floridan Aquifer System (FAS). The SAS is exposed at the land surface and is primarily recharged by rainfall. It interacts with surface water features, such as rivers, canals, and lakes. The FAS is a deeper carbonate aquifer which is overlain by a confining layer in most areas of the basin. This deeper aquifer is the primary source of ground water for the basin. It is recharged by ground water inflow from outside the basin and recharge occurring in the Kissimmee Basin region. Aquifer discharge generally occurs along the Kissimmee River and floodplain and along the St. Johns River to the east (see **Plate 3**). This is discussed in more detail in the Surface Water/Ground Water Interactions section at the end of this chapter. The Floridan aquifer in other parts of the District are recharged by the ground water flow from the Kissimmee area. Identifying activities in the Kissimmee Basin that could reduce the volume of water moving into the Floridan aquifer in the Upper East Coast region was one of the recommendations of the Upper East Coast Water Supply Plan (SFWMD, 1998).

SURFACE WATER RESOURCES

Development of the Kissimmee Basin

The Kissimmee Basin has undergone over a century of development for drainage, flood control, and navigation. In 1884, the Atlantic and Gulf Coast Canal and Okeechobee Land Company dredged canals to connect Lake Tohopekaliga to Lake Okeechobee via Lakes Cypress, Hatchineha, and Kissimmee. The company also dredged another canal to connect Lake Okeechobee to the Gulf of Mexico through the Caloosahatchee River.

Major hurricanes swept across the state in 1926, 1928, 1945 and 1947. The storm of 1947 caused extensive flooding on the farms south of Lake Okeechobee, southeast coastal cities and suburbs, and in the Kissimmee Basin. The flooding of 1947 prompted the U.S. Congress to authorize the U.S. Army Corps of Engineers (USACE) to design and construct the Central and Southern Florida Flood Control Project (C&SF Project). The construction of the C&SF Project in the Kissimmee Basin began in 1962 and was completed in 1971. This resulted in the channelization of the 103 mile Kissimmee River into a 56 mile canal. In addition, the Kissimmee Chain of Lakes were connected, and structures were added to regulate water levels.

Water levels in the Kissimmee Chain of Lakes are managed according to a regulation schedule for each lake subbasin (see Appendix C). Typically, the regulation schedules vary from high stages in the late fall and winter to low stages at the beginning of the wet season. The minimum levels are set to provide for sufficient flood control storage and navigation depths.

Kissimmee River Restoration

Changes in the Kissimmee River's water quality, wetlands, and ecosystem due to channelization in the lower Kissimmee River Valley have been the subject of numerous federal, state, and local studies. The USACE's first feasibility study of restoring the Kissimmee River was started in 1978 in response to Congressional authority. The SFWMD also studied restoration from 1984 to 1990, and the federal government conducted a second feasibility study from 1990 to 1992.

As a result of these studies, the Kissimmee River restoration project was developed with the goal to restore the ecological integrity of the river and floodplain ecosystem. To achieve this goal, the physical form and the historic hydrology of the system had to be re-created. The two primary components of the restoration project that provide the basis for this project are the headwaters revitalization and lower basin backfilling. The headwaters revitalization will modify the way water is released to the river in an effort to simulate historic flow conditions. The lower basin backfilling will fill the middle portion (22 miles) of C-38, and re-create the river's physical form and flows.

Surface Water Features

The KB Planning Area is divided at the outlet of Lake Kissimmee into upper and lower basins. The Upper Kissimmee Basin includes 17 subbasins while the Lower Kissimmee Basin includes 9 subbasins (see Appendix C for specific information on subbasins). A detailed map of the major surface water features, including lakes, rivers, canals, and structures is provided as **Plate 2**.

Upper Kissimmee Basin

The Upper Kissimmee Basin is dotted with hundreds of lakes, ranging in size from less than an acre to over 55 square miles (Lake Kissimmee). The surface water drainage includes a series of interconnected lakes in its northern portion, called the Kissimmee Chain of Lakes. Alligator Lake forms the drainage divide of the chain of lakes and water can be released either to the north or to the south from this point. Water flows north through several canals and smaller lakes to Lake Mary Jane; the flow proceeds through Lakes Hart, East Tohopekaliga, and Tohopekaliga, then finally to Cypress Lake. Southward flow travels a shorter route through Lake Gentry and then to Cypress Lake. From Cypress Lake, water flows southward to Lake Hatchineha and then to Lake Kissimmee. Most of these lakes are shallow, with mean depths varying from 6 to 13 feet.

The major streams feeding into the Kissimmee Chain of Lakes are Shingle Creek, Reedy Creek, and Boggy Creek. The headwaters for these creeks are located in urban areas. From here, flow moves through wetlands on the way into their respective lakes.

The headwaters of Shingle Creek are formed in the city of Orlando. The creek then runs southward for 24 miles through Shingle Creek Swamp and the city of Kissimmee before emptying into Lake Tohopekaliga. About 13 miles of the creek, from its headwaters to just south of the swamp, have been channelized.

Reedy Creek originates in Walt Disney World, then runs southeast for 29 miles before splitting into two branches near Cypress Lake. One branch enters Cypress Lake and the other enters Lake Hatchineha. During most of its course, the creek flows through Reedy Creek Swamp.

Boggy Creek has two main branches: East and West. The East Branch, which is 12 miles in length, is the main watercourse of Boggy Creek. The headwaters of this branch are formed in the city of Orlando northwest of Orlando International Airport. The East Branch runs through Boggy Creek Swamp before emptying into East Lake Tohopekaliga. The headwaters of West Branch originate in another highly urbanized area of Orlando (Lake Jessamine). The West Branch flows to Boggy Creek Swamp.

Lower Kissimmee Basin

The Lower Kissimmee Basin includes the tributary watersheds of the Kissimmee River between the outlet of Lake Kissimmee (S-65) and Lake Okeechobee. The Kissimmee River and Lake Istokpoga are the major surface water features in the basin. Fisheating Creek and Taylor Creek/Nubbin Slough are prominent surface water features in the southern region of the KB Planning Area. Fisheating Creek marks the southernmost extent of the KB Planning Area and flows into Lake Okeechobee. Taylor Creek/Nubbin Slough is the site of one of the priority clean-up projects identified as part of the Okeechobee Surface Water Improvement and Management (SWIM) and Everglades restoration projects. There are no known large uses of water from either creek. Information on these streams is available in the Lake Okeechobee SWIM Plan (SFWMD, 1997).

The Kissimmee River was originally 103 miles in length until it was channelized in the 1960s into a 56 mile canal (C-38). Currently, the Kissimmee River is divided into five pools (pools A-E) by a series of combined locks and spillways. The water level in each of these pools is regulated according to an interim regulation schedule (**Plate 2**). The Kissimmee River Restoration Project, which is underway, will backfill 22 miles of the C-38 Canal, directing flows through the historic river channel and restoring the ecological functions of the river/floodplain system. Backfilling will begin midway between S-65A and S-65B and will end just north of S-65D.

Lake Istokpoga at 44 square miles, is the fifth largest lake in Florida. The lake is connected to the Kissimmee River via the Istokpoga Canal and the C-41A Canal. The Istokpoga Canal consists of two reaches, one upstream and one downstream of the G-85 Structure. The Istokpoga Canal drains into the Kissimmee River approximately 1.5 miles upstream of the S-65C Structure. These structures will be removed as part of the Kissimmee River Restoration Project. Rate of flow in the Istokpoga Canal is controlled by the G-85 Control Structure. The Istokpoga Canal will be modified and the G-85 Structure, which maintains the stage of Istokpoga Canal, will be replaced with a gated spillway. The restoration project is expected to re-establish the historic hydrology of the river and floodplain in areas north of the S-65E Structure. As a result, water surface elevations in the lower reach of the Istokpoga Canal, downstream of the G-85 Structure, are expected to fluctuate seasonally.

The main outlet for Lake Istokpoga is S-68, which regulates discharges from the lake to the C-40, C-41, and C-41A canals. The C-41A Canal discharges into the Kissimmee River below S-65E, passing through two additional water control structures (S-83 and S-84). The C-41 and C-40 canals also assist in discharging water from Lake Istokpoga draining to Lake Okeechobee. The C-40, C-41, and C-41A canals and associated structures make it possible to regulate the stages of Lake Istokpoga for irrigation water supply. Tests performed by the USACE, USGS, and SFWMD showed design deficiencies in the S-68, S-83, and S-84 structures (Abtew, 1992). These structures will be enlarged to allow design discharges from the lake. The USACE, Jacksonville District, is responsible for design and construction of structure modifications. The modifications at S-68 include adding a single bay spillway. Modifications at the S-83 and S-84 structures include the addition of a tailwater weir. Construction is scheduled to begin in early 2000 on the G-85 structure with modifications to the other structures to follow.

GROUND WATER RESOURCES

The hydrogeology of South Florida is best defined as a series of layered aquifers and aquitards that vary in thickness and depth. This includes both semi-confined and unconfined aquifers. For the Kissimmee Basin and surrounding areas, ground water is the main source of water supply. In Central Florida, three aquifers with varying water supply potential exist. They are the Floridan Aquifer System (FAS), Intermediate Aquifer System (IAS), and the Surficial Aquifer System (SAS). Within an individual aquifer, hydraulic properties and water quality may vary vertically and horizontally. The aquifers in each of the counties in the basin and surrounding areas are described below.

Orange County

There are two important ground water systems in Orange County, the SAS and the FAS. **Table 6** provides a description of the relative positions and productivity of each hydrologic component.

The SAS occurs throughout Orange County, and is capable of producing small to moderate amounts of water at a rate generally under 20 GPM. The SAS ranges in thickness from just a few feet to in excess of 100 feet and is used in some portions of the county as a source of residential self supply. Due to the low yield, the SAS is not considered a regional supply source in Orange County.

The IAS underlies the SAS and consists primarily of fine sands and silts of the Hawthorn Group and Tampa Formation. This aquifer system has a low permeability and separates the SAS from the underlying FAS. The IAS confines the FAS which is under

Table 6. Ground Water Systems in Orange County.

Hydrogeologic System	Geologic Unit	Thickness (feet)	Water Resource Potential
Surficial Aquifer System	Undifferentiated clastic deposits	0-100	Yields low to moderate amounts of water to wells. Used sporadically as a source of individual domestic supply in a few areas.
Intermediate Aquifer System	Hawthorn Group Confining Beds	50-250	Acts as a confining zone for the underlying Floridan Aquifer System. A few locally occurring producing zones exist, but they do not produce large amounts of water. Some limited domestic use occurs.
Upper Floridan Aquifer	Ocala Limestone and Avon Park Limestone	200-400	Capable of producing large amounts of water. Susceptible to local contamination as a result of receiving surface runoff through drainage wells.
Middle Semi-Confining Unit	Lower Avon Park and Upper Lake City	300-700	Unit separating the upper and lower producing units.
Lower Floridan Aquifer	Lake City and Oldsmar Limestone	1,100-1,600	Yields generally exceed 2,000 GPM, Yield can be less predictable than the upper zone as less is known about this aquifer.

artesian pressure. Locally occurring sand or limestone lenses within the IAS may produce moderate amounts of water and is typically used for residential self-supplied use.

The FAS is composed primarily of limestone and dolomite and provides nearly all of the ground water used in Orange County. The FAS behaves as a confined or semi-confined aquifer in all portions of the county. The FAS contains two producing zones, the Upper and Lower Floridan aquifers. These units are separated by the middle semi-confining unit, which has a comparatively lower yield. Both the Upper and Lower Floridan aquifers are capable of yielding large amounts of water. Water in the Upper Floridan aquifer is of potable quality throughout the county except for the extreme east section along the St. Johns River. The Lower Floridan aquifer is also fresh in all but the eastern portion of the county, where it is brackish. The Lower Floridan aquifer also contains gypsum mineralized waters in the southwest portion of the county (letter dated November 24, 1999 from Herb Stangland Jr., Ardaman and Associates Inc., Orlando, FL).

Osceola County

There are two ground water systems in Osceola County, the SAS and the FAS. **Table 7** provides a description of the relative positions and productivity of each hydrologic component.

Table 7. Ground Water Systems in Osceola County.

Hydrogeologic System	Geologic Unit	Thickness (feet)	Water Resource Potential
Surficial Aquifer System	Undifferentiated clastic deposits	20-270	Yields low to moderate amounts of water to wells. Not a major water source in Osceola County. Water quality varies widely.
Intermediate Confining Unit	Hawthorn Group	10-370	Acts as a confining zone for the underlying Floridan Aquifer System. There may be limestone units within the Hawthorn Group, which may produce moderate amounts of water. These units have not been studied extensively.
Upper Floridan Aquifer	Ocala Group and Avon Park Limestone	100-500	Capable of producing large amounts of water. In general, the upper zone produces more water than the lower zone.
Middle Semi-Confining Unit	Lower Avon Park and Upper Lake City	450-700	Acts as a confining zone for the lower producing zone, although capable of producing significant amounts of water in some areas of the county.
Lower Floridan Aquifer	Lake City Limestone	1,400-2,100	Capable of producing large amounts of water. Water quality limitations on the eastern side of the county.

The SAS occurs throughout Osceola County thickening from the northwest section of the county towards the southeast. The SAS is capable of producing small to moderate amounts of water, generally not exceeding 20 gpm. Due to the low yield, the SAS is not considered a regional supply source in Osceola County.

The IAS underlies the SAS and consists primarily of fine clastics. This layer is characterized by having a low permeability, separating the SAS and the underlying FAS systems. This unit acts a confining zone or cap to the FAS allowing for the development of artesian pressure in the FAS. Locally occurring sand or limestone lenses within the IAS may produce moderate amounts of water for residential self-supplied use.

The FAS is a limestone and dolomite aquifer system providing nearly all of the ground water used within Osceola County. The FAS contains two producing zones, the Upper Floridan and Lower Floridan aquifers. These units are separated by the middle semi-confining unit, which has a comparatively lower yield. Both the Upper Floridan and Lower Floridan aquifers are capable of yielding large amounts of water. The Lower Floridan aquifer does appear to have a limited production capability in the northwest portion of the county where lithologic changes in the aquifer appear to reduce the porosity of the limestone. Water within the Upper Floridan aquifer is of potable quality throughout the county. The Lower Floridan aquifer is also fresh in most areas, but exhibits poorer water quality in the extreme eastern portion of the county located outside the basin KB Planning Area. The development of water supplies in these areas will likely require additional levels of water treatment. Recent wells drilled in the southwest portion of the county have also discovered gypsum mineralized waters in portions of the Lower Floridan aquifer.

Polk County

The FAS, IAS, and SAS are the three aquifer systems in Polk County. The relative positions and production capabilities of these aquifer systems are described in **Table 8**.

The SAS produces small quantities of good-to-fair quality water, better than other counties within the KB Planning Area. Generally, it is moderately to highly acidic, has high concentrations of dissolved iron, and is colored. Isolated areas may also contain elevated levels of natural radiation stemming from the weathering of phosphorite deposits. Wells drilled into the surficial aquifer rarely yield more than 100 GPM, and average closer to 25 GPM. Though hundreds of wells tap the SAS, these wells are limited to the central ridge areas where the aquifer is thickest. Water use from the aquifer is for residential self-supply, lawn irrigation, and small scale agricultural irrigation.

The IAS consists of limestone and dolostones of the Hawthorn Group and Tampa Member. It is confined by low permeability silts and clays. In a portion of Polk County, the lower Tampa confining beds are thin or absent and the Tampa Member of the IAS and FAS appear to be connected. Water from the IAS is used primarily for residential self supply, but is also used for livestock watering, small public utilities, and agricultural irrigation. Most irrigation wells penetrating the upper FAS are open to the Intermediate aquifers as well. Average well yields range from 25 GPM in small diameter domestic wells to more than 200 GPM in large diameter irrigation wells. Water quality is generally within potable standards, except for isolated areas which have excessive hardness. Some areas may show elevated concentrations of natural radiation, resulting from weathered phosphorite deposits.

The upper portion of the FAS is the principal source of all major municipal, industrial, and irrigation water supplies. Large wells tapping the Floridan aquifer have yielded as much as 8,000 GPM of potable quality water. Polk County is an important recharge area for the FAS. Primary recharge areas occur along a linear band associated with the sandy Lake Wales Ridge.

Highlands County

The FAS, IAS, and SAS are the three aquifer systems in Highlands County. The relative positions and production capabilities of these aquifer systems are described in **Table 9**.

Yields from the SAS vary considerably with location, but are generally less than 100 GPM. This aquifer furnishes water for cattle watering and residential self-supplied residents throughout the county. The SAS produces potable quality water, with the exception of isolated areas with high iron and organic concentrations.

Table 8. Ground Water Systems in Polk County.

Hydrogeologic System	Geologic Unit	Thickness (feet)	Water Resource Potential
Surficial Aquifer System	Undifferentiated clastic deposits	10-100	Produces small quantities of relatively good quality water. Most wells yield less than 50 GPM. Use is restricted to residential self supply, lawn irrigation and small scale agricultural irrigation.
Intermediate Aquifer System	Hawthorn Group	10-300	Used primarily for residential self supply, livestock watering, and small public utilities. The aquifer produces small to moderate quantities of potable quality water. Most productive in the central and southern portions of the county.
Upper Floridan Aquifer	Tampa Member, Suwannee and Ocala Limestones, Upper portion of Avon Park	300-600	Principal aquifer in Polk County. Supplies all major municipal, industrial, and irrigation water demands. Produces large quantities of good quality water. Eastern portions of the county experience artesian conditions.
Middle Semi-Confining Unit	Lower Avon Park, Lake City Limestone	200-400	Lower yielding portions of the Avon Park, introduction of dolomites reduces permeabilities.
Lower Floridan Aquifer	Lake City and Oldsmar Limestone	>600	Little is know of this portion of the Floridan system, as it is not extensively used. It is believed that transmissivity for the aquifer is less than that of the upper section.

The IAS contains isolated beds of sand and gravel, which yield large amounts of good quality water. These beds are important water supply sources to localized areas along the upland ridge. Since these producing zones are discontinuous, however, the IAS is not generally regarded as an important source of either public or large agricultural water supply for most of Highlands County. Rather, this aquifer is used primarily for domestic purposes.

The FAS is the single most important source of water in Highlands County. It is composed of several zones with varying productivity. Wells tapping the most productive zones of the FAS are capable of yielding 500 to 1,500 GPM. Water quality varies with depth and location, becoming increasingly mineralized with depth and distance to the south. With the exception of the southeast corner of the county, water quality suitable for most uses can be found as deep as the Lake City Limestone (**Table 9**). All major potable water systems in Highlands County withdraw from the FAS, except for the city of Lake Placid, which gets its water from Lake Sirena. The FAS is also the predominant source of water for citrus irrigation.

Table 9. Ground Water Systems in Highlands County.

Hydrogeologic System	Geologic Unit	Thickness (feet)	Water Resource Potential
Surficial Aquifer System	Undifferentiated clastic deposits and Tamiami Formation	40-200	Except for isolated areas with high iron and organics, produces small to moderate amounts of good quality water. Furnishes residential self supplied and livestock watering locally throughout the county.
Intermediate Aquifer System	Hawthorn Group	300-650	Confining unit for the Floridan Aquifer System. Isolated beds of sand and gravel yield large amounts of water locally along the ridge, but they are discontinuous. Not an important source of water over most of the county.
Floridan Aquifer System	Suwannee Limestone	0-80	Most important source of water in Highlands County. Productivity tends to increase with depth. TDS, sulfates, and chloride concentrations increase with depth and distance to the south from the Highlands Ridge, but water of a quality acceptable for most uses can be found as deep as the Lake City Limestone.
	Ocala Limestone	150-250	
	Moody’s Branch Formation	50-150	
	Avon Park Limestone	200-300	
	Lake City Limestone	>400	
	Oldsmar Limestone	>600	Water is too highly mineralized for most purposes.
	Cedar Keys Limestone	>670	

Okeechobee County

There are two major ground water systems in Okeechobee County, the SAS and the FAS. **Table 10** shows the relative positions and production characteristics of these two systems.

The SAS is the major source for domestic self-supplied use in Okeechobee County. It is also used to supply livestock. Productivity in the aquifer tends to increase with depth, but most wells yield less than 100 GPM. Productivity of the SAS is significantly lower in the western portion of the county near the Kissimmee River. Water from the surficial aquifer is generally potable with minimal treatment, except in the southeast portion of the county, where chloride concentrations in excess of 250 mg/L have been measured (Parker et al., 1955).

Separating the SAS from the FAS is the IAS comprised of the Hawthorn Group. The IAS contains some isolated beds of sand and gravel which together yield minor quantities of good quality water. However, the lenses are more limited than in other counties and the IAS is not generally regarded as an important source of water supply for public or agricultural uses. Rather, it is used for primarily for domestic purposes.

Table 10. Ground Water Systems in Okeechobee County.

Hydrogeologic System	Geologic Unit	Thickness (feet)	Water Resource Potential
Surficial Aquifer System	Undifferentiated clastic deposits	100-240	Yields small quantities of good quality water, except near Lake Okeechobee where chloride concentrations exceed potable standards. Wells commonly yield 100 GPM or less. The SAS is the primary source of potable water in unincorporated areas.
Intermediate Aquifer System	Hawthorn Group	200-600	Does not yield significant quantities of water within Okeechobee County.
Upper Floridan Aquifer Middle Floridan Unit Lower Floridan Aquifer	Ocala and Avon Park Limestone Formation	860-960	Produces large to moderate quantities of water, with productivity increasing to the north. Wells generally yield more than 200 GPM. Water quality varies, ranging from very good in the north to brackish in the south and east. The FAS is the primary source of supply of agricultural uses. Sodium, chloride, TDS, and sulfate concentrations increase with depth throughout the county. Little information is available about this unit. Little is known about this aquifer because few wells penetrate this unit. Water quality is generally known to be poor exceeding chloride concentrations of 1,000 mg/L in locations.

The FAS is the principal water source used for irrigation and cattle watering in Okeechobee County. Transmissivities within the aquifer vary significantly throughout the county, ranging from 2,000 gallons per day per unit foot (GPD/ft) in the south to more than 500,000 GPD/ft in northern Okeechobee County. Generally, sodium, chloride, TDS, and sulfate concentrations increase with depth and distance to the south. In the central and northern portion of the county, FAS water is of good quality, requiring little to no treatment for potable use. Waters in the southern and eastern portions of the county; however, may contain localized chloride concentrations in excess of 1,000 mg/L. Although FAS waters are not potable in some areas, they are used extensively for irrigation throughout the county.

Glades County

Three aquifer systems have been identified in Glades County; the SAS, the IAS, and the FAS. **Table 11** shows the relative positions and productivities of these systems.

Little data have been documented on the water bearing characteristics of these aquifer systems in Glades County.

Table 11. Ground Water Systems in Glades County.

Hydrogeologic System	Geologic Unit	Thickness (feet)	Water Resource Potential
Surficial Aquifer System	Undifferentiated clastic deposits	20-100	Varies widely in productivity. Near Lake Okeechobee the shallow ground water is high in chlorides. Moore Haven obtains its potable water from the surficial aquifer.
	Tamiami Formation	0-100	Source of some domestic and stock supply wells.
Intermediate Aquifer System	Equivalent to the sandstone aquifer of Hendry and Lee counties	90-230	Low to moderate productivity. Supplies water for residential self-supplied use and for irrigating small citrus groves.
Floridan Aquifer System	Suwannee Limestone Ocala Limestone	270-1,200	Artesian flow through much of the county. High productivity. Potable in the north to unsuitable for irrigation in the south. Chloride, TDS, and sulfate concentrations increase with depth throughout the county.

The SAS generally has low-to-moderate permeability and productivity. Near the Caloosahatchee River, the shallow ground water contains relatively high chloride and dissolved solids concentrations. The city of Moore Haven obtains its potable water from the SAS.

In the southwest corner of the county, an aquifer exhibiting low-to-moderate productivity exists in the IAS. The IAS is used for residential self supply, as well as for irrigation by several small citrus groves in the area. Little data is available on the IAS for the rest of the county.

The FAS underlies all of Glades County. It consists of several aquifers or producing zones capable of yielding large volumes of water. Floridan wells are under artesian pressure over much of the county. Water quality in the FAS varies from potable in the north to unpotable and unsuitable for most irrigation uses to the south along the Hendry County boundary. Generally, chloride, TDS, and sulfate concentrations increase with depth in the FAS throughout the county.

SURFACE WATER/GROUND WATER INTERACTIONS

The relationship between a surface water feature and the underlying ground water system is one of the most difficult hydrologic relationships to understand. This relationship is based upon the hydraulic characteristics of each aquifer and the thickness and type of soils separating the two features. When a river, canal, or wetland has a higher water level than the water table, these surface water bodies provide seepage into the local shallow ground water system. Conversely, when the water level of the surface water bodies are lower than the water table, ground water discharge may occur. The rate at which this transfer occurs is dependent upon the difference in these two levels and permeability and thickness of the materials separating the two aquifers.

The FAS experiences both natural and artificial recharge. Natural recharge of the FAS within the KB Planning Area is greatest along the Lake Wales, Mount Dora and Bombing Range ridges (**Plate 3**). These areas represent locations where the differences in surface and FAS levels are greatest, and the thickness of the IAS is thinnest or breached by karst activity. Recharge areas are often evident as potentiometric highs on the surface of the FAS. **Figure 6** shows the potentiometric surface of the FAS in May 1997. This is not always the case however. The potentiometric high located in Polk County is not a high recharge, but is instead an artifact of the several surrounding discharge areas.

A large, flat surface in the potentiometric surface of the FAS is indicative of individual recharge areas (letter dated November 24, 1999 from Herb Stangland Jr., Ardaman and Associates Inc., Orlando FL). Along the eastern part of the Green Swamp, high recharge occurs in the sand-filled cavities that extend into the top of the Upper Floridan aquifer along U.S. Highway 27 at the edge, and not in the middle of Green Swamp.

There are about 400 drainage wells in the city of Orlando that discharge into the FAS. Approximately 50 percent of the water these drainage wells receive is from direct stormwater runoff; another 30 percent is from lake overflow; while 15 percent is from excess overflow from wetlands; and the remaining 5 percent is from unused wells that in the past were used to dispose of industrial effluent, sewage and air conditioner return water (SFWMD, 1992).

Springs occur at locations where there is a direct location between an aquifer and surface waters. Florida has more springs than any other state, with 27 first magnitude springs having an average flow of 65 MGD or more. The state also has 49 springs with an average flow of between 6.5 and 65 MGD (Rosenau et al., 1977). These major springs result from the upward movement of water from the FAS in areas where the artesian pressure in the aquifer is elevated above the land surface.

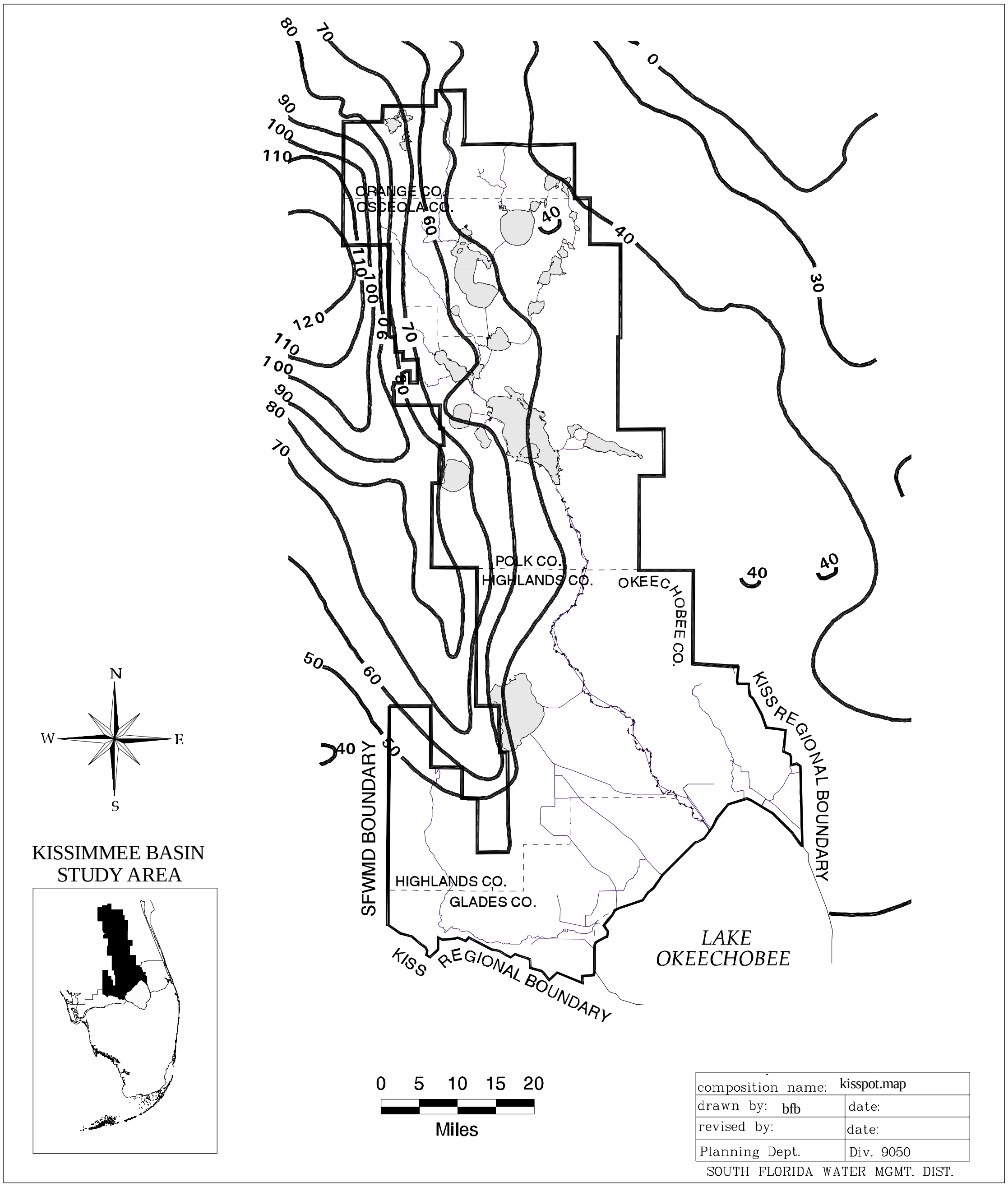

Figure 6. Potentiometric Surface of the Floridan Aquifer System, May 1997.

Chapter 4
NATURAL RESOURCES

The Kissimmee Basin (KB) Planning Area contains a variety of natural resources. The wetlands, uplands, and wildlife of the KB Planning Area all have water needs and require protection.

WETLANDS

Water bodies and wetlands together cover about a quarter of the KB Planning Area. Hydrophytic vegetation, hydric soils, and hydrology typically characterize wetlands. Chapter 62-340, F.A.C. provides the statewide methodology for delineating wetlands in Florida and includes the following definition of wetlands:

> Those areas that are inundated or saturated by surface water or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soils.

Functions and Values of Wetlands

Wetlands perform a number of hydrologic and biological functions. Hydrologic functions include receiving and storing surface water runoff. This is important in controlling flooding, erosion, and sedimentation. Surface water that enters a wetland is stored until the wetland overflow capacity is reached and water is slowly released downstream. As the water is slowed by wetland vegetation, sediments in the water (and chemicals bound to the sediments) settle out of the water column, improving water quality.

Wetlands also function hydrologically as ground water recharge/discharge areas. Wetlands may recharge the ground water when the water level of a wetland is higher than the water table. Conversely, ground water discharge to wetlands may occur when the water level of the wetland is lower than the water table of the surrounding land.

Biological wetland functions include providing habitat for fish and wildlife, including organisms classified as endangered, threatened, or species of special concern. Some species depend on wetlands for their entire existence, while other semi-aquatic and terrestrial organisms use wetlands during some part of their life cycle. Their dependence on wetlands may be for over-wintering, residence, feeding and reproduction, nursery areas, den sites, or corridors for movement. Wetlands are also an important link in the aquatic food web. They are important sites for microorganisms, invertebrates and forage fish which are consumed by predators such as amphibians, reptiles, wading birds, and mammals.

Types of Wetlands

Inland or freshwater wetlands within the KB Planning Area can be grouped into three major categories based on hydroperiod: permanently flooded or irregularly exposed; seasonally or semipermanently flooded; and temporarily flooded or saturated. Uplands are also represented on the Florida Land Use, Cover and Forms Classification System (FLUCCS). The FLUCCS map was created in 1998 using 1994-1995 aerial photography and was used to delineate wetlands in the Lower West Coast Planning Area. The hydroperiod categories were created by combining FLUCCS coverage classifications with the National Wetlands Inventory hydrologic classifications. This methodology and resulting map (**Plate 4**) is being applied to the KB Water Supply Planning Area. The hydrologic categories are broadly defined as:

- **Permanently Flooded or Irregularly Exposed**. Water covers the substrate throughout the year in all years or the substrate is exposed by tides less often than daily. This category corresponds to lakes, rivers, ponds and reservoirs.
- **Seasonally or Semipermanently Flooded**. Surface water persists throughout the rainy season and much of the dry season in most years. When surface water is absent, the water table is at or very near the land surface and seasonally flooded soils remain saturated. Corresponds to swamps, sloughs, mixed wetland hardwoods, cypress, mixed wetland forest, freshwater marshes, sawgrass and or cattail, emergent and submergent aquatic vegetation.
- **Temporarily Flooded or Saturated.** Surface water is present during the rainy season, but the water table usually lies below the soil surface for most of the year. Plants that grow in both uplands and wetlands are characteristic of this regime. The substrate is saturated to the surface through out the rainy season or for extended periods of during the rainy season in most years. This category corresponds to cypress–pine–cabbage palm, wet prairie–with pine intermittent ponds, pine–mesic oak, Brazilian pepper, melaleuca, and waxed myrtle-willow.

Distribution of Wetlands

Most wetland systems in the KB Planning Area drain into the Kissimmee River, and subsequently Lake Okeechobee. Shingle Creek Swamp and Reedy Creek Swamp, two large forested wetlands in the northernmost reaches of the KB Planning Area, start the headwaters of the Kissimmee Chain of Lakes. Water from these two wetland systems flow slowly southward and drain into Lake Tohopekaliga. Outflows from Lake Tohopekaliga and the Alligator Chain of Lakes drain into Cypress Lake, which in turn flows into Lake Hatchineha and then into Lake Kissimmee. Large herbaceous marshes surround Cypress Lake, the north end of Lake Hatchineha, and the entire shoreline of Lake Kissimmee. The

Alligator Chain of Lakes is surrounded by large areas of forested cypress and mixed hardwood swamps as well as smaller pockets of herbaceous marsh.

The drainage basins within the SFWMD boundary of Polk County can be divided into the portions above and below Lake Hatchineha. Above the lake, the relatively low-lying flat prairies and shallow lake systems of Lake Marion and Saddlebag Lake drain into Lake Kissimmee. Lake Marion overflows through an extensive forested wetland system into Lake Hatchineha, which discharges to Lake Kissimmee. Saddlebag Lake flows in a northwesterly direction through a series of small lakes into Big Gum Lake, which in turn overflows into Lake Pierce and subsequently into Lake Hatchineha.

Below Lake Hatchineha there are the lake systems of Lake Weohyakapka and Arbuckle Lake. Lake Weohyakapka flows into Lake Rosalie via Weohyakapka Creek, which is surrounded by forested floodplains. Lake Rosalie then drains in a southeasterly direction into Tiger Lake, which flows into Lake Kissimmee. Arbuckle Lake drains in a southerly direction into the Kissimmee River.

Lake Istokpoga, the largest lake in Highlands County, drains into the Kissimmee River through the Istokpoga Canal and C-41A. The lake used to be surrounded by extensive wetlands, but now only has remnant marshes. Pasture now surrounds a large portion of the lake, and residential development has taken place on the southwest shore of the lake.

UPLANDS

Native uplands are non-wetland areas with intact ground cover, understory, and canopy. Native uplands in the KB Planning Area include longleaf and slash pine forests, live oak hammocks, sand pine scrub, cabbage palm, turkey oak, hardwood forest, palmetto prairies, and dry prairie grasslands. Uplands often have ground water storage available in the SAS where rainfall infiltrates the surface soils with part used by plants as evapotranspiration, and the remainder percolates to ground water storage. Ground water storage in upland areas reduces runoff during extreme rainfall events, while plant cover reduces erosion and absorbs nutrients and other pollutants that might be generated during a storm. Upland vegetative areas also provide climate moderation, noise barriers, wildlife habitat, and recreational resources.

Pine flatwoods are an important upland community in the KB Planning Area. These plant associations are characterized by a low, flat topography and poorly drained, acidic, sandy soils. Under natural conditions, fire maintains flatwoods as a stable plant association. However, when the natural frequency of fire is altered by increased drainage and the construction of roads and other fire barriers, flatwoods can succeed to other community types. The nature of this succession depends on soil characteristics, hydrology, available seed sources or other local conditions (Myers and Ewel, 1990).

The Longleaf Pine-Turkey Oak Hills ecological community occurs nowhere else in the SFWMD except in eastern Polk and northern Highlands counties. This community occurs on rolling land. Water moves rapidly through the soils. There are several variations of this community. Mature natural stands of trees have scattered longleaf pine as an overstory. Areas on which pines have been removed are predominantly oaks. Ground cover is scattered and numerous bare areas are noticeable. This community is influenced by fire, heat and drought. The natural vegetation is adapted to withstand the effects of occasional fire. Without the occurrence of fire, the longleaf pine cannot withstand the invasion of hardwood species and would change into an upland hardwood hammock. In this habitat, water moves rapidly through the soil to the aquifer with little runoff and minimal evapotranspiration (Soil and Water Conservation Society, 1989)

The Kissimmee Prairie Ecosystem is located in Okeechobee County, east of C-38. In 1998, the District and CARL purchased the entire tract. It has a total area of about 46,000 acres, of which 7,000 acres lie within the boundary of the Kissimmee River Restoration Project. The remaining 39,000 acres form one of the most unique land mosaics in Florida. This ecosystem is mostly undisturbed, and includes 10 separate community types which provide breeding habitat for numerous wildlife species. The dominant community type is dry prairie, and this tract is likely to be the largest and best example of its type in the world (SFWMD, 1999). This area has been acquired for conservation/preservation purposes.

WATER NEEDS OF INLAND RESOURCES

Wetland Water Needs and Concerns

Maintaining appropriate wetland hydrology (water levels and hydroperiod) is the single most critical factor in maintaining a viable wetland ecosystem (Duever, 1988; Mitch and Gosselink, 1986; Erwin, 1991). Rainfall, along with associated ground water and surface water inflows, is the primary source of water for the majority of wetlands in the KB Planning Area. Because wetlands exist along a continuous gradient, changes in the hydrologic regime may result in a change in the position of plant and animal communities along the gradient. The effects of hydrologic change are both complex and subtle. They are influenced by, and reflect regional processes and impacts as well as local ones (Gosselink et al., 1994). Hydrology, as well as other factors which influence wetland systems, such as fire, geology and soils, and climate, is further discussed in Appendix E.

James Gosselink states in a 1994 study on wetland protection from aquifer drawdown that a critical issue to be considered in the water supply planning process is how wellfield induced ground water drawdowns affect wetlands. An adverse environmental impact can be defined as: (1) a change in surface or shallow ground water hydrology that leads to a measurable change in the location of the boundary of a wetland; or (2) a measurable change in one or more structural components of a wetland as compared to control or reference wetlands, or to the impacted wetland before the change occurred (Gosselink et al., 1994). Lowered ground water tables in areas adjacent to wetland communities have been shown to decrease wetland surface water depths and shorten the hydroperiod (length of inundation).

Aquifer drawdown and its subsequent effect on wetlands are best measured using three parameters; severity (the depth of the drawdown), duration (the length of time), and frequency (how often that drawdown occurs). The most obvious impact of reducing hydroperiod is a decrease in the size of a wetland. This is especially true of shallow, low gradient wetlands, which may be entirely eliminated by lowered water levels. Decreased wetland size reduces the available wildlife habitat and the area of vegetation capable of nutrient assimilation. Lowered water levels and reduced hydroperiod also: (a) induce a shift in community structure towards species characteristic of drier conditions; (b) reduce rates of primary and secondary aquatic production; (c) increase the destructiveness of fire; (d) cause the subsidence of organic soils; and (e) allow for exotic plant invasion (Gosselink et al., 1994). The size of a wetland may also be reduced because of changes in hydropattern. Hydropattern or surface water flow through a wetland is equally important (letter dated November 24, 1999 from Herb Stangland Jr., Ardaman and Associates Inc., Orlando, FL).

Rivers and Floodplains

The Kissimmee River and its floodplains contain forested, wetland shrub, and marsh wetlands, and at one time meandered through the Osceola Plain. The ability of a floodplain to store and slow the movement of water is a critical water management concern. When development occurs on a floodplain, it loses its storage functions, potentially causing flooding in areas that were previously flood free. In addition to serving as a temporary water storage system, the floodplain around the Kissimmee River served as a filtration system and wildlife habitat. The floodplain helped to regulate the velocity and timing of the flood discharge by slowing the waters that spilled over the banks of the river. Pollutants and nutrients (nitrogen and phosphorus) were taken up by the floodplain vegetation before water flowed into Lake Okeechobee or seeped into the aquifer.

The floodplain was once used by a larger number of song birds, wading birds, hawks, waterfowl, shrew, mice, raccoons, squirrels, deer, turtles, otter, fish, and other species. Restoration of parts of the river to a meandering state is taking place which will restore wetland habitat values. The federally authorized (PL 102-580) Kissimmee River Restoration Project will restore over 40 square miles of the existing channelized system, including 43 continuous miles of river channel and about 27,000 acres of wetlands. The project is expected to benefit over 320 fish and wildlife species (Toth et al., 1998).

Lakes

The KB Planning Area has hundreds of lakes. A lake can be classified according to its trophic level. Oligotrophic lakes have low levels of nutrients, good water clarity, and low levels of plant and animal life. Mesotrophic lakes have moderate levels of nutrients, moderate water clarity, and a moderate amount of plants and animals. Eutrophic lakes are characterized by high levels of nutrients, reduced water clarity, and an abundance of aquatic plant and animal life. Hypereutrophic lakes are those that often have a pea soup appearance from the amount of algae in the water column, the presence of algal mats, and an overabundance of nutrients. As rotting plant material uses oxygen, aquatic animal life may die off from a lack of dissolved oxygen in the water. Eventually, the mucky bottom of the lake fills up with sediments and converts into a marsh. Eutrophication is a natural process, however, human activities can accelerate this process (cultural eutrophication).

A decrease in nutrients to the lake systems should slow eutrophication. In the 1970s the water quality in the Upper Kissimmee Basin (especially Lake Tohopekaliga) was significantly degraded by nutrients that originated from sewage treatment plants in Orlando, and from untreated nonpoint urban and agricultural sources. When the nutrient sources were identified and consequently reduced or eliminated, the water quality in the lakes improved. Better water quality in the Upper Kissimmee Basin may lead to improved quality in the Lower Kissimmee Basin and Lake Okeechobee.

Springs

There are no known documented natural springs located with in the KB Planning Area. There are anecdotal discussions with local residents of existing shallow aquifer seeps or springs located along the eastern edge of the Lake Wales Ridge in Polk County. The location of these springs has not been identified. These springs are described as small and are used for domestic use.

There are several natural springs located adjacent to, but outside the KB Planning Area. The most noteworthy of these are the springs of the Wekiva Basin, located approximately 15 miles to the north of the KB Planning Area in northwestern Orange County. These springs are the result of discharges from the FAS in areas where the confining units are thin and have been breached, allowing for the upward artesian flow of water. Discharges from seven of the springs flow to the Wekiva River, a protected Outstanding Florida Waterway. These springs include Wekiva, Sanlando, Starbuck, Miami, Rock, Palm, and Seminole springs. The St. Johns River Water Management District (SJRWMD) has determined that these springs provide an important base flow component to the river and to those vegetative communities dependant on this water. SJRWMD has determined that a 15 percent reduction in the 1995 observed spring discharge for these seven springs is enough to pose a reasonable likelihood of harm to natural systems along the Wekiva River and its tributaries. These minimum spring discharges have been set forth in Chapter 40C-8, F.A.C. This chapter also specifies specific minimum discharges for several springs located in the Wekiva Basin and throughout the SJRWMD.

The SJRWMD Water Supply Needs and Sources Assessment (1994) suggests that future withdrawals, including areas within the SFWMD may be contributing anticipated impacts to these springs. The KB Water Supply Plan Planning Document (Chapter 4) addresses this potential link between Floridan withdrawals and reduction in spring flow.

Upland Water Needs

Seasonal variations play an important role in determining the type of upland vegetation that will develop. It is general thought that plant communities located in uplands are better able to adapt to dry season hydroperiod fluctuation as compared to plants in wetlands.

Wildlife Water Needs

Appropriate hydrology is not just an issue for the plant communities, but also for the associated wildlife, including endangered and threatened species, and species of special concern (a list of endangered, threatened, and species of special concern found in the KB Planning Area is provided in Appendix E). Species composition, distribution and abundance are influenced by the annual pattern of rainfall, water level fluctuations, and fire. Alterations in ground and surface water depth and/or hydroperiod that result in changes to vegetative composition and diversity may lead to the degradation of fish and wildlife habitat.

PROTECTION OF NATURAL RESOURCES

The District protects and enhances natural resources through its wetland policies and rules, wellfield location criteria, wetland buffers, wellfield monitoring, wetland mitigation banking, and land acquisition programs.

Wetland Policies

The District prevents harm to wetlands from ground water withdrawals by implementing numerous state laws through technical criteria (Appendix A) into its consumptive use permitting process which limits drawdowns beneath wetlands. The obligation to leave enough water in natural areas to maintain their functions and protect fish and wildlife is central to water supply planning.

The State Comprehensive Plan (Chapter 187, F.S.) states as a goal that Florida "shall maintain the functions of natural systems and the overall present level of surface and ground water quality." The same document lists as a policy: "Reserve from use that water necessary to support essential non-withdrawal demands, including navigation, recreation, and the protection of fish and wildlife." Chapter 373, F.S., authorizes several means of accomplishing this goal. Some of the most noteworthy include: (1) Section 373.042 concerning minimum flows and levels; (2) Section 373.223(4) concerning reservation of water for fish and wildlife; and (3) Section 373.223 concerning the three part test for permit issuance (copies of these statutory provisions are provided in Appendix A).

The extent to which wetland preservation conflicts with water supply development depends greatly on the approach of that development. For example, options that increase water storage relieve the conflict between wetlands and human development, as does appropriate location and design of wellfields or the use of surface water. The challenge is to accept wetland protection as a constraint and then come up with the most reliable and cost-effective water supply strategy.

Wellfield Location

Locating wellfields away from wetlands is an approach that can reduce local environmental effects but is not always easy to implement. Often the choice is reduced to either locating the wellfield in undeveloped areas with environmentally sensitive wetlands or in developed uplands where the potential for wellfield contamination is a serious concern. From a planning perspective, wellfields near environmentally sensitive wetlands, should be sited in areas where leakance to the Upper Floridan aquifer is low, and not high and/or where wetlands receive runoff from a relatively large watershed as opposed to near an isolated wetland system. In developed areas, wellfields should be in areas where leakance to the Upper Floridan aquifer is low.

Wetland Buffers

Another approach involves using man-made lakes or reservoirs as a buffer between wellfields and natural wetland systems. The water in these lakes act as a buffer by managing the local water table at a sufficient level to avoid impacts to nearby wetlands. The surface water that is available in these reservoirs can also be used to supplement ground water withdrawals.

Wellfield Impact Monitoring

The District's Resource Assessment division began a research program in 1995 to support development of wetland drawdown criteria. The research project is broken down into three phases.

Phase I consisted of: (1) a literature review to determine if sufficient information is present to support existing drawdown criteria or to recommend new criteria; (2) ground water modeling; and (3) a scientific wetland expert workshop. This phase was completed in November 1995.

Phase II consisted of: (1) determining the extent and severity of impacts, if possible, using a historical approach to determine impacts from ground water drawdowns through aerial photograph interpretation; and (2) identify wetland sites throughout the District for well installation and hydrobiological monitoring. This phase was completed April 1997.

Phase III has two main objectives: (1) implement long-term hydrobiological monitoring at wetlands located along a gradient of drawdown in selected study sites; and (2) test hypotheses regarding: (a) the effects of ground water drawdowns on wet season biological productivity; (b) the dependence of surface soil moisture on the dry season water table position; (c) differences in ecosystem structure and function between wetlands subject to different amounts of drawdown; (d) the effects of local versus regional calibration of ground water models used in the permit application process; and (e) symptoms of impact observed during drought.

Site characterization and well drilling contracts are presently underway in the Lower West Coast and Kissimmee Basin water supply planning areas. Biological studies will facilitate the characterization of biotic communities of the selected wetland sites and development of non-destructive long-term monitoring methods. To date, inventories of plant, fish, aquatic insect, bird, moss, algae, and amphibian populations have been conducted. Various sampling methods are presently under investigation for incorporation into a long-term monitoring effort.

In the Lower West Coast at Flint Pen Strand, there are currently thirteen agricultural monitoring sites with sixteen associated wells, with an additional nine monitoring sites with ten associated wells. At the Stairstep project site (Corkscrew Mitigation Bank) there are three reference sites with five associated wells. These sites were outfitted with the appropriate instrumentation in December 1999. Surveying will be completed in June 2000 and complete analyses on these sites are expected in late 2000. In the Kissimmee Basin at the Disney Wilderness Preserve, there are six monitoring sites with seven associated wells and one weather station. The above wells have been monitored since the spring of 1997.

Monitoring wetlands adjacent to wellfields ensures that withdrawal impacts are detected. Steps can then be taken to limit further impacts. Long-term monitoring of wetlands adjacent to wells provides documentation of impacts to wetlands that occur over time.

The hydrologic and biologic consequences of ground water withdrawal from wellfields in the Northern Tampa Bay region have been documented by the Southwest Florida Water Management District (SWFWMD). After long-term monitoring of wells and wetland systems, SWFWMD concluded that adverse impacts are especially evident in areas where ground water modeling of withdrawals indicates a drawdown of one foot or more.

The type of impacts noted for marsh and cypress wetlands were:

- Extensive invasion of weedy upland species
- Destructive fires
- Abnormally high treefall
- Excessive soil subsidence/fissuring
- Disappearance of wetland wildlife

The SWFWMD ground water modeling has also shown that it may take one to two decades for the full effect of wellfield pumpage to be realized. Therefore, actual water levels in newer wellfields, or in wellfields currently not pumping at their maximum permitted levels, could become lower in the future. For these and other reasons, SWFWMD suggests that continued environmental monitoring will be necessary to ensure that Florida's wetlands are adequately protected (Rochow, 1994).

Wetland Mitigation Banking

Wetland mitigation banking is a relatively new natural resource management concept which provides for compensation of unavoidable wetland losses due to development. The Florida Environmental Reorganization Act of 1993 directed the water management districts and FDEP to participate in and encourage the establishment of public and private regional mitigation areas and mitigation banks. The act further directed the WMDs and FDEP to adopt rules by 1994, which led to the state's mitigation banking rule (Chapter 62-342, F.A.C.), becoming effective January 1994. In 1996, House Bill 2241 further developed this program by providing for the acceptance of monetary donation as mitigation in District and FDEP endorsed off-site regional mitigation areas. This modification clarified service area requirement credit criteria and release schedules, assurances and provisions that apply equally to public and private banks. As a result, the District and FDEP will adopt rules to implement these provisions. In the long-term, wetland mitigation banking should apply to water use permitting. Wetland mitigation banking does not currently apply to water use related impacts.

Minimum Flows and Levels

The purpose of establishing minimum flows and levels (MFLs) is to avoid diversions of water that would cause significant harm to the water resources or ecology of an area. The Florida Legislature has mandated that all water management districts establish MFLs for surface waters and aquifers within their jurisdiction. Section 373.042(1) defines the minimum flow as "the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area." It further defines the minimum level as the "level of ground water in an aquifer and the level of surface water at which further withdrawals would be harmful to the water resources of the area." The District is further directed to use the best available information in establishing a minimum flow or a minimum level.

The overall purpose of Chapter 373 is to ensure the sustainability of water resources of the state (Section 373.016, F.S.) To carry out this responsibility, Chapter 373 provides the District with several tools, with varying levels of resource protection standards. MFLs play one part in this framework. Determination of the role of MFLs and the protection that they offer, versus other water resource tools available to the District, are discussed below.

The scope and context of MFLs protection rests with the definition of significant harm. The following discussion provides some context to the MFLs statute, including the significant harm standard, in relation to other water resource protection statutes.

Sustainability is the umbrella of water resource protection standards (Section 373.016, F.S.). Each water resource protection standard must fit into a statutory niche to achieve this overall goal. Pursuant to Parts II and IV of Chapter 373, surface water management and consumptive use permitting regulatory programs must prevent **harm** to the water resource. Whereas water shortage statutes dictate that permitted water supplies must be restricted from use to prevent **serious harm** to the water resources. Other protection tools include reservation of water for fish and wildlife, or health and safety (Section 373.223(3)), and aquifer zoning to prevent undesirable uses of the ground water (Section 373.036). By contrast, MFLs are set at the point at which **significant harm** to the water resources, or ecology, would occur. The levels of harm cited above, harm, significant harm, and serious harm, are relative resource protection terms, each playing a role in the ultimate goal of achieving a sustainable water resource.

Where does the significant harm standard lie in comparison to the consumptive use permitting and water shortage standards? The plain language of the standards of harm versus significant harm, although undefined by statute, implies that the minimum flow or level criteria should consider impacts that are more severe than those addressed by the consumptive use permitting harm standard, but less severe than the impacts addressed by the serious harm water shortage standard. The conceptual relationship among the terms harm, significant harm, and serious harm are shown in **Figure 7**.

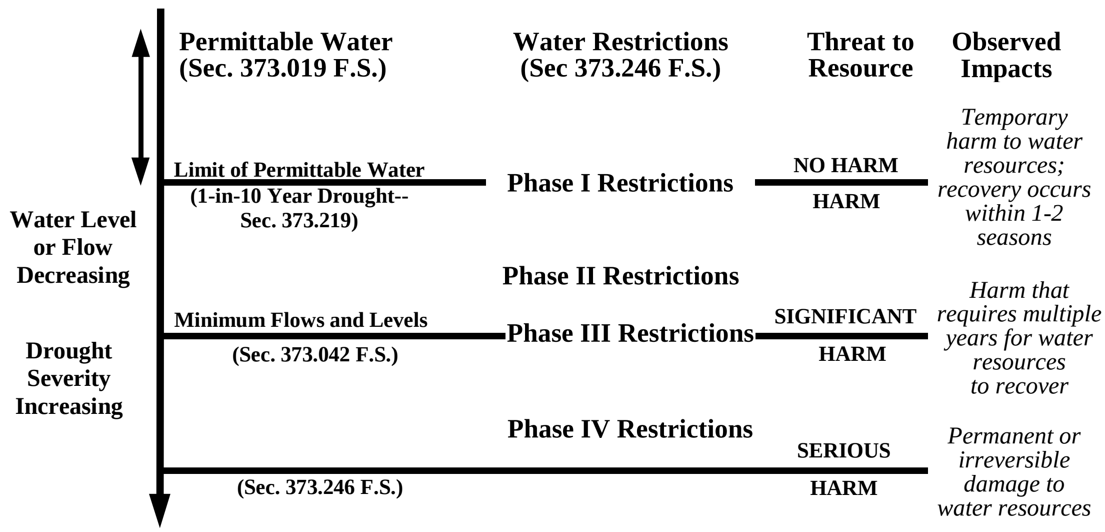

Figure 7. Conceptual Relationship among the Terms Harm, Significant Harm, and Serious Harm.

Within the KB Planning Area, 12 surface water bodies and the Floridan aquifer are on the District's priority list for establishment of MFLs. These MFLs will be established in 2004 and 2006.

Land Acquisition Programs

The ongoing acquisition efforts in the KB Planning Area include the Save Our Rivers (SOR) and the Conservation and Recreational Lands (CARL) programs.

Florida's SOR Program was started in 1981. The purpose of the SOR Program is to purchase lands necessary for water management, water supply, and the conservation and protection of water resources.

The CARL Program was established by the Florida Legislature in 1979. The primary purpose of this land acquisition program is conservation and protection of environmentally unique, irreplaceable ecological resources.

Chapter 5
RESOURCE REGULATION

There are several programs that the District, as well as federal, state, and local governments may implement to protect water resources. The District's programs include permitting for both wetland protection and water resource allocation, and water shortage management. In addition, there are special agreements unique to the Kissimmee Basin that the District shares with the Seminole Tribe and other water management districts.

The U.S. Environmental Protection Agency (USEPA), through the reauthorization of the Safe Drinking Water Act, state agencies, through enacting administrative rules, and local governments, through implementing wellhead protection ordinances, strive to prevent ground water contamination. Of particular import to the Kissimmee Basin are the wellhead protection ordinances of the counties and cities in the region.

ENVIRONMENTAL RESOURCE PERMITTING

The Environmental Resource Permitting (ERP) Program deals with the construction of surface water management systems and dredge and fill activities. Surface water management systems are required for all forms of development ranging from agriculture to commercial and residential. This means that developed sites containing more impervious surfaces or altered topography, must provide a way for storm water to be directed to water management areas for water quality treatment and flood attenuation.

During the ERP process, wetlands are evaluated both on and adjacent to the project site. If wetland impacts are proposed in an ERP application, an analysis is conducted to determine if the impacts can be eliminated or reduced. Impacts to wetlands can occur through direct physical alteration, such as filling or dredging, or through alteration of the normal hydrologic regimes, such as lowering of the water table. All types of impacts are reviewed during the ERP process.

If the proposed wetland impacts are determined to be permittable, an applicant will need to provide compensation for the loss of the wetland functions. Generally this is accomplished through mitigation, consisting of the restoration or enhancement of existing wetlands, the creation of new wetland habitat, or a combination of these methods. The mitigation areas must be monitored and maintained over the long-term and protected with a conservation easement.

If the applicant proposes to preserve the wetlands on the project site, an analysis is conducted to determine what effects the development will have on the wetlands. An applicant must provide an upland buffer, must ensure that adequate quantities of water will be available to wetlands and that the wetlands will not be over inundated for prolonged periods of time. A conservation easement is required to ensure the long-term protection of the wetlands.

CONSUMPTIVE USE PERMITTING

The District has the authority and responsibility to establish policies for the use and regulation of water that maximize reasonable-beneficial uses that are in the public interest, as long as these policies safeguard the environment, other legal users, and water resources. These policies are implemented through intergovernmental coordination, establishment of programs, and the permitting process.

Water resources are used for many purposes including agricultural, landscape, and golf course irrigation; potable water; commercial; and industrial uses. All water withdrawals within the District require a District water use permit except: (1) water used in a single family dwelling or duplex, and provided that the water is obtained from one well for each single family dwelling or duplex, and is used either for domestic purposes or outdoor uses; (2) water used for fire fighting; and (3) the use of reclaimed water. The first exemption is provided in state legislation; the latter two are District exemptions.

The District issues water use permits in two forms, individual water use permits and general water use permits. An individual water use permit is issued for projects whose water use exceeds 100,000 gallons per day (GPD), while general permits are issued when the use does not exceed 100,000 GPD, except in reduced threshold areas. A general water use permit is issued for a duration of up to 20 years while individual permits are generally issued for a shorter period. Individual permits are issued with an expiration date that corresponds with the basin expiration date, at which time water use permits for the entire Kissimmee Basin will have to be renewed. The current basin expiration date in the Kissimmee Basin (KB) Planning Area is December 15, 2001.

The District has issued 477 individual consumptive use permits in the KB Planning Area (**Table 12**). Most of these permits are for agricultural uses.

Table 12. Individual Permit Allocations.

County	Agriculture[a]		Public Water Supply		Recreation[b]		Industrial		Dewatering	
	# permits	Alloc. (MGY)	# permits	Alloc. (MGY)	# permits	Alloc. (MGY)	# permits	Alloc. (MGY)	# permits	Alloc. (MGY)
Glades	18	45,884	0	0	0	0	0	0	0	0
Highlands	128	103,916	2	154	2	228	1	361	0	0
Okeechobee	58	21,812	4	1,160	2	131	0	0	4	1,427
Orange	67	5,405	7	57,414	24	3,517	4	1,163	6	1,990
Osceola	101	18,874	13	15,336	6	428	1	75	4	696
Polk	17	2,254	4	731	4	256	0	0	0	0
Total	389	198,145	30	74,795	38	4,560	6	1,599	14	4,113

a. Includes agriculture, aquaculture, livestock, and nursery.
b. Includes golf courses and landscape.
Source: April 1999 consumptive use permitting data.

Basis of Review Criteria

The permitting process involves reviewing water use permits for consistency with criteria in the District's Basis of Review (BOR). Chapter 2 of the BOR, Water Need and Demand Methodologies, include criteria for demonstration of need, calculation of water demands, and water conservation requirements for the different use classes. The criteria in Chapter 3 of the BOR, Water Resource Evaluations, address the evaluation of the potential impacts to the resource, existing legal users, the environment, saline water intrusion, and movement of pollution (SFWMD, 1994).

Due to the predominant utilization of the Floridan aquifer in the KB Planning Area, the potential for significant resource impacts resulting from the withdrawals of most water uses is generally considered to be minimal. However, some uses are restricted due to their location in high sinkhole prone areas, or because of the potential to cause regional saline water movement, impact spring flow, or result in adverse environmental impacts.

Areas with Increased Permitting Restrictions

An increased level of consumptive use permitting restrictions is applied to areas where there is potentially a lack of water available to meet demands. These areas include Reduced Threshold Areas, Restricted Allocation Areas, Areas of Special Concern, and Critical Water Supply Problem Areas. Limited portions of the KB Planning Area are included in these areas.

Reduced Threshold Areas

The volume of usage which delineates a general permit from an individual permit is referred to as the permit threshold. In most of the District, the permit threshold is 100,000 GPD. However, in resource depleted areas, where there has been a history of saline water movement into ground water and surface water bodies or the lack of water availability to meet projected needs of a region, the District has reduced this threshold to 10,000 GPD average or 20,000 GPD maximum. These areas are referred to as Reduced Threshold Areas (RTAs). No RTAs have been established in the KB Planning Area.

Restricted Allocation Areas

In addition to RTAs, the District has also designated areas as Restricted Allocation Areas (RAAs). These are designated areas within the District for which allocation restrictions are applied to the use of specific water sources. The water resources in these areas are managed in response to specific sources of surface water and ground water for which there is a lack of water availability to meet the needs of the region. The area to the southeast of Lake Istokpoga and to the northwest of Lake Okeechobee (**Figure 8**) is the only restricted allocation area in the KB Planning Area, as identified in the District's BOR for Water Use Permit Applications. This area has received this designation due to a history of water shortage in the area, indicating a limit on the availability of surface water from Lake Istokpoga to meet all of the demands of the Indian Prairie Agricultural Area.

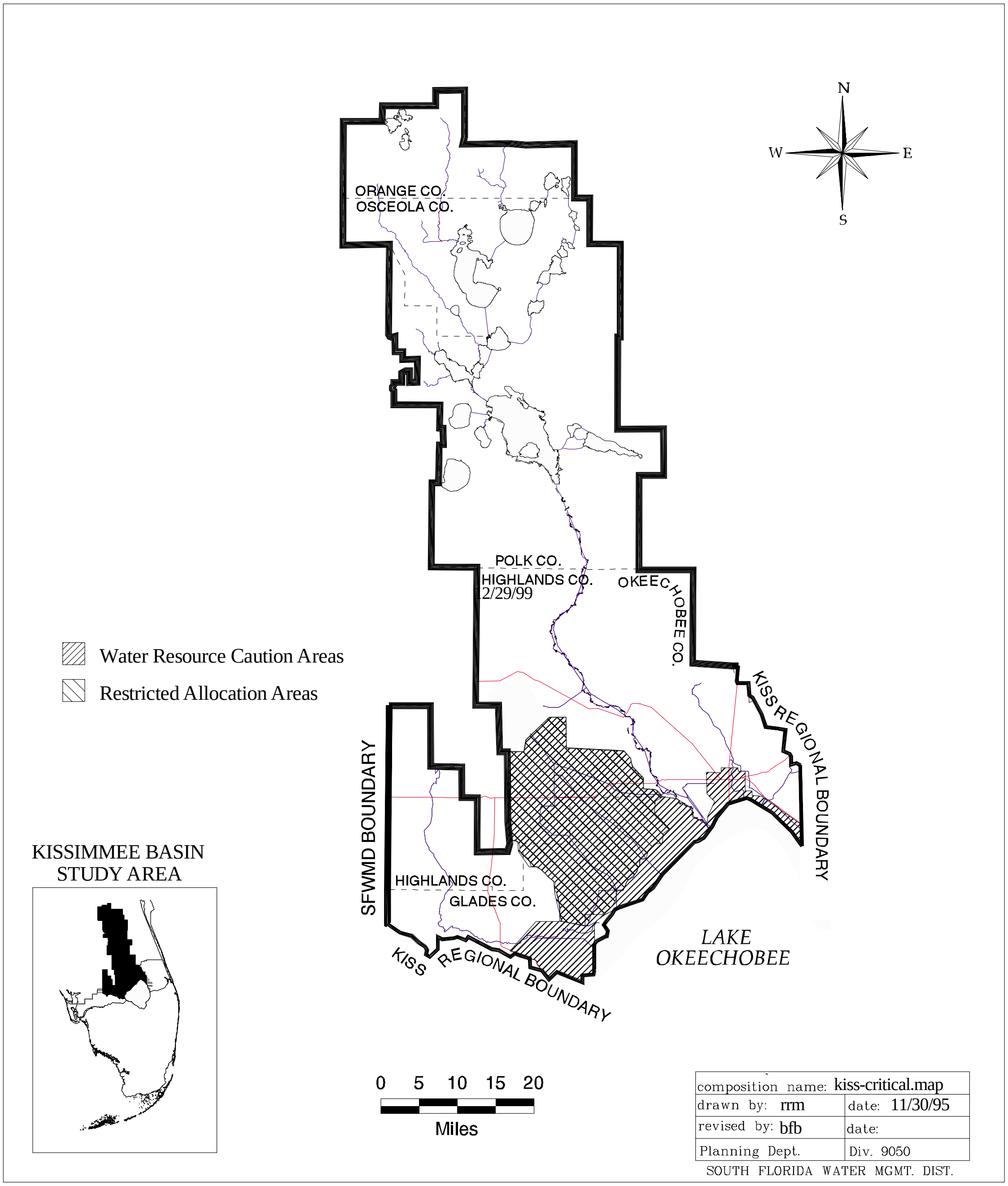

Figure 8. Consumptive Use Permitting Specially Designated Areas.

Areas of Special Concern

Areas of Special Concern are areas where there are limitations on water availability or there are other potentially adverse impacts associated with a proposed withdrawal. These areas are determined by the District on a case-by-case basis. There are no designated areas of special concern in the KB Planning Area.

Water Resource Caution Areas

Water Resource Caution Areas (WRCAs) are areas that have existing water resource problems or areas in which water resource problems are projected to develop during the next 20 years. These areas were formerly referred to as critical water supply problem areas and were required to be designated by rule by each water management district pursuant to Chapter 62-40, F.A.C., the Water Resource Implementation Rule. This chapter further states that applicants withdrawing from areas designated as Critical Water Supply Problem Areas must make use of a reclaimed water source unless the applicant demonstrates that its use is not economically, environmentally or technologically feasible. The area to the southeast of Lake Istokpoga and to the northwest of Lake Okeechobee, and a coastal strip adjacent to Lake Okeechobee are designated as Water Resource Caution Areas within the KB Planning Area in Chapter 40E-23, F.A.C. (**Figure 8**). The Water Resource Implementation Rule requires that these designations be updated within one year of completion of the District Water Management Plan and its future updates.

WATER SHORTAGE MANAGEMENT

Water shortages, and the associated restrictions, are declared by the District's Governing Board when there is not enough water available for present or anticipated needs, or when a reduction in demand is needed to protect water resources. Ground water and surface water levels are continuously monitored, and if they fall to levels considered critical for the time of year and anticipated demands, then the water shortage process is initiated. There are different levels of drought, and these require corresponding levels of restrictions. Water shortage declarations range from a "warning," which has voluntary moderate restrictions, through four phases of water shortage, to an "emergency," which can restrict withdrawals up to the point of disallowing any further withdrawals from a source.

The water shortage phases reflect the percent reduction in withdrawals necessary to reduce demand to the anticipated available water supply.

The phases are as follows:

- Phase I: Moderate - up to 15 percent reduction
- Phase II: Severe - up to 30 percent reduction
- Phase III: Extreme - up to 45 percent reduction
- Phase IV: Critical - up to 60 percent reduction

Each declared source class is assigned a water shortage phase, and source classes can be combined if appropriate. A water shortage warning has the same restrictions associated with a Phase I, but participation is voluntary. Any of the phases of water shortage can be modified by the Governing Board if necessary. The District's Water Shortage Plan is located in Chapter 40E-21, F.A.C. The current water shortage procedure was originally adopted by the District in 1982. Prior to that, restrictions were made during periods of drought but did not necessarily correspond to the current requirements of the phases of water shortage.

In June 1985, a Phase I water shortage was declared in the Lake Istokpoga-Indian Prairie Water Use Basin area of the KB Planning Area for both ground and surface water, and restrictions were in place through August of that year (**Table 13**). Another drought in the region resulted in a water shortage warning with voluntary Phase I restrictions on surface water withdrawals for that same region for August through November 1987.

Table 13. History of Water Shortages.

Year	Order #	Restrictions	Area Affected	Date Declared	Date Rescinded
1985	85-4	Phase I: Ground and surface water	Lake Istokpoga-Indian Prairie Water Use Basin	6-13-85	8-8-85
1987	87-4	Warning: Voluntary phase I -- surface water	Lake Istokpoga-Indian Prairie Water Use Basin	8-17-87	11-10-87

INTERGOVERNMENTAL AGREEMENTS

Intergovernmental agreements are critical to the success of a coordinated planning effort. Two existing intergovernmental agreements in the KB Planning Area that facilitate coordination between the SFWMD and other entities are the Memorandum of Understanding between the SFWMD, SJRWMD, and SWFWMD; and the agreement between the SFWMD and Seminole Tribe.

Memorandum of Understanding

In order to improve coordination between the SFWMD, SJRWMD, and SWFWMD in the Central Florida area, staff from the three districts have developed a Memorandum Of Understanding (MOU). The MOU includes agreements on coordination in water resource investigation, water resource planning, water resource regulation, and water shortage declarations. A copy of the MOU is presented in Appendix A.

The water resource investigation portion of the MOU outlines agreements for the three districts to coordinate in the collection and sharing of hydrologic, geologic, and water use permit information; GIS coverages; and the development of ground water models.

The water resource planning portion of the MOU outlines agreements for the three districts to coordinate and be consistent in water demand projection methodology and demand projection numbers; population projection sources and population projection numbers; ground water model runs; identification, funding, and implementation of alternative water supply strategies; review of comprehensive plan amendments; and the provision of technical assistance to local governments.

The water resource regulation portion of the MOU outlines agreements for the three districts to coordinate applicant information for proposed uses of the Floridan aquifer. The reviewing district will provide the other district with copies of water use permit applications, support information, and correspondence, and will incorporate the other districts comments into its permit review process.

In order to ensure the orderly administration of this MOU, the water management districts will: (1) designate one position each, for water resource investigation, water resource planning, and water resource regulation, to oversee the administration of this MOU; (2) meet in April and October of each year to assess compliance with this MOU and its effectiveness in achieving the stated purposes and goals; and (3) individually and jointly seek to obtain the funding from the governing boards needed to implement this agreement and to achieve the stated goals.

Seminole Tribe Agreement

The Seminole Tribe of Florida, the State of Florida and the District executed a Water Rights Compact in 1987. The Compact provides a framework for harmonizing the relationship between the Tribe, Florida, and the District on issues concerning the water resource. Of particular import to this Plan are the Compact provisions concerning the Tribe's Brighton Reservation water entitlement and the Work Plan process which addresses the process through which the Tribe perfects water rights. The Tribe's Brighton Reservation water entitlement was further detailed in an Agreement which was executed by the Tribe and District in November 1992 after publication of a District technical report. This Agreement outlines surface water control strategies to assure maximum reliability of delivering the 15 percent water entitlement set forth in the Compact for the Brighton Reservation. The Agreement also outlines the schedule of releases from Lake Istokpoga and operation schedules for the pumps at S-71 and S-72. A copy of this Agreement is presented in Appendix A.

WELLHEAD PROTECTION ORDINANCES

The purpose of a wellhead protection program is to protect the ground water in the vicinity of a public water supply wellfield from potential sources of contamination. A wellhead protection program entails a management process that acknowledges the relationship between activities that take place in wellfield areas and the quality of the ground water supply for those wells. A Wellhead Protection Area (WHPA) is delineated as the surface area, projected from the subsurface, surrounding a well or wellfield through which water (and potential contaminants) will pass and eventually reach the well(s).

Wellhead protection area boundaries (zones) are determined based on a variety of criteria (e.g., travel time, drawdown, distance, etc.) and methods (e.g., analytical/ numerical flow models, fixed radii, etc.). Factors such as the such as the aquifer physical characteristics, aquifer boundaries, the extent of pumping, the degree of confinement, the vulnerability of the aquifer to surface contamination, and the degree of development and land use activity surrounding the well(s) are used in the process. Because methods/criteria employed and physical conditions vary, WHPAs can range anywhere from a distance of a few hundred feet to several miles from pumping wells. Management activities commonly employed within these protection areas include regulation of land use through special ordinances and permits, prohibition of specified activities, and acquisition of land.

Wellhead protection efforts include federal, state and local laws and ordinances. These efforts focus on protecting public water supply wellfields from activities that present a possible contamination threat.

Federal Aquifer Protection

The first cohesive federal effort aimed at aquifer protection came in 1984, when the USEPA published its Ground Water Protection Strategy. This strategy recognized the need to prevent future ground water contamination and emphasized the protection of pubic water supply aquifers or those linked to unique ecosystems. As a result of this approach, federal provisions focused specifically at public water supply well protection, were adopted as part of the reauthorization of the Safe Drinking Water Act (SDWA) in 1986. This legislation established a nationwide policy to encourage states to develop systematic and comprehensive wellhead protection programs to protect public water supply areas from all man-made sources of contamination, which may cause or contribute to adverse health effects.

State, County, and City Wellhead Protection

State agencies, such as the FDEP, the Florida Department of Health (FDOH), the Department of Agriculture and Consumer Services (FDACS), and the water management districts have enacted a series of administrative rules directed towards aquifer protection. The FDEP has a number of regulations under the Florida Administrative Code which function to regulate activities, such as hazardous and solid waste, storm water discharge, storage tank systems, etc. The primary goal of these legislative policies, aimed at aquifer protection, is to prevent problems before they occur as contrasted to correcting or providing remedial action for pre-existing problems.

Four of the six counties in the KB Planning Area have some form of wellhead protection (**Table 14**). Highlands and Okeechobee counties have permanent wellhead protection ordinances, while Orange County has an interim wellhead protection ordinance. Polk County provides for wellhead protection in its Comprehensive Plan; the county plans to include wellhead protection in its future Land Development Codes. The cities of Kissimmee and St. Cloud, within Osceola County, provide for wellhead protection within their Land Development Codes. FDEP has a wellhead protection rule (Chapter 62-521, F.A.C.).

Table 14. Status of Wellhead Protection Ordinances.

Agency, City, County	Information Source Code	Status (as of April 1999)
FDEP	a	Waiting for approval by USEPA
Glades County	b	None
Highlands County	c	Ordinance
Okeechobee County	d	Ordinance
Osceola County	e	None
City of Kissimmee	f	Wellhead Protection in Land Development Code
City of St. Cloud	g	Wellhead Protection in Land Development Code
Orange County	h	Interim Ordinance
City of Orlando	i	None
Polk County	j	Wellhead Protection in Comprehensive Plan; will be included in Land Development Code in future

a. FDEP (Kara Daily).
b. Administration, Glades County (Mrs. Stafford).
c. Planning Dept., Highlands County (Duane Neiderman).
d. County Attorney Office, Okeechobee County (John Cassels).
e. Clerk of Board of County Commissioners, Osceola County (Rita Nacey).
f. Planning Dept., city of Kissimmee (Barry Campbell).
g. Planning Dept., city of St. Cloud (Eric Peterson).
h. Planning Dept., Orange County (Bryon Kellenberger).
i. Planning Dept., city of Orlando (Scott Baker).
j. County Attorney Office, Polk County (Mark Carpanini).

The intent of these ordinances is to protect and safeguard the health, safety, and welfare of the public by providing criteria for regulating and prohibiting the use, handling, production and storage of certain harmful substances which may impair present and future public water supply wells and wellfields.

Chapter 6
DEMAND ESTIMATES AND PROJECTIONS

Demand assessments for 1995 and projections for 2020 were made for two major categories of water use, urban and agricultural. Urban type use is further divided into five categories as indicated in **Table 15**. All categories of urban use are self-supplied with the exception of public water supply (PWS). Although electric power generation facilities can withdraw large amounts of water, virtually all of this water is returned to the hydrologic system near the point of withdrawal. Agricultural water use is water used for crop irrigation and cattle watering and in facilities supporting these activities.,

Table 15. Water Use Categories.

Water Use Categories	Description
Urban	
Public Water Supply	Potable water supplied by regional water treatment facilities with pumpages greater than 100,000 GPD[a] to all types of customers
Domestic Self-Supplied	Households with private wells as primary source of water and water treatment facilities with pumpages less than 100,000 GPD
Commercial and Industrial Self-Supplied	Operations with pumpages greater than 100,000 GPD
Recreation Self-Supplied	Landscape (water used for parks, cemeteries, and other irrigation applications greater than 100,000 GPD, and golf course irrigation
Thermoelectric Self-Supplied	Power generation and cooling
Agricultural	Water used for crop irrigation, cattle watering and the preparation of products for market

a. gallons per day.

For 1995, the total estimated water demand for the Kissimmee Basin (KB) Planning Area was 148,270 million gallons for the year. The distribution of this demand among water use categories is shown in **Figure 9**. The category of thermoelectric self-supplied is not represented in **Figure 9** as power plants within this basin are believed to utilize reclaimed water as as the primary source.

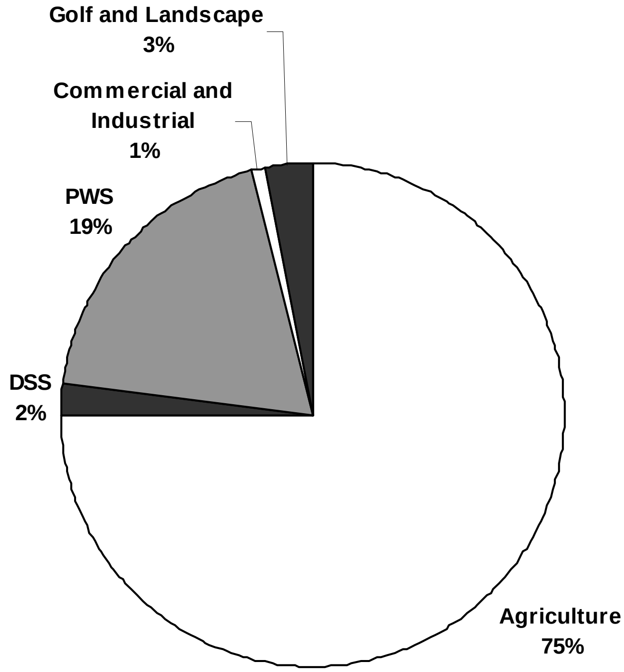

Figure 9. Total Water Demands for 1995 in the Kissimmee Basin Planning Area.

From 1995 to 2020, the total water demand for the KB Planning Area is projected to increase by 63 percent from 148,270 to 242,148 million gallons per year (MGY), as shown in **Table 16** and **Figure 10**. PWS has the largest projected increase (103 percent), from 26,040 MGY in 1995 to 53,035 MGY in 2020. However, agriculture is projected to remain the single largest category of use. In 1995, agriculture accounted for 75 percent of the total demand at an estimated 112,668 MGY. Agricultural demands are projected to increase by 54 percent by 2020 to 173,995 MGY, accounting for 72 percent of the total demand for that year.

A critical component of the water supply planning process is the determination of the 1995 and projected 2020 water use patterns. This effort required the estimation of the total water use and a determination of the distribution of that use. The following sections describe how the 1995 and 2020 water use estimates and projections were determined and how the water use was distributed. Appendix F provides detailed information on the methodology used for determining urban and agricultural demands.

URBAN DEMAND

Public Water Supply and Domestic Self-Supplied

Urban water demands were 35,602 MGY in 1995 and are projected to increase by 76 percent to 68,163 MGY in 2020. PWS was the largest component of urban water

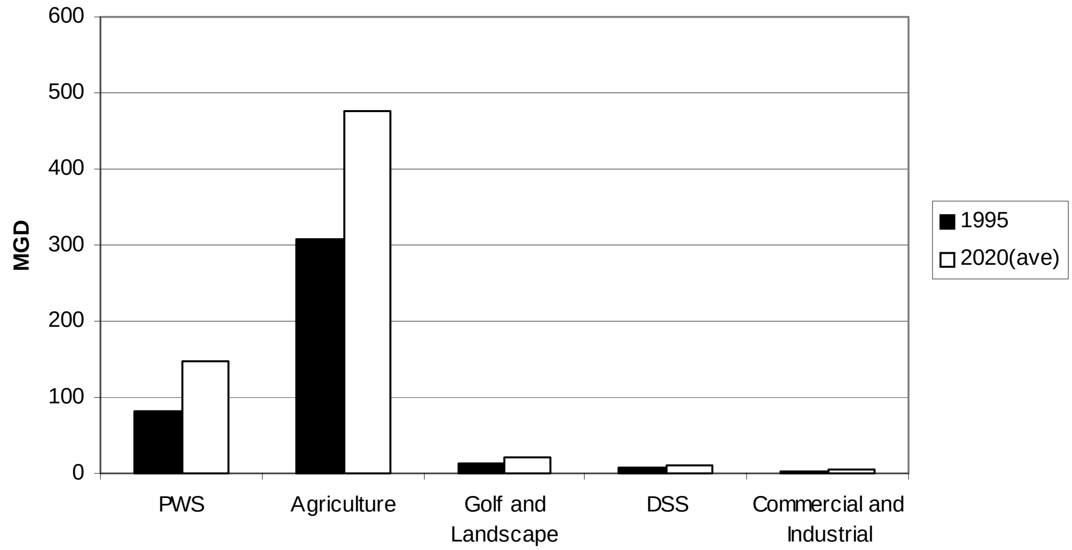

Figure 10. Comparison of 1995 and 2020 Water Demands (MGD).

Table 16. Overall Water Demands for 1995 and 2020 (MGY)[a].

Category (1-in-10)	Demand 1995	% Total	Demand 2020 (ave.)	% Total	% Change 1995-2020	Demand 2020 (1-in-10)
Agriculture	112,668	75	173,995	72	54	202,590
Public Water Supply	26,040	19	53,035	22	103	56,210
Domestic Self-Supplied	3,014	2	4,307	2	42	4,526
Commercial & Industrial	1,299	1	2,117	1	63	2,117
Recreational Self-Supplied	5,249	3	8,694	3	66	9,998
Totals	148,270	100	242,148	100	63	279,441

a. Some totals may not equal column sum due to rounding.

demand in 1995, followed by recreation self-supplied, domestic self-supplied, commercial and industrial self-supplied.

All permitted public water supply systems are required to report their use of water to both the FDEP office and the SFWMD as conditions of their respective permits. This information is typically submitted for each water treatment plant and is often submitted for individual wells. This information is available for facilities pumping greater than 0.1 MGD. The locations of these pumping facilities are identified as part of the District's consumptive use permitting process. This distribution information provides the basis on which existing and future water use is distributed.

Domestic self-supplied (DSS) water use is defined as those public supply users withdrawing less than 0.1 MGD. These users are not served by the larger utilities, but may reside within a utility service area boundary. The Districtwide Water Supply Assessment (1998) estimates that total DSS water use for 1995 was about 8.26 MGD. Water use projections for the year 2020 are 11.8 MGD.

The major driving force behind urban demand is population. Population estimates for 1995 were taken from the U.S. Bureau of the Census. The year 2020 population projections were determined from Bureau of Economic and Business Research using the medium range county estimates (**Table 17**), The total population of the KB Planning Area for 1995 was 362,837 and is projected to increase 89 percent to 686,696 in 2020.

Table 17. Estimated Population in the Kissimmee Basin Planning Area 1995-2020.

Region	1995			2020		
	Total	PWS	DSS	Total	PWS	DSS
Orange Area	186,131	171,729	14,402	349,453	335,051	14,402
Osceola Area	130,605	99,528	31,077	260,937	202,432	58,505
Polk Area	6,375	5,212	1,163	13,832	12,238	1,594
Highlands Area	7,700	0	7,700	11,590	0	11,590
Okeechobee Area	28,737	21,200	7,537	45,244	33,258	11,986
Glades Area	3,289	0	3,289	5,640	0	5,640
Total Kissimmee Basin	362,837	297,669	65,168	686,696	582,979	103,717

Source: SFWMD Districtwide Water Supply Assessment, 1998.

Urban demand is projected for the portions of counties that fall within the SFWMD. These demands are concentrated in Orange and Osceola areas, with these two counties accounting for approximately 87 percent of the KB Planning Area's urban population.

The estimated water demand for PWS and residential self-supplied users was 29,054 million gallons per year (MGY) in 1995. Per captia use rates determined from the individual utilities along with 2020 population projections were used to estimated the 2020 water supply demands. The initially projected 2020 demands were then given to the respective utilities and local government agencies for comment on the estimates and distribution of withdrawals. Some adjustments to the demands were made based upon this additional input from the utilities. The total water demand is projected to increase 105 percent from 1995 to 2020 to a total water demand of about 57,342 MGY. About 11 percent of the 1995 population were self-supplied and this is projected to decline slightly to about 8 percent in 2020 (**Table 18**). More specific information on utility service area populations and water demands, as well as the methodology used to develop these values is provided in Appendix F.

Table 18. Public Water Supply and Domestic Self-Supplied Demand (MGY).

Region	1995 PWS	1995 DSS	2020[a] PWS	2020[a] DSS	Total Percent Change 1995-2020
Orange Area	18,179	650	37,017	654	96
Osceola Area	6,872	1,597	14,227	2,520	97
Polk Area	288	66	675	88	117
Highlands Area	0	296	0	460	58
Okeechobee Area	701	252	1,116	397	59
Glades Area	0	153	0	188	22
Total Kissimmee Basin	26,040	3,014	53,035	4,307	97

a. 2020 (1-in-10) drought use estimates.

Commercial and Industrial Self-Supplied

Commercial and industrial demands supplied by public utilities are included in the PWS demands. Orange, Osceola, and Polk counties are the only counties reporting commercial and industrial self-supplied demands (**Table 19**) operating outside the PWS utilities. **Table 19** shows the estimated commercial/industrial demands within each county area. The projection methodology for commercial and industrial self-supplied demand is discussed in Appendix F.

Table 19. Commercial and Industrial Self-Supplied Demand (MGY).

Region	1995	2020	% Change
Orange Area	799	1,263	58
Osceola Area	266	533	100
Polk Area	234	321	37
Highlands Area	0	0	0
Okeechobee Area	0	0	0
Glades Area	0	0	0
Total Kissimmee Basin	1,299	2,117	63

Source: SFWMD Districtwide Water Supply Assessment, 1998.

Recreation Self-Supplied

Recreational demands supplied by PWS utilities are included in the PWS demands. Recreational demands include self-supplied withdrawals for landscape and golf course irrigation. Demand projections for this section include irrigated acreage permitted for landscaping and recreation, including golf course irrigation not supplied through a PWS system.

Golf course irrigation makes up the majority of this use category. In 1995, there were a total of 35 golf courses located within in the KB Planning Area. Of these courses, 24 use ground or surface water while the remaining 11 courses use reclaimed water as their primary irrigation source. Highlands, Okeechobee and Glades counties are expected to have no additional golf course irrigation by year 2020. Osceola County is expected to have the greatest increase in the number of golf courses. An estimated 14 new courses will be built over the planning horizon, 6 of which are projected to use reclaimed water. Future golf courses were estimated to average 150 acres in size and were distributed in those areas of largest proposed growth. Landscape uses were assumed to increase at the same rate as the county population. **Table 20** shows the estimated amount of fresh water use from the proposed new landscape and recreational uses. The projection methodology is discussed in Appendix F.

Landscaping makes up 42 percent of this category with the remaining 58 percent distributed among the golf course acreage. These percentages remain the same for 1995 and 2020.

AGRICULTURAL DEMAND

1995 Water Use Estimates

Determination of the actual water use for 1995 was limited because only a small amount of agricultural water use is reported. It therefore became necessary to develop a

Table 20. Landscape and Recreation Self-Supplied Demand (MGY).

Region	1995	2020	% Change
Orange Area	3,106	4,071	11
Osceola Area	497	2,147	276
Polk Area	278	436	44
Highlands Area	1,268	1,918	52
Okeechobee Area	100	122	22
Glades Area	0	0	0
Total Kissimmee Basin	5,249	8,694	66

Growth projections from: SFWMD Districtwide Water Supply Assessment, 1998.

process to determine the number and location of irrigated acres in order to estimate crop watering demands. A process was also needed to correlate the demand estimates with the District's consumptive use permitting (CUP) database which provided the water source information. The tool chosen to perform this data intensive analysis was a Geographical Information System (GIS).

In 1998, the District completed a contract to create a GIS land use/land cover electronic coverage for the entire district. In this coverage, crop types, acreage and location, among other items, are identified along with property ownership. Fifteen representative crop types were identified through this process. The collected crop information was then associated with the well location, property ownership and water source information available in the District CUP database. This provided a means to correlate irrigated crops with withdrawal locations and water sources.

Based upon the large number of water use permits and the reliability of well location information provided in the database, the search of the water use database was limited to permits allocating more than 100,000 GPD (Individual Permits). This set of permittees represent the majority of the total agricultural water use and are collectively identified as "permitted uses."

In addition to the identification of the larger permitted users, agricultural operations using water at a rate less than 100,000 GPD (General Permits) and those water uses not found in the water use database (including below threshold or non-permitted uses) were also identified. These identified uses were grouped together to create an "other" water use category. Because no location of source information is associated with these uses, the location of the water withdrawals was assigned to the center of each field (polygon) and the source was assigned the most commonly used aquifer/water body in the area. The total agricultural water use demands include both the permitted and "other" water use categories. The crop acres identified in this process became the baseline for future agricultural acreage increases. The distribution of the 1995 acreage totals among the counties is shown in **Figure 11**.

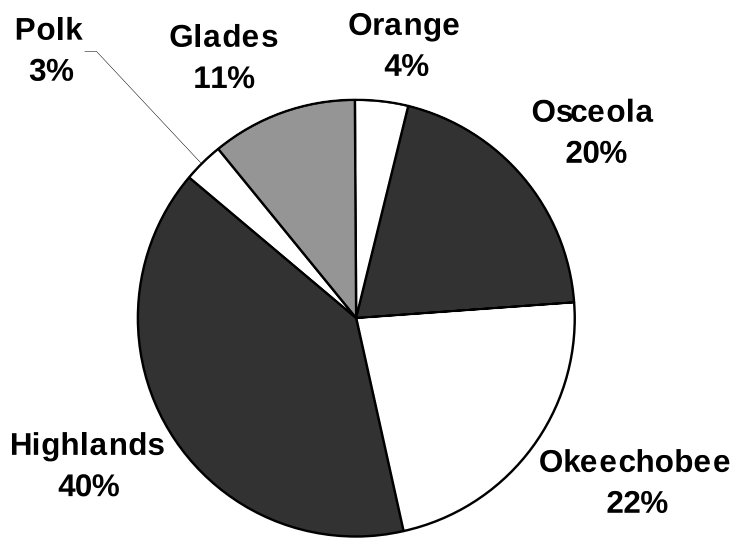

Figure 11. Distribution of Agricultural Acreage per County for 1995.

Identified agricultural operations less than five acres were removed from consideration because the confidence limit of the land use/land cover is 5 acres. These small areas are thought to be due primarily to spatial differences between the permit boundaries and the land use/land cover caused by differences in methods used to capture the information.

The crop acreage and crop type information identified through the land use/land cover for permitted agricultural operations was compared with the information sent in by the permit applicant and quantified in the CUP database. In most cases, the crop type and acreage identified through the land use/land cover information compared well to the crop type and acreage information contained in the CUP database. Differences were addressed by using the land use/land cover information unless other information was available. For those identified agricultural operations that did not have a corresponding SFWMD permit, the crop type and acreage identified through the land use/land cover was used.

Irrigation efficiencies were also obtained from the CUP database and standards set forth in the BOR. If an irrigation system was identified in the CUP database, it was used in the calculations. If no system was identified, the system efficiency was based upon crop type. If the agricultural operation was identified as citrus, an irrigation efficiency of 0.85 was used. If the crop was identified as sod, row crop, field crop, or golf course an irrigation efficiency of 0.75 was given. If the crop was identified as sugarcane, an irrigation efficiency of 0.5 was assigned. It was presumed for this exercise that pasture was not irrigated from a ground water source in less than 1-in-10 drought conditions.

Agricultural acreage not identified as located in a permit were assigned a water source and irrigation system type based on surrounding permitted agricultural operation water use practices. The exception to this was sugarcane which was assigned a surface water source. Primary water sources vary throughout the KB Planning Area.

Upon identifying the acreage and type of agricultural activity, a water use estimate was generated. Water use was calculated based upon estimated acreage for each crop type identified using a modified Blaney-Criddle method. The Blaney-Criddle method of determining supplemental irrigation requirement requires information on rainfall, soil conditions and irrigation efficiency to calculate water demand.

Agricultural water demand was estimated for 1995 to be approximately 308 MGD. Citrus has by far the largest 1995 agricultural acreage (61%) and is followed by row crops (11%). The combined water demand for cattle watering and aquaculture account for less than 1 percent of total agricultural demand. These percentages are predicated on the assumption that pasture is seldom irrigated.

2020 Water Use Projections

The KB Planning Area continues to experience growth in its agricultural industry, especially in citrus production. Projecting when and where this growth will occur involves reviewing the historical crop production and factoring in the past climatic and economic conditions that influenced its growth. The relationship between these factors was estimated using a statistical analysis that is described in Appendix F. This method and analysis was also performed for the Districtwide Water Supply Assessment (DWSA) that was completed in July 1998. The baseline numbers specified in Appendix F differ from those used in that plan. This is because these numbers were adjusted for a revised 1995 baseline number of acres determined from aerial photography. The growth trends identified by the DWSA and explained in Appendix F were used to estimate new water use in the basin beyond the 1995 baseline acreage. **Table 21** shows the projected change in agricultural operations within the KB Planning Area for 2020.

Increases and decreases in projected acreage were distributed evenly with existing CUP permit boundaries where room permitted. In the case of citrus, the number of projected acres exceeded the amount that could be placed within the existing permit bounders. In order to place the additional citrus acreage, the District contracted with the University of Florida's IFAS office to identify land feasibility for new citrus production. The university assisted the District in identifying parcels of land whose ownership and location were most favorable for new citrus production. This information was incorporated into the GIS system, where it was combined with land use/land cover and soils information to identify the most suitable location. The citrus acreage that was not previously distributed among the existing land owners was then evenly distributed among the identified parcels receiving the highest ranking. According to the IFAS study, the most probable locations for future citrus operations were areas that had a flatwood soils (determined through the National Resources Conservation Service), had a land use of cleared pasture (identified by the land use/land cover), and was owned by a party who had

Table 21. Projected Change in Agricultural Operations within the Kissimmee Basin Planning Area for 2020.

County	Projected Change (acres)	Source
Glades	+3,909 Citrus	DWSA
Glades	+1,144 Field crops	DWSA
Glades	+11,050 Sugarcane	Agriculture community
Highlands	+21,713 Citrus	DWSA
Highlands	+9,000 Fruits/vegetables	DWSA
Highlands	+950 Sugarcane	Agriculture community
Highlands	+100 Potatoes	Agriculture community
Okeechobee	+6,874 Citrus	DWSA
Okeechobee	+1,027 Nursery	DWSA
Okeechobee	+250 Potatoes	Agriculture community
Orange	-2,935 Citrus	DWSA
Osceola	-399 Citrus (NSC)	DWSA
Polk	-438 Citrus (NSC)	DWSA

NSC = no significant change.

existing agricultural operations, some or all of which were citrus, of more than 160 acres. This process did not identify specific parcels for future growth, but rather provided a reasonable means for identifying the most likely distribution of citrus growth for the year 2020.

The placement of fruits and vegetables within Highlands County was based on local agriculture knowledge, all of which fell outside permitted areas. The placement of additional nursery operations within Okeechobee County was also based on local agriculture knowledge. The placement of Glades County sugarcane was based on local agriculture knowledge.

A summary of the projected number of acres for each crop type is presented in **Table 22**.

Projected sugarcane acres were placed on lands identified by these growers. **Figure 12** presents a graphical comparison of agricultural demand by crop type for 1995 and 2020.

Agricultural water demand was estimated for 2020 to be approximately 476.7 MGD or 173,995 MGY. Citrus has by far the largest 2020 agricultural acreage (61%) and is followed by row crops, including sugarcane, increasing at a rate of 18 percent. The majority of the agricultural growth is projected for Highlands and Glades counties while decreases are projected for Orange, Osceola, and Polk counties. The fastest growth for any

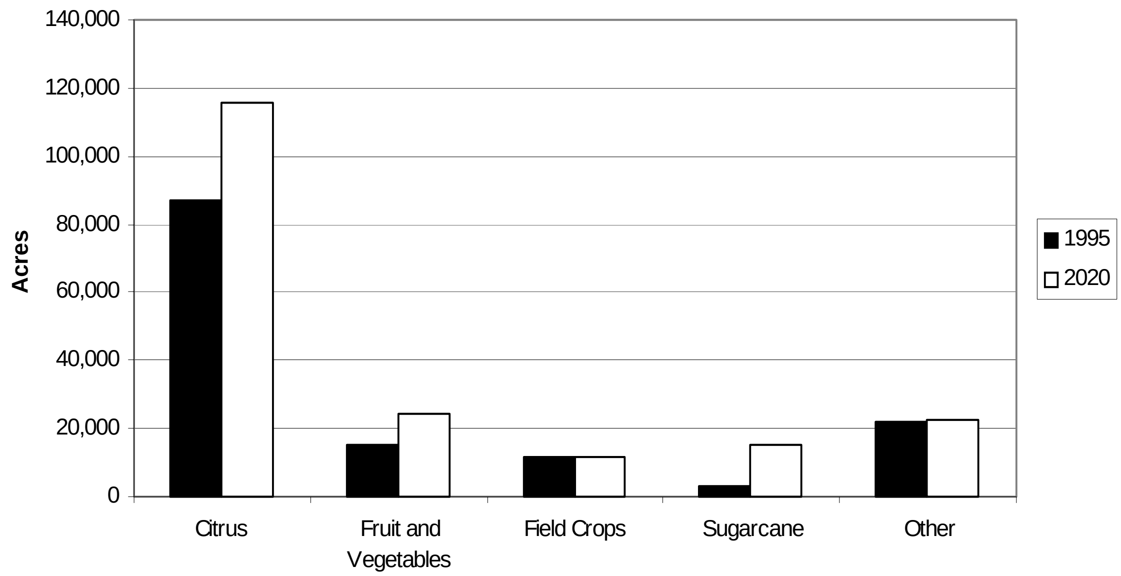

Figure 12. Comparison of 1995 to 2020 Crop Acres.

Table 22. Existing and Projected Irrigated Acreage by Crop Type.

Category	Total Irrigated Acreage 1995	Total Irrigated Acreage 2020	% Change
Citrus	87,190	115,520	32.5
Tropical Fruit and Nuts	1,131	1,131	0
Vegetables and Melons	14,092	23,092	64
Field Crops	11,474	11,474	0
Sod	3,970	4,270	8
Greenhouse and Nursery	2,664	3,755	41
Sugarcane	3,308	15,308	363
Dairy, Cattle, and Aquaculture[a]	13,838	13,838	0
Other	4,262	4,262	0
Total Planning Area	141,929	192,650	36

a. acres related to production, not irrigation.

one crop type is sugarcane at 363 percent, all of which is expected to withdrawal from surface water resources in Highlands and Glades counties.

Chapter 7
WATER CONSERVATION

Water conservation, also called demand management, refers to water use practices and technologies that provide the services desired by the users while using less water. The water conservation measures discussed in this section achieve long-term permanent reductions in water use. This separates them from the short-term water conservation measures and cutbacks that are required of users during water shortage situations or when short-term problems with the capacity of supply systems occur. Because of their short-term emergency nature, water shortage reductions rely almost exclusively on behavioral changes by the users (e.g., skipping or rescheduling lawn watering and taking shorter showers). Water conservation, on the other hand, generally requires changes in water use systems and technology, and little behavioral change. The water use reductions resulting from conservation will provide a basis for adjusting historical rates and patterns of water use in the modeling of the Kissimmee Basin (KB) Water Supply Plan.

This chapter discusses both mandatory and supplementary conservation measures. Mandatory measures are those measures that are required by District rules for individual water use permittees. These rules are intended to achieve long-term permanent reductions in water use. Supplementary measures are those measures that have been demonstrated to have water reduction benefits, but are not required by the District's water conservation rule.

MANDATORY WATER CONSERVATION MEASURES

In District water use permitting rule amendments adopted in October 1992, specific water conservation requirements were imposed on public water supply utilities (and associated local governments), on commercial/industrial users, on landscape and golf course users, and on agricultural users. All of these requirements apply to users required to obtain individual water use permits. Water use (consumptive use) permitting is further discussed in Chapter 5.

Public Water Supply Utilities

All individual permit applicants for a public water supply permit must submit a water conservation plan as a condition of issuance. The conservation plan must include the following elements:

- Adoption of an irrigation hours ordinance
- Adoption of a Xeriscape™ landscape ordinance
- Adoption of an ultra-low volume fixtures ordinance
- Adoption of a rain sensor device ordinance
- Adoption of a water conservation-based rate structure

- Implementation of a leak detection and repair program
- Implementation of a water conservation public education program
- An analysis of reclaimed water feasibility

The Mandatory Water Conservation Program requires that each utility evaluate and take applicable action on all elements. The elements consist of a combination of water conservation ordinances and water conservation activities. Utilities must rely on local governments to codify the water conservation ordinances. Depending on the demographics and location of the service area, utilities can choose to demonstrate which water conservation activities are more cost effective for the situation and emphasize implementation of those activities in their conservation plan.

The implementation status of these water conservation measures within public water supply utility service areas are indicated in **Table 23**. All utilities listed in the table have complied with the reclaimed water feasibility analysis requirements; therefore this item is not included in the table. Implementation of the measures within the Glades and Highlands areas are not discussed due to the lack of public water supply utilities.

Four of the water conservation measures require adoption of an ordinance by a local government. Positive responses in **Table 23** reflect the adoption of the appropriate ordinance by the applicable local government. In cases where the utility is privately owned and operated, the District's rules require that the utility demonstrate a request has been made to the local government encouraging adoption of the ordinance.

Adoption of an Irrigation Hours Ordinance

The ordinance, at a minimum, limits all lawn and ornamental irrigation to the hours of 4:00 P.M. to 10:00 A.M. Exemptions such as hand watering with a self-canceling nozzle, low volume irrigation systems, irrigation systems whose sole source is reclaimed water, or to operations for the purpose of system repair or maintenance may be included in the ordinance.

Irrigation during daytime hours is generally less efficient. The sunlight and increased winds during the daytime hours cause some of the water to evaporate before hitting the ground or to blow onto impervious surfaces such as sidewalks, roads and driveways. The wind also causes the water that reaches the plants to be more unevenly applied. In addition to changing the time of irrigation, users should reduce the length and frequency of irrigation. Public education programs can contribute to the irrigation hours ordinance by informing irrigators how they can reduce applications while still meeting the water requirements of their plants.

Adoption of a Xeriscape™ Landscape Ordinance

Xeriscape™ is defined by the Florida Legislature to mean "a landscaping method that maximizes the conservation of water by the use of site-appropriate plants and an

Table 23. Implementation Status of Mandatory Water Conservation Measures.

Utility	Ordinance Required				Ordinance Not Required		
	Irrigation Hours	Xeriscape™ / Landscape	Ultra Low Volume Plumbing Fixture	Rain Sensor Device	Conservation Rate Structure	Utility Leak Detection/ Repair	Water Conservation Public Education
Okeechobee County							
Okeechobee Utility Authority	N	N	N	N	Y	Y	N
Orange County							
Orange County Utilities	Y	Y	Y	N	Y	Y	Y
Orlando Utilities Commission	Y	Y	Y	Y	N	Y	Y
Reedy Creek	Y	Y	Y	N	Y	Y	Y
Osceola County							
Kissimmee	N	Y	Y	N	N	Y	Y
Lake Buenaventura	N	N	N	N	N	Y	Y
Poinciana Utilities	N	N	N	N	N	Y	Y
St. Cloud	N	Y	Y	N	Y	Y	Y
Polk County							
Poinciana Utilities	N	N	N	N	N	Y	Y

Source: March 1996 phone survey of utilities and District files.

efficient watering system” (Section 373.185, F.S.). The principles of Xeriscape™ include planning and design, soil analysis, efficient irrigation, practical turf areas, appropriate plant selection, and mulching.

The legislation requires that the water management districts establish incentive programs and provide minimum criteria for qualifying Xeriscape™ codes. These codes prohibit the use of invasive exotic plant species, set maximum percentages of turf and impervious surfaces, include standards for the preservation of existing native vegetation, and require a rain sensor for automatic sprinkler systems. District rules, as mandated by the legislature, require that all local governments consider a Xeriscape™ ordinance and that the ordinance be adopted if the local government finds that Xeriscape™ would be of significant benefit as a water conservation measure relative to the cost of implementation. The Xeriscape™ landscape ordinance will affect new construction and landscapes undergoing renovation which require a building permit.

Adoption of an Ultra-Low Volume Fixture Ordinance

This measure requires adoption of an ordinance which requires the installation of ultra-low volume (ULV) plumbing fixtures in all new construction. The District's water use permit regulations specify that the fixtures have a maximum flow volume when the water pressure is 80 pounds per square inch (psi) as follows: toilets, 1.6 gallons per flush (gal/flush); showerheads, 2.5 gallons per minute (gal/min.); and faucets, 2.0 gal/min. The previous standard for plumbing devices was: toilets, 3.5 gal/flush; showerheads, 3.0 gal/min.; and faucets, 2.5 gal/min.

ULV fixtures save water by using less water to provide the services desired. Available data indicate that the performance of the systems is such that the savings per unit (per flush or per minute) will not be offset by having the users increase the number of units (number of double flushes or length of shower). Thus these permanent ongoing water savings can be obtained without any behavioral changes by the users.

Adoption of a Rain Sensor Device Ordinance

This measure requires adoption of an ordinance which requires any person purchasing or installing an automatic sprinkler system to install, operate, and maintain a rain sensor device or an automatic switch. This equipment will override the irrigation cycle of the sprinkler system when adequate rainfall has occurred.

Adoption of a Conservation Rate Structure

A conservation rate structure is a charging system used by utilities that provides a financial incentive for users to reduce demands. Water conservation rates are generally either (a) increasing block rates, where the marginal cost of water to the user increases in two or more steps as water use increases; or (b) seasonal pricing, where water consumed in the season of peak demand, such as from October through May, is charged a higher rate than water consumed in the off-peak season. Maddaus (1987) also lists uniform commodity rates as a conservation rate structure.

Users faced with higher rates will often achieve water conservation by implementing a number of the conservation measures discussed in this chapter. The most frequently used conservation rate structure used by utilities is increasing block rates. This rate structure generally is expected to have the largest impact on heavy irrigation users. The responsiveness of the customers to the conservation rate structure depends on the existing price structure, the water conservation incentives of the new price structure, and the customer base and their water uses.

Adoption of a Utility Leak Detection and Repair Program

The District encourages public water supply systems to have no more than 10 percent unaccounted-for water losses. The implementation of leak detection programs by utilities with unaccounted-for water losses greater than 10 percent is required. The leak detection program must include water auditing procedures, and in-field leak detection and repair efforts.

Implementation of a Water Conservation Public Education Program

Public information, as a water conservation measure, involves a series of reinforcing actions to inform citizens of opportunities to reduce water use, give reasons why they should choose to practice water conservation, and publicize the conservation options being promoted by the District, local governments, and utilities. Virtually all users can be affected by public information efforts, although they are typically targeted at the uses with the broadest participation, including domestic indoor and outdoor uses.

Analysis of Reclaimed Water Feasibility

For potable public water supply utilities who control a wastewater treatment plant, an analysis of the economic, environmental, and technical feasibility of making reclaimed water available is required. Wastewater reuse is discussed in Chapter 8, Water Source Options.

Commercial/Industrial Users

District regulations require that all individual commercial/industrial permit applicants submit a conservation plan. This plan must include the following:

- An audit of water use
- Implementation of cost-effective conservation measures
- An employee water conservation awareness program
- Procedures and time frames for implementation
- The feasibility of using reclaimed water

Landscape and Golf Course Users

Landscape and golf course permittees are required to use Xeriscape™ landscaping principles for new projects and modifications when they find this to be of significant benefit as a conservation measure relative to its cost. They are also required to install rain sensor devices or switches, irrigate between the hours of 4:00 P.M. and 10:00 A.M., and analyze the feasibility of using reclaimed water. There are, however, six specific exceptions to the irrigation hours limitations in the rule which provide for protection of the landscape during stress periods and help assure the proper maintenance of irrigation systems.

Agricultural Users

Citrus and container nursery permittees are required to use micro irrigation or other systems of equivalent efficiency. This applies to new installations or upon modifications to existing irrigation systems. The permittees are also required to analyze the feasibility of using reclaimed water.

SUPPLEMENTARY WATER CONSERVATION MEASURES

Residential Users

Indoor Audit and Retrofit. Indoor audits provide information and services directly to households and other urban water users to achieve greater efficiency in the use of indoor water-using appliances. This option generally includes inspections to locate leaks and determine if plumbing devices are operating properly, repair of minor problems, and providing information on conservation measures and devices. In some cases, a retrofit program will include installation of water-conserving showerheads and toilet dams.

Residential retrofit measures encourage the installation of ULV plumbing fixtures or modifications which improve the performance of existing fixtures. One possible incentive is a partial financial subsidy to increase the installation of ULV water fixtures. Another incentive, recently undertaken in Tampa, is the delivery of retrofit kits to homes. The targeting and participation in efforts such as this will generally affect only a portion of the population. Utilities and local governments can devise programs that carefully target the most cost-effective applications of these measures. In retrofit programs, one option is to target residences with only high water consuming fixtures (generally those built pre-1980). Another option is to include residences with low water use fixtures (post-1980) for retrofit with ULV water use fixtures.

Another characteristic which will increase the savings and the cost effectiveness of retrofit of the earlier dwelling units (homes) is that many of these units have fewer bathrooms and fixtures per unit and per person. The larger the number of people using a retrofit device, the more cost effective and water saving the retrofit. An appropriate strategy would be to target homes with large numbers of persons per fixture for complete retrofit, and other homes for retrofit of only the most heavily used fixtures. This suggests that a particularly suitable target for retrofit programs are public restrooms and other facilities which have high use rates.

Landscape Audit and Retrofit. Landscape audits are measures that improve the efficiency of irrigation systems, and include services to determine if the irrigation system is operating properly. This may include adjustments to irrigation timers (to assure that a water-conserving schedule is being followed), head replacement (to assure that the system is providing adequate coverage and not wasting water by irrigating impervious surfaces), recalibration of the irrigation system, and installation of rainfall sensing/ irrigation controlling devices.

Audits are generally implemented by utilities and other water management agencies. Because of the large outdoor component of water use in South Florida, irrigation audits can be effective. This is particularly important due to the peaking of outdoor demand during periods of low rainfall and maximum stress on water resources.

Landscape retrofit measures provide information and incentives for users to implement physical changes to their landscapes and irrigation systems. Devices suitable for landscape retrofit include those that prevent unnecessary irrigation by detecting recent rainfall or sensing soil moisture. Other retrofit options include replacing existing landscaping with site-appropriate plants and practicing landscape management which includes rezoning irrigation systems and mulching.

Cost and water savings for several indoor and outdoor urban retrofit water conservation measures are provided in **Tables 24** and **25**. In addition, the cost and water savings for irrigation system conversion for agricultural uses are discussed. This information in this section should not be interpreted as a cost-benefit analysis of these conservation measures, since no discounting is applied to the streams of cost and benefits.

Table 24. Representative Water Use and Cost Analysis for Urban Irrigation System Water Conservation Measures.

Representative Water Use Component	Rain Switch		Mobile Irrigation Lab	
	Costs	Water Savings	Costs	Water Savings
Cost/unit or visit ($)	$68	---	$50[a]	---
Acres/unit	---	0.11	---	0.11
Water savings (inches/ year)	---	70	---	70
Water savings (gallons/ year)	---	209,070	---	209,070
Life (years)	---	10 years	---	7 years
Water savings/life (gallons)	---	2,090,700	---	1,463,493
Cost/1,000 gallons saved ($)	$0.033	---	$0.034	---
Savings per 1,000 gallons/ cost	---	30.75	---	29.27

a. Represents additional cost of site visit.

For the urban water conservation methods, the analysis indicated the savings are greater than the costs. The savings per unit of cost associated with the outdoor conservation measures are generally greater than those for indoor conservation measures, primarily because of the larger volumes of water involved per unit affected by the outdoor conservation measures. Water savings associated with implementation of retrofit

Table 25. Representative Water Use and Cost Analysis for Retrofit Indoor Water Conservation Measures.

Representative Water Use Component	Toilet		Showerhead	
	Costs	Water Savings	Costs	Water Savings
Cost/unit ($)	$200	---	$20	---
Flushes/day/person	---	5	--	---
Gallons saved/flush	---	1.9	--	---
Minutes/day/person	---	---	---	10
Gallons saved/minute	---	---	---	2
Persons/unit	---	2.5	---	2.5
Life (years)	---	40	---	10
Savings/year/unit (gallons)	---	8,670	---	9,125
Savings/unit over life (gallons)	---	346,800	---	91,250
Cost/1,000 gallons saved	$0.58	---	$0.22	---
Savings/cost	---	1.73	---	4.56

programs can be significant. For example, if 10,000 showerheads were retrofitted in an area, this could result in a water savings of 182 MGY (0.50 MGD). Likewise, if 10,000 irrigation systems were retrofitted with rain switches, this could result in a water savings of over 2 BGY (5.73 MGD).

Public Water Supply Utilities

Filter Backwash Recycling. This measure encourages water utilities using filter systems that are cleaned by backwashing (cleaning the filter by reversing the flow of water) to recycle the backwash water to the head of the treatment plant for retreatment. Otherwise, the backwash water is usually disposed of into a pit from which the water seeps back into the ground.

Distribution System Pressure Control. Potable water distribution system pressure control measures reduce water usage while providing acceptable water pressures to all customers. System pressure should keep water using devices working properly while providing for public health and fire safety needs. Pressure reduction valves and interconnecting and looping utility mains, are methods used to equalize and, therefore, reduce overall operating pressure. Unlike the pressure reduction efforts during water shortages, which call for reductions in pressures to levels necessary to meet minimums for fire flow, these changes target reductions at locations where pressures are high within the system.

Control of pressures can save water in a number of ways. High pressures increase losses of water through leaks, and increase use when the amount of water used is based on time rather than the volume of water discharged. Irrigation systems on timers are the major uses wherein the use is for set periods of time. High pressures cause increases in water application and can cause atomization of the spray, which reduces irrigation efficiency. Low pressures, however, reduce the areas covered by poorly designed sprinkler systems, and this results in stress to the uncovered areas. This may encourage users to increase irrigation time in an attempt to improve the results of the irrigation efforts.

Wastewater Utility Infiltration Detection and Repair. Wastewater utility infiltration detection and repair includes estimation and detection efforts to quantify and locate the infiltration of ground water or surface water into wastewater collection systems, and repair efforts to reduce the infiltration. Infiltration is important in the KB Planning Area because many wastewater collection lines are located below the water table for much of the year. Reducing infiltration of ground water prevents waste by allowing the ground water to be used for other purposes. In coastal areas, infiltration of saline ground water minimizes the potential reuse of the wastewater by increasing the chloride level. Infiltration also uses available treatment and disposal capacity.

Agricultural Users

Irrigation Audit and Improved Scheduling. Growers are encouraged to adopt irrigation management practices, which conserve water. To assist growers with agricultural irrigation, audits are carried out by the federally funded Mobile Irrigation Laboratory which operates in the KB Planning Area. Agriculture is a major water user in the KB Planning Area. Changing on-farm irrigation scheduling and water management practices will play an increasingly important role in agricultural water conservation.

Irrigation management practices and technology interact so that, for example, a change in the type of irrigation system will generally require a change in irrigation scheduling to achieve the goal of water conservation while maintaining crop yield and economic return. An additional benefit in agricultural water conservation is the energy savings possible through water conservation.

Micro Irrigation Systems. Micro irrigation systems achieve water savings by directly applying a high percentage of water to the root zone of the crop in controlled amounts, so losses through deep percolation or drainage are reduced. In addition, application of water to areas not underlain by the root zone is limited. Installation of micro irrigation systems, or systems of equivalent efficiency, are required for new citrus and container nursery projects. Additional water savings can be achieved by promoting the installation of water-conserving irrigation systems on crops where it is not required (such as vegetables), and retrofitting irrigation systems for existing citrus and nursery crops.

Conversion of existing flood-irrigated citrus to micro irrigation is another potential source of water savings (**Table 26**). It is estimated by IFAS that the initial cost to install a micro irrigation system on citrus is $1,000 per acre and the system would have estimated annual maintenance costs of $25 per acre per year (IFAS, 1993).

Table 26. Irrigation Costs and Water Use Savings Associated with Conversion from Seepage Irrigation to Low Volume.

Irrigation Conversion Component	Costs	Water Savings
Initial cost ($/acre)	$1,000	---
Operating cost ($/acre)	$25	---
Water savings (inches/year)	---	8.519
Water savings (gallons per year)	---	230,805
Life (years)	---	20
Cost over life ($)	$1,500	---
Water savings over life (total gallons)	---	4,616,100
Cost/1,000 gallons saved ($)	$0.33	---

The table summarizes the cost and potential water savings from one acre of conversion. The water savings from converting 25,000 acres of citrus from flood irrigation with a 50 percent efficiency to micro irrigation with an 85 percent efficiency could result in a water savings of approximately 6 BGY (15.8 MGD). The analysis illustrates that given the large volumes of water used for irrigation by agriculture, water conservation savings (which can be achieved at a reasonable cost) will often be extremely cost effective compared to the costs of developing additional water supplies.

Chapter 8
WATER SOURCE OPTIONS

Water source options are defined as options that make additional water available from existing or new sources, such as wellfield expansion and wastewater reuse, or options that reduce water use, such as increased irrigation efficiency or water conservation. Other options are presented to offer management techniques, such utility interconnects or ASR, which look to manage either the demand or source of water to minimize potential impacts. This chapter discusses these options. Water conservation is another water supply/demand management option, but is given a separate detailed discussion in Chapter 7.

GROUND WATER

For existing uses where ground water is primary source, the development of additional ground water is usually the least cost and preferred option. This fact, along with the historic precedent of the use of ground water, has made the choice of expanding fresh ground water the primary identified future option for nearly every utility and agricultural user located within the Kissimmee Basin (KB) Planning Area. Although all of the potable aquifers within the basin are utilized to some extent, the surficial and Floridan aquifers are the most frequently used. The surficial aquifer is generally limited to smaller uses such as household or small agricultural uses. This is due to the relatively small well yields. One notable exception is Okeechobee Utilities which withdraws an estimated 1.0 MGD from the surficial and intermediate aquifers. In some areas, horizontal well technologies may be implemented to obtain higher yields from the Surficial Aquifer System (SAS), but these type wells are generally limited to specific applications due to the potential of the water table lowering and causing wetland harm. With the exception of Okeechobee Utilities, nearly all other ground water use within the planning basin comes from the fresh water portion of the Floridan Aquifer System (FAS).

Cost estimates associated with these two source alternatives have been broken into construction and capital costs and production costs. An example of the costs associated with expanding fresh ground water use in the KB Planning Area is given in **Table 27**. Construction and capital costs are those costs associated with the initial installation of the facilities, in this case the wells and pump fixtures only. Other costs related to piping, electrical service, land acquisition, and treatment/storage facilities are not included in the table and could increase the cost of expansion considerably. Estimates are based upon assuming an 8-inch diameter surficial aquifer well with a maximum depth of 200 feet and a 16-inch diameter Floridan well of 900 feet in depth. Operational costs identified are those related to the maintenance of the well and the cost of operation of the well.

Table 27. Well Costs for Aquifer Systems.

Aquifer System	Drilling Cost (per well)	Equipment Cost (per well)	Engineering Cost (per well)	Operations and Maintenance Cost (per 1,000 gallons)	Energy Cost (per 1,000 gallons)
Surficial	$15,000	$6,000	$12,000	$0.004	$0.022
Floridan	$112,500	$50,400	$17,500	$0.004	$0.022

UTILITY INTERCONNECTIONS

Interconnection of treated and/or raw water distribution systems is an option typically limited the purpose of providing backup water service in the event of disruption of a water service. This operation, although currently employed by many utilities, is thought of a means to address local or temporary service shortfalls. Regional implementation of a utility interconnection system could be employed as a demand management tool. The purpose of implementing this alternative would be to shift withdrawals in those areas deemed to be at highest risk of being adversely impacted to areas where the withdrawals are projected to have less impact. This would be completed through bulk purchase of raw or treated water from neighboring utilities in lieu of expanding an existing withdrawal and/or treatment plant. A detailed study of distribution systems proposed for interconnection would need to be made to address system pressures, physical layout of the supply mains, impacts on fire flows and compatibility of the waters, among other items.

The costs associated with wellfield interconnects are difficult to estimate and could vary greatly depending on the size, distance and potential engineering hurdles. Typically, an interconnect system includes the transmission main, pump facilities and storage facilities. An interconnect system may also include an operation and maintenance component for the transmission main and facilities, and energy pumping costs. Cost estimates for this option are provided below (**Table 28**).

Table 28. Utility Interconnect Cost Estimates.

Transmission Line Size	Installation Cost (unit measure)	Engineering Cost (unit measure)	Land Costs $/ft[a]	Easement Costs $/ft[b]
16-inch	$44	$20	$56.25	$37.50
24-inch	$69	$31	$56.25	$37.50
30-inch	$87	$39	$75.00	$50.00

a. Based on suburban land costs- urban or rural costs will vary.
b. Does not include jack and bone, tunnels, or valves.
Source: West Coast Regional Water Supply Authority, 1995.

WASTEWATER REUSE

Reuse is the deliberate application of reclaimed water for a beneficial purpose, in compliance with the FDEP and water management district rules. Reclaimed water is wastewater that has received at least secondary treatment and is reused after flowing out of a wastewater treatment plant (Chapter 62-610, F.A.C.). Potential uses of reclaimed water include landscape and agricultural irrigation, ground water recharge, industrial uses, environmental enhancement and fire protection. Additional discussion of reuse, including reclaimed water regulations and more detailed information on potential uses, is provided in Appendix F. Although the FDEP definition of reuse would include nearly all facilities that do not directly discharge to an open water body, not all reuse is equally effective. The most effective reuse projects are those that apply reclaimed water for irrigation or have infiltration basins located in designated high recharge areas.

Encouragement and promotion of wastewater reuse and water conservation are formal state objectives. The State Water Policy requires the FDEP and water management districts to advocate and direct the reuse of reclaimed water as an integral part of water management programs, rules, and plans. Several regulations also require an evaluation of reuse versus other disposal methods prior to issuance of department permits.

Reuse Costs

The costs associated with implementation of a reuse program vary depending on the size of the reclamation facility, the facility equipment needed, the extent of the reclaimed water transmission system, and the regulatory requirements. Some of the major costs to implement a public access reuse system are as follows:

- Advanced secondary treatment
- Reclaimed water transmission system
- Storage facilities
- Alternate disposal
- Application area modifications

Cost savings include negating the need for or reducing the use of alternative disposal systems, negating the need for an alternate water supply by the end user, and reduction in fertilization costs for the end user.

Existing Treatment Facilities

There are 18 existing regional wastewater treatment facilities in the KB Planning Area. These facilities treated 60.59 MGD of wastewater in 1995. Of this amount, approximately 49 MGD was used for beneficial purposes such as irrigation or percolation ponds in high or moderate recharge (Floridan) areas. The remaining 11.28 MGD went to lower beneficial uses such a surface water discharge or percolation pond in low recharge areas. The use of water that was discharged to surface water or to percolation ponds in low recharge areas could be made available for more beneficial reuse with more strategic planning and the proper infrastructure. The volume of wastewater treated by regional wastewater treatment facilities is projected to increase to about 136 MGD by 2020 with an additional 88 MGD potentially going to higher beneficial purposes. Summarized wastewater facility information is provided in Appendix D.

STORMWATER USE

This option is defined as the collection of stormwater runoff from urban areas and should be distinguished from runoff collection from agricultural land, which is addressed under surface water storage. The stormwater use option is thought to be most applicable to landscape irrigation practices on a localized scale. A common application of stormwater use is the use of urban development ponds to supplement golf course irrigation demands or entry way landscaping. The costs associated with these types of uses are considered to be nominally above those for the ground water alternative that it would replace.

SURFACE WATER STORAGE

This option involves the capture and storage of excess surface water during rainy periods and subsequent release during drier periods for environmental and human uses. The capture of excess surface water runoff and ground water seepage from canals and rivers, and storage of these waters in existing or new surface water reservoirs or impoundments, provides an opportunity to increase the supply of fresh water during subsequent dry periods. The primary problems associated with surface water storage are the expense of constructing and operating large capacity pumping facilities, the cost of land acquisition, appropriate treatment costs, the availability of suitable locations, and the high evaporation rates of surface water bodies.

Costs associated with surface water storage vary depending on site-specific conditions of each reservoir. A site located near an existing waterway will increase the flexibility of design and management and reduce costs associated with water transmission infrastructure. Another factor related to cost would be the existing elevation of the site. Lower site elevations would allow for maximum storage for the facility while reducing costs associated with water transmission and construction excavation. Depth of the reservoir will have a large impact on the costs associated with construction. Deeper reservoirs result in higher levee elevations, which can significantly increase construction costs.

Costs associated with two types of reservoirs are depicted in **Table 29**. The first is a minor facility with pumping inflow structures and levees designed to handle a maximum water depth of 4 feet. It also has internal levees and infrastructure to control internal flows and discharges. The second type shown below is a major facility with similar infrastructure as the minor facility. However, the water design depths for this facility range from 10 to 12 feet. Costs increase significantly for construction of higher levees but can be offset somewhat by the reduced land requirements.

Table 29. Surface Water Storage Costs.

Reservoir Type	Construction Cost $/Acre	Engineering/ Design Cost $/Acre	Construction Administration $/Acre	Land $/Acre	Operations and Maintenance Cost $/Acre
Minor Reservoir	2,842	402	318	4,500	118
Major Reservoir	7,980	904	451	4,500	105

Costs for the minor reservoir are based on actual construction bid estimates received and awarded for similar projects currently being built in the Everglades Agricultural Area (EAA). Costs of these four Stormwater Treatment Areas (STAs) were averaged to develop the $/acre construction and operation costs. Costs for the major reservoir were developed based on the average cost estimates from the proposed Ten Mile Creek project (in St. Lucie County) and from the Regional Attenuation Facility Task Force Final Report, April 1997 estimates for major Water Preserve Areas.

AQUIFER STORAGE AND RECOVERY

Aquifer storage and recovery (ASR) is defined as the underground storage of injected water in an acceptable aquifer during times when water is available, and the subsequent recovery of this water when it is needed. Simply stated, the aquifer acts as an underground reservoir for the injected water, reducing the water loss to evaporation. Sources of injection water could include treated and untreated ground and surface water, and reclaimed water.

Because of limited water resources, increasing demands, and more stringent water quality standards, ASR technology is receiving growing attention. The regulatory criteria for ASR permitting is discussed in KB Water Supply Plan Appendices.

ASR Costs

Estimated project costs for ASR consisting of a 900-foot, 16-inch well, with two monitoring wells using treated water are shown in **Table 30**. One system uses pressurized water from a utility; whereas the second ASR system uses unpressurized treated water, thus requiring pumping equipment as part of the system cost. However, utilities implementing ASR systems may incur additional costs for surface facilities, such as piping, storage, and rechlorination. Other available data indicate that typical unit costs for water utility ASR systems now in operation tend to range from $200,000 to $600,000 per MGD of recovery capacity (CH2M Hill, 1993). At the same annual recovery rate used above (100 days at the daily recovery capacity), the costs per thousand gallons recovered would be $.30 to $.70 per thousand gallons. These systems have well capacities from

0.3 to 3 MGD and store treated water. Savings in treatment system costs are likely to be substantial when the ASR system offsets the need for additional treatment capacity to meet peaks in demands.

Table 30. Aquifer Storage and Recovery System Costs.

System	Well Drilling Cost (per well)	Equipment Cost (per well)	Engineering Cost[a] (per well)	Operations and Maintenance Cost (per 1,000 gallons)	Energy Cost (per 1,000 gallons)
Treated Water at System Pressure	$200,000	$30,000	$360,000	$.004	$.06
Treated Water Requiring Pumping	$200,000	$100,000	$400,000	$.006	$.06

a. Engineering costs include the permitting process, hydrogeologic investigation, monitoring during well construction, and design.

Source: PBS&J, 1991, Water Supply Cost Estimates.

Existing ASR Facilities

ASR facilities are already in operation in New Jersey, Nevada, California, and Florida. Five operational facilities exist in Florida: Manatee County (1983), Peace River (1984), Cocoa (1987), Port Malabar (1989), and Boynton Beach (1993). These facilities all use treated water and are further discussed in KB Water Supply Plan Appendices. There are ASR development studies currently underway in Washington, Utah, Arizona, Georgia, South Carolina, Texas, and Virginia. More recently ASR has been proposed as part of the Central and South Florida Restudy project as a means of adding storage of water associated with Lake Okeechobee. The recommendation proposes locations of wells north of the Lake Okeechobee in the KB Planning Area.

DRAINAGE WELLS

Although technically drainage wells are injection wells and are regulated under the same guidelines as ASR wells, the function and costs associated with these wells is different. Like ASR wells, drainage wells function is to store surface water that is captured in the underground aquifer system. Unlike ASR wells, however, there is no extraction operation associated with these wells. The storage function is in the form of aquifer recharge which in turn can be withdrawn from multiple wells operating in the region.

The metro-Orlando area is the only location in the planning region where drainage wells exist. There are an estimated 350 to 400 wells that are known. The majority of these wells were installed 30 to 40 years ago to assist in controlling lake levels. The wells generally receive storm water discharged to lakes, but there are wells that take water directly in from street runoff. Street runoff is a potential source of contamination to the aquifer system. It is estimated that as much as 20 inches a year of recharge may be due to drainage wells in the Orlando area.

The costs associated with drainage wells are similar to those of normal production wells, with the exception that there are no energy costs. In addition, drainage wells into the surficial aquifer are not considered a viable option.

The permitting of these wells is similar to that of ASR wells and requires approval from the FDEP. Recently, however, the potential water quality problems associated with these wells have been brought to the attention of the FDEP. Thus, the number of drainage wells permitted has dropped dramatically. Consideration of this option would include a lengthy permitting effort to document risks associated with direct injection to the fresh water aquifer.

SALTWATER/BRACKISH WATER

Brackish water in the Floridan aquifer exists in the southern portion of the KB Planning Area near the north shore of Lake Okeechobee. This source is relatively untapped in the KB Planning Area. The only other source of brackish water in the region is surface water from the St. Johns River in eastern Orange County, located outside the SFWMD. The use of brackish water for agricultural purposes is limited to chloride values less the 1,000 mg/L and is generally used only for short durations. The use of brackish water for public water supply typically requires the treatment of water by lime softening or reverse osmosis. A disadvantage with lime softening or reverse osmosis treatment is the disposal of brine concentrate from the treatment process. The permitting of such discharge can be a significant hurdle. The costs associated with brackish water treatment are provided in Chapter 9.

FRESH SURFACE WATER USE

Surface water from lakes, rivers and canals is currently used for agricultural irrigation and a minor amount of landscape irrigation. In particular, areas surrounding Lake Istokpoga and Lake Okeechobee in the southern end of the basin use surface water as the primary source for most agriculture, with the exception of citrus. The delivery of water to points of individual withdrawal is controlled by a master system of canals, control gates, and pumps operated by the District. Additional use of surface water delivered by this system may require the installation of new pumps to move water to a new location. Estimates of costs for the installation of these facilities are provided in **Table 31**. For the purposes of the estimate, a pump rated at 60,000 GPM is assumed.

Table 31. Pump Installation and Operating Costs.

Pump Type	Engineering/ Design Cost	Construction Costs	Operation and Maintenance Cost
Electric	$50,000	3-4 million[a]	$60 /hr
Diesel	$50,000	$1.5-3 million	$40 /hr

a. Does not include cost of installing electrical power to site.

Chapter 9
WATER QUALITY AND TREATMENT

There are water quality standards that must be met for different types of uses. These standards are generally based on health or water use technology requirements; water frequently needs treatment in order to meet these standards. Technology can also be employed to augment and make the most of available water resources. Human activities, such as waste disposal or pollution spillage, have the potential of degrading ground and surface water quality.

WATER QUALITY STANDARDS

Drinking Water Standards

There are two types of drinking water standards, primary and secondary. Both of these standards are the maximum contaminant levels for public drinking water systems. Primary drinking water standards include contaminants which can pose health hazards when present in excess of the maximum contaminant level (MCL). Secondary drinking water standards, commonly referred to as aesthetic standards, are those parameters which may impart an objectionable appearance, odor or taste to water, but are not necessarily health hazards. Current Florida Department of Environmental Protection (FDEP) primary and secondary drinking water standards are presented in Appendix G.

The U.S. Environmental Protection Agency (USEPA) is developing a ground water rule that specifies the appropriate use of disinfection and to assure public health protection. The ground water rule proposal is anticipated to be established by the end of the year 2000. More information on the ground water rule can be obtained from the USEPA; internet access is also available at the following site: http://www.epa.gov/OGWDW/standard/gwr.html.

Large surface water systems must comply with the Stage 1 Disinfectants and Disinfection By-products Rule by December 2001. Ground water systems and small surface water systems must comply by December 2003. The new total trihalomethanes (TTHM) MCL may have an impact on public water supplies in the Kissimmee Basin (KB) Planning Area. Most systems in the KB Planning Area have been able to meet the current TTHM standard of 0.10 mg/L by modifying or optimizing operation of their treatment and/or disinfection processes. TTHM concentrations in some cases are close to the current MCL of 0.10 mg/L. Some utilities in the KB Planning Area will have difficulty in meeting more stringent TTHM standards without some plant modification. TTHM MCL information is given in Appendix G.

The Interim Enhanced Surface Water Treatment Rule (IESWTR) (December, 1998) will strengthen protection against microbial contaminants, especially *Cryptosporidium* (Federal Register CFR 40, Parts 9, 141, and 142). The treatment rule applies to public water systems that use surface water or ground water under the direct influence of surface water (GWUDI) and serve at least 10,000 people. States must conduct surveys on smaller systems (USEPA, 1998). This rule will come into affect with the Stage I D/DBP. This rule contains new standards for turbidity. For more information, internet access is available at the following site: http://www.epa.gov/OGWDW/mdbp/ieswtr.html.

Nonpotable Water Standards

Water for potable and nonpotable water uses have different treatability constraints. Nonpotable water sources include surface water, ground water, and reclaimed water. Unlike potable water, with very specific quality standards to protect human health, water quality limits for nonpotable uses are quite variable and are dictated by the intended use of the water. For example, high iron content is usually not a factor in water used for flood irrigation of food crops, but requires removal for irrigation of ornamentals, which if iron stained, are not marketable. Excessive iron must also be removed for use in micro irrigation systems which become clogged by iron precipitate.

Nonpotable water uses include agricultural, landscape, golf course, and recreational irrigation. This water may also be acceptable for some industrial and commercial uses. For a source to be considered for irrigation for a specific use, there must be sufficient quantities of that water at a quality that is compatible with the crop it is to irrigate. Agricultural irrigation uses require that the salinity of the water not be so high as to damage crops either by direct application or through salt buildup in the soil profile. In addition, constituents that can damage the irrigation system infrastructure or equipment must be absent or economically removable. Water used for landscape, golf course, or recreational irrigation uses often has additional aesthetic requirements regarding color and odor. Irrigation water quality requirements are summarized in Appendix G.

In addition to water quality considerations associated with the intended use of nonpotable water, reclaimed water is subject to wastewater treatment standards which ensure the safety of its use (see Appendix G). As with any irrigation water, reclaimed water may contain some constituents at concentrations that are not desirable. Problems that might be associated with reclaimed water are no different from those of other water supplies and are only of concern if they hinder the use of the water or require special management techniques to allow its use. A meaningful assessment of irrigation water quality, regardless of the source, should consider local factors such as the specific chemical properties, the irrigated crops, climate, and irrigation practices (WSTB, 1996).

GROUND WATER CONTAMINATION AND IMPACTS TO WATER SUPPLY

The Surficial Aquifer System (SAS) is easily contaminated by activities occurring at land's surface in the KB Planning Area. Once a contaminant enters the aquifer, it may be difficult to remove. In many cases, leaks, spills or discharges of contaminants migrate over long periods of time, resulting in contamination of large areas of the aquifer. The preferred method of addressing the issue of water supply contamination, therefore, is to prevent contamination of the aquifer, and protect public water supply wells and wellfields from activities that present a possible contamination threat.

Ground Water Contamination Sources

There are many potential ground water contamination sources in the KB Planning Area. These include solid waste sites, hazardous waste sites, Superfund Program sites, and septic tanks. All these sites do not necessarily contain contamination. The USEPA and the FDEP each supervise different programs. The USEPA supervises Superfund programs, while the FDEP supervises petroleum cleanup, hazardous waste sites, and dry cleaning clean-up programs.

Solid Waste Sites

Landfills are just one type of solid waste site, also included are sludge disposal areas, biohazard storage sites, etc. There are 16 class I, II, and III solid waste sites identified by the FDEP within the KB Planning Area. These sites are active, inactive, or closed. Included in those sites are 3 active, and 4 closed class I landfills, 1 closed and 2 inactive class II landfills, and 2 active, 1 closed, and 3 inactive class III landfills.

Older landfills and dumps were often used for years with little or no control over what materials were disposed of in them. Many older landfills have no liners underneath to prevent leakage of contaminates into the ground water. These facilities often have associated ground water problems (Miller et al., 1987). Although most have not been active for some time, they may still be a potential threat to the ground water resource. Ground water monitoring began in the early 1980s for most unlined landfills in the KB Planning Area. No contamination problems were noted in any of these sites (Krumbholz, 1998).

Contaminants from landfills are called leachates. Leachates often contain high concentrations of nitrogen and ammonia compounds, iron, sodium, sulfate, total organic carbon (TOC), biological oxygen demand (BOD), and chemical oxygen demand (COD). Less common constituents, which may also be present, include metals such as lead or chromium, and volatile or synthetic organic compounds associated with industrial solvents, such as trichloroethylene, tetrachloroethylene, and benzene. The presence and concentration of these constituents in the ground water are dependent upon several factors that dictate the extent and character of the resulting ground water impacts, these factors include the following:

- Landfill size and age
- Types and quantities of wastes produced in the area
- Local hydrogeology
- Landfill design/landfilling techniques

An effective ground water monitoring program is crucial for accurate determination of ground water degradation. Improperly located monitoring wells can result in the oversight of a contaminant plume, or certain parameters may not be observed in the ground water for many years, depending upon soil adsorption capacities and ground water gradient.

Hazardous Waste Sites

The Florida Department of Environmental Protection (FDEP) Waste Management Division sponsors several programs which provide support for hazardous waste site cleanup. There are many potential Hazardous Waste Sites in the KB Planning Area. Many older gas stations and dry cleaning facilities require some cleanup. Not all the potential hazardous waste sites actually contain contamination. The potential hazardous waste sites include locations in the Early Detection Incentive (EDI) Program, the Petroleum Liability and Restoration Program (PLIRP), the Abandoned Tank Restoration Program (ATRP), the Petroleum Cleanup Participation Program (PCPP), Pre-approved Advanced Cleanup Program (PACP) and other programs. Locations and cleanup status can be obtained through the FDEP Waste Management Division at http://www2.dep.state.fl.us/dwm.

Superfund Program Sites

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), commonly known as "Superfund," authorizes the USEPA to identify and remediate uncontrolled or abandoned hazardous waste sites. The National Priorities List (NPL) targets sites considered to have a high health and environmental risk. There are no NPL sites in the KB Planning Area. The USEPA has a web site with more information about the Superfund Program sites at http://www.epa.gov/superfund/sites.

Petroleum Contaminant Sites

Sites are reported to the FDEP, if contamination was noticed in the soil, surface water, ground water or monitoring wells. For more information on the petroleum clean up program please refer to the FDEP world wide web site at http://www.dep.state.fl.us/dwm/programs/pcp/default.htm.

Septic Tanks

Septic systems are a common method of on-site waste disposal. There were 201,101 septic tanks in 1995 in Orange, Osceola, Polk, Highlands, Okeechobee, and Glades counties (Marella, 1998), but only parts of these counties are in the KB Planning Area. There are approximately 25,636 septic tanks in the KB Planning Area (estimated from data in Marella, 1998). Septic tanks may threaten ground water resources used as drinking water sources.

Impacts to Water Supply

The costs and difficulty of removing a contaminant by a drinking water treatment plant can be considerable, depending on the material to be removed. Many of the major contamination sources identified in the KB Planning Area can generate contaminants that are not easily treated. For example, nitrate is generated by septic systems or by fertilizer application, benzene from leaking gasoline tanks, and volatile organic compounds from various hazardous waste contamination sites. Water quality treatment methods for potable and nonpotable uses are described in the remaining portions of this section.

WATER TREATMENT TECHNOLOGIES

Several water treatment technologies are currently employed by the regional water treatment facilities in the KB Planning Area. In the northern part of the Kissimmee Basin, only disinfection is needed prior to distribution, due to the very high water quality from the Floridan Aquifer System (FAS). In the southern part of the Kissimmee Basin, the only PWS utility (located in Okeechobee) uses additional methods (coagulation/filtration for surface water; and aeration/filtration for ground water, which is from the SAS).

Higher levels of treatment may be required to meet increasingly stringent drinking water quality standards. In addition, higher levels of treatment may be needed where lower quality raw water sources are pursued to meet future demand. This section provides an overview of several water treatment technologies and their associated costs.

Disinfection

Disinfection, the process by which pathogenic microorganisms are destroyed, provides essential public health protection. All potable water requires disinfection as part of the treatment process prior to distribution. Chlorination and ozonation are the methods of disinfection used in the KB Planning Area.

Chlorination

Community public water supplies are required to provide adequate disinfection of the finished/treated water and to provide a disinfectant residual in the water distribution system. Disinfectant may be added at several places in the treatment process, but adequate disinfectant residual and contact time must be provided prior to distribution to the consumer. Chlorine is a common disinfectant used in the United States. The use of free chlorine as a disinfectant often results in the formation of levels of trihalomethanes (THMs) and other disinfectant by-products (DBP) when free chlorine combines with naturally occurring organic matter in the raw water source. All facilities use chlorination to disinfect the drinking water prior to distribution to the infrastructure. In December of 1998, President Clinton announced tighter regulations in the Disinfectant/Disinfection By-product Rule, (D/DBPR) for TTHMs, water borne pathogens and regulates for the first time, *Cryptosporidium*. This may require that facilities modify their treatment processes to comply with the standards for these groups of compounds. Add on treatment technologies that are effective at removing these compounds or preventing their formation include ozone disinfection, granular activated carbon (GAC), enhanced coagulation, membrane systems, and switching from chlorine to chlorine dioxide (Jack Hoffbuhr, of American Water Works Association Memorandum [December, 1998] regarding the Interim Enhanced Surface Water Treatment Rule).

The primary disinfectant used in the KB Planning Area is chlorination or chlorine used with ammonia to form chloramine. The rate of disinfection depends on the concentration and form of available chlorine residual, time of contact, pH, temperature, and other factors. Current disinfection practice is based on establishing an amount of chlorine residual during treatment and, then, maintaining an adequate residual to the customer's faucet. Chlorine is also effective at reducing color. Chlorination has widespread use in the United States.

The use of free chlorine as a disinfectant can result in the formation of levels of THMs that could exceed the current maximum contaminant level (MCL) of 0.10 mg/L. THMs are formed when free chlorine combines with naturally occurring organic matter in the raw water source. Information obtained from local utilities and state regulatory agencies indicate that the utilities in the KB Planning Area are meeting the current TTHM MCL.

Capital and construction costs of a chlorination system are 70 to 80 percent less than a comparable ozonation system, while the operating costs are 25 to 50 percent less. Capital, operation, and maintenance costs for chlorination are presented in **Table 32**.

Table 32. Chlorination Treatment Costs.

Facility Size (MGD)	Capital Cost (per 1,000/gallons)	Engineering Cost (per 1,000/gallons)	Operations and Maintenance Cost ($ per 1,000 gallons)
1	$.0638	$.00954	$.0577
3	$.0276	$.00414	$.0264
5	$.0216	$.00324	$.0207
10	$.0141	$.00211	$.0151
20	$.0100	$.00151	$.0126

Source: PBS&J, 1991, Water Supply Cost Estimates.

Ozonation

The use of ozone reduces unwanted disinfection by-products. However, ozone does not leave a residual like chlorine and chloramine which are persistent and can be measured. Ozone is an unstable gas that is produced on-site. After it is generated, the ozone gas is transferred into the water to be treated. Contact times required for disinfection by ozone are short (seconds to several minutes) when compared to the longer disinfection time required by chlorine. Ozone, however, does not produce trihalomethanes as does chlorine and it is also effective at reducing color. Ozonation has widespread use in Europe and Canada, and limited use in the United States (Montgomery, 1985).

Disadvantages of ozone disinfection include its inability to maintain a persistent residual and unknown health effects associated with ozonation by-products. None of these by-product compounds have been shown to have potential health significance but only limited information is available on this subject. Compared to chlorine, ozone appears to generate less mutagenic by-products. A mutagenic compound is one which has the ability to produce a change in the DNA of a cell. Ozone by-products appear to be generally more biodegradable than their precursors. As a result, water receiving ozone treatment may promote regrowth of bacteria in the distribution system. Ozonation is planned for four water treatment facilities, as well as for upgrades to several existing water treatment facilities, to treat for hydrogen sulfide. Capital, operation, and maintenance costs for ozonation are presented in **Table 33**.

Table 33. Ozonation Costs.

Facility Size (MGD)	Capital Cost (per 1,000/ gallons)	Engineering Cost (per 1,000/ gallons)	Operations and Maintenance Cost ($ per 1,000 gallons)	Energy Cost ($ per 1,000 gallons)
1	$.1644	$.0251	$.0602	$.0157
3	$.1167	$.018	$.0330	$.0157
5	$.0936	$.014	$.0246	$.0013
10	$.0773	$.011	$.0166	$.0105
20	$.0575	$.009	$.0133	$.0105

Source: PBS&J, 1991, Water Supply Cost Estimates.

Aeration

Aeration is used by 22 of the 31 water treatment facilities in the KB Planning Area. This treatment process is used in areas with high quality raw water which only needs to be aerated to remove hydrogen sulfide, which causes tastes and odors, or the removal of carbon dioxide, which can reduce the lime demand in lime softening treatment. Aeration also adds oxygen to the water. More recently, aeration has been used to remove trace volatile organic contaminants from water, which are believed to cause adverse health effects.

Aeration Process

In most water treatment aeration process applications, air is brought into contact with water in order to remove a substance from the water, a process referred to as desorption or stripping. This can be accomplished through packed towers, diffused aeration, or tray aerators.

A packed tower consists of a cylindrical shell containing packing material. The packing material is usually individual pieces randomly placed into the column. The shapes of the packing material vary and can be made of ceramic, stainless steel, or plastic. Water is introduced at the top of the tower and falls down through the tower as air is passing upward.

Diffused aeration consists of bringing air bubbles in contact with a volume of water. Air is compressed and then released at the bottom of the water volume through bubble diffusers. The diffusers distribute the air uniformly through the water cross section and produce the desired air bubble size. Diffused aeration has not found wide spread application in the water treatment field.

Cascading tray aerators depend on surface aeration that takes place as water passes over a series of trays arranged vertically. Water is introduced at the top of a series of trays. Aeration of the water takes place as the water cascades from one tray to the other.

Aeration Costs

The cost of aeration is relatively low. Costs decrease with facility size as shown in **Table 34**.

Table 34. Aeration Treatment Costs.

Facility Size (MGD)	Capital Cost (per 1,000/gallons)
1	$.01125
3	$.00825
5	$.0075
10	$.005125
20	$.005

Source: PBS&J, 1991, Water Supply Cost Estimates.

Lime Softening

Lime softening is not used at any of the 31 existing regional water treatment facilities in the KB Planning Area. Lime softening treatment systems are designed primarily to soften hard water, reduce color and to provide the necessary treatment and disinfection to ensure the protection of public health.

Lime Softening Process

Lime softening refers to the addition of lime to raw water to reduce water hardness. When lime is added to raw water, a chemical reaction occurs that reduces water hardness by precipitating calcium carbonate and magnesium hydroxide. Disinfectant may be added at several places in the treatment process, but adequate disinfectant residual and contact time must be provided prior to distribution to the consumer. The lime softening process is effective at reducing hardness, but is relatively ineffective at controlling contaminants such as chloride, nitrate, THM precursors and others (Hamann et al., 1990).

Lime softening is ineffective in removing the chloride ion and only fairly effective at reducing total dissolved solids (TDS). Chloride levels of raw water sources expected to serve lime softening facilities should be below the chloride maximum contaminant level of 250 mg/L to avoid possible exceedences of the standard in the treated water. The current finished water TDS MCL is 500 mg/L. Concentrations above 500 mg/L in the treated water are acceptable so long as no other MCLs are exceeded.

Nitrate is not effectively removed by the lime softening process. Lime softening facilities with raw water sources with nitrate concentrations exceeding the MCL of 10 mg/L will probably require additional treatment to meet the standard.

Proposed Safe Drinking Water Act regulations for TTHMs and disinfection by-products (DBPs) will require that many existing lime softening facilities modify their treatment processes to comply with the standards for these groups of compounds. Add-on treatment technologies that are effective at removing these compounds or preventing their formation include ozone disinfection, granular activated carbon (GAC), and air stripping.

Lime Softening Treatment Costs

Capital construction costs for lime softening treatment facilities tend to be similar to those of other treatment processes (**Table 35**). Lime softening's cost advantages are in operating and maintenance expenses, where costs are typically 20 percent less than for comparable membrane technologies. However, an increase in total hardness of the raw water source will require increased amounts of lime to maintain the same water quality. In addition, any free carbon dioxide present in the raw water must first be satisfied by the lime before any significant softening can occur, which will impact the costs associated with this treatment process.

Membrane Processes

Membrane technology has continued to improve in anticipation of the more stringent water quality regulations that the USEPA announced in December 1998. Membrane processes can remove dissolved salts, organic materials that react with chlorine

Table 35. Lime Softening Treatment Costs.

Facility Size (MGD)	Capital Cost (per 1,000/ gallons)	Engineering Cost (per 1,000/ gallons)	Land Requirements (Acres)	Operations and Maintenance Cost (per 1,000 gallons)	Energy Cost (per 1,000 gallons)
3	$1.63	$.25	1.5	$.60	$.023
5	$1.57	$.24	2.5	$.56	$.023
10	$1.53	$.23	4.0	$.50	$.021
15	$1.26	$.19	6.0	$.41	$.020
20	$1.13	$.16	8.0	$.38	$.020

Source: PBS&J, 1991, Water Supply Cost Estimates.

known as disinfection by-product (DBP) precursors as well as provide softening. Several membrane technologies are used to treat drinking water: reverse osmosis (RO), nanofiltration, ultrafiltration, and microfiltration. Each membrane process has a different ability in processing drinking water.

Reverse Osmosis

Reverse Osmosis (RO) technology has been used in Florida for a number of years. About 100 membrane treatment systems are operational in the state with a combined capacity of about 50 MGD. Major Florida public water supply RO facilities include Cape Coral, Venice, Sanibel, Englewood, and Jupiter. There are no RO facilities in the KB Planning Area.

Reverse Osmosis Process

RO is a pressure-driven process that relies on forcing water molecules (feed water) through a semipermeable membrane to produce fresh water (product water). Dissolved salts and other molecules unable to pass through the membrane remain behind (concentrate or reject water). RO is capable of treating feed waters of up to 45,000 mg/L TDS. Most RO applications involve brackish feed waters ranging from about 1,000 to 10,000 mg/L TDS. Transmembrane operating pressures vary considerably depending on TDS concentration (**Table 36**). In addition to treating a wide range of salinities, RO is effective at rejecting naturally occurring and synthetic organic compounds, metals, and microbiological contaminants. The molecular weight cutoff (MWC) determines the level of rejection of a membrane.

Advantages of RO treatment systems include their ability to reject organic compounds associated with formation of THMs and other DBPs, small space requirements, modular type construction and easy expansion. Disadvantages of RO systems include high capital cost, requirements for pretreatment and post-treatment

Table 36. Reverse Osmosis Operating Pressure Ranges.

System	Transmembrane Pressure Operating Range (psi)	Feed Water TDS Range (mg/L)	Recovery Rates (%)
Seawater	800-1,500	10,000-50,000	15-55
Standard pressure	400-650	3,500-10,000	50-85
Low pressure	200-300	500-3,500	50-85
Nanofiltration	45-150	Up to 500	75-90

Source: AWWA, 1990, Water Quality and Treatment.

systems, high corrosivity of the product water, and disposal of the reject. RO is also less efficient than lime softening, so more raw water is needed to produce finished water.

Disposal of RO reject is regulated by the FDEP. Various disposal options include surface water discharge, deep well injection, land application and reuse. Whether a disposal alternative is permittable depends on the characteristics of the reject water and disposal site (letter dated December 12, 1990 from B.D. DeGrove, Point Source Evaluation Section, FDEP, Tallahassee, FL).

Reverse Osmosis Costs

RO treatment and associated concentrate disposal costs for a typical South Florida system, (2,000 mg/L TDS, 400 PSI) are provided in **Tables 37** and **38**. Variables unique to RO capital costs include system operating pressures and concentrate disposal, while variables unique to RO operations and maintenance costs include electrical power, chemical costs, membrane cleaning and replacement, and concentrate disposal.

Methods of determining capital and operations and maintenance costs vary from utility to utility, and as a result, cost comparisons of treatment processes can be difficult (Dykes and Conlin, 1989). Site-specific costs can vary significantly as a result of source water quality, reject disposal requirements, land costs, use of existing water treatment plant infrastructure, etc. Detailed cost analyses are necessary when considering construction of RO water treatment facilities. As a general rule, however, RO costs are 10 to 50 percent higher than lime softening.

Membrane Softening

Membrane softening or nanofiltration is an emerging technology that is currently in use in Florida. Membrane softening differs from standard RO systems in that the membrane has a higher MWC, lower operating pressures and feed water requirements of 500 mg/L or less of TDS. One significant advantage of the membrane softening technology is its effectiveness at removing organics that function as THM and other DBP precursors. Given the direction of increasing federal and state regulation of drinking water

Table 37. Reverse Osmosis Treatment Costs.

Facility Size (MGD)	Capital Costs (per 1,000/ gallons)	Engineering Cost (per 1,000/ gallons)	Land Requirements (Acres)	Operations and Maintenance Cost (per 1,000 gallons)	Energy Cost (per 1,000 gallons)
3	$1.76	$.26	.40	$.58	$.29
5	$1.59	$.24	.40	$.54	$.29
10	$1.47	$.23	.50	$.51	$.29
15	$1.43	$.21	.63	$.50	$.29
20	$1.40	$.20	.78	$.38	$.29

Source: PBS&J, 1991, Water Supply Cost Estimates.

Table 38. Concentrate Disposal Costs.

Deep Well Disposal Facility (MGD)	Capital Cost (per 1,000/ gallons)	Engineering Cost (per 1,000/ gallons)	Land Requirements (Acres)	Operations and Maintenance Cost (per 1,000 gallons)
3	$.73	$.109	0.5	$.040
5	$.55	$.083	0.5	$.030
10	$.50	$.075	1.0	$.028
15	$.46	$.070	2.0	$.025
20	$.38	$.056	3.0	$.020

Source: PBS&J, 1991, Water Supply Cost Estimates.

quality, membrane softening seems to be a viable treatment option towards meeting future standards. A number of membrane softening facilities have been installed in Florida. However, there are no membrane softening facilities in the KB Planning Area.

The costs associated with membrane softening are similar to those of reverse osmosis, with operations and maintenance expenses tending to be lower. Membrane softening treatment costs are shown in **Table 39**.

Ultrafiltration

Ultrafiltration is a pressure driven processes that removes nonionic matter, higher molecular weight substances and fractions colloids. Colloids are extremely fine sized suspended materials that will not settle out.

Table 39. Membrane Softening Treatment Costs.

Facility Size (MGD)	Capital Cost (per 1,000/ gallons)	Engineering Cost (per 1,000/ gallons)	Land Requirements (Acres)	Energy Cost (per 1,000 gallons)	Operations and Maintenance Cost (per 1,000 gallons)
3	$1.67	$.25	0.40	$.200	$.55
5	$1.52	$.23	0.40	$.200	$.53
10	$1.41	$.21	0.50	$.200	$.50
15	$1.38	$.21	0.63	$.200	$.48
20	$1.33	$.20	0.78	$.200	$.46

Source: PBS&J, 1991, Water Supply Cost Estimates.

Microfiltration

Microfiltration is also a pressure driven process but it removes coarser materials than ultrafiltration. Although this membrane type removes micrometer and submicrometer particles it allows dissolved substances to pass through.

Electrodialysis and Electrodialysis Reversal

Electrodialysis (ED) is an electrochemical process that involves the movement of ions through anion- and cation-selective membranes from a less concentrated solution to a more concentrated solution by the application of direct electrical current. Electrodialysis reversal (EDR) is a similar process but provides for the reversing of the electrical current which causes a reversing in the direction of ion movement. ED and EDR are useful in desalting brackish water with TDS feedwater concentrations of up to 10,000 mg/L. ED/ EDR, however, is generally not considered to be an efficient and cost-effective organic removal process and therefore is usually not considered for THM precursor removal applications (AWWA, 1988). Available cost data for ED/EDR is limited, but for the same area appear to be 5 to 10 percent higher than RO treatment (Boyle Engineering, 1989). There are no ED facilities in the KB Planning Area.

WATER TREATMENT FACILITIES

Potable Water Treatment Facilities

Potable water in the KB Planning Area is supplied by three main sources: (a) regional water treatment facilities, municipal or privately owned; (b) small developer/ homeowner association or utility owned water treatment facilities; (c) self-supplied individual wells that serve individual residences. Many of the smaller facilities are constructed as interim facilities until regional potable water becomes available. At that time, the smaller water treatment facility is abandoned upon connection to the regional water system.

There are 35 existing and 4 proposed regional water treatment facilities in 8 service areas within the KB Planning Area. The service areas are in Orange, Osceola, and Okeechobee counties, with small portions extending into Polk and Glades counties (**Figures 13** through **15**). Detailed information on these utilities is provided in Appendix D, including the source aquifer and pump capacity for each of the wells; existing, proposed, and future sources of raw water; and water treatment methods for each facility.

The existing treatment technologies employed by the facilities are aeration, chlorination, coagulation/filtration, and ozonation. Of the 35 existing facilities, 21 use aeration, 9 use chlorination, 1 uses ozonation, and the remaining 4 use a combination of these and other treatment methods. All four of the proposed facilities plan to use ozonation when they are operational.

All facilities use ground water except for the Okeechobee Utility Authority surface water plant, where water is withdrawn from Lake Okeechobee. A total of 70.19 MGD of water was distributed by these facilities in 1995, including 1.06 MGD from irrigation wells for the Reedy Creek Service Area.

PWS systems in the KB Planning Area are regulated by the FDEP for all facilities, with the following exceptions: (1) those water systems that have less than 15 service connections, or (2) facilities which regularly serve less than 25 individuals daily at least 60 days out of the year, or (3) facilities which serve at least 25 individuals daily less than 60 days out of the year. All other systems are regulated by the local health departments (Chapter 62-550, F.A.C.).

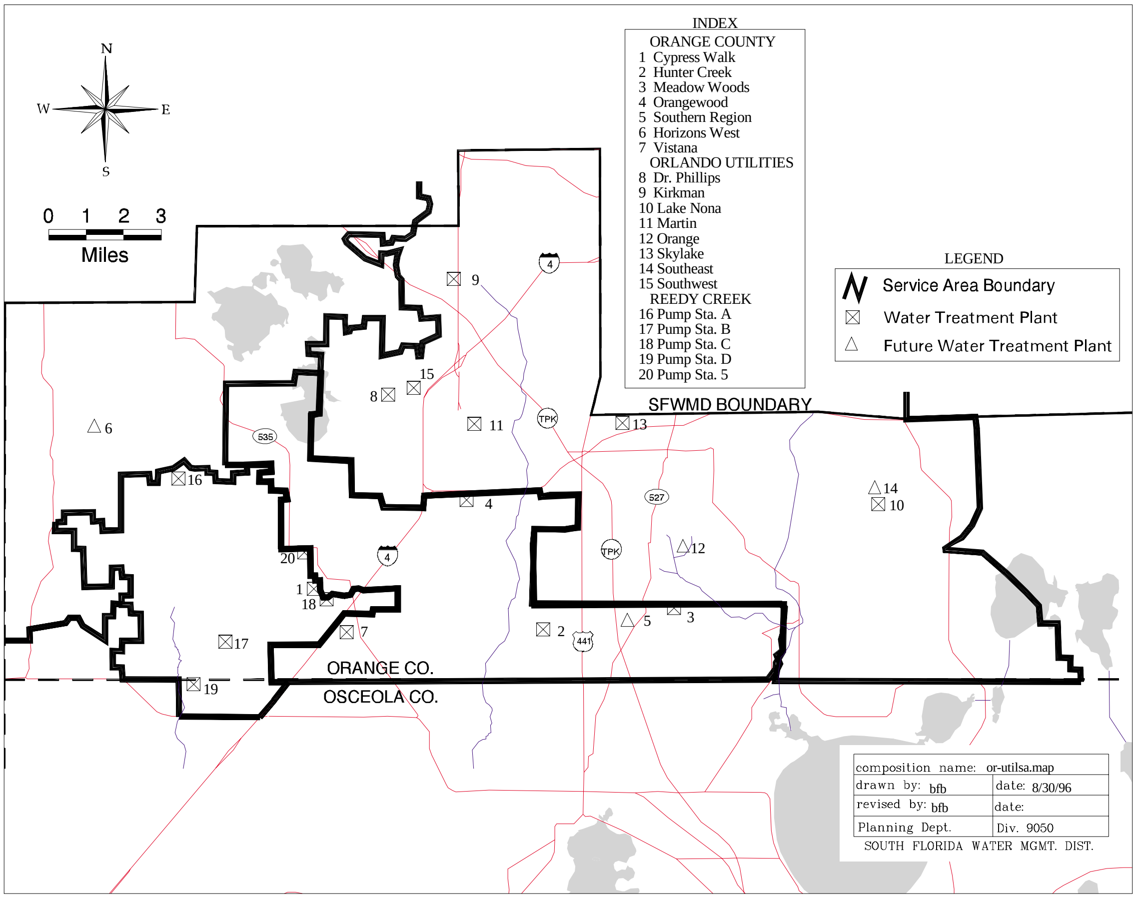

Figure 13. Potable Water Treatment Facilities in the Orange Area.

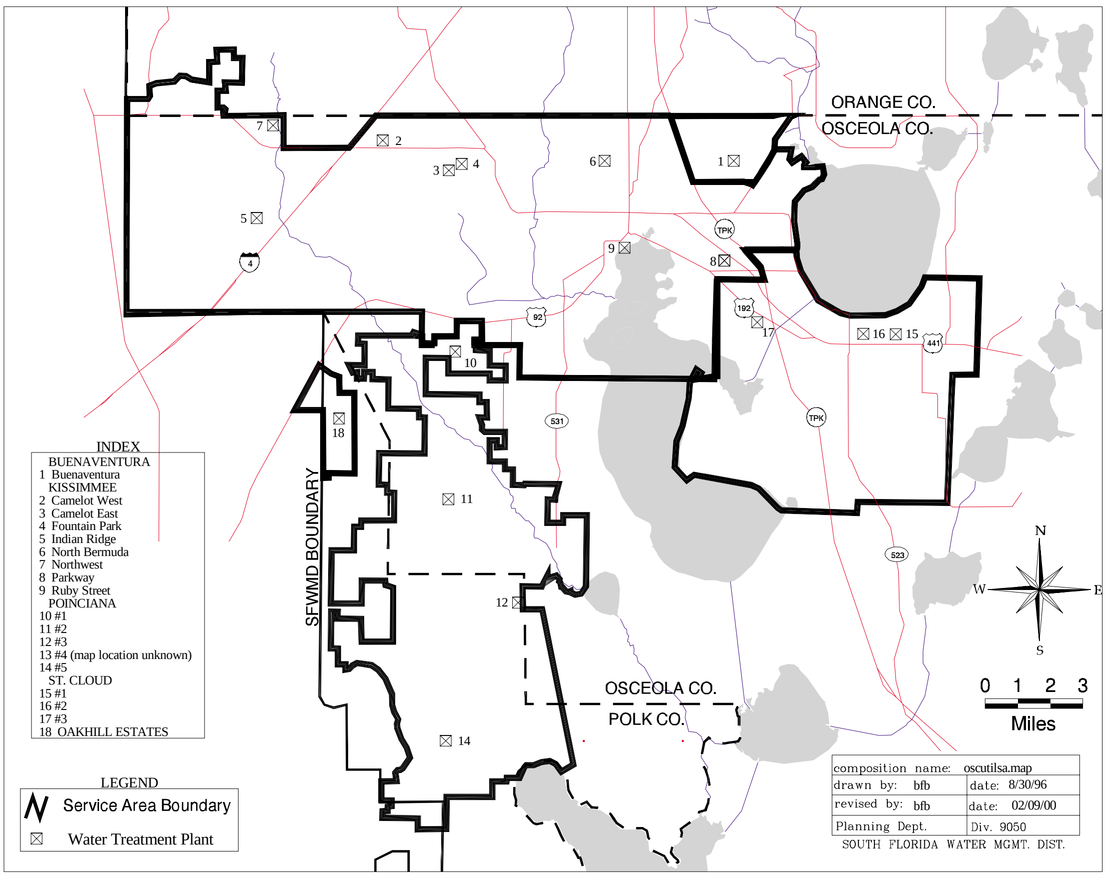

Figure 14. Potable Water Treatment Facilities in the Osceola Area.

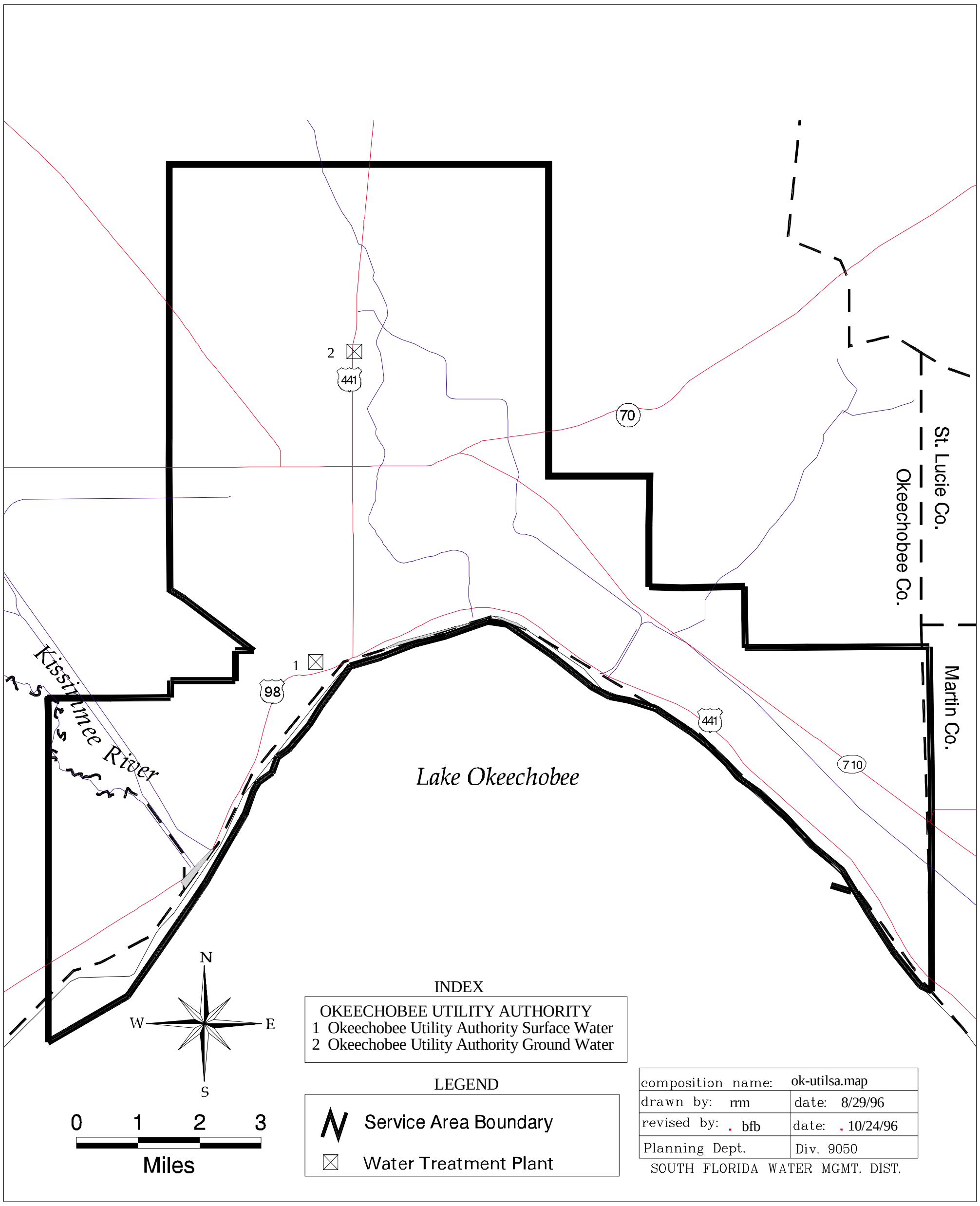

Figure 15. Potable Water Treatment Facilities in the Okeechobee Area.

Wastewater Treatment Facilities

Wastewater treatment in the KB Planning Area is provided by: (a) regional wastewater treatment facilities, municipal or privately owned, (b) small developer/ homeowner association or utility owned wastewater treatment facilities, and (c) septic tanks. This section concentrates only on large wastewater treatment facilities (those with FDEP-rated capacities of 0.50 MGD or greater).

Many of the smaller facilities are constructed on an interim basis until regional wastewater facilities become available, at which time the smaller wastewater treatment facility is abandoned upon connection to the regional wastewater system. There are 18 existing (and 1 proposed) regional wastewater treatment plants within the KB Planning Area. These treatment plants and their respective service areas are in Orange, Osceola, and Okeechobee counties, with small portions extending into Polk and Glades counties (**Figures 16** through **18**).

All 18 facilities use the activated sludge treatment process, and 17 of the facilities reused all or a portion of their 1995 flow. Two facilities used a surface water discharge for all or a portion of their disposal. Reuse in the KB Planning Area includes agricultural, golf course, residential lawn, nursery and other green space irrigation; wetland restoration; and ground water recharge by rapid-rate infiltration basins. These facilities processed an average of 60.34 MGD in 1995, and 98 percent, or 59.06 MGD was reused. The wastewater flow for these facilities are projected to increase to approximately 135 MGD by 2020.

Wastewater treatment in the KB Planning Area is regulated by the FDEP for all facilities with the following exceptions: (1) those with a design capacity of 2,000 GPD or less which serve the complete wastewater and disposal needs of a single establishment, or (2) septic tank drain field systems and other on-site sewage systems with subsurface disposal and a design capacity of 5,000 GPD (3,000 GPD for restaurants) or less, which serve the complete wastewater disposal needs of a single establishment. All other systems are regulated by the local health department for each county (Chapter 62-600, F.A.C.).

Specific information on each of the wastewater treatment facilities is provided in Appendix D. This information includes summaries of the existing, proposed, and future wastewater treatment and disposal methods.

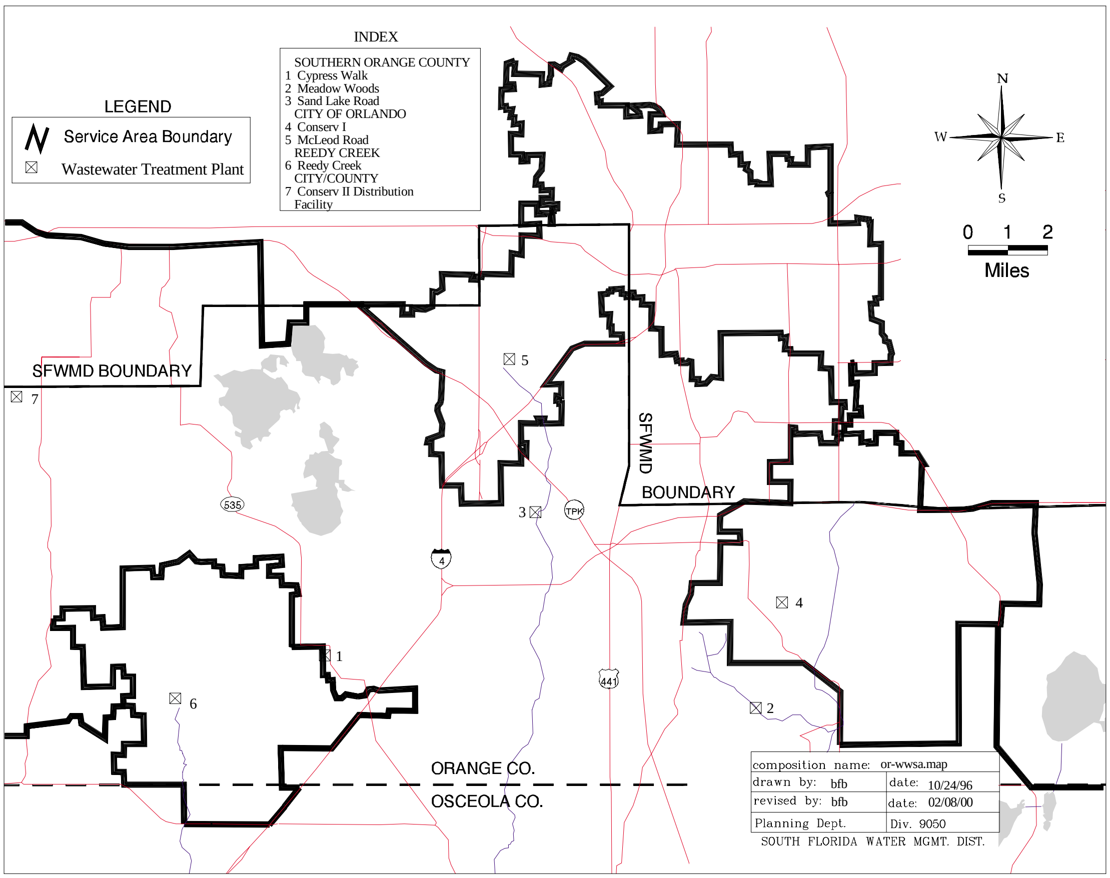

Figure 16. Regional Wastewater Treatment Facilities in Orange County.

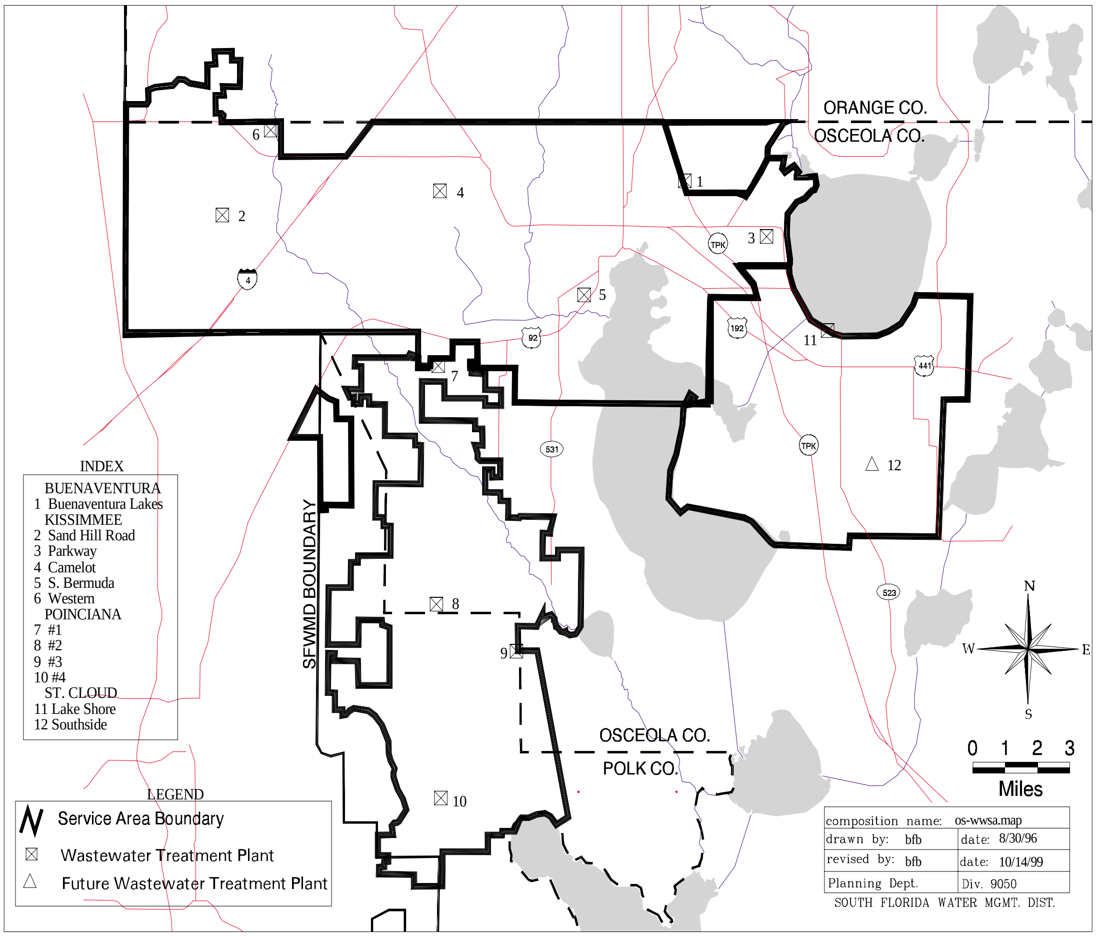

Figure 17. Regional Wastewater Treatment Facilities in Osceola and Polk Counties.

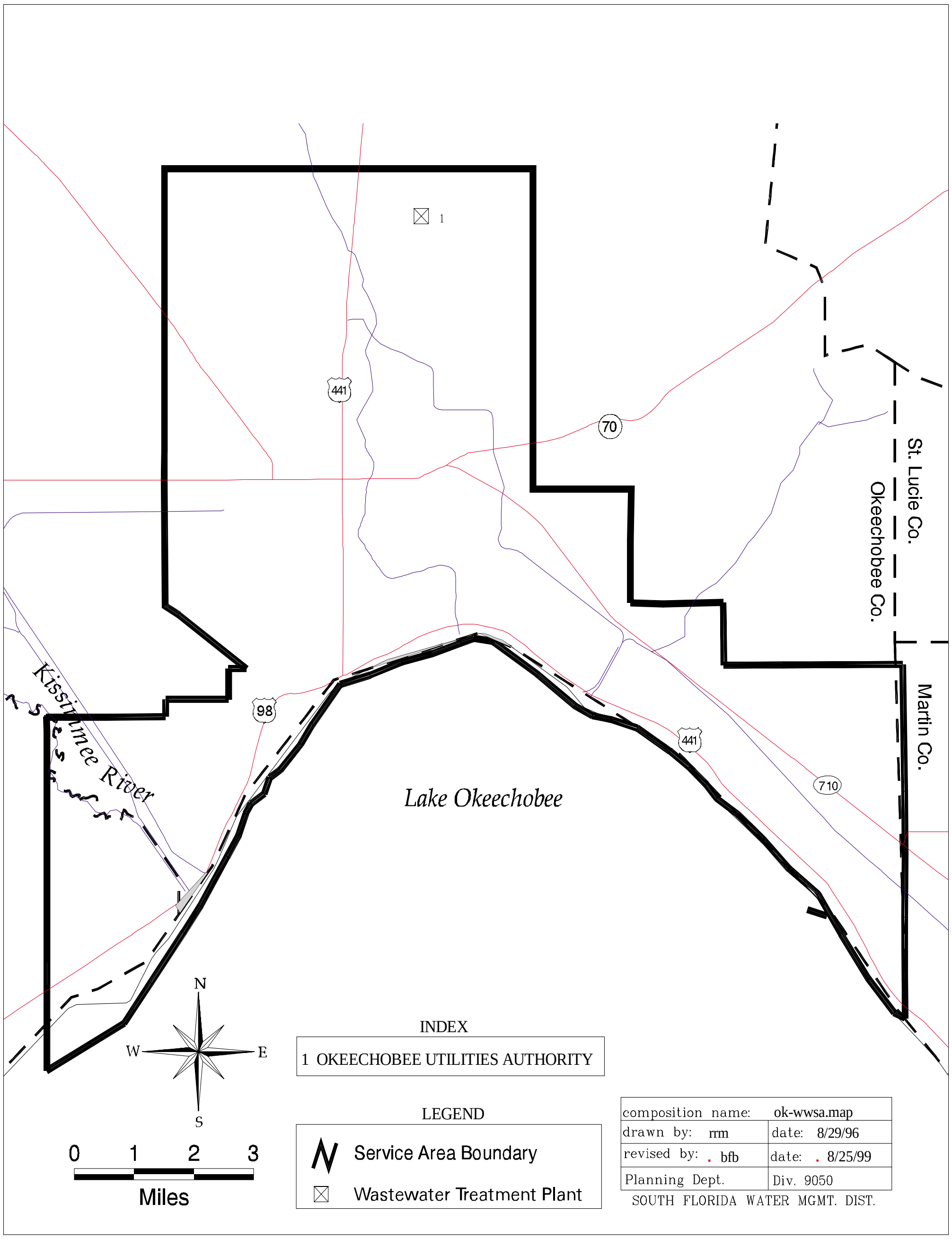

Figure 18. Regional Wastewater Treatment Facilities in Okeechobee County.

Chapter 10
ANALYTICAL TOOLS AND MODEL ASSUMPTIONS

ANALYTICAL TOOLS

A part of the water supply planning effort it is necessary to gain insight into the reaction of the natural system to the projected future water uses. There are several tools available to assist in performing this analysis. The type of tool selected is a result of the complexity of the natural system and the amount of information available to complete the analysis. In considering the complexity of the Central Florida geology and the information available, the most typical approach of assessing ground water conditions has been through the use of computer assisted models. Ground water models provide a means of simulating real world conditions using mathematical equations which describe the physical processes that occur in that system.

The analytical tools used in the development of this plan include ground water models, surface water management assessments, vulnerability mapping and a simple comparative presumptive analysis. Ground water flow models developed for this plan were used to simulate the effects of projected 2020 water demands on the environment and ground water sources in the Kissimmee Basin (KB) Planning Area. A surface water management assessment was made to focus on the management issues associated with the Lake Istokpoga and Indian Prairie Canal system that supply agricultural uses in that area. Vulnerability mapping was used to identify areas where the potential is greatest for future harm to wetlands from ground water withdrawals. Where data was the least available to complete a rigorous analysis, a comparative evaluation was performed to determine of possible movement of poor quality water and the increased potential for sinkhole occurrence. The following sections present the approach taken in evaluating the possible impacts from the projected future water use.

USE OF GROUND WATER MODELS

There are several tools available to help assess the movement of ground water within an aquifer system. A common method of characterizing these flow conditions is through the application of computer models. Most of these models have in common the idea of applying a programming code to solve a mathematical equation defining the movement of water in a porous media. The more popular models are well documented and have Windows based software developed for ease of use. The most popular of these ground water flow models is the U.S. Geological Survey (USGS) Modular Three-Dimensional Finite-Difference Ground Water Flow Model (MODFLOW) code (McDonald and Harbaugh, 1988). This is a well-documented modeling code that has previously been used by the District, USGS and other outside consultants. The SFWMD, USGS, St. Johns River Water Management District (SJRWMD), and Southwest Florida Water Management District (SWFWMD) are all active in the evaluation of ground water resources in Central Florida. Each of their efforts are discussed in the following sections.

SFWMD Modeling Approach

In an effort to assess the ground water conditions within the KB Planning Area, three MODFLOW models were used. Two of these models were developed by SFWMD staff and include the Osceola County model and the Glades, Okeechobee, Highlands (GOH) County model. The third model used in the evaluation was a model developed under contract with the USGS and in conjunction with the SJRWMD and SFWMD. This model focuses on Orange County and the surrounding metropolitan Orlando area. The aerial relationship of these three models is shown in **Figure 19**. In addition to these three models, efforts were made to compare the results of these models with the modeling efforts being made by the SJRWMD and SWFWMD where their respective work overlapped portions of the KB Planning Area. Efforts were made to ensure the information used in these models is consistent as possible.

Osceola County Model

The Osceola County model was developed as a conceptual model focusing on the Upper Floridan aquifer in Osceola County. This model uses the MODFLOW code to create a steady-state simulation of the movement of the ground water within the Floridan aquifer and the surrounding aquifer systems. It contains five layers representing the surficial aquifer, intermediate confining units and the upper, middle and lower sections of the Floridan Aquifer System (FAS). In this model, the surficial aquifer is maintained at a fixed elevation. The elevation is set at what is believed to be the average water table condition for 1995. This was done primarily because of limitations on data for the surficial aquifer and leakance to the underlying aquifers. The remaining layers are all free to fluctuate in response to the natural stresses of the system. The model was calibrated to observed field conditions for 1995. The model is believed to be well calibrated for the Upper Floridan aquifer and reasonably calibrated for the intermediate confining unit, and the middle and Lower Floridan aquifers. Fewer measurements and aquifer test parameters are available for the intermediate and Lower Floridan aquifer layers of the model and therefore less effort was placed on calibrating these layers. In those areas where the model domain extends beyond the boundary of the KB Planning Area, cooperation was sought from the other water management districts in determining the hydrology and water use patterns within their boundaries. An estimated 6,000 water use withdrawals were included within the model. A detailed report of the modeling effort is included in Appendix H.

After initial construction of the model, a calibration process of adjusting the parameters with the model to match responses of the physical system was completed. A trial and error method was applied in calibration of this model. In order to measure the success of the calibration, the model results were compared to the actual water levels obtained from the monitoring well network. The monitoring network of 53 wells were distributed throughout the study area. Layer 3, the Upper Floridan aquifer, was the focus of calibration. Three success criteria were used to measure the steady-state calibration. These criteria included a standard deviation from the averaged water level, simulated level within the range of measured values, and a simulated level within one foot of the averaged measured level. The details of the calibration process are found in the model report included in Appendix H.

Upon satisfactory calibration of the model, the 1995 water use information was revised to reflect the 2020 average and 2020 (1-in-10) drought water use conditions. For an explanation of how the 1995 and 2020 water use estimates were developed, the reader is referenced to Appendix F. The results of these simulations were then compared to those of the calibration simulations to determine the projected change in the water levels in the Upper Floridan aquifer. The projected change in Floridan aquifer levels were then used in the evaluation of the identified resource constraints. The results of these efforts are discussed further in Chapter 4 of this report.

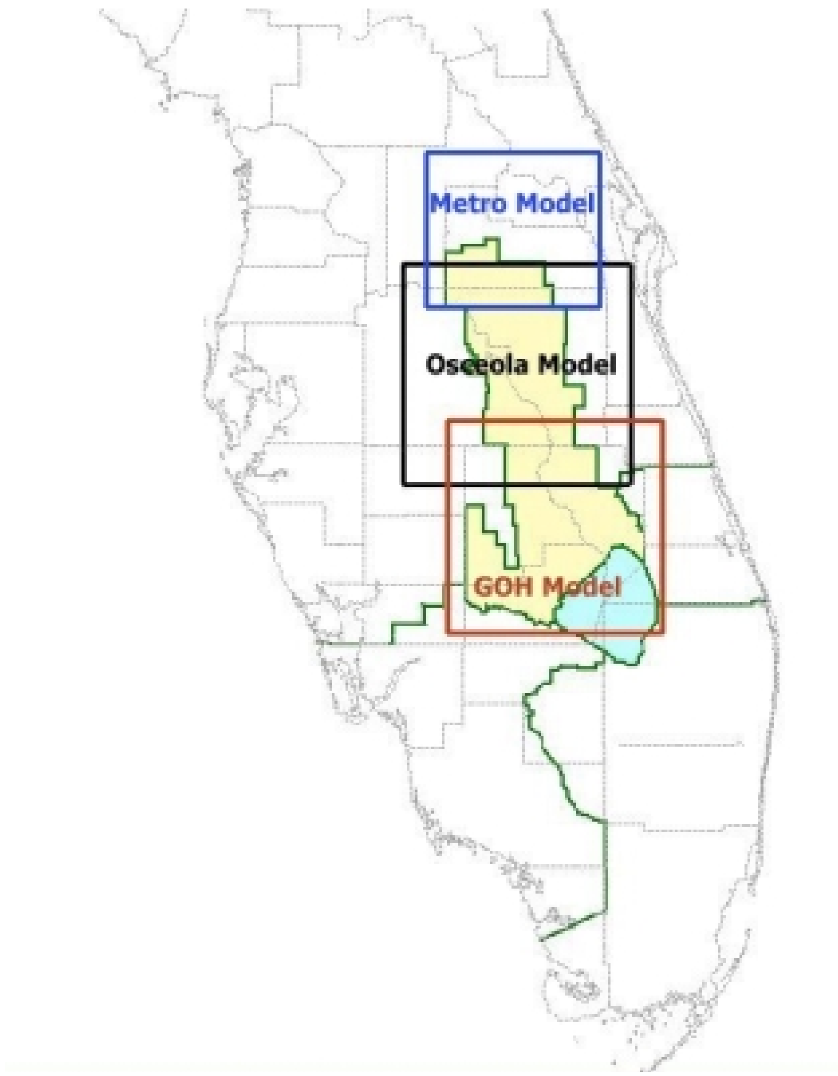

Figure 19. Location of Model Domains.

GOH Model

The Glades, Okeechobee, Highlands (GOH) County model is the second model developed by District staff to address ground water flow conditions in the KB Planning Area. This model covers Okeechobee and Highlands counties, most of Glades County, as well as portions of Charlotte, Martin, and St. Lucie counties. The extent of the model domain can be seen in **Figure 19**. The GOH model uses the MODFLOW code to create a steady-state simulation of the ground water conditions observed in this area. Similar to the Osceola County model, the GOH model contains five layers representing the surficial aquifer, intermediate confining units and the upper, middle, and lower sections of the FAS. In this model, the surficial aquifer and the Lower Floridan aquifers are maintained at a fixed elevation as determined from the average 1995 observed conditions. This was done primarily because of limitations on data for the surficial aquifer and the belief that the connection between the surficial and underlying aquifers is poor. The remaining layers are all free to fluctuate is response to natural systems stresses. The model was calibrated to observed field conditions for 1995. It is believed to be well calibrated for the Upper Floridan aquifer and reasonably calibrated for the intermediate confining unit, and the Middle Floridan aquifer. Fewer measurements and aquifer test parameters are available for the intermediate and middle Floridan layers of the model and therefore less effort was placed on calibrating these layers. In those areas where the model domain extends beyond the boundary of the KB Planning Area, cooperation was sought from the other water management districts in determining the hydrology and water use patterns within their district. An estimated 5,000 water use withdrawals were included within this model.

After initial construction of the model, a calibration process of adjusting the parameters with the model to match responses of the physical system was completed. A trial and error method was applied in calibration of this model. In order to measure the success of the calibration, the model results were compared to the actual water levels obtained from the monitoring well network. The monitoring network of 53 wells were distributed throughout the study area. Layer 3, the Upper Floridan aquifer, was the focus of calibration. Three success criteria were used to measure the steady-state calibration. These criteria included a standard deviation from the averaged water level, simulated level within the range of measured values, and a simulated level within one foot of the averaged measured level. The details of the calibration process are found in Appendix H.

Upon satisfactory calibration of the model, the 1995 water use information in the model was revised to reflect the 2020 average and 2020 (1-in-10) drought water use conditions. The results of these simulations were then compared to those of the calibration simulations to determine the projected change in the water levels of the upper Floridan system.

USGS Model

In 1996, the USGS completed work on a MODFLOW simulation of the hydrologic conditions of the greater Orlando metropolitan area (Murray and Halford, 1996). This work was completed in cooperation with the SJRWMD and SFWMD. This model is often referenced to as the Orlando Metro model. The location of the model domain is shown in

Figure 19. This model simulated the effects of increased ground water use from 1988 to 2010 on the Upper and Lower Floridan aquifers. In 1997, the USGS began updating its previous work by providing an additional calibration period for 1995 and revising its future water use information to reflect estimated ground water use for the year 2020. Additional steady-state simulations for water use during wet and dry periods were also made in an attempt to bracket the projected water level changes from the 1995 average conditions. The Metro model was used in the KB Water Supply Plan evaluation to assist in quantifying the reduction of spring discharges in northern Orange County due to the projected 2020 withdrawals occurring in both the SJWMD and SFWMD, and to provide additional insight on the potential movement of saline water in the eastern portion of the county.

SJRWMD Model

The SJRWMD has worked several years to develop and improve the East Central Florida regional ground water flow model to cover portions of Lake, Orange, Osceola, Seminole, and Polk counties. This model was originally developed for the agency's preparation of the Water Supply Needs and Sources Assessment (SJRWMD, 1994). More recently, the model was updated to address water use conditions consistent with the year 2020 as part of SJRWMD water supply planning effort. The model represents the most advanced effort made to date in simulating ground water conditions in Central Florida. The model domain for the SJRWMD model includes portions of the KB Planning Area north of Lake Kissimmee in Osceola County. A cooperative effort in the development of this model assures that the geologic data and water use information used in the model is consistent with the information used to develop the Osceola County model in areas where the two models overlap. The East Central Florida model was used to compare to the results derived from the efforts completed as part of SFWMD planning effort.

GROUND WATER MODELING PROCESS

The modeling effort simulates ground water conditions within the planning region. This is the foundation upon which the evaluation of resource protection criteria are made. The results of the vulnerability mapping, saltwater movement, and sinkhole analysis all incorporate the results of the projected change in water levels in the Upper Floridan aquifer between 1995 and 2020. The following discussion covers the basic assumptions and processes incorporated into the models developed by the SFWMD staff and the subsequent analyses that used the results of these ground water simulations. The specifics on model construction are presented in Appendix H. For the assumptions used in the USGS and SJRWMD modeling efforts, we direct the reader to the references cited in this plan.

Model Assumptions

Ground water models in general are calibrated by matching computed responses to observed conditions in the natural system. The calibration process involves altering initially estimated model parameters to match, as closely as possible, observed field measurements. The level of calibration, and thereby the ability to accurately predict future conditions, is highly dependant upon the amount of information available for use to construct and calibrate the model. Although models can be loosely or tightly calibrated based upon the available field information, all models that are reasonably calibrated can provide some insight into the hydrologic conditions they are attempting to simulate. The following sections discuss how models handle certain hydrologic input and how this may affect the results of the simulations.

Aquifer Recharge

Recharge to the aquifer is defined in this document as recharge to the FAS. In terms of the modeling effort, this water is derived from leakage from the overlying and underlying aquifers, lateral inflow from the edges of the model, and the direct recharge from drainage wells. Recharge is a positive value where the infiltration of water is into the FAS. Recharge can also be a negative value where water is being discharged from the aquifer. These discharge areas occur where the water levels in the Floridan are elevated above those of the water table. This is the case along the eastern edge of the Lake Wales Ridge and in the southernmost portion of the KB Planning Area. Recharge is a parameter that the model results can be very sensitive to and is difficult to measure in the field. In the case of the Osceola and GOH county models, recharge has been dealt with as a “background” calibration parameter since no direct measurements are available. The resultant recharge/discharge distribution pattern determined from the calibration process compared well with previously published recharge maps produced by the USGS for the KB Planning Area.

In the predictive simulations completed for the year 2020 withdrawals, recharge to the Floridan aquifer is allowed to fluctuate based upon the changing head difference between the intermediate confining unit and Floridan aquifer layers. As the elevation of the water levels in these aquifers are lowered due to increased water use, the amount of recharge is increased due to increased difference in head between the fixed water table and intermediate confining unit head conditions. In those areas where the anticipated change in aquifer levels is predicted to be small, this is a reasonable assumption for the model. In those areas where the change in water levels becomes large, this assumption can lead to under estimating the amount of water level change in the Floridan aquifer that is expected to occur.

In addition to recharge related to climatic conditions, other man-made additions to recharge also occur in the region. Examples of these include the application of treated wastewater to infiltration ponds and recharge related to excess irrigation. These additional factors were addressed through the calibration process for 1995, but not addressed is the future expansion of wastewater systems or increases in recharge due to additional irrigated acreage. These factors may work to moderate the extent of areas identified as vulnerable to wetland harm or to reduce the severity of the changes in aquifer levels in the Floridan aquifer. There effect, however, is likely limited to areas surrounding the point of water application.

Evapotranspiration

Evapotranspiration (ET), the loss of water through evaporation and the uptake in plants (transpiration), is controlled in part by the elevation of the water table. ET is not considered in the construction of the Osceloa and GOH county models, as each of these models contain fixed water table aquifers, eliminating the need to address this parameter. ET is given consideration in the calculation of the water use estimates that are included in the models.

Water Well Withdrawals

Water use assessments and the associated water well withdrawals were made for five use categories including: public supply, agriculture, recreational, commercial/ industrial and landscape irrigation type uses. A total exceeding 11,000 wells was used in modeling the basin. A discussion of the demand projections and projection methodology for withdraws occurring within the SFWMD are provided in Chapter 6 and Appendix F.

Although every effort was made to accurately estimate the 1995 water use and project 2020 water use pattern, there is inherently some error. In particular, the projection of the water use over the next 20 years is based upon historic trends that may change in the future and thereby alter the estimate or distribution of use. The estimates of water use are thought to be reasonable, but represent sources of error in the modeling effort.

Water use estimates from the SJRWMD and SWFMWD were also incorporated into the modeling effort where the model domains encompassed portions of the respective districts. For the SJRWMD, water use estimates for 1995 and 2020 were obtained from their staff and are consistent with the estimates used in the SJRWMD planning process. This water use information represents actual public water supply use and permitted urban type uses (other than PWS) and agriculture for uses greater than 100,000 GPD. The water use information for the SWFWMD was collected only for 1995. This information came from their Annual Water Use Survey. SWFWMD estimates that over 70 percent of the water use in their District is monitored. The remaining use is estimated based upon similar uses in the basin and permitted acreage. Only 1995 use information was used to represent the SWFWMD withdraws in order to be consistent with their effort to maintain water levels on the ridge through no net change in ground water withdrawals.

Aerial and Vertical Discretization

A requirement of most computer modeling codes is that the system being simulated must be divided into smaller, more character consistent parts. The process is called discretization and occurs on both an aerial and vertical basis. In the case of a MODFLOW simulation, the discretization occurs in cubes or cells and can be of varying sizes. The aquifer parameters of each of these cells is then given a single value that can be mathematically defined by a set of constants. In the Osceola and GOH county models, the aerial discretization was set at uniform one-half mile by one-half mile squares. Vertical discretization, most often called layering, was established to be consistent with the thickness of the individual aquifers. In each model, layers are created for the surficial and intermediate aquifers as well as for the upper, middle and lower portions of the Floridan aquifer for a total of 5 layers (**Figure 20**). The model discretization is thought to have only a minimal effect on regional model simulations.

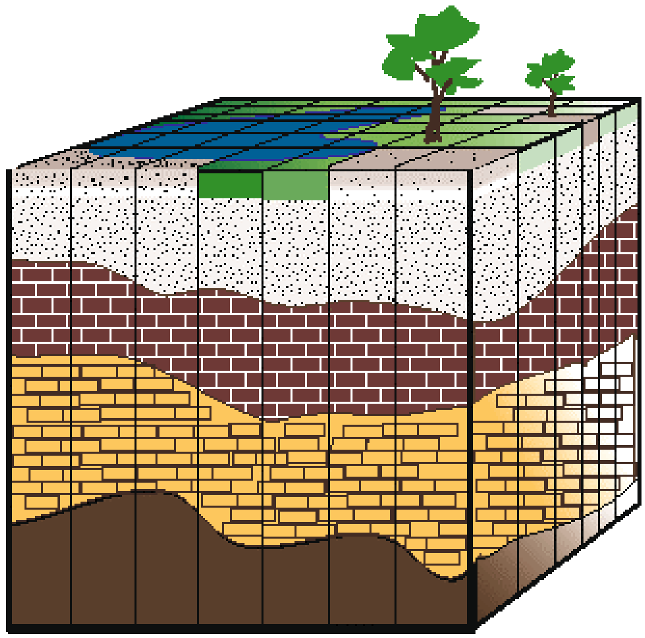

Figure 20. Example of Vertical and Aerial Discretization.

Aquifer Properties

Aquifer properties are variables that define a given characteristic of that aquifer. These variables change from location to location, but do not generally change over time. Examples of aquifer properties are hydraulic conductivity and aquifer storage. These variables define how an aquifer system will react when placed under stress. In modeling the system, an attempt is made to acquire as much information as possible about aquifer properties to assist in model development. Where this information in not available, the modeler attempts to estimate these parameters as part of the calibration process. Information regarding the aquifer parameters for the Upper Floridan aquifer is adequate within the basin. Information regarding the surficial, intermediate, middle Floridan, and Lower Floridan aquifers is less abundant in the KB Planning Area. Appendix H includes a discussion of the aquifer information used as part of the modeling efforts.

Model Calibration

After initial construction of the model, a calibration process of adjusting the parameters of the numerical model so that the model responds similarly to the physical system was made. Calibration is accomplished by finding a set of parameters, boundary conditions, and stresses that produce simulated heads and fluxes that match field measured values within an acceptable range of error. Both the Osceola County and GOH models were calibrated to steady-state or long-term average conditions. Steady-state conditions also presume that no changes in stress rates occur during that time. A trial and error method was applied in calibration of these two models.

Calibration was defined as being achieved when the water level were simulated within the calibration target. A calibration target is defined as a calibration value and its associated range. Basic statistics, including the standard deviation and variance, were estimated for each monitoring well to determine the target. In most cases, the standard deviation and variance were relatively small. This infers that there is little deviation from the mean water level.

In order to measure the success of the calibration, the model results were compared to the actual water levels obtained from the monitoring well network. The monitoring network of roughly 50 wells for each model were distributed throughout the study areas. Water levels from the wells were obtained on a monthly basis for a majority of the wells. Layer 3, the Upper Floridan aquifer, was calibrated using water levels.

In addition to examining the water levels, the calibration procedure also examines the vertical flow (recharge/discharge) between the Upper Floridan aquifer and the SAS, and the model budget. A comparison was made between the model calibrated recharge/ discharge distribution and that of the published values (see **Plate 3**). Appendix H includes the details of model calibration for each model.

Presentation of Results

In preparing the presentation of the modeling results, it was necessary to combine the output of the three different modeling efforts. This was accomplished through the use of the GIS system. During the construction of the Osceola County and GOH models, nodal locations were carefully selected so the model grids align geographically. During this process, each center node was georeferenced. The data output form these models were then combined and the surface regridded. Results of the remaining model, the USGS Metro model (1997) were interpreted from the publications and were used to provide guidance on extending the drawdown contours produced by the Osceola County model into the northernmost four miles of the basin. The interpreted points were also included into the regridded dataset and the information was then contoured. Possible errors associated with this process include small math errors cased by the recontouring process and the interpretation of the USGS model results. Errors associated with this process are anticipated to be small and are located in the northern tip of the basin.

SURFACE WATER MANAGEMENT ASSESSMENT

Lake Istokpoga-Indian Prairie Basin

Within Glades and Highlands counties, surface water has historically been used as the primary source of water. Agriculture within these two counties is highly dependent upon surface water from Lake Istokpoga and the associated Indian Prairie Basin canal system to meet its supply needs. During the mid-1980s, the District was forced to put in place water use restrictions limiting the use of surface water. Prior to this period water levels in the canal system leading from Lake Istokpoga were falling below levels where the existing pumps were able to withdraw water. Several corrective actions were taken in the late 1980s and early 1990s to prevent the further occurrence of similar problems during drought periods. The actions taken at that time appear to have corrected the water shortage problem, but no additional surface water use has been permitted in this basin since that time. As part of this planning effort, an analysis of the water availability from Lake Istokpoga and the Indian Prairie canal system was undertaken as part of the overall evaluation of the needs and sources in the basin.

The analysis of surface water availability included an assessment of the water released under the current regulatory operation through the primary release structures of S-71, S-72, and S-84. This approach involved the reviewed 20 years of flow records on these and other structures and 60 years of rainfall information to determine an estimated discharge from the basin under a 1-in-10 drought condition. The estimate for current structure releases under a 1-in-10 drought was identified as the first source of water in meeting the projected basin demand.

A budget approach was applied to determine the potential available supply of water that is in storage above the minimum operating schedule in Lake Istokpoga during a 1-10 drought event. The analysis presumes that the minimum operation schedule for Lake Istokpoga is defined as the level below which harm to the water resources is projected to occur. The details of this analysis can be found in Appendix I.

Lake Okeechobee Analysis

The use of additional water from Lake Okeechobee to supply the projected needs for the Indian Prairie Basin was made using the South Florida Water Management Model (SFWMM). The SFWMM is a regional-scale computer model that simulates the hydrology and the management of the surface water resources system from Lake Okeechobee to Florida Bay. It covers an area of 7,600 square miles using a mesh of 2 mile x 2 mile cells. In addition, the model includes inflows from the Kissimmee River, discharges and withdrawals from the Istokpoga and Indian Prairie Basin, and runoff and demands in the Caloosahatchee River and St. Lucie canal basins.

The model simulates the major components of the hydrologic cycle in South Florida including rainfall, evapotranspiration, infiltration, overland and ground water flow, canal flow, canal-ground water seepage, levee seepage, and ground water pumping.

The model incorporates current or proposed water management control structures and current or proposed operational rules. The ability to simulate water shortage policies affecting urban, agricultural, and environmental water uses in South Florida is a major strength of this model.

The SFWMM simulates hydrology on a daily basis using climatic data for the 1965-1995 period which includes many droughts and wet periods. The model has been calibrated and verified using water level and discharge measurements at hundreds of locations distributed throughout the region within the model boundaries. Technical staffs of many federal/state/local agencies and public/private interest groups have accepted the SFWMM as the best available tool for analyzing regional-scale structural and/or operational changes to the complex water management system in South Florida.

Projected surface water demands from each of the District's four planning areas as well as consideration of the components identified in the Restudy and minimum level for Lake Okeechobee were incorporated into simulations of the model. As part of these simulations, requests for additional use from the Lake Istokpoga/Indian Prairie Basin were made along with the other components listed above.

Kissimmee River Evaluation

An analysis of the availability of water from the Kissimmee River and its tributaries was not performed as part of this planning effort. The Kissimmee River is currently undergoing efforts to restore portions of its original flow and flood control functions as part of the Kissimmee River Restoration Project. This is a major effort and a high priority for the District. As part of this project, an analysis of the river’s historic flow conditions was performed. Results of the analysis suggest that the river and its supporting systems will be operating at a deficit to meet its full restoration goals (Toth, 1985). It is therefore believed at this time that additional water use from the river and supporting systems above the S-65E Structure is not a viable regional water resource option. This does not preclude the use of the river and its support system from water use permitting.

MODEL APPLICATIONS

Ground water models and surface water management assessments were used to evaluate the effects of anticipated changes in demand and water management practices on the water resources of the KB Planning Area. The results of these analyses were then used to assess whether the projected water use would cause harm to occur with regards to the defined resource protection criteria. The following sections discuss an overview of the methods employed in applying the individual resource protection criteria to the ground water and surface water analysis results.

Wetlands Vulnerability Mapping

One of the resource protection criteria proposed by the advisory committee is the protection of wetlands. The District's Basis of Review for Water Use Permit Applications (BOR) requires that withdrawals of water must not cause harm to environmental features sensitive to magnitude, seasonal timing and duration of inundation. Maintaining appropriate wetland hydrology (water levels and hydroperiod) is generally accepted as the most critical factor in maintaining a viable wetland ecosystem (Duever, 1988; Mitch and Gosselink, 1986; Erwin, 1991). Water use inducing drawdowns under wetlands, may potentially affect water levels, hydroperiod, and the aerial extent of the wetlands. The guideline currently used for Consumptive Use Permitting (CUP) evaluates the potential for harm to wetland environments is that: Ground water levels changes in the surficial aquifer after a withdrawal of the maximum recommended allocation for 90 days with no recharge are less than one foot at the edge of the wetlands for more than one month during any drought event that occurs as frequently as once every 10 years.

Due to the assumptions used in the ground water modeling tools developed, the direct calculation of the change in water table conditions was not possible. Instead, the Wetlands Vulnerability Analysis (WVA) was developed to approach the issue of wetland drawdown by assessing those factors that may influence a change in water levels within the wetland aquifer. The goal of this analysis is to identify areas where the combination of factors combine producing zones that are more susceptible to wetland harm as a result of ground water withdrawals. The factors included in the analysis are: the ability of water to move vertically thought the intermediate aquifer, location of wetland features, and the change in potentiometric head within the Upper Floridan aquifer due to changes in water use from 1995 to 2020.

Using a Geographical Information System (GIS), data for each of the factors were spatially located and then gridded to create a mesh coverage with uniform 1,100 foot dimensions. A scoring system was applied to each of the factors involved with each of the cells within the gridded mesh receiving individual scores. The score for each factor was then combined to construct a composite map showing areas of highest, moderate and lowest potential for reduction of water levels in the surficial aquifer. Details of the analysis can be found in Appendix J.

Water Quality Assessment

The movement of saline water was determined by the advisory committee to represent a limit on the amount of ground water that could be withdrawn without causing harm. The approach taken to address this issue involved mapping the existing location of the known poorer water quality areas within the Upper Floridan aquifer and comparing that information to the projected change in Floridan aquifer levels resulting from increased water use from 1995 and 2020 (1-in-10).

In instances where the saline water and fresh water zones are in close proximity, the relationship of their position to one another can be defined, in part, by the density between the two fluids and the pressure head at different points in the aquifer. The location of this interface between the fresh and saline water conditions will shift if the pressure head for either is altered. A simplistic application of this principle is applied in this planning effort to identify the potential for movement due to the proposed future withdrawals. Areas identified as having greater than 1 foot of anticipated change in the Upper Floridan aquifer in the areas where the existing water quality is above 250 mg/L are designated as having a higher risk of having a degradation in the local water quality.

Spring Discharge Assessment

Although there are no natural springs located within the KB Planning Area, several sensitive springs are located in northern Orange County in an area called the Wekiva Basin. The SJRWMD has identified minimum flow values for eight located in this area. These minimum flows are established in rule under Chapter 40C-8, F.A.C. and are also used as constraints in their planning effort. The established minimum flow requirements are based upon the minimum water levels required to maintain vegetation along the Wekiva River and its tributaries. The USGS Metro model was applied to address this issue. This model, cooperatively developed with the SJRWMD and SFWMD, directly simulates springs discharges as a function of Floridan aquifer head levels. The USGS model provides simulations of the 2020 wet and the 2020 dry conditions. The results of both of these simulations were averaged to provide an estimate of the projected spring reductions. The average condition was used to be consistent with the criteria set forth in Chapter 40C-8, F.A.C. which is based upon long-term average flow requirements for the specified springs. The resultant average 2020 spring discharges calculated by the model were compared to those set forth in Chapter 40C-8, F.A.C., to determine compliance with this resource criteria.

Sinkhole Assessment

Sinkholes are a common occurrence in certain portions of the state where unstable geologic and fluctuating hydrologic conditions work together to cause potentially dangerous forms of land subsidence. In certain instances, the conditions that lead to the formation of sinkholes can be enhanced if the hydrostatic head difference between the surficial and Floridan aquifers is significantly increased. Although a relationship between aquifer drawdown in the Floridan aquifer and the rapid formation of sinkholes has been documented in areas where the overburden is relatively thin, the degree to which these two factors are related is less defined. Two studies, one completed by the USGS and another by the Florida Sinkhole Research Institute (FSRI, University of Central Florida), described the soil conditions in Central Florida in relationship to the formation of sinkholes. These studies identify the factors involved in sinkhole development and the location where the combination of geologic factors result in the most frequent development of a specified type of sinkhole. Southwest Orange and Northeast Osceola Counties are identified as having areas were the occurrence of sinkholes are most numerous. The FSRI report also describes an effort to correlate historic Floridan aquifer levels and the frequency of sinkhole occurrence.

As part of this planning effort, maps prepared by the USGS and the FSRI were compared to the drawdown projected to occur within the Upper Floridan aquifer. Those locations expected to show the greatest change in water levels and being identified as having geologic conditions making them more susceptible to the formation of sinkholes were identified as having increased risk to possible sinkhole formation.

Impacts to Lakes Levels

Concerns over the levels of lakes within the KB Planning Area as a result of continued surface and ground water withdrawals was identified by the advisory committee as a resource limitation. With the exception of lakes like the Butler Chain of Lakes in Southwest Orange County, most of the major lakes within the KB Planning Area are on a regulation schedule. It is the presumption of this plan that the possible impacts from water use withdrawals to lake levels on lakes that have a regulation schedule would be minor compared to those changes to the lake levels resulting from the regulation schedule. For this planning level effort, lake levels for non-regulated lakes were presumed to be equally affected by Floridan aquifer water level changes as the wetland areas surrounding the lake. Under this presumption, the possible impacts to alteration of lake levels of non-regulated lakes were addressed as part of the wetland vulnerability mapping project previously discussed.

As an additional concern, the advisory committee identified several lakes along the Lake Wales Ridge that needed to be evaluated for possible lake level impacts due to withdrawals occurring within the KB Planning Area. These lakes are located within the SWFWMD and have been identified by that District as having trouble meeting historic water levels. The SWFWMD staff has related these problems to decreases in water levels in the ground water system, specifically the Floridan aquifer. As part of their own planning and recovery efforts, the SWFWMD is making efforts to prevent further declines in the Floridan aquifer levels beneath the ridge area. This SWFWMD goal has been translated into the SFWMD planning process as a limiting criteria of no more than one foot change in Floridan aquifer levels at the boundary line between the two Districts. The ground water modeling completed as part of this planning effort addresses this concern.

GLOSSARY AND LIST OF ABBREVIATIONS

Acre-foot The volume would cover one acre to a depth of one foot; 43,560 cubic feet; 1,233.5 cubic meters; 325,872 gallons.

Application Efficiency The ratio of the volume of irrigation water available for crop use to the volume delivered from the irrigation system. This ratio is always less than 1.0 because of the losses due to evaporation, wind drift, deep percolation, lateral seepage (interflow), and runoff that may occur during irrigation.

Aquifer A portion of a geologic formation or formations that yield water in sufficient quantities to be a supply source.

Aquifer Compaction The reduction in bulk volume or thickness of a body of fine-grained sediments contained within a confined aquifer or aquifer system. The compaction of these fine-grained sediments results in subsidence, and sometimes fissuring, of the land surface.

Aquifer Storage and Recovery (ASR) The injection of freshwater into a confined aquifer during times when supply exceeds demand (wet season), and recovering it during times when there is a supply deficit (dry season).

Aquifer System A heterogeneous body of intercalated permeable and less permeable material that acts as a water-yielding hydraulic unit of regional extent.

Artesian When ground water is confined under pressure greater than atmospheric pressure by overlying relatively impermeable strata.

Available Supply The maximum amount of reliable water supply including surface water, ground water and purchases under secure contracts.

Average-day Demand A water system's average daily use based on total annual water production (total annual gallons or cubic feet divided by 365).

Average Irrigation Requirement Irrigation requirement under average rainfall as calculated by the District's modified Blaney-Criddle model.

Backpumping The practice of pumping water that is leaving the area back into a surface water body.

Basin (Ground Water) A hydrologic unit containing one large aquifer or several connecting and interconnecting aquifers.

Basin (Surface Water) A tract of land drained by a surface water body or its tributaries.

BEBR Bureau of Economic and Business Research is a division of the University of Florida, with programs in population, forecasting, policy research and survey.

Best Management Practices (BMPs) Agricultural management activities designed to achieve an important goal, such as reducing farm runoff, or optimizing water use.

BOR Basis of Review (for Water Use Applications with the South Florida Water Management District).

Brackish Water with a chloride level greater than 250 mg/L and less than 19,000 mg/L.

Budget (water use) An accounting of total water use or projected water use for a given location or activity.

Central and Southern Florida Project Comprehensive Review Study (Restudy) A five-year study effort that looked at modifying the current C&SF Project to restore the greater Everglades and South Florida ecosystem while providing for the other water-related needs of the region. The study concluded with the Comprehensive Plan being presented to the Congress on July 1, 1999. The recommendations made within the Restudy, that is, structural and operational modifications to the C&SF Project, are being further refined and will be implemented in the Comprehensive Everglades Restoration Plan (CERP).

Cone of Influence The area around a producing well which will be affected by its operation.

Control Structures A man-made structure designed to regulate the level and/or flow of water in a canal (e.g., weirs, dams).

Conservation (water) Any beneficial reduction in water losses, wastes, or use.

Conservation Rate Structure A water rate structure that is designed to conserve water. Examples of conservation rate structures include but are not limited to, increasing block rates, seasonal rates and quantity-based surcharges.

Consumptive Use Use that reduces an amount of water in the source from which it is withdrawn.

Demand The quantity of water needed to be withdrawn to fulfill a requirement.

Demand Management (Water Conservation) Reducing the demand for water through activities that alter water use practices, improve efficiency in water use, reduce losses of water, reduce waste of water, alter land management practices and/or alter land uses.

Demographic Relating to population or socioeconomic conditions.

Desalination A process which treats saline water to remove chlorides and dissolved solids.

Domestic Use Use of water for the individual personal household purposes of drinking, bathing, cooking, or sanitation.

Drawdown The distance the water level is lowered, due to a withdraw at a given point.

DWMP District Water Management Plan. Regional water resource plan developed by the District under Section 373.036, F. S.

Effective Rainfall The portion of rainfall that infiltrates the soil and is stored for plant use in the crop root zone, as calculated by the modified Blaney-Criddle model.

Evapotranspiration Water losses from the surface of soils (evaporation) and plants (transpiration).

Exotic Nuisance Plant Species A non-native species which tends to out-compete native species and become quickly established, especially in areas of disturbance or where the normal hydroperiod has been altered.

FASS Florida Agricultural and Statistics Service, a division of the Florida Department of Agriculture and Consumer Services.

Flatwoods (Pine) Natural communities that occur on level land and are characterized by a dominant overstory of slash pine. Depending upon soil drainage characteristics and position in the landscape, pine flatwoods habitats can exhibit xeric to moderately wet conditions.

Florida Water Plan State-level water resource plan developed by the FDEP under Section 373.036, F.S.

Governing Board Governing Board of the South Florida Water Management District.

Ground Water Water beneath the surface of the ground, whether or not flowing through known and definite channels.

Harm *(Term will be further defined during proposed Rule Development process)* An adverse impact to water resources or the environment that is generally temporary and short-lived, especially when the recovery from the adverse impact is possible within a period of time of several months to several years, or less.

Hydroperiod The frequency and duration of inundation or saturation of an ecosystem. In the context of characterizing wetlands, the term hydroperiod describes that length of time during the year that the substrate is either saturated or covered with water.

IFAS The Institute of Food and Agricultural Sciences, that is the agricultural branch of the University of Florida, performing research, education, and extension.

Infiltration The movement of water through the soil surface into the soil under the forces of gravity and capillarity.

Inorganic Relating to or composed of chemical compounds other than plant or animal origin.

Irrigation The application of water to crops, and other plants by artificial means.

Irrigation Audit A procedure in which an irrigation systems application rate and uniformity are measured.

Irrigation Efficiency The average percent of total water pumped or delivered for use that is delivered to the root zone. of a plant.

Irrigation Uniformity A measure of the spatial variability of applied or infiltrated water over the field.

Lake Okeechobee Largest freshwater lake in Florida. Located in Central Florida, the lake measures 730 square miles and is the second largest freshwater lake wholly within the United States.

Leakance Movement of water between aquifers or aquifer systems.

Leak Detection Systematic method to survey the distribution system and pinpoint the exact locations of hidden underground leaks.

Levee An embankment to prevent flooding, or a continuous dike or ridge for confining the irrigation areas of land to be flooded.

Level of Certainty Probability that the demands for reasonable-beneficial uses of water will be fully met for a specified period of time (generally taken to be one year) and for a specified condition of water availability, (generally taken to be a drought event of a specified return frequency). For the purpose of preparing regional water supply plans, the goal associated with identifying the water supply demands of existing and future reasonable beneficial uses is based upon meeting those demands for a drought event with a 1-in-10 year return frequency.

Marsh A frequently or continually inundated wetland characterized by emergent herbaceous vegetation adapted to saturated soil conditions.

Micro Irrigation The application of water directly to, or very near to the soil surface in drops, small streams, or sprays.

Mobile Irrigation Laboratory A vehicle furnished with irrigation evaluation equipment which is used to carry out on-site evaluations of irrigation systems and to provide recommendations on improving irrigation efficiency.

NGVD National Geodetic Vertical Datum, a nationally established references for elevation data relative to sea level.

NRCS The Natural Resources Conservation Service is a federal agency that provides technical assistance for soil and water conservation, natural resource surveys, and community resource protection

One-in-Ten Year Drought Event A drought of such intensity, that it is expected to have a return frequency of 10 years (see Level of Certainty).

Organics Being composed of or containing matter of, plant and animal origin.

Overhead Sprinkler Irrigation A pressurized system, where water is applied through a variety of outlet sprinkler heads or nozzles. Pressure is used to spread water droplets above the crop canopy to simulate rainfall.

Per Capita Use Total use divided by the total population served.

Permeability Defines the ability of a rock or sediment to transmit fluid.

Potable Water Water that is safe for human consumption (USEPA, 1992).

Potentiometric Head The level to which water will rise when a well is drilled into a confined aquifer.

Potentiometric Surface An imaginary surface representing the total head of ground water.

Process Water Water used for nonpotable industrial usage, e.g., mixing cement.

Projection Period The period over which projections are made. In the case of this document, the 25 year period from 1995 to 2020.

Public Water Supply (PWS) Utilities Utilities that provide potable water for public use.

Rapid-Rate Infiltration Basin (RIB) An artificial impoundment that provides for fluid losses through percolation/seepage as well as through evaporative losses.

Rationing Mandatory water-use restrictions sometimes used under drought or other emergency conditions.

Reasonable-Beneficial Use Use of water in such quantity as is necessary for economic and efficient utilization for a purpose and in a manner which is both reasonable and consistent with the public interest.

Reclaimed Water Water that has received at least secondary treatment and basic disinfection and is reused after flowing out of a domestic wastewater treatment facility.

RECOVER A comprehensive monitoring and adaptive assessment program formed to perform the following for the Comprehensive Everglades Restoration Program: restoration, coordination, and verification.

Reduced Allocation Areas Areas in which a physical limitation has been placed on water use.

Reduced Threshold Areas (RTAs) Areas established by the District for which the threshold separating a General Permit from an Individual Permit has been lowered from the maximum limit of 100,000 GPD to 20,000 GPD. These areas are typically resource-depleted areas where there have been an established history of sub-standard water quality, saline water movement into ground or surface water bodies, or the lack of water availability to meet projected needs of a region.

Regional Water Supply Plan Detailed water supply plan developed by the District under Section 373.0361, F.S.

Retrofit The replacement of existing equipment with equipment that uses less water.

Retrofitting The replacement of existing water fixtures, appliances and devices with more efficient fixtures, appliances and devices for the purpose of water conservation.

Restudy Shortened name for C&SF Restudy.

Reverse Osmosis (RO) Process used to produce fresh water from a brackish supply source.

Saline Water Water with a chloride concentration greater than 250 mg/L, but less than 19,000 mg/L.

Saline Water Interface The hypothetical surface of chloride concentration between fresh water and saline water, where the chloride concentration is 250 mg/L at each point on the surface.

Saline Water Intrusion This occurs when more dense saline water moves laterally inland from the coast, or moves vertically upward, to replace fresher water in an aquifer.

Sea Water Water which has a chloride concentration equal to or greater than 19,000 mg/L.

Seepage Irrigation Systems Irrigation systems which convey water through open ditches. Water is either applied to the soil surface (possibly in furrows) and held for a period of time to allow infiltration, or is applied to the soil subsurface by raising the water table to wet the root zone.

Semi-Closed Irrigation Systems Irrigation systems which convey water through closed pipes, and distribute it to the crop through open furrows between crop rows.

Semi-Confining Layers Layers with little or no horizontal flow, and restrict the vertical flow of water from one aquifer to another. The rate of vertical flow is dependent on the head differential between the aquifers, as well as the vertical permeability of the sediments in the semi-confining layer.

Sensitivity Analysis An analysis of alternative results based on variations in assumptions (a "what if" analysis).

Serious Harm (*Term will be defined during proposed Rule Development process)* An extremely adverse impact to water resources or the environment that is either permanent or very long-term in duration. Serious harm is generally considered to be more intense than significant harm.

Significant Harm *(Term will be defined during proposed Rule Development process)* An adverse impact to water resources or the environment, when the period of recovery from the adverse impact is expected to take several years; more intense than harm, but less intense than serious harm.

Slough A channel in which water moves sluggishly, or a place of deep muck, mud or mire. Sloughs are wetland habitats that serve as channels for water draining off surrounding uplands and/or wetlands.

Stage The elevation of the surface of a surface water body.

Storm Water Surface water resulting from rainfall that does not percolate into the ground or evaporate.

Subsidence An example of subsidence is the lowering of the soil level caused by the shrinkage of organic layers. This shrinkage is due to biochemical oxidation.

Surface Water Water that flows, falls, or collects above the surface of the earth.

Superfund Site A contamination site, of such magnitude, that it has been designated by the federal government as eligible for federal funding to ensure cleanup.

SWIM Plan Surface Water Improvement and Management Plan, prepared according to Chapter 373, F. S.

TAZ Traffic analysis zone; refers to a geographic area used in transportation planning.

Transmissivity A term used to indicate the rate at which water can be transmitted through a unit width of aquifer under a unit hydraulic gradient. It is a function of the permeability and thickness of the aquifer, and is used to judge its production potential.

Turbidity The measure of suspended material in a liquid.

Ultra-low-volume Plumbing Fixtures Water-conserving plumbing fixtures that meet the standards at a test pressure of 80 psi listed below.

Toilets - 1.6 gal/flush

Showerheads - 2.5 gal/min.

Faucets - 2.0 gal/min.

Uplands Elevated areas that are characterized by non-saturated soil conditions and support flatwood vegetation.

Wastewater The combination of liquid and waterborne discharges from residences, commercial buildings, industrial plants and institutions together with any ground water, surface runoff or leachate that may be present.

Water Resource Caution Areas Areas that have existing water resource problems or where water resource problems are projected to develop during the next 20 years (previously referred to as critical water supply problem areas).

Water Resource Development The formulation and implementation of regional water resource management strategies, including: the collection and evaluation of surface water and ground water data; structural and nonstructural programs to protect and manage the water resource; the development of regional water resource implementation programs; the construction, operation, and maintenance of major public works facilities to provide for flood control, surface and underground water storage, and ground water recharge augmentation; and, related technical assistance to local governments and to government-owned and privately owned water utilities.

Water Shortage Declaration *Rule 40E-21.231, Fla. Admin. Code:* "If …there is a possibility that insufficient water will be available within a source class to meet the estimated present and anticipated user demands from that source, or to protect the water resource from serious harm, the Governing Board may declare a water shortage for the affected source class." Estimates of the percent reduction in demand required to match available supply is required and identifies which phase of drought restriction is implemented. A gradual progression in severity of restriction is implemented through increasing phases. Once declared, the District is required to notify permitted users by mail of the restrictions and to publish restrictions in area newspapers.

Water Supply Plan District plans that provide an evaluation of available water supply and projected demands, at the regional scale. The planning process projects future demand for 20 years and develops strategies to meet identified needs.

Water Supply Development The planning, design, construction, operation, and maintenance of public or private facilities for water collection, production, treatment, transmission, or distribution for sale, resale, or end use.

Wetlands Areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soil conditions.

Wetland Drawdown Study Research effort by the South Florida Water Mangement District to provide a scientific basis for developing wetland protection criteria for water use permitting.

Xeriscape™ Landscaping that involves seven principles: proper planning and design; soil analysis and improvement; practical turf areas; appropriate plant selection; efficient irrigation; mulching; and appropriate maintenance.

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Land Use/Land Cover in the Kissimmee Basin Planning Area

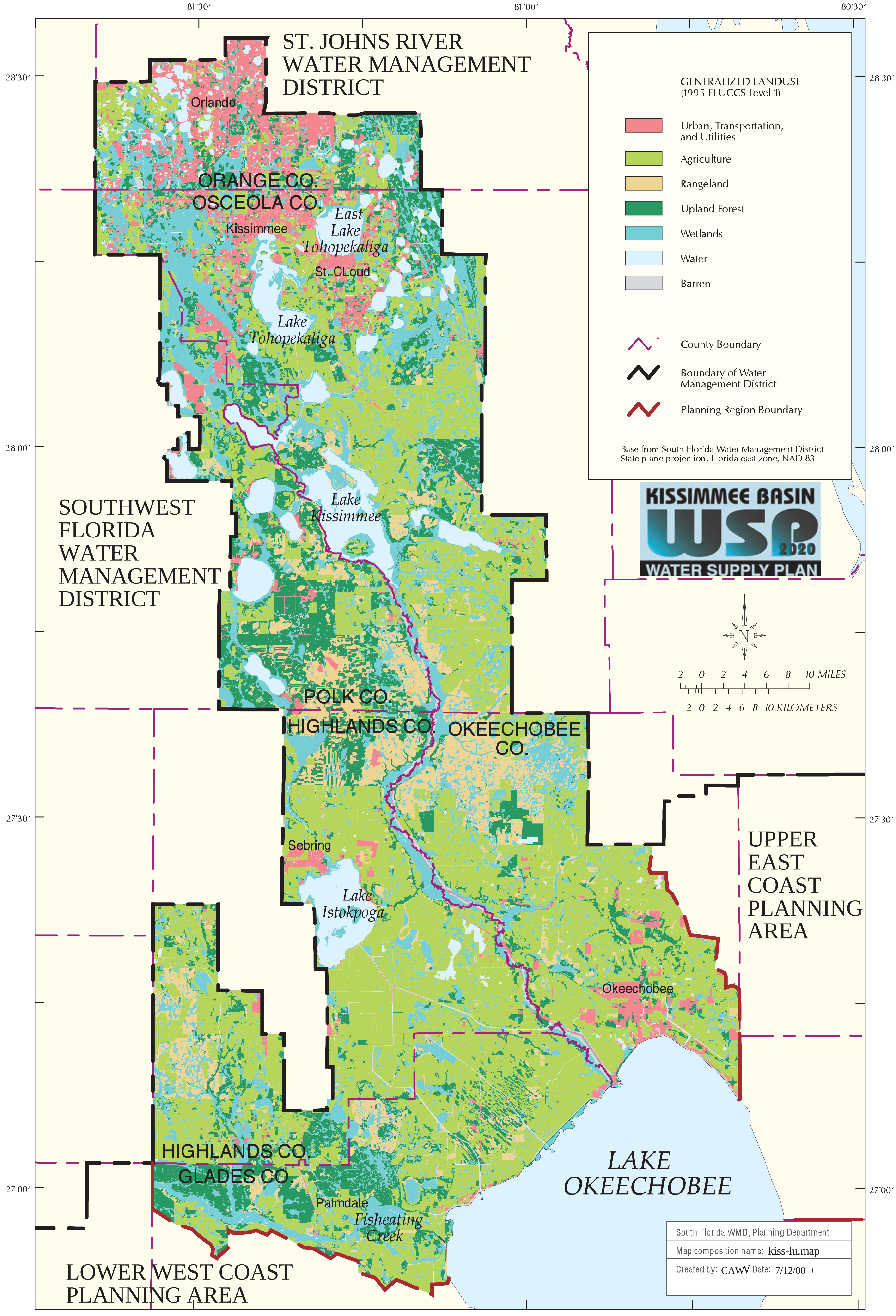

Plate 1. Land Use/Land Cover in the Kissimmee Basin Planning Area.

Major Lakes, Rivers, and Canals in the Kissimmee Basin Planning Area

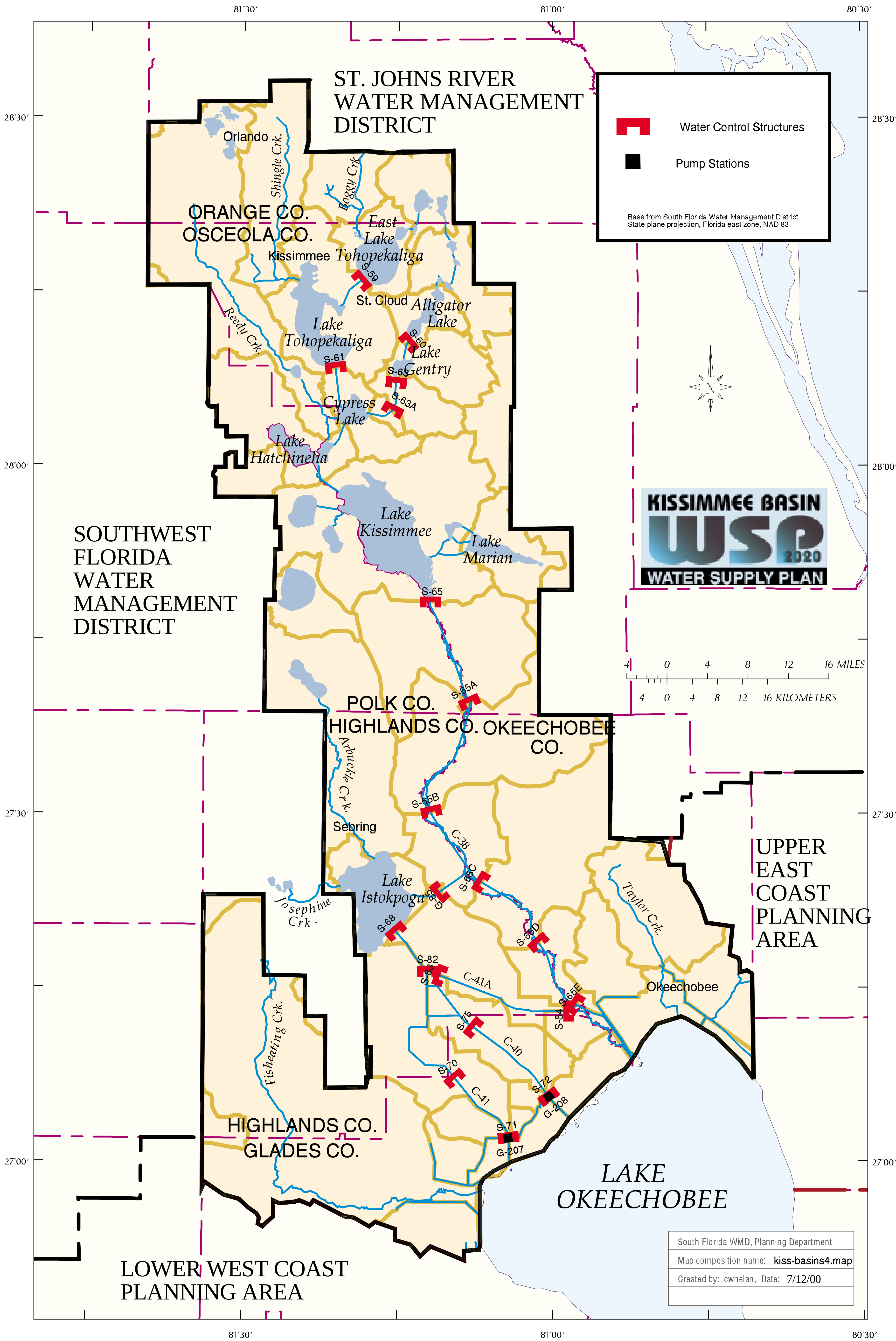

Plate 2. Major Lakes, Rivers, and Canals in the Kissimmee Basin Planning Area .

Potential Upper Floridan Aquifer Recharge/Discharge for the Kissimmee Basin Planning Area

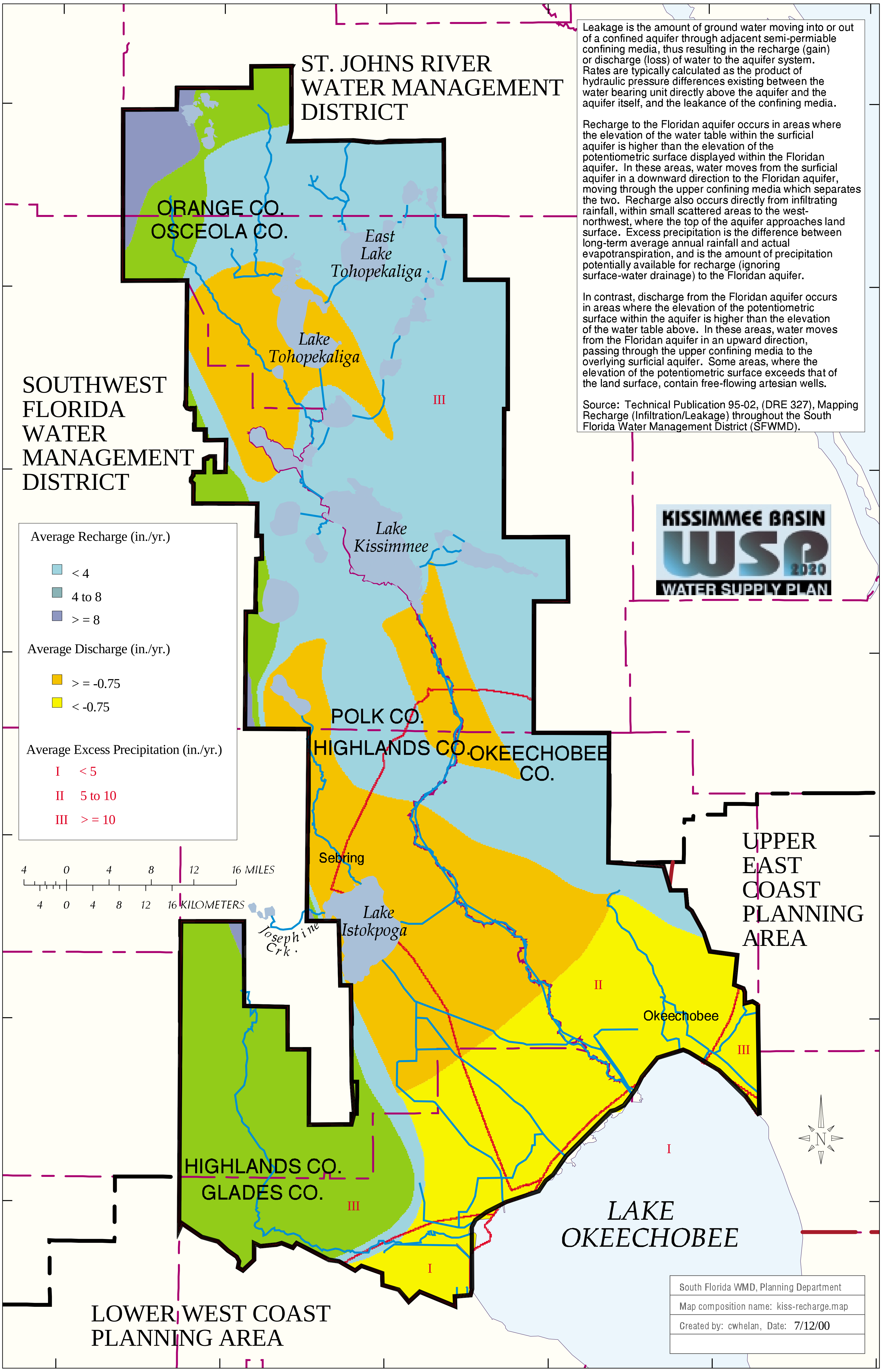

Plate 3. Potential Upper Floridan Aquifer Recharge/Discharge in the Kissimmee Basin Planning Area .

Wetland Systems in the Kissimmee Basin Planning Area

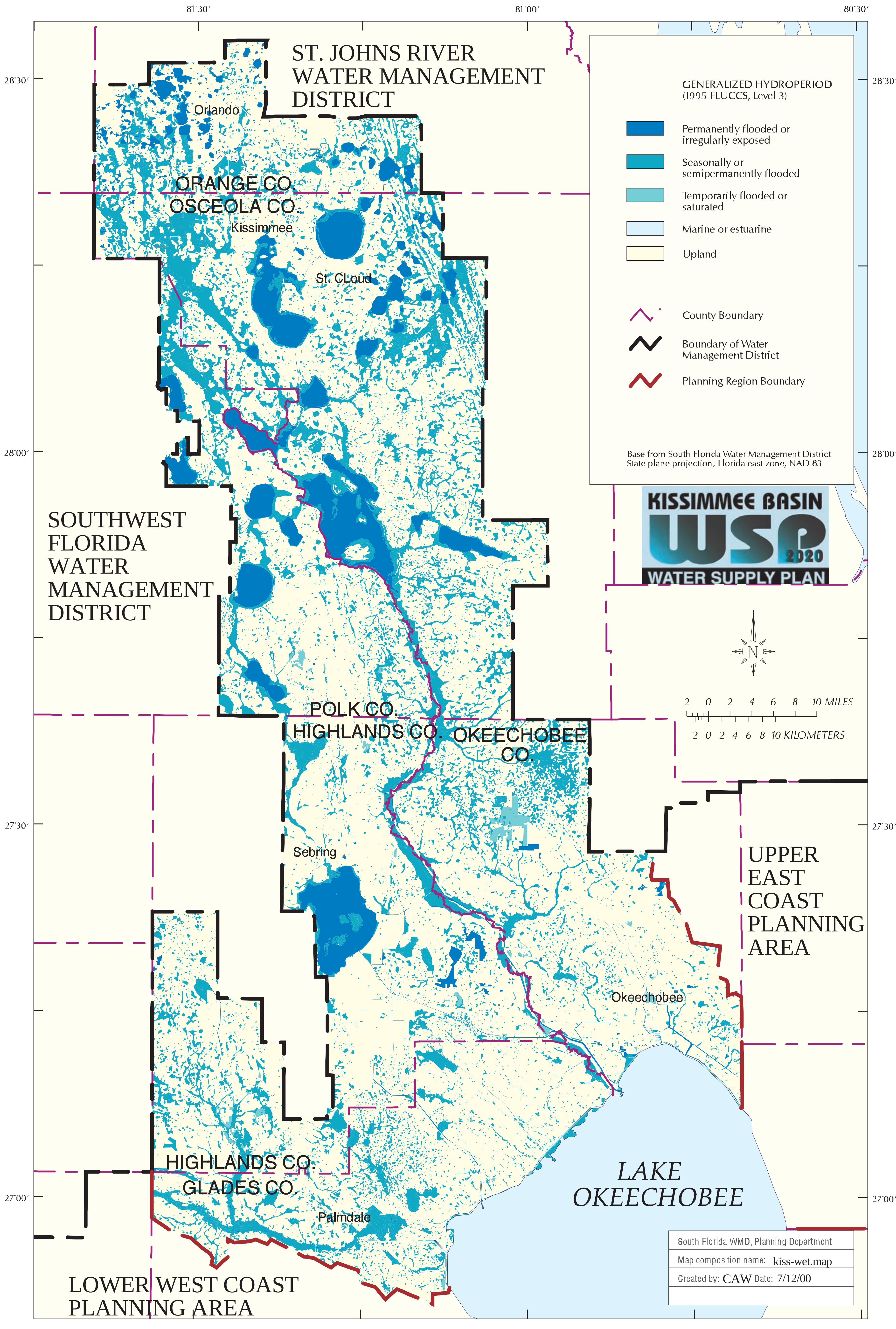

Plate 4. Wetland Systems in the Kissimmee Basin Planning Area .