Technical Publication SJ94-7

WATER SUPPLY NEEDS AND SOURCES ASSESSMENT
1994
ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

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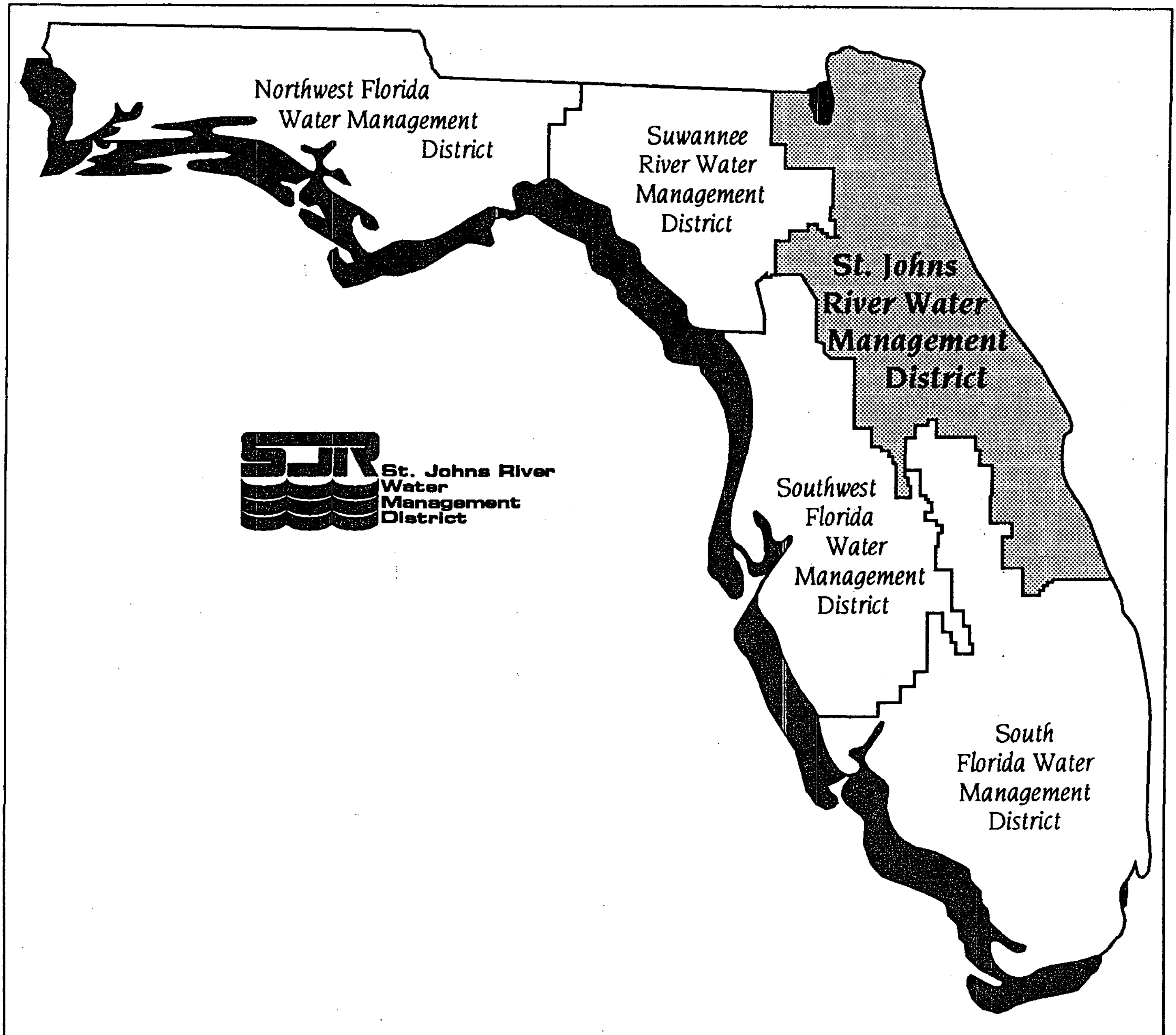
December 27, 1994

Seal

St. Johns River Water Management District
Palatka, Florida

1994



The **St. Johns River Water Management District** (SJRWMD) was created by the Florida Legislature in 1972 to be one of five water management districts in Florida. It includes all or part of 19 counties in northeast Florida. The mission of SJRWMD is to manage water resources to ensure their continued availability while maximizing environmental and economic benefits. It accomplishes its mission through regulation; applied research; assistance to federal, state, and local governments; operation and maintenance of water control works; and land acquisition and management.

Technical reports are published to disseminate information collected by SJRWMD in pursuit of its mission. Copies of this report can be obtained from:

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EXECUTIVE SUMMARY

The 1994 water supply needs and sources (WSNS) assessment for the St. Johns River Water Management District (SJRWMD) has been performed to meet the requirements of Section 62-40.520, *Florida Administrative Code* and Paragraph 373.0391(2)(e), *Florida Statutes*. This assessment was designed to identify areas in which water resource problems have become critical or are projected to become critical within 20 years (water resource caution areas) and to identify remedial or preventive actions designed to correct or prevent these problems.

Development of the 1994 WSNS assessment began in fiscal year 1989–90 and extended through fiscal year 1993–94. The direct costs (primarily staff salaries and support costs, costs to collect data, and consultant services) associated with development of this assessment are about $4 million.

The 20-year projection period, which is the focus of this assessment, extends through the year 2010. This assessment will be revised every 5 years, with the first revision scheduled for 1999.

SJRWMD, in this WSNS assessment, considered four primary factors in the assessment of water resource problems. These factors are impacts to natural systems, impacts to ground water quality, impacts to existing legal users of water, and failure to identify an adequate supply source. For each factor considered, SJRWMD developed a method for identifying areas that have or are projected to have critical water resource problems. These methods are dependent on the definition of limits of impacts to the water resource. These limits are considered critical and are considered to be limits beyond which inadequate quantities of water are available to meet projected needs.

Water use needs have been inventoried for the year 1990 and have been projected to the year 2010 for three categories: public supply, agricultural irrigation self-supply, and recreation self-supply. An analysis of historical water use records indicates that these categories have consistently accounted for approximately three-fourths of the total fresh ground water use in SJRWMD and are expected to increase more than other categories. The combined water use from these three categories accounted for 74 percent of the total fresh ground water use in 1990.

Water use projections are not presented in this document for the other four major use categories: domestic self-supply, industrial/commercial self-supply, thermoelectric power generation self-supply, and miscellaneous self-supply (abandoned artesian wells). However, projections for some industrial/commercial self-supply users were made to support the development of the ground water models.

Combined, these categories accounted for 26 percent of the total fresh ground water use in 1990. Information obtained from historical trend analyses and contacts with users in these categories indicate that water use rates are not expected to change significantly through the year 2010.

Total water use (all seven categories, ground and surface water) is expected to increase by 401.46 million gallons per day (26 percent) over the period 1990 through 2010. Water use data for 1990 were obtained from an SJRWMD staff report; projections of future water use needs for 2010 are based on historical trends, local government comprehensive plans, and direct communication with federal and state agencies, water users, and publicly and privately owned public water supply utilities.

A data base was created by SJRWMD containing 1990 and 2010 water use amounts for agriculture and public supply, distributed spatially by well point. The information in this data base was used in the development of numerical ground water flow models designed to assess the potential impact of future withdrawals.

Regional, subregional, and local assessments of the impacts of withdrawals on ground water flow and water quality were performed. These models were developed using the best information available. However, the paucity of data in some areas may affect the accuracy of the projections. The need for collecting additional data and for modeling has been identified as a means of improving the accuracy of the projections. Projections of possible future water resource conditions identified as part of this assessment represent conditions that have a reasonable likelihood of occurring if all projected 2010 withdrawals of water occur at the locations and in the quantities currently proposed by water users in SJRWMD. These projections do not, however, represent conditions that are certain to exist.

Water resource caution areas identified as a result of this assessment are based almost exclusively on water resource problems that are anticipated to become critical based on projected 2010 water use rather than on existing problems. These areas of anticipated critical water resource problems, located in Orange, Seminole, Volusia, Lake, St. Johns, Flagler, and Brevard counties, are related largely to projected increases in public supply water use to serve an increasing population. The only area with an identified existing critical water resource problem is the area of eastern Putnam County–western St. Johns County impacted by seasonal ground water withdrawals associated with potato crop irrigation. Strategies for achieving remedial or preventive actions in these areas will be developed cooperatively with major water suppliers and affected governments.

CONTENTS

FIGURES

TABLES

INTRODUCTION—by Barbara Vergara, P.G.

The 1994 water supply needs and sources (WSNS) assessment for the St. Johns River Water Management District (SJRWMD) (Figure 1) has been performed to meet the requirements of Section 62-40.520, *Florida Administrative Code* (*F.A.C.*), and Paragraph 373.0391(2)(e), *Florida Statutes* (*FS*), (Appendix A). This assessment was designed to identify areas in which water resource problems have become critical or are projected to become critical within 20 years (water resource caution areas) and to identify remedial or preventive actions designed to correct or prevent these problems.

The 20-year projection period, which is the focus of this assessment, extends through the year 2010. This assessment will be revised every 5 years, with the first revision scheduled for 1999.

Development of the 1994 WSNS assessment began in fiscal year 1989–90 and extended through fiscal year 1993–94. The direct costs (primarily staff salaries and support costs, costs to collect data, and consultant services) associated with development of this assessment are about $4 million.

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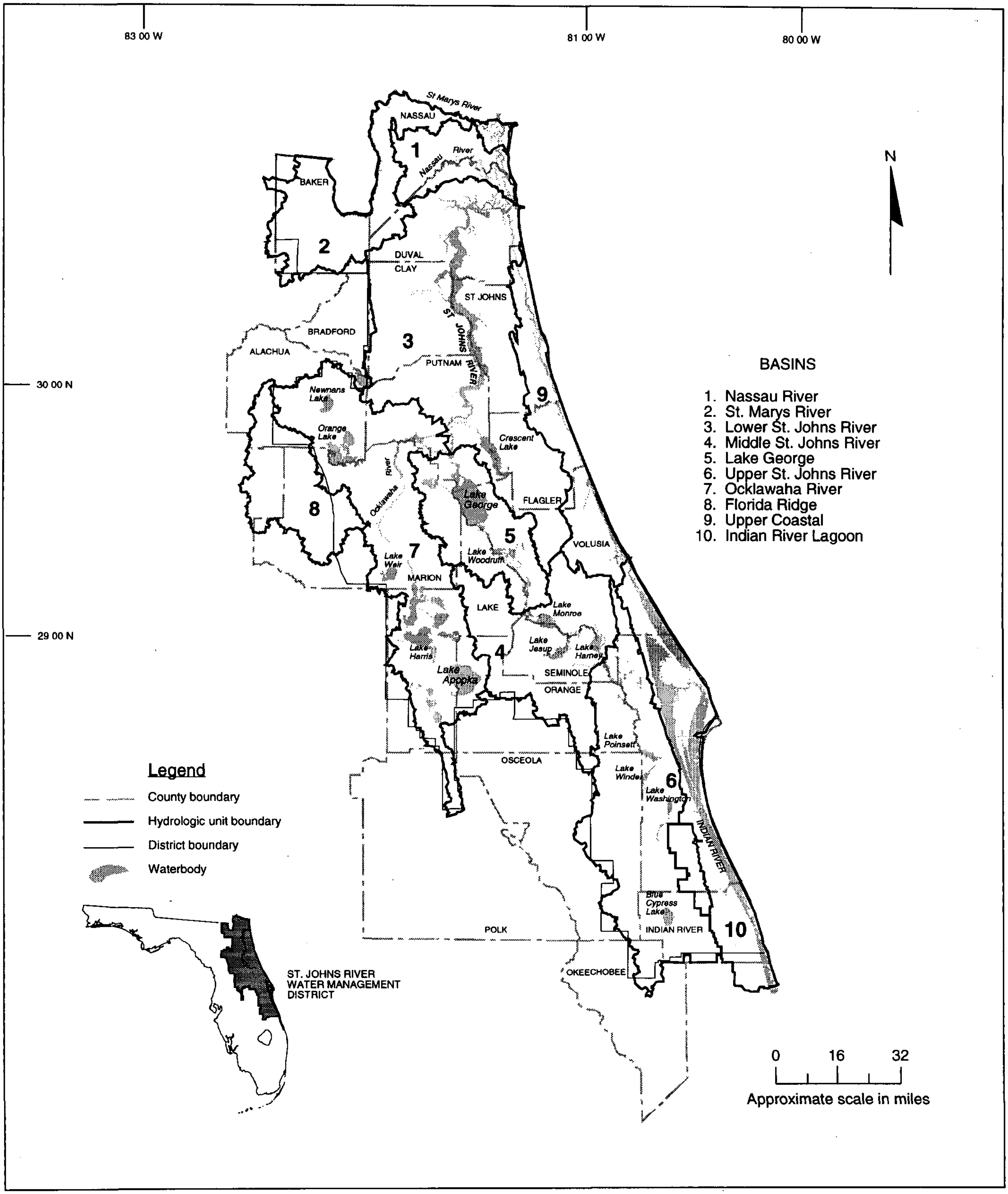

Figure 1. St. Johns River Water Management District

METHODS—by Barbara Vergara, P.G.

The WSNS assessment was designed to address the water supply needs and sources related requirements of Section 62-40.520, *F.A.C.*, and Paragraph 373.0391(2)(e), *FS* (Appendix A).

The SJRWMD approach to addressing these requirements consisted of the following.

- Defining the limits of water resource impacts beyond which a water resource related problem would occur
- Projecting the impacts that would occur in 2010 as a result of projected increases in water use
- Identifying water resource caution areas
- Identifying courses of remedial or preventive action in water resource caution areas

The application of this approach consisted of the following components.

- Impact criteria development
- Water use assessment
- Ground water assessment
- Surface water assessment
- Water resource caution area identification
- Intergovernmental, water supplier, and public coordination
- Data collection and water resource investigation
- Economic, environmental, and technical analyses
- Remedial or preventive actions identification

IMPACT CRITERIA DEVELOPMENT

SJRWMD, in this WSNS assessment, considered four primary factors in the assessment of water resource problems. These factors are as follows.

- Impacts to natural systems
- Impacts to ground water quality
- Impacts to existing legal users of water
- Failure to identify an adequate supply source

Other factors have been identified for future assessment. These factors include impacts to land uses, to karst development, and to aquifer compaction.

For each factor considered, SJRWMD developed a method for identifying areas that have or are projected to have critical water resource problems. These methods are dependent on the definition of limits of impacts to the water resource. These limits are considered critical and are considered to be limits beyond which inadequate quantities of water are available to meet projected needs.

A more detailed description of the methods developed to address each of the factors is included in the chapter titled "Water Resource Caution Area Identification" (p. 77).

WATER USE ASSESSMENT

Water use needs have been inventoried and have been projected to the year 2010 for the following categories of water use.

- Public supply
- Agricultural irrigation self-supply
- Recreation self-supply (golf course and recreational turf irrigation)

Water use for these three categories in 1990 accounted for 84 percent of the water use in SJRWMD (Florence 1992).

Other water use categories of interest are as follows:

- Domestic self-supply
- Industrial/commercial self-supply
- Thermoelectric power generation self-supply
- Miscellaneous self-supply (abandoned artesian wells)

Because of the nature of water withdrawals associated with these other water use categories and because water use in these categories is not expected to increase significantly, increases in these water use needs through 2010 are assumed not to have a significant regional impact on the water resource.

SJRWMD has made a concerted effort to develop water use projections that are consistent with the specific plans of major water users. To this end, SJRWMD invested considerable time in sharing its projections with major water users and revising these projections in response to comments received from these users.

A detailed description of the water use needs assessment is included in the chapter titled "Water Use 1990 Estimates and 2010 Projections" (p. 12).

Ground Water Assessment

SJRWMD performed an assessment on the impacts of projected 2010 ground water withdrawals in order to delineate areas that have or are projected to have inadequate ground water available to meet the projected 2010 demand. The ground water assessment consisted of the following list of tasks, performed in sequence.

1. Identify areas in need of detailed source evaluations based on

    - the concentrations and magnitudes of current and projected ground water withdrawals,
    - the existing ground water quality conditions, and
    - the historic water resource concerns.

2. Review existing water resource data and literature concerning the areas identified in task 1.

3. Develop a conceptual model of the ground water flow system.

4. Develop and use ground water models to evaluate the impacts of current and projected water use on ground water levels and ground water quality. These models are based on the conceptual model developed in task 3.

5. Identify areas where existing ground water levels or ground water quality or projected changes in ground water levels or ground water quality will cause impacts to natural systems, ground water quality, or existing legal users of water—impacts that are considered to result in critical water resource problems. The identification of a critical water resource problem will be based on a comparison of existing and projected ground water levels and ground water quality to the impact limits described on pages 77–83.

6. Use outreach efforts to obtain refined water use estimates and to develop alternative water withdrawal scenarios.

7. Determine data deficiencies.

8. Acquire additional data as necessary.

9. Refine conceptual models as necessary.

10. Refine existing evaluation tools as necessary.

11. Perform updated impact evaluations as necessary.

SURFACE WATER ASSESSMENT

SJRWMD performed an assessment of the impacts of current surface water withdrawals and projected 2010 surface water withdrawals in order to delineate areas that have or are projected to have inadequate surface water available to meet the existing or projected 2010 demand. The surface water assessment consisted of the following list of tasks performed in sequence.

1. Identify areas in need of detailed source evaluations based on

   - the concentrations and magnitudes of current and projected surface water withdrawals,
   - the existing surface water quality conditions,
   - the potential for projected ground water impacts to affect surface water quality and quantity,
   - the historic water resource concerns, and
   - the delineated areas of inadequate ground water to meet current or projected needs.

2. Review existing water resource data and literature concerning the areas identified in task 1.

3. Evaluate the impacts of current and projected water use on surface water levels and surface water quality. This evaluation may be based on the use of

   - models to evaluate ground water–surface water interactions,
   - water budget flow models,
   - water quality models,
   - analytical models,
   - hydraulic models for stream reaches, and
   - surface water monitoring and statistical analysis.

4. Identify areas where existing surface water flows and levels or surface water quality or projected changes in surface water flows and levels or surface water quality will cause impacts to natural systems, surface water quality, or existing legal users of water—impacts that are considered to result in critical water resource problems. The identification of a critical water resource problem will be based on a comparison of existing and projected surface water flows and

levels and surface water quality to the impact limits described on pages 77–83.

5. Use outreach efforts to obtain refined water use estimates and to develop alternative water withdrawal scenarios.

6. Determine data deficiencies.

7. Acquire additional data as necessary.

8. Perform updated impact evaluations as necessary.

WATER RESOURCE CAUTION AREA IDENTIFICATION

SJRWMD identified water resource caution areas based on the impact criteria and the results of water use, ground water, and surface water assessments. Water resource caution areas are those locations where the impacts of current or projected demands exceed the impact criteria limits for natural systems, for ground water quality, or to existing legal users of water or where the water supplier has failed to identify an adequate supply source to meet the projected need. This process is presented in the chapter titled "Water Resource Caution Area Identification" (p. 77).

INTERGOVERNMENTAL, WATER SUPPLIER, AND PUBLIC COORDINATION

SJRWMD made a concerted effort to coordinate its WSNS assessment activities with other governments, water suppliers, and the public. This coordination was carried out in an effort to achieve the following objectives.

- To disseminate and explain project-related information

- To assure, to the extent possible, that data being used to perform the assessment are the best data available

- To address the project-related concerns of other governments, water suppliers, and the public
- To encourage water suppliers to develop future water supply plans which would not result in critical problems
- To develop a consensus among those coordinated with concerning the identification of water resource caution areas
- To develop a consensus among those coordinated with concerning necessary additional data collection and water resource investigations, and economic, environmental, and technical feasibility analyses
- To develop a consensus among those coordinated with concerning the identification of preventive and remedial actions

This project coordination was carried out through direct contacts with water suppliers; through working groups composed of local, regional, and state governments, water suppliers, special interest groups, and the public representing the areas identified in the early stages of the project as potential water resource caution areas (Orange, Seminole, and Volusia counties); and through presentations and discussions with local government representatives.

DATA COLLECTION AND WATER RESOURCE INVESTIGATION

Based on the results of the water use, ground water, and surface water assessments, SJRWMD identified areas where data collection and water resource investigations need to be performed in order to better evaluate the potential for future problems and to prevent water resource problems from occurring. These necessary data collection and water resource investigations were identified by SJRWMD staff through coordination with its consultants, water suppliers, and the working groups.

ECONOMIC, ENVIRONMENTAL, AND TECHNICAL ANALYSES

SJRWMD has identified economic, environmental, and technical analyses necessary to prescribe a course of remedial or preventive action for water resource caution areas. These analyses were identified by SJRWMD staff through coordination with water suppliers and the working groups and are described on pages 92–93.

REMEDIAL OR PREVENTIVE ACTIONS IDENTIFICATION

SJRWMD identified possible courses of remedial or preventive actions aimed at preventing or solving problems in water resource caution areas. These possible remedial or preventive measures were identified by SJRWMD staff through coordination with water suppliers and the working groups and are described in the chapter titled "Alternative Water Supply Strategies" (p. 92).

WATER USE 1990 ESTIMATES AND 2010 PROJECTIONS—by Cynthia Moore

Water use needs have been inventoried for the year 1990 and have been projected to the year 2010 for the following three categories.

- Public supply
- Agricultural irrigation self-supply
- Recreation self-supply

An analysis of historical water use records indicates that these categories have consistently accounted for approximately three-fourths of the total fresh ground water use in SJRWMD and are expected to increase more than other categories. The combined water use from these three categories accounted for 74 percent of the total fresh ground water use in 1990 (Florence 1992).

Water use projections are not presented in this document for the other four major use categories.

- Domestic self-supply
- Industrial/commercial self-supply
- Thermoelectric power generation self-supply
- Miscellaneous self-supply (abandoned artesian wells)

However, projections for some industrial/commercial self-supply users were made to support the development of the ground water models discussed on pages 34–42.

Combined, these four categories accounted for 26 percent of the total fresh ground water use in 1990 (Florence 1992). Information obtained from historical trend analyses and contacts with users in these categories indicate that water use rates are not expected to change significantly through the year 2010.

Total water use (all seven categories, ground and surface water) is expected to increase by 401.46 million gallons per day (mgd) (26 percent) over the period 1990 through 2010 (Table 1).

Water use data for 1990 were obtained from Florence (1992). Projections of future water use needs for 2010 are based on historical trends, local government comprehensive plans, and direct communication with federal and state agencies, water users, and publicly and privately owned public water supply utilities.

A data base was created by SJRWMD containing 1990 and 2010 water use amounts for agriculture and public supply, distributed spatially by well point. The information in this data base was used in the development of numerical ground water flow models designed to assess the potential impact of future withdrawals.

PUBLIC SUPPLY WATER USE

The public supply water use category consists of water supplied to homes and industries by utilities that serve 400 or more people or that withdraw more than 0.01 mgd from ground water or surface water sources. Surface water accounts for only 3 percent of the total public supply water needs in both 1990 and 2010 (Tables 2 and 3).

Reclaimed water is used by an increasing number of suppliers to furnish a portion of the demand for public supply water, especially for non-potable uses such as irrigating domestic lawns and golf courses. In 1990, permitted reuse of reclaimed water accounted for 39.7 percent (108.27 mgd) of a total permitted capacity of 457.17 mgd within SJRWMD (Brandes 1994, draft). Although the use of reclaimed water is expected to continue to increase through the year 2010, further information is needed to determine to what extent this source will impact the need for water delivered through public drinking water supply.

Public supply water use projections were obtained from local government comprehensive plans and direct communication with public and private suppliers. Public supply water use projections reflect the plans of individual public suppliers and were not made independently by SJRWMD, unless the projections were not available from the supplier despite repeated attempts by SJRWMD to obtain them. SJRWMD attempted to verify all projections by direct communication with the suppliers through mailings, phone communication, public meetings, and visits to the utilities. Water use in the public supply category refers to withdrawals from the source (ground water or surface water), not actual consumption. Withdrawal and consumption do not necessarily occur in the same county or in the same utility service area.

Transfers of water between counties and service areas may occur on a temporary basis, through supply system interconnection in response to a specific request by a neighboring utility or plant, or transfers may be permanent, as in the case of the City of Cocoa in Brevard County (Figure 1). The City of Cocoa withdraws all of its ground water from wellfields located in neighboring Orange County and expects to withdraw up to 9.0 mgd from Taylor Creek Reservoir in Osceola County by 2010.

Water use for counties serviced by more than one water management district reflects the needs of the population falling only within the boundaries of SJRWMD, with the sole exception of Orange County (Table 2). Needs for Orange County are considered for the entire county, as well as for the SJRWMD portion. Counties serviced by more than one water management district include the following.

- Alachua
- Baker
- Bradford
- Lake
- Marion
- Okeechobee
- Orange
- Osceola
- Polk

- Putnam

Total public supply water use in SJRWMD is projected to increase by 447.09 mgd (79 percent) to 800.04 mgd in 2010 from 480.81 mgd in 1990 (Table 2). Increases in urban population and the expansion of services to unincorporated areas are expected to account for the greatest part of this increase. Counties projected to experience a greater than 100 percent increase in water needs are Bradford (300 percent), Flagler (297 percent), Indian River (190 percent), Lake (104 percent), St. Johns (114 percent), and Volusia (110 percent). The two counties with the highest public supply water use, Duval and Orange, are projected to experience a lower rate of growth in demand (70 percent and 76 percent respectively) but together account for 190.24 mgd (47 percent) of the projected increase.

Service area boundary maps (Figure 2) were used by SJRWMD to associate withdrawals with consumption and to verify that all major urbanized areas were accounted for in the water use needs analyses.

Agricultural Irrigation Self-Supply Water Use

The agricultural irrigation self-supply category includes water used to irrigate food crops and non-food crops such as pasture grass and nursery crops. This category does not include turf grass grown for recreational purposes such as golf and other recreational-related lawn irrigation.

Surface water accounted for 214.86 mgd (38 percent) of the total agricultural irrigation water use in 1990 (Table 4).

Projections are based on methods outlined in Lynne and Kiker (1992). Adjustments were made by SJRWMD for specific counties and crops based on additional information obtained from the SJRWMD data base on consumptive use permits, staff of state agencies, growers, and individuals.

Agricultural irrigation self-supply water use is expected to decrease by 24.14 mgd (4 percent) to 542.24 mgd in 2010 from 566.38 mgd in 1990. The decrease in need is expected to occur as a result of urbanization of lower value agricultural lands. Volusia County is expected to experience the largest increase in agricultural water use needs. In Volusia County, the cut foliage increased by almost 2,000 acres between 1990 and 1994. This increase resulted in an estimated increase in irrigation and frost-and-freeze protection water use of 10.27 mgd on an average annual basis. The cut foliage acreage in Volusia County is expected to increase an additional 1,500 acres by 2010 and in excess of 1,000 acres in Putnam and Lake counties.

RECREATION SELF-SUPPLY WATER USE

The recreation self-supply water use category includes water used for irrigation of turf grass. The largest single user in this category is golf courses.

Projections are based on historical trend analyses, personal communication with golf course superintendents, and information provided by the golf industry of northeast Florida. The methods used in the historical trend analyses are described in Lynne (1992).

Reclaimed water is an increasingly important source of water for irrigating turf grass and sod, and in particular for golf course turf. A statewide survey of turf growers estimated that 16 percent of the total water use in 1991 came from reclaimed sources (Haydu et al. 1994, draft). The amount of reclaimed water used by the golf course industry is expected to increase by the year 2010. Additional monitoring of this use is necessary to determine the potential impact on the total demand for water obtained from publicly or privately owned ground water and surface water sources.

Recreation self-supply water use is expected to increase significantly between 1990 and 2010. Total recreational self-supply water use from ground water and surface water sources in 1990 was 38.93 mgd (Table 5). Surface water accounted for 28 percent (11.07 mgd) of this amount. Total water use for recreation self-supply is expected to increase by 23.75 mgd (61 percent) to 62.68 mgd in 2010 from 38.93 mgd in 1990. St. Johns and Seminole counties are expected to experience a greater than 100 percent increase, with the greatest water use in St. Johns County. Although the percent increase in water use may appear to be significant, the amount of increase, 23.75 mgd, accounts for only 6 percent of the total increase (409.42 mgd) projected to occur.

DOMESTIC SELF-SUPPLY WATER USE

Domestic self-supply includes water withdrawn by individual domestic wells or provided by utilities serving fewer than 400 people or withdrawing less than 0.01 mgd. All domestic self-supplied water is assumed to be ground water and is assumed to be obtained from the easiest accessible aquifer, usually the surficial aquifer. Water use from this category is estimated from population and per capita water use figures. The method used to determine domestic self-supply water use is described in Florence (1992).

In 1990, domestic self-supply was estimated to account for 83.86 mgd or 8 percent of total ground water use (1,085.97 mgd) (Florence 1992). Domestic self-supply has consistently accounted for less than 10 percent of the total ground water use since SJRWMD began performing annual water use inventories in 1978. Domestic self-supply sources generally produce minimal quantities of water on an average annual basis and are generally located in rural areas with a low density of wells per unit area. Therefore, the withdrawals from these wells are considered to have a minimal impact on ground water levels. In addition, water use needs in this category are expected to remain stable or decline through 2010. Therefore, no domestic self-supply water use projections have been made.

INDUSTRIAL/COMMERCIAL SELF-SUPPLY WATER USE

Most of the water use in this category supplies the pulp and paper industries of Putnam, Nassau, and Duval counties or is associated with the mining of mineral resources in several other counties. In 1990, 109.42 mgd of fresh water from ground water and surface water sources, or 60 percent of the total freshwater use of 137.65 mgd in this category, supplied the pulp, paper, and mining industries (Florence 1992). Based on historical trends of relative stability in water use needs over the past 15 years and the industries' commitment to improving efficiencies in water use, little to no net change is expected in water use demands to the year 2010.

THERMOELECTRIC POWER GENERATION SELF-SUPPLY WATER USE

The thermoelectric power generation category of water use consists of water used by power plants primarily for cooling. The majority of the water used is saline, obtained from surface waterbodies. Nearly all of the cooling water is returned to its original source.

In 1990, 139.99 mgd of fresh water from ground water and surface water sources and 1,710.93 mgd of saline water from surface water sources were used for thermoelectric power generation (Florence 1992). This use accounted for approximately 10 percent of the fresh water and 97 percent of the saline surface water used in 1990. Based on historical trends of the past 15 years, little to no change is expected in water use demands to the year 2010.

MISCELLANEOUS SELF-SUPPLY WATER USE

The miscellaneous category of water use includes only water flowing from abandoned artesian wells. The SJRWMD Abandoned Artesian Well Plugging Program, initiated in 1976, has identified 1,311 abandoned wells (Florence 1992). As of 1990, only 471 of these wells remained free flowing. All currently identified wells are expected to be plugged or repaired by 2010, but additional abandoned artesian wells are expected to be added to the inventory. Some of these currently unidentified wells may exist today. Others may not currently be characterized as abandoned artesian wells based on the definition included in Section 377.203, *FS*, but may develop these problems by 2010. Although these wells may result in undesirable local impacts on water quality and water levels, the net flow of water from these wells is assumed to remain fairly constant through 2010. The location and character of these currently unidentified wells cannot be determined with a reasonable degree of accuracy.

Table 1. Water use in the St. Johns River Water Management District, in million gallons per day (mgd), 1990 and 2010

County	1990			2010			Percent Change
	Ground	Surface	Total	Ground	Surface	Total	
Alachua	35.56	0.18	35.74	43.21	0.20	43.41	21
Baker	7.08	2.20	9.28	6.81	1.63	8.44	-9
Bradford	0.32	0.00	0.32	0.44	0.00	0.44	38
Brevard[a,b]	150.38	26.64	177.02	170.92	24.07	194.99	10
Clay	25.95	0.44	26.39	35.54	0.11	35.65	35
Duval	155.39	1.40	156.79	219.73	1.31	221.04	41
Flagler	13.47	1.20	14.67	24.43	1.62	26.05	78
Indian River	84.82	117.73	202.55	111.82	118.38	230.20	14
Lake	86.39	12.63	99.02	114.88	8.69	123.57	25
Marion	37.60	1.39	38.99	47.83	2.24	50.07	28
Nassau	43.04	0.60	43.64	43.41	1.59	45.00	3
Okeechobee	9.92	0.25	10.17	8.01	0.00	8.01	-21
Orange[c]	160.74	60.03	220.77	286.89	48.84	335.73	52
Osceola[d]	6.57	8.09	14.66	4.94	17.38	22.32	52
Polk	4.41	0.35	4.76	5.26	0.53	5.79	22
Putnam	64.89	19.33	84.22	65.04	20.14	85.18	1
St. Johns	53.31	1.39	54.70	58.94	3.05	61.99	13
Seminole	71.44	1.80	73.24	106.35	1.78	108.13	48
Volusia	77.56	203.35	280.91	132.26	211.03	343.29	22
TOTAL	1,088.84	459.00	1,547.84	1,486.71	462.59	1,949.30	26

[a]Does not include 23.52 mgd (in 1990) and 30.07 (in 2010) of water withdrawn or expected to be withdrawn in Orange County for public supply use in Brevard County

[b]Does not include projected 9.00 mgd of surface water to be withdrawn in 2010 in Osceola County for public supply use in Brevard County

[c]Does include 23.52 mgd (in 1990) and 30.07 mgd (in 2010) of water withdrawn or expected to be withdrawn in Orange County for public supply use in Brevard County.

[d]Does include projected 9.00 mgd of surface water to be withdrawn in 2010 in Osceola County for public supply use in Brevard County.

Source: Florence 1992; Lynne and Kiker 1992; Dyer, Riddle, Mills, and Precourt 1994

Table 2. Public supply water withdrawals in the St. Johns River Water Management District (SJRWMD) in million gallons per day (mgd), 1990 and 2010

County	1990			2010			Percent Change
	Ground	Surface	Total	Ground	Surface	Total	
Alachua	20.97	0.00	20.97	30.76	0.00	30.76	47
Baker	0.81	0.00	0.81	1.02	0.00	1.02	26
Bradford	0.04	0.00	0.04	0.16	0.00	0.16	300
Brevard[a,b]	11.55	16.24	27.79	35.79	16.65	52.44	89
Clay	11.23	0.00	11.23	21.03	0.00	21.03	87
Duval	96.32	0.00	96.32	163.56	0.00	163.56	70
Flagler	3.85	0.00	3.85	15.27	0.00	15.27	297
Indian River	13.17	0.00	13.17	38.17	0.00	38.17	190
Lake	22.36	0.00	22.36	45.61	0.00	45.61	104
Marion	11.56	0.00	11.56	19.94	0.00	19.94	72
Nassau	3.85	0.00	3.85	5.26	0.00	5.26	37
Okeechobee	0.00	0.00	0.00	0.00	0.00	0.00	0
Orange[c]	161.84	0.00	161.84	284.84	0.00	284.84	76
Orange (SJRWMD)[c]	128.12	0.00	128.12	202.07	0.00	202.07	58
Osceola[d]	0.00	0.00	0.00	0.00	9.00	9.00	100
Polk	0.06	0.00	0.06	0.07	0.00	0.07	17
Putnam	3.15	0.00	3.15	3.21	0.00	3.21	2
St. Johns	8.39	0.00	8.39	17.93	0.00	17.93	114
Seminole	50.79	0.00	50.79	80.71	0.00	80.71	59
Volusia	44.63	0.00	44.63	93.83	0.00	93.83	110
TOTAL	464.57	16.24	480.81	857.16	25.65	882.81	84
TOTAL (SJRWMD)	430.85	16.24	447.09	774.39	25.65	800.04	79

[a]Does not include 23.52 mgd (in 1990) and 30.07 (in 2010) of water withdrawn or expected to be withdrawn in Orange County for public supply use in Brevard County
[b]Does not include projected 9.00 mgd of surface water to be withdrawn in 2010 in Osceola County for public supply use in Brevard County
[c]Does include 23.52 mgd (in 1990) and 30.07 mgd (in 2010) of water withdrawn or expected to be withdrawn in Orange County for public supply use in Brevard County.
[d]Does include projected 9.00 mgd of surface water to be withdrawn in 2010 in Osceola County for public supply use in Brevard County.

Source: Florence 1992 (Table 3 and Appendix); Lynne and Kiker 1992; Dyer, Riddle, Mills, and Precourt 1994

Table 3. Public supply water use by public water supply utilities in the St. Johns River Water Management District (SJRWMD) in million gallons per day, 1990 and 2010

County	Utility	1990			2010			Percent Change
		Ground	Surface	Total	Ground	Surface	Total	
Alachua	Gainesville Regional Utilities	20.32	0.00	20.32	29.50	0.00	29.50	45
	All others	0.65	0.00	0.65	1.26	0.00	1.26	94
	Total	20.97	0.00	20.97	30.76	0.00	30.76	47
Baker	Total	0.81	0.00	0.81	1.02	0.00	1.02	26
Bradford	Total	0.04	0.00	0.04	0.16	0.00	0.16	300
Brevard	Cocoa Water Utility	23.52	0.00	23.52	30.07	9.00	39.07	66
	GDU, Palm Bay	4.38	0.00	4.38	7.59	0.00	7.59	73
	Melbourne, City of	0.00	16.24	16.24	14.70	16.65	31.35	93
	N. Brevard Utilities (Mims)	0.65	0.00	0.65	1.90	0.00	1.90	192
	Titusville, City of	5.62	0.00	5.62	9.80	0.00	9.80	74
	All others	0.90	0.00	0.90	1.80	0.00	1.80	100
	Total	35.07	16.24	51.31	65.86	25.65	91.51	78
Clay	Clay Utility Co.	0.90	0.00	0.90	2.24	0.00	2.24	149
	Green Cove Springs, City of	0.83	0.00	0.83	1.56	0.00	1.56	88
	Kingsley Service Co.	7.14	0.00	7.14	14.04	0.00	14.04	97
	Lake Asbury Utilities	0.23	0.00	0.23	0.57	0.00	0.57	148
	Magnolia Springs Utilities	0.16	0.00	0.16	0.11	0.00	0.11	-31
	Orange Park, Town of	1.43	0.00	1.43	1.86	0.00	1.86	30
	Penney Retirement Community	0.06	0.00	0.06	0.17	0.00	0.17	183
	All others	0.48	0.00	0.48	0.48	0.00	0.48	0
	Total	11.23	0.00	11.23	21.03	0.00	21.03	87
Duval	Atlantic Beach, City of	2.65	0.00	2.65	5.20	0.00	5.20	96
	Beauclerc Utilities	0.65	0.00	0.65	0.96	0.00	0.96	48
	Harbor View Subdivision	0.19	0.00	0.19	0.20	0.00	0.20	5
	Jacksonville Beach, City of	2.84	0.00	2.84	6.20	0.00	6.20	118
	Jacksonville, City of	70.49	0.00	70.49	116.65	0.00	116.65	65
	Jacksonville Suburban Utilities	9.93	0.00	9.93	18.34	0.00	18.34	85
	Lamplighter Mobile Home Park (MHP)	0.15	0.00	0.15	0.36	0.00	0.36	140
	Londontown Apartments	0.23	0.00	0.23	0.91	0.00	0.91	296

Table 3—*Continued*

County	Utility	1990			2010			Percent Change
		Ground	Surface	Total	Ground	Surface	Total	
Duval (Continued)	Neighborhood Utilities	0.04	0.00	0.04	0.15	0.00	0.15	275
	Neptune Beach, City of	1.21	0.00	1.21	0.52	0.00	0.52	-57
	Normandy Village Utilities	0.44	0.00	0.44	0.87	0.00	0.87	98
	Oaks of Atlantic Beach	0.10	0.00	0.10	0.15	0.00	0.15	50
	Ortega Utilities	1.02	0.00	1.02	2.32	0.00	2.32	127
	Regency Utilities	0.80	0.00	0.80	1.40	0.00	1.40	75
	Springtree (Shadowrock Utilities)	0.24	0.00	0.24	0.19	0.00	0.19	-21
	Southern States Utilities	1.31	0.00	1.31	3.13	0.00	3.13	139
	Southside Utilities	1.16	0.00	1.16	2.72	0.00	2.72	134
	All others	2.87	0.00	2.87	3.29	0.00	3.29	15
	Total	96.32	0.00	96.32	163.56	0.00	163.56	70
Flagler	Beverly Beach Utility	0.03	0.00	0.03	0.07	0.00	0.07	133
	Bunnell, City of	0.33	0.00	0.33	0.65	0.00	0.65	97
	Flagler Beach, City of	0.57	0.00	0.57	1.13	0.00	1.13	98
	Palm Coast Utilities	2.87	0.00	2.87	12.90	0.00	12.90	349
	Plantation Bay	0.05	0.00	0.05	0.52	0.00	0.52	940
	Total	3.85	0.00	3.85	15.27	0.00	15.27	297
Indian River	Indian River County Utilities	2.36	0.00	2.36	26.02	0.00	26.02	1003
	Vero Beach, City of	9.79	0.00	9.79	9.55	0.00	9.55	-2
	All others	1.02	0.00	1.02	2.60	0.00	2.60	155
	Total	13.17	0.00	13.17	38.17	0.00	38.17	190
Lake	Astor/Astor Park Water Assoc.	0.27	0.00	0.27	0.70	0.00	0.70	159
	Brittany Estates	0.07	0.00	0.07	0.10	0.00	0.10	43
	Clermont, City of	1.52	0.00	1.52	2.47	0.00	2.47	63
	Deanza, Mid-Florida Lakes	0.68	0.00	0.68	1.23	0.00	1.23	81
	Eustis, City of	2.82	0.00	2.82	5.78	0.00	5.78	105
	Fruitland Park, City of	0.42	0.00	0.42	0.58	0.00	0.58	38
	Groveland, City of	0.29	0.00	0.29	0.79	0.00	0.79	172
	Hawthorne Subdivision	0.49	0.00	0.49	0.74	0.00	0.74	51
	Howey-in-the-Hills, Town of	0.24	0.00	0.24	0.45	0.00	0.45	88

Table 3—*Continued*

County	Utility	1990			2010			Percent Change
		Ground	Surface	Total	Ground	Surface	Total	
Lake (Continued)	Leesburg, City of	4.17	0.00	4.17	12.10	0.00	12.10	190
	Mascotte, Town of	0.20	0.00	0.20	0.29	0.00	0.29	45
	Minneola, City of	0.22	0.00	0.22	0.45	0.00	0.45	105
	Molakai Park Water System	0.04	0.00	0.04	0.07	0.00	0.07	75
	Montverde, Town of	0.12	0.00	0.12	0.22	0.00	0.22	83
	Mount Dora, City of	2.82	0.00	2.82	4.46	0.00	4.46	58
	Orange Blossom Gardens MHP	2.52	0.00	2.52	3.48	0.00	3.48	38
	South Umatilla Water Association	0.06	0.00	0.06	0.09	0.00	0.09	50
	Southern States Utilities	0.22	0.00	0.22	1.05	0.00	1.05	377
	Sunlake Estates	0.31	0.00	0.31	0.24	0.00	0.24	-23
	Tavares, City of	1.40	0.00	1.40	3.36	0.00	3.36	140
	Umatilla, City of	0.49	0.00	0.49	0.97	0.00	0.97	98
	Utilities Inc. of Florida	0.16	0.00	0.16	0.37	0.00	0.37	131
	Water Oak Estates	0.27	0.00	0.27	0.38	0.00	0.38	41
	All others	2.56	0.00	2.56	5.24	0.00	5.24	105
	Total	22.36	0.00	22.36	45.61	0.00	45.61	104
Marion	Ocala, City of	8.24	0.00	8.24	16.00	0.00	16.00	94
	All others	3.32	0.00	3.32	3.94	0.00	3.94	19
	Total	11.56	0.00	11.56	19.94	0.00	19.94	72
Nassau	Callahan, Town of	0.15	0.00	0.15	0.24	0.00	0.24	60
	Florida Public Utilities Company	2.65	0.00	2.65	3.00	0.00	3.00	13
	Southern States Utilities (Amelia Island)	0.73	0.00	0.73	1.57	0.00	1.57	115
	All others	0.32	0.00	0.32	0.45	0.00	0.45	41
	Total	3.85	0.00	3.85	5.26	0.00	5.26	37
Orange	Apopka, City of	5.29	0.00	5.29	14.90	0.00	14.90	182
	Eatonville, Town of	0.69	0.00	0.69	1.41	0.00	1.41	104
	Econ Utilities, Wedgefield	0.16	0.00	0.16	0.16	0.00	0.16	0
	Maitland, City of	3.16	0.00	3.16	2.60	0.00	2.60	-18
	Oakland, Town of	0.11	0.00	0.11	0.13	0.00	0.13	18
	Ocoee, City of	2.69	0.00	2.69	5.48	0.00	5.48	104

Table 3—*Continued*

County	Utility	1990			2010			Percent Change
		Ground	Surface	Total	Ground	Surface	Total	
Orange (Continued)	Orange County Public Utilities (OCPU)	27.76	0.00	27.76	79.00	0.00	79.00	185
	-- SJRWMD portion of OCPU	18.88	0.00	18.88	56.13	0.00	56.13	197
	Orlando Utilities Commission (OUC)	79.28	0.00	79.28	128.49	0.00	128.49	62
	-- SJRWMD portion of OUC	54.44	0.00	54.44	68.59	0.00	68.59	26
	Rock Springs MHP	0.24	0.00	0.24	0.28	0.00	0.28	17
	Southern States Utilities	1.00	0.00	1.00	1.64	0.00	1.64	64
	Starlight Ranch MHP	0.18	0.00	0.18	0.23	0.00	0.23	28
	Utilities Inc. of Florida	0.10	0.00	0.10	0.02	0.00	0.02	-80
	Winter Garden, City of	1.78	0.00	1.78	2.52	0.00	2.52	42
	Winter Park, City of	13.62	0.00	13.62	15.28	0.00	15.28	12
	Zellwood Station Utilities	0.96	0.00	0.96	1.28	0.00	1.28	33
	Zellwood Water Assoc.	0.33	0.00	0.33	0.37	0.00	0.37	12
	All others	0.98	0.00	0.98	0.98	0.00	0.98	0
	Total (SJRWMD)	104.60	0.00	104.60	172.00	0.00	172.00	64
	Total (all county)	138.32	0.00	138.32	254.77	0.00	254.77	84
Polk	Total	0.06	0.00	0.06	0.07	0.00	0.07	17
Putnam	Crescent City	0.34	0.00	0.34	0.39	0.00	0.39	15
	Palatka, City of	2.42	0.00	2.42	2.37	0.00	2.37	-2
	Southern States Utilities	0.20	0.00	0.20	0.26	0.00	0.26	30
	All others	0.19	0.00	0.19	0.19	0.00	0.19	0
	Total	3.15	0.00	3.15	3.21	0.00	3.21	2
St. Johns	St. Johns County Utilities	2.17	0.00	2.17	5.08	0.00	5.08	134
	Intracoastal Utilities	0.72	0.00	0.72	2.08	0.00	2.08	189
	North Beach Water System	0.21	0.00	0.21	0.75	0.00	0.75	257
	Palm Valley Water System	0.12	0.00	0.12	0.09	0.00	0.09	-25
	Ponte Vedra Utilities	0.84	0.00	0.84	1.10	0.00	1.10	31
	St. Augustine, City of	1.83	0.00	1.83	3.82	0.00	3.82	109
	St. Johns Service Co.	1.55	0.00	1.55	3.40	0.00	3.40	119
	S. Ponte Vedra Beach Utilities	0.08	0.00	0.08	0.16	0.00	0.16	100

Table 3—*Continued*

County	Utility	1990			2010			Percent Change
		Ground	Surface	Total	Ground	Surface	Total	
St. Johns (Continued)	Wesley Manor Water System	0.08	0.00	0.08	0.08	0.00	0.08	0
	All others	0.79	0.00	0.79	1.37	0.00	1.37	73
	Total	8.39	0.00	8.39	17.93	0.00	17.93	114
Seminole	Altamonte Springs, City of	8.00	0.00	8.00	10.19	0.00	10.19	27
	Casselberry, City of	5.98	0.00	5.98	6.33	0.00	6.33	6
	Lake Harney Water Assoc.	0.03	0.00	0.03	0.04	0.00	0.04	33
	Lake Mary, City of	1.14	0.00	1.14	5.60	0.00	5.60	391
	Longwood, City of	2.21	0.00	2.21	3.15	0.00	3.15	43
	Mullet Lake Water Assoc.	0.04	0.00	0.04	0.09	0.00	0.09	125
	Oviedo, City of	1.99	0.00	1.99	9.64	0.00	9.64	384
	Palm Ventures MHP	0.16	0.00	0.16	0.22	0.00	0.22	38
	Sanford, City of	5.63	0.00	5.63	7.53	0.00	7.53	34
	Sanlando Utilities	10.43	0.00	10.43	10.76	0.00	10.76	3
	Seminole County Water & Sewer	9.15	0.00	9.15	18.62	0.00	18.62	103
	Southern States Utilities	1.43	0.00	1.43	1.48	0.00	1.48	3
	Utilities Inc. of Florida	0.90	0.00	0.90	1.08	0.00	1.08	20
	Winter Springs, City of	3.60	0.00	3.60	5.80	0.00	5.80	61
	All others	0.10	0.00	0.10	0.18	0.00	0.18	80
	Total	50.79	0.00	50.79	80.71	0.00	80.71	59
Volusia	Daytona Beach, City of	12.11	0.00	12.11	19.81	0.00	19.81	64
	De Land, City of	3.70	0.00	3.70	8.39	0.00	8.39	127
	Edgewater, City of	1.65	0.00	1.65	4.01	0.00	4.01	143
	Hacienda Del Rio	0.06	0.00	0.06	0.10	0.00	0.10	67
	Holly Hill, City of	1.07	0.00	1.07	1.52	0.00	1.52	42
	John Knox Village	0.07	0.00	0.07	0.14	0.00	0.14	100
	Kingston Shores Water Assoc.	0.02	0.00	0.02	0.04	0.00	0.04	100
	Lake Beresford Water Assoc.	0.18	0.00	0.18	0.33	0.00	0.33	83
	Lake Helen, City of	0.23	0.00	0.23	0.58	0.00	0.58	152
	New Smyrna Beach, City of	4.12	0.00	4.12	8.35	0.00	8.35	103
	Orange City Country Village	0.20	0.00	0.20	0.39	0.00	0.39	95

Table 3—*Continued*

County	Utility	1990			2010			Percent Change
		Ground	Surface	Total	Ground	Surface	Total	
Volusia (Continued)	Orange City	0.64	0.00	0.64	3.65	0.00	3.65	470
	Ormond Beach, City of	4.76	0.00	4.76	7.63	0.00	7.63	60
	Pierson, Town of	0.18	0.00	0.18	0.26	0.00	0.26	44
	Port Orange, City of	4.81	0.00	4.81	9.43	0.00	9.43	96
	Southern States Utilities, Deltona Utilities	8.95	0.00	8.95	24.89	0.00	24.89	178
	Southern States Utilities, Sugar Mill	0.12	0.00	0.12	0.24	0.00	0.24	100
	Tymber Creek Utilities	0.10	0.00	0.10	0.18	0.00	0.18	80
	Volusia County Utilities	1.59	0.00	1.59	3.79	0.00	3.79	138
	All others	0.07	0.00	0.07	0.10	0.00	0.10	43
	Total	44.63	0.00	44.63	93.83	0.00	93.83	110
TOTAL		464.58	16.24	480.82	857.16	25.65	882.81	84
TOTAL (SJRWMD)		430.86	16.24	447.10	774.39	25.65	800.04	79

Table 4. Agricultural irrigation self-supply water use in the St. Johns River Water Management District, in million gallons per day, 1990 and 2010

County	1990			2010			Percent Change
	Ground	Surface	Total	Ground	Surface	Total	
Alachua	7.60	0.07	7.67	5.00	0.05	5.05	-34
Baker	3.09	2.20	5.29	2.50	1.63	4.13	-22
Bradford	0.00	0.00	0.00	0.00	0.00	0.00	0
Brevard	99.41	9.07	108.48	95.14	6.07	101.21	-7
Clay	1.84	0.00	1.84	0.40	0.00	0.40	-78
Duval	5.32	0.42	5.74	1.89	0.27	2.16	-62
Flagler	7.34	0.00	7.34	6.81	0.00	6.81	-7
Indian River	48.36	116.54	164.90	49.09	116.54	165.63	0
Lake	42.27	11.59	53.86	46.27	6.73	53.00	-2
Marion	8.50	0.66	9.16	9.60	1.09	10.69	17
Nassau	0.65	0.33	0.98	0.21	0.00	0.21	-79
Okeechobee	9.78	0.25	10.03	7.87	0.00	7.87	-22
Orange	21.61	59.50	81.11	22.60	47.87	70.47	-13
Osceola	6.05	8.09	14.14	4.42	8.38	12.80	-9
Polk	3.66	0.35	4.01	4.50	0.53	5.03	25
Putnam	20.17	1.35	21.52	20.14	2.16	22.30	4
St. Johns	38.29	0.10	38.39	31.60	0.00	31.60	-18
Seminole	8.25	1.10	9.35	10.32	0.24	10.56	13
Volusia	19.33	3.24	22.57	21.99	10.35	32.34	43
TOTAL	351.52	214.86	566.38	340.35	201.91	542.26	-4

Source: Florence 1992 (Table 7 and Appendix)

Table 5. Recreation self-supply water use in the St. Johns River Water Management District, in million gallons per day, 1990 and 2010

County	1990			2010			Percent Change
	Ground	Surface	Total	Ground	Surface	Total	
Alachua	1.82	0.11	1.93	2.28	0.15	2.43	26
Baker	0.21	0.00	0.21	0.32	0.00	0.32	52
Bradford	0.12	0.00	0.12	0.12	0.00	0.12	0
Brevard	1.37	1.33	2.70	1.94	1.35	3.29	22
Clay	1.16	0.44	1.60	2.39	0.11	2.50	56
Duval	4.21	0.98	5.19	4.70	1.04	5.74	11
Flagler	0.16	1.20	1.36	0.23	1.62	1.85	36
Indian River	2.48	1.19	3.67	3.75	1.85	5.60	53
Lake	1.39	1.04	2.43	2.64	1.96	4.60	89
Marion	1.16	0.73	1.89	1.91	1.15	3.06	62
Nassau	1.75	0.27	2.02	1.15	1.59	2.74	36
Okeechobee	0.00	0.00	0.00	0.00	0.00	0.00	0
Orange	2.83	0.53	3.36	4.98	0.97	5.95	77
Osceola	0.00	0.00	0.00	0.00	0.00	0.00	0
Polk	0.00	0.00	0.00	0.00	0.00	0.00	0
Putnam	0.31	0.00	0.31	0.43	0.00	0.43	39
St. Johns	2.25	1.29	3.54	5.03	3.05	8.08	128
Seminole	2.94	0.70	3.64	5.86	1.54	7.40	103
Volusia	3.70	1.26	4.96	6.73	1.83	8.56	73
TOTAL	27.86	11.07	38.93	44.46	18.21	62.67	61

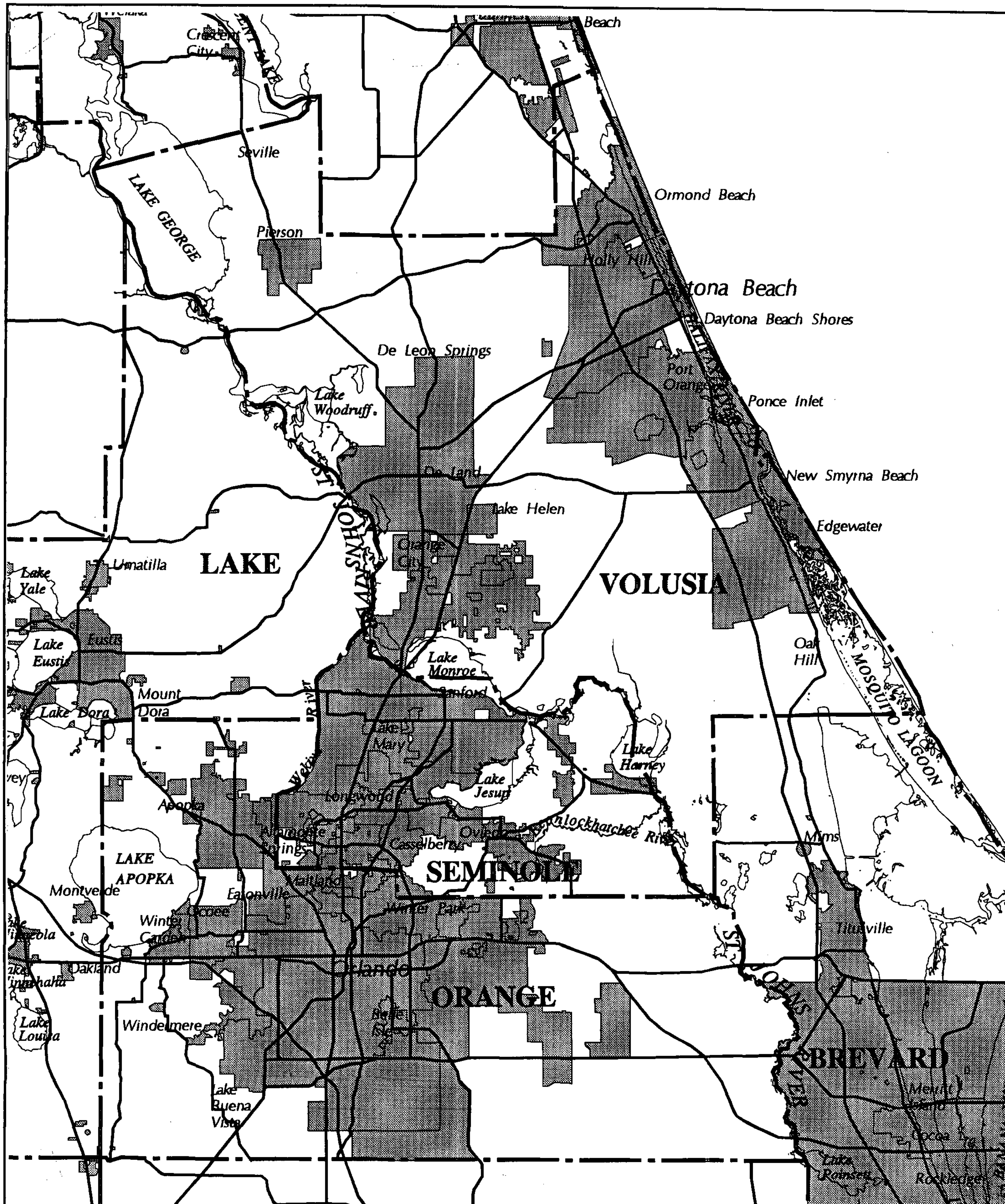

Figure 2. Service areas of public water supply in Orange, Seminole, Volusia, and surrounding counties

County boundary
Road
Public supply service area

Miles
0 4 8
Scale 1:597252
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SOURCE EVALUATION—by Barbara Vergara, P.G.; David Toth, Ph.D., P.G.; Andrew Lieuwen, Ph.D.; Donthamsetti Rao, Ph.D., P.E.; and David Clapp

The 1994 WSNS assessment includes an evaluation of the ground water and surface water resources of the SJRWMD 19-county area. This evaluation was performed to assess the availability of these resources to supply water to meet current and projected needs through 2010.

GROUND WATER SOURCE EVALUATION

Overview of Resources

Three aquifer systems supply ground water in SJRWMD: the surficial, the intermediate, and the Floridan (Figure 3). The hydrogeologic nature of these aquifers is described by Southeastern Geological Society (1986).

Surficial Aquifer System. The surficial aquifer system is composed primarily of sand and sandy clay and is located from land surface downward to the top of the confining unit of the intermediate aquifer system, where present, or to the top of the confining unit of the Floridan aquifer system where there is no intermediate aquifer system, or to the top of the Floridan aquifer system where there is no confining unit. The surficial aquifer system contains the water table, which is the top of the saturated zone within the aquifer. Water within the surficial aquifer system occurs mainly under unconfined conditions, but beds of low permeability cause semiconfined or locally confined conditions to prevail in its deeper parts.

Water quality in the surficial aquifer system is generally good. Chloride, sulfate, and total dissolved solids (TDS) concentrations are generally below the secondary drinking water standards of 250, 250, and 500 milligrams per liter (mg/L), respectively (Subsection 62-550.320(1), *F.A.C.*). Iron concentrations, however, are generally high and in many places exceed the secondary drinking water standard of 0.3 mg/L (Subsection 62-550.320(1), *F.A.C.*). In coastal areas, such as the barrier islands, this aquifer is prone to saltwater intrusion.

The surficial aquifer system is a source of water for public supply in St. Johns, Flagler, Brevard, and Indian River counties. It is also used as a source of water for individual domestic self-supply, mainly along the coastal portions of SJRWMD but also in inland areas scattered throughout SJRWMD.

Intermediate Aquifer System. The intermediate aquifer system is composed of thin water-bearing zones of sand, shell, and limestone, which lie within or between less permeable units of clayey sand to clay. In places, poorly yielding to non-water yielding strata occur, and there the term "intermediate confining unit" applies. This intermediate confining unit is geologically referred to as the Hawthorn Group. In other places, one or more low-to-moderate yielding aquifers may be inter-layered with relatively impermeable confining beds. The aquifers within this aquifer system contain water under confined conditions. Within the intermediate aquifer system, confining units are generally more extensive than water-bearing units.

The top of the intermediate aquifer system or intermediate confining unit coincides with the base of the surficial aquifer system. The base of the intermediate aquifer system or intermediate confining unit lies immediately above the Floridan aquifer system.

Water quality in the intermediate aquifer system is generally good in the northern part of SJRWMD where chloride, sulfate, and TDS concentrations are below the secondary drinking water standards. Water quality in the southern part of SJRWMD approaches or exceeds the secondary drinking water standards for chloride and TDS concentrations.

The intermediate aquifer system is used as a source of water for individual domestic self-supply in Duval and Clay counties.

Floridan Aquifer System. The Floridan aquifer system is one of the world's most productive aquifers. The sediments that comprise the aquifer system underlie the entire state, although this aquifer does not contain potable water at all locations. The Floridan aquifer system is generally composed of limestone and dolomite. Water in the Floridan aquifer system occurs under confined conditions throughout most of SJRWMD. Unconfined conditions occur in parts of Alachua and Marion counties.

The Floridan aquifer system is subregionally divided on the basis of the vertical occurrence of two zones of relatively high permeability (Miller 1986). These zones are called the "Upper Floridan" and "Lower Floridan" aquifers. A less permeable limestone and dolomitic limestone sequence generally separates the Upper Floridan and Lower Floridan aquifers. It is referred to as the "middle semiconfining unit." Throughout much of Baker, Union, Bradford, western Alachua, and northwestern Marion counties, the middle semiconfining unit is missing and the Lower Floridan aquifer does not occur (Miller 1986).

Water quality in the Upper Floridan aquifer varies depending on its location in SJRWMD. Water quality in this aquifer is generally good in the northern and western portions of SJRWMD where chloride, sulfate, and TDS concentrations are below the secondary drinking water standards (Figure 4). Chloride and TDS concentrations in the Upper Floridan aquifer generally exceed the secondary drinking water standards throughout Brevard and Indian River counties, in southern St. Johns and most of Flagler counties, in areas bordering the St. Johns River south of Clay County, (in parts of Putnam, Marion, Lake, Volusia, Seminole, Orange, and Osceola counties), and in eastern Volusia County. Sulfate concentrations also often exceed the secondary drinking water standards.

Water quality in the Lower Floridan aquifer also varies depending on its location in SJRWMD. Water quality in this aquifer is generally good in the northern and western portions of SJRWMD where chloride and TDS concentrations are below the secondary drinking water standards. Chloride concentrations in the Lower Floridan aquifer generally exceed the secondary drinking water standards throughout all of Flagler, Brevard, and Indian River counties, in eastern Nassau and Volusia counties, and in areas bordering the St. Johns River in Putnam, Marion, Lake, Volusia, Seminole, Orange, and Osceola counties (Sprinkle 1989). TDS concentrations in the Lower Floridan aquifer generally exceed the secondary drinking water standards throughout all of St. Johns, Flagler, Brevard, and Indian River counties, in most of Nassau and Duval counties, in eastern Clay and Volusia counties, and in areas bordering the St. Johns River in Putnam, Marion, Lake, Volusia, Seminole, Orange, and Osceola counties (Sprinkle 1989).

The Upper Floridan aquifer is the primary source of water for public supply water use in SJRWMD. This aquifer is a source of water for public supply in the northern and central portions of SJRWMD where the aquifer contains water that generally meets primary and secondary drinking water standards. The Upper Floridan aquifer is also a source of water for public supply in the southern portion of SJRWMD where water withdrawn from the aquifer is treated by reverse osmosis. Portions of the Lower Floridan aquifer are also tapped as a source of water for public supply in Duval, central and western Orange, and southern and southwestern Seminole counties. The Floridan aquifer system in the southern portion of SJRWMD, where the aquifer generally contains water that exceeds secondary drinking water standards for chloride, sulfate, and TDS, is widely used as a source of irrigation water.

Ground Water Impact Assessment

Regional, subregional, and local assessments of the impacts of withdrawals on ground water flow and water quality were performed based on the following criteria.

- Concentrations and magnitudes of current and projected ground water withdrawals
- Existing ground water quality conditions

- Consideration of historic water resource conditions

Ground water flow and water quality models served as the primary tools for performing these assessments. Several factors can affect the accuracy of the model predictions. Among these are (1) assumptions about the model boundary conditions, (2) simplifications in the representation of the aquifer system, (3) lack of data, and (4) data inaccuracies. The relevance of these factors to the model predictions used as part of this assessment is described in the reports detailing the models (Tables 6, 7, and 8).

Numerical ground water flow models developed on regional scales and calibrated to steady-state conditions were developed for seven areas (Figure 5 and Table 6). These models were designed to simulate the effects of projected ground water withdrawals on the potentiometric surface of the Floridan aquifer system. These regional ground water flow models are considered to be the best tools available to perform regional evaluations of the responses of water levels to ground water withdrawals. However, the predictions resulting from these models are not considered suitable for use in making site-specific evaluations, because the aquifer parameters, withdrawals, and impacts are averaged over each grid cell in the model. This averaging lessens the resolution of predicted water levels. Improvements in data related to aquifer characteristics, water levels, and water use would improve the accuracy of the model predictions.

Within the regional ground water flow model areas, other than the area covered by the Titusville/Mims regional ground water flow model (Williams 1994c, draft), changes in the elevation of the water table of the surficial aquifer system were projected using a technique described in Huang et al. (1994, draft). This technique also was used to produce revised 2010 potentiometric surface elevations that are thought to be more realistic than those produced by the regional ground water flow models. The regional flow models assume constant water table elevations, an assumption that probably results in underestimations of the decline in the potentiometric surface of the Floridan aquifer system.

In addition to using these regional ground water flow models to predict changes in the potentiometric surface of the Floridan aquifer system, including discharges from springs, analytical models have been developed and have been used to evaluate the impacts of proposed withdrawals from several public supply wellfields. These wellfields are not located within the domains of the regional ground water flow models, or they are located in areas where the regional model grids are considered too coarse to provide adequate predictions of changes in the elevation of the potentiometric surface in the vicinity of these wellfields (Figure 6 and Table 7).

Subregional ground water flow and water quality models were developed in areas considered most likely to experience significant changes in ground water quality as a result of projected declines in the elevation of the potentiometric surface of the Floridan aquifer system (Figure 7 and Table 8). These models represent the best tools available to assess the potential impacts of projected ground water withdrawals on future ground water salinity; but these models are not able to predict chloride concentration changes precisely enough to predict exactly where or when specific water quality changes will occur. These models need to be improved upon with additional data on water use, aquifer characteristics, ground water levels, and ground water quality.

Ground Water Levels. The regional ground water flow models, the analytical models, and the iterative modeling procedure described by Huang et al. (1994, draft) were used to produce a simulated map of the potentiometric surface of the Upper Floridan aquifer for 2010 (Figure 8).

In addition to the simulated 2010 potentiometric surface of the Upper Floridan aquifer, the regional ground water flow models were used to produce a simulated map of the potentiometric surface of the 1988 steady-state condition of the Upper Floridan aquifer (Figure 9) for the purpose of comparison to the simulated 2010 potentiometric surface. The 1988 steady-state condition, rather than the 1990 condition, was used for comparison to the

2010 condition, because 1988 climatic conditions are considered to be normal, whereas 1990 climatic conditions are considered to represent drought conditions.

Based on a comparison of the configuration of the projected 2010 potentiometric surface to the simulated 1988 potentiometric surface, a predicted change in the potentiometric surface between these two periods was calculated using the ARCInfo geographic information system GRID module. Associated with this exercise is the assumption that regional climatic conditions will be similar in 2010 to those for the years used to calibrate the model. Evaluation of the resulting change map (Figure 10) indicates that, if current 2010 water supply plans are carried out, the greatest regional impacts to the Floridan aquifer system will occur in Seminole and Orange counties.

The regional ground water flow models were also used to project reductions in discharges from springs supplied by the Floridan aquifer system between 1988 and 2010 (Figure 11 and Table 9). The projected reductions in discharge from springs are the result of projected declines in the hydraulic pressure in the Floridan aquifer system that result from the projected increases in ground water withdrawals between 1988 and 2010. The method used to project reductions in spring discharges are based on Rao and Clapp (1994, draft). Review of these projected reductions in spring discharges indicates that 18 springs are projected to experience reductions in discharge of 15 percent or greater (Table 9). Seven of these springs are projected to experience flows that are less than the minimum flows for the springs established by Section 40C-8.031, *F.A.C.* (Appendix B). The impacts of these reductions in spring discharge on the receiving surface waterbodies are discussed on pages 46–48.

One notable spring, Bugg Spring in Lake County (Figure 11), was not included in this evaluation because it was located outside of the active portion of the Wekiva River Basin regional ground water flow model domain (Rosenau et al. 1977; GeoTrans 1992a). Because of the close proximity of Bugg Spring to Blue and Holiday springs (Figure 11), the percent reduction in discharge from Bugg Spring is assumed to be similar to that of Blue and Holiday springs, which are projected to experience reductions in discharges of 56.3 percent and 70.0 percent, respectively (Table 9). These projected reductions in discharge are the result of projected increases in water use throughout the domain of the regional flow model. About one-half of the projected impact is the result of projected increases in water use in Orange, Seminole, and Osceola counties. The remaining portion is the result of projected increases in the City of Leesburg area of the Wekiva River Basin regional ground water flow model domain.

Using the techniques described by Huang et al. (1994, draft), declines in the water table of the surficial aquifer system were projected for the period 1988 to 2010 (Figure 12). Based on this evaluation, if current 2010 water supply plans are carried out, the most extensive regional impacts to the water table will occur in Seminole, Orange, Volusia, and Lake counties.

Ground Water Quality. The regional sharp-interface model for northeast Florida and the subregional ground water quality models (Table 8, Figure 7) were used to predict changes in ground water quality (chlorides) in the Floridan aquifer system in response to projected changes in water use through 2010. Because ground water quality changes occur relatively slowly in response to changes in the potentiometric surface of the Floridan aquifer system, probably on the order of tens to hundreds of years, the impacts of projected 2010 water use were projected at least for periods of 50 and 100 years beyond 2010.

Ground water quality models are

- Northeast Florida Regional Sharp-Interface Ground Water Model,
- Eastern Volusia Subregional Flow and Solute Transport Model,
- Western Volusia Subregional Ground Water Flow and Water Quality Model,
- Seminole County Subregional Ground Water Flow and Solute Transport Model,

- Eastern Orange County Subregional Ground Water Flow and Solute Transport Model, and
- Wekiva River Basin Subregional Flow and Solute Transport Model.

Decriptions of the results of the ground water quality assessment using these models follow.

Northeast Florida Regional Sharp-Interface Ground Water Model Area. The sharp-interface model developed to address the potential for saltwater intrusion and upconing in the northeast Florida area was run in a transient mode to predict the position of the saltwater–freshwater interface for the years 2010, 2060, 2110, and 2985 (Figure 13) (Durden and Huang 1994, draft). The results indicate insignificant saltwater migration in both lateral and vertical directions for these time periods.

Eastern Volusia Subregional Flow and Solute Transport Model Area. The subregional flow and transport model developed for the east Volusia County area was used to assess predicted changes in chloride concentrations in the Floridan aquifer system for the years 2010, 2060, and 2110 (Figure 14) (Williams 1994a, draft). This assessment indicates the following.

- Upconing of relict seawater has occurred to date and will continue to occur under major public supply wellfields near the saltwater–freshwater interface.

- Lateral intrusion of the saltwater–freshwater interface has occurred and will continue to occur in response to increasing pumping demands.

- The thickness of available fresh water is projected to decline by up to 50 percent in coastal areas of Volusia County east of I-95 and by approximately 10–20 percent in east-central Volusia County by 2060.

- Public supply wellfields in eastern Volusia County (eastern wellfields for the Cities of Port Orange, Ormond Beach, Holly Hill, and Daytona Beach) will be unable to deliver adequate quantities of water of suitable quality (chlorides <250 mg/L, sulfates <250 mg/L, and TDS <500 mg/L) to meet the projected demand by 2010.

Western Volusia Subregional Ground Water Flow and Water Quality Model Area. The subregional ground water flow model for the southwest Volusia County area, including the U.S. Geological Survey (USGS) particle-tracking codes MODPATH and MODPATH-PLOT (McDonald and Harbaugh 1988; Pollock 1989), was used to assess the potential for saltwater intrusion in the Floridan aquifer system as a result of projected 2010 ground water withdrawals (McGurk 1994b, draft). The results indicate that a strong potential exists for vertical upconing of water with a chloride concentration greater than 250 mg/L in the Deltona area by 2010 (Figure 15). However, SJRWMD does not have strong confidence in these results because the model is considered to be based on inadequate information concerning the depth to various concentrations of chlorides in the ground water system and the hydraulic parameters of the Lower Floridan aquifer and the middle semiconfining unit.

Seminole County Subregional Ground Water Flow and Solute Transport Model Area. The subregional ground water flow and solute transport model developed for the Seminole County area (Birdie and Blandford 1994) was used to assess changes in chloride concentrations in water in the Floridan aquifer system for the years 2010, 2060, and 2110 (Figure 16). This assessment indicates a combination of southwestward lateral and vertical movement of the 250-mg/L isochlor within the Upper Floridan aquifer. The magnitude of this movement is approximately 1.5 miles over a 100-year period in an area northeast and east of Oviedo. This predicted change in chloride concentrations is not projected to interfere with any existing or planned uses of water.

This model is based on inadequate data concerning water quality and hydraulic parameters in the Lower Floridan aquifer. For example, information from a recent Lower Floridan aquifer observation well construction project at Oviedo indicates that the current depth to the 250-mg/L chloride concentration is actually several hundred feet below the depth used in the model. Additional data collection and model revisions should improve the predictive capability of the model.

Eastern Orange County Subregional Ground Water Flow and Solute Transport Model Area. The subregional ground water flow and solute transport model developed for the eastern Orange County area (Blandford and Birdie 1993) was used to assess predicted changes in chloride concentrations in the Floridan aquifer system in response to projected 2010 ground water withdrawals for the years 2010, 2060, and 2110 (Figure 17). This assessment indicates the following.

- Continued upconing of water with chloride concentrations greater than 250 mg/L in the vicinity of the City of Cocoa wellfield, in response to projected increases in regional ground water withdrawals

- A combination of upconing and westward lateral intrusion of the 250-mg/L isochlor in the Upper Floridan aquifer in an area north and east of the City of Cocoa wellfield due to the projected regional decline in the potentiometric surface of the Upper Floridan aquifer

These projected increases in chloride concentrations are projected to result in the production of water with chloride concentrations greater than 250 mg/L from public supply wells owned and operated by the City of Cocoa and Econ Utilities. The eastern Orange County subregional ground water flow and solute transport model contains inadequate information concerning the water quality and the hydraulic parameters in the Lower Floridan aquifer and the middle semiconfining unit between the Upper and Lower Floridan aquifers. This lack of information restricts the usefulness of the model for making accurate predictions of water quality changes in those units.

Wekiva River Basin Subregional Flow and Solute Transport Model Area. The subregional flow and solute transport model developed for the Wekiva River subbasin (GeoTrans 1992b) was used to assess predicted changes in chloride concentrations in the Floridan aquifer system in response to projected 2010 ground water withdrawals for the years 2010, 2060, and 2110 (Rabbani 1994, pers. com.). This assessment indicates no predicted significant change in chloride concentrations in the water of the Floridan aquifer system for these time periods except in the vicinity of the Wekiva River in eastern Lake County just north of the Lake County–Orange County line. These predicted changes are in response to a projected reduction in ground water withdrawals from the Floridan aquifer system at Wekiva Falls Resort (Figure 18).

SURFACE WATER SOURCE EVALUATION

Overview of Resources

Streams, lakes, canals, and other surface waterbodies in SJRWMD provide water for various consumptive and non-consumptive uses. Although aquifers usually contain relatively high-quality water and are likely to remain the most widely used freshwater supply sources in SJRWMD, pressure to develop surface water sources could increase as ground water becomes less available. If environmentally and economically feasible, additional surface water could be made available for future use.

Water quality can limit surface water availability for certain uses if it is not economically feasible to treat the water to the level required for those intended uses. Surface water quality in SJRWMD varies both spatially and temporally due to natural processes and human activities that affect the chemical and microbiological character of waterbodies. The linkage between water quality and water availability is determined by the quality requirements for different intended uses. For example, TDS concentrations of 35,000 mg/L (equivalent to seawater) can be used by some industries, whereas a maximum of 500 mg/L is recommended for public supply (Prasifka 1988).

Compared to most ground water sources in SJRWMD, surface water sources generally are of lower quality. Surface waters tend to contain silts and suspended sediments, dissolved organic matter from topsoil, and chemical and microbiological contaminants from municipal wastewater discharges, stormwater runoff, and industrial and agricultural activities. The quality of surface water may vary seasonally with variation in flow rates or water levels.

Salinity is one of the most important water quality considerations in SJRWMD. In the coastal rivers of SJRWMD and the tidal reaches of the St. Johns, St. Marys, and Nassau rivers, the influx of seawater limits potential water uses to recreation and power plant cooling. Chloride concentrations generally decrease upstream from the mouths of these rivers as tidal influence diminishes.

In addition to the influence of tides, inflows of ground water with salinities higher than in receiving waters affect the spatial distribution of chloride concentrations in the St. Johns River. During low-flow periods, when there is little dilution from freshwater inflows, higher chloride concentrations occur in the tidally influenced lower reach of the river and in an upper reach between Lakes Harney and Poinsett. The higher chloride concentrations in the upper reach are due to inflows of ground water with higher chloride concentrations than in the receiving water, primarily through diffuse upward leakage and possible spring discharge (Tibbals 1990). In some reaches of the St. Johns River, the cost of treating saline water to the degree necessary for most agricultural and public supply needs may be too high.

Water Availability from Streams. Monthly stream discharges generally reflect the seasonal distribution of annual rainfall. Streams in SJRWMD usually exhibit at least two high- and low-flow seasons over the course of the year. The highest average monthly discharges throughout SJRWMD tend to occur in August, September, and October, when summer thunderstorms are common and tropical storms are most likely to occur. The high flow period in March and April is more signficant in the northern area of SJRWMD than in the southern area. More important, the lowest average monthly discharges tend to occur during the late fall to early winter months (November and December) and the late spring to early summer months (May and June). Because some of the highest demands for surface water occur during these low-flow periods, temporal fluctuations of water supply do not coincide with fluctuations in water demand. High irrigation water demands often occur during May and June and December, which is the beginning of the season for frost-and-freeze protection. USGS *Water Resources for Northeast Florida* reports, published on a water year basis (October through September) for all active surface water gages, are the most comprehensive sets of surface water stage and discharge data available for waterbodies in SJRWMD. As of September 1990 (USGS 1991), 84 stream gages, 16 canal gages, and 48 lake gages were active in SJRWMD.

A review of available USGS discharge data indicates that there are very few sites in SJRWMD where substantial quantities of water are likely to be available throughout the year. With the rare exception of streams with very stable base flows resulting from constant ground water discharge, most streams in SJRWMD would require artificial storage for an assured supply of water. An example is Lake Washington, which is a natural waterbody with a dam to improve water storage, located within the St. Johns River near Melbourne. The City of Melbourne receives its water supplies from Lake Washington (about 15 mgd) even though flow ceases occasionally in the St. Johns River. If the pressure to withdraw water from surface waterbodies becomes significant, the feasibility of providing storage may need to be incorporated into water availability assessments.

Quantities of water that can be developed from surface sources will be limited by the requirements of natural systems and the costs of treatment, storage, and distribution facilities. Streams with high flows generally offer greater potential as sources of water to meet projected needs. Table 10 lists streams with a mean discharge of 20 cubic feet per second (cfs) or greater including discharge values that were exceeded 50 percent and 75 percent of the time during the period of record. These sites are potential sites for surface water development. The feasibility of developing any of these potential sites for water supply should be assessed based upon the quantity of water to be withdrawn, the associated impacts on natural systems, and the cost of treatment, storage, and distribution facilities.

Water Availability from Stormwater Retention/Detention Facilities. Stormwater throughout developed areas is typically captured in constructed stormwater drainage and retention/detention systems. Water from these systems can be directly used to meet many non-potable water needs. Stormwater is commonly used as a source of golf course irrigation water.

A comprehensive assessment of the availability of water from these facilities has not been performed as part of the 1994 WSNS assessment.

Water Availability from Lakes. Most of the larger lakes in SJRWMD are part of the Ocklawaha or St. Johns river systems, and the quality and stage fluctuations of these lakes are similar to that of the rivers of which they are a part. Water quality problems currently limit water availability in the upper Ocklawaha River chain of lakes, including Lakes Apopka, Harris, Eustis, Griffin, Dora, and others. Major lakes of the St. Johns River system include Lakes George, Harney, Monroe, Jesup, Poinsett, and Washington and Crescent Lake. Other major lakes, including Newnans, Lochloosa, and Orange, are located in the Ocklawaha River Basin.

SJRWMD has begun the process of setting minimum lake levels pursuant to the provisions of Section 373.042, *FS*. These minimum lake levels may restrict the amount of water available from lakes. Levels established to date are included in Chapter 40C-8 *F.A.C.* (Appendix B). Proposed increases in water use through 2010 are not expected to result in the lowering of the surface water elevations of lakes below established minimum levels. The plan for establishment of additional levels is described in SJRWMD (1994).

Surface Water Impact Assessment

Surface water impact assessments were performed in areas considered to be in need of such assessments, based on

- the concentrations and magnitude of current and projected surface water withdrawals,
- existing surface water quality conditions,
- the potential for projected ground water impacts to affect surface water quality and quantity, and
- a consideration of historic water resource concerns.

The Upper St. Johns River Basin, the Wekiva River subbasin, and portions of the Middle and Lower St. Johns River basins and the Ocklawaha River Basin are areas that were assessed based on these criteria. Surface water source assessments will be scheduled for the future in delineated areas of inadequate ground water to meet projected needs.

Upper St. Johns River Basin. The surface water impact assessment for the Upper St. Johns River Basin focused on the basin within Indian River County where increases in surface water use are projected to support proposed increases in agricultural irrigation (Ritter and Moore, unpublished) and on Lake Washington in Brevard County where the continued withdrawal of surface water from Lake Washington is proposed to continue to supply drinking water to the City of Melbourne (Fox et al. 1993).

This assessment indicates that, at the present time, no additional surface water from the water management areas of the Upper St. Johns River Basin Project is available to meet projected increases in water use for agricultural irrigation or to compensate for possible reductions in the use of ground water as a backup source of supply. However, existing reservoirs and reservoirs to be constructed on area farms, in combination with tailwater recovery and captured rainfall runoff, should be adequate to supply the projected water needs through the year 2010, except during periods of extended drought when ground water may be used to supplement surface water supplies.

SJRWMD, in cooperation with the U.S. Fish and Wildlife Service and other governments, is preparing a water management plan for the Blue Cypress Water Management Area. A reassessment of the availability of water in this area is proposed following completion of this water management plan.

In addition, the assessment indicates that Lake Washington should continue to be available as a source of drinking water for the City of Melbourne provided "a comprehensive aquatic weed management approach that incorporates in-plant treatment, nuisance plant control, and long-term water quality improvement" (Fox et al. 1993) is developed and adequately implemented. Such a plan has been developed, but implementation depends on a continued source of funding, which at the current time has not been identified.

SJRWMD is currently completing studies designed to provide the information necessary to set minimum levels for Lake Washington and minimum flows for the St. Johns River downstream of the lake (SJRWMD 1994). Although it is not anticipated that these levels will significantly affect proposed withdrawals from the lake, a reassessment will be completed when these studies are complete.

Wekiva River Subbasin. The impact assessment of surface water in the Wekiva River subbasin focused on the effect of projected decreases in the discharges of springs in the basin on the flow of the river as a result of projected increases in ground water withdrawals between 1988 and 2010. Projected changes in spring discharge are reported on pages 34–42.

Projected decreases in spring discharges are projected to decrease median flows in the Wekiva River at State Road 46 by 41.1 cfs (26.5 mgd) between 1988 and 2010 (Rao and Clapp 1994, draft).

This reduction in spring flow represents a 16.5 percent reduction in river flow (Rao and Clapp 1994, draft) (Table 11).

Middle and Lower St. Johns River Basins. The impact assessment for the Middle and Lower St. Johns River basins focused on the effect of projected decreases in the discharges of springs in these basins on the flow of the St. Johns River as a result of projected increases in ground water withdrawals between 1988 and 2010. Projected changes in spring discharges are reported on pages 34–42.

Projected decreases in spring discharge are projected to decrease median flows in the St. Johns River at De Land (State Road 44) by 85.7 cfs (55.3 mgd) between 1988 and 2010 (Rao and Clapp 1994, draft) (Table 11). This reduction in flow represents a projected 3.6 percent reduction in flow. Reduced spring discharges in the Wekiva River subbasin account for 54 percent of this impact.

Ocklawaha River Basin. The impact assessment for the Ocklawaha River Basin focused on the effect of projected decreases in the discharges of springs in the basin. Projected decreases in the spring discharges are reported on pages 34–42.

Projected decreases in spring discharges to streams and lakes in the basin are projected to decrease flows and levels in the receiving waterbodies. However, no quantitative assessment of these projected impacts has been made to date.

Table 6. Summary of regional numerical ground water flow models. *All models used the MODFLOW model code (McDonald and Harbaugh 1988).*

Model Name	Publication Describing Model	Counties within Model Boundaries	Grid Size Range	Model Layers	Water Table Active or Constant Head	Calibration Periods	Predictive Simulation Periods
Northeast Florida Regional Ground Water Flow Model	"Finite-difference simulation of the Floridan aquifer system in northeast Florida and Camden County, Georgia" (Durden 1994, draft)	Parts of Duval, St. Johns, Nassau, and Clay counties and Camden County, Georgia	6,058 ft by 5,200 ft to 18,280 ft by 23,500 ft	SA-U, UCU, UFA, MSU, LSU, LFA, FPZ	Constant	Predevelopment and 1985	Predevelopment, 1985, and 2010
North-central Florida Regional Ground Water Flow Model	"North-central Florida regional ground water investigation and flow model" (Motz et al. 1994, draft)	Parts of Columbia, Baker, Duval, Union, Bradford, Clay, Alachua, Putnam, Marion, and Levy counties	5,000 ft by 5,000 ft to 15,000 ft by 20,000 ft	SA-U, UCU, UFA, MSU, LFA, LSU, FPZ	Constant	Predevelopment and 1985	Predevelopment, 1985, and 2010
Wekiva River Basin Regional Ground Water Flow Model	"Wekiva River Basin ground water flow and solute transport modeling study: Phase I: Regional ground water flow model development" (GeoTrans 1992a)	Parts of Lake, Seminole, Orange, Polk, Marion, and Volusia counties	3,400 ft by 3,400 ft to 15,300 ft by 20,600 ft	SA-U, UCU, UFA, MSU, LFA	Constant	Predevelopment and 1985	1988 and 2010
Volusia Basin Regional Ground Water Flow Model	"Revision and recalibration of a regional flow model of the Volusia ground water basin" (Williams 1994b, draft)	Volusia County and parts of Flagler, Putnam, Lake, and Seminole counties	1,320 ft by 1,320 ft to approx 7,920 ft by 7,920 ft	SA-U, UCU, UFA, MSU, LFA	Active	Predevelopment and 1988	Predevelopment, 1988, and 2010

Table 6—*Continued*

Model Name	Publication Describing Model	Counties within Model Boundaries	Grid Size Range	Model Layers	Water Table Active or Constant Head	Calibration Periods	Predictive Simulation Periods
Titusville/Mims Regional Ground Water Flow Model	"Development and application of a regional ground water flow model of the surficial aquifer system in the Titusville/Mims area of Brevard County, Florida" (Williams 1994c, draft)	Northern Brevard County	1,000 ft by 1,000 ft to 2,500 ft by 2,500 ft	SA-U, UCU, UFA, MSU, LFA	Active	Predevelopment and 1988	Predevelopment, 1988, and 2010
East-central Florida Regional Ground Water Flow Model	"Regional ground-water flow modeling for east-central Florida with emphasis on Orange and Seminole counties" (Blandford and Birdie 1992)	All of Orange and Seminole counties and parts of Brevard, Osceola, Polk, Lake, and Volusia counties	900 ft by 1,050 ft to 5,280 ft by 5,280 ft	SA-U, UCU, UFA, MSU, LFA	Constant	Predevelopment and 1988	1991 and 2010
West Volusia-Southeast Putnam Regional Ground Water Flow Model	"Regional simulation of projected ground water withdrawals from the Floridan aquifer system in western Volusia County and southeastern Putnam County, Florida" (McGurk 1994a, draft)	All of Volusia and Flagler counties and parts of Putnam, Lake, and Seminole counties	1,500 ft by 1,500 ft to 10,000 ft by 10,000 ft	SA-U, UCU, UFA, MSU, LFA	Constant	Predevelopment and 1988 (steady-state); and 1/22/91–2/1/91 (transient)	2010 (steady-state) and short-term freeze event (transient)

SA-U = Surficial aquifer unconfined
MSU = Middle semiconfining unit
LFA = Lower Floridan aquifer
UCU = Upper confining unit
LSU = Lower semiconfining unit
UFA = Upper Floridan aquifer
FPZ = Fernandina permeable zone

Table 7. Summary of analytical ground water flow models

Area Modeled	Publication Describing Model	Analytical Technique	Aquifers Simulated
Gainesville Regional Utilities wellfield area, Alachua County	"Projected aquifer drawdowns: Murphree wellfield, Gainesville Regional Utilities: Alachua County, Florida" (Fischl 1994a)	DRAWDOWN (Motz 1981)	SA-C, UFA
City of Ocala wellfield area, Marion County	"Projected aquifer drawdowns: City of Ocala Wellfield: Marion County, Florida" (Fischl 1994b)	DRAWDOWN (Motz 1981)	SA-U, UFA
City of Leesburg wellfield area, Lake County	"Projected aquifer drawdowns: City of Leesburg wellfields: Lake County, Florida" (Fischl 1994c, draft)	MLTLAY (Bear 1979)	SA-C, UFA
Palm Coast Utilities wellfield area, Flagler County	"Projected aquifer drawdowns: Palm Coast Utility wellfields: Flagler County, Florida" (Huang 1994, draft)	MLTLAY (Bear 1979) and DRAWDOWN (Motz 1981)	SA-U, SA-C, UFA
Tillman Ridge wellfield, St. Johns County	"Projected aquifer drawdowns: Tillman Ridge wellfield: St. Johns County, Florida" (Toth 1994a)	MLTLAY (Bear 1979) and SURFDOWN (Huang et al. 1994, draft)	SA-U, SA-C, UFA
City of St. Augustine wellfield, St. Johns County	"Projected aquifer drawdowns: City of St. Augustine wellfield: St. Johns County, Florida" (Toth 1994b)	MLTLAY (Bear 1979) and SURFDOWN (Huang et al. 1994, draft)	SA-U, SA-C, UFA
City of Vero Beach and Indian River County wellfields, Indian River County	"Projected aquifer drawdowns: City of Vero Beach and Indian River County wellfields: Indian River County, Florida" (Toth 1994c)	MLTLAY (Bear 1979)	SA-U, UFA
Palm Bay Utility Corporation wellfield, Brevard County	"Projected aquifer drawdowns: Palm Bay Utilities Corporation wellfield: Brevard County, Florida" (Toth 1994d)	MLTLAY (Bear 1979) and SURFDOWN (Huang et al. 1994, draft)	SA-U, SA-C, UFA

SA-U = Surficial aquifer unconfined
SA-C = Surficial aquifer confined
UFA = Upper Floridan aquifer

Table 8. Summary of subregional flow and ground water quality models

Model Name	Publication Describing Model	Model Code	Grid Size Range	Number of Model Layers	Calibration Periods	Predictive Simulation Periods*
Eastern Volusia Subregional Flow and Solute Transport Model	"Development and application of a saltwater intrusion model of eastern Volusia County, Florida" (Williams 1994a, draft)	DSTRAM (Huyakorn and Panday 1991)	1,320 ft by 1,320 ft to 2,640 ft by 2,640 ft	17	Predevelopment and 1988	Predevelopment, 1988, 2010, 2060, and 2110
Northeast Florida Regional Sharp-Interface Ground Water Model	"Sharp-interface model of the Floridan aquifer in northeast Florida and Camden County, Georgia" (Durden and Huang 1994, draft)	SIMLAS (Park and Huyakorn 1993)	5,200 ft by 6,100 ft to 23,400 ft by 21,350 ft	3	Predevelopment and 1985	Predevelopment, 1985, 2010, 2060, 2110, and 2985
Wekiva River Basin Subregional Flow and Solute Transport Model	"Wekiva River Basin ground water flow and solute transport modeling study: Phase III: Three-dimensional density dependent ground water flow and solute transport model development" (GeoTrans 1992b)	SWICHA (GeoTrans 1991)	660 ft by 1,980 ft to 2,640 ft by 2,640 ft	14	Predevelopment and 1988	1988 and 2010
Northwest Volusia-Southeast Putnam Subregional Ground Water Flow Model	"Subregional simulations of projected ground water withdrawals from the Floridan aquifer system in western Volusia County and southeastern Putnam County, Florida, with particular reference to saltwater intrusion" (McGurk 1994b, draft)	MODFLOW with MODPATH and MODPATH-PLOT (McDonald and Harbaugh 1988; Pollock 1989)	2,000 ft by 2,000 ft	10	Predevelopment and 1988	2010, 2060, and 2110

Table 8—*Continued*

Model Name	Publication Describing Model	Model Code	Grid Size Range	Number of Model Layers	Calibration Periods	Predictive Simulation Periods*
Eastern Orange County Subregional Ground Water Flow and Solute Transport Model	"Ground-water flow and solute transport modeling study for eastern Orange County, Florida, and adjoining regions" (Blandford and Birdie 1993)	DSTRAM (Huyakorn and Panday 1991)	2,640 ft by 5,610 ft to 3,168 ft by 5,610 ft	19	Predevelopment and 1988	2010, 2060, and 2110
Seminole County Subregional Ground Water Flow and Solute Transport Model	"Ground-water flow and solute transport modeling study for Seminole County, Florida, and adjoining regions" (Birdie and Blandford 1994)	DSTRAM (Huyakorn and Panday 1991)	1,320 ft by 3,168 ft to 2,640 ft by 3,168 ft	19	Predevelopment and 1988	2010, 2060, and 2110
Western Volusia Subregional Ground Water Flow and Water Quality Model	"Subregional simulations of projected ground water withdrawals from the Floridan aquifer system in western Volusia County and southeastern Putnam County, Florida, with particular reference to saltwater intrusion" (McGurk 1994b, draft)	MODFLOW with MODPATH and MODPATH-PLOT (McDonald and Harbaugh 1988; Pollock 1989)	2,000 ft by 2,000 ft	10	Predevelopment and 1988	2010, 2060, and 2110

*All predictive simulations other than predevelopment are based on projected 2010 ground water withdrawals

Table 9. Projected changes in median spring discharge as a result of projected increases in ground water withdrawals between 1988 and 2010

Spring Name	County	Historic Median Discharge (cfs)	Projected 2010 Discharge (cfs)	Changes in Median Spring Discharge by 2010 (cfs)	Percent Reduction by 2010	Required Minimum Discharge* (cfs)
Springs discharging to the St. Johns River upstream of U.S. Highway 17 at Sanford						
Harney, south	Volusia	24.6	19.6	5.0	20.4	-----
Harney, north	Volusia	20.2	15.9	4.3	21.5	-----
Clifton Springs	Seminole	1.7	1.1	0.6	37.1	-----
Lake Jesup Spring	Seminole	1.0	0.7	0.3	30.6	-----
Lake Jesup	Seminole	5.6	4.2	1.4	24.9	-----
Gemini Springs	Volusia	8.5	6.8	1.7	20.0	-----
Green Springs	Volusia	0.8	0.4	0.4	50.0	-----
Springs discharging to the Wekiva River upstream of State Road 46						
Wekiva Springs	Orange	67.8	58.8	9.0	13.4	62.00
Rock Springs	Orange	60.9	49.1	11.8	19.4	53.00
Witherington Spring	Orange	4.7	3.8	0.9	19.3	-----
Miami Springs	Seminole	4.7	3.9	0.8	16.9	4.00
Sanlando Springs	Seminole	19.7	11.3	8.4	42.6	15.00
Starbuck Spring	Seminole	14.5	7.4	7.1	49.0	13.00
Palm Springs	Seminole	7.7	4.6	3.1	40.4	7.00
Springs discharging between the Wekiva River at State Road 46 and the St. Johns River at State Road 44						
Island Spring	Seminole	6.1	5.9	0.2	3.4	-----
Seminole Springs	Lake	35.8	31.8	4.0	11.2	34.00
Messant Spring	Lake	14.9	14.0	0.9	6.2	12.00
Camp La No Che Spring	Lake	0.9	0.8	0.1	12.7	-----
Blue Spring	Volusia	158.4	132.9	25.5	16.1	-----
Springs discharging to the St. Johns River below State Road 44 at De Land						
St. Johns River	Volusia	8.9	7.0	1.9	20.9	-----
Ponce de Leon Springs	Volusia	27.0	25.6	1.4	4.9	-----
Alexander Springs	Lake	108.2	105.4	2.8	2.6	-----
Alexander Creek	Lake	30.0	29.2	0.8	2.6	-----
Croaker Hole Spring	Putnam	86.7	82.5	4.2	4.8	-----
Beecher Springs	Putnam	9.9	9.5	0.4	3.4	-----

Table 9—*Continued*

Spring Name	County	Historic Median Discharge (cfs)	Projected 2010 Discharge (cfs)	Changes in Median Spring Discharge by 2010 (cfs)	Percent Reduction by 2010	Required Minimum Discharge* (cfs)
Mud and Forest springs	Putnam	2.6	2.6	0.0	0.0	-----
Welaka Spring	Putnam	2.4	2.4	0.0	0.0	-----
Satsuma and Nashua springs	Putnam	2.0	2.0	0.0	0.0	-----
Springs discharging in the Ocklawaha River Basin						
Apopka Spring	Lake	36.0	21.3	14.7	40.8	-----
Blue Springs	Lake	3.0	0.9	2.1	70.0	-----
Holiday Springs	Lake	3.6	1.6	2.0	56.3	-----

*Required by Rule 40C-8, *Florida Administrative Code*

Note: cfs = cubic feet per second
----- = no projection

Table 10. U.S. Geological Survey gaged streams in the St. Johns River Water Management District with mean discharges of at least 20 cubic feet per second (cfs)

Stream Name	Mean Discharge	Discharge Exceeded 75% of Time	Discharge Exceeded 50% of Time	Period of Record
Nassau River Basin				
Thomas Creek	35	5.0	11	1965–93
St. Marys River Basin				
Turkey Creek (St. Marys)	28	2.0	5.8	1956–69, 1976–77
Middle Prong St. Marys River	107	4.7	34	1956–67, 1976–93
South Prong St. Marys River	152	9.0	33	
North Prong St. Marys River	156	12	49	1921–23, 1927–30, 1932–34, 1950–93
St. Marys River near MacClenny	665	77	232	1927–93
Lower St. Johns River Basin				
Pablo Creek	35	9.8	19	1974–93
Ortega River	38	4.5	12	1965–93
Rice Creek	41	6.8	13	1974–93
Simms Creek	44	12	19	1974–93
Middle Haw Creek	73	1.7	14	1975–93
Little Haw Creek	80	7.0	28	1951–93
Etonia Creek	95	58	74	1974–90
South Fork, Black Creek	151	44	73	1940–93
North Fork, Black Creek	192	37	73	1932–93
Middle St. Johns River Basin				
Little Econolockhatchee River	28	6.7	14	1960–93
Howell Creek	28	10	19	1972–79, 1981–93
Little Wekiva River	33	15	23	1972–79, 1982–93
Blackwater Creek	58	17	35	1967–69, 1981–93
Deep Creek near Osteen	99	7.8	32	1965–66, 1981–92
Econolockhatchee River	267	53	109	1936–93
Wekiva River	285	217	250	1936–93
St. Johns River at De Land	3,025	1,449	1,852	1934–93
Upper St. Johns River Basin				
Wolf Creek	30	1.7	5.4	1956–93
Fort Drum Creek	43	5.0	14	1977–93
Jane Green Creek	210	7.2	40	1954–93
St. Johns River at Melbourne	655	111	295	1940–93

Table 10—*Continued*

Stream Name	Mean Discharge	Discharge Exceeded 75% of Time	Discharge Exceeded 50% of Time	Period of Record
St. Johns River at Cocoa	933	223	576	1954–93
St. Johns River at Christmas	1,270	303	796	1934–93
St. Johns River at Lake Harney	1,774	622	1,273	1982–93
Ocklawaha River Basin				
Hogtown Creek	20	6.1	11	1972–93
Big Creek	23	1.6	6.9	1958–92
Palatlakaha River at Cherry Lake Outlet	41	1.1	2.5	1957–93
Ocklawaha River at Buckman Lock	42	15	35	1970–93
Prairie Creek	66	11	33	1978–93
Apopka Beauclair Canal	73	23	33	1958–93
Camps Canal	75	8.1	30	1957–60, 1978–93
Orange Lake Outlet	88	1.7	22	1947–55, 1982–93
Palatlakaha River at Mascotte	95	17	54	1945–56, 1964–65
Orange Creek	136	15	55	1942–52, 1956–71, 1975–93
Haines Creek	239	46	204	1942–78, 1985–93
Ocklawaha River at Moss Bluff	256	31	139	1944–55, 1967–93
Ocklawaha River at Ocala	407	181	328	1930–68
Silver Springs	798	698	784	1933–93
Ocklawaha River at Conner	1,099	789	996	1930–46, 1977–93
Ocklawaha River at Eureka	1,240	824	1,132	1930–34, 1943–52, 1981–93
Ocklawaha River at Rodman Dam	1,338	732	1,091	1969–93
Ocklawaha River at Riverside	2,017	1,241	1,775	1944–68
Upper Coastal Basin				
Spruce Creek	31	1.9	6.2	1951–93
Tomoka River	51	4.6	17	1965–93
Indian River Lagoon				
North Canal	32	11	17	1951–93
South Canal	39	9.5	17	1951–93
Main Canal	76	26	42	1949–93

Table 11. Impacts of projected changes in spring discharge on receiving surface waterbodies

Spring Name	Changes in Median Spring Discharge by 2010 (cfs)	Historic Median Flow St. Johns River at SR 44 (cfs)	Projected* Median Discharge St. Johns River at SR 44 by 2010 (cfs)	Percent Change in Median Discharge St. Johns River at SR 44 by 2010 (cfs)
Springs discharging to the St. Johns River upstream of U.S. Highway 17 at Sanford				
Harney, south	5.0	2,358	2,353	0.2
Harney, north	4.3	2,358	2,354	0.2
Clifton Springs	0.6	2,358	2,357	less than 0.1
Lake Jesup Spring	0.3	2,358	2,358	less than 0.1
Lake Jesup	1.4	2,358	2,357	0.1
Gemini Springs	1.7	2,358	2,356	0.1
Green Springs	0.4	2,358	2,358	less than 0.1
SUBTOTAL	13.8	2,358	2,344	0.6
Springs discharging to the Wekiva River upstream of SR 46				
Wekiva Springs	9.1	250	241	3.6
Rock Springs	11.8	250	238	4.7
Witherington Spring	0.9	250	249	0.4
Miami Springs	0.8	250	249	0.3
Sanlando Springs	8.4	250	242	3.4
Starbuck Springs	7.1	250	243	2.8
Palm Springs	3.1	250	247	1.3
SUBTOTAL	41.1	250	209	16.5
Springs discharging between the Wekiva River at SR 46 and the St. Johns River at SR 44				
Island Spring	0.2	2,358	2,358	less than 0.1
Seminole Springs	4.0	2,358	2,354	0.2
Messant Spring	0.9	2,358	2,357	less than 0.1
Camp La No Che Spring	0.1	2,358	2,358	less than 0.1
Blue Spring	25.5	2,358	2,332	1.1
SUBTOTAL	30.8	2,358	2,327	1.3
All springs discharging upstream of SR 44				
GRAND TOTAL	85.7	2,358	2,272	3.6

Table 11—*Continued*

Spring Name	Changes in Median Spring Discharge by 2010 (cfs)	Historic Median Flow St. Johns River at SR 44 (cfs)	Projected* Median Discharge St. Johns River at SR 44 by 2010 (cfs)	Percent Change in Median Discharge St. Johns River at SR 44 by 2010 (cfs)
Springs discharging to the St. Johns River below SR 44 at De Land				
St. Johns River	1.9	2,358	------	0.1
Ponce de Leon Springs	1.3	2,358	------	0.1
Alexander Springs	2.8	2,358	------	0.1
Alexander Creek	0.8	2,358	------	less than 0.1
Croaker Hole Spring	4.2	2,358	------	0.2
Beecher Springs	0.3	2,358	------	less than 0.1
Mud and Forest springs	0.0	2,358	------	0.0
Welaka Spring	0.0	2,358	------	0.0
Satsuma and Nashua springs	0.0	2,358	------	0.0
TOTAL	11.3	2,358	------	0.5
Springs discharging in the Ocklawaha River Basin				
Apopka Spring	14.7	150	135	9.8
Blue Springs (Lake)	2.1	150	148	1.4
Holiday Springs	2.0	150	148	1.4
TOTAL	18.8	150	131	12.6

*Projected river discharges reflect only the impact of projected changes in individual spring discharges

Note: cfs = cubic feet per second
SR = State Road
----- = no projection

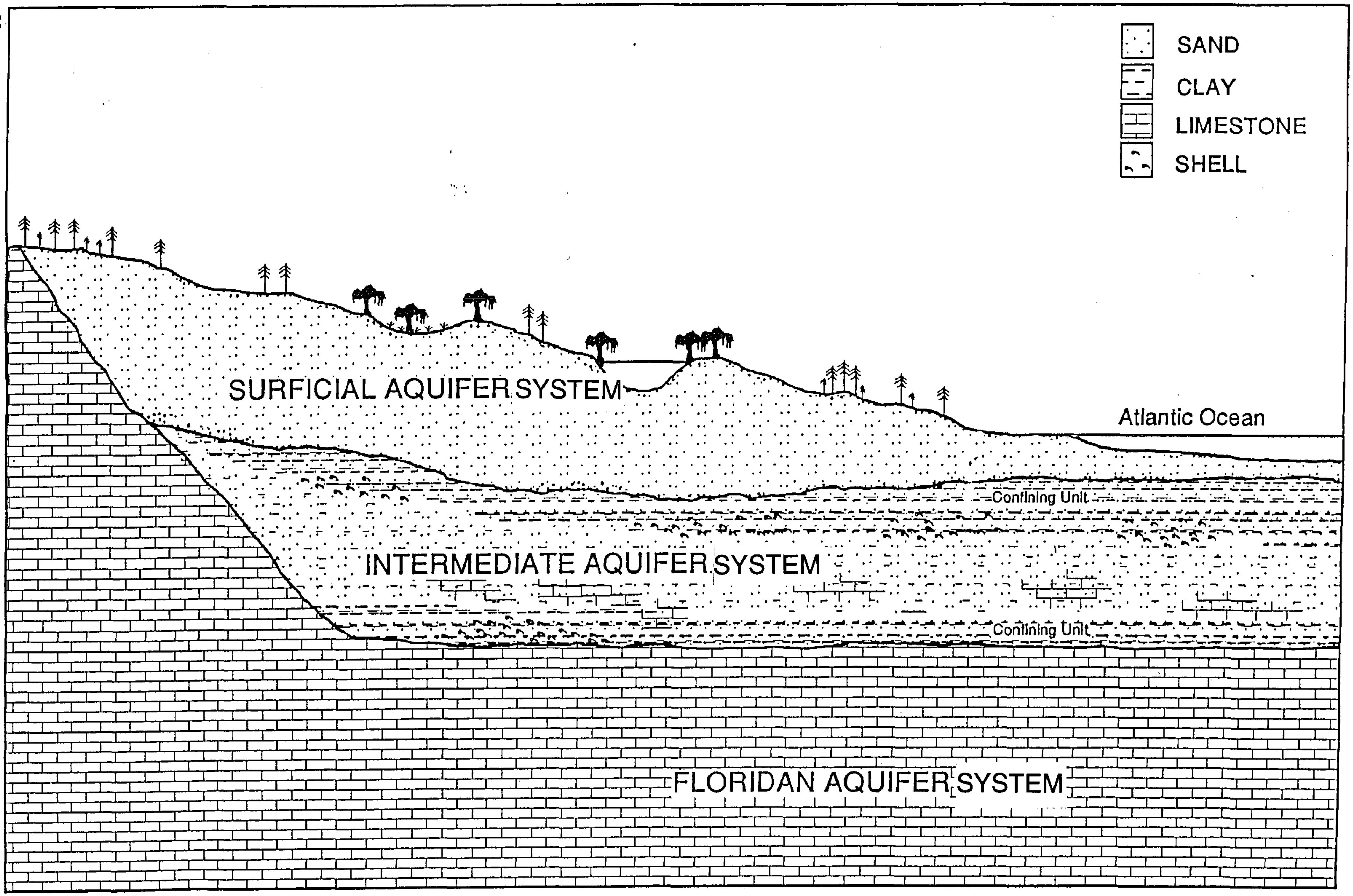


Figure 3. Generalized east-west hydrogeologic cross section of the St. Johns River Water Management District

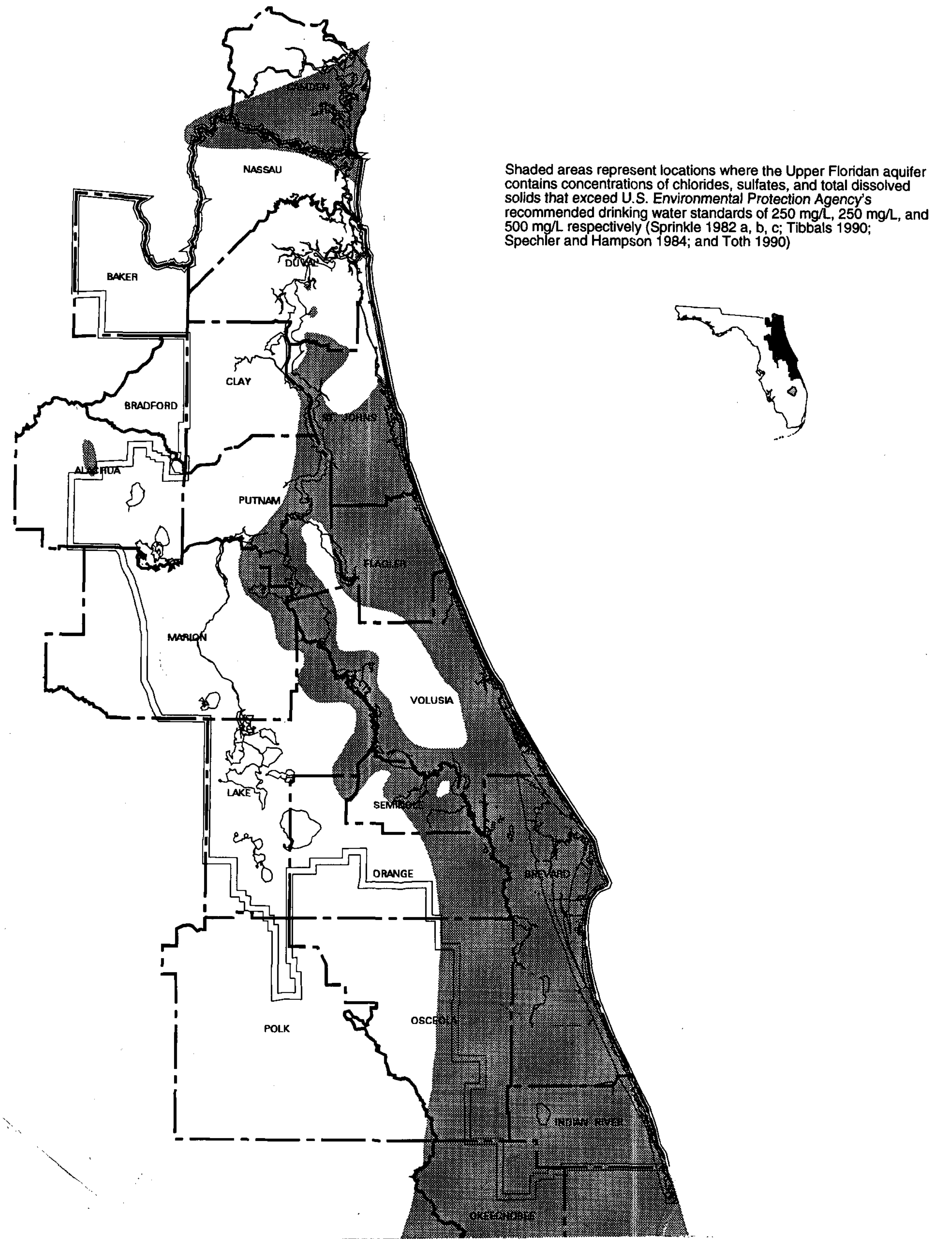


Figure 4. Areas where concentrations of chlorides, sulfates, and total dissolved solids exceed secondary drinking water standards in the Upper Floridan aquifer

County boundary
District boundary
Public supply service area

Miles
0 4 8
Scale 1:1858579
N

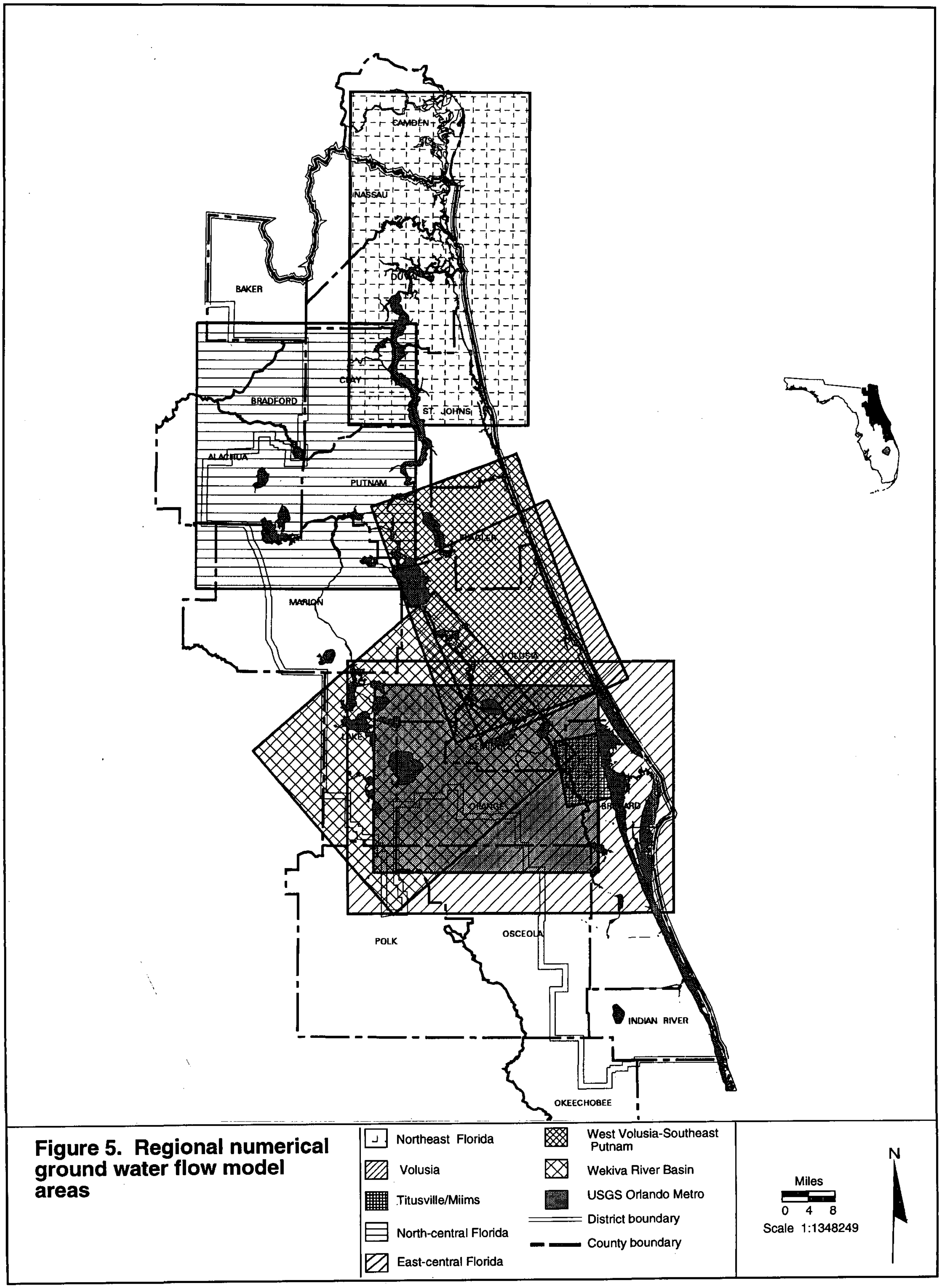


Figure 5. Regional numerical ground water flow model areas

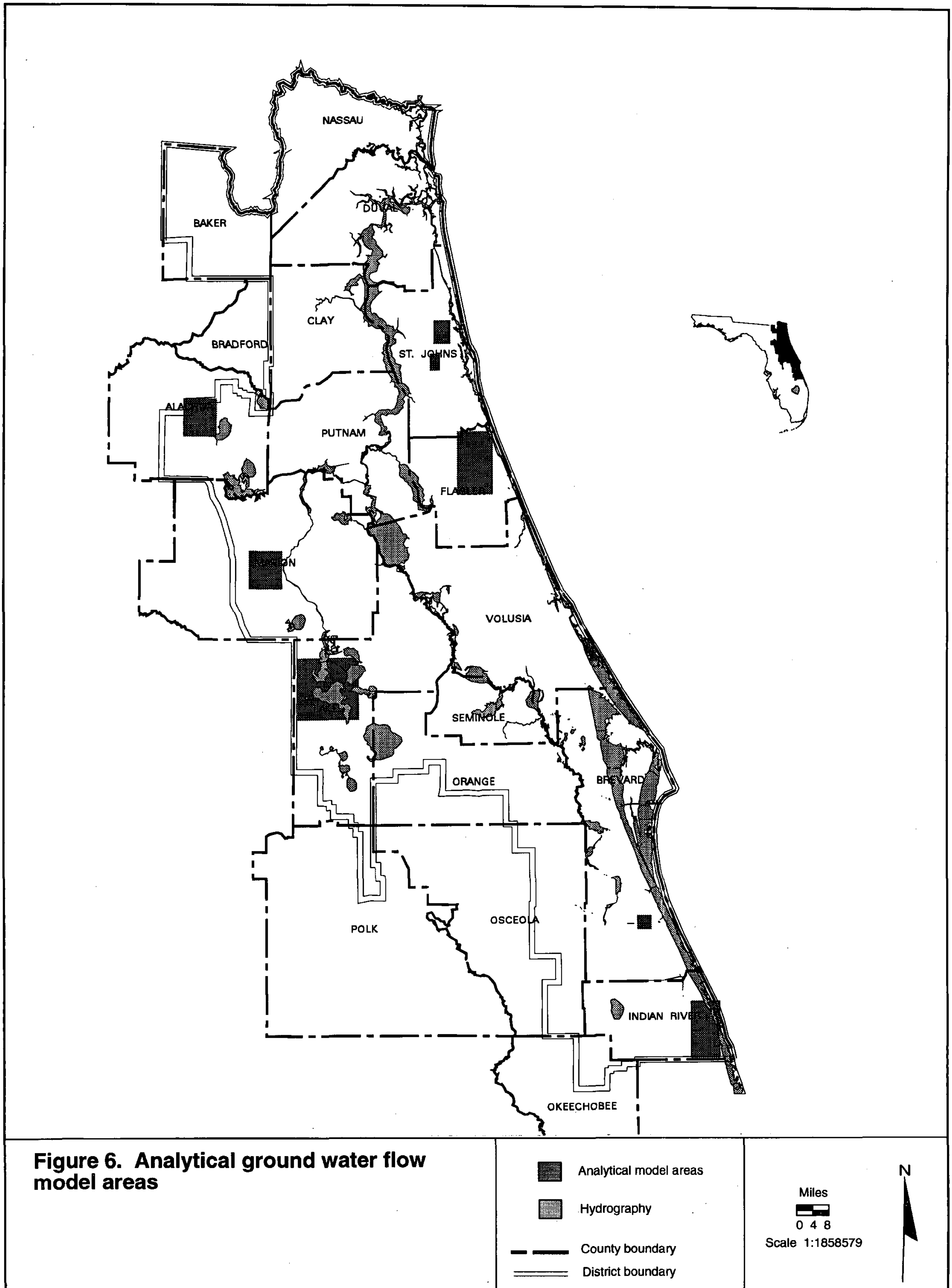


Figure 6. Analytical ground water flow model areas

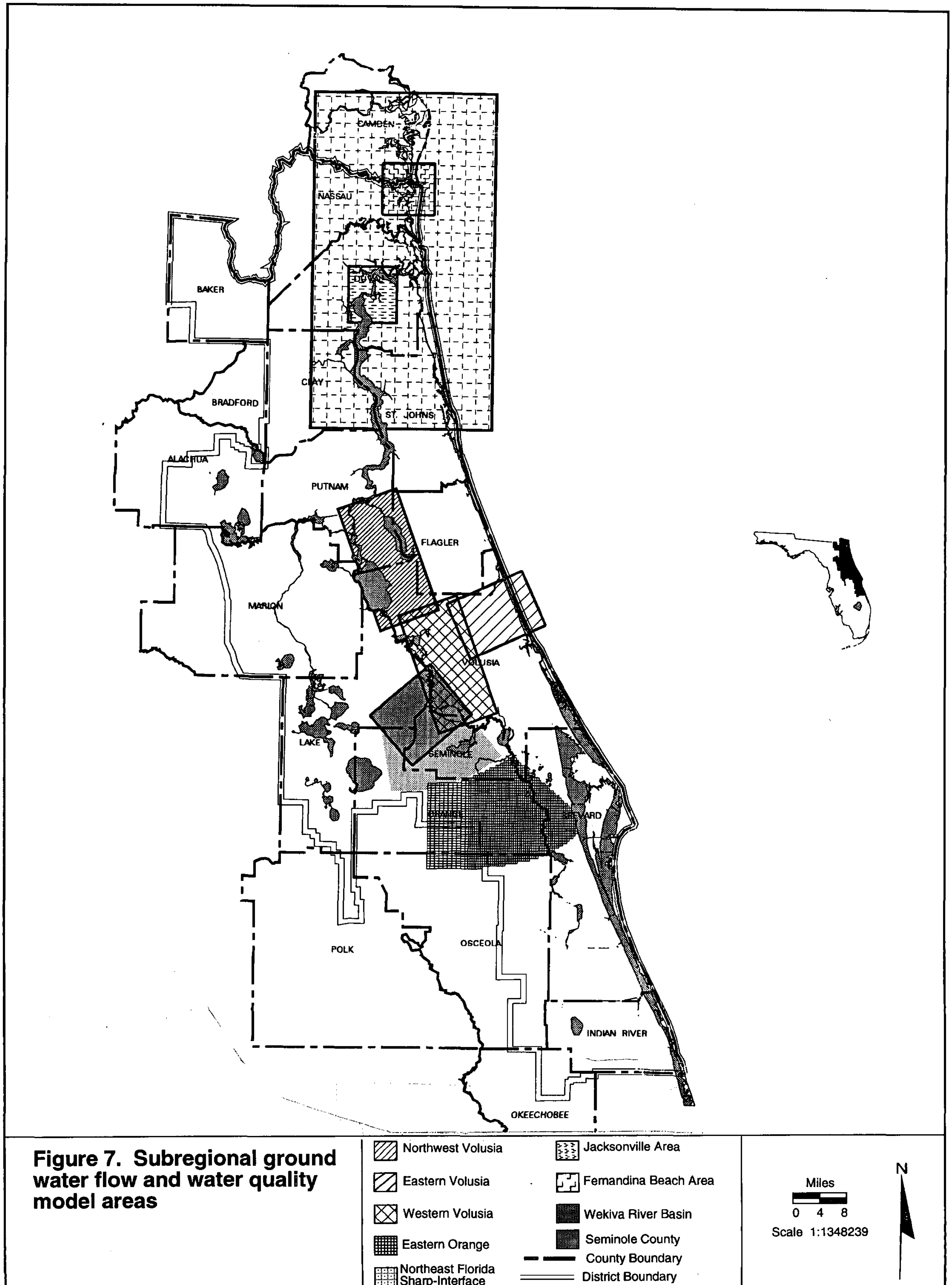


Figure 7. Subregional ground water flow and water quality model areas

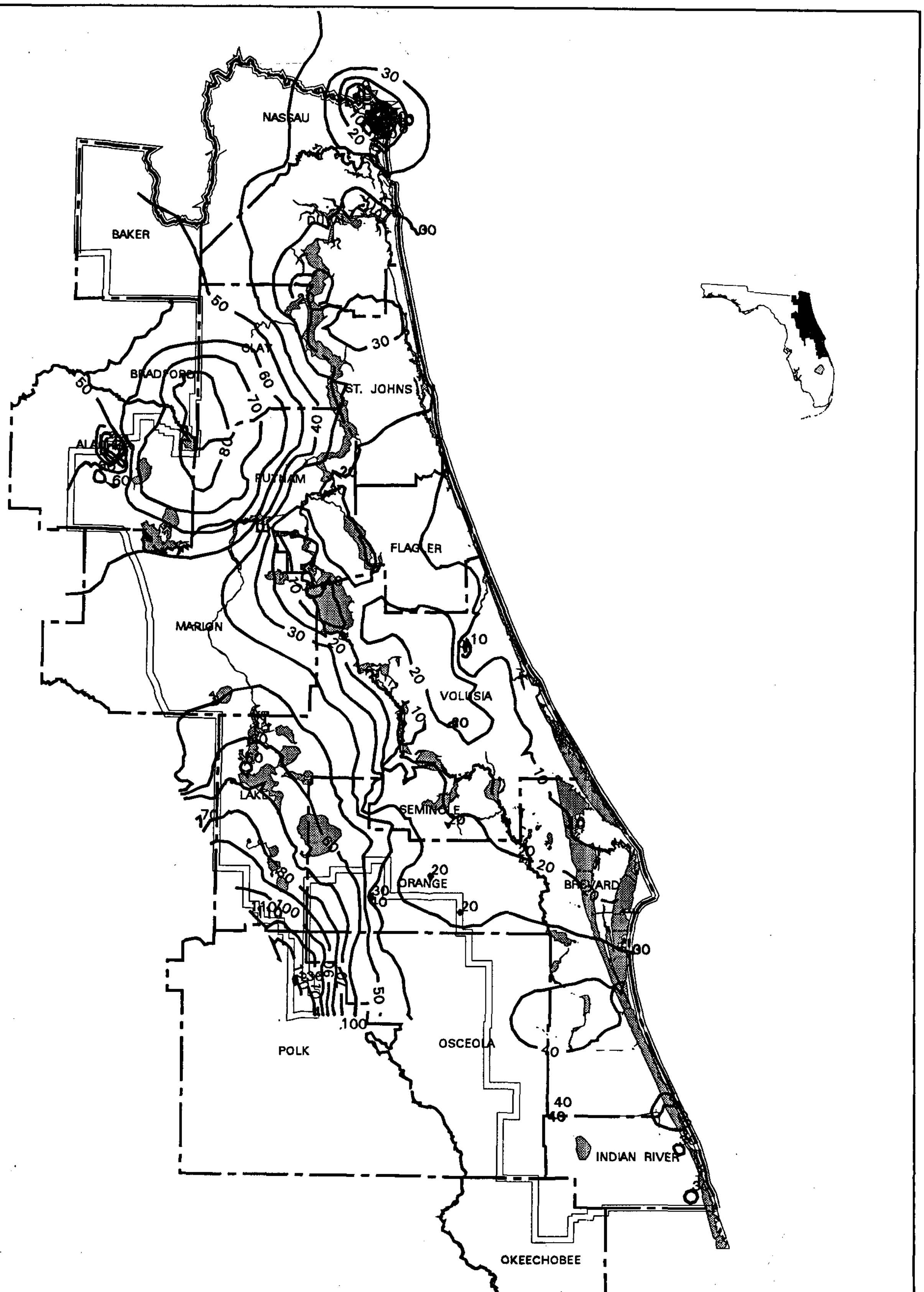


Figure 8. Simulated potentiometric surface of the Upper Floridan aquifer, 2010

-10- Potentiometric contour
Datum is sea level
(NGVD, 1929)

Hydrography

District boundary

County boundary

Miles
0 4 8
Scale 1:1858579

N

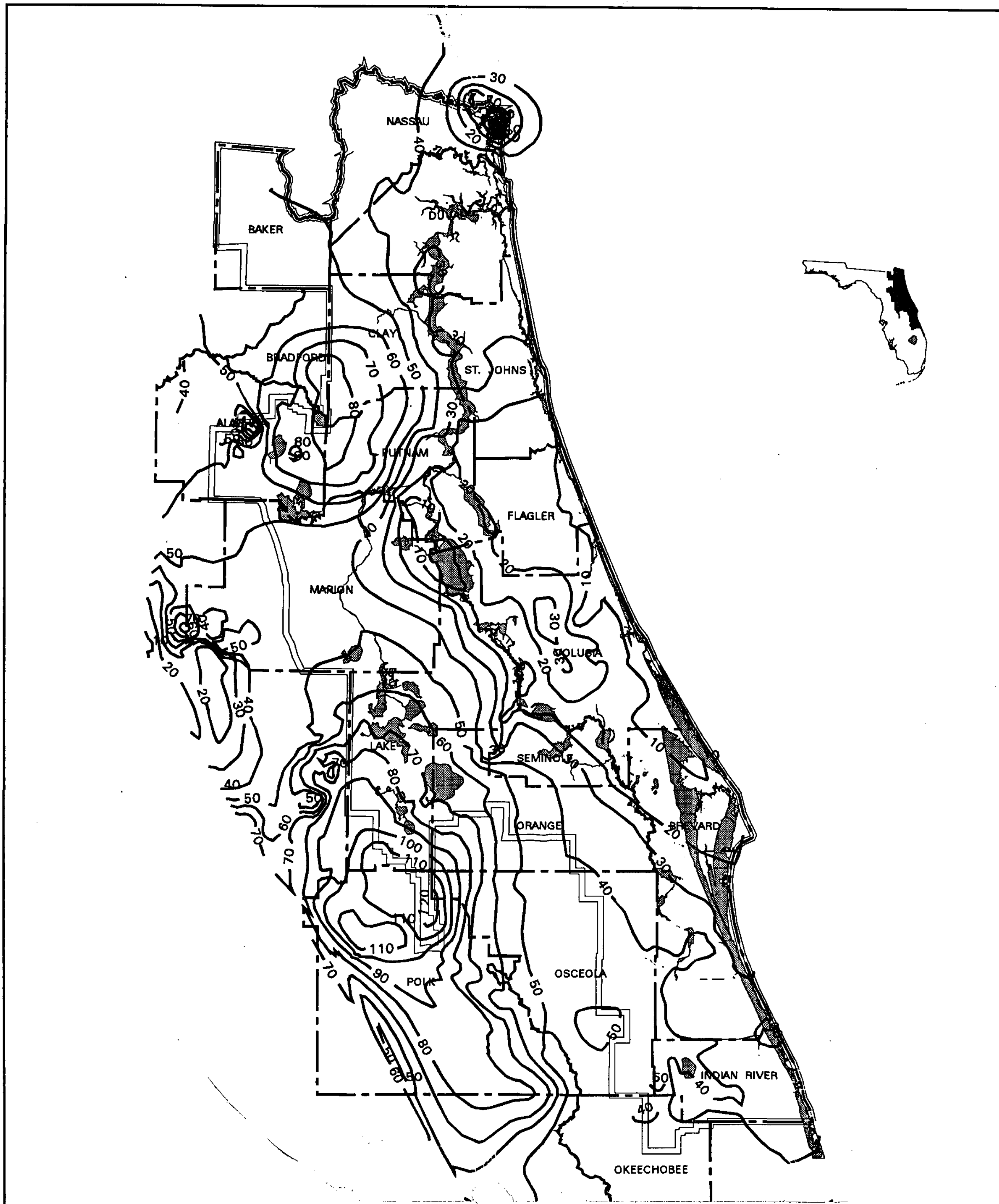


Figure 9. Simulated potentiometric surface of the Upper Floridan aquifer, 1988

-10- Potentiometric contour
Datum is sea level
(NGVD, 1929)

Hydrography

District boundary

County boundary

Miles
0 4 8
Scale 1:1858579

N

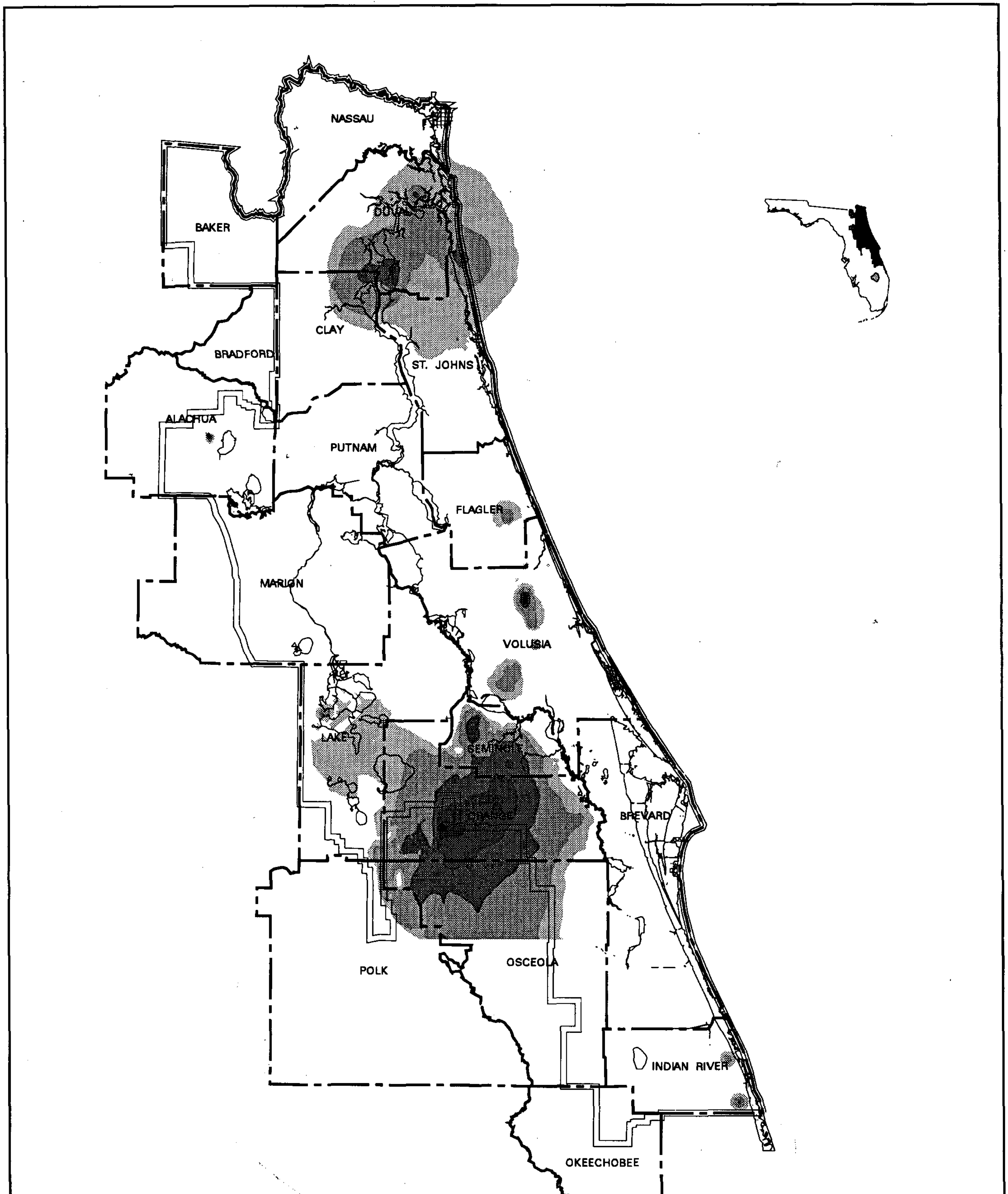


Figure 10. Projected change in the potentiometric surface of the Upper Floridan aquifer, 1988 to 2010

Increase 0 to 5 ft
Decrease < 3 ft
Decrease 3 to 5 ft
Decrease 5 to 10 ft
Decrease 10 to 15 ft
Decrease 15 to 20 ft
Decrease 20 to 25 ft
Decrease > 25 ft
District boundary
County boundary

Miles
0 4 8
Scale 1:1858579

N

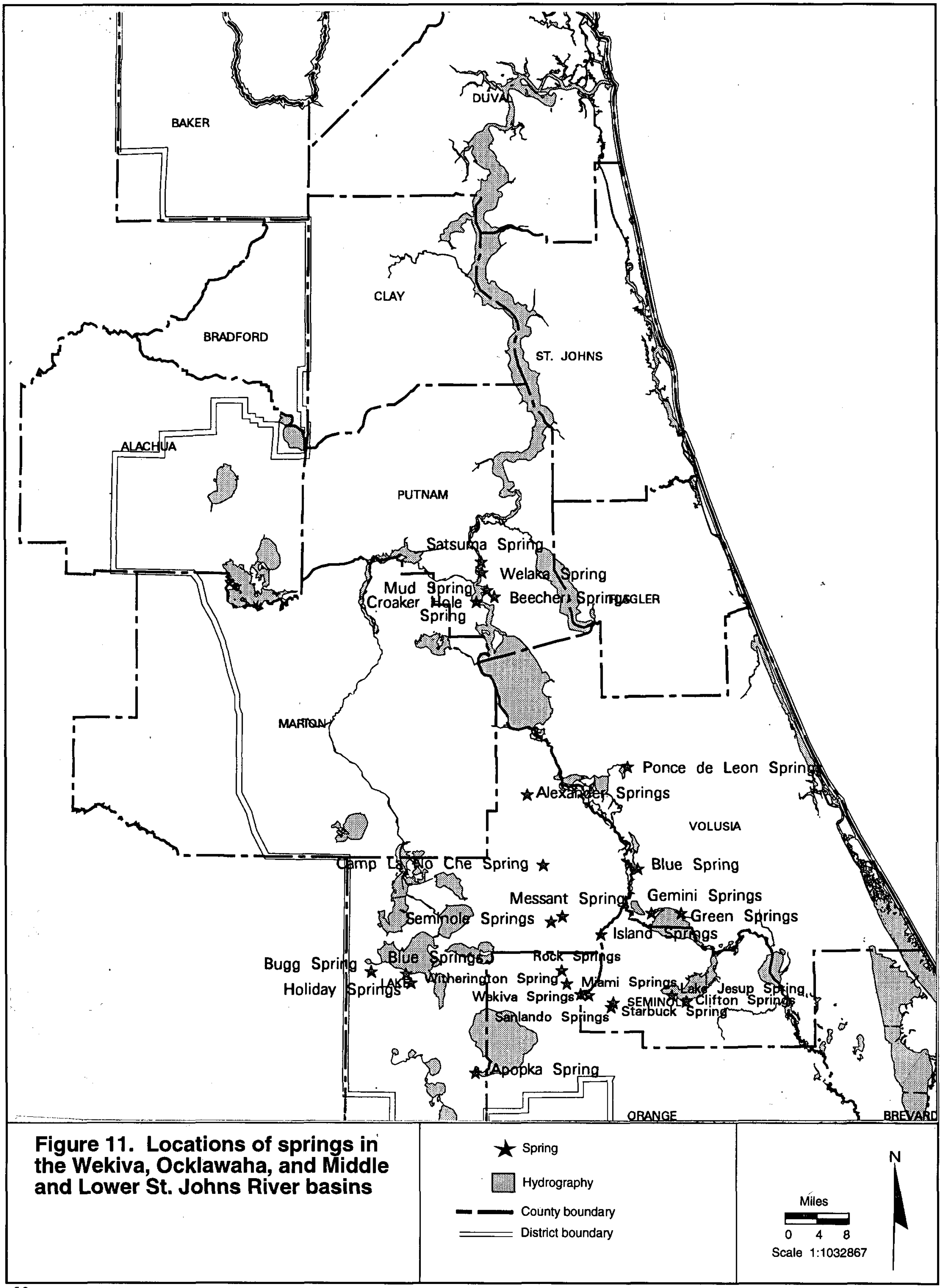


Figure 11. Locations of springs in the Wekiva, Ocklawaha, and Middle and Lower St. Johns River basins

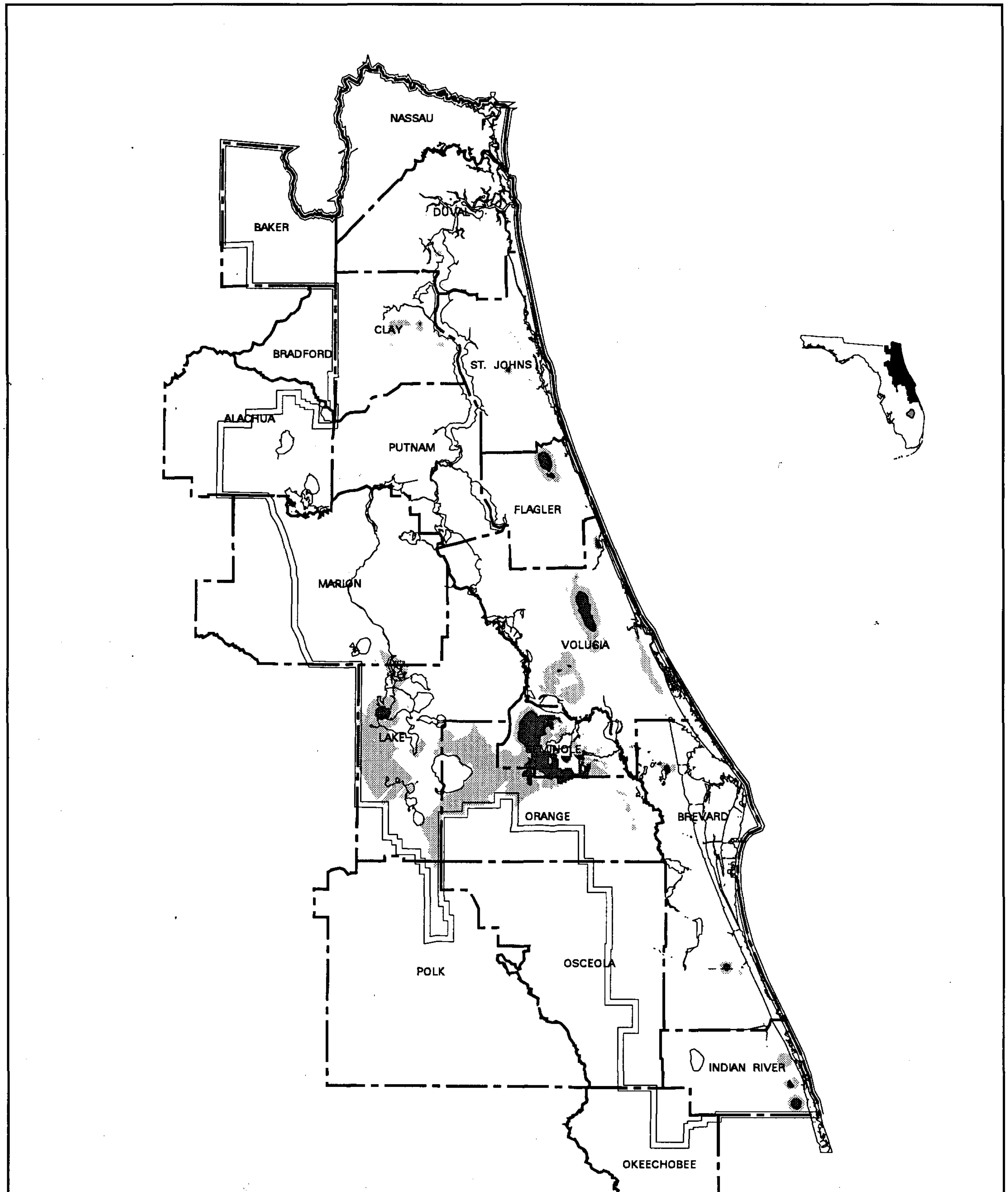


Figure 12. Projected change in the elevation of the water table of the surficial aquifer system, 1988 to 2010

Decline in elevation of less than 1 ft

Decline in elevation of 1 to 2.5 ft

Decline in elevation of greater than 2.5 ft

County boundary

District boundary

Miles

0 4 8

Scale 1:1858579

N

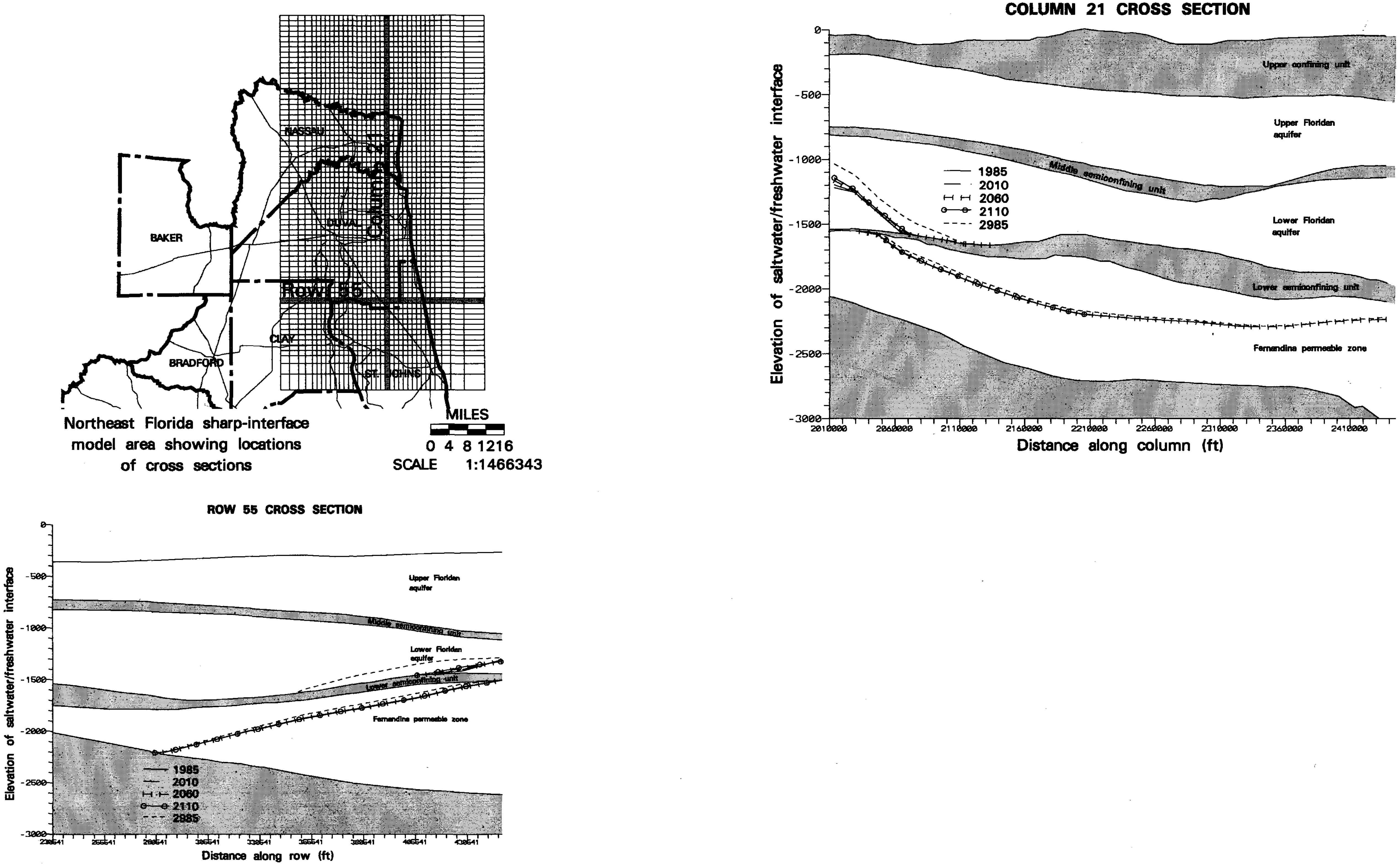


Figure 13. Simulated position of the saltwater-freshwater interface in the northeast Florida sharp-interface model area for 1985, 2010, 2060, 2110, and 2985 (Durden and Huang 1994, draft)

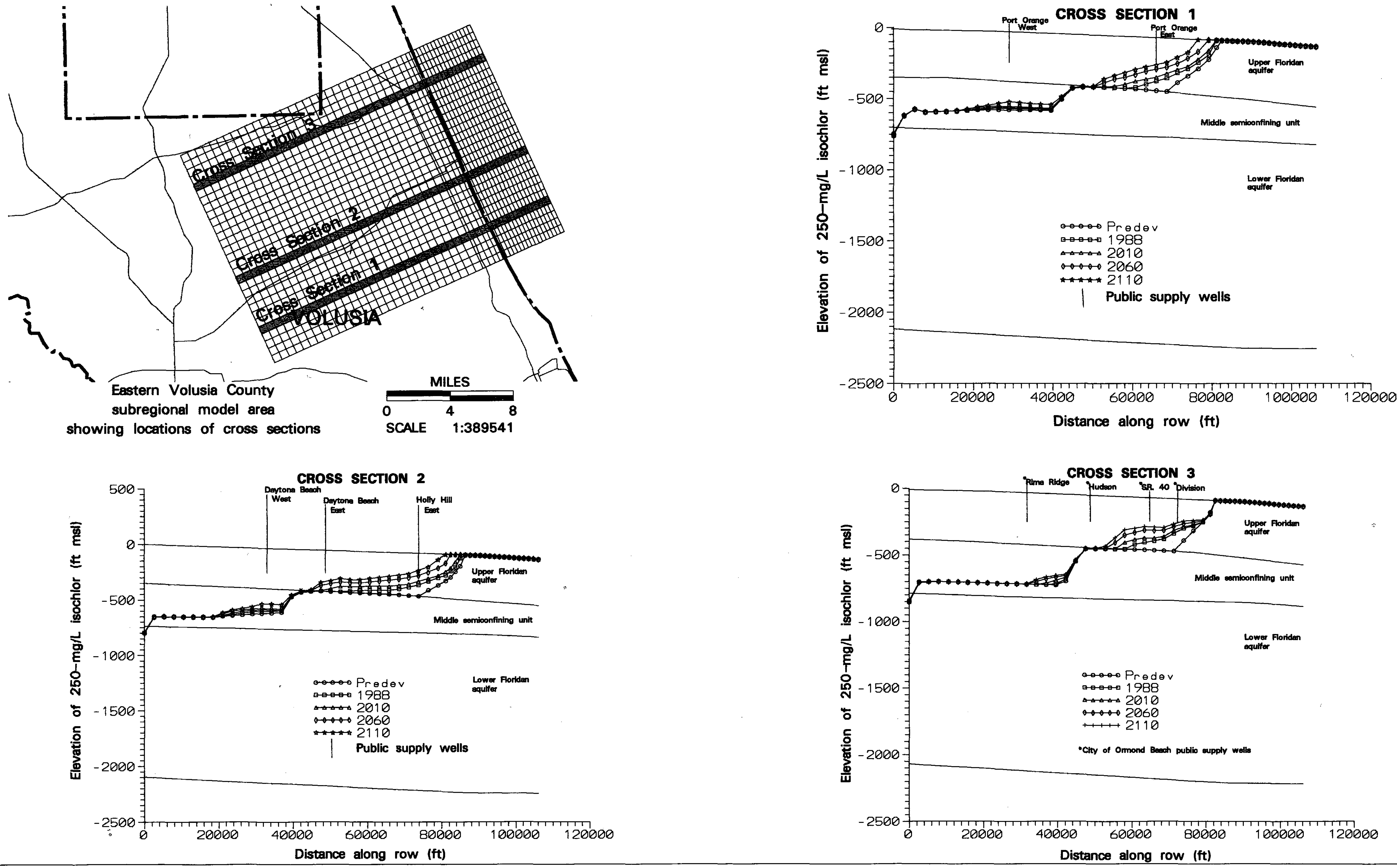


Figure 14. Simulated position of the 250-mg/L isochlor in the eastern Volusia subregional ground water flow and solute transport model area for 1988, 2010, 2060, and 2110 (Williams 1994a, draft)

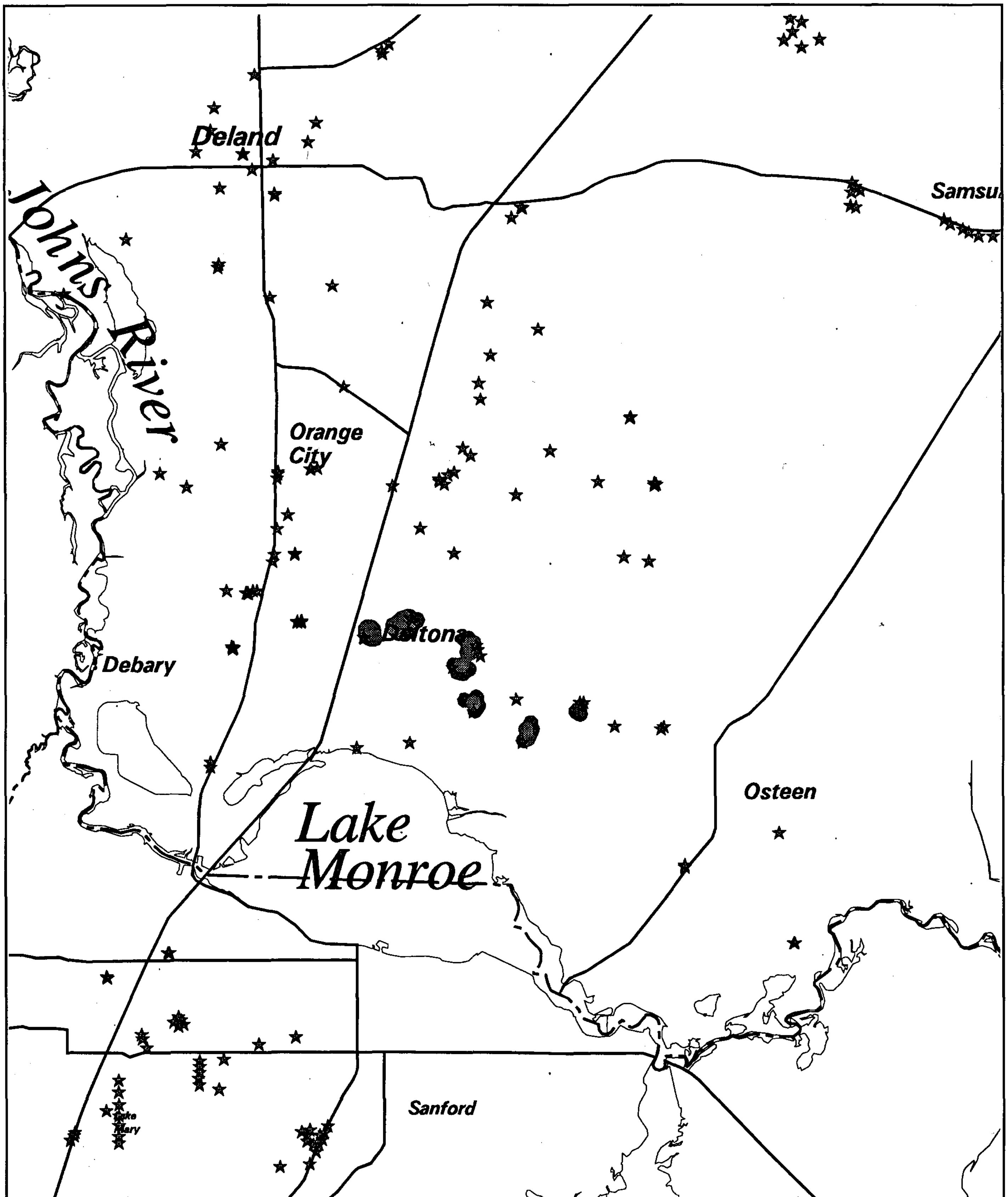


Figure 15. Areas of projected saltwater upconing in the western Volusia subregional ground water flow and water quality model area for 2010 and 2060

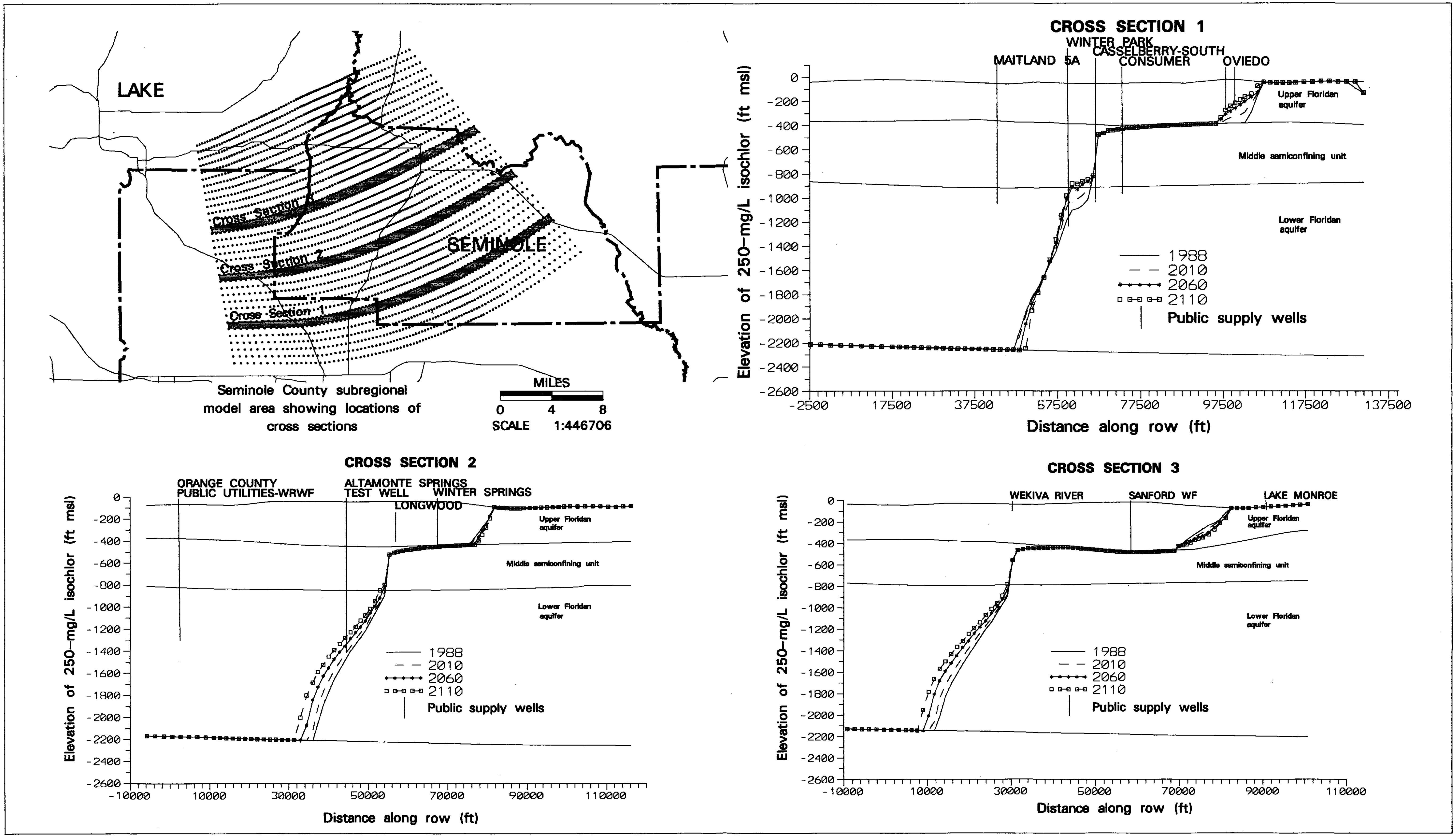


Figure 16. Simulated position of the 250-mg/L isochlor in the Seminole County subregional ground water flow and solute transport model area for 1988, 2010, 2060, and 2110 (based on Birdie and Blandford 1994)

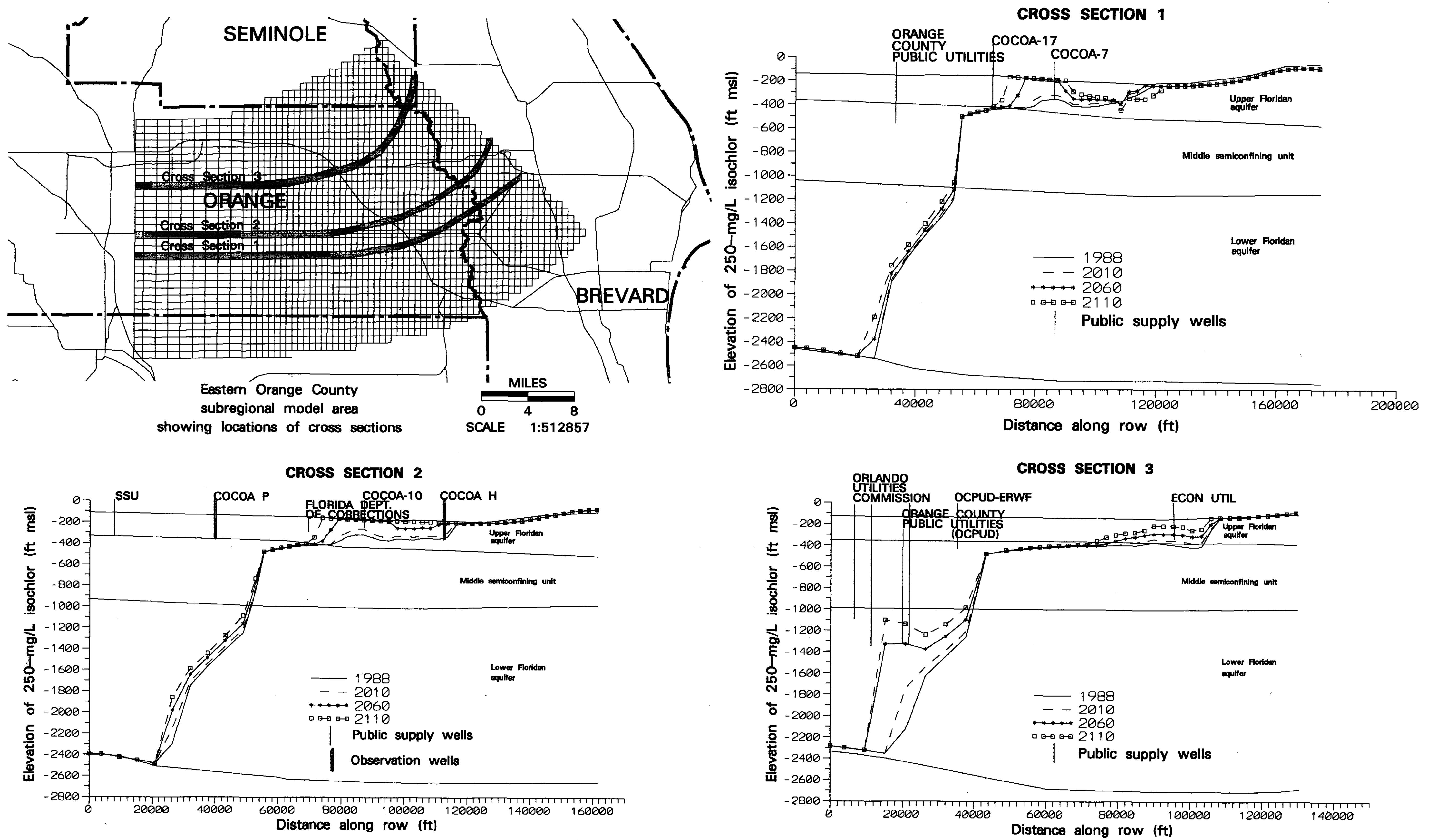


Figure 17. Simulated position of the 250-mg/L isochlor in the eastern Orange County subregional ground water flow and solute transport model area for 1988, 2010, 2060, and 2110 (based on Birdie and Blandford 1992a)

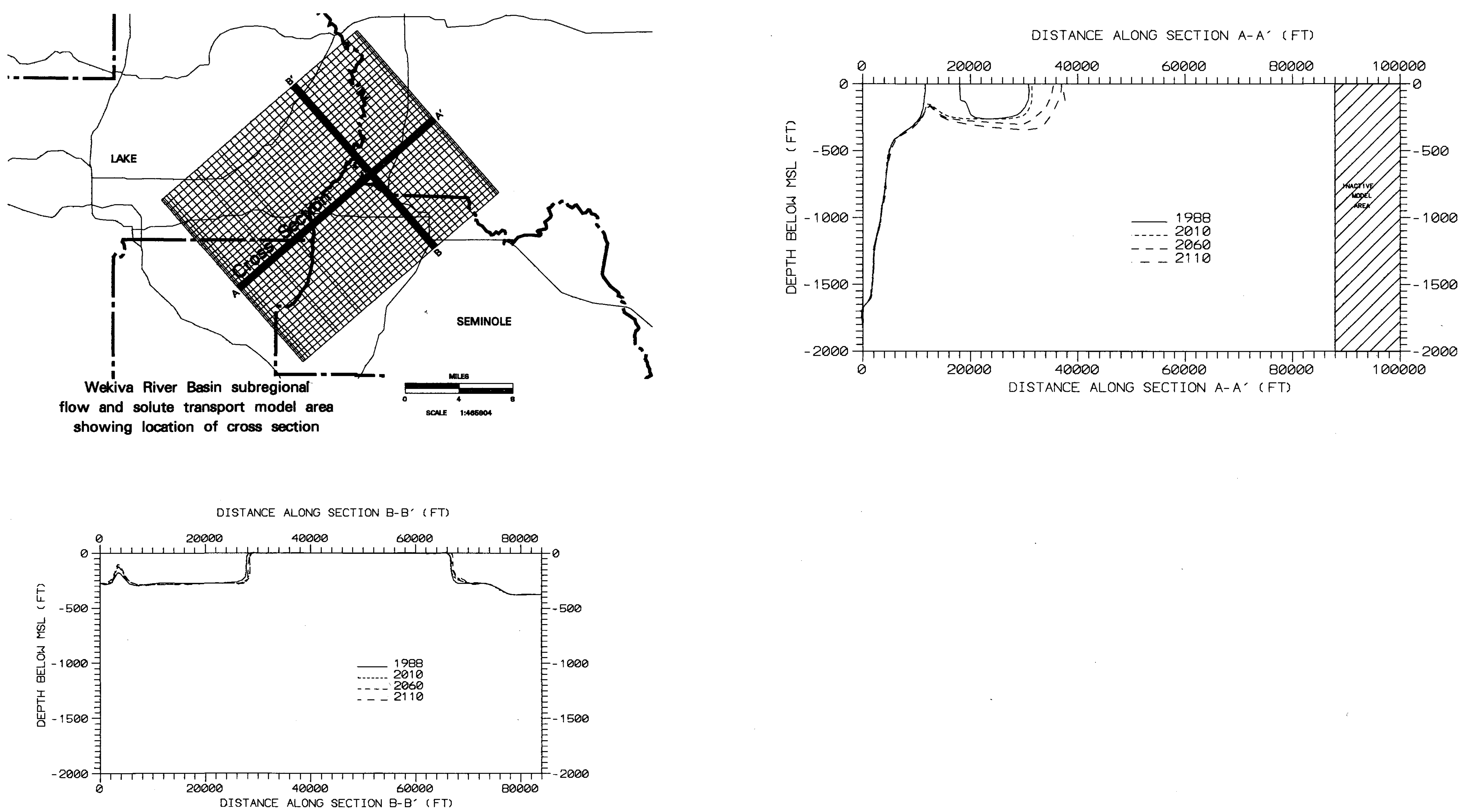


Figure 18. Simulated position of the 250-mg/L isochlor in the eastern Wekiva River Basin subregional ground water flow and solute transport model area for 1988, 2010, 2060, and 2110 (based on GeoTrans 1992b)

WATER RESOURCE CAUTION AREA IDENTIFICATION—by Barbara Vergara, P.G.

Section 62-40.520, *F.A.C.*, requires the identification of "specific geographical areas that have water resource problems which have become critical or are anticipated to become critical within the next 20 years." SJRWMD has identified such areas based on a comparison of impact criteria limits to the results of the water use, ground water, and surface water assessments. Within these identified areas, the impacts of current or projected demands exceed the impact criteria limits for natural systems, for ground water quality, or to existing legal users of water or where the water user has failed to identify an adequate supply source to meet the projected need. These identified areas are referred to as *water resource caution areas.*

IMPACTS TO NATURAL SYSTEMS

SJRWMD considered two factors in its identification of water resource caution areas based on natural systems.

- Impacts to native vegetation
- Impacts to minimum flows and levels

Impacts to Native Vegetation

A key SJRWMD process for assessing impacts to native vegetation is described in Kinser and Minno (1994, draft). This key process is based on a geographic information system model that uses soil permeabilities, sensitivities of plant communities to dewatering, and projected declines in the water table of the surficial aquifer system to estimate the relative likelihood of harm to native plant communities. The results of the modeling process highlight areas of SJRWMD having low, moderate, and high likelihoods of harm to native vegetation as a result of projected declines in the water table of the surficial aquifer system between 1988 and 2010 (Figure 19). The projected declines in the water table of the surficial aquifer system (Figure 12) are those presented on pages 34–42.

SJRWMD has identified those areas having moderate to high likelihoods of harm to native vegetation, in combination with the areas where projected declines in the potentiometric surface of the Floridan aquifer system contribute to this condition, and the public supply service areas associated with projected ground water withdrawals that contribute to these projected declines as areas anticipated to experience critical water resource problems by 2010 based on this process (Figure 20).

Impacts to Minimum Flows and Levels

SJRWMD assessed the potential for impacts to minimum flows and levels by 2010 by comparing established minimum flows and levels for surface water courses or minimum ground water levels to surface water flows and levels or ground water levels projected to occur in 2010 as a result of projected increases in ground water withdrawals. In cases where a projected 2010 flow or level is less than a minimum flow or level contained in Chapter 40C-8, *F.A.C.*, a critical water resource problem is anticipated by 2010.

Proposed increases in ground water withdrawals between 1988 and 2010 are projected to cause the discharge of seven springs in the Wekiva River subbasin to fall below the minimum discharges set forth in Chapter 40C-8, *F.A.C.* These springs are Wekiva, Rock, Miami, Sanlando, Starbuck, Palm, and Seminole. A critical water resource problem is anticipated by 2010 in the Wekiva River downstream of these springs, in areas where projected declines in the potentiometric surface of the Floridan aquifer system contribute to these projected declines in spring discharge, and in the public supply service areas associated with the projected ground water withdrawals that contribute to these projected declines (Figure 21).

SJRWMD has not yet established minimum discharges for springs outside of the Wekiva River subbasin. In general, a projected decrease of 15 percent or more in discharge of a spring is considered to be enough decrease to pose a reasonable likelihood of natural systems problems and to warrant further investigation in order to establish minimum discharges.

Several of the springs that are projected to experience decreases in discharge of 15 percent or more (Table 9) are used for public and private recreational purposes. One spring, Bugg Spring (Figure 11), is the location of the underwater acoustic measurement facility for the U.S. Department of the Navy, Naval Research Laboratory. Changes in discharge from Bugg Spring could jeopardize the continued use of this facility.

Another of these springs, Blue Spring near Orange City (Volusia County, Figure 11), is projected to experience a 16.1 percent reduction in discharge between 1988 and 2010 (Table 9). This spring is a wintering place for manatees, an aquatic mammal listed as an endangered species on the list of *Endangered and Threatened Wildlife and Plants* developed by the U.S. Fish and Wildlife Service under the provisions of the Endangered Species Act 50 *Code of Federal Regulations* (C.F.R.) Sections 17.11 and 17.12 (1992). Manatees are sensitive to winter temperatures and frequent the Blue Spring run in the winter months when the temperature of the spring water is considerably warmer than the water of the St. Johns River (Rosenau et al. 1977). The projected 16.1 percent reduction in spring discharge could change the temperature regime and depth of water in the spring run. These changes could significantly limit the amount of suitable habitat available to the manatees.

Although no detailed investigation to determine the impact of these types of changes has been performed, SJRWMD staff believes that manatees could be unacceptably impacted by the projected 16.1 percent reduction in discharge.

Springs with projected decreases in discharge of 15 percent or more, areas where projected declines in the potentiometric surface of the Floridan aquifer system contribute to these decreases in discharge, and service areas for public supply associated with the projected ground water withdrawals that contribute to these projected declines also are considered to be areas anticipated to experience critical water resource problems by 2010 (Figure 22).

Projected declines in the potentiometric surface of the Floridan aquifer system are expected to affect the levels of lakes. However, SJRWMD has not developed a method for the quantitative assessment of these effects.

IMPACTS TO GROUND WATER QUALITY

SJRWMD considered the impacts of projected saltwater intrusion on the future availability of ground water. Projected changes in the concentrations of chlorides in water in the Floridan aquifer system were the basis of assessing the projected magnitude of saltwater intrusion. Other water quality constituents, such as sulfates and TDS, also are important factors to consider when assessing the suitability of ground water for various uses. However, concentrations of chlorides are considered to be a reasonable indicator, perhaps the best indicator, of the presence of saltwater intrusion. The subregional ground water flow and water quality model results described on pages 34–42 were used to describe the projected magnitude of saltwater intrusion.

SJRWMD relied heavily on the input of a group of technical and legal consultants to define, for purposes of this assessment, ground water quality limits beyond which water resource problems would occur (SJRWMD, unpublished). Water resource problems related to saltwater intrusion are considered to be critical or are anticipated to become critical by 2010 in areas where chloride concentrations in the water in the Floridan aquifer system result in an inadequate thickness of water with quality suitable to supply existing or projected 2010 uses through the year 2110, in areas where projected declines in the potentiometric surface of the Floridan aquifer system contribute to this condition, and in the public supply service areas associated with the projected ground water withdrawals that contribute to these projected declines.

SJRWMD has projected the impacts of projected 2010 water use through the year 2110, because saltwater intrusion occurs slowly in response to declines in the potentiometric surface of the Floridan aquifer system, probably on the order of tens to hundreds of years.

The specific evaluations performed to identify critical saltwater intrusion problems concentrated on projected changes in the location of the 250-mg/L isochlor. This 250-mg/L limit of chloride concentration was chosen because it is the recommended limit of the U.S. Environmental Protection Agency (EPA) for chloride concentrations in public drinking water. As such, waters with chloride concentrations above this limit generally require different and more expensive public drinking water treatment systems.

Because the specific evaluations concentrated on changes in the location of the 250-mg/L isochlor, the critical water resource problem areas identified based on the saltwater intrusion criteria are areas that are anticipated to have critical problems with drinking water supplies. The availability of ground water supplies for other water use purposes (e.g., agricultural self-supply) will be limited by higher concentrations of chlorides and other constituents such as TDS than for drinking water. SJRWMD has not developed a specific method for the assessment of the potential impacts of saltwater intrusion on the availability of ground water to supply uses other than public supply and domestic self-supply.

Comparison of the criteria limit for saltwater intrusion to the results of the ground water quality models, described on pages 39–42, indicates two areas that are anticipated to experience water resource problems, which will become critical by 2110 based on the projected impacts of 2010 water use (Figure 23). Within these two areas are subareas anticipated to experience inadequate thickness of water with quality suitable to supply projected 2010 uses through 2110. In these subareas, one in coastal Volusia County and the other in eastern Orange County, the 250-mg/L isochlor is projected to move upward and to intersect the open hole portion of public supply wells. SJRWMD anticipates that this will result in an increase in the chloride concentration in water produced from these wells from less than 250 mg/L to 250 mg/L or greater.

IMPACTS TO EXISTING LEGAL USERS OF WATER

SJRWMD considered one factor in its evaluation of projected impacts to existing legal users of water based on projected 2010 water use. This factor is interference with withdrawals of water from wells.

SJRWMD considers an impact to an existing legal user of water to be a critical water resource problem if significant potential exists for an existing user of water to be unable to withdraw adequate quantities of water from his well as a result of water level declines in the well that are caused by ground water withdrawals by other users. This situation currently exists seasonally in portions of northeast Putnam County and southwest St. Johns County during periods of potato crop irrigation (Figure 24).

During these irrigation periods, ground water withdrawals result in a regional lowering of the potentiometric surface, which historically has caused privately owned wells and aeration systems supplying water for domestic use to be rendered inoperable for short periods of time, usually on the order of days. The Putnam County Board of County Commissioners enacted Ordinance 87-2 to require well construction standards for new wells in a portion of Putnam County where this problem occurs (Figure 24). These well construction standards were designed to prevent future interference with withdrawals of water from new wells by requiring that new wells be constructed to adequate depths and be equipped with appropriate pumping equipment. Similar requirements are not in place in the remaining portions of Putnam County and in St. Johns County within the area experiencing interference problems.

Although the well construction standards enacted by Putnam County are effective in preventing future interference problems, these standards do not prevent problems in wells that were constructed prior to the effective date of the ordinance.

FAILURE TO IDENTIFY AN ADEQUATE SUPPLY SOURCE

SJRWMD anticipates a critical water resource problem to occur by 2010 in public supply service areas that have failed to identify a source of supply adequate to meet projected 2010 demands. Only one service area in SJRWMD, that belonging to the City of Titusville in Brevard County, meets this criteria (Figure 25).

The City of Titusville projects the need for 9.8 mgd of water in 2010. The City projects that 6.5 mgd will come from its existing wellfields and that 3 mgd will be purchased from the City of Cocoa. A source for the remaining 0.3 mgd has not been identified.

WATER RESOURCE CAUTION AREAS

SJRWMD has identified areas within SJRWMD that have water resource problems that have become critical or are anticipated to become critical as a result of the projected 2010 water use as *water resource caution areas* (Figure 26). These water resource caution areas cover 38 percent (4,683 square miles) of SJRWMD. Changes in projected quantities and locations of 2010 ground water and surface water withdrawals can change the boundaries of these areas. Therefore, areas located outside of the identified water resource caution areas should not be assumed to be able to support future ground water and surface water withdrawals without resulting in critical water resource problems.

Review of Figures 20–23 indicates that projected 2010 water use in areas to the south of the SJRWMD boundary, in the South Florida Water Management District (SFWMD), will contribute to the anticipated problems. These areas meet the SJRWMD criteria for identification of water resource caution areas; however, SJRWMD has no authority to identify such areas beyond its boundaries.

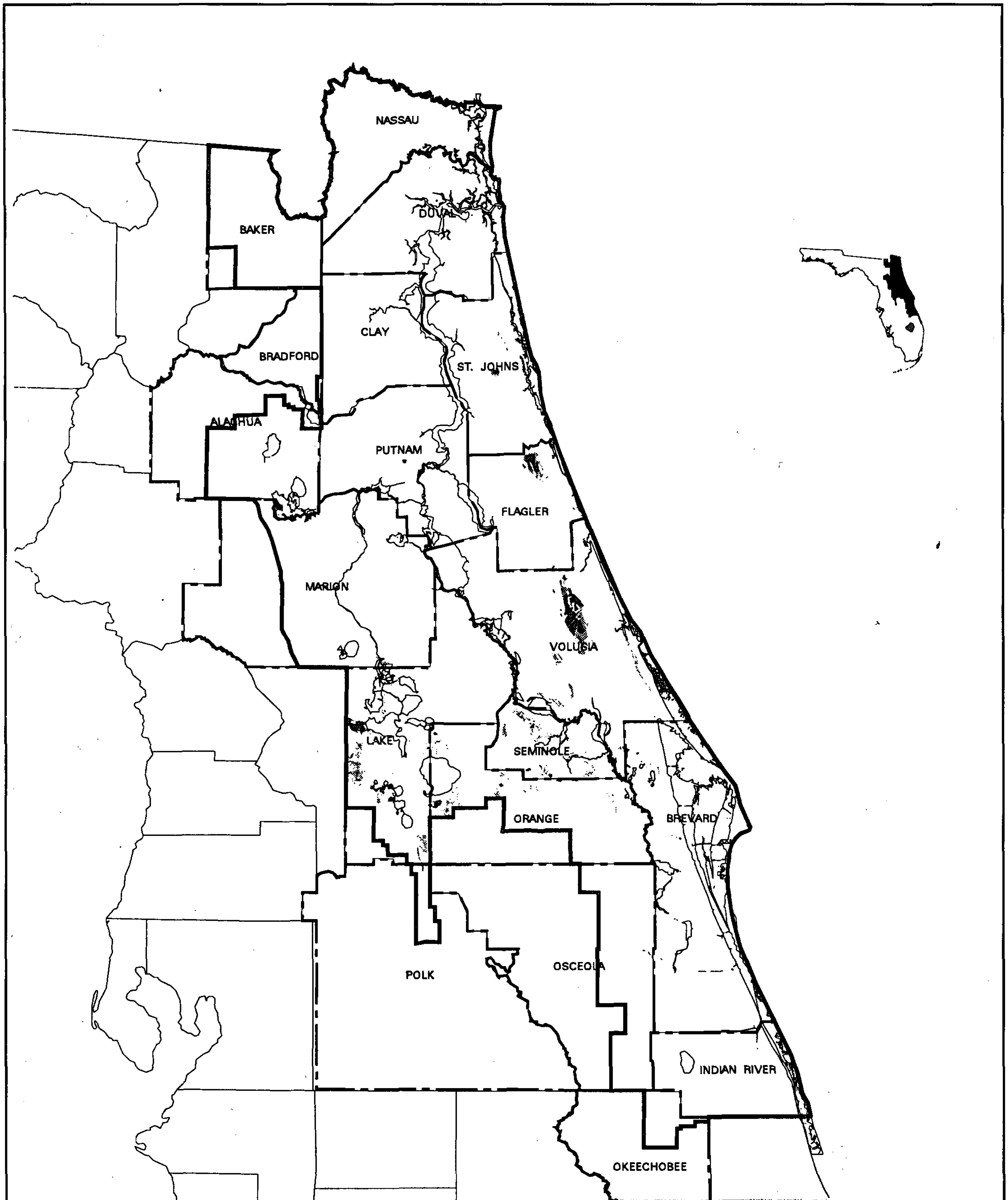


Figure 19. Likelihood of harm to native vegetation as a result of projected declines in the water table of the surficial aquifer system between 1988 and 2010

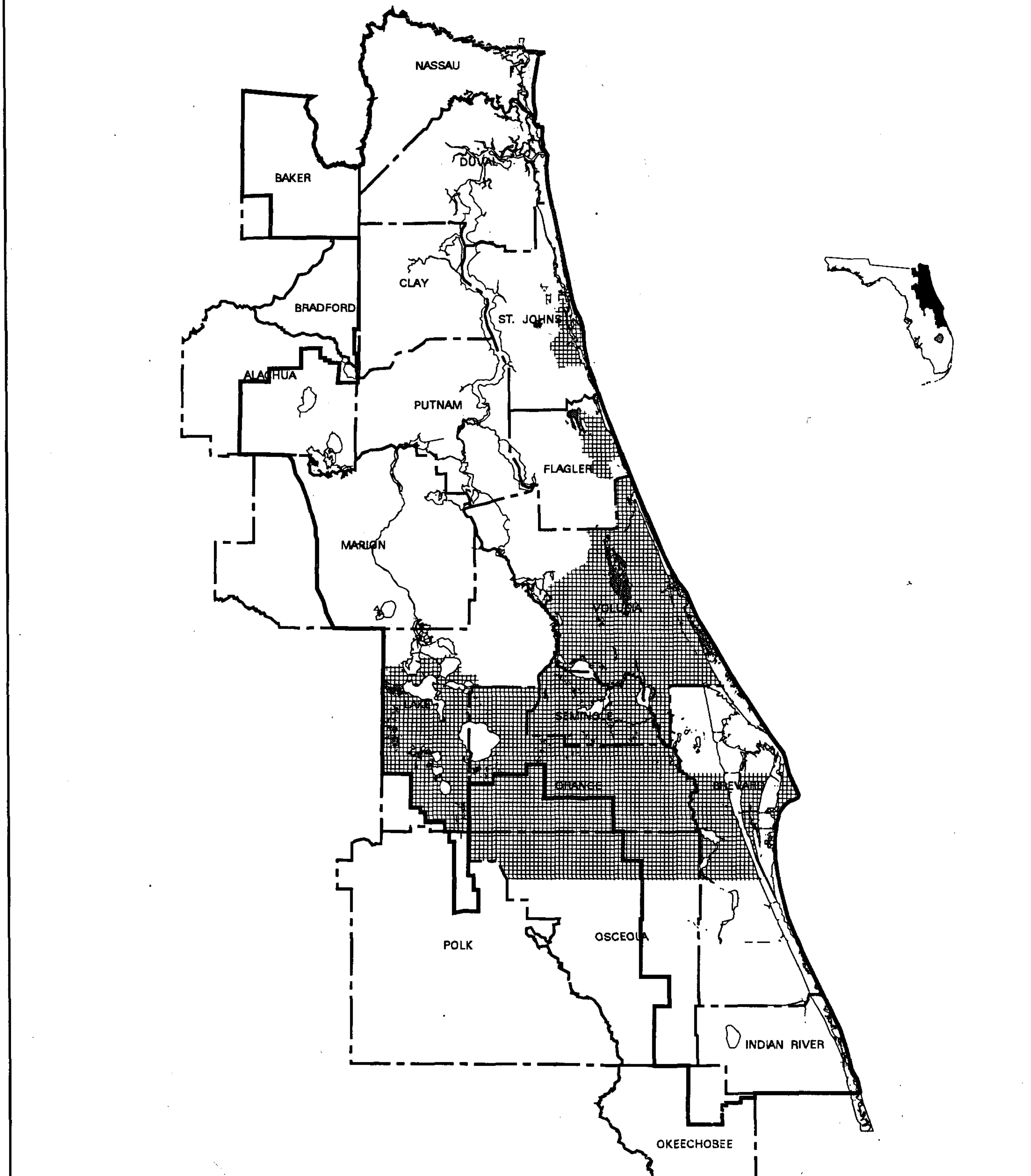


Figure 20. Areas associated with anticipated impacts to native vegetation

Area of moderate to high likelihood of harm to native vegetation

Area containing withdrawals and service areas that contribute to likelihood of harm to native vegetation

County boundary

District boundary

Miles

0 4 8

Scale 1:1858579

N

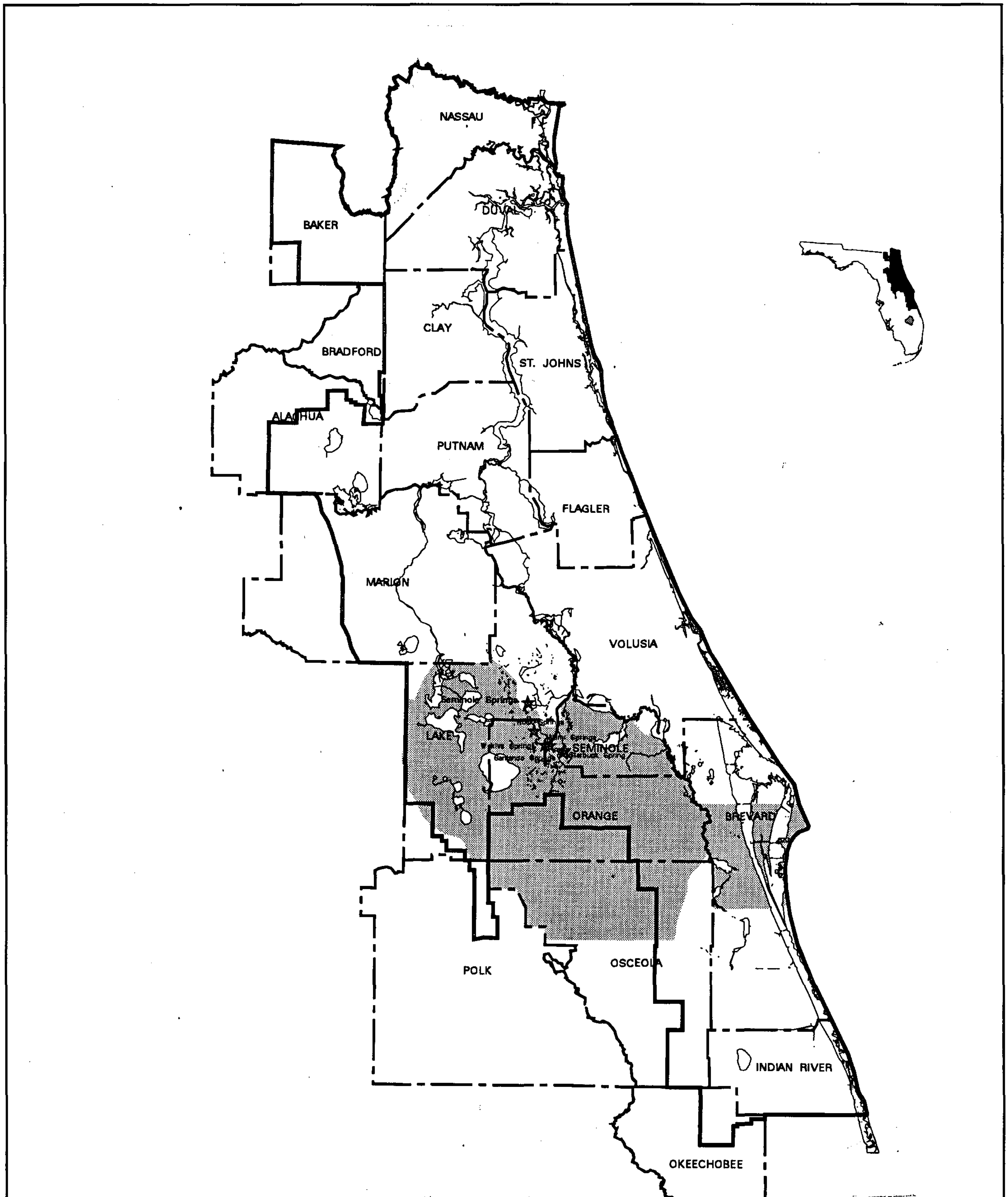


Figure 21. Areas associated with anticipated impacts to springs based on established minimum spring discharges

Area containing withdrawals and service areas that contribute to projected decreases in spring discharge below established minimum discharges in the Wekiva River Basin

County boundary

District boundary

Spring

Miles

0 4 8

Scale 1:1858579

N

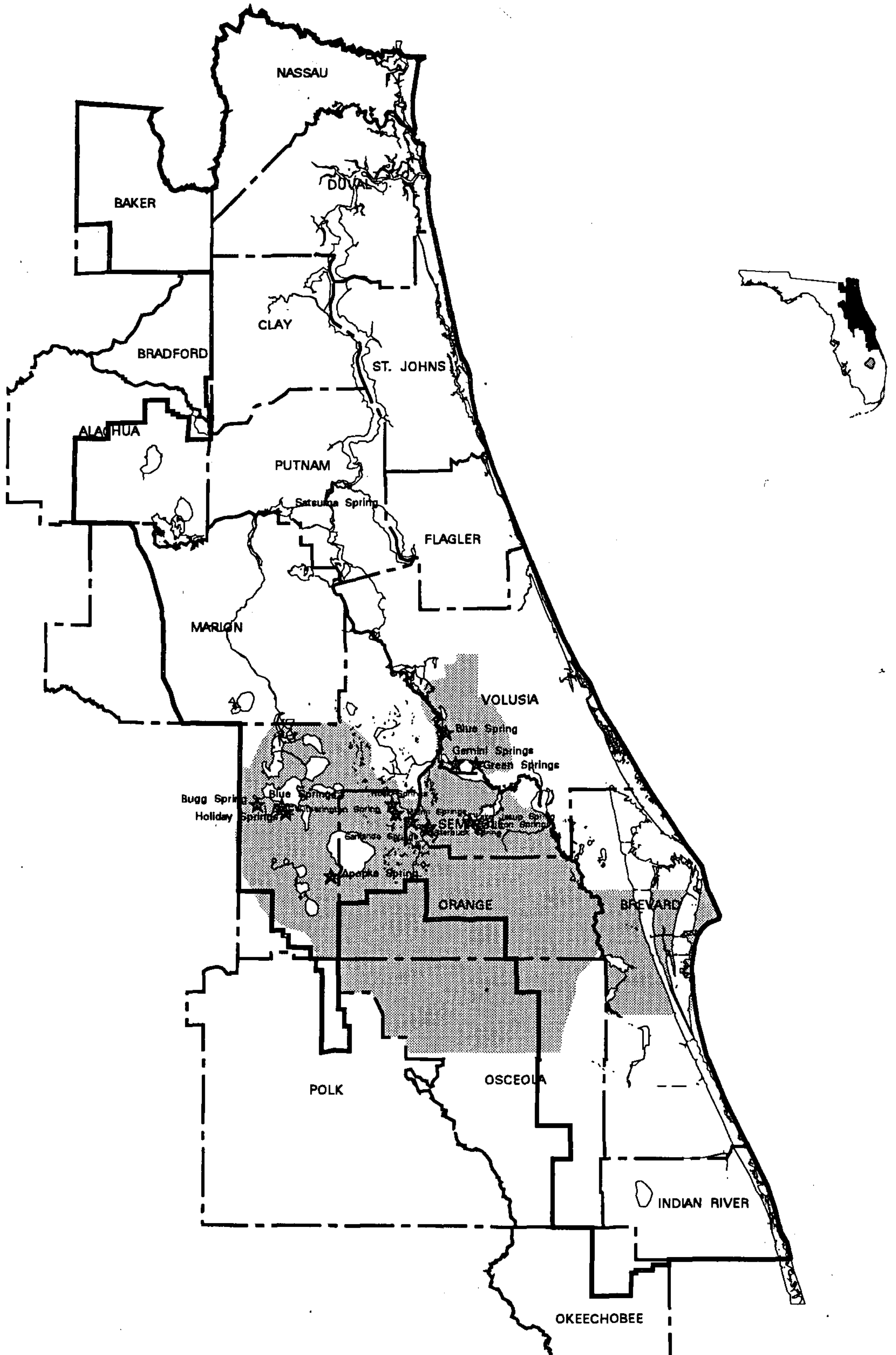


Figure 22. Areas associated with anticipated impacts to springs based on a 15 percent or greater decline in spring discharge

Area containing withdrawals and service areas that contribute to projected decreases in spring discharge of 15 percent or more

County boundary

District boundary

Spring

Miles
0 4 8
Scale 1:1858579

N

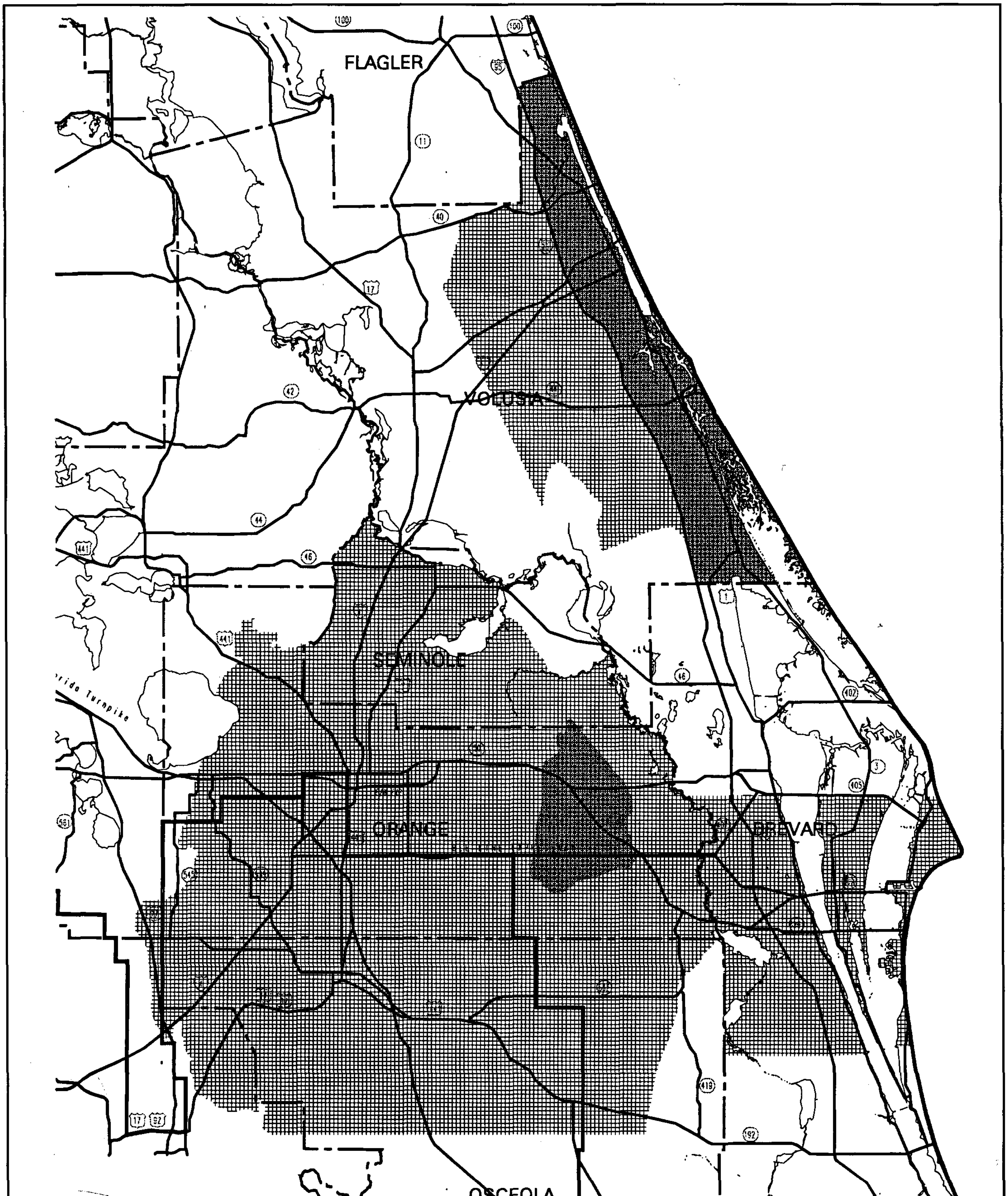


Figure 23. Areas associated with anticipated changes in ground water quality

Area projected to have inadequate thickness of suitable quality water

Area containing ground water withdrawals and service areas that contribute to projected inadequate thickness of suitable quality water

County boundary

District boundary

Highway

N

Miles

0 4 8

Scale 1:743400

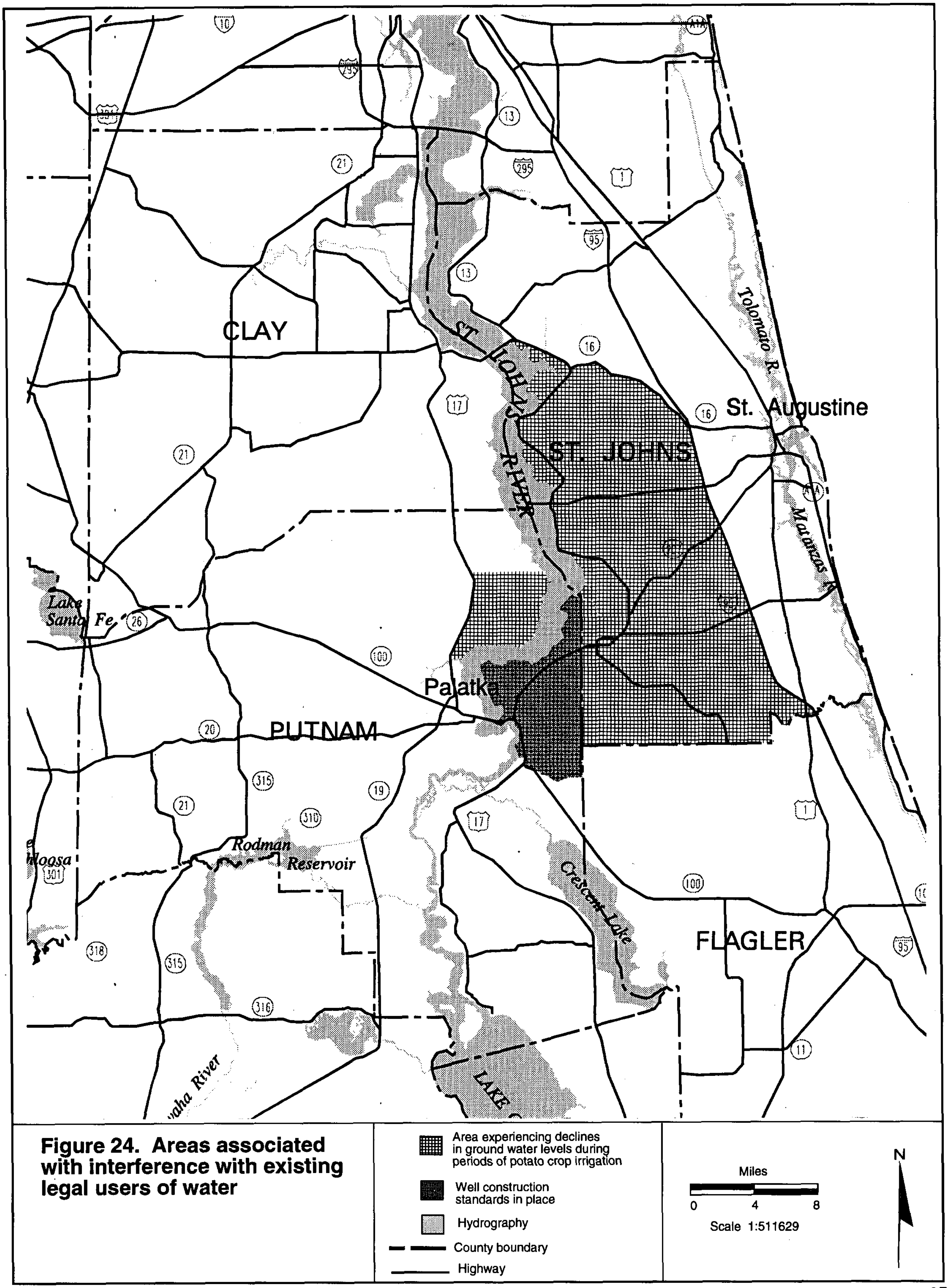


Figure 24. Areas associated with interference with existing legal users of water

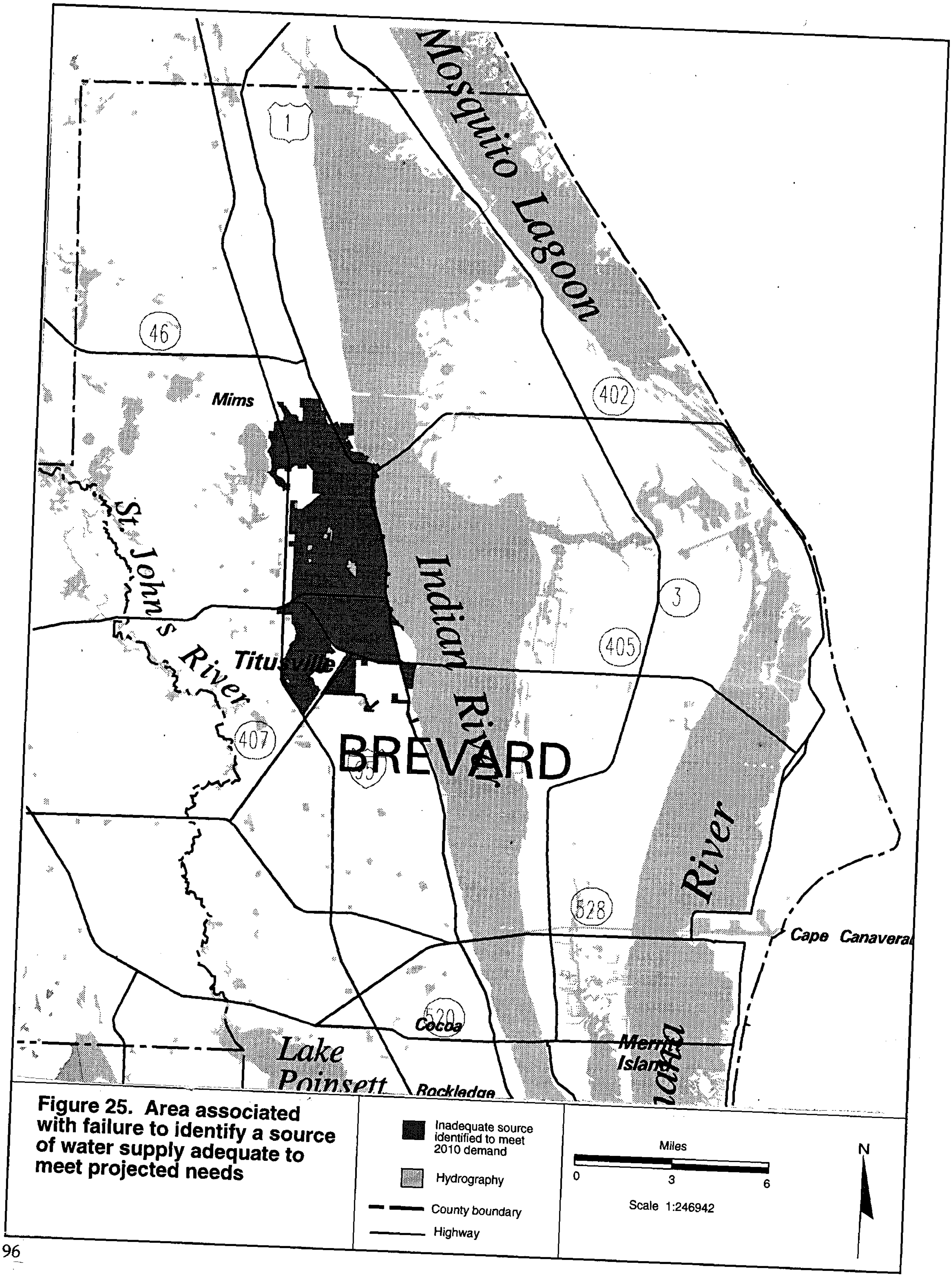


Figure 25. Area associated with failure to identify a source of water supply adequate to meet projected needs

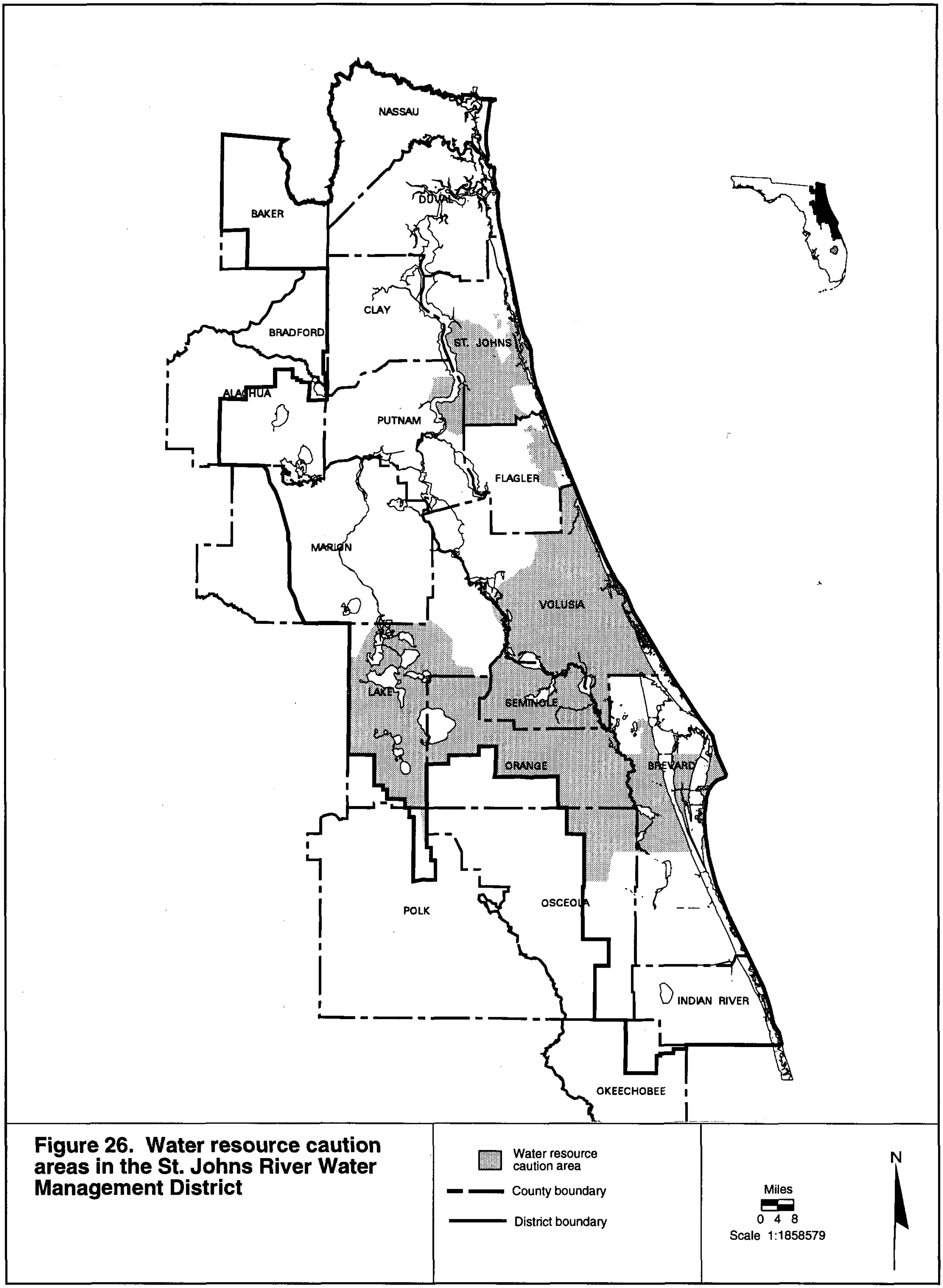


Figure 26. Water resource caution areas in the St. Johns River Water Management District

ALTERNATIVE WATER SUPPLY STRATEGIES—by Barbara Vergara, P.G.

SJRWMD proposes to develop alternative strategies for water supply within identified water resource caution areas. The purpose of these alternative strategies is to identify courses of action to remediate water resource problems that have become critical and to prevent water resource problems that are projected to become critical as a result of projected increases in water use by 2010.

Subsection 62-40.520(2), *F.A.C.*, requires that these courses of remedial or preventive action be developed based on economic, environmental, and technical feasibility analyses. SJRWMD proposes to perform economic, environmental, and technical feasibility analyses to support the development of alternative water supply strategies. SJRWMD proposes to develop the scope of these analyses and the priority for their performance through coordination with major water suppliers in water resource caution areas, with appropriate governments, and with other appropriate parties including private sector interests. SJRWMD also proposes to seek cooperative funding to support the cost of performance of these analyses.

To date, SJRWMD has identified a need for the following economic, environmental, and technical analyses in order to prevent the critical water resource problems anticipated as a result of projected 2010 water use. These analyses include

- determining the feasibility of alternative water supply sources, such as
    - relocating and rescheduling of proposed ground water withdrawals,
    - replacing currently proposed ground water sources with surface water sources,

  - designing aquifer storage and recovery systems to store and retrieve water withdrawn from ground water and surface water sources, and
  - desalination of ground water and surface water (including seawater) and process concentrate disposal;

- determining the feasibility of using local and regional strategies relating to reuse of reclaimed water and stormwater;

- determining the feasibility of reducing projected increases in water use through water conservation;

- determining the feasibility of irrigating native vegetation in impacted areas using reclaimed water, stormwater, and ground water; and

- determining the feasibility of reclaiming drainage canals in Volusia County.

Further, these remedial or preventive actions may include, but are not limited to the following (Subsection 62-40.520(3), *F.A.C.*).

- Water resources projects
- Water resources restoration projects pursuant to Section 403.0615, *FS*
- Purchase of lands
- Conservation of water
- Use of reclaimed water
- Enforcement of EPA or SJRWMD rules
- Actions taken by local government pursuant to a local government comprehensive plan, local ordinance, or zoning regulation

Subsection 62-40.520(4), *F.A.C.*, requires that SJRWMD identify areas where (1) data collection, (2) water resource investigations, (3) water resource projects, or (4) implementation of regulatory programs are necessary to prevent water resource problems from becoming critical. SJRWMD has identified such areas as part of the process of identifying alternative water supply strategies.

DATA COLLECTION

SJRWMD has identified the need for additional water resource data to support its continued efforts associated with the WSNS assessment. Additional data are needed on

- aquifer characteristics,
- ground water quality,
- ground water levels,
- water use,
- vegetation changes in response to changes in ground water levels, and
- desalination and process concentrate disposal.

SJRWMD proposes to expand its existing network of ground water monitoring wells to support the continued development of regional and subregional ground water flow and water quality models (Figure 27 and Appendix C). This expansion will require the construction of new observation wells or the rehabilitation of existing wells, aquifer performance testing, and water level and water quality monitoring. SJRWMD will seek cooperative funding for the construction, testing, and monitoring of the proposed expanded network.

SJRWMD proposes to develop and to implement plans for expanded ground water monitoring in portions of water resource caution areas evaluated with the use of analytical models. SJRWMD plans to involve major water suppliers in these areas in this process.

SJRWMD also proposes to continue to develop its water use data base to support the requirements of the WSNS assessment. More detailed ground water flow and water quality modeling will require data concerning ground water withdrawals from the surficial aquifer system and will require the development of monthly data concerning all ground water withdrawals in addition to the average annual data used to perform ground water modeling associated with the 1994 WSNS assessment.

SJRWMD has started to monitor several sites designed for long-term collection of ground water level and vegetation data (Figure 28 and Appendix D). These sites are located in remote areas that are considered to be unaffected by ground water withdrawals. This work will allow SJRWMD to develop an understanding of the normal hydrological characteristics associated with several major plant communities and will serve as a basis of comparison for assessing areas in which vegetation has been impacted by ground water withdrawals.

WATER RESOURCE INVESTIGATIONS

SJRWMD proposes several water resource investigations be designed to aid in the development of alternative water supply strategies and to aid in better definition of water resource caution areas. These investigations include the following.

- Revisions to the regional ground water flow models
- Revisions to the subregional ground water transport models
- Development of new subregional ground water flow and transport models
- Development of optimization models in water resource caution areas
- Development of a ground water–lake interaction model designed to predict changes in lake stage in response to declines in the potentiometric surface of the Floridan aquifer system
- Development of a telescoping module for MODFLOW to provide an improved means of modeling portions of regional model domains

- Determination of the impacts of spring discharges on the quality, quantity, and biota of the receiving waterbody for the purpose of establishing minimum flows and levels for surface waterbodies or minimum levels for ground water

- Determination of the impact of withdrawal of saline ground water and surface water, including seawater, for the purpose of desalination

- Determination of the impact of disposal of desalination process concentrate

WATER RESOURCE PROJECTS

Water resource projects may be considered necessary to prevent the occurrence of critical water resource problems. These projects may involve the design, construction, and operation of physical improvements and the purchase of lands. The necessity of such projects will be assessed following completion of adequate data collection, water resource investigations, and economic, environmental, and technical feasibility analyses. SJRWMD proposes to assess the necessity for such projects through coordination with major water suppliers in water resource caution areas, appropriate governments, and other appropriate parties including private sector interests. Funding sources for these water resource projects will be identified based upon the nature of the project and those who will benefit from it.

REGULATORY PROGRAMS

SJRWMD will consider the use of the consumptive use permitting program and other regulatory programs as a means of remedial or preventive actions in water resource caution areas. A specific plan for adopting regulations to address the potential problems in the identified water resource caution areas has not been developed; however, the following will be considered.

- Integration of cumulative regional ground water impact evaluations into the consumptive use permitting process

- Development of a regulatory strategy for remediating impacts to existing legal users of water in areas in which withdrawals of water from wells result in critical water resource problems (Figure 24)

- Adoption of minimum flows and levels for surface waterbodies and minimum levels for ground water

- Strengthening of requirements for water conservation and the reuse of reclaimed water and stormwater

- Development of a regulatory strategy to encourage the investigation and development of alternative sources of water supply, including but not limited to

  - relocating and rescheduling of proposed ground water withdrawals,

  - replacing currently proposed ground water sources with surface water sources,

  - designing aquifer storage and recovery systems to store and retrieve water withdrawn from ground water and surface water sources, and

  - desalting of saline ground water and surface water (including seawater) and disposing of associated process concentrate or residue

OTHER GOVERNMENT PROGRAMS

Local Government

SJRWMD will work with local governments to encourage the adoption of local ordinances that will aid in the prevention of critical water resource problems. To date, SJRWMD has identified the need for an ordinance requiring minimum well construction and pumping equipment standards for new construction in those portions of St. Johns and Putnam counties where critical water resource problems related to interference with existing legal users are anticipated to occur (Figure 24), but that are not covered by such an ordinance.

Water Management Districts

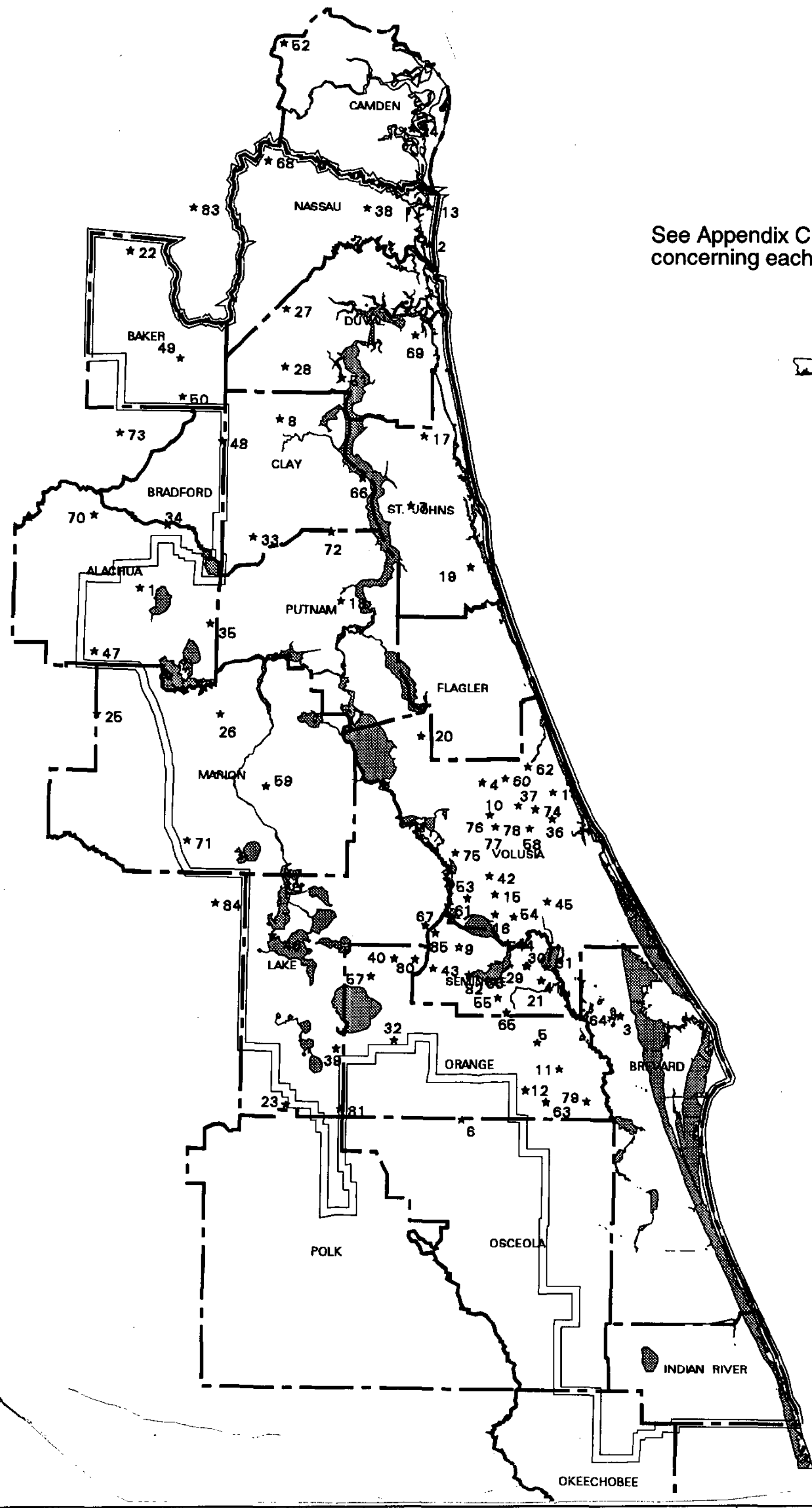
SJRWMD will work with other water management districts in an attempt to achieve consistency in the development of WSNS assessments, particularly in areas involving district boundaries. Where areas anticipated to experience critical water resource problems span a district boundary, SJRWMD will work with the adjacent district(s) to identify and implement appropriate preventive actions. To date, SJRWMD has identified one such area, southern Orange County and northern Osceola County south of the SJRWMD–SFWMD boundary.

SJRWMD proposes to work with other water management districts to promote and to facilitate the reasonable reuse of reclaimed wastewater and stormwater, the development of necessary desalination projects, including associated process concentrate.

State Government

SJRWMD will work with the Department of Environmental Protection, the Public Service Commission, and other appropriate governmental entities to promote and to facilitate the reasonable reuse of reclaimed wastewater and stormwater, the development of necessary desalination projects, including associated process concentrate disposal, in identified water resource caution areas. In those instances where state rules or procedures are not consistent with SJRWMD objectives concerning implementation of desirable alternative water supply strategies, SJRWMD will coordinate with the appropriate state governmental entities to achieve consistency.

See Appendix C for information concerning each numbered site



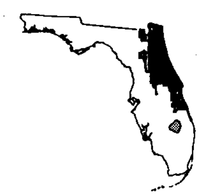


Figure 27. Proposed additions to the St. Johns River Water Management District ground water monitoring network

★ Site of proposed new monitor well, with reference number

Hydrography

County boundary

District boundary

Miles
0 4 8
Scale 1:1858579

N

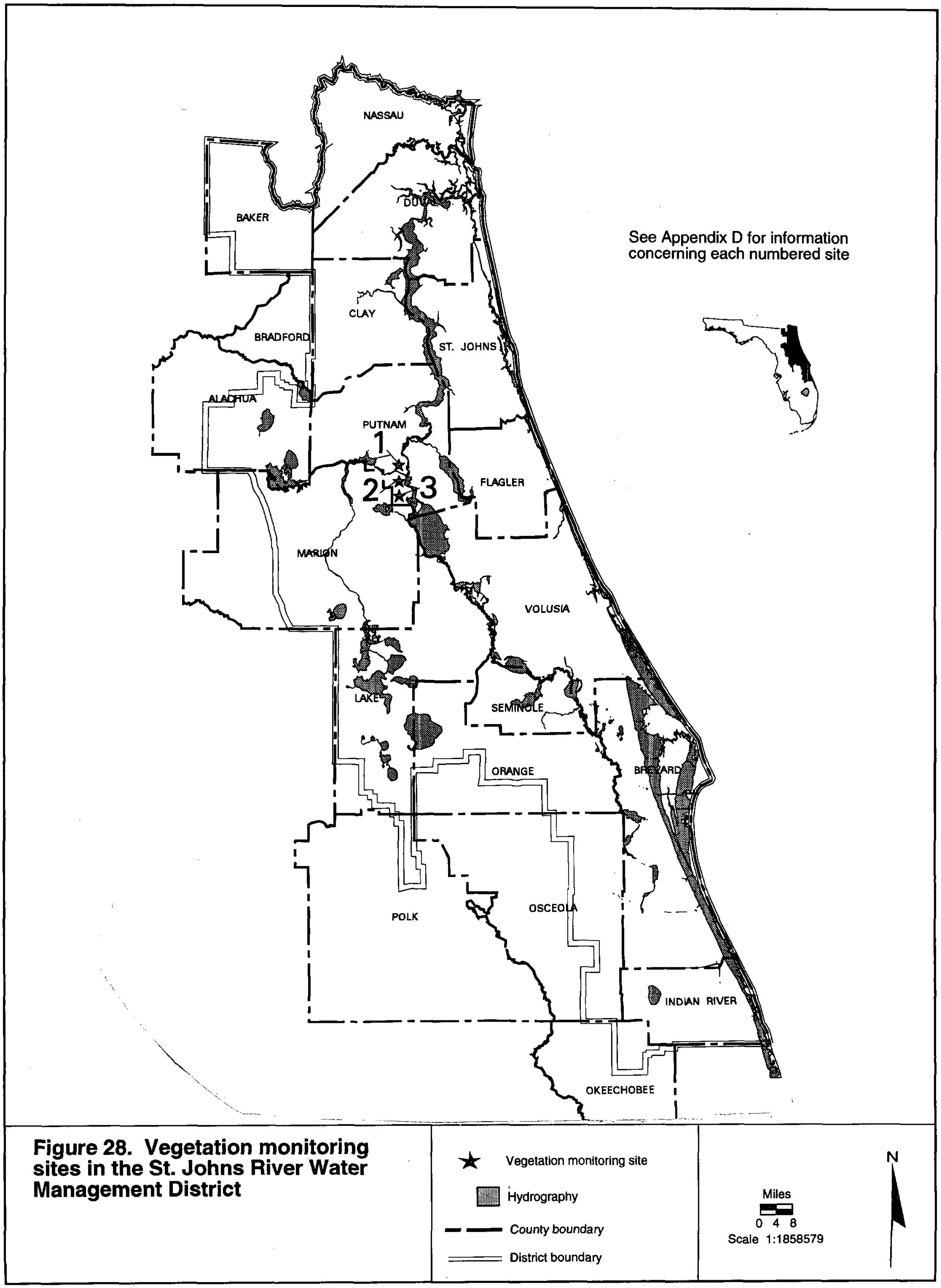


Figure 28. Vegetation monitoring sites in the St. Johns River Water Management District

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APPENDIX A—*FLORIDA STATUTES* AND *FLORIDA ADMINISTRATIVE CODE* RELATED TO WATER SUPPLY NEEDS AND SOURCES

Paragraph 373.0391(2)(e), *FS*, Technical assistance to local governments.—

"A description of groundwater characteristics, including existing and planned wellfield sites, existing and anticipated cones of influence, highly productive groundwater areas, aquifer recharge areas, deep well injection zones, contaminated areas, an assessment of regional water resource needs and sources for the next 20 years, and water quality."

Rule 62-40.520, *F.A.C.*, District Water Management Plans.

"(1) As required by Section 373.036(4), *F.S.*, a water management plan shall be prepared by each District which is consistent with the provisions of this Chapter and Section 373.036, *Florida Statutes*. The District plan shall include an assessment of water needs and sources for the next 20 years. The District plan shall identify specific geographical areas that have water resource problems which have become critical or are anticipated to become critical within the next 20 years. Identification of critical water supply problem areas needed for imposition of reuse requirements pursuant to Rule 17-40.401(5), *F.A.C.*, may be accomplished before publication of the complete District Plan.

"(2) Based on economic, environmental, and technical feasibility analyses, a course of remedial or preventive action shall be specified for each current and anticipated future critical problem.

"(3) Remedial or preventive measures may include, but are not limited to, water resource projects; water resources restoration projects pursuant to Section 403.0615, *Florida Statutes*; purchase of lands; conservation of water; reuse of reclaimed water;

enforcement of Department or District rules; and actions taken by local government pursuant to a Local Government Comprehensive Plan, local ordinance, or zoning regulation.

"(4) District Plans shall also provide for identifying areas where collection of data, water resource investigations, water resource projects, or the implementation of regulatory programs are necessary to prevent water resource problems from becoming critical.

"(5) By November 1, 1989, each District shall prepare a detailed plan of study for the preparation of the District Plan.

"(6) District Plans shall be developed expeditiously and may be phased. All District Plans shall be completed no later than November 1, 1994.

"(7) At a minimum, District Plans shall be updated every five years after the initial plan development."

APPENDIX B—*FLORIDA ADMINISTRATIVE CODE* RELATED TO MINIMUM FLOWS AND LEVELS

Rule 40C-8.031, *F.A.C.,* Minimum Surface Water Levels and Flows and Groundwater Levels.

"(1) The following minimum surface water levels and flows and minimum groundwater levels are established:

Wekiva River at the SR 46 Bridge.

	Level (ft NGVD)	Flow (cfs)	Duration (days)	Return Interval (years)
Minimum Infrequent High	9.0	880	≥7	≤5
Minimum Frequent High	8.0	410	≥30	≤2
Minimum Average	7.6	240	≤180	≥1.7
Minimum Frequent Low	7.2	200	≤90	≥3
Phase I Restriction	7.0	190	NA	NA
Phase 2 Restriction	6.9	180	NA	NA
Phase 3 Restriction	6.7	160	NA	NA
Phase 4 Restriction	6.5	150	NA	NA
Minimum Infrequent Low	6.1	120	≤7	≥100

Wekiva River Minimum Groundwater Levels and Spring Flows.

Spring	Head (ft NGVD)	Discharge (cfs)
Messant Spring	32	12
Seminole Spring	34	34
Rock Spring	31	53
Wekiva Spring	24	62
Miami Spring	27	4
Sanlando Spring	28	15
Starbuck Spring	31	13
Palm Spring	27	7

Black Water Creek at the SR 44 Bridge.

	Level (ft NGVD)	Flow (cfs)	Duration (days)	Return Interval (years)
Minimum Infrequent High	27.0	340	≥7	≤5
Minimum Frequent High	25.8	145	≥30	≤2
Minimum Average	24.3	33	≤180	≥1.7
Minimum Frequent Low	22.8	2.5	≤90	≥15
Phase I Restriction	22.7	2	NA	NA
Phase 2 Restriction	22.5	1	NA	NA
Phase 3 Restriction	22.4	0.6	NA	NA
Phase 4 Restriction	22.3	0.3	NA	NA
Minimum Infrequent Low	21.9	0	≤7	≥100

"(2) Ground or surface water withdrawals or surface water works must not cause the infrequent high or frequent high surface water flows and levels to occur less frequently or for at lesser duration than stated. Ground or surface water withdrawals or surface water works must not cause the minimum average, frequent low, or infrequent low surface water levels and flows to occur more frequently or for longer durations than stated.

"(3) The following minimum surface water levels are established:"

Lake Location	Minimum Levels (feet NGVD)					Duration (days)	Return Interval (years)	Hydroperiod Categories
	Minimum Infrequent High	Minimum Frequent High	Minimum Average	Minimum Frequent Low	Minimum Infrequent Low			
Bell Lat. 292545 Long. 813214		42.5				NA	NA	Temporarily Flooded
			40.5			NA	NA	Typically Saturated
				38.7		NA	NA	Semi-Permanently Flooded
Como Lat. 292186 Long. 813458		38.0				NA	NA	Seasonally Flooded
			36.2			NA	NA	Typically Saturated
				34.4		NA	NA	Semi-Permanently Flooded

Lake Location	Minimum Levels (feet NGVD)					Duration (days)	Return Internal (years)	Hydroperiod Categories
	Minimum Infrequent High	Minimum Frequent High	Minimum Average	Minimum Frequent Low	Minimum Infrequent Low			
Daugharty Lat. 290632 Long. 811659	46.3					≥30	≤5	NA
		45.5				≥30	≤2	NA
			44.5			≤180	≥2	NA
				43.0		≤180	≥5	NA
					41.5	≤365	≥25	NA
Emporia		37.5				NA	NA	Seasonally Flooded
Lat. 291144 Long. 813214			36.4			NA	NA	Typically Saturated
				35.0		NA	NA	Semi-Permanently Flooded
Pierson		35.5				NA	NA	Seasonally Flooded
Lat. 291400 Long. 812825			34.2			NA	NA	Typically Saturated
				32.5		NA	NA	Semi-Permanently Flooded
Shaw	38.5					≥30	≤5	NA
Lat. 291404 Long. 812641		36.9				≥30	≤2	NA
			36.2			≤180	≥2	NA
				34.0		≤120	≥5	NA
					32.0	≤90	≥10	NA
Silver		36.5				NA	NA	Seasonally Flooded
Lat. 292644 Long. 813420			35.1			NA	NA	Typically Saturated
				34.0		NA	NA	Semi-Permanently Flooded

APPENDIX C—PROPOSED ADDITIONS TO THE MONITORING WELL NETWORK, NOVEMBER 1994

County	Number on Figure 27	Name of Well Site	Latitude	Longitude	Aquifer	Estimated Casing (feet)	Estimated Depth (feet)
Alachua	1	Alachua Fairgrounds	294105	821715	Lower Floridan	1,460	1,510
	35	Hawthorne	293556	820434	Lower Floridan	550	650
	47	Levy Lake	293120	822454	Unconfined	50	60
	47	Levy Lake	293120	822454	Upper Floridan	160	260
	47	Levy Lake	293120	822454	Lower Floridan	1,450	1,550
	County total					3,670	4,030
Baker	22	Eddy Fire Tower	303235	822035	Lower Floridan	1,650	1,760
	49	MacClenny Ft	301618	821109	Lower Floridan	930	1,030
	50	Manning	301022	821033	Unconfined	50	60
	50	Manning	301022	821033	Lower Floridan	860	960
	County total					3,490	3,810
Bradford	34	Graham	295038	821234	Unconfined	40	60
	34	Graham	295038	821234	Upper Floridan	200	300
	34	Graham	295038	821234	Lower Floridan	1,500	1,550
	48	Lewis Hill	300338	820319	Lower Floridan	800	900
	70	Santa Fe	295159	822539	Unconfined	40	60
	70	Santa Fe	295159	822539	Upper Floridan	120	220
	70	Santa Fe	295159	822539	Lower Floridan	1,300	1,400
	County total					4,000	4,490
Brevard	3	Arthur Dunn A.P.	283700	805100	Upper Floridan	200	300
	3	Arthur Dunn A.P.	283700	805100	Saltwater transition	300	600

County	Number on Figure 27	Name of Well Site	Latitude	Longitude	Aquifer	Estimated Casing (feet)	Estimated Depth (feet)
Brevard (continued)	64	Seminole Ranch	283644	805749	Saltwater transition	400	500
	County total					900	1,400
Clay	8	Black Creek	300722	815312	Unconfined	50	60
	8	Black Creek	300722	815312	Upper Floridan	420	520
	8	Black Creek	300722	815312	Lower Floridan	1,300	1,400
	66	SJRWMD - J.P. Hall	295833	813810	Lower Floridan	740	840
	66	SJRWMD - J.P. Hall	295833	813810	Fernandina permeable zone	1,600	1,700
	72	Sun Garden	295016	814335	Lower Floridan	770	870
	County total					4,880	5,390
Duval	27	Garden Street	302416	815226	Floridan	500	1,000
	27	Garden Street	302416	815226	Floridan (middle confined)	1,200	1,500
	28	Gate Petroleum	301522	815226	Upper Floridan	500	1,000
	28	Gate Petroleum	301522	813313	Floridan (middle confined)	1,200	1,500
	33	Gold Head State Park	294911	815726	Lower Floridan	700	800
	51	NAS Jax	301347	814218	Lower Floridan	950	1,050
	51	NAS Jax	301347	814218	Fernandina permeable zone	1,900	2,000
	69	Sandlewood	302034	812921	Unconfined	50	60
	69	Sandlewood	302034	812921	Upper Floridan	490	590
	69	Sandlewood	302034	812921	Lower Floridan	1,140	1,240
	County total					8,630	10,740

County	Number on Figure 27	Name of Well Site	Latitude	Longitude	Aquifer	Estimated Casing (feet)	Estimated Depth (feet)
Lake	23	Eva - Lake County	282245	814926	Lower Floridan	1,000	1,100
	39	Johns Lake	283128	814047	Lower Floridan	800	1,000
	46	Leesburg	284830	815224	Upper Floridan	70	170
	46	Leesburg	284830	815224	Lower Floridan	590	690
	67	SJRWMD - Carter East	285028	812533	Lower Floridan	800	900
	67	SJRWMD - Carter East	285028	812533	Saltwater transition	1,000	1,100
	80	Wekiva Swamp	284515	812710	Unconfined	50	60
	80	Wekiva Swamp	284515	812710	Secondary	80	90
	80	Wekiva Swamp	284515	812710	Upper Floridan	150	300
	80	Wekiva Swamp	284515	812710	Saltwater transition	700	800
	80	Wekiva Swamp	284515	812710	Saltwater flow zone	900	1,000
	81	West of Lake Oliver	282210	813955	Unconfined	50	60
	81	West of Lake Oliver	282210	813955	Secondary	100	120
	81	West of Lake Oliver	282210	813955	Upper Floridan	250	500
	81	West of Lake Oliver	282210	813955	Lower Floridan	1,200	1,300
	County total					7,740	9,190
Levy	25	East Williston	292140	822413	Unconfined	20	40
	25	East Williston	292140	822413	Lower Floridan	1,600	1,700
	County total					1,620	1,740
Marion	26	Fort McCoy	292204	820228	Lower Floridan	670	570
	59	Redwater Lake	291117	815405	Lower Floridan	460	560
	71	Shady	290240	820743	Unconfined	10	20

County	Number on Figure 27	Name of Well Site	Latitude	Longitude	Aquifer	Estimated Casing (feet)	Estimated Depth (feet)
Marion (continued)	71	Shady	290240	820743	Lower Floridan	470	570
	County total					1,610	1,720
Nassau	2	Amelia Island Corp	303435	812714	Lower Floridan	1,200	1,400
	13	Container Corp	304024	812721	Unconfined	10	40
	13	Container Corp	304024	812721	Upper Floridan	550	1,000
	13	Container Corp	304024	812721	Lower Floridan	1,300	1,400
	13	Container Corp	304024	812721	Fernandina permeable zone	2,000	2,100
	38	ITT Rayonier A1A	303955	813828	Unconfined	30	40
	38	ITT Rayonier A1A	303955	813828	Lower Floridan	1,300	1,400
	38	ITT Rayonier A1A	303955	813828	Fernandina permeable zone	2,100	2,200
	68	St. Marys Boulogne	304654	815618	Lower Floridan	1,180	1,280
	County total					9,670	10,860
Orange	5	Bithlo	283248	810532	Saltwater transition	1,200	1,300
	6	Boggy Creek NR Orl	282051	811834	Saltwater transition	2,000	2,100
	11	Cocoa H	282847	810137	Saltwater transition	500	600
	12	Cocoa S	282529	810732	Upper Floridan	400	500
	12	Cocoa S	282529	810732	Saltwater transition	1,200	1,300
	32	Gotha	283250	813040	Unconfined	50	60
	32	Gotha	283250	813040	Secondary	100	120
	32	Gotha	283250	813040	Upper Floridan	250	500
	32	Gotha	283250	813040	Lower Floridan	1,200	1,300

County	Number on Figure 27	Name of Well Site	Latitude	Longitude	Aquifer	Estimated Casing (feet)	Estimated Depth (feet)
Orange (continued)	40	Kelley Park Road	284520	813050	Unconfined	50	60
	40	Kelley Park Road	284520	813050	Secondary	100	120
	40	Kelley Park Road	284520	813050	Floridan	250	500
	40	Kelley Park Road	284520	813050	Lower Floridan	1,100	1,200
	57	Plymouth Tower	284230	813453	Lower Floridan	1,200	1,300
	63	SE of Cocoa A	282338	810355	Saltwater transition	1,200	1,300
	65	Seminole-Orange CL	283720	811100	Saltwater transition	1,700	1,800
	79	USGS Palmetto	282348	805647	Saltwater transition	400	500
	79	USGS Palmetto	282348	805647	Saltwater flow zone	800	900
	County total					13,700	15,460
Putnam	18	District Headquarters	293951	814139	Lower Floridan	740	840
	County total					740	840
St. Johns	7	Bakersville	295427	812931	Lower Floridan	840	940
	7	Bakersville	295427	812931	Fernandina permeable zone	1,560	1,660
	17	Durbin Fire Tower	300507	812727	Lower Floridan	960	1,070
	17	Durbin Fire Tower	300507	812727	Fernandina permeable zone	1,720	1,820
	19	Dupont Center	294519	811845	Lower Floridan	930	1,030
	County total					6,010	6,520
Seminole	9	CDM-1	284718	811936	Unconfined	50	60
	9	CDM-1	284718	811936	Secondary	80	100
	9	CDM-1	284718	811936	Upper Floridan	400	600

County	Number on Figure 27	Name of Well Site	Latitude	Longitude	Aquifer	Estimated Casing (feet)	Estimated Depth (feet)
Seminole (continued)	9	CDM-1	284718	811936	Saltwater transition	1,000	1,100
	21	Econ North Bank	284220	810500	Unconfined	10	20
	21	Econ North Bank	284220	810505	Secondary	50	60
	21	Econ North Bank	284220	810500	Saltwater transition	100	150
	21	Econ North Bank	284220	810500	Saltwater flow zone	300	350
	29	Geneva Center	284428	810725	Unconfined	50	60
	29	Geneva Center	284428	810725	Upper Floridan	150	300
	29	Geneva Center	284428	810725	Saltwater transition	400	500
	30	Geneva NW	284430	810740	Unconfined	30	40
	30	Geneva NW	284430	810740	Upper Floridan	100	200
	30	Geneva NW	284430	810740	Saltwater transition	300	400
	31	Geneva SW	284420	810400	Unconfined	30	40
	31	Geneva SW	284420	810400	Upper Floridan	100	200
	31	Geneva SW	284420	810400	Saltwater transition	300	400
	41	Kilbee West	284217	810452	Saltwater transition	200	500
	43	Lake Mary	284400	812400	Unconfined	50	60
	43	Lake Mary	284400	812400	Secondary	70	80
	43	Lake Mary	284400	812400	Upper Floridan	300	500
	43	Lake Mary	284400	812400	Lower Floridan	1,100	1,200
	55	Oviedo WTP	283933	811231	Unconfined	30	40
	56	Oviedo WTP	283933	811231	Secondary	60	70

County	Number on Figure 27	Name of Well Site	Latitude	Longitude	Aquifer	Estimated Casing (feet)	Estimated Depth (feet)
Seminole (continued)	56	Oviedo WTP	283933	811231	Upper Floridan	300	400
	61	S. Lake Monroe	285150	812050	Unconfined	20	30
	61	S. Lake Monroe	285150	812050	Secondary	50	60
	61	S. Lake Monroe	285150	812050	Upper Floridan	200	300
	61	S. Lake Monroe	285150	812050	Saltwater transition	400	500
	61	S. Lake Monroe	285150	812050	Saltwater flow zone	600	700
	65	Seminole-Orange CL	283720	811100	Unconfined	50	60
	65	Seminole-Orange CL	283720	811100	Secondary	90	100
	65	Seminole-Orange CL	283720	811100	Upper Floridan	300	500
	65	Seminole-Orange CL	283720	811100	Lower Floridan	1,200	1,300
	82	Winter Springs	284300	811740	Unconfined	20	30
	82	Winter Springs	284300	811740	Secondary	50	60
	82	Winter Springs	284300	811740	Upper Floridan	200	300
	82	Winter Springs	284300	811740	Saltwater flow zone	400	500
	85	Yankee Lake STP	284923	812348	Unconfined	50	60
	85	Yankee Lake STP	284923	812348	Secondary	70	80
	85	Yankee Lake STP	284923	812348	Upper Floridan	300	400
	85	Yankee Lake STP	284923	812348	Saltwater transition	650	750
	County total					10,210	13,160
Sumter	84	Wildwood	285313	820232	Unconfined	40	60
	84	Wildwood	285313	820232	Lower Floridan	500	600
	County total					540	660

County	Number on Figure 27	Name of Well Site	Latitude	Longitude	Aquifer	Estimated Casing (feet)	Estimated Depth (feet)
Union	73	Swift Creek	300437	822133	Lower Floridan	1,500	1,600
	County total					1,500	1,600
Volusia	4	Banks Island	291230	811600	Lower Floridan	800	900
	4	Banks Island	291230	811600	Saltwater transition	900	1,100
	10	Clark Bay	290730	811430	Lower Floridan	800	900
	14	Daytona Beach A.P.	291107	810324	Saltwater transition	600	900
	15	Deltona Section 16	285522	811324	Unconfined	50	60
	15	Deltona Section 16	285522	811324	Upper Floridan	100	200
	15	Deltona Section 16	285522	811324	Saltwater transition	800	900
	16	Deltona South	285218	811320	Unconfined	50	60
	16	Deltona South	285218	811320	Secondary	50	60
	16	Deltona South	285218	811320	Upper Floridan	100	200
	16	Deltona South	285218	811320	Saltwater transition	300	400
	20	East of Seville	291922	812658	Upper Floridan	140	200
	36	I95 - Port Orange	290700	810330	Upper Floridan	300	400
	36	I95 - Port Orange	290700	810330	Saltwater transition	500	600
	37	Indian Lake	290900	810930	Upper Floridan	200	250
	37	Indian Lake	290900	810930	Floridan (middle confined)	600	700
	37	Indian Lake	290900	810930	Saltwater transition	800	1,000
	42	Lake Helen	285810	811424	Secondary	60	70
	42	Lake Helen	285810	811424	Upper Floridan	150	200
	42	Lake Helen	285810	811424	Lower Floridan	800	900

County	Number on Figure 27	Name of Well Site	Latitude	Longitude	Aquifer	Estimated Casing (feet)	Estimated Depth (feet)
Volusia (continued)	44	Lemon Bluff Road	284800	811100	Unconfined	30	40
	44	Lemon Bluff Road	284800	811100	Secondary	70	80
	44	Lemon Bluff Road	284800	811100	Upper Floridan	100	200
	44	Lemon Bluff Road	284800	811100	Saltwater transition	200	300
	44	Lemon Bluff Road	284800	811100	Saltwater flow zone	300	400
	45	Lk Ashby Twr	285419	810410	Saltwater transition	700	800
	53	Orange City FT	285442	811814	Lower Floridan	700	800
	54	Osteen	285200	811000	Unconfined	20	30
	54	Osteen	285200	811000	Secondary	70	80
	54	Osteen	285200	811000	Upper Floridan	100	200
	54	Osteen	285200	811000	Saltwater transition	300	400
	58	Port Orange West	290530	810730	Upper Floridan	200	250
	58	Port Orange West	290530	810730	Floridan (middle confined)	700	800
	58	Port Orange West	290530	810730	Saltwater transition	800	1,000
	60	Rima Ridge	291310	811200	Upper Floridan	200	250
	60	Rima Ridge	291310	811200	Floridan (middle confined)	700	800
	60	Rima Ridge	291310	811200	Saltwater transition	900	1,000
	62	S.R. 40 - Ormond	291500	810800	Upper Floridan	300	400
	62	S.R. 40 - Ormond	291500	810800	Saltwater transition	500	600
	74	Tomoka River	290830	810630	Upper Floridan	300	400
	74	Tomoka River	290830	810630	Saltwater transition	500	600
	75	TW J-2 W. De Land	290138	812032	Saltwater transition	500	600

County	Number on Figure 27	Name of Well Site	Latitude	Longitude	Aquifer	Estimated Casing (feet)	Estimated Depth (feet)
Volusia (continued)	76	USGS 04 Replace	290541	811329	Upper Floridan	85	640
	77	USGS 05 Replace	290541	811329	Floridan (middle confined)	640	1,200
	78	USGS 06 Replace	290541	811329	Lower Floridan	1,275	1,290
	County total					18,290	23,160
Brantley, Georgia	52	North Georgia	310503	815400	Unconfined	30	60
	52	North Georgia	310503	815400	Upper Floridan	600	700
	52	North Georgia	310503	815400	Lower Floridan	1,150	1,250
	52	North Georgia	310503	815400	Fernandina permeable zone	2,200	2,300
	County total					3,980	4,310
Camden, Georgia	24	East Georgia	305210	813040	Unconfined	50	60
	24	East Georgia	305210	813040	Upper Floridan	600	700
	24	East Georgia	305210	813040	Lower Floridan	1,260	1,360
	24	East Georgia	305210	813040	Fernandina permeable zone	2,170	2,270
	County total					4,080	4,390
Charlton, Georgia	83	West Georgia	303928	820928	Unconfined	40	60
	83	West Georgia	303928	820928	Upper Floridan	350	450
	83	West Georgia	303928	820928	Lower Floridan	1,000	1,100
	83	West Georgia	303928	820928	Fernandina permeable zone	2,200	2,300
	County total					3,590	3,910
Network total						108,850	127,380