UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

WATER RESOURCES INFORMATION NEEDS FOR THE ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

by
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1. INTRODUCTION

In order to realize the full beneficial use of the water resources of Florida, the State Legislature enacted the *Water Resources Act of 1972* (Chapter 72.299, Florida Statutes). This act provides for the creation of five major water management districts under the general supervision of the Department of Natural Resources.

The Department's Division of Interior Resources, recognizing that a background of hydrologic data and related information is essential in implementing the Act, requested the U.S. Geological Survey to initiate a cooperative investigation to assess the availability of water data and to portray future data needs in the three newly created water management districts.

Many U.S. Geological Survey staff personnel participated in and contributed to the preparation of the report. Kenneth Vanlier served as coordinator and prepared the overall format, set forth the basic objectives, and developed the relation of water resources information needs to the management functions of the District. J. O. Kimrey, G. W. Leve, D. A. Goolsby, H. G. Healy, R. H. Musgrove, N. D. Hoy, S. D. Leach, A. A. Garrett, and D. F. Tucker made major contributions to the report.

1.1 Purpose and Scope

This report summarizes the hydrology of the St. Johns River Water Management District (the District) and briefly summarizes the availability of hydrologic data and applicability of that information to the requirements of the District. It also portrays future data needs and the data networks and programs needed in order to obtain data not already available. That additional data will be needed is presumed, on the basis of the specific functions or responsibilities given the District as mandated in the 1972 Act. The types of data needed, of course, provide the key to the nature of the water management programs that probably will be required in the District.

1.2 Location and Extent

The District, in northeast Florida, includes the St. Johns River basin north of St. Lucie County, the St. Marys River basin in Florida, and the adjacent coastal areas which drain to the sea. The north-south length is about 230 mi. and its maximum width is about 75 mi. (Figure 1). It includes all of Indian River, Brevard, Seminole, Volusia, Flagler, Putnum, Clay, St. Johns, Duval, and Nassau Counties, the major parts of Orange, Lake, Marion, Alachua, and Baker Counties, and small parts of Okeechobee, Osceola and Polk Counties. The area of the District is about 12,400 mi^2. Its boundary follows political and land survey lines and differs slightly from the St. Johns River basin drainage divide.

Heavily populated cities in the District are Jacksonville, Orlando, Daytona Beach, Gainesville, and Melbourne; other heavily populated localities are in the vicinity of the Space Center complex in Brevard County and suburbs of Jacksonville and Orlando.

1.3 Economic Development

The District has a well balanced economy based on agriculture, livestock, tourism, industry, mining, forest products, and transportation. Citrus groves, truck farms, and livestock are centered in the southern and central parts of the District; manufacturing in most of the larger cities; mining of phosphate rock, limestone and clay in the west-central part, and heavy minerals along coastal ridges; forestry and forest products mostly in the northern half; and tourism throughout the District. Economic growth has been more rapid in the District than in the Nation on the average and the growth is expected to continue. Employment is expected to triple and gross income to grow 10 times by the year 2020 (Florida Department of Natural Resources 1970).

All major centers of population, industry, and agriculture are well connected by transportation routes. Principal highways such as Interstate 4, 10, 75 and 95, the Florida Sunshine Parkway, and numerous other Federal and State highways criss-cross the area. Jacksonville is an important railway and airline hub. The intracoastal waterway extends along the entire east coast, and the coastal reach of the St. Johns River accommodates ocean-going ships for movement of bulk goods.

2. HYDROLOGIC SETTING

2.1 Climate

The climate of the District varies from humid temperate in the north to humid subtropical in the south. Summers are generally long and wet; winters are mild and relatively dry. The average annual temperature is about 72°F; the temperature is below freezing (32°F) usually at least once a year except in the southernmost part of the District (Florida Department of Natural Resources, 1970, p. 30).

Average annual rainfall is about 53 in. for the District as a whole. Ranging about from 50 to 57 in., it is generally higher in the southeast. On the average, more than half of the rain falls during June—September. Summer rains typically are local thunderstorms; winter rains generally are frontal storms. Tropical storms or hurricanes occasionally invade the area, usually during late summer or fall.

Lake evaporation ranges from about 45 in. in the north to about 50 in. in the south. Evapotranspiration, though less than lake evaporation, is capable of using all but a few inches of the average annual rainfall anywhere in the District.

2.2 Topography

The District lies in two physiographic provinces defined by Cooke (1939, p. 14). The western half is in the Central Highlands and the rest is in the Coastal Lowlands (fig. 2). Relief throughout the District is generally low. Land surface ranges in altitude from sea level in many parts of the Coastal Lowlands to more than 300 ft at one point in the Central Highlands. In general, altitudes of 0 to 50 feet characterize the Coastal Lowlands and altitudes of 50 to more than 150 feet characterize the Central Highlands.

The Coastal Lowlands consist of several marine terraces that are generally alined parallel to the coast. The most discernable are the lower terraces, the Silver Bluff, Pamlico, Talbot, and Penholoway Terraces which, respectively, are about 8, 25, 42, and 70 feet above present sea level. Less distinct terraces are at higher altitudes. Most of the relief is along the edges of the terraces. Elsewhere the flat terrace plains, which originally were sea bottoms, are preserved over large areas except where they have been modified by underground solution and surface erosion. A large part of the Coastal Lowlands is covered by pine forests and an understory of palmetto scrub. Cypress swamps occur in lower, more poorly drained areas. Extensive marsh areas are covered with little vegetation except wetland grasses and shrubs.

The Central Highlands are a series of low rolling hills and ridges, interspersed with broad plains. Closed topographic depressions, many containing lakes, are common; these result largely from solution of the underlying limestone and associated sinkhole activity. The Central Highlands originated as extensive deposits of sand and clay in seas that at one time covered the Florida Peninsula. After the seas receded, the topography was modified by stream erosion, marine erosion which formed terraces, and by solution of the underlying limestone. In the District, altitude and relief are maximum in the Central Highlands where, on the west side of Lake Apopka in Lake County, the altitude is more than 310 ft. The adjacent mucklands are at an altitude of about 64 ft. Native vegetation in the northern part of the District (generally north of the 25° F average annual minimum temperature line) is typified by oak and pine forest. In the southern part of the District, much of the native vegetation on higher land has been replaced by citrus.

2.3 Drainage Basins

The District is drained by the St. Johns River and its tributaries, by the coastal drainage basins, and by the Nassau-St. Marys basins (fig. 3). Except where modified by canals, drainage is usually dendritic. Sluggish flowing streams are typical and swamps or wetlands occupy large areas. Drainage of individual basins is discussed below.

2.31 St. Marys River Basin

The St. Marys River drains an area of about 1,480 mi^2 and its basin includes part of the Okefenokee Swamp. The headwaters are in the southeastern part of Georgia west of Folkston and drain about 540 mi^2 of that state. The Florida-Georgia boundary follows the river for about 125 miles above its mouth which is at the Atlantic Ocean near Fernandina Beach, Florida.

At its headwaters the St. Marys River is about 125 ft above mean sea level and when it enters Florida near Moniac, Georgia it is about 100 ft above mean sea level. The length of the river in Florida is 125 mi and its average fall is 0.8 ft/mi. At the Geological Survey gaging station at Gross, Florida, 21 mi upstream from the mouth, the river reverses flow about twice daily but does not reverse its flow at Geological Survey gaging station near Macclenny, 100 mi above the mouth. From its headwaters, the river flows south about 25 mi into Florida, then turns east for about 20 mi, then north for about 40 mi, and east again for about 40 mi to its mouth. Two major tributaries enter near Macclenny, the Middle Prong St. Marys River and South Prong St. Marys River. Their drainage areas are 220 and 160 mi^2, respectively.

2.32 St. Johns River Basin

The St. Johns River drains an area of about 9,400 mi^2, which includes the 2,870-mi^2 drainage area of the Oklawaha River, its largest tributary. Both the St. Johns and Oklawaha flow generally northward. Their courses are influenced to some degree by joints and faults in the underlying limestone.

The St. Johns is the largest stream system entirely in Florida. Its headwaters are in a broad marshy area west of Fort Pierce. From there, it flows about 300 river mi to its mouth at Mayport, east of Jacksonville. The headwater marshes are at an altitude of about 25 ft so the average gradient of the river is less than 0.1 ft/mi.

From the headwaters, the marshes extend northward about 40 mi before a natural channel becomes discernible near Sawgrass Lake in Brevard County. This headwaters area has been extensively altered by canals, so there is now considerable interchange of water with the coastal drainage basins to the east and the Kissimmee-Okeechobee basin complex to the west and south.

From the Sawgrass Lake area to Jacksonville, the river flows north about 250 mi through eight relatively large shallow lakes. In its course to Jacksonville, the river is joined by numerous small streams including the Econlockhatchee and Wekiva Rivers, and by the Oklawaha River. At Jacksonville, the river flows east about 23 mi to its mouth.

During low flow the St. Johns River is tidal as far upstream as Lake George, 106 mi from the mouth; and tides have occured as far south as Lake Monroe at Sanford, 161 mi from the mouth. The river is navigable to Sanford. Downstream from Palatka, the river is more than 1 mile wide on the average. According to Snell and Anderson (1970), the surface area of the main stem at low water exceeds 300 mi^2.

The Oklawaha tributary joins the main stem south of Palatka. Its extreme headwaters are southwest of Orlando where the Palatlakaha River flows from the Green Swamp area. The Palatlakaha flows into Lake Harris, then to Lake Eustis, where it is joined by drainage from Lakes Apopka, and Dora. Flow from Lake Eustis then passes through Lake Griffin. At the mouth of Lake Griffin, the name "Oklawaha" is applied to the flow system. The large lakes in the Oklawaha headwaters have been connected by canals and control structures to regulate flow. Eight miles north (downstream) of Lake Griffin the Oklawaha flows to a lock and dam. North of the lock and dam, the Silver River, which drains Silver Springs, joins the Oklawaha. The other major tributary to the Oklawaha is Orange Creek which joins the Oklawaha about half way between the Silver River confluence and the mouth. Downstream from the Orange Creek confluence, the river flows into Lake Rodman, an artificial lake constructed as part of the currently (1974) defunct Cross Florida Barge Canal. Below Lake Rodman, to the river's mouth, the flow is not regulated.

Large areas in the St. Johns River basin are drained internally, that is, they do not contribute to direct runoff. These areas coincide generally with areas of karst (sinkhole) topography. Ground water is eventually discharged from these areas to streams and lakes by means of seeps and springs. The largest of these internal drainage areas is in Marion, Levy and Alachua Counties which discharges at Silver Springs east of Ocala. Smaller internally drained areas are in the northwest part of Orange and south part of Lake Counties (Palatlakaha and Lake Apopka drainage); the north-central part of Orange and southwest part of Seminole Counties (Wekiva River drainage); in west part of Volusia County; and in Putnam and Clay Counties.

Most tributaries of the St. Johns go dry during droughts. Exceptions are tributaries such as the Silver and Wekiva Rivers whose discharge is made up largely of ground-water seepage or spring flow. The mainstem of the St. Johns also receives ground-water seepage, including discharge from numerous springs, through almost all its length. Zero flow, however, has been recorded in the main stem as far upstream as Christmas. In the tidal part of the river, the direction of flow commonly reverses; that is, water moves upstream, depending upon such factors as tides, tributary inflow, winds, and evaporation.

2.33 Coastal Canal and Stream Basins

An area of about 2,000 mi^2 in the narrow coastal strip between the St. Johns basin and the ocean is drained by numerous small streams and canals that flow directly into the lagoons and the ocean. The Intracoastal Waterway facilitates eventual drainage to the ocean by connecting the various lagoons.

The largest of the coastal drainage basins is the Tomaka River basin in Volusia County, which drains an area of 152 mi^2. Flow characteristics of the coastal basins are often highly variable because of extensive canal networks and water control structures. This is particularly true in the southern part of the area where Turkey Creek, Fellsmere, North, Main, and South Canal drain parts of the St. Johns Marsh that originally drained to the main stem of the St. Johns River.

2.4 Aquifers

The District is underlain by sedimentary rocks that range in age from Eocene, or older, to Holocene. The formations penetrated by water wells in the District, their general characteristics and thickness, and their structural and stratigraphic relations are shown in figure 4, as are the surface distribution and lithology.

The geologic materials at land surface throughout most of the District are sand, clayey sand, or shell deposits of Miocene to Holocene age. Deposits of Eocene age crop out only locally. Thickness of the post-Eocene materials range from 0 to about 400 ft. The various formations overlie those of Eocene age except, of course, where the deposits of Eocene age are at the surface.

The Eocene formations are composed of a thick sequence of limestone and dolomite limestone. In the District the combined thickness of the several limestone formations ranges from about 500 to more than 1,000 ft. Eocene deposits are at or near land surface in parts of Marion, Lake, and Alachua Counties, and the top of the Eocene is more than 400 ft below land surface at the extreme north and south ends of the District, as shown in figure 5.

Water yielding deposits that are of economic importance to the District are the Floridan aquifer, secondary artesian aquifers, and shallow aquifers. The aquifer descriptions that follow are brief. Detailed descriptions of one or more of the aquifers are available in the published reports whose titles are cited on figure 11.

2.41 Floridan Aquifer

The Floridan aquifer consists, in general, of deposits of Eocene age. The confining materials are usually the clay and clayey sand of the Hawthorn Formation of Miocene age. In areas where basal shell and limestone beds of the Hawthorn are hydraulically connected to the Eocene limestones, however, these basal beds are included in the Floridan aquifer. The configuration of the top of the Floridan aquifer is shown on figure 5.

The Floridan aquifer is the most important source of water in the District. It contains water under confined or artesian conditions. Except in some coastal areas and parts of the St. Johns River Valley, wells that tap the Floridan yield as much as several thousand gallons of fresh water per minute. Public water supplies are obtained almost exclusively from this aquifer except in the areas where it contains saline or brackish water. The depth to the base of potable water in the Floridan aquifer, and areas where the Floridan yields non-potable water are shown in figure 6.

The level at which water will stand in a tightly cased well tapping a given aquifer constitutes a point on the potentiometric surface of that aquifer. Ground water in the Floridan aquifer moves from areas where the potentiometric surface is high to areas where it is low. Thus the general circulation pattern of ground water in the Floridan aquifer may be discerned from figure 7 which shows the potentiometric surface of the upper part of the aquifer during May 1973. This potentiometric surface is characterized by two large highs, the Green Swamp and the Clay County-Bradford County highs, and the smaller Volusia County high. Numerous lows, or depressions in the surface, are related to spring discharge, seepage to the St. Johns River valley or the ocean, and to pumping from wells. Springs discharging from the Floridan aquifer are shown on figure 8.

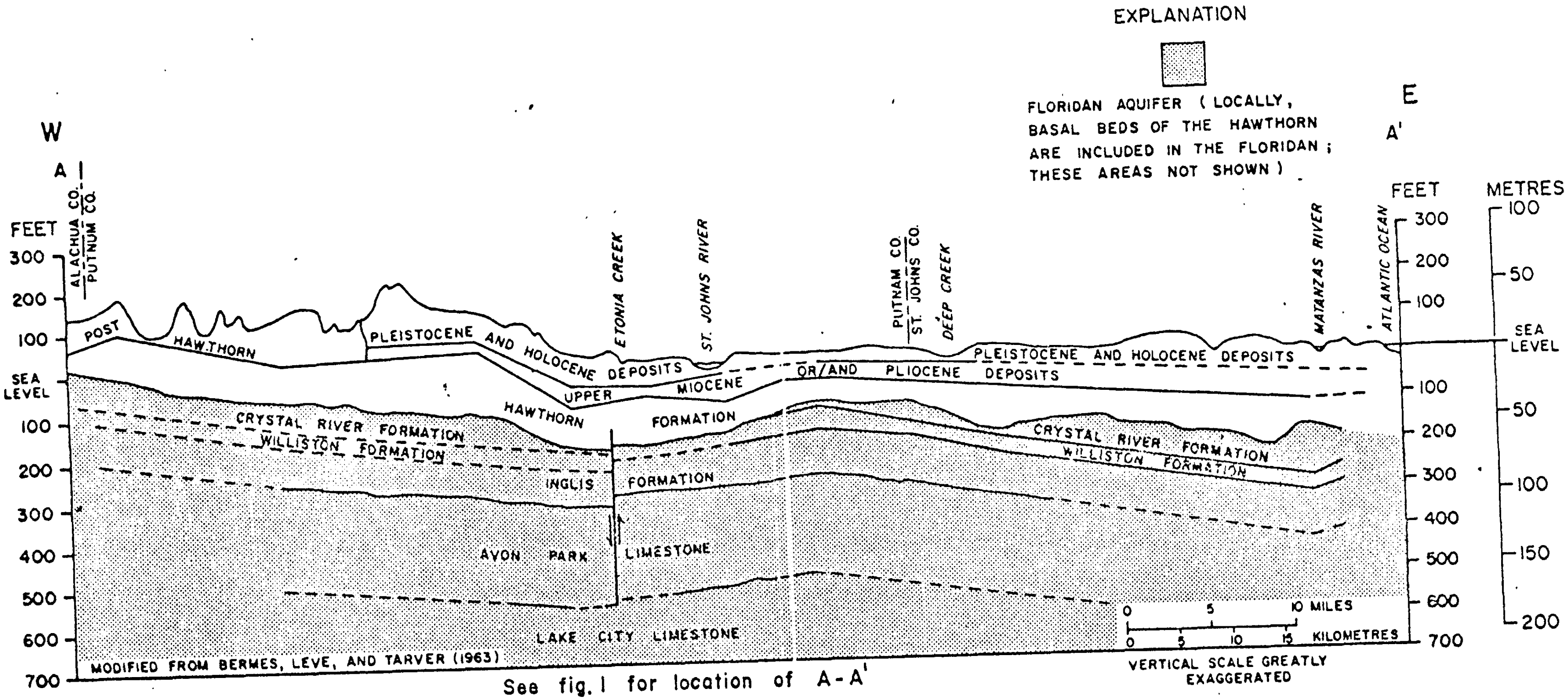

Figure 4.--Geologic section across the St. Johns River.

Because ground water is constantly, though slowly, moving through the aquifer to points of discharge, an understanding of the manner and areas in which the aquifer is recharged is important. In the District as a whole, topographic highs, potentiometric surface highs, and recharge areas to the Floridan aquifer coincide, in general. This coincidence is not everywhere meaningful: the areas where the potentiometric surface is the highest are not necessarily those where recharge is greatest. Other factors must be considered when comparing the rate of recharge from one place to another.

Basically, only two conditions are necessary for recharge of the Floridan aquifer to take place. They are, (1) vertical permeability of the overlying deposits must be great enough to allow water to move downward to the Floridan aquifer; and (2) the hydraulic gradient must be downward, that is, the potentiometric surface of the water in the more permeable parts of the overlying deposits must be higher than the potentiometric surface of the Floridan. Some recharge occurs whenever these two conditions are met; the amount of recharge is proportional to the vertical permeability and the hydraulic gradient.

A third condition, advantageous but not necessary, is that the permeable parts of the overburden be thick and unsaturated. The unsaturated part of the overburden provides temporary storage for surface water that otherwise would run off or be lost to evapotranspiration. Hence, ultimate recharge to the Floridan aquifer is enhanced. Most water stored in the overburden is not lost through evapotranspiration and is recharged to the aquifer.

2.42 Secondary Artesian Aquifer

Various shell and sand beds, mainly in the Hawthorn Formation, commonly are referred to as "secondary artesian aquifers." These waterbearing zones contain water that is confined, or semiconfined, by overlying and underlying clay or sandy clay. Recharge to secondary artesian aquifers occurs by downward seepage from the water-table aquifer when the potentiometric surface of the water-table aquifer is higher than that in the secondary artesian aquifer or by upward seepage from the Floridan aquifer when the potentiometric surface of the Floridan is higher than that in the secondary artesian aquifer.

These aquifers locally may yield as much as several hundred gallons per minute to wells, but because they are not present over much of the District their overall potential is small. Major use of secondary artesian aquifers has been in the Cocoa well-field area of Orange County.

2.43 Shallow Aquifer

This term "shallow aquifer" is applied to materials that lie above the Hawthorn Formation or a depth of about 175 ft and that contain water under unconfined or water-table conditions. The water-bearing materials are sand and shells, and shelly limestone. The shallow aquifers are recharged primarily by downward percolation of local rainfall.

Well yields are usually less than 50 gal/min except where thick zones of coarse material are present. Where they are present, well yields of 100 to 250 gal/min are common and some wells yield as much as 350 gal/min. The shallow aquifers are little used in the District except where higher yielding aquifers are not present. They are used for public supply east of the mainstem of the St. Johns River where they are the only source of fresh ground water. Vero Beach, Titusville, and St. Augustine obtain water from wells that tap the coarser grained parts of these aquifers.

3. EXISTING WATER DEVELOPMENTS AND PRINCIPAL WATER MANAGEMENT CONCERNS

Water management concerns are those chiefly of municipal, agricultural, industrial, commercial, and recreational development. Changes in land use and the encroachment of development into natural forest and marsh areas affect water quality, recharge to aquifers, and water availability. Because developing areas are not necessarily where water availability and quality are favorable, the concern about water and water management problems is increased.

Of the 53-in. average annual rainfall in the District about three-quarters is lost by evapotranspiration after having supported vegetation and maintained lake and stream levels. The rest percolates downward to aquifers or moves to the ocean. Thus, about one-quarter of the water which falls on the District as rain (about 11,000 ft^3/s, or 7,100 Mgal/d) is available for interception and use

Table 1.—Major types of water use and water consumed in the St. Johns River Water Management District in 1970 [million gallons per day].

Type of Use	Quantity used		Water consumed	
	Fresh	Saline	Fresh	Saline
Thermo-electric power (cooling water)	658	1,959	5	18
Irrigation	293	—	202	—
Public Supply	185	—	50	—
Industrial (Self supplied)	176	29	10	—
Rural Use	60	—	47	—

by man. Water may be obtained from the shallow sand and shell aquifers and from the Floridan aquifer by wells, and from streams and lakes by pumping or by diversion after construction of dams to impound or divert the waters. In addition to the fresh water in aquifers, streams, and lakes an unlimited supply of sea water is available as is an almost unlimited supply of saline water (water with more than 1,000 mg/l of dissolved solids) in Mosquito Lagoon, Indian River and other coastal lagoons. Saline and brackish water may be used for industrial cooling.

3.1 Major Water Uses

The major types of water use in the District, and the total use for each type are shown in Table 1. The quantity of water consumed compared to the quantity withdrawn varies considerably depending on the type of use. Almost all water used for cooling is returned; most water used by industry is also returned, although it may be greatly reduced in quality; more than two-thirds of the water used for public supply is returned to a stream or aquifer; about one-third of the water used for agriculture is returned although virtually none is returned when sprinklers are used. Water is reused or recycled by industry more than by other users. Water reuse is a primary means of conserving water. Recreational uses of water are largely non-consumptive and generally are compatible with the support and propagation of fish and other aquatic life.

3.11 Public and Municipal

Municipal or public use of water is generally a priority use inasmuch as it sustains human life and provides for many essential services. These services are many: public supply for homes, schools, public and commercial buildings and enterprises; maintenance of lawns, parks, gardens, and street cleaning; fire protection; maintenance of municipal recreation projects such as swimming pools, and various esthetic uses.

Table 2 lists public water utilities in the District with an output of more than 1 Mgal/d. Many of the utilities in the more populated areas are privately owned and supply the many residential subdivisions that have been developed. The centers of largest use are Jacksonville and Orlando areas which, combined, account for about 62 percent of

Table 2.—Public Water Utilities with output of more than 1 million gallons per day (adapted from Pride, 1973).

County	Municipality	Output (mgd)	
		1965	1970
Alachua	Gainesville	7.96	10.9
Baker	(none)		
Brevard	Titusville	4.00	3.49
	Cocoa	14.1	15.3
	Melbourne	3.60	7.72
Clay	(none)		
Duval	Jacksonville Beach	1.88	2.0
	Jacksonville	36.09	44.0
Flagler	(none)		
Indian River	Vero Beach	1.50	2.66
Lake	Leesburg	3.30	4.64
	Eustis	2.00	1.96
Marion	Ocala	2.50	3.34
Nassau	Fernandina Beach	1.00	1.70
Okeechobee	(none)		
Orange	Orlando	25.41	32.4
	Winter Park	5.60	9.46
	Maitland	(a)	1.30
	Winter Garden	(a)	1.10
Osceola	(none)		
Polk	(none)		
Putnam	Palatka	(a)	2.21
Seminole	Sanford	2.30	2.70
St. Johns	St. Augustine	1.91	1.90
Volusia	Ormond Beach	1.52	2.01
	Daytona Beach	5.38	9.58
	New Smyrna Beach	1.75	1.71
	Deland	2.50	2.45

(a) Less than 1 million gallons per day.

the total water withdrawn for public use. Other centers of substantial public use are in Brevard and Volusia Counties which use 20 percent; the remaining 18 percent is distributed among other population centers throughout the District. The quantities of water used for public supply in 1970 in the District, by county, are listed in table 3.

3.12 Industrial

Water use by industry is also a high priority use. Although many industries are supplied with water by the cities in which they are located, about 80 percent of the fresh water used by industry is self-supplied.

The largest users of industrial water are pulp and paper mills which account for about 60 percent of all industrial water used in the District. The food industry, including citrus processing, dairies, bakeries and soft-drink bottling plants, is the second largest user (about 20 percent of the total). Industrial use, by counties, is as follows: Duval County, 35 percent; Nassau County, 28 percent; Putnam County, 18 percent; Lake County, 11 percent; the remaining counties or segments of counties, 8 percent.

Self-supplied industrial use of water for 1970, is listed by counties in Table 4. The table lists the quantities of both fresh and saline water withdrawn from surface and ground-water sources and the quantities consumed. Water for thermo-electric use is also included. The places where most of the industrial water is used are shown in Figure 9.

The fresh water consumed through industrial use is about 5 percent of the water withdrawn. Because most of the water is returned to a stream or reaches the ground-water reservoir through drains, sumps, or other means, industrial waste water can contaminate both ground and surface waters.

The quantity of water used for thermo-electric cooling is very large and is withdrawn from both fresh and saline surface-water sources; the amount of ground water used for this purpose is negligible. The water consumed is less than 1 percent of that withdrawn; the energy in the heated waste water is, of course, lost; the heat serves only to increase the temperature of the receiving water bodies.

Table 3.—Water used for public supply by counties, in 1970 in St. Johns River Water Management District (Adapted from Pride, 1973).

COUNTY	POPULATION SERVED				WATER WITHDRAWN			
	Percent of County in District	Ground Water 1000's	Surface Water 1000's	All Water 1000's	Ground Water Mgal/d	Surface Water Mgal/d	All Uses Mgal/d	Per Capita gal/d
Alachua	50	71.9	——	71.9	22.3	——	22.3	282
Baker	90	2.6	——	2.6	0.3	——	0.3	115
Brevard	100	204.0	——	204.0	(a) 11.2	——	11.2	130
Clay	100	12.7	——	12.7	1.6	——	1.6	126
Duval	100	345.3	——	345.3	67.8	——	67.8	196
Flagler	100	2.8	——	2.8	.3	——	.3	107
Indian River	100	21.0	——	21.0	3.1	——	3.1	148
Lake	95	42.2	——	42.2	10.0	——	10.0	237
Marion	60	28.4	——	28.4	3.9	——	3.9	137
Nassau	100	8.9	——	8.9	2.0	——	2.0	225
Okeechobee	5	4.5	——	4.5		0.6	0.6	133
Orange	65	290.0	——	290.0	(a) 65.8	——	65.8	174
Osceola	30	14.5	——	14.5	2.7	——	2.7	186
Polk	4	170.0	——	170.0	27.7	——	27.7	163
Putnam	99	14.0	——	14.0	2.7	——	2.7	193
St. Johns	100	10.0	7.0	17.0	1.4	1.1	2.5	147
Seminole	100	58.9	——	58.9	6.3	——	6.3	107
Volusia	100	142.3	——	142.3	19.2	——	19.2	135
County Totals		1,444.0	7.0	1,451.0	248.3	1.7	250.0	172
Management District		1,115.1	7.0	1,122.1	183.5	1.1	184.6	165

(a) 15.3 Mgal/d exported from Orange County to Brevard County.

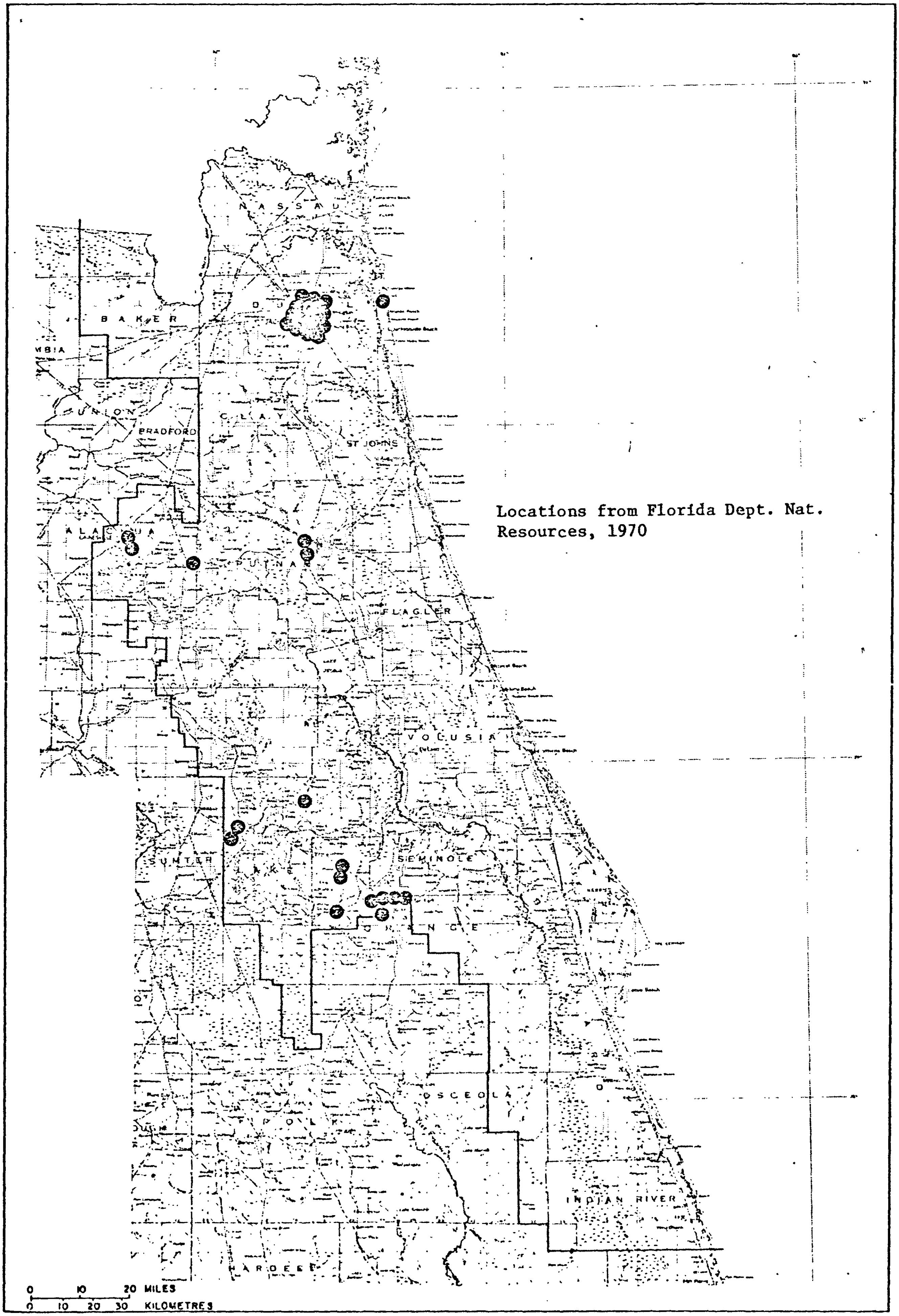

Figure 9.--Location of major industrial water use.

Table 4.—Self-supplied industrial water use by counties, 1970 in St. Johns River Water Management District, million gallons per day. (Adapted from Pride, 1973).

COUNTY	WATER WITHDRAWN							THERMO-ELECTRIC POWER						
	Ground Water		Surface Water		All Water		Con-sumed	Surface Water		Ground Water		Total	Consumed	
	Fresh	Saline	Fresh	Saline	Fresh	Saline		Fresh	Saline	Fresh	Saline		Fresh	Saline
Alachua	1.4	—	—	—	1.4	—	0.3	—	—	—	—	—	—	—
Baker		negligible												
Brevard	.4	—	—	—	.4	—	.2	—	1077	0.3	0.1	1078	0.2	10.0
Clay	1.5	—	—	—	1.5	—	.2	—	—	—	—	—	—	—
Duval	60.9	—	—	20.0	60.9	20.0	4.0	—	767	.3	—	767	.2	7.5
Flagler	—	—	—	2.0	—	2.0	—	—	—	—	—	—	—	—
Indian River	.5	—	—	—	.5	—	.1	—	72	.1	—	72	.1	.3
Lake	19.4	—	—	—	19.4	—	.5	—	—	—	—	—	—	—
Marion	2.1	—	.1	—	2.2	—	.1	—	—	—	—	—	—	—
Nassau	50.0	—	—	2.0	50.0	2.0	2.5	—	43	—	—	43	—	.2
Okeechobee	0.2	—	—	—	0.2	—	0.1	—	—	—	—	—	—	—
Orange	7.0	—	—	—	7.0	—	.5	128	—	.1	—	128	.5	—
Osceola	0.1	—	—	—	0.1	—	0.1	—	—	1.6	—	1.6	—	—
Polk	236.0	—	71.0	—	307.0	—	48.0	110	—	0.4	—	110.4	1.4	—
Putnam	15.5	—	16.0	5.0	31.5	5.0	1.2	123	—	—	—	123	.6	—
St. Johns		negligible												
Seminole	.5	—	—	—	.5	—	.2	—	—	—	—	—	—	—
Volusia	.5	—	—	—	.5	—	.3	406	—	—	—	406	3.2	—
County totals	369.0		87.1	29.0	433.1	29.0	58.3	767	1959	2.8	0.1	2729.	6.2	18.0
Mngmnt Dist	159.7		16.1	29.0	175.8	29.0	10.1	657	1959	0.9	0.1	2617.0	4.8	18.0

3.13 Irrigation

Withdrawal of fresh water for irrigation in the District constitutes 22 percent of all fresh water withdrawn and 63 percent of all fresh water consumed. Of the total quantity of water withdrawn for irrigation, 42 percent is in Indian River County and 16 percent in Brevard County. About 80 percent of water used for irrigation comes from wells or springs. Table 5 lists the estimated water use for irrigation for 1970, by counties. The average increase in the District since 1965 is about 20 percent. The largest increase is in Indian River County.

In 1965 about 68 percent of the irrigation demand was obtained from wells or springs; in 1970, about 80 percent. This represents an average increase of about 60 Mgal/d in ground-water use and a decrease of almost 20 Mgal/d in surface-water use in the Management District. This trend toward increasing stress on the ground-water resource is one that may shape future water management programs. At least locally, this trend may not be long-lived, however. A projection of irrigation needs compiled by the Soil Conservation Service, U. S. Department of Agriculture, (oral commun., 1974) shows that the proportion of surface-water in use by the year 2020 will increase, especially in Indian River and Brevard Counties. The projection is based on completion of proposed water storage reservoirs in these counties as well as in Clay and Putnam Counties.

3.14 Rural

Rural water use includes domestic use and livestock use in areas not supplied by public water systems. Although it is only 4 percent of the total quantity of fresh water withdrawn, it represents 14 percent of the total consumed because much of the water used by livestock and gardening is not returned to streams or aquifers. In 1965, more than half of the rural use was in Brevard, Orange, Marion, Volusia and Seminole Counties, where the non-urban population is relatively large and most suburban areas are supplied by private wells. Of about 60 Mgal/d of fresh water estimated for rural use, only about 2 Mgal/d is from surface sources.

3.15 Recreational

Recreational water use is non-consumptive, and of high priority in Florida. Recreational uses require the conservation and maintenance of streams, lakes, springs, and natural water habitats of wildlife to preserve the features which make Florida attractive to tourists and residents. Improvement in quality of the waste water

Table 5.—Water used for irrigation by counties in St. Johns River Water Management District, 1970.

County	Percent of county in District	Acres irrigated	WATER WITHDRAWN: Acre-feet: Surface water	Acre-feet: Ground water	Acre-feet: Total	Million gallons per day: Surface water	Million gallons per day: Ground water	Million gallons per day: Total	WATER CONSUMED: Ac-ft	WATER CONSUMED: Mgal/d
Alachua	50	7,500	750	3,000	3,750	0.7	2.7	3.4	2,800	2.5
Baker	90	Negligible	—	—	—	—	—	—	—	—
Brevard	100	24,600	—	53,600	53,600	—	47.9	47.9	38,000	33.9
Clay	100	3,400	—	4,590	4,590	—	4.1	4.1	3,400	3.0
Duval	100	1,400	—	4,100	4,100	—	3.7	3.7	3,100	2.8
Flagler	100	8,230	200	10,100	10,300	.2	9.0	9.2	7,200	6.4
Indian River	100	72,100	38,000	109,100	147,100	33.9	97.4	131.3	96,000	86.7
Lake	95	46,500	8,600	15,000	23,600	7.7	13.4	21.1	18,000	16.1
Marion	60	13,700	1,230	6,440	7,670	1.1	5.7	6.8	5,800	5.2
Nassau	100	Negligible	—	—	—	—	—	—	—	—
Okeechobee	5	46,000	6,600	32,400	39,000	5.9	28.9	34.8	23,000	20.5
Orange	65	39,000	10,000	12,500	22.500	8.9	11.1	20.1	17,000	15.2
Osceola	30	20,000	6,000	9,000	15,000	5.4	8.0	13.4	11,200	10.0
Polk	4	129,000	19,400	174,800	194,210	17.3	156.1	173.4	145.000	129.5
Putnam	99	11,200	2,300	8,550	10,850	2.1	7.6	9.7	8,100	7.2
St. Johns	100	19,000	—	24,800	24,800	—	22.1	22.1	17,000	15.2
Seminole	100	10,600	2,970	3,850	6,820	2.7	3.4	6.1	4,500	4.0
Volusia	100	4,700	320	7,780	8,100	.3	6.9	7.2	5,700	5.1
County totals		416,030	93,370	479,610	575,980	86.2	428.0	514.2	405,800	362.3
Management District		250,093	62,465	265,436	327,901	55.9	236.8	292.7	226,250	202.0

discharged to streams after industrial, public, and agricultural uses can assure that these uses will be compatible with recreational uses.

Recreational water use cannot be readily quantified except where the water is withdrawn from a stream, lake or aquifer, to be used in off-channel structures. Consumptive use of water (through evapotranspiration) may be increased if water from wells or streams is used to maintain levels of large lakes or marshlands for recreational use.

3.2 Major Water Development Facilities

Water development facilities are those that supply water to, or carry water from a community, an irrigated area, an industrial facility, or an individual domestic unit. Ground-water development for public supply and agriculture is extensive. Except for drainage canals and ditches mainly in Indian River and southern Brevard Counties used to drain marshlands for citrus groves and other agricultural pursuits, there are no large-scale surface-water developments in the District. In general, the District's topography is not suitable for high dams to impound large volumes of water, and hydroelectric installations are negligible. Water development facilities include reservoirs and diversion works, drainage systems, well fields and waste disposal facilities, in addition to the water supply or water use facilities discussed in the previous sections.

3.21 Reservoirs

Although impoundment of water behind high dams is not possible in the District because of the relatively low relief, many natural lakes have outlet structures to control the water levels for recreational use or for esthetic purposes. The lakes then also act as water impoundments or small reservoirs. A few streams, such as the Oklawaha River, also have been dammed. Rodman Dam on the Oklawaha, which forms the Rodman Pool (Lake Ocklawaha) is part of the partly completed Cross-Florida Barge Canal project.

Moss Bluff lock and dam—also on the Oklawaha— is a multi-purpose facility for flood control and movement of small boats as well as lake level control. Storage of water for irrigation is not a primary consideration in such impoundments but they may be so used. Lake Washington, the source of public water supply for Melbourne and Eau Gallie, is controlled by a low outlet structure.

The physical features of some lakes not now controlled or with only slight control are such that storage of water in them can be increased by building control structures or raising existing structures. Also, dams and levees can be erected on numerous streams. Impoundment of water in streams or lakes may not increase evaporation significantly if the lands which would be submerged are marshlands with existing high evapotranspiration rates. However, increasing storage by impoundment could cause problems of minimum stream flow and higher lake stages. Offsetting these problems are regulated flows, water-conservation, irrigation and the advantages of public water supply benefits from the increased storage.

3.22 Drainage Systems

Draining of marshlands to transform them into citrus groves and vegetable farms has been carried on intensively in parts of the District. Examples of highly developed drainage systems are in Indian River County, where 250 mi^2 are ditched and drained, and in southern Brevard County and the truck-farming areas near Lake Apopka in Lake and Orange counties. The intricate pattern of ditches and drainage canals is too detailed to be shown on a small illustration, so that it is necessary to refer to standard U.S. Geological Survey topographic maps, county maps, and individual drainage district maps to adequately view the ditch and canal systems.

Large residential communities which cover thousands of acres along the Atlantic coast were created through surface-water drainage systems similar to those for citrus groves. Canals, which extend inland from lagoons to create marina-type areas effectively drain such communities. They also provide paths for salt-water intrusion unless salinity-control structures are installed.

3.23 Wells

Wells for public water supply, industrial use, and irrigation, and individual wells for home and farm water supplies, constitute the most extensive type of water development in the District as well as the greatest volume of fresh water withdrawn. Individual wells are located throughout the District where homes and farms require water; many wells of large yield are located in or near municipalities and industrial sites; many other wells, also of large yield, supply large-scale irrigation projects.

Wells supply all municipal water utilities except that for Melbourne-Eau Gallie, which uses surface water, and St. Augustine which obtains part of its supply from an infiltration gallery. The pulp and paper mill at Palatka in Putnam County uses water from Rice Creek and Etonia Creek. Nearly all municipal wells are located within or very near the municipality served; however, wells in east central Orange County supply the city of Cocoa and the Space Center complex in Brevard County.

3.24 Waste-Water Disposal Facilities

Waste effluent from most municipalities and industries is disposed of into lakes, streams, and coastal lagoons; effluent from some is disposed of into ponds without surface outlets, as at Ocala in Marion County. Until recent years some industries injected fluid waste into wells. This practice, however, has been largely discontinued. The efforts of Federal and State agencies to reduce contamination of both surface and ground waters has resulted in the better treatment and disposal of wastes. Solid waste disposal in land fills and dumps can also contaminate ground water; investigations of land fills and their effects are under constant study.

The location of waste-water facilities in the District is shown in Figure 10; Table 6 lists waste-water facilities that handled more than 1 Mgal/d in 1965 and pertinent information for these utilities.

Small industrial facilities in cities dispose of their wastes in the municipal systems; others, such as the large pulp and paper mills and citrus processing plants, have their own waste disposal or treatment systems. Waste water from irrigated lands in Brevard and Indian River Counties moves to the coastal lagoons by way of canals and ditches. Most of the irrigation return water is highly mineralized. Part of this mineralized water in the drainage system recharges the shallow aquifer and degrades the quality of the water in the aquifer.

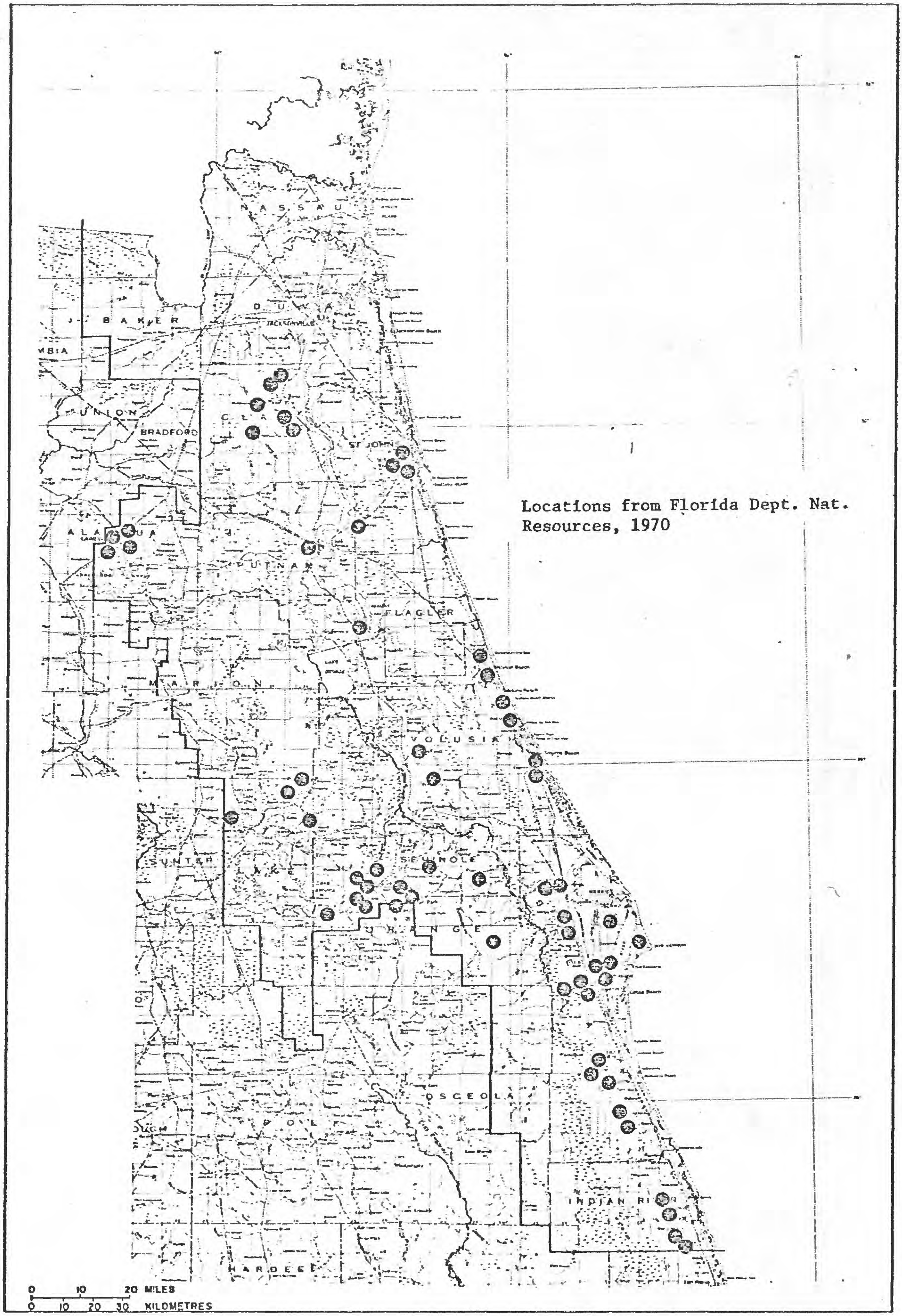

Figure 10.--Location of major waste-water facilities.

Table 6.—Major Wastewater Facilities

County	Urban unit served by facility	Ownership*	Capacity (Mgal/d)	Treatment†	Effluent discharged to:
Alachua	Gainesville	G	5	S	Sweetwater Branch, Paynes Prairie
	Univ. of Florida	G	2.4	S	Lake Alice
Brevard	Titusville North	G	2.0	S	Indian River
	Cocoa	G	2.0	S	Indian River
	Surfside Estates	P	1.0	S	Banana River
	Cocoa Beach	G	3.0	S	Banana River
	Patrick AFB	G	1.0	S	Banana River
	St. Patrick Shores	P	1.0	S	Banana River
	Capehart	G	1.0	S	Banana River
	Eau Gallie	G	1.65	S	Elbow Creek, Indian River
	Melbourne	G	2.5	S	Crane Creek, Indian River
	Titusville South	G	2.0	S	Indian River
Duval	Cedar Hills	P	1.4	S	Cedar Creek, Ortega River
	Jacksonville	G	17.5	S	St. Johns River
	Jacksonville Beach	G	2.0	S	Pablo Creek, Intracoastal Waterway
Indian River	Vero Beach	G	2.2	S	Indian River
Lake	Eustis	G	1.1	S	Trout Lakes, Lake Eustis Oklawaha River
	Leesburg	G	3.35	S	Lake Griffin, Oklawaha River
Marion	Ocala	G	2.34	S	
Orange	Winter Garden	G	1.0	S	Apopka-Dora, Oklawaha River
	Orlando #2	G	4.0	S	Shingle Creek
	S. W. Orange Co. San. District	G	8.0	S	Little Econlockhatchee
	Winter Park	G	4.5	S	Howell Branch-Lake Howell-Lake Jessup, St. Johns
	N. W. Drainage Co. Sewer District (Pinehills)	G	1.5	S	Lawne Lake to Wekiva River
	Orlando AFB	G	1.0	S	Little Econlockhatchee to Econlockhatchee
Putnam	Palatka	G	2.5	P	St. Johns River
St. Johns	St. Augustine	G	3.0	P	Matanzas River
	St. Augustine Davis Shores	G	1.5	P	Matanzas River
Seminole	Sanford	G	4.0	P	Lake Monroe
Volusia	Ormond Beach	G	2.0	S	Halifax River
	Holly Hill	G	1.2	S	Halifax River
	Daytona Beach	G	10.0	S	Halifax River
	New Smyrna Beach	G	1.2	S	Indian River
	Deland	G	1.2	S	St. Johns River

* G - Government Ownership
P - Private Ownership

† S - Secondary Treatment
P - Primary Treatment

3.25 Drainage Wells

Drainage wells are commonly used to drain developed areas in the District that have no natural surface drainage. They convey water to the Floridan aquifer by gravity. Drainage wells may degrade ground water quality in the future. There are about 200 drainage wells in Orange County, which is an indication of the magnitude of the drainage well problem. Other cities have used drainage wells for waste disposal; some use sumps or sinkholes as receivers of surface runoff. Surface runoff in an urban area may be contaminated to some degree but sand overlying the limestone provides filtration and some purification.

3.3 Existing Major Water Management Concerns

The District includes several existing local agencies involved in water management including the Oklawaha River Basin Recreation and Water Conservation and Control Authority in Lake County; the Indian River Drainage District in Indian River County; and the North Ormond Drainage District in Volusia County. Other agencies and the Counties in the District also have some water-management functions.

Local government officials and others in the District are continuing to be concerned about all phases of water, ranging from excess water to water shortages at various times and places; water quality is a concern everywhere at all times. Major existing water management concerns of local government officials are:

1. Fresh-water availability for major population centers, especially Jacksonville, Orlando, and coastal cities.
2. The effects of excessive water withdrawals from wells on the potentiometric levels of the Floridan aquifer throughout the District.
3. The use of mineralized water for irrigation that results in increased mineralization of surface water and water in shallow aquifers as in the Fellsmere and Sanford areas.
4. Lack of control of the many free-flowing wells. Data provided by Hendry and Lavender (1959) suggest that, in the aggregate, uncontrolled flow from wells in the District is more than 50 Mgal/d.
5. Contamination of ground water by drainage wells; from use of sinkholes as sumps for waste water; from garbage dumps and landfills.
6. Salt-water encroachment along the coast and elsewhere as the result of canals and ditches without salt-water barriers and excessive water withdrawal from wells.
7. Movement of fertilizers and pesticides from agricultural areas into surface and ground water, which contaminates the water and contributes to eutrophication of lakes.
8. Inadequate treatment of waste water from municipalities and industry before disposal.
9. The possible elimination of septic tanks by increasing the capability of municipal disposal facilities.
10. Zoning to prevent building of homes and other high risk developments in flood-prone areas. Providing flood protection and drainage improvements in those flood-prone areas that are already developed.
11. Improper development of recharge areas that result in increased runoff and reduced recharge to aquifers.

3.4 Potential Major Water Management Concerns

Potential concerns of local government officials generally will be an extension of existing concerns, some possibly in modified form. Even with effective control over some of the current (1974) problem items such as free-flowing wells, overdevelopment in recharge areas, and widespread construction of dwellings and other buildings in flood-prone areas, the principal concern will remain: availability of a sufficient supply of potable water for all needs for the existing population centers and for future major population centers. This principal concern undoubtedly will exist for decades. In addition, the rapid population growth and development expansion will continually introduce new concerns and problems.

In the following list are tabulated those concerns that are, as outlined above, continuations of existing concerns or of existing concerns in modified form:

1. The effects of water withdrawal on the water table and artesian water pressures.
2. Salt-water intrusion along the coast and into the shallow aquifer from additional canals and ditches and from overpumped and defective wells.
3. Contamination of aquifers by increased use of drainage wells, sinkholes and sumps for drainage, and from garbage landfills.
4. Contamination from expanded use of agricultural fertilizers and pesticides.
5. Adequate treatment of waste water and a reduction in the number of septic tanks in areas where they function poorly.
6. The education of the public to recognize the need for zoning of flood-prone areas, the conservation of recharge areas, and the protection of the District's water resources.

7. Reclamation of eutrophic lakes and control of noxious weeds.
8. Accessibility of public to water-related recreational areas.
9. Sodium build-up in agricultural soils in areas where brackish water is used for irrigation.

As of 1974 water in the District as a whole is plentiful, but potable water for domestic use and water of adequate quality for industrial and agricultural use is becoming less plentiful in many areas. The availability of water to meet demands becomes less certain as the demand increases.

Some parts of the District are water-rich; other parts are water-poor. The Oklawaha River subbasin contains much of the available fresh water in the District, a fact that will undoubtedly become a concern to both the water-poor areas, such as coastal parts of Brevard, Volusia and other Counties, and the water-rich Marion and Lake Counties. Long-range planning may involve the consideration of the transportation of water from the Oklawaha River to the water-poor areas. Transportation of water across political boundaries may become a major concern when the need for imported water for congested urban areas arises.

4.0 EXISTING DATA BASE

Hydrologic and hydrologically related data have been acquired by the U. S. Geological Survey and other agencies over the last several decades. Most of the data have been collected by the Survey as part of cooperative programs with State, Federal, and local agencies. Current cooperative hydrologic data and investigative programs of the U. S. Geological Survey in the District are listed in table 7.

The data available for the District have been collected either through areal investigations within a county, drainage basin or other area unit, or through data networks. Data obtained from areal investigations commonly are published as maps or in book reports containing maps. Data from networks generally are published as tables, books of tables or as graphs.

The following description of data available includes information acquired by State agencies, by the U. S. Geological Survey and by other Federal agencies.

4.1 Areal Investigations

4.11 Topographic Maps

Topographic maps portray the configuration of the land surface and the location of cultural features on the land surface. Such maps, suitable for general planning purposes, are available for all of the District. The topographic map names of each quadrangle are indicated on figure 13, which also shows availability of flood-prone area maps.

The topographic maps are 7½-minute quadrangles (60 minutes equal 1 degree latitude and longitude), published at a scale of 1 to 24,000 (one in. equals 2,000 ft.). Many of these maps were prepared two or more decades ago; hence, in areas of recent rapid growth the cultural features shown (roads, buildings, power lines) are outdated. However, the land surface data generally are valid except for areas of excavation or fill and areas along the coast that have been altered by erosion or deposition.

4.12 Geologic Investigations

A large quantity of geologic information for the District is available in several reports that discuss some aspect of stratigraphy, paleontology, or geomorphology, usually on a regional basis. Much geologic information is available also in reports for investigations that are primarily concerned with the occurrence of ground water. Such reports—those concerned with the occurrence of ground water but which contain considerable geologic information, particularly as related to the hydrologic framework—are available for 16 of the 18 counties in the District. Figure 11 shows the counties for which ground water reports are available and lists the report titles.

4.13 Hydrologic Investigations

Descriptive interpretative reports on water resources of county-wide scope are available for all of the District except for Osceola and Okeechobee Counties. Because of the nature of the cooperation with local government units most of these reports cover a single county or group of counties; other reports cover particular problem areas or developments. During the 1974 fiscal year, water-resources investigations involving the collection and interpretation of hydrologic data were being made in 12 of the 18 counties of the District. Figure 12 shows the areas of active investigations and the titles of these projects.

Table 7.—Agencies sponsoring present [1974] hydrologic data and investigative programs of the U. S. Geological Survey in the St. Johns River Water Management District.

PROGRAM	FUNDING AGENCIES
1. Hydrologic records related to waste water disposal, City of Gainesville.	City of Gainesville; U. S. Geological Survey.
2. Artificial recharge study and continuing collection of hydrologic records for Cocoa wells.	City of Cocoa; U. S. Geological Survey.
3. Study of ground-water supply for the City of Titusville.	Board of County Commissioners of Brevard County; and the U. S. Geological Survey.
4. Basic Hydrologic records, Lake County.	Lake County Water Authority, Board of County Commissioners of Lake County and the U. S. Geological Survey.
5. County-wide study of flood frequencies, Marion County.	Board of County Commissioners of Marion County; U. S. Geological Survey.
6. Program of study of function of recharge areas, artificial recharge and disposal of storm runoff, Orange County; continuing hydrologic records program, Orange County.	Board of County Commissioners of Orange County; U. S. Geological Survey.
7. Hydrologic Study of Osceola County.	Board of County Commissioners of Osceola County; U. S. Geological Survey.
8. Study of availability of ground water and effects of urbanization on water resources, Seminole County.	Board of County Commissioners of Seminole County; U. S. Geological Survey.
9. Study of induced recharge in central Volusia County; collection of basic hydrologic records.	Volusia County Council; U. S. Geological Survey.
10. Hydrologic data network; studies of connector well recharge; of "capture" function for salvaged evapotranspiration, and of surface water runoff.	Central and Southern Florida Flood Control District and the U. S. Geological Survey.
11. Basic hydrologic records and special studies.	Southwest Florida Water Management District; U. S. Geological Survey.
12. Studies of the geohydrology of the shallow aquifer; techniques of artifical recharge; and hydrologic aspects of land use, six county area.	East Central Florida Regional Planning Council; U. S. Geological Survey.
13. Basic hydrologic network of surface water, ground water, and quality of water stations.	Florida Bureau of Geology, Department of Natural Resources; U. S. Geological Survey.
14. Study of the effects of road construction on lake quality.	Florida Department of Transportation; U. S. Geological Survey.
15. Hydrologic records of lakes program.	Florida Internal Improvement Trust Fund; U. S. Geological Survey.
16. Statewide program of water quality data collection.	Florida Department of Pollution Control; U. S. Geological Survey.
17. Basic hydrologic records collection, (particularly in the area of the proposed Cross Florida Barge Canal).	U. S. Corps of Engineers.
18. Hydrologic data input to national lake eutrophication study.	Environmental Protection Agency.
19. National stream quality accounting network.	U. S. Geological Survey.
20. Maintenance of stream gaging stations.	U. S. Geological Survey.
21. Water resources, Duval and Nassau counties.	Consolidated City of Jacksonville; U. S. Geological Survey.
22. Urban Hydrology Study, Jacksonville.	Jacksonville Area Planning Board; U. S. Geological Survey.
23. Kathryn Abbey Hanna Park	Recreation Department, City of Jacksonville; U. S. Geological Survey.

4.14 Flood-Prone Area Investigations

Investigations to delineate areas prone to inundation during a flood with a recurrence probability of once every 100 years on the average have been completed for much of the District. Information on flood-prone areas is published on 7½-minute topographic quadrangle maps. Figure 13 shows quadrangles on which flood-prone areas are outlined as of June 1974 and the name of the quadrangle maps. Table 8 lists the flood prone maps of figure 13 by county. Additional flood prone area maps are under preparation and the plan is to complete the State by 1976.

4.2 Repetitive Data-Acquisition Networks

Hydrologic and water-quality monitoring networks have been maintained in the District for several decades in cooperation with the Department of Natural Resources and several other agencies.

4.21 Water Use

The U. S. Geological Survey collects water use data for most municipalities and large industries in the District. Estimates of use are also made every 5 years. Municipal water-use data collection points are shown on figure 14 which also lists pertinent data on municipalities in the network.

Table 8.—Index of Flood-prone Area Maps in St. Johns River Water Management District.

ALACHUA COUNTY

Quadrangle Name	Lat.	Long.	Quadrangle Name	Lat.	Long.
Alachua	2945	8222	McIntosh	2922	8207
Archer	2930	8230	Melrose	2937	8200
Arredondo	2930	8222	Micanopy	2930	8215
Bronson NE	2922	8230	Mikesville	2952	8230
Brooker	2952	8215	Monteocha	2945	8215
Citra	2922	8200	Newberry SW	2930	8237
Flemington	2922	8215	Newberry	2937	8230
Gainesville East	2937	8215	Orange Heights	2937	8207
Gainesville West	2937	8222	Rochelle	2930	8207
Hawthorne	2930	8200	Waldo	2945	8207
High Springs SW	2945	8237	Waters Lake	2937	8237
High Springs	2945	8230	Williston	2922	8222
			Worthington Springs	2952	8222

BAKER COUNTY

Quadrangle Name	Lat.	Long.	Quadrangle Name	Lat.	Long.
Big Gum Swamp	3015	8222	Sanderson NW	3022	8222
Olustee	3007	8222	Sanderson South	3007	8215
Sanderson North	3015	8215	Taylor	3022	8215

BREVARD COUNTY

Quadrangle Name	Lat.	Long.	Quadrangle Name	Lat.	Long.
Aurantia	2837	8052	Lake Poinsett NW	2822	8052
Cape Canaveral	2822	8030	Lake Poinsett	2815	8045
Cocoa Beach	2815	8030	Maytown	2845	8052
Cocoa	2815	8037	Melbourne East	2800	8030
Courtenay	2822	8037	Melbourne West	2800	8037
Deer Park NE	2807	8045	Mims	2837	8045
Eau Gallie	2807	8037	Oak Hill	2845	8045
False Cape	2830	8030	Orsino	2830	8037
Fellsmere NW	2752	8037	Sebastian NW	2752	8022
Fellsmere SW	2745	8037	Sebastian	2745	8022
Fellsmere	2745	8030	Sharpes	2822	8045
Grant	2752	8030	Titusville SW	2830	8052
Kenansville NE	2752	8045	Titusville	2830	8045
Kenansville SE	2745	8045	Tropic	2807	8030

Table 8.—Index of Flood-prone Area Maps in St. Johns River Water Management District. [Cont'd.]

CLAY COUNTY

Quadrangle Name	Lat.	Long.	Quadrangle Name	Lat.	Long.
Fiftone	3007	8152	Middleburg SW	3000	8152
Fleming Island	3000	8137	Middleburg	3000	8145
Jacksonville Heights	3007	8145	Orange Park	3007	8137
Melrose	2937	8200			

DUVAL COUNTY

Quadrangle Name	Lat.	Long.	Quadrange Name	Lat.	Long.
Amelia City	3030	8122	Italia	3030	8137
Arlington	3015	8130	Jacksonville Beach	3015	8122
Baldwin	3015	8152	Jacksonville Heights	3007	8145
Bayard	3007	8130	Jacksonville	3015	8137
Bryceville	3022	8152	Marietta	3015	8145
Dinsmore	3022	8145	Mayport	3022	8122
Durdin	3000	8122	Orange Park	3007	8137
Eastport	3022	8130	Orangedale	3000	8130
Fiftone	3007	8152	Palm Valley	3007	8122
Fleming Island	3000	8137	Trout River	3022	8137
Hedges	3030	8130			

FLAGLER COUNTY

Quadrangle Name	Lat.	Long.	Quadrangle Name	Lat.	Long.
Beverly Beach	2930	8107	Flagler Beach East	2922	8100
Dinner Island NE	2937	8115	Flagler Beach West	2922	8107
Favoretta	2915	8107	Matanzas Inlet	2937	8107

INDIAN RIVER COUNTY

Quadrangle Name	Lat.	Long.	Quadrangle Name	Lat.	Long.
Fellsmere SW	2745	8037	Indrio	2730	8015
Fellsmere 4 NE	2737	8030	Kenansville SE	2745	8045
Fellsmere 4 NW	2737	8037	Kenansville SW	2745	8052
Fellsmere 4 SE	2730	8030	Oslo	2730	8022
Fellsmere 4 SW	2730	8037	Riomar	2737	8015
Fellsmere	2745	8030	Sebastian	2745	8022
Fort Drum NE	2737	8045	Vero Beach	2737	8022
Fort Drum	2730	8045			

LAKE COUNTY

Quadrangle Name	Lat.	Long.	Quadrangle Name	Lat.	Long.
Bay Lake	2822	8152	Poyner	2815	8145
Center Hill	2837	8152	Rock Ridge	2815	8152
Clermont West	2830	8145	Sanford SW	2845	8122
Lake Nellie	2822	8145	Sanford	2845	8115
Mascotte	2830	8152			

MARION COUNTY

Quadrangle Name	Lat.	Long.	Quadrangle Name	Lat.	Long.
Anthony	2915	8200	Dunnellon	2900	8222
Belleview	2900	8200	Fairfield	2915	8215
Citra	2922	8200	Flemington	2922	8215
Cotton Plant	2907	8215	Hawthorne	2930	8200
Dunnellon SE	2900	8215	Lake Panasoffkee NW	2852	8207

Table 8.—Index of Flood-prone Area Maps in St. Johns River Water Management District. [Cont'd.]

MARION COUNTY (Cont'd.)

Quadrangle Name	Lat.	Long.	Quadrangle Name	Lat.	Long.
McIntosh	2922	8207	Romeo	2907	8222
Morriston	2915	8222	Shady	2900	8207
Ocala East	2907	8200	Stokes Ferry	2852	8215
Ocala West	2907	8207	Tidewater	2907	8230
Oxford	2852	8200	Williston	2922	8222
Reddick	2915	8207	Yankeetown SE	2900	8230

NASSAU COUNTY

Quadrangle Name	Lat.	Long.	Quadrangle Name	Lat.	Long.
Amelia City	3030	8122	Gross, FL-GA	3037	8137
Baldwin	3015	8152	Hedges	3030	8130
Bryceville	3022	8152	Italia	3030	8137
Dinsmore	3022	8145	St. George, FL-GA	3030	8200
Fernandina Beach, FL-GA	3037	8122	St. Marys, FL-GA	3037	8130
Folkston, FL-GA	3045	8200	Toledo, FL-GA	3037	8200

ORANGE COUNTY

Quadrangle Name	Lat.	Long.	Quadrangle	Lat.	Long.
Bithlo	2830	8100	Narcoossee NW	2822	8107
Casselberry,	2837	8115	Narcoossee SE	2815	8100
Forest City	2837	8122	Orlando East	2830	8115
Intercession City	2815	8130	Orlando West	2830	8122
Kissimmee	2815	8122	Oviedo SW	2830	8107
Lake Jessamine	2822	8122	Pine Castle	2822	8115
Lake Poinsett NW	2822	8052	Sanford SW	2845	8122
Lake Poinsett SW	2815	8052	St. Cloud North	2815	8115
Lake Poinsett	2815	8045	Titusville SW	2830	8052
Narcoossee	2815	8107	Windermere	2822	8130
Narcoossee NE	2822	8100	Winter Garden	2830	8130

PUTNAM COUNTY

Quadrangle Name	Lat.	Long.	Quadrangle Name	Lat.	Long.
Citra	2922	8200	Melrose	2937	8200
Hawthorne	2930	8200			

OSCEOLA COUNTY

Quadrangle Name	Lat.	Long.	Quadrangle Name	Lat.	Long.
Ashton	2807	8107	Kenansville	2752	8052
Cypress Lake	2800	8115	Kissimmee	2815	8122
Davenport	2807	8130	Lake Hatchineha	2800	8122
Deer Park NE	2807	8045	Lake Marian NW	2752	8107
Deer Park NW	2807	8052	Lake Marion SE	2745	8100
Deer Park	2800	8052	Lake Marion NW	2745	8107
Fort Drum NE	2737	8045	Lake Marion NE	2752	8100
Fort Drum NW	2737	8052	Lake Poinsett SW	2815	8052
Fort Kissimmee NE	2737	8100	Lake Poinsett	2815	8045
Fort Kissimmee NW	2737	8107	Lake Tohopekaliga	2807	8122
Hesperides	2752	8122	Lake Weohyakapka NE	2752	8115
Holopaw SE	2800	8100	Lake Weohyakapka SE	2745	8115
Holopaw SW	2800	8107	Narcoossee	2815	8107
Holopaw	2807	8100	Narcoossee SE	2815	8100
Intercession City	2815	8130	St. Cloud North	2815	8115
Kenansville NE	2752	8045	St. Cloud South	2807	8115
Kenansville SW	2745	8052			

Table 8.—Index of Flood-prone Area Maps in St. Johns River Water Management District. [Cont'd.]

ST. JOHNS COUNTY

Quadrangle Name	Lat.	Long.	Quadrangle Name	Lat.	Long.
Bayard	3007	8130	Mickler Landing	3007	8115
Dinner Island NE	2937	8115	Orangedale	3000	8130
Durbin	3000	8122	Palm Valley	3007	8122
Fleming Island	3000	8137	South Ponte Vedra Beach	3000	8115
Jacksonville Beach	3015	8122	St. Augustine Beach	2945	8115
Matanzas Inlet	2937	8107	St. Augustine	2952	8115

SEMINOLE COUNTY

Quadrangle Name	Lat.	Long.	Quadrangle Name	Lat.	Long.
Aurantia	2837	8052	Osteen	2845	8107
Bithlo	2830	8100	Oviedo SW	2830	8107
Casselberry	2837	8115	Oviedo	2837	8107
Forest City	2837	8122	Sanford SW	2845	8122
Geneva	2837	8100	Sanford	2845	8115
Orlando East	2830	8115	Titusville SW	2830	8052
Osceola	2845	8100			

VOLUSIA COUNTY

Quadrangle Name	Lat.	Long.	Quadrangle Name	Lat.	Long.
Ariel	2852	8045	Maytown	2845	8052
Aurantia	2837	8052	New Smyrna Beach	2900	8052
Daytona Beach NW	2907	8107	Oak Hill	2845	8045
Daytona Beach SW	2900	8107	Ormond Beach	2915	8100
Daytona Beach	2907	8100	Osceola	2845	8100
Edgewater	2852	8052	Osteen	2845	8107
Favoretta	2915	8107	Port Orange	2907	8052
Flagler Beach East	2922	8100	Samsula	2900	8100
Flagler Beach West	2922	8107	Sanford	2845	8115
Geneva	2837	8100	Titusville SW	2830	8052

4.22 Streamflow

Streamflow data have been obtained at 71 gaging stations equipped with continuous recording gages (fig. 15). Data from these stations, among other uses, can be utilized to define streamflow characteristics in terms of frequency of occurrence or duration of flows of various magnitude. Proposed surface-water gaging stations are shown on figure 16.

4.23 Ground-Water Levels

Ground-water levels are measured in 159 wells in the District. Pertinent data for these wells are listed in table 9. All but one of the wells in the existing ground-water level network tap the Floridan aquifer. Locations of proposed additional observation well sites are shown on figure 18.

4.24 Lake Levels

Lake level stations are maintained at 50 lakes in the District (fig. 19). Lake levels are affected by a variety of factors including surface and ground water inflow and outflow, rainfall, water use and control structures. The existing network of lake gaging stations is sparse in some areas, but provides the basic framework for a more extensive network. Locating of additional stations that will provide for network extension are shown on figure 20.

4.25 Water-Quality Network

Water quality data are presently being collected on a systematic basis by the U. S. Geological Survey at 39 sites in the District. This network is shown in figure 21. Sampling at additional sites is to be implemented in the next year or two as part of a national water quality network operated by the U. S.

Geological Survey. Locations of proposed additions to the network are shown in figure 22.

A comprehensive water quality network must be capable of meeting many varying needs including those of water managers, State and Federal regulatory agencies, natural resource agencies and the general public. Periodic evaluation of the network will lead to modification as new needs for water quality data arise. Some of the purposes and objectives for operating stations in a water quality network are given in table 10. Although the list in table 10 could be expanded, it is sufficient to describe the rationale for all sampling stations in the District.

Table 11 shows the general type of water quality data being collected at each station in the network, the sampling frequency and the purpose of the station.

The Florida Department of Pollution Control also has a network that includes sites in the District. The main purpose of this network is for surveillance and to determine if the waters meet State water quality standards.

Table 9.—Water levels in observation wells in the St. Johns River Water Management District.

Map number	Well number	Highest (feet)	Lowest (feet)	End of 1972 (feet)	Type of measure	Frequency of measure	Period of record	Aquifer
			BAKER COUNTY					
114	302620NO821730.1	—54.43 3/65	—65.14 9/71	—63.23	SP	B	1963-	F
115	302610NO821430.1	—13.96 9/64	—21.97 3/62	—17.69	SP	B	1960-	H
116	301535NO821620.1	—93.63 3/65	—103.29 11/72	—101.42	SP	B	1963-	F
			NASSAU COUNTY					
117	304205NO815425.1	— 3.82 10/60	—11.67 5/68	—10.2	SP	A	1960-	F
118	304002NO813812.1	+36.5 5/40	+13.6 5/68	+13.4	SP	A	1940-	F
119	303939NO813126.1	— 8.38 5/72	——	——	SP	A	1972-	F
120	304010NO812645.1	+29.5 3/39	—35.4 11/72	—23.59	SP	B	1939-	F
121	304022NO812750.1	+43.0 6/39	—39.74 5/66	—33.62	SP	A	1939-	F
122	303801NO812737.1	+40.9 3/39	—19.85 6/56	— 5.48	SP	S	1939-	F
123	303703NO813050.1	+35.1 7/44	+ 1.85 5/71	+ 3.16	SP	S	1940-	F
124	303754NO813627.1	+22.5 8/38	— 4.54 5/71	— 3.89	SP	S	1934-	F
125	303658NO814226.1	+40.5 5/40	+16.0 5/68	+20.6	SP	S	1940-	F
126	303340NO815000.1	+42.5 7/47	+23.0 1/73	+23.0	SP	S	1940-	F
			DUVAL COUNTY					
127	302801NO813751.1	+24.2 6/47	+ 2.38 5/71	+ 3.9	SP, C	S	1940-	F
128	302608NO813549.2	+36.2 2/54	+20.8 5/71	+22.7	SP	S	1951-	F
129	302747NO813401.1	+34.4 7/40	+15.6 5/71	+17.0	SP	S	1940-	F

Table 9.—Water levels in observation wells in the St. Johns River Water Management District. [Cont'd.]

Map number	Well number	Highest (feet)	Lowest (feet)	End of 1972 (feet)	Type of measure	Frequency of measure	Period of record	Aquifer
130	302548NO812531.1	+45.0 8/30	+23.7 5/68	+26.2	SP, C	B B	1934-	F
131	302608NO813549.3	+36.0 1/52	+20.7 5/71	+22.0	SP, C	S	1951-	F
132	302540NO813610.1	+43.5 3/51	+18.2 4/63	+24.5	SP	A	1951-	F
133	302608NO813549.1	+37 6/51	+21.0 9/71	+21.9	SP, C	B B	1951-	F
134	302410NO814435.1	+34.7 7/40	+16.1 5/72	+16.1	SP	A	1940-	F
135	302351NO813902.1	+45.2 1/52	+26.6 5/71	+28.0	SP	S	1940-	F
136	302441NO813649.1	+28.5 7/47	+ 3.1 5/71	+ 6.9	SP	S	1940-	F
137	302304NO813832.1	+47.0 8/30	+21.8 8/71	+24.3	SP, C	M	1930-	F
138	302307NO812938.1	+32.3 12/66	+25.0 7/69	+27.4	SP	S	1966-	F
139	301852NO812342.1	+41.7 6/34	+17.5 7/69	+25.8	SP, C	B	1940-	F
140	301715NO813000.1	+ 2.20 5/64	— 4.16 5/68	— 3.02	SP	A	1961-	F
141	301906NO813325.1	+ 6.68 8/30	—15.20 1/69	—19.16	SP, C	S S	1930	F
142	301825NO813620.1	+27.9 2/39	+ 0.87 5/70	+ 4.32	SP, C	A A	1938-	F
143	301844NO814038.1	+43.2 11/38	+18.7 9/72	+24.3	SP, C	S	1938-	F
145	301725NO815845.1	—25.25 1/61	—33.41 5/71	—30.0	SP	A	1961-	F
146	301833NO814318.1	+34.5 4/42	+11.9 5/62	+13.9	SP	S	1939-	F
147	301740NO813610.1	+27.3 9/60	+18.3 5/71	+19.1	SP	A	1960-	F
148	301617NO814216.1	+40.0 8/30	+10.8 9/72	+16.1	SP	B	1930-	F
149	301551NO814157.1	+42.3 7/40	+17.4 5/62	+22.8	SP	S	1940-	F
150	301144NO814138.1	+39.0 11/40	+15.2 5/71	+17.8	SP, C	A A	1940-	F
151	301255NO813710.1	+31.9 5/64	+18.6 5/62	+23.0	SP, C	A A	1961-	F
152	301401NO813540.1	+30.1 7/47	+ 9.91 5/71	+11.6	SP, C	S	1940-	F
153	301312NO814110.1	+44.6 9/40	+24.13 5/68	+25.9	SP	A	1940-	F
			CLAY COUNTY					
154	300957NO814235.1	+41 5/34	+17.0 5/71	+19.8	SP	A	1966-	F
155	300649NO814859.1	+36.9 4/44	+19.0 6/56	+21.5	SP	S	1944-	F

Table 9. — Water levels in observation wells in the St. Johns River Water Management District. [Cont'd.]

Map number	Well number	Highest (feet)	Lowest (feet)	End of 1972 (feet)	Type of measure	Frequency of measure	Period of record	Aquifer
156	295207NO814749.1	—14.25 4/60	—24.59 5/68	—16.30	SP	S	1967-	F
157	294807NO820209.1	—44.02 10/60	—53.16 6/69	—47.17	SP	B	1960-	H
158	294807NO820209.2	—27.29 10/60	—38.42 9/69	—29.86	SP	B	1960-	NA
159	294807NO820209.3	—53.66 10/60	—61.52 7/69	—57.32	SR	C	1960-	F
			ST. JOHNS COUNTY					
160	300759NO812307.1	+46.2 11/48	+32.1 5/68	+30.7	SP	A	1934-	F
161	300556NO812910.1	+37.0 8/38	+20.7 5/68	+22.0	SP	A	1934-	F
162	294702NO812632.1	— 0.33 4/59	—33.22 5/71	— 5.59	SP	B	1956-	F
163	295849NO812614.1	+ 5.95 1/72	— 4.37 5/71	+ 5.79	SR	C	1971-	H
164	294702NO812632.1	— 0.33 4/59	—33.22 5/71	— 5.59	SP	B	1956-	F
165	294120NO812920.1	+11.4 9/60	—11.51 5/68	+ 6.12	SP, T	B B	1955-	F
166	293729NO812212.1	—15.59 9/60	—25.28 5/68	—20.28	SR	C	1958-	F
			ALACHUA COUNTY					
167	294207NO821632.1	—86.49 9/65	—95.39 7/68	—92.29	SP	B	1957-	F
			PUTNAM COUNTY					
168	293910NO813850.1	+12.1 10/53	— 0.73 5/68	+ 2.09	SP	B	1936-	F
169	292530NO813840.1	— 4.9 9/43	—10.36 5/68	— 7.60	SP	B	1936-	F
170	293940NO813430.1	+ 5.68 11/60	— 9.67 5/68	+ 1.19	SP	B	1958-	F
171	293720NO815345.1	—27.67 1/66	—35.72 4/57	—30.08	SP	A	1934; 1935-1956-	F
172	294356NO815258.1	—41.56 11/60	—47.39 2/57	—43.98	SP	B	1956-	H
			MARION COUNTY					
173	292030NO820643.1	—38.51 9/64	—48.09 5/68	—47.64	SP	B	1961-	F
174	292546NO815133.1	—113.24 10/65	—120.50 7/68	—118.68	SP	B	1964-	F
175	291240NO820340.1	—11.30 4/70	—15.94 6/68	—15.44	SR	C	1968-	F
176	291115NO815925.1	+15.59 10/60	+ 3.35 5/57	+ 6.65	SR	C	1933-	F
177	290222NO815620.1	—10.39 10/60	—24.67 4/56	—22.14	SP	B	1936-.	F

Table 9.—Water levels in observation wells in the St. Johns River Water Management District. [Cont'd.]

Map number	Well number	Highest (feet)	Lowest (feet)	End of 1972 (feet)	Type of measure	Frequency of measure	Period of record	Aquifer
178	285920NO814905.1	+ 0.2 10/45	—10.90 4/57	— 7.92	SP	B	1936-	F
179	291015NO813850.1	—23.20 11/60	—31.91 1/73	—31.91	SP	B	1936-	F
			FLAGLER COUNTY					
180	292820NO812210.1	— 5.86 9/60	—21.75 4/56	— 9.94	SP	B	1956-	F
181	292750NO811520.1	— 2.7 9/47	—10.41 5/68	— 5.95	SP	B	1936-	F
			VOLUSIA COUNTY					
182	291905NO812510.1	— 0.4 9/47	— 7.07 5/68	— 4.44	SP	B	1936-	F
183	291904NO810555.1	+ 1.05 9/67	— 5.00 5/67	— 2.33	SP, C K	S S	1967-	F
184	291607NO810423.1	——	——	——	SP, C K	A A	1972-	F
185	291715NO812818.1	+13.0 7/61	+ 6.61 5/68	+ 7.6	SP	B	1936-	F
186	291133NO810406.1	—13.63 10/55	—33.02 7/69	—24.45	SP	B	1955-	F
187	291133NO810406.2	— 8.98 11/60	—16.83 5/68	—13.32	SP, C K	B B	1955-	F
188	291113NO810506.1	—24.70 1/70	—32.13 5/69	—26.17†	SP, C K	B B	1969-	F
189	290920NO810630.2	— 4.99 10/55	—12.43 5/68	—10.75	SP	B	1955-	F
190	290920NO810630.1	— 2.76 10/55	—11.63 5/68	— 9.20	SR	C	1955-	F
191	290742NO810139.1	——	——	——	SP, C K	A A	1972-	F
192	290959NO812316.1	+ 4.80 11/53	+ 0.05 5/68	+ 1.96	SP, C K	S S	1967-	F
193	290655NO811112.1	— 1.48 10/69	— 4.88 7/69	— 2.20	SR	C	1966-	F
194	290541NO811329.3	— 4.46 3/70	— 8.18 5/72	6.90	SP, C K	S S	1969-	F
195	290541NO811329.2	+ 0.85 9/60	— 4.20 5/62	— 0.46	SP, C K	S S	1969-	F
196	290541NO811329.4	— 6.47 3/70	—12.62 5/72	—11.27	SP, C K	S S	1969-	F
197	290138NO812032.2	—26.04 9/69	—34.24 6/68	—30.77	SP, C K	S S	1966-	F
198	290251NO810014.1	— 9.34 11/68	—13.37 5/68	—10.86	SP, C K	S S	1966-	F
199	285951NO805747.1	——	——	——	SP, C K	A A	1972-	F
200	285904NO805546.1	——	——	——	SP, C K	A A	1972-	F
201	285745NO810540.1	— 3.80 9/45	— 8.80 5/68	— 5.47	SR	C	1936-	F

Table 9.—Water levels in observation wells in the St. Johns River Water Management District. [Cont'd.]

Map number	Well number	Highest (feet)	Lowest (feet)	End of 1972 (feet)	Type of measure	Frequency of measure	Period of record	Aquifer
202	285643NO811226.1	—13.92 11/69	—22.06 5/68	——	SR	C	1966-	F
203	285525NO811059.1	—24.32 12/72	—26.04 3/72	—24.34	SR	C	1970-	F
204	285106NO811908.1	——	——	——	SP, C K	S S	1966-	F

† well being pumped.

LAKE COUNTY

Map number	Well number	Highest (feet)	Lowest (feet)	End of 1972 (feet)	Type of measure	Frequency of measure	Period of record	Aquifer
205	290950NO813155.1	+ 0.5 10/45	— 5.30 5/68	— 2.54	SP	B	1936-	F
206	290000NO0813800.1	— 8.58 3/70	—15.08 5/68	—14.54	SP	B	1961-	F
207	285730NO814045.1	—23.52 11/69	—29.23 9/72	——	SP A, N	A A	1969-	NA
208	285425NO813234.1	—12.11 10/69	—15.06 11/71	——	SP A, N	A A	1969-	NA
209	285432NO815346.1	—21.03 3/70	—28.38 9/72	——	SP A, N	A A	1969-	NA
210	285129NO815451.1	—37.00 3/70	—43.27 10/72	—42.52	SP	B	1968-	F
211	284953NO813932.1‡	—31.45 11/69	—36.61 11/71	——	SP A, N	A A	1969-	NA
212	284728NO813222.1	—70.90 3/70	—78.63 10/72	—78.27	SP	B	1967-	F
213	284445NO814621.1	+ 5.70 3/70	+ 0.02 5/68	+ 1.75	SP	B	1963-	F
214	284232NO815330.1	—42.65 3/70	—48.56 5/72	—48.82	SP	B	1963-	F
215	284213NO815245.1	—26.10 11/69	—34.93 5/71	——	SP A, N	A A	1969-	NA
216	284054NO814814.1	—21.30 11/69	—26.09 11/71	——	SP A, N	A A	1969-	NA
217	283201NO815450.2	— 0.00 9/60	— 5.80 5/68	— 2.37	SR	C	1959-	NA
218	283201NO815450.1	— 1.02 9/60	— 6.57 5/68	— 3.19	SR	C	1959-	F
219	283230NO814559.1	—25.84 7/72	—27.20 10/72	—26.80	SR	C	1972-	F
220	282829NO814136.1	—44.40 3/70	—51.52 1/73	—51.52	SP	B	1969-	F
221	282245NO814926.1	— 0.75 9/60	— 5.95 5/68	— 3.16	SP	B	1959-	F
222	282245NO814926.2	+ 1.00 9/60	— 4.45 5/68	— 2.12	SP	B	1959-	NA

‡ Destroyed in 1973.

SEMINOLE COUNTY

Map number	Well number	Highest (feet)	Lowest (feet)	End of 1972 (feet)	Type of measure	Frequency of measure	Period of record	Aquifer
223	284750NO811323.1	+ 7.84 10/53	— 0.74 5/68	+ 2.58	SP	B	1951-	F
224	284130NO812100.1	—29.89 9/60	—44.33 5/68	—41.87	SR	C	1951-	F

Table 9.—Water levels in observation wells in the St. Johns River Water Management District. [Cont'd.]

Map number	Well number	Highest (feet)	Lowest (feet)	End of 1972 (feet)	Type of measure	Frequency of measure	Period of record	Aquifer
			ORANGE COUNTY					
225	284529NO813010.1	—35.30 5/70	—38.37 5/68	—36.74	SP	A	1961-	F
226	284352NO813617.1	—20.80 12/60	—28.71 5/68	—24.95	SP	A	1960-	F
227	284025NO813017.1	—54.90 10/60	—70.50 5/68	—69.01	SP	A	1931-33; 1943; 1960-	F
228	283816NO812255.1	—17.54 7/61	—26.92 5/71	—22.82	SP	A	1961-	F
229	283619NO813318.1	—30.66 10/60	—48.48 5/65	—43.77	SP	A	1960-	F
230	283417NO813314.2	—32.49 10/60	—55.50 5/65	——	SP	A	1931-34: 1943; 1960-	F
231	283318NO813744.1	—32.73 10/60	—48.27 5/71	—44.61	SP	A	1960-	F
232	283134NO813648.1	—33.73 6/60	—44.63 5/68	——	SP	A	1960-	F
233	283204NO813514.1	—31.69 6/60	—42.69 5/68	——	SP	A	1960-	F
234	283407NO811341.1	— 6.38 3/61	—15.75 5/71	—11.55	SP A	A	1961-	F
235	283249NO810532.2	+ 0.24 10/61	— 3.88 6/64	— 1.17	SP A	B A	1960-	NA
236	283249NO810532.2	— 7.46 10/60	—13.29 6/71	—10.85	SP A	B A	1960-	H
237	283215NO805835.1	+19.2 3/47	+ 9.5 5/71	+12.4	SP A	A A	1960-	H
238	283249NO810532.1	—20.60 10/60	—31.16 5/71	—26.69	SP A	C A	1960-	F
239	283049NO811417.1	—29.21 4/61	—38.53 5/71	—35.92	SP	A	1961-	F
240	282623NO811538.1	—37.30 2/61	—47.00 5/71	—42.25	SP	A	1961-	F
241	282531NO810957.1	—30.27 10/64	—41.26 5/71	—29.51	SP	A	1961-	F
242	282532NO810756.1	—18.90 10/64	—34.74 4/71	—37.28	SP	B	1962-	F
243	282739NO810545.1	—37.46 2/61	—47.01 5/71	—42.40	SP	A	1960-	F
244	282847NO810137.1	—21.81 12/69	—28.30 5/71	—24.16	SP A	A A	1961-	F
245	282341NO810401.1	—31.32 10/60	—42.40 5/71	—38.39	SR A	C C	1960-	F
246	282348NO805647.1	+ 1.70 10/60	— 8.65 5/71	— 7.12	SP A	A A	1960-	F
247	282052NO805531.1	——	——	——	SP C	S S	1967-	F
			BREVARD COUNTY					
248	283644NO805749.1	+15.0 9/69	+ 9.2 5/68	——	SP C	S S	1965-	F

Table 9.—Water levels in observation wells in the St. Johns River Water Management District. [Cont'd.]

Map number	Well number	Highest (feet)	Lowest (feet)	End of 1972 (feet)	Type of measure	Frequency of measure	Period of record	Aquifer
249	283708NO804954.1	——	——	——	SR	C	1971-	NA
250	283404NO803945.1	+17.2 12/46	+ 8.2 5/58	+11.0	SP	S	1946-47; 1949-	F
252	282204NO805143.2	+21.2 3/65	+16.0 5/68	+18.0	SP K, C	S S	1965-	F
253	282204NO805143.1	+19.8 3/65	+13.8 5/68	——	SP A	S A	1965-	F
254	280750NO803900.1	— 4.57 9/63	— 9.13 5/56	— 6.80	SR	C	1956-	NA
255	275953NO804517.1	— 2.71 4/58	— 7.15 6.62	— 5.67	SR	C	1958-	NA
256	275956NO804347.1	+30.9 8/34	+15.2 5/68	+17.0	SP C	B B	1934-	F
257	282245NO804716.1	+ 9.40 9/60	— 0.50 5/71	+ 3.50	SR C	C B	1955-	F
			POLK COUNTY					
258	281440NO814317.1	— 5.80 10/60	—12.64 5/71	——	SP	S	1960-	F
259	281511NO813931.1	—62.06 9/60	—72.33 9/72	—69.67	SP	S	1960-	F
260	281440NO814317.2	— 4.43 9/68	— 8.48 5/68	— 5.52	SP	S	1960-	NA
261	281511NO813931.2	—64.30 5/70	—69.72 5/68	—68.92	SP	S	1960-	NA
			OSCEOLA COUNTY					
262	281722NO805430.1	+33.56 9/60	+27.48 6/67	+30.95	SR	C	1950-	NA
263	281722NO805430.2	——	——	——	A	S	1968-	NA
264	280619NO805426.2	——	——	——	A	S	1968-	NA
265	280619NO805426.1	+45.38 9/60	+42.67 6/67	+47.42	SR	C	1949-	NA
266	280501NO805237.1	——	——	——	C, K	S	1967-	F
			INDIAN RIVER COUNTY					
267	274815NO802541.1	——	——	——	SP	S	1951; 1972-	F
268	274635NO803630.1	——	——	——	SP, C K	S S	1951;	F
269	274549NO802452.1	——	——	——	SP, C K	S S	1951; 1972-	F
270	274453NO802753.1	——	——	——	SP, C K	S S	1951; 1972-	F
271	273833NO804619.1	——	——	——	S, C K	A A	1951; 1972-	F
272	273940NO804750.1	——	——	——	A	S	1962; 1972-	NA
273	273923NO804718.1	+31.83 10/65	+25.16 6/67	+27.74	SR	C	1950-	NA

Table 9.—Water levels in observation wells in the St. Johns River Water Management District. [Cont'd.]

Map number	Well number	Highest (feet)	Lowest (feet)	End of 1972 (feet)	Type of measure	Frequency of measure	Period of record	Aquifer
274	273431NO802210.1	——	——	——	SP, C K	S S	1952; 1972-	F

Explanation of Data and Symbols

Map number refers to number on Fig. 17

Well number is the 16-digit latitude—longitude well number under which additional information is on file with the U. S. Geological Survey.

Highest is the highest water-level elevation in the well for the period of record.

Lowest is the lowest water-level elevation in the well for the period of record.

End of 1972 is the water-level elevation in the well closest to the end of the year. Data may include January 1973 measurement if the December 1972 measurement is not available.

Type of measurement:

- **SP** - Water level, periodic measurement
- **SR** - Water-level recorder, continuous measurement
- **A** - Complete analysis
- **K** - Specific conductivity
- **N** - Nitrogen analysis
- **T** - Temperature
- **C** - Chloride information available

Frequency of measurement is the frequency of water-level measurements or of quality-of-water information available.

- **A** - Annual
- **B** - Bimonthly
- **C** - Continuous (graphic recorder)
- **M** - Monthly
- **S** - Semiannual

Period of record indicates the years of record that water-level or water quality information is available. Network stations still in operation are indicated by open-ended dates followed by a dash.

Aquifer indicates the type of aquifer for each well in St. Johns River Water Management District operated by the U. S. Geological Survey.

- **F** - Floridan aquifer
- **H** - Hawthorn aquifer
- **NA** - Nonartesian aquifer

NOTE: WATER-LEVEL INFORMATION IS WITH REFERENCE TO LAND-SURFACE DATUM.

4.3 Miscellaneous Water Level Flow and Quality Data

In addition to the data collected through the above networks, a large quantity of data on streamflow, water levels, water-quality and water wells has been acquired during past water resources investigations. Miscellaneous streamflow or stream-stage data have been acquired at several hundred sites; surface-water-quality data have been acquired at about 250 miscellaneous sites; and ground-water-quality data have been acquired at about 600 miscellaneous sites. About 2,930 records of wells were in the computer-data file as of 1974.

5. DATA ANALYSIS

Basic hydrologic data, although a necessity in the process of developing, utilizing and managing water resources, may not in themselves serve as the final decision making tool. Analyzing data will assist in determining the cause and effect relations in the light of the problem and management plan

Table 10.—Rationale for surface water quality network.

Purpose	Objective
1. Areal Assessment	Provide basic water quality data on a basinwide or regional basis and in various hydrogeologic environments; provide data on variations in water quality with streamflow and provide information on extremes in water quality conditions.
2. Assessment of Land Use Influences	To determine the effects of various types of land use and known major pollution sources on water quality; determine if pollution abatement improves water quality.
3. Benchmark	Determine baseline quality of water in undeveloped "pristine" areas; provide a basis for determining the effects of man's activities and a base by which to determine the pollution load component of man-affected streams.
4. Eutrophic Condition Assessment	Determine trophic status of major lakes, identify problem lakes and provide early detection of deterioration.
5. Surveillance	Monitor water quality at selected flow points to detect and abate water pollution; determine water quality trends and possible degradation due to basin development; determine if water meets state water quality standards.
6. Water Quality Accounting	Determine long-term trends in water quality; determine variations in water quality with streamflow and season; provide for an accounting of the loads of organic and inorganic materials leaving the basin; provide input to water quality simulation models and provide baseline data for river quality assessments. (Many of these stations are or will be operated under the U. S. Geological Survey's National Stream Quality Accounting Network.)
7. Water Quality Management	Determine effects of water management operations on water quality and provide management alternatives that would minimize adverse effects or improve water quality.

Table 11.—Surface Water Quality Network, list of stations, parameter coverage and sampling frequency.

Map reference number	Station name and location	Field Determinations[1]	Discharge[2]	Major Nitrogen and phosphorus species[3]	Bacteriology[4]	Suspended Sediment[5]	Organic carbon[6]	Major constituents[7]	Trace metals[8]	Specific conductance and temperature[9]	Biochemical oxygen demand 5-day	Phytoplankton[10]	Periphyton[11]	Benthic invertebrates[12]	Radioactivity	Pesticides[13]	Purpose(s) of station[14]
41	St. Marys River near MacClenny	M	C	M	M	M	Q	M	Q	D	Q	M	Q	—	—	A	6
42	St. Johns River at Jacksonville	B	C	B	—	S	S	S	S	—	S	—	—	—	—	—	1
43	Moultrie Creek near St. Augustine	S	C	S	—	S	S	S	S	—	S	—	—	—	—	—	1, Pr
44	Rice Creek near Palatka	S	C	S	—	S	S	S	S	—	S	—	—	—	—	—	1
45	St. Johns River at Palatka	M	C	M	M	M	B	M	Q	C	B	M	Q	—	—	—	1,5, 6
46	Lake Ocklawaha near Orange Springs	B	—	B	B	—	B	—	—	—	B	—	—	—	—	—	5,7
47	Oklawaha River at Rodman Dam	B	C	B	B	S	B	S	S	—	B	—	—	—	—	—	1,5,7
48	Oklawaha River near Salt Springs	S	C	S	—	S	S	S	S	D	S	—	—	—	—	—	1
49	Orange Lake at Orange Lake	T	—	T	—	S	T	S	S	—	T	T	—	—	—	—	1,4
50	Oklawaha River at Eureka	B	C	B	B	—	B	—	—	—	B	—	—	—	—	—	5,7
51	Lake Kerr near Eureka	T	—	T	—	S	T	S	S	—	T	T	—	—	—	—	1,4
52	Oklawaha River near Conner	B	—	B	B	—	B	—	—	—	B	—	—	—	—	—	5,7
53	Silver Springs at Silver Springs	B	C	S	—	—	S	A	A	—	S	—	—	—	—	—	1,7
54	Oklawaha River at Moss Bluff	B	C	B	B	S	B	S	S	D	B	—	—	—	—	—	1,5,7
55	Lake Weir at Oklawaha	B	—	T	—	S	T	S	S	—	T	T	—	—	—	—	1,4
56	Lake Griffin at Leesburg	B	—	T	—	S	T	S	S	—	T	T	—	—	—	—	1,4
57	Lake Yale at Grand Island	B	—	T	—	S	T	S	S	—	T	T	—	—	—	—	1,4
58	Lake Dora at Mt. Dora	B	—	T	—	S	T	S	S	—	T	T	—	—	—	—	1,4
59	Apopka-Beauclair Canal near Astatula	B	C	S	—	S	S	S	S	—	S	—	—	—	—	—	1,4
60	St. Johns River near Deland	S	C	S	—	S	S	S	—	—	S	—	—	—	—	—	1
61	Blue Springs near Orange City	A	B	A	—	—	A	A	A	—	—	—	—	—	—	—	1
62	Spruce Creek near Samsula	—	C	—	—	—	—	—	—	—	—	—	—	—	—	—	Pr

Table 11.—Surface Water Quality Network, list of stations, parameter coverage and sampling frequency. (Cont'd.)

number	Station name and location	Field determinations[1]	Discharge[2]	Major nitrogen and phosphorus species[3]	Bacteriology[4]	Suspended Sediment[5]	Organic carbon[6]	Major constituents[7]	Trace metals[8]	Specific conductance and temperature[9]	Biochemical oxygen demand 5-day	Phytoplankton[10]	Periphyton[11]	Benthic invertebrates[12]	Radioactivity	Pesticides[13]	Purpose(s) of station[14]
	Lake Apopka at Winter Garden	B	—	T	—	S	T	S	S	—	T	T	—	—	—	—	1,r
	Econlockhatchee River near Chuluota	B	C	B	—	S	B	S	S	—	B	B	—	—	—	A	1,5,7
	St. Johns River near Geneva	B	—	B	—	S	B	S	S	—	B	B	—	—	—	A	1,5,7
	St. Johns River near Cocoa	B	C	B	—	S	B	S	S	—	B	B	—	—	—	S	1,5,7
	St. Johns River near Melbourne	B	C	B	—	S	B	S	S	—	B	B	—	—	—	A	1,5,7
	Taylor Creek Impoundment Site 1 near Cocoa	B	—	B	—	S	B	S	S	—	B	B	—	—	—	A	4,5,7
	Taylor Creek Impoundment Site 3 near Cocoa	B	—	B	—	S	B	S	S	—	B	B	—	—	—	—	4,5,7
	Taylor Creek below S-164 near Cocoa	B	B	B	—	S	B	S	S	—	B	—	—	—	—	—	4,5,7
	Wolf Creek near Deer Park	B	C	B	—	S	B	S	S	—	B	—	—	—	—	—	5,7
	Jane Green Creek near Deer Park	B	C	B	—	S	B	S	S	—	B	B	—	—	—	A	5,7
	Blue Cypress Lake Site 1 near Fellsmere	B	—	B	—	S	B	S	S	—	B	B	—	—	—	A	1,4,5,7
	St. Johns headwaters near Vero Beach	B	—	B	—	S	B	S	S	—	B	—	—	—	—	A	5,7
	Indian River at Wabasso	B	—	B	—	—	B	S	—	—	—	—	—	—	—	—	1
	North Canal near Vero Beach	B	C	B	—	—	B	S	—	—	—	—	—	—	—	—	1
	Main Canal at Vero Beach	B	C	B	—	—	B	S	—	—	—	—	—	—	—	—	1
	South Canal near Vero Beach	B	C	B	—	—	B	S	—	—	—	—	—	—	—	—	1
	St. Johns River near Christmas	S	C	—	—	—	—	—	—	D	—	—	—	—	—	—	1

Table 11.—Surface Water Quality Network, list of stations, parameter coverage and sampling frequency (Cont'd.)

EXPLANATION OF SAMPLING FREQUENCY CODES AND PARAMETER COVERAGE

Sampling Frequency	Code
Continuous	C
Daily	D
Monthly	M
Bimonthly	B
Quarterly	Q
3 per year	T
Semiannually	S
Annually	A

Parameter Name and Reporting Units	USGS and STORET Parameter Code
[1]Field determinations (includes some or all of the following)	
Temperature °C	00010
Conductivity, micromhos/cm at 25°C	00095
Dissolved Oxygen, mg/l	00300
pH, units	00400
Secchi disk transparency, inches	00077
[2]Discharge	
Instantaneous discharge, ft³/s	00061
(mean discharge used for daily records)	00060
Stage, ft. above datum	00065
[3]Major nitrogen and phosphorus species	
Ammonia—N mg/l	00610
Nitrite - N mg/l	00615
Nitrate - N mg/l	00620
Nitrate + Nitrite - N mg/l	00630
Organic - N mg/l	00605
Total Kjeldahl - N mg/l	00625
Total N mg/l	00600
Orthophosphate - P mg/l	70507
Total Phosphorus - P mg/l	00665
Also includes Color — Pt-Co units	00080

Parameter Name and Reporting Units	USGS and STORET Parameter Code
[4]Bacteriology (includes one or more of the following)	
Total coliform, MF, immediate colonies/100 ml	31501
Fecal Coliform, MF, colonies/100 ml	31616
Fecal Streptococci, MF, M-entero, colonies/100 ml	31679
[5]Suspended sediment, mg/l	80154
[6]Total organic carbon, mg/l	00680
[7]Major constitutents	
Silica, dissolved, mg/l	00955
Calcium, dissolved, mg/l	00915
Magnesium, dissolved, mg/l	00925
Sodium, dissolved, mg/l	00930
Potassium, dissolved, mg/l	00935
Bicarbonate, dissolved, mg/l	00440
Carbonate, dissolved, mg/l	00445
Sulfate, dissolved, mg/l	00945
Chloride, dissolved, mg/l	00940
Fluoride, dissolved, mg/l	00950
Dissolved solids, residue at 180°C, mg/l	70300
Dissolved solids, sum of major constituents, mg/l	70301
Total Hardness as $CaCO_3$, mg/l	00900
Non-Carbonate Hardness, mg/l	00902
pH, units (laboratory)	00403
Turbidity, JTU	00070

Table 11.—Surface Water Quality Network, list of stations, parameter coverage and sampling frequency. (Cont'd.)

[8]Trace metals (includes some or all of the following)	Parameter Code (Dissolved)	(Suspended)	(Total)
Arsenic, ug/l	01000	01001	01002
Cadmium, ug/l	01025	01026	01027
Chromium, ug/l	01030	01031	01034
Cobalt, ug/l	01035	01036	01037
Copper, ug/l	01040	01041	01042
Iron, ug/l	01046	01044	01045
Lead, ug/l	01049	01050	01051
Manganese, ug/l	01056	01054	01055
Mercury, ug/l	71890	71895	71900
Selenium, ug/l	01145	01146	01147
Zinc, ug/l	01090	01091	01092

Parameter Name and Reporting Units	USGS and STORET Parameter Code
[9]Specific conductance [umhos] and temperature [°C]	00095
Measured once daily or continuously	00010
[10]Phytoplankton	
Phytoplankton, total, cells/ml	60050
Phytoplankton, identification of 3 co-dominants	none
Phytoplankton, 3 co-dominants percentage of total	none

Parameter and Reporting Units	USGS and STORET Parameter Code
[11]Periphyton	
Periphyton, biomass, dry weight, g/m^2	none
Periphyton, biomass, ash weight, g/m^2	none
Chlorophyll a, ug/l	32230
Chlorophyll b, ug/l	32231

[12]Benthic invertebrates

Intertebrates, taxa identification
Invertebrates, biomass, wet weight, g/m^2
Invertebrates, diversity index of Insecta

[13]Pesticides & PCB's	Parameter Codes Water	Sediment
Aldrin, ug/l	39330	39333
Chlordane, ug/l	39350	39351
DDD, ug/l	39360	39363
DDE, ug/l	39365	39368
DDT, ug/l	39370	39373
Dieldrin, ug/l	39380	39383
Endrin, ug/l	39390	39393
Heptachlor, ug/l	39410	39413
Heptachlor Epoxide, ug/l	39420	39423
Lindane, ug/l	39340	39343
Methoxychlor, ug/l	39480	——
Toxaphene, ug/l	39400	39403
Polychlorinated Biphenyls, ug/l	39516	39519

[14]Purpose(s) of station

1. Areal Assessment
2. Assessment of Land Use Influences
3. Benchmark
4. Eutrophic Condition Assessment
5. Surveillance
6. Water Quality Accounting
7. Water Quality Management

Pr Proposed Water Quality Accounting Station

5. DATA ANALYSIS (Cont'd.)

being considered. A single measurement of a water level, for example, may be vital to an immediate problem; however, knowledge of why water levels fluctuate and how they may fluctuate in the future is essential to viable planning of the use of water resources. Statistical analyses of past water-level fluctuations provide a means of predicting future levels in terms of the frequency of occurrence or the percentage of time a given level will be exceeded. The analytical techniques used in making such predictions require input of data collected over a relatively long period, but shorter periods of record, if properly analyzed, can also be of great value in planning the use of the water resource.

Basically, data analyses involve the assimilation and reduction of bulk data through the use of statistics and other extrapolations to provide water-resources information in terms of averages, means, extremes, probabilities, durations, and other summaries. Such analyses are essential to the description of various water parameters or phenomenon in quantitative terms. The specific technique to be used in analyzing data depends largely on potential use of the information. Table 12 summarizes some of the types of data and analysis needed for particular uses.

6.0 TECHNIQUES OF DATA COLLECTION

Water data are a basic necessity for the judicious management development and utilization of a water resource. Confidence in the reliability of data can best be accomplished through the use of standard techniques. Federal, State and local agencies all participate in the collection of data, either directly or indirectly. To obtain the maximum beneficial use, data collected by all agencies could be integrated into a common data system which would require the use of standard data collection techniques.

Table 12.—Examples of types of data and analyses needed for various water-management programs.

Problem or need	Types of analysis	Basic data
Development of surface waters for water supply	Statistical analysis (1) flow duration (2) low-flow frequency (3) draft-storage relations for streams Stream or basin simulation (modeling)	Streamflow Basin characteristics Channel geometry Drainage area Spring discharge
Development of ground waters for water supply	Aquifer (pumping test) analyses (1) quantify aquifer characteristics (2) define boundary conditions (3) define salt-water intrusion potential Flow-net analysis: Aquifer simulation (modeling)	Water level drawdown Pumping rate Subsurface mapping Ground-water quality Ground-water level Spring discharge Stream flow Ground-water withdrawal rate Subsurface mapping Historic and current water levels Historic and current ground-water withdrawal rate Historic and current spring discharge
Flood protection and management	Statistical analyses (1) flood-flow frequencies (2) mean annual flow Flood profiles Draft-storage-analyses	Peak stage and flow Channel geometry Drainage areas Topography Soils type Urban area
Waste disposal to streams	Flow frequencies Waste assimilation capacities Water-quality simulation (modeling)	Streamflow Water temperature Stream biota Water quality Channel characteristics

6.1 Standard Techniques

The need for standard data collection techniques is recognized by the various Federal and State agencies. As authorized under the Office of Management and Budget Circular A-64, the U. S. Geological Survey is the lead agency in developing standard techniques of water-data acquisition for all concerned federal agencies. State and local agencies will find the standard techniques of particular value in developing a common base. Under the leadership of the Geological Survey, a Federal Interagency Work Group in 1972 prepared a report entitled, "Designation of Standards for Water Data Acquisition." The report covers the following areas of concern:

(1) Surface-water stage and quantity
(2) Chemical (inorganic) and physical quality
(3) Biologic, bacteriologic, and chemical (organic) quality.
(4) Sediment
(5) Ground water
(6) Automatic water-quality monitors

The report also serves as a source of reference material on each subject.

6.2 Publications on Standard Techniques

The U. S. Geological Survey has prepared 29 manuals describing procedures for planning and executing specialized work in water-resources investigations. The material is grouped under major subject headings called "Books" and is further divided into sections and chapters. These manuals in a series entitled "Techniques of Water-Resources Investigations" (TWRI) are listed below.

Application of boreholes geophysics to water-resources investigations,—TWRI Book 2, Chapter E1.

General field and office procedures for indirect discharge measurements,—Book 3, Chapter A1.

Measurement of peak discharge by the slope-area method,—Book 3, Chapter A2.

Measurement of peak discharge at culverts by indirect methods,—Book 3, Chapter A3.

Measurement of peak discharge at width contractions by indirect methods,—Book 3, Chapter A4.

Measurement of peak discharge at dams by indirect methods,—Book 3, Chapter A5.

General procedure for gaging streams,—Book 3, Chapter A6.

Stage measurements at gaging stations,—Book 3, Chapter A7.

Discharge measurements gaging stations,—Book 3, Chapter A8.

Measurement of discharge by movingboat method, —Book 3, Chapter A11.

Fluorometric procedures for dye tracing,—Book 3, Chapter A12.

Aquifertest design, observation, and data analysis, —Book 3, Chapter B1.

Fluvial sediment concepts,—Book 3, Chapter C1.

Field methods for fluvial sediment measurements, —Book 3, Chapter C2.

Computation of fluvial sediment discharge,—Book 3, Chapter C3.

Some statistical tools in hydrology,—Book 4, Chapter A1.

Frequency curves,—Book 4, Chapter A2.

Lowflow investigations,—Book 4, Chapter B1.

Storage analyses for water supply,—Book 4, Chapter B2.

Regional analyses of streamflow characteristics,—Book 4, Chapter B3.

Computation of rate and volume of stream depletion by wells,—Book 4, Chapter D1.

Methods for collection and analysis of water samples for dissolved minerals and gases,—Book 5, Chapter A1.

Determination of minor elements in water by emission spectroscopy,—Book 5, Chapter A2.

Methods for analysis of organic substances in water, —Book 5, Chapter A3.

Methods for collection and analysis of aquatic biological and microbiological samples, —Book 5, Chapter A4.

Laboratory theory and methods for sediment analysis,—Book 5, Chapter C1.

A digital model for aquifer evaluation,—Book 7, Chapter C1.

Methods of measuring water levels in deep wells,—Book 8, Chapter A1.

Calibration and maintenance of verticalaxis type current meters,—Book 8, Chapter B2.

6.3 Transition to Metric Units

Closely related to techniques of data collection is the use of metric units of measure. The Survey formally began the period of transition to metric units in July 1973.

This report, in giving recognition to that policy, includes a table of metric equivalents for each English unit cited.

7. THE NATIONAL WATER DATA SYSTEM —A COMPUTERIZED DATA BANK

Hydrologic and related environmental data are being collected by several public agencies in Florida. These data serve many purposes—operational, management, environmental analysis, and long-term trend analysis, among others. Even

CONVERSION FACTORS

Multiply English Unit	By	To obtain metric unit
ft (feet)	0.3048	metres
in. (inches)	25.4	millimetres
mi (mile)	1.609	kilometres
mi^2 (square mile)	2.589	square kilometres
gal (gallons)	3.785	litres
gal/min (gallons per minute)	$6.309x10^{-2}$	litres per second
ft^3/sec (cubic feet per second)	$2.832x10^{-2}$	cubic metres per second
Mgal/d (million gallons per day)	$3.785x10^3$	cubic metres per day
ac-ft (acre-feet)	$1.234x10^3$	cubic metres

though they may have been collected for a single purpose, much of these data have multiple uses. However, if the format of these data is uniform and the data stored in a common data bank that would be accessible to all users the data can serve the widest possible uses. The U. S. Geological Survey computer system in Reston, Virginia is now the largest water data storage system for Florida data. This system can accommodate all water data collected in the State that are considered to be of sufficient usefulness to be stored in a permanent file for use through terminal facilities by cooperating agencies.

The U. S. Geological Survey computer system serves water-resources activities throughout the Nation and therefore is a permanent national system. This National Water Data System is made up of an IBM-370/155 computer with a large software component. The operating programs have been developed over the years and are being continually expanded and updated as need arises. In 1974 the system serves 31 terminals, 3 of which are in U. S. Geological Survey offices in Florida. Of these three, one is in Tallahassee, and the other two are in Miami and Tampa.

The National Water Data System is designed to acquire, process, store, and disseminate water data needed for planning, development, and management of the water resource. A data-handling system is that part of the National Water Data System relating to the recording, storing, disseminating, and processing of water data. Data stored in the system include:

Streamflow	Aquifer characteristics
Stage/water level	Well logs
Point discharges	Chemical analyses
Drainage areas	Pumpage
Land slopes	Biologic analyses
Land use	Water surface areas
Water use	Precipitation (quantity and chemical analysis)
Well characteristics	

These data are handled through a combination of manual and automated techniques. About 95 percent of the active streamflow stations in Florida are equipped with automatic recording gages. These recorders are of the digital type wherein data are recorded on punched paper tape which is automatically processed to produce computerized record of stage and discharge. Miscellaneous data such as point discharges, low flows, drainage areas, land slopes, land use, water surface areas, water use, and pumpage are manually processed for computer storage. Digital recorders are being installed on wells to facilitate automated processing of ground water levels. However, data on aquifer characteristics and well logs are manually processed for storage. Most chemical and biologic analyses are entered directly into computer storage immediately after analysis of samples in the U. S. Geological Survey Laboratory in Atlanta.

Some 100 computer programs have been developed and are operational to store, retrieve and analyze data within the National Data System. Many of these programs provide only tabular data; others provide results from sophisticated analysis of data such as the computation of step back water to provide flood profiles and frequencies. A program that has proven to be most useful is a plotting routine from the CAL/COMP plotter. This program automatically plots hydrographs, water-level contour maps, point data sources, or any other plots where curved or straight lines are needed from point data. A special product can be acquired either through the development of a new program or by an adaptation of an existing program.

8.0 HYDROLOGIC, WATER QUALITY, AND RELATED SIMULATION MODEL STUDIES

Water management programs require an accurate assessment of the long range effects of proposed water developments or water management programs. Such assessments become increasingly important when the water resources of an area or basin approach the limits of development.

The best means currently available for assessing the effects of a proposed water development and the management options is through simulation modeling of the water resources system. Simulation models are based on the mathematical relation between stimulus (cause) and response (effect) of hydrologic or other natural systems. A mathematical model is an algebraic statement of the physical phenomenon being simulated. Because of their mathematical complexity, simulation models generally are solved with large digital computers. Other types of simulation (analog) models are fashioned utilizing components that have physical characteristics that are analogous to the hydrologic or chemical systems being modeled.

A common highway map is like a simulation model. It simulates road networks and other cultural features of the land surface. The mathematical relation between land surface and the map is one of a specific ratio, which is the map scale. A road map provides a wealth of data that aids the traveler in composing options, making decisions, such as data on distance, probable travel time, type of roads, service facilities, and scenic attractions. The map provides a means of determining the optimum of several alternative routes, depending upon the objective of the traveler, for example, time or scenic quality. A road map, however, is a print-out of the situation at a particular time, most hydrologic simulation models provide a means of defining change through time.

8.1 Objectives of Simulation Modeling

The value of a hydrologic simulation model is that, if properly designed and fashioned, it can assess the effects through time of various stresses or stimuli resulting from water management or development programs. Owing to the complex character of hydrologic systems, the effects of stress and stimuli are difficult to evaluate or quantify by other means.

The accuracy with which the effects of proposed new stresses or stimuli to a hydrologic system can be expressed through simulation modeling depends upon the accuracy of the values assigned to the various parameters of the hydrologic system. The accuracy with which various parameters are quantified is dependent almost entirely upon the availability of pertinent hydrologic and geologic data. Further, the desired accuracy depends upon the problem at hand and may change with time. That is, the accuracy required need not be great when proposed stresses on the system are small in comparison to the magnitude of flow and storage in the system. When existing and proposed stresses on the system approach the limits of the system, accuracy requirements are much greater.

8.2 Types of Simulation Models

The following types of simulation models could have application to water management concerns in the District.

8.21 Stream Models

Simulation models of stream systems are capable of analyzing the effects of water development on the flow of a stream. The effects of water impoundment, water withdrawal, discharges of effluent, and urbanization can be analyzed. Thus, models can be used to predetermine the effects resulting either from water use or other stress or from water-management works such as impoundments. An assessment of the effects of proposed water developments can be of considerable value in deciding whether a particular rate of water use should be permitted or whether a proposed water management facility should be constructed. Stream simulation models also can provide information on the optimal use of water management facilities.

8.22 Aquifer Models

Models that simulate aquifer systems can provide information on the effects of changes in the rate of withdrawal from or recharge of water to the aquifer. Effects such as lowering of water levels through time and space, as a result of ground-water withdrawal, can be quantified. Aquifer simulation models also can be used to predict the effects of ground-water withdrawals on streamflow, the effects of artificial recharge facilities on ground-water levels, and the rate of migration of saline water into fresh-water zones of an aquifer in response to lowered ground-water levels.

8.23 Estuarine Models

In general, estuarine simulation models provide information relating to changes in water flow in the estuary and the resultant changes in water quality. Estuarine simulations can also provide information on the effects of discharge of wastes into estuaries.

8.24 Water-Quality Models

The effects on the quality of water in streams and aquifers resulting from water withdrawals, discharge of wastes, and other factors can also be predicted through simulation models. For example, a water-quality simulation model of a stream system can be used to predict the improvement in water quality resulting from augmentation of streamflow. The effects on water quality of a reduction in streamflow resulting from water withdrawals can also be predicted.

8.3 Status of Simulation Modeling in the Water Management District

At present (1974) a simulation model is being developed for the Floridan aquifer in the Jacksonville area. Much of the data that have been and are being collected in the other parts of the District can be utilized to develop one or more of the types of models previously described. The data collection network is an integral part of modeling as it provides the information input required for modeling.

9. WATER-DATA INPUT TO DISTRICT MANAGEMENT FUNCTIONS

Most of the water-management mandated functions and concerns of the District require a comprehensive base of hydrologic and land resources data. The following table lists those functions mandated in the 1972 Act that require input of water and related resource data:

District Management Functions Mandated by the 1972 Act

1. Formulate a state water use plan (Part I, Section 6)
2. Establish minimum flows for all surface watercourses in the area (Part I, Section 6, Subsection 7)
3. Establish minimum ground-water levels (Part I, Section 6, Subsection 7b)
4. Establish minimum surface-water levels (Part I, Section 6, Subsection 7b)
5. Plan, construct, operate and maintain storage reservoirs (Part I, Section 17, Subsections 3 and 4)
6. Plan, construct, operate and maintain artificial recharge facilities. (Part I, Section 18, Subsection 2(f)
7. Issue permits for artificial recharge projects (Part I, Section 18, Subsection 7b)
8. Acquire real property for necessary management works or facilities (Part I, Section 26, Subsection 2)
9. Authorize transport of water outside of the watershed in which it is taken (Part II, Section 3, Subsection 2)
10. Declare water shortage or emergency (Part II, Section 10, Subsection 1)
11. Issue permits for consumptive use of water (Part II, Section 2, Subsection 1, and Section 4, Subsection 2)
12. Issue permits for drilling wells and regulate their operation (Part III, Section 4)
13. Issue permits to construct and alter facilities or works for management and storage of surface water (Part III, Section 4, Subsection 1)

The 1972 Act authorizes four principal types of management functions: (1) Issuance of permits for and regulation of water oriented activities, (2) declaration of water shortage or emergency, (3) formulation of water use plans, and (4) construction and operation of water-management works.

Both the mandated functions and the general day-to-day water-management concerns will require a broad base of water and environmental data. The matrix in figure 23 illustrates the

WATER OR RELATED RESOURCE DEVELOPMENT OR USE / MANAGEMENT CONCERNS	1. WITHDRAWAL OF WATER FROM STREAMS	2. WITHDRAWAL OF WATER FROM WELLS	3. DRAINAGE OF URBAN AND AGRICULTURAL LANDS	4. CONSTRUCTION OF RESERVOIRS OR IMPOUNDMENTS	5. INTERBASIN DIVERSION OF WATER	6. STREAMS	7. SEPTIC TANKS	8. SEWAGE LAGOONS	9. INCREASED RUNOFF FROM URBANIZED AREAS	10. SANITARY LANDFILLS	11. SPRAY DISPOSAL OF LIQUID WASTES ON THE LAND SURFACE	12. CONSTRUCTION OF "REAL ESTATE" LAKES	13. AGGREGATE OR OTHER MINERAL QUARRYING OR MINING	14. DEVELOPMENT ON FLOOD PRONE LANDS	15. AGRICULTURAL, OR URBAN INDUCED EROSION
1. STREAMFLOWS, LEVELS AND SURFACE WATER AVAILABILITY	●	○	○	●	○	●			○			○		●	○
2. GROUND-WATER LEVELS AND AVAILABILITY		●	●				●		●	○	●		●		
3. LAKE, RESERVOIR AND CANAL LEVELS	●	○	○	●	○				○			○	○	○	○
4. RESERVOIR STORAGE VOLUMES	○			●		○			○						●
5. FLOWS OF SPRINGS		●	●				○		●		○		○		
6. SURFACE-WATER QUALITY	●	○	●	●	●	○		○	●			○	●		●
7. GROUND-WATER QUALITY		●				○	●	●		●	●		○		
8. SALT-WATER INTRUSION		●	●						●						
9. PROTECTION AND PROCREATION OF FISH AND WILDLIFE	●		●	●		●		○			○	●	●	○	●

● PRIMARY RELATIONSHIP

○ SECONDARY RELATIONSHIP

(blank) MINIMAL RELATIONSHIP

Figure 23.--Matrix showing relation between management concerns and common types of resources development.

relation between continuing management concerns and common types of resources development. The matrix also reveals the complexity of the water management concerns as they relate to the impact of development.

9.1 Implementation of Management Policy

As indicated previously, the 1972 Act authorizes four principal types of management functions. The management programs to achieve the goals as defined in the policy statement of the 1972 Act will relate to these four types of management.

9.11 Permit and Regulation Function

This function includes issuing permits for and regulation of water use, management and development including the construction, operation, and maintenance of water management facilities, the use of water consumptively, drilling and maintaining of wells, and the storage and management of surface waters. This function is authorized in Parts II, III and IV of the Act. Issuing permits for the transfer of water outside of the watershed from which it is taken (Part II, section 3(2) and of the artificial recharge or intentional introduction of water into any underground formation, "except as permitted in Chapter 377, Fla S," (Part I, section 18 (1)) can also be included in this function. This function probably constitutes the principal means of controlling water use and development in the District.

9.12 Water Shortage or Emergency Function

Part II, section 10 of the 1972 Act authorizes the implementation of an additional function, that of requiring "temporary reduction in total use." This function would provide for temporary change in the condition of a permit, suspension of a permit or any other restriction on the use of water for the duration of a water shortage.

9.13 Water Use Plan Function

Part I, section 6 of the 1972 Act calls for the progressive formulation of a State Water Use Plan. Although planning does not necessarily imply management, subsections 7a and 7b of the section 6 mandate the establishment of minimum flows for streams and minimum levels for surface waters and for ground-water levels in aquifers. The provision for establishing legal minimum flows and levels is a means of managing the water resources.

9.14 Construction and Operation of Water Management Works Function

Part I, sections 17, 18 and 26 of the 1972 Act authorizes the construction, operation and maintenance of works of the District. Such works as defined in the 1972 Act would provide for the storage and transport of water at the surface and the artificial recharge of ground-water reservoirs as well as other water-management programs. These works could greatly increase the availability of a dependable supply of water, and could significantly alter flows and levels. The authorization to physically manage water also is a primary water management tool.

9.2 Data Needed for Implementation of Management Functions

All of the four primary types of management functions authorized by the 1972 Act require a broad base of water data. The need for data and information to implement these functions was recognized by the legislature inasmuch as the Act mandates the study of the water resources of the State and the formulation of "an integrated, coordinated plan for the use and development of the water of the State based on the above studies." The relation of water data to each of the management functions is illustrated in the diagram of figure 24.

Monitoring networks are vital to several of the functions. The water use plan function, with its responsibilities for establishing minimum flows and levels, and the function of operating and maintaining water management works, require a broad base of previously collected data as well as data to be acquired through a broad range of future water studies.

9.3 An Analytical Approach to Determining Data Needs

Defining the specific management functions as mandated by the 1972 Act makes it possible to define the types of water-resource evaluations required for water management decisions, programs, and projects. After the evaluations are defined, they can then be related to the type and format of study or report products required. These, in turn, provide insight into the types of data acquisition programs that can be started or continued to provide the required information

A series of three matrices has been utilized to define the foregoing relations. The first matrix

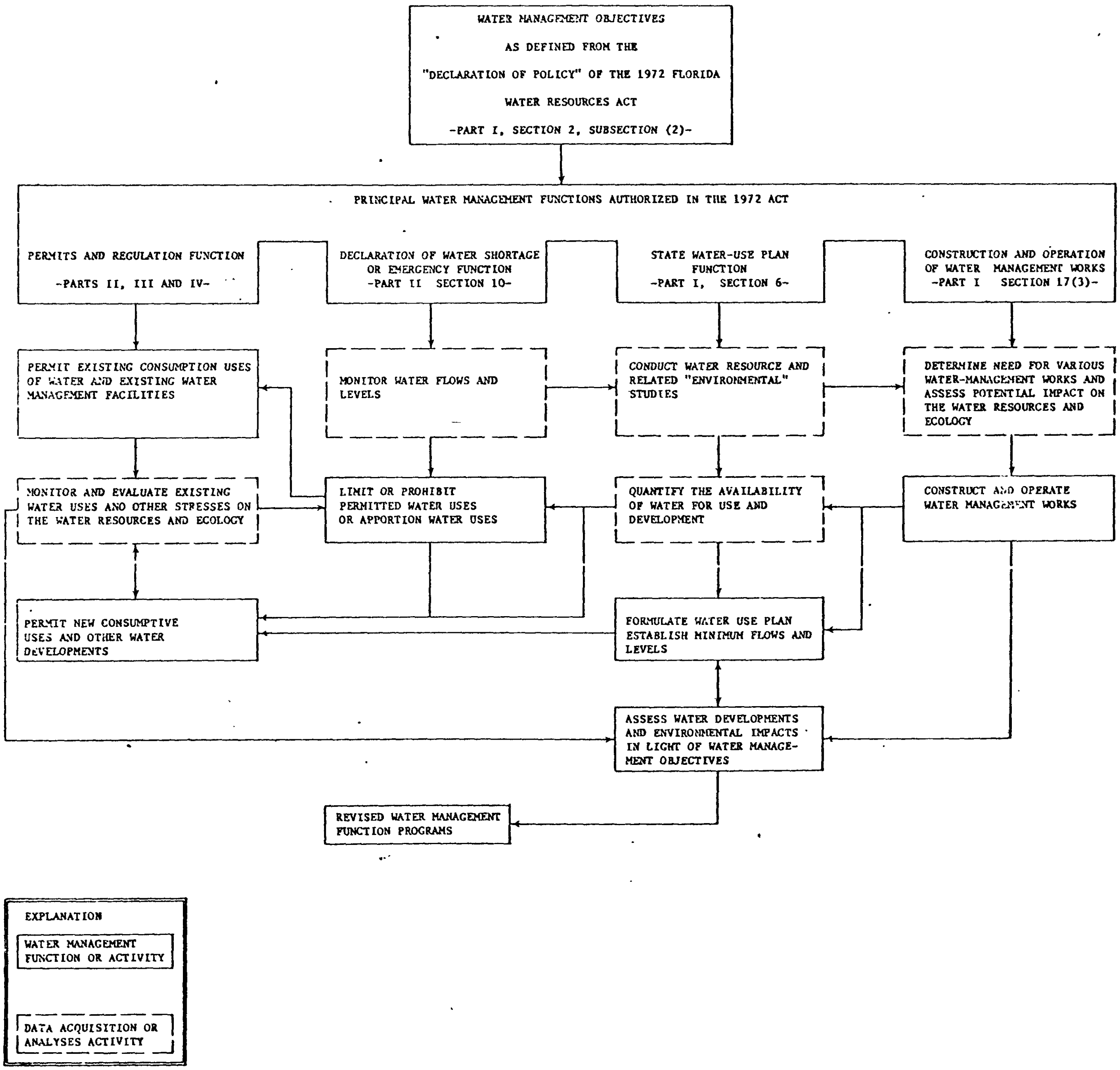

Figure 24.--Flow diagram illustrating the relation of water data to each of the management functions.

WATER RESOURCE EVALUATIONS / WATER MANAGEMENT FUNCTIONS	1. GROUND-WATER AVAILABILITY	2. GROUND-WATER LEVEL INFORMATION	3. ARTIFICIAL RECHARGE POTENTIAL	4. INDUCED RECHARGE POTENTIAL	5. POTENTIAL FOR WATER STORAGE IN AQUIFERS	6. HYDRAULIC CHARACTERISTICS OF AQUIFERS	7. GROUND-WATER QUALITY	8. SURFACE-WATER AVAILABILITY	9. LOW FLOW FREQUENCY CURVES	10. STAGE-DURATION CURVE FOR LAKES	11. POTENTIAL IMPOUNDMENT SITES AND STORAGE CAPACITIES	12. POTENTIAL STREAM STORAGE	13. SURFACE-WATER QUALITY	14. CURRENT WATER LEVELS AND STREAM FLOWS
1. FORMULATION OF A STATE WATER USE PLAN (PART I, SECTION 6)	○	○	○	○	○	○	○	○	○	○	○	○	○	○
2. ESTABLISH MINIMUM FLOWS FOR ALL SURFACE WATER COURSES IN THE AREA (PART I, SECTION 6, SUBSECTION 7)								○	○	○	○	○		○
3. ESTABLISH MINIMUM GROUND-WATER LEVELS (PART I, SECTION 6, SUBSECTION 7b)	○	○	○	○	○	○								
4. ESTABLISH MINIMUM SURFACE-WATER LEVELS (PART I, SECTION 6, SUBSECTION 7b)								○	○	○	○	○	○	○
5. PLAN, CONSTRUCT, OPERATE AND MAINTAIN STORAGE RESERVOIRS (PART I, SECTION 17, SUBSECTIONS 3 and 4)								○	○	○	○	○	○	○
6. PLAN, CONSTRUCT, OPERATE AND MAINTAIN ARTIFICIAL RECHARGE FACILITIES (PART I, SECTION 18, SUBSECTION 2(f)		○	○	○	○	○	○	○	○				○	
7. PERMIT ARTIFICIAL RECHARGE PROJECTS (PART I, SECTION 18, SUBSECTION 7b)		○	○	○	○	○	○	○	○				○	
8. ACQUIRE REAL PROPERTY FOR NECESSARY MANAGEMENT WORKS OR FACILITIES (PART I, SECTION 26, SUBSECTION 2).	○		○	○	○	○	○	○	○	○	○	○	○	○
9. AUTHORIZE TRANSPORT OF WATER OUTSIDE OF THE WATERSHED IN WHICH IT IS TAKEN (PART II, SECTION 3, SUBSECTION 2)	○	○	○	○	○	○	○	○	○	○	○	○	○	
10. DECLARATION OF WATER SHORTAGE OR EMERGENCY (PART II, SECTION 10, SUBSECTION 1)	○	○						○	○	○				○
11. PERMITTING CONSUMPTIVE USE OF WATER (PART II, SECTION 2, SUBSECTION 1, AND SECTION 4, SUBSECTION 2)	○	○			○	○		○				○	○	
12. PERMITTING AND REGULATION OF WELLS (PART III, SECTION 4)	○	○	○	○	○	○	○							
13. PERMITTING CONSTRUCTION AND ALTERATIONS OF FACILITIES OR WORKS FOR MANAGEMENT AND STORAGE OF SURFACE WATERS (PART III, SECTION 4, SUBSECTION 1)				○				○	○	○	○	○	○	○

Figure 25.--Matrix showing relation between management functions and water resources evaluations.

(fig. 25) lists the various water management functions on the left side of the matrix and types of water-resource evaluations required to implement these functions at the top of the matrix. Resource evaluations pertinent to the various management functions are indicated by a circle at the intersection of the rows andcolumnsof the matrix. The second matrix (fig. 26) relates in a similar fashion the resource evaluations listed on the first matrix to the various study or report products evolving from data collection and analysis programs. The third matrix (fig. 27) relates the study products of the second matrix to actual data-collection. The analysis of data acquisition programs for specific management functions through the three matrices can be diagrammed as follows:

Matrix 1

Management function Water Resources Evaluation

Matrix 2

Water Resource Evaluation Study Products

Matrix 3

Study Products Basic Data Acquisition Programs

The matrices can thus be used to evaluate the types of basic data, data analysis, and report products that are important inputs to decisions involved in water management functions.

9.4 Anticipated Phases of Management

The hydrologic data acquisition program and hydrologic investigations conducted by the U. S. Geological Survey in the District during the past several decades constitute a broad base of water facts upon which adjudications and management decisions can be supported. These data acquisition programs, however, were not specifically designed to provide all the information required by the District; nearly all the programs were started before the need for water management districts was recognized. Thus, certain deficiencies exist in the data required for implementation of District functions and actions. Such deficiencies can be corrected during future acquisition programs.

Possible management thrusts of the District are herein separated into three principal phases, which broadly define the principal types of management concerns that may evolve in the District through time. It should be recognized that water development in one part of the District may call for complex management programs while activities in the remaining parts of the District may require only broad water management programs.

9.41 Phase I Management

Phase I management involves the specific mandates of the 1972 Act. Initial management programs of the District probably will be in response to these mandates, which can be separated into the following categories:

1. Formulation of water-use plan.
2. Establishment of various water criteria such as minimum flows in water courses, minimum ground-water levels and minimum surface-water levels.
3. Planning and starting mandated studies.
4. Issuing permits for regulation of existing consumptive water use.

9.42 Phase II Management

Phase II Management probably will involve water monitoring and accounting to insure that flow and level criteria established under phase I management are maintained and that the impacts of permitted consumptive water uses, wells and storage facilities are quantified. Phase II may also include management program including construction of facilities to maintain flows and water levels by means of dams, flood-gates and other structures or facilities and by regulating withdrawal from or discharge into streams or other water bodies. Whether new consumptive uses of water are permitted may relate in part to increases in availability resulting from new water management facilities, either public or private. Water resource studies geared to aspects of Phase II management can also be planned and started.

9.43 Phase III Management

Phase III management is an extension of Phase II management, the principal difference being the increased complexity of the management programs involved and the increased sophistication of techniques needed to evaluate potential impacts of requested or proposed water development. Phase III management probably will involve the use of simulation models to predict the effects of proposed developments on the water resource as well as on the environment of the area involved. That is, Phase III management differs from Phase II management in that it includes social, economic, and esthetic inputs in the decision making process. Simulation model studies can provide a basis for needed amendments or additions to the water use plan. Managing water under this phase would require programs for quantifying the integrated effects of complex systems of facilities for water storage and control, as well as the cumulative impacts of multiple uses and developments.

WATER RESOURCE EVALUATIONS \ STUDY PRODUCTS	1. STATISTICAL DETERMINATIONS OF STREAMFLOW CHARACTERISTICS	2. STATISTICAL DETERMINATIONS OF FREQUENCY OF LOW LAKE LEVELS ACCORDING TO CLASSES OF LAKES	3. STATISTICAL DETERMINATIONS OF FREQUENCY OF LOW GROUND-WATER LEVELS	4. GROUND-WATER SURFACE-WATER RELATIONS	5. CONFIGURATION OF THE POTENTIO-METRIC SURFACE	6. DRAFTS FROM STREAM STORAGE	7. VARIATIONS IN AQUIFER TRANS-MISSIVITIES	8. LOCATION OF SALT/FRESH WATER INTERFACE AND AREAS WHERE AQUIFERS CONTAIN SALT WATER	9. SITES FOR WATER IMPOUNDMENT AND STORAGE	10. LOCATION AND RATE OF EXISTING MAJOR WATER USE	11. LOCATION AND RATE OF WASTE DISCHARGE TO STREAMS	12. GROUND-WATER LEVEL DATA	13. STREAMFLOW AND STREAM-LEVEL DATA	14. LAKE-LEVEL DATA	15. SURFACE-WATER QUALITY CHARACTER-ISTICS	16. GROUND-WATER QUALITY CHARACTER-ISTICS	17. AQUIFER BOUNDARY CONDITIONS	18. AQUIFER GEOMETRY	19. STREAM WASTE ASSIMILATION CAPACITY	20. AQUIFER WASTE ASSIMILATION CAPACITY
1. GROUND-WATER AVAILABILITY			O	O	O		O	O		O		O				O	O	O		O
2. GROUND-WATER LEVEL INFORMATION		O	O	O	O		O			O		O				O	O	O		O
3. ARTIFICIAL RECHARGE POTENTIAL	O			O			O	O	O			O			O	O	O	O		O
4. INDUCED RECHARGE POTENTIAL	O			O			O					O			O		O	O		
5. POTENTIAL FOR WATER STORAGE IN AQUIFERS	O						O	O	O	O		O		O	O	O	O	O		O
6. HYDRAULIC CHARACTERISTICS OF AQUIFERS		O	O	O	O	O	O		O	O		O		O			O			O
7. GROUND-WATER QUALITY				O				O								O	O	O		O
8. SURFACE-WATER AVAILABILITY	O	O		O		O				O	O		O		O				O	
9. LOW-FLOW FREQUENCY CURVES	O	O		O		O							O						O	
10. STAGE DURATION CURVES FOR LAKES		O		O									O	O						
11. POTENTIAL IMPOUNDMENT SITES AND STORAGE CAPACITIES	O	O			O	O			O	O	O		O	O	O				O	
12. POTENTIAL STREAM STORAGE	O	O				O			O		O		O		O					
13. SURFACE-WATER QUALITY				O		O					O				O				O	
14. CURRENT WATER-LEVELS AND STREAM FLOWS	O									O		O	O	O					O	

Figure 26.--Matrix showing relation between water resource elevation and various study products.

STUDY PRODUCTS \ BASIC DATA COLLECTION PROGRAMS	QUANTITATIVE SURFACE-WATER INVESTIGATIONS							QUANTITATIVE GROUND-WATER INVESTIGATIONS								GEOLOGIC & GEOPHYSICAL					WATER CHEMICAL QUALITY STUDIES						
	1. CONTINUOUS RECORDING OF FLOW AND LEVELS AT SELECTED SITES	2. PERIODIC MEASUREMENTS OF FLOW AND LEVEL AT SELECTED SITES	3. "SEEPAGE RUN" MEASUREMENTS ALONG SELECTED STREAMS	4. MEASUREMENT OR OTHER QUANTIFICATION OF WITHDRAWALS FROM STREAMS OR LAKES	5. MEASUREMENT OR OTHER QUANTIFICATION OF WASTE EFFLUENTS TO STREAMS OR LAKES	6. MEASUREMENT OR OTHER QUANTIFICATION OF RUNOFF FROM VARIOUS TYPES OF URBAN DEVELOPMENT	7. QUANTIFICATION OF FLOOD FLOWS	1. CONTINUOUS RECORDING OF GROUND-WATER LEVELS	2. PERIODIC MEASUREMENTS OF GROUND-WATER LEVELS	3. WELL YIELD - DRAWDOWN MEASUREMENTS THROUGH TIME (INCLUDING AQUIFERTESTS)	4. INVENTORY OF WELLS	5. INVENTORY OF MAJOR GROUND-WATER WITHDRAWALS	6. LABORATORY QUANTIFICATION OF THE HYDRAULIC CONDUCTIVITY OF SEDIMENTS	7. GROUND-WATER TRACER STUDIES	8. GROUND-WATER AGE (DATING) INVESTIGATIONS	1. TEST DRILLING	2. GEOLOGIC MAPPING	3. WELL CUTTING AND CORE ANALYSES	4. BORE-HOLE GEOPHYSICAL LOGGING	5. SEISMIC AND RESISTIVITY SURVEYING	1. QUANTIFICATION OF INORGANIC CHEMICAL QUALITY	2. QUANTIFICATION OF ORGANIC CHEMICAL QUALITY	3. WATER TEMPERATURE MEASUREMENTS	4. DEFINE CHARACTERISTICS OF BOTTOM SEDIMENTS OF STREAMS	5. ANALYSIS OF CONTAMINANT CONCENTRATIONS IN BOTTOM SEDIMENTS OF CANALS AND RIVERS	6. LABORATORY DETERMINATIONS OF ABSORPTION AND ION EXCHANGE MECHANISMS OF VARIOUS SOILS AND SEDIMENTS	7. OXYGEN CONCENTRATION AND DEMAND
1. STATISTICAL DETERMINATIONS OF STREAMFLOW CHARACTERISTICS	O	O	O	O		O	O																				
2. STATISTICAL DETERMINATIONS OF FREQUENCY OF LOW LAKE LEVELS ACCORDING TO CLASSES OF LAKES	O	O						O	O	O			O														
3. STATISTICAL DETERMINATIONS OF FREQUENCY OF LOW GROUND-WATER LEVELS								O	O		O	O															
4. GROUND-WATER SURFACE WATER RELATIONSHIPS	O		O					O	O	O																	
5. CONFIGURATION OF THE POTENTIOMETRIC SURFACE								O	O		O	O				O											
6. DRAFTS FROM STREAM STORAGE	O	O		O																							
7. VARIATIONS IN AQUIFER TRANSMISSIVITIES								O		O		O	O	O	O	O	O	O	O	O							
8. LOCATION OF SALT/FRESH WATER INTERFACE AND AREAS WHERE AQUIFERS CONTAIN SALT WATER								O	O		O	O				O	O	O	O	O	O						
9. SITES FOR WATER IMPOUNDMENT AND STORAGE	O	O	O		O	O	O									O	O										
10. LOCATION AND RATE OF EXISTING MAJOR WATER USE				O							O	O															
11. LOCATION AND RATE OF WASTE DISCHARGE TO STREAMS			O		O																O	O	O				
12. GROUND-WATER LEVEL DATA								O	O	O	O	O	O			O	O										
13. STREAMFLOW AND STREAM-LEVEL DATA	O																										
14. LAKE-LEVEL DATA	O	O		O		O	O	O	O			O				O	O										
15. SURFACE-WATER QUALITY CHARACTERISTICS					O																O	O	O	O	O	O	O
16. GROUND-WATER QUALITY CHARACTERISTICS																					O	O	O			O	
17. AQUIFER BOUNDARY CONDITIONS			O					O		O	O	O	O	O			O	O		O							
18. AQUIFER GEOMETRY								O		O	O			O		O	O	O	O	O							
19. STREAM WASTE ASSIMILATION CAPACITY	O	O	O		O																O	O	O	O	O		O
20. AQUIFER WASTE ASSIMILATION CAPACITY																					O	O	O				

Figure 27.--Matrix showing relation between study products and basic data acquisition programs.

10. THE APPLICABILITY OF THE EXISTING DATA BASE TO DISTRICT FUNCTIONS

The existing data base probably will be adequate for the implementation of most of the District's water management functions, especially at Phase I management level.

The following discussion of data availability and applicability includes a review of various District functions as mandated by the Water Resources Act, a breakdown of the types of data that are applicable to these functions, and a summary of the existing data as they relate to these functions.

10.1 Adequacy of the Existing Data Base for the Preparation of a Water Use Plan

Part I, Section 6, subsection 4, directs the governing boards of the Water Management Districts to "assist the department (DNR) in the formulation and drafting of those portions of the state (water) plan applicable to the district." It is assumed the District, in cooperation with the DNR, will draft a District Water Use Plan which will become a part of the State Water Plan. The adequacy of existing data for the preparation of a District Water Use Plan can be assessed in the light of the requirements of the 1972 Act.

The assessment will be difficult because the Act does not clearly indicate what is to be included in a water use plan or how a plan will be formulated. Because the scope of the studies mandated to be the basis of the plan is broad and encompasses most aspects of the hydrologic regimen, it is assumed the water use plan will provide for control of nearly all aspects of water use and management.

Although it is not possible to conceive all the aspects of the plan, it appears that the general objective would be to provide for the maximum beneficial uses of water that are not harmful to the resource or the environment. Were the plan to include criteria for water use, flow and level limits, and means or methods of conserving and augmenting water, the plan would provide the general philosophical and technical basis for decision making.

The parts of Section 6 pertinent to the existing availability of data are as follows:

"(1) The department shall proceed as rapidly as possible to study existing water resources in the state; means and methods of conserving and augmenting such waters; existing and contemplated needs and uses of water for protection and procreation of fish and wildlife, irrigation, mining, power development and domestic, municipal and industrial uses, and all other related subjects including drainage, reclamation, floodplain or flood-hazard area zoning, and selection of reservoir sites.....

"(4) Each governing board is directed to cooperate with the department in conducting surveys and investigations of water resources, to furnish the department with all available data of a technical nature, and to advise and assist the department in the formulation and drafting of those portions of the State plan applicable to the district.

"(7) Within each section, or the water management district as a whole, the department and the governing board shall establish the following:

(a) Minimum flow for all surface watercourses in the area. The minimum flow for a given watercourse shall be the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area.

(c) The minimum flow and minimum water level shall be calculated by the department and the governing board using the best information available. Where appropriate, minimum flows and levels may be calculated to reflect seasonal variations. The department shall also consider and at its discretion may provide for the protection of nonconsumptive uses in the establishment of minimum flows and levels."

10.11 Applicability of the Data Base to Studies of the Water Resource

Studies of the water resources as mandated in section 6, sub-section (1) will be affected to a large degree by the availability of data and information obtained from previous investigations as outlined below.

To study existing water resources—A review of the extent and scope of previous studies and the availability of basic water data would help to provide a basis on which to formulate studies of water and related resources. Figure 9 shows the location and areal extent of published reports on geological and water-resource studies in the district. In addition, a relatively broad base of data on streamflow water quality, water wells, aquifer geometry and ground-water levels can be retrieved from the computerized data bank. These data will aid greatly in making studies of the water resource.

To study means and methods of conserving and augmenting water—Potentially several types of water management projects could be used to conserve and augment water in the District. Included are surface reservoirs, artificial recharge programs, the injection and storage of fresh water in saline water aquifers and water reuse.

The facilities or works needed to conserve and augment water supplies will require detailed information on the hydrology of specific sites or localities. Acquisition of such information can form an integral part of future data collection programs. The existing data base on topography, geology and hydrology can, however, aid in general planning of water augmentation and conservation programs and in the design of the studies needed to quantify the effects of proposed programs.

To study existing and contemplated needs and uses of water for protection and procreation of fish and wildlife, irrigation, mining, power development, and domestic, municipal and industrial uses, and all other related subjects including drainage, reclamation, flood-plain or flood-hazard area zoning and selection of reservoir sites—Most of the Survey's data on existing water use is for municipalities. Figure 14 shows where municipal water use data have been or are being acquired on a continuing basis. Tables 2, 3, 4 and 5 list quantities of water being used, and the type of use. Pride (1973) and Healy (1972) provide additional information on water use in the district.

Maps on which flood-prone areas have been delineated are shown on figure 13. The selection of potential reservoir sites requires topographic and streamflow characteristics data. Figure 13 is also a topographic map index. It shows the availability of topographic maps suitable for preliminary identification of potential reservoir sites. Figure 15, which shows the location of stream gaging stations, provides an index of data needed to estimate the availability of water for storage.

10.12 Establishment of Various Water Criteria

The Water Resources Act requires the Department of Natural Resources and the Water Districts to establish minimum flows for all surface watercourses and minimum water levels for ground and surface waters. It also requires the Districts to "determine, establish and control level of water to be maintained in all canals, lakes, rivers, channels, reservoirs, streams or other bodies controlled by the District."

The peculiarities inherent in these requirements make it particularly difficult to assess the adequacy and applicability of existing data to the establishment of the required criteria. For example, the Act does not specify the minimum size of the watercourse for which minimum stages are to be established, nor does it specify the spatial density of points where minimum flows and levels will be established. In that levels are to be determined, established and controlled in *all* "canals, lakes, rivers, channels, reservoirs, streams, or other water bodies controlled by the District," however, strongly suggests that network of points where minimum flows and levels need to be established and maintained will be rather dense.

10.121 Minimum Flows: Minimum flows are to be calculated by the DNR and the District using the best information available. When appropriate, minimum flows and levels may be calculated to reflect seasonal variations. Therefore it is assumed that the process of establishing minimum flows will include recognition of climatically induced variations. Because droughts produce lowest natural minimum flows, data on drought flows will, of course, be a significant input to the establishment of minimum flows. Although predicting the time of occurrence and the severity of future drought flows is impossible, quantifying —through statistical analysis—the rate of low streamflow during a drought and the anticipated frequency of recurrence is possible.

One of the most commonly used means of describing low flows is in terms of 7-day low-flows, which is the lowest average flow during a seven consecutive day period. The theoretical frequency at which annual 7-day low-flows will occur commonly are calculated for 1-, 2-, 5-, 10-, 15-, 50- and 100-year recurrence intervals. The availability of sufficient data to compute the 7-day low-flow with an average recurrence interval of 10 years (7-day Q10) is used herein as an index of the availability of streamflow data in the District. At least 10 years of continuous streamflow record is required for reasonably accurate determination of 7-day Q10. Figure 15 shows the location of gaging stations with 10 years of continuous record. This illustration includes a summary of the data available for the gaging stations shown.

10.122 Minimum Levels: Minimum water levels are defined in the 1972 Act as the "level of ground water in an aquifer and the level of surface water at which further withdrawals would be significantly harmful to the water resources of the area." For unregulated streams the rate of flow generally is a direct function of water level or stage for a given channel configuration or characteristic. Thus, the establishment of a minimum flow also provides a basis for establishment of a minimum level. As the configuation of the channel of many streams changes with time, stage-flow relationships are not direct and the establishment of a minimum flow does not provide for the establishment of an exact minimum level. Stage-discharge data, which are available for the gaging stations of Figure 15, however, could provide a means of establishing a general correlation between the legal minimum flows and legal minimum levels.

The establishment of minimum levels for impounded water bodies on streams, lakes with controlled outlets, and in canals, reservoirs and other water bodies whose levels are regulated, requires data input markedly different from that required for non-regulated water bodies. Minimum levels of most regulated water bodies generally are set by management policy and relate to the elevation of control structures so that there is no direct relationship between flow and level. Legal minimum levels can be established for most regulated water bodies in accordance with management objectives. Water level data for Lake Washington, near Eau Gallie, are available from 1942 to present. Lake Washington supplies the Melbourne-Eau Gallie area and is the only "conventional" municipal reservoir in the District. St. Augustine also uses some surface water to augment municipal supply, which is withdrawn from an improved borrow pit.

Data on natural low levels will assist in establishing minimum levels for non-regulated lakes. Because lake level fluctuation data are not available for many lakes in the District and as the lakes are too numerous for levels to be measured periodically in all, information on natural low levels probably will have to be obtained through correlation of levels between lakes with similar environmental characteristics. The Gazetteer of Florida Lakes (Florida Board of Conservation, 1969) lists four major types of lakes:

1. Lakes with streams flowing into them.
2. Lakes with streams flowing out of them.
3. Lakes with streams flowing in and out of them.
4. Lakes that are landlocked.

This classification system can be broadened to distinguish between lakes with good hydraulic connection to the ground-water reservoirs and lakes with poor hydraulic connection. The broadened system could be used to estimate natural minimum levels in ungaged lakes through correlation with levels in gaged lakes. The active and discontinued lake-stage-gages in the District are shown on Figure 17.

To determine whether existing data are adequate or even applicable in establishing minimum levels in aquifers is difficult. The Water Resources Act of 1972 does not stipulate whether a minimum level applies to an entire aquifer, part of an aquifer or at a single point. A consideration of the following hydrologic factors can aid in establishing realistic minimum water levels in aquifers.

1. The potentiometric surface is not a horizontal plane. Its configuration is primarily a function of transmissivity, the location of areas or points of recharge and discharge, and the rate of recharge or discharge at these points.

2. Where an aquifer has good hydraulic connection to an overlying body of surface water, ground water withdrawals can result in increased infiltration of surface water into the aquifer. Such infiltration can reduce the flow and (or) levels of hydraulically connected surface waters.

The rate at which surface water can be induced to infiltrate into an underlying aquifer is a function of the hydraulic conductivity of the sediments between the surface-water body and the aquifer, the transmissivity of the aquifer, and the head difference.

3. The configuration or shape of ground-water level in the vicinity of a pumping well is similar to that of a cone with the apex downward. Drawdown cones are narrow and steep where transmissivity is low, and wide and flat where transmissivity is high. Generally, the apex of the cone, which is at the pumped well, can be markedly lower than the water level a few hundred feet from the cone without harming the water resource. Thus, the District may need to determine whether or not minimum water levels generally should apply to the water level in a pumping well.

4. If an aquifer contains both salt water and fresh water, the salt water will migrate into the area of fresh water if water levels in the fresh-water area are lowered. Extensive migration of the salt water is harmful to the water resource. In the vicinity of a salt/fresh water interface the primary objective for establishing a minimum ground-water level could be to limit salt-water migration.

5. Some aquifers include several water-bearing zones. Natural water levels in these zones common-

ly are at different altitudes. A well drilled through and open to two or more of these zones will allow water to move from one zone to another. In time, the movement of water from one zone to another will result in a common water level. The altitude of that common water level will depend on the characteristics of the individual zones. The process of establishing a "common" minimum level for the aquifer requires a considerably different data input than the process of establishing minimum levels for each zone.

The following kinds of information probably will be useful in establishing minimum water levels in an aquifer:

1. Configuration of potentiometric surfaces.

2. The natural low water level estimated to occur during severe drought conditions at points with a spatial density of about one every 100 mi^2.

3. Hydrographs of water level in observation wells in areas of appreciable ground-water development.

4. Minimum, maximum, and average pumping rates of all wells that yield at least several hundred gallons per minute.

5. Data on the transmissivity of all aquifers and important water producing zones in multi-zoned aquifers.

6. Data on the hydraulic conductivity of the sediments separating aquifers from surface water.

7. Data on the position of the salt/fresh water interface.

8. Data on the quantity of surface water available for artificial recharge to the aquifer.

9. Storage capacity of the aquifer.

10. Natural recharge and discharge rates for the aquifer.

Existing data applicable to the process of establishing minimum ground-water levels in aquifers are contained in a number of the reports shown on Figure 11, which provide information on water levels and other hydrologic information on the various aquifers of the District. Figure 12 shows most areas of municipal ground-water withdrawal. The record of water-level fluctuations for the observation wells of Figure 17 provide the most useful data available for establishment of minimum ground-water levels. In addition to the ground-water level data in published reports, a large base of water-level and spring discharge data can be retrieved from the computerized data bank.

10.2 Issuing Permits and Regulating Consumptive Uses of Water

The 1972 Act authorizes the implementation of programs for regulating consumptive use of water. The need for data for such programs relates to the availability of water and especially to potential conflict where two or more applications are pending for a quantity of water that is inadequate for both or all.

The primary data needed for a program of regulation of consumptive water use is related to water availability as it compares to existing and (or) requested water use. During Phase I management the availability of water probably will have to be determined on the basis of flow data for streams and well yield/drawdown data for aquifers. The quantities of surface water available for consumptive use can be estimated on the basis of statistical computation of the average recurrence of various flows. (See Figure 15 for availability of surface water data.) Additional data on ground-water availability are contained in the reports listed on Figure 11. Data on individual well yields can be retrieved from the computerized data bank.

10.3 Adequacy of Existing Data Base for Issuing Permits to Drill Water Wells

Whether drilling of new water wells is permitted involves considerations of existing water uses as well as local hydrologic and geologic conditions that will affect the design of proposed wells. Information needed as a basis for a decision regarding whether to issue a permit for a new well includes:

1. Location of areas where substantial quantities of ground water are being withdrawn. Additional uses of water in such areas could reduce the yield of existing wells and cause water levels to decline below desirable minimums.

2. Location of the fresh-salt-water interface in aquifers in coastal areas such as Duval and Volusia Counties. Large withdrawals in such areas could lower water levels and cause salt-water encroachment.

3. Depth to highly mineralized water. Where such water underlies fresh water zones, control of well depths could prevent upward movement of poor-quality water into fresh-water zones.

4. Location of streams whose flows could be diminished by withdrawal of water from wells.

5. Location of abandoned or poorly main-

tained wells that would provide an avenue for the upward or downward movement of poor-quality water into fresh-water aquifers.

Figure 14 shows the location of present major municipal withdrawals of ground-water. Data are available for preparation of interpretive maps which would provide much of the information needed for issuance of well permits. Data for several hundred wells in the District are in the Survey's computerized data bank and can be retrieved as required for issuing permits to drill water wells and to regulate their use.

10.4 Adequacy of Existing Data Base for Management and Storage of Surface Water

Whether or not to issue permits for managing and storing surface water will require data on (1) the topography and geologic characteristics of the area where water is to be impounded or diverted, (2) the size and runoff characteristics of the drainage area above the impoundment or diversion, and (3) the flow characteristics of streams and springs to be managed, including the availability of water for storage or diversion. If a permit for storage or diversion is issued, stream-flow data above and below the diversion or storage will be required so that the stream will not be "harmed" by management practices. The general topographic characteristics of a proposed impoundment or diversion can be defined from existing topographic maps as can the size of the basin above the proposed impoundment or diversion. General information on the geologic characteristics can be obtained from geologic data contained in various water reports (Figure 11). Figure 15 can be used as an index of the availability of data for which streamflow characteristics, including availability of water for storage or diversion, and runoff characteristics can be computed.

11. FACTORS AFFECTING PLANNING OF DATA ACQUISITION PROGRAMS

Prudent design of studies to determine information needs can assist in ensuring that all of the needed data are collected to meet the developing needs for information through time.

11.1 Data Acquisition Goals

The hydrologic systems of the District are large and complex. The rapid acquisition of comprehensive data on all the systems would require extraordinarily large expenditures of effort and resources. Optimal data acquisition programs permit collection of data necessary for immediate use, but with full consideration of factors that provide for maximum use of the data over the long term.

Effective management of water requires a reasonably accurate evaluation of the potential effects of a proposed water use or development. In a hydrologic system, where existing and proposed uses affect only a small part of the available supply, relatively large errors in the evaluation of potential effects may not be serious. However, as a system approaches maximum or optimum development, the problem of assessing potential effects becomes increasingly difficult and relatively large assessment errors could be serious.

The needs for data to assess effects of proposed use and development in a relatively undeveloped system may be small. Nonetheless, if programs to acquire such data are carefully designed they can provide information needed for more complex water-management decisions in the future. Figure 28 illustrates the flow of data through time into decisions at the three anticipated levels of management. Data acquisition programs started during the earliest phases of management eventually can provide much of the data needed to fashion simulation models for level III management. Thus, the goals of all data acquisition programs need to reach beyond immediate needs to the long range needs for evaluating cause and effect relations.

11.2 Idealized Sequence of Studies to Achieve Data Acquisition Goals

With proper design, studies can be implemented to acquire data adequate to meet needs for the three phases of management as they arise. Proper study design entails the progression of studies from collection of basic data, to analysis and interpretation of data, and to preparation of reports so that the needed information will be available as various management functions are implemented.

If studies are properly designed, they can initially provide the foundation of data for intermediate studies which in turn form the basis for long-range studies. Study design also must recognize that many of the District functions can provide data inputs to many of the needed studies.

Figures 29, 30, and 31 are flow diagrams of idealized studies showing the flow of activities and reports into District functions as well as the input from various functions involved with issuing permits into data acquisition activities. If the sequence of studies as outlined in the flow diagram is implemented, the progression from studies to reports to management functions should produce the greatest benefits at the lowest cost.

11.3 Management Input to the Design and Planning of Data Acquisition Programs

To design an optimum data acquisition program would require perfect foresight of all future water uses and developments. As such foresight is not possible, data acquisition programs at any one time can only meet needs as anticipated from normal economic and population growth. With adequate planning, all data acquisition programs could be modified to respond to needs arising from managment experience. The role of management in determining the need for future data acquisition programs in response to changing requirements through time and various phases of management is illustrated in the flow diagram of Figure 26.

11.4 Multiple Uses of Data

Programs to obtain needed data can be designed to optimize usefulness through recognition of potential uses of the data. Ground-water-level data obtained during a well inventory program, for example, would provide information on the configuration of the potentiometric surface, which would be an essential input to the establishment of minimum ground-water levels. The configuration of the potentiometric surface can also be used in flow-net analysis to quantify aquifer transmissivity, a prerequisite for modeling of an aquifer system. Also, hydrologic, geologic, and other ground-water data obtained from drillers completion reports for wells for which permits to drill have been issued will provide some data useful for aquifer evaluation.

Streamflow data used to determine whether an emergency water shortage exists can also be used for statistical definition of flow recurrence, a prerequisite to quantifying surface-water availability. Programs to obtain data which are useful to several types of management functions will be the most economical. Multiple uses of data can be most readily accomplished by utilizing the computerized data bank, which provides for data synthesis and analyses by the computer.

11.5 Real-Time Data Retrieval

Many functions of the District will, sooner or later, require some real-time data on water levels, flows, rates of use and other dynamic parameters. "Real-time" simply means receipt in an office of current water conditions in the field so that management decisions can be made currently. For example, real-time information on flood stages are essential to flood evaluation and other emergency flood programs. Several techniques are used for obtaining real-time data. Direct telephone communication has proven fairly successful, as have radio transmitters. The most recent development in transmitting real-time data is the use of an orbiting satellite communications system such as ERTS-1. Data collection platforms, equipped for relaying data to a satellite, transmit hydrologic data from the field site to a central office within one hour. Although the system is in an early stage of development and improvements are continually being made, it has already demonstrated a high degree of accuracy and reliability. The planning of future monitoring networks could include consideration of real-time data retrieval by means of communications satellite.

11.6 Basic Types of Data Acquisition Programs

Data acquisition activities can be separated into two basic types: those that are concerned with quantifying (1) the physical characteristics of hydrologic systems and (2) the hydrodynamic characteristics. Physical characteristics include basin or aquifer geometry, lithology, permeability, and storage capacity of earth materials, and in some areas geochemical factors. Hydrodynamic characteristics include stream flows, water levels, evapotranspiration, and biologic communities. Hydrodynamic data are used to quantify change in input, storage, and output of water for hydrologic system or changes in biology or water quality. The physical characteristics control the rates and paths of water movement as well as the quantity of water in storage.

Physical characteristics generally remain constant whereas flows, levels, quality and rates are dynamic and constantly change. Generally, it is not possible to directly measure all the physical or hydrodynamic parameters of a system. However, most hydrodynamic parameters are controlled by and are related to the physical

FLOW DIAGRAM ILLUSTRATING THE RELATION
BETWEEN DATA ACQUISITION ACTIVITIES
AND THREE PHASES OF WATER MANAGEMENT

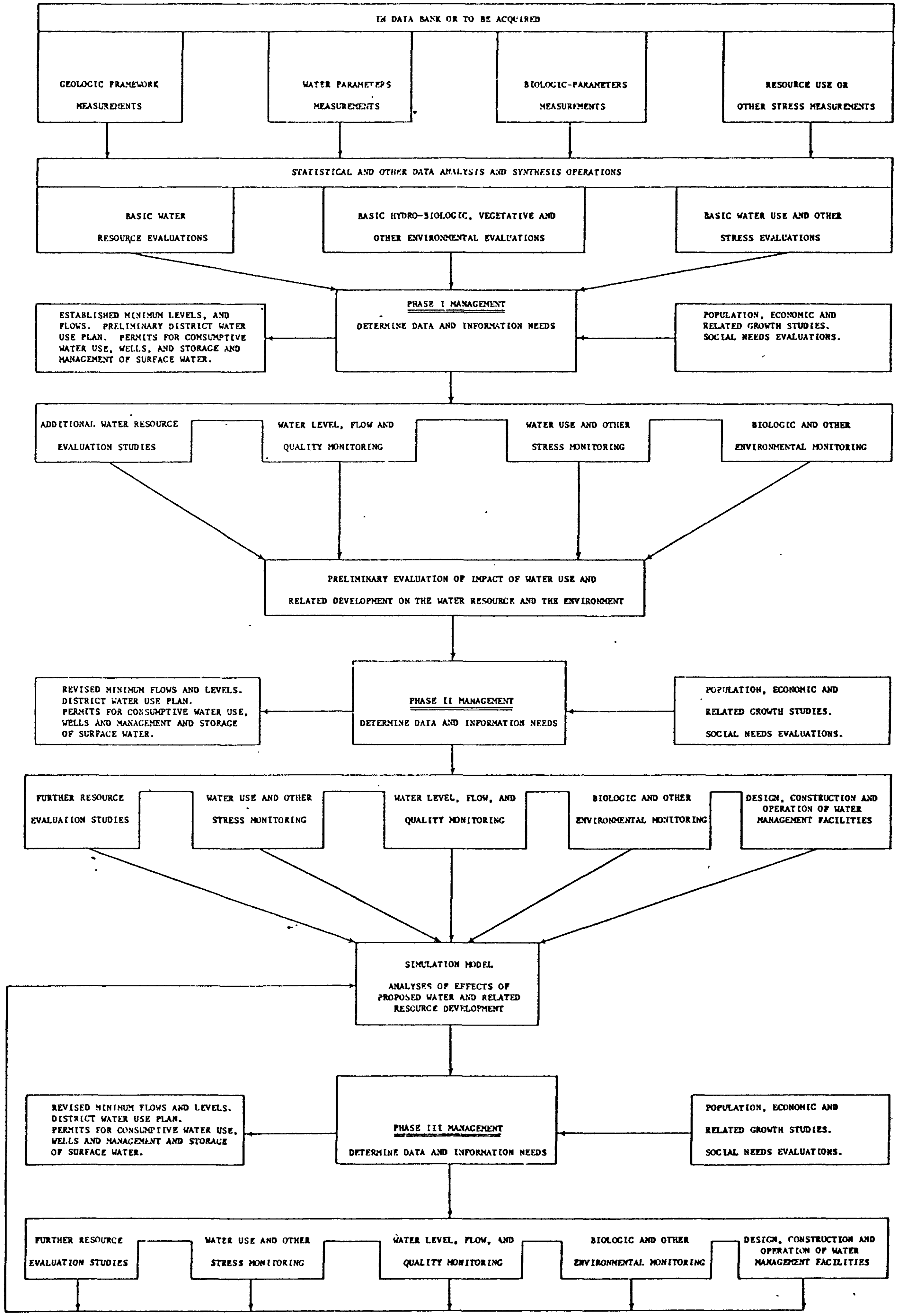

Figure 28.--Flow diagram illustrating the relation between data acquisition and three phases of management.

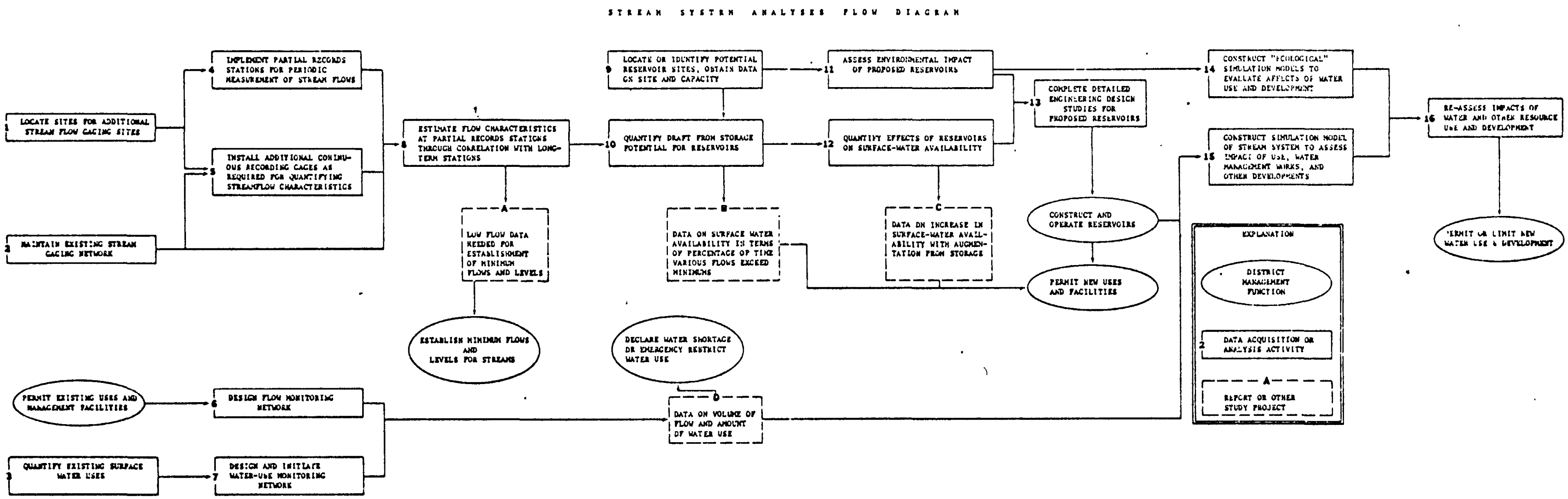

Figure 29.--Flow diagram of stream-system analysis.

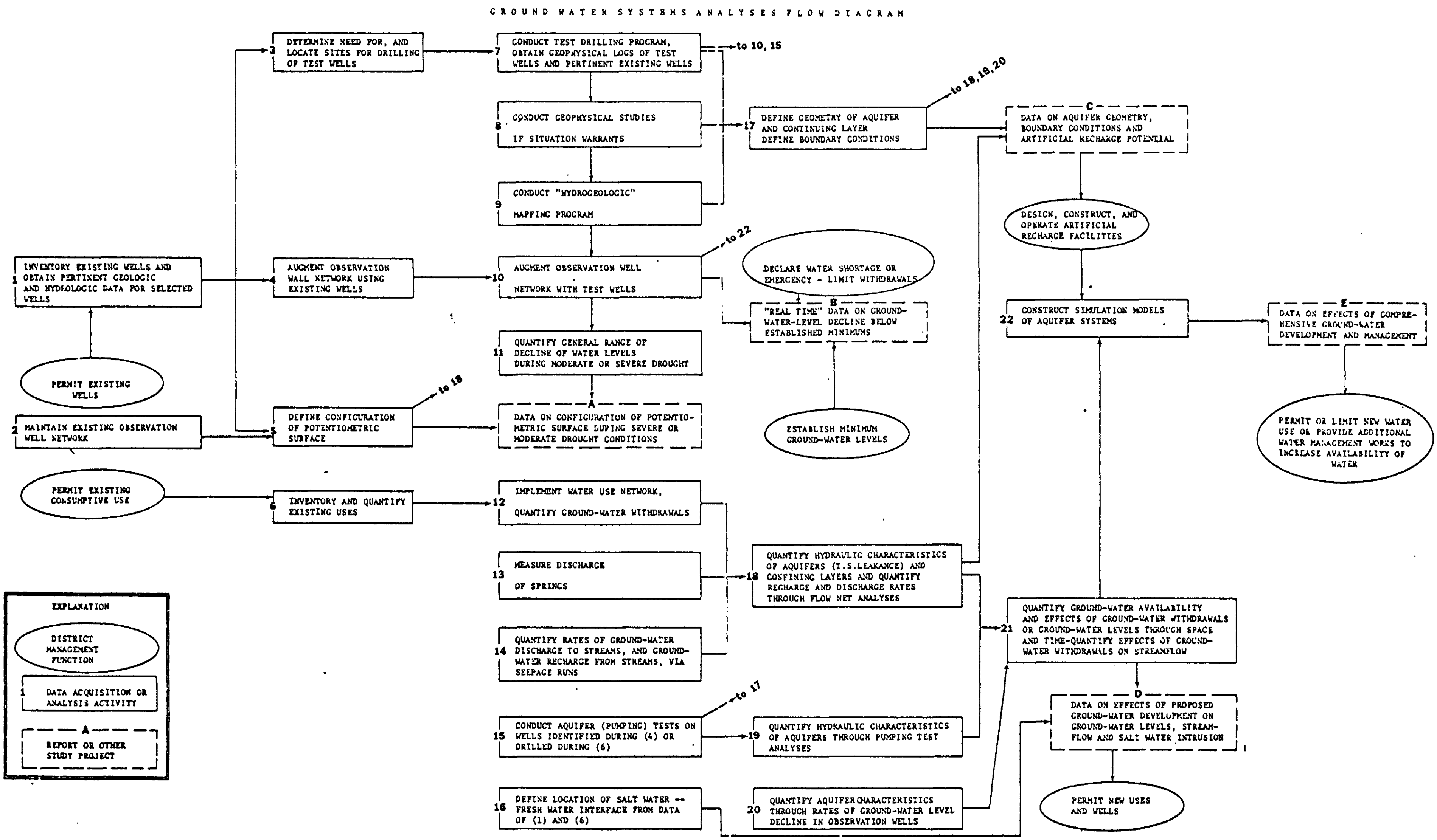

Figure 30.--Flow diagram of ground-water system analysis.

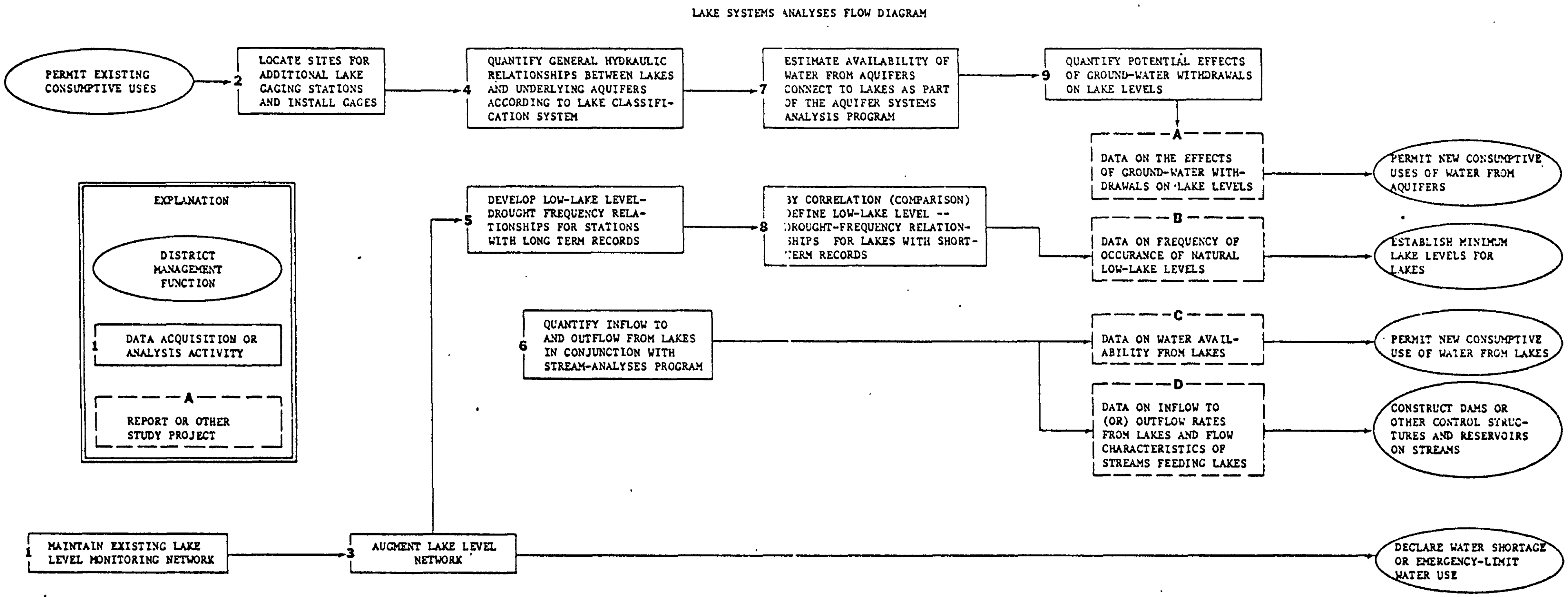

Figure 31.--Flow diagram of lake system analysis.

characteristics of the system. Thus, parameters that cannot be measured directly commonly can be quantified with reasonable accuracy if related physical parameters are known.

Use or other development of water may affect rates of flow and the quantity and quality of water in storage. Effective water management requires continuing evaluation of the potential effects of proposed uses, or other developments, on flows, levels and quality. To evaluate potential effects the physical and hydrodynamic parameters of the system need to be quantified.

Generally, data on physical parameters are obtained by areal studies, whereas hydrodynamic parameter data are usually obtained by data collection networks. However, many areal studies include short-term hydrodynamic data networks. An assessment of cause and effect relationships of proposed water development requires data on physical characteristics as well as on changes in dynamic conditions from natural phenomena and (or) the stresses imposed on the system by man.

12. FUTURE DATA ACQUISITION

Future data-acquisition programs in the District should be scheduled to reflect priorities as the needs arise for data required for implementation of various management functions. For administrative purposes, needs for data can be placed in three priority categories: immediate needs, intermediate needs, and long-range needs. The degree of priority for these three categories of data acquisition is relative for different areas of the District, being dependent on development and attendant stress on the water resource in various areas. As an example, an intermediate need for data acquisition in a highly developed area might need to be scheduled closely after or even concurrent with the immediate needs for data acquisition; whereas, in a less developed area, pursuit of intermediate needs for data acquisition could proceed at a less pressing pace.

Immediate needs relate principally to the permit-issuing functions and the establishment of minimum flows and levels. Intermediate needs relate to studies to be the basis for the formulation of a water-use plan including studies of water availability, means and methods of conserving water, and to future uses and needs for water. Such studies should provide much of the data needed for general water resources managment. Long-range needs relate to the accumulation of data and information needed to accurately assess cause and effect relations. Long-range studies generally will be extensions of repetitive data collection networks and areal investigations initiated under immediate and intermediate programs.

12.1 Investigations to Meet Immediate Needs for Data

Certain types of data will be required by the District immediately, in order to implement the following District functions:

1. Issuing permits for new consumptive uses of water.
2. Issuing permits for drilling and regulation of water wells.
3. Issuing permits for management and storage of surface water.
4. Establishing minimum flows of streams.
5. Establishing minimum levels for lakes.
6. Establishing minimum ground-water levels.

The investigations that would be required to supply information needed as a basis for implementation of each of these functions are described in detail in the following sections of the report.

12.11 Issuing Permits for New Consumptive Uses of Water

Investigations that form a basis for issuing permits for new consumptive use require quantifying existing uses, making preliminary assessments of water availability, and identifying areas where important new uses could adversely affect the water resources and the ecology. This will involve a relatively complete inventory of water use, other than use for individual domestic supply. Such an inventory would be expedited through the issuance of permits for existing uses. Application forms submitted by existing users, if properly designed, and used as a basis for decisions or whether or not to issue permits, would provide data on the sources of water used, and type of use. A water-use inventory would provide data needed to help determine that new uses do not conflict with existing uses or that the combined effect of existing and new uses is not harmful to the environment or the water resource. The water-use inventory could also provide data needed for augmenting the existing water-use network.

Preliminary assessments of water availability can be made from existing water resources reports, and from other well-yield and streamflow characteristics data. Initiation of these as soon as possible would provide such water availability information—especially if emphasis were given to areas of existing large water use because most problems caused by additional consumptive use probably will be in these areas. Additional uses in such areas could prove harmful to the water resource or could interfere with existing uses.

Preparation of generalized water budgets would expedite preliminary estimates of water availability suitable as a basis for permitting new water uses at the Phase I management level. Such budgets would involve computation of all inflow into and all outflow from various drainage basins. Generalized water-budget studies of "Immediate" status would become the basis for more detailed budget investigations needed for phase II management.

12.12 Issuing Permits for Drilling and Regulation of Water Wells

The well-permit function will be concerned primarily with determining whether a proposed well will be harmful to the water resources or the environment, either through an excessive lowering of ground-water levels or through contamination of the water in the aquifer. Compiling available information on maps would expedite evaluation of the impact of a proposed well on the hydrologic system.

Following are types of information amenable to compilation: (1) the approximate depth to the base of fresh water, which will provide a depth limit for fresh-water wells; (2) the location of the fresh-salt-water interface which will affect the location and withdrawal rates of proposed wells; (3) the location of areas where water levels have been lowered appreciably by withdrawals from existing wells; (4) the location of springs, streams, and lakes whose levels or flows would be greatly affected by additional large withdrawals of ground water from nearby wells; and (5) the location of abandoned or poorly maintained wells that provide avenues for the migration of salt water into fresh water zones.

A continuing inventory of wells also is essential as a basis for issuing permits for construction of new wells. Permits for existing and new water uses and new wells could provide a means to identify most existing and all new non-domestic wells. Proper permit and application-form design would expedite such identification. To be most useful the permits could provide a description of the location of wells, quantity of water used, and other pertinent data on well design and construction such as anticipated depth, and diameter.

12.13 Issuing Permits for Management and Storage of Surface Water

To permit storing water in impoundments and diverting water from one basin to another will require information on the availability and effect of storage or diversion of water; the topography of the impoundments or diversion site; and the hydrogeology of the impoundment site or area where water is to be diverted.

Investigations to define the availability of water for storage in small stream basins will require the establishment of additional stations for periodic measurement of streamflows. Availability of water for storage would be a part of general streamflow studies needed to evaluate general water availability, flood characteristics, and to establish a correlation between rainfall and runoff.

The availability of water for storage in impoundments is best expressed as draft-storage relations, which can be computed on a regional basis. Although regional draft-storage analyses—as part of an immediate investigations program—probably are not adequate for final design of reservoirs they are of particular importance in that they would provide an estimate of the availability of water for storage and for evaluating stream flows under managed conditions.

The storage of a reservoir is affected by the quantity of water that seeps into the sediments surrounding the reservoir. For that reason an evaluation of the potential effects of ground-water (bank) storage on reservoir management is an integral part of the hydrogeologic studies required to assess the suitability of proposed reservoir sites.

12.14 Establishing Minimum Flows of Streams

The establishment of legal minimum flows of streams will require data on natural low-flow characteristics, which are best expressed in terms of frequency of low flow, 7-day Q10 for example. Seven-day Q-10 can be defined with reasonable accuracy at stations with at least 10 years of record (Figure 15) computation of low-flow frequencies data through correlation with flow records from long-term stations is important to the effectiveness of an immediate investigations program.

In addition to the low-flow data from existing gaging stations, the proposed additions to the stream gaging network as shown on Figure 14 will materially increase the number of streams where minimum flows can be established on the basis of low-flow frequency information obtained through correlation analyses.

Natural low-flow data on ungaged streams also could be obtained through mass measurement of flows at miscellaneous sites. Such measurements can be correlated with records from long-term stations to provide reasonably accurate estimates of low-flow frequencies. Miscellaneous measurements have been made at several hundred sites as a part of previous investigations in the District. These sites provide a basic network for a mass measurement program.

Regional estimates of low-flow characteristics of streams can be made utilizing existing data in the District. Such regional analysis, however, may not identify small streams with anomalous flow characteristics owing to the large base of low-flow data and the regional distribution of such data. A regional study would provide data useful for establishing minimum flows. Were such a study to be started soon it would provide for immediate data needs for establishing preliminary minimum low flows.

12.15 Establishing Minimum Levels for Lakes

Establishing minimum levels for lakes will require data on natural low-levels, data not available for most of the lakes in the District. Investigations started to acquire data on natural low levels will require some augmentation of the basic lake-level network as indicated in Figure 18. Data from short-term lake-level measurement programs on lakes not included in the basic network can be correlated with the data obtained from the basic network to provide level data needed for establishment of minimum lake levels.

12.16 Establishing Minimum Ground-Water Levels

The primary data needed for establishing minimum ground water levels are information on natural low-ground-water levels, the potential effects of ground-water withdrawals on ground-water and surface-water levels, and the hydraulic connection between streams and aquifers.

To acquire the needed data, immediate investigations can best be concerned with defining natural low-ground-water levels in terms of frequency of recurrence. Existing data on well yields and drawdown, aquifer characteristics, and stream-aquifer relations probably are suitable for establishing, on a preliminary basis, minimum ground-water levels. Studies to acquire additional data on the effects of ground-water withdrawals on water levels and on the hydraulic connection between aquifers and streams would best be completed as part of an intermediate study program.

Natural low-ground-water levels can be defined for most of the wells in the present ground-water observation well network (Figure 17). Adding observation wells to the network as indicated in Figure 18 would facilitate the establishment of minimum ground-water levels over the long term.

12.2 Investigations to Meet Intermediate Needs for Data

In the following discussion of investigations that will fulfil intermediate needs for data, the relative priority of need is considered equal throughout the District, unless otherwise noted.

Intermediate needs for data relate to quantifying water availability, evaluating the potential for augmenting and conserving water supplies, and to other studies mandated as the basis for the formulation of a water-use plan. Most of these investigations would be conducted with optimum efficiency on a drainage "basin" basis; others, on a regional basis. Figure 32 shows drainage basins that should provide for efficient areal evaluations of hydrologic systems. Individual counties are also suited to areal investigations. The investigations could be designed to provide the following kinds of data.

12.21 Water Availability

Total water availability is best defined on the basis of a detailed water budget; however, for management purposes, the evaluation is best expressed in terms of surface-water availability and ground-water availability. The relation of surface water to ground water can be defined through water-budget analyses. Management works, such as storage reservoirs, will alter the short-term water availability by increasing the availability of water during droughts.

12.211 <u>Surface Water Availability</u>—Investigations to define surface-water availability will involve expansion of the stream gaging network (Figure 16) and the extension of data from the existing network through analytic and correlation techniques to define flow characteristics of streams for which little factual flow data exist. Analysis of stream-flow data to quantify water availability would best be accomplished as basin studies, as a result of which, surface-water-availability can be defined in terms of peak flows, mean flow, and rainfall-runoff relations as well as statistical flow data.

12.212 Ground Water Availability—Of the several types of investigations that will lead to a quantification of ground-water availability, those that will provide a definition of the following parameters will be particularly useful:

(1) Aquifer geometry
(2) The geometry of sediments and surfaces constituting aquifer boundaries.
(3) Hydraulic conductivities and storage capacities of aquifers and boundary layers.
(4) Natural or existing rates of water flow into (recharge) and out of (discharge) the aquifer system.
(5) Availability of water from streams hydraulically connected to aquifers.
(6) Quality of water in the aquifer and in sediments or surface water bodies connected to the aquifer.
(7) Potential for artifically recharging aquifers.

Investigations to define the geometry and hydraulic characteristics of aquifers and associated boundary sediments involve studies of surficial geology, and of subsurface geology through use of data gained from wells including geophysical logs of wells. Investigations to determine hydraulic conductivities involve pumping tests, analysis of ground-water flow patterns, evaluation of water-level declines in observation wells, and laboratory analyses of sediments. Studies to define water quality will primarily involve sampling of water from various zones in aquifers via wells and springs.

A review of the above types of studies indicates clearly that quantification of ground-water availability is highly dependent upon obtaining data from wells, much of which can best be obtained during the well-drilling process. Although test drilling will be an integral part of studies to quantify ground-water availability, the need for test drilling can be reduced if data are also collected during the drilling of new wells permitted under the Water Resources Act. Thus, optimum efficiency in studies to quantify ground-water availability could result from coordination of the District's well-permit function with ground-water availability studies.

Ground-water availability studies including an inventory of existing non-domestic wells, would be expedited by the data made available through the water-use permitting function. Data from such an inventory in conjunction with the proposed observation well network, water use inventory, stream flow measurements, and the program to obtain data as wells are drilled would provide for the most accurate assessment of ground-water availability at lowest cost.

Both surface water and ground-water availability studies are best conducted with the drainage basin or basins rather than the county as the study unit. Data obtained during such studies are directly applicable to basin water budget studies. Water availability studies have generally equal priority throughout the District except for Flagler and Brevard Counties. In these two counties giving water availability studies high priority is of special importance because surface-water sources and shallow aquifers provide only small supplies and the Floridan aquifer generally does not yield fresh water.

12.213 Water Budgets—Detailed water-budget investigations are a primary input to defining water availability. Water budgets will be most useful if prepared for the drainage basins shown on Figure 32 rather than for county units. Budgets of wet and dry periods, which will reveal the seasonal variation in rates of runoff to the ocean as well as seasonal changes in quantity of water in storage, will provide a means of evaluating potential increases in water availability through water-management works.

The generalized water budgets completed under the immediate investigations program would provide basic information needed for the design of detailed budget studies.

12.22 Conservation and Augmentation of Water

Investigations to assess potential means and methods for conserving and augmenting water will be enhanced in value if the investigations are implemented by relating them to the physical characteristics of the various drainage basins. Table 13 lists types of water conservation and augmentation facilities that can potentially be utilized, and the topographic, hydrologic and geologic factors required.

Studies to define the potential for augmenting or conserving water through construction and operation of various water management facilities should include assessment of the impact on the local environment. Some water conservation practices, for example, could result in a decrease in

Table 13.—Water conservation and augmentation facilities and required topographic, geologic and hydrologic conditions.

Types of water conservation and augmentation facilities	Required topographic, geologic and hydrologic conditions
I. Surface storage impoundments.	1. Incised stream valleys 2. Impermeable or lowly permeable soils, and subsoils. 3. Non-cavernous underlying bedrock. 4. Suitable dam site (a) Adequate bearing strength. (b) Relatively short dam length. (c) Impermeable strata or lowly permeable strata. (d) Adequate volume for impoundment. 5. Streams suitable for coastal flood control structures. 6. Flat area suitable to impoundment by dikes. 7. Sufficiently large watershed. 8. Adequate excess flow.
II. Artificial recharge pits and infiltration galleries.	1. Relatively flat areas adjacent to streams. 2. Permeable soils and subsoils. 3. Permeable aquifers with their potentiometric surface below stream level. 4. Absence of confining layer or confining layer at depth shallow enough for excavation. 5. Excess streamflow of relatively good quality.
III. Recharge Wells for injection of excess surface water into fresh-water aquifers.	1. Permeable aquifer. 2. Excess streamflow. 3. Water low in sediment, nutrients, dissolved gases, and contaminants.
IV. Connector Wells that permit water to move from shallow aquifers to deeper aquifers.	1. Permeable shallow aquifer with high water table and recharge rates. 2. Permeable deep aquifer with potentiometric surface below the water table of the shallow aquifer. 3. Water of good quality in the shallow aquifer.
V. Injection Wells for injection and storage of fresh water in saline water zone.	1. Permeable confined saline water aquifer. 2. Excess water of good quality.
VI. Wells for injection of fresh or slightly brackish water into the fresh/salt water interface zone to control intrusion of seawater.	1. Adequate supply of fresh or slightly brackish water.
VII. Spray or "land spreading" disposal of liquid wastes.	1. Relatively flat surface. 2. Permeable soils and subsoil. 3. Adequate thickness of unsaturated sediments. 4. Sufficient land area for volume of wastes to be disposed and for "buffer" zone.

the quantity of fresh water discharged to the estuarine zones along the coast which could have serious impact on marine life.

Projects to conserve and augment water may involve: (1) storage of excess water during wet periods and release of the stored water during dry periods, (2) artificial recharge of aquifers with surface water; and (3) aquifer recharge by another aquifer through "connector" wells. Water conservation and augmentation can also be accomplished through methods which salvage water normally lost be evapotranspiration; by reducing contamination; through injection of waste water into aquifers; or by water reuse.

The particular types of water management programs or projects that potentially can be implemented in the District are controlled by the topographic, geologic, and hydrologic characteristics of each basin. These vary considerably from one basin to another. For example, the previously mentioned recharging of the Floridan Aquifer with water from the sand-and-gravel aquifer can operate only under specific geologic-hydrologic conditions that exist in a few of the basins of the District.

12.23 Flooding and Drainage

Areas prone to flooding on the average of once every 100 years have been delineated for much of the District. The planning of impoundments, levees, dikes, canals, and other flood control facilities, as well as the design of roads, culverts and bridges requires detailed information on the frequency and magnitude of floods that is not available from the flood-prone area maps. A flood studies program is generally related to the streamflow measurement program. If flood index stations for flood forecasting are included in the program, such stations would provide data, on a "real-time" basis, on river stage, rate of rise, and rainfall intensity. These data are needed to predict time and magnitude of peak flood flows.

Studies to quantify changes in runoff characteristics resulting from construction of streets, parking lots, roofs, and other impermeable areas are important segments of a flood studies program, because the increased runoff resulting from a decrease in permeable surfaces can markedly increase flooding. Such increases result in the need for larger storm sewers, culverts, and for channel improvements in local natural drains. It is advisable to start studies to obtain information pertinent to the effects of drainage projects on the water resources before any urban and agricultural developments are undertaken.

Data obtained from a program of flood studies would be necessary for the preparation of a master-drainage plan for the District.

12.24 Water Quality

Although water-quality studies are not identified in the 1972 Act as necessary to the formulation of a water-use plan, such studies are authorized by the 1972 Act. Water quality does influence water use. Areal water-quality investigations could be concerned to a large extent with characteristics of drainage basins that control or affect water quality.

An extensive program of sampling of rainfall as well as water from wells, streams and lakes for chemical and biological constituents and for sediment content and color is essential to an effective water-quality study; water-quality characteristics significantly affect water use.

Geochemical studies if included, will define sources of dissolved mineral matter, including the occurrence of saline ground water. Studies to quantify waste assimilation capacities of streams and the ion-exchange and absorption potentials of sediments in and overlying aquifer systems, may be required to properly plan for waste disposal and for water use.

Including monitoring programs with water-quality studies will permit assessment of the effects of water use on water quality with time, particularly if these programs are coordinated with those of other agencies.

Augmentation of the water-quality network (Figure 22) will provide for defining the effects of water uses on water quality.

Directly related to water-quality studies are time-of-travel studies, which provide information on the time required for a "slug" of water to move down a stream. Time-of-travel data are especially important if dangerous contaminants are accidentally spilled into streams.

The effects of "drainage" wells on the quality of water in the Florida Aquifer are of particular interest in several areas of the District. These wells are used for the disposal of storm runoff and related wastes in urban areas that are internally drained, such as Orlando and Ocala. The runoff and wastes flow by gravity down the wells into the upper zones of the Floridan aquifer. The effects of such disposal on the quality of the water in the Floridan aquifer could become an important part of future water-quality studies in the District.

12.3 Long-Range Investigations

An important concern of long-range investigations is the assessment of the effects of proposed water uses or other development. Cause-and-effect investigations of complex hydrologic systems require a large data input and the data are best analyzed through the use of simulation models. Relating the long-range investigations largely to obtaining the information needed for the design, fashioning, and calibration of simulation models will expedite such analysis. Much of the data required for defining cause and effect relation through simulation modeling will be acquired as a part of the immediate and intermediate studies already outlined. However, planning of long-range data acquisition programs to acquire data needed for simulation models should also relate to water use and development problems as they evolve through time.

12.4 Synopsis of a Future Data-Acquisition Program

The separate studies to acquire data as described above constitute an overall program of hydrologic investigations that can be sequentially initiated to meet immediate, intermediate and long-range goals. A generalized schedule of possible study tasks is outlined below:

A. Immediate Studies

1. Augment the existing stream gaging network to provide for monitoring of streamflow in critical or ungaged areas. This will provide for establishment of minimum flows, quantifying surface-water availability, and draft-storage relations.

2. Inventory water use, utilizing data obtained from the function that issues permits for water use to define location and areal distribution of use, sources of water, and types of use. Expand the existing water use monitoring network on the basis of need as determined from the water-use inventory.

3. Prepare generalized water budgets for basins outlined in Figure 30 to assess availability of water as an aid when issuing new water-use permits.

4. Augment the existing water-quality monitoring network on the basis of data from the water-use inventory to ensure that water supplies are not being degraded and to help identify causes of water-quality change.

5. Inventory non-domestic wells utilizing data from the water-use and well-drilling permits. The inventory records will provide data on well depths, yields, aquifer tapped, ground-water levels, and water quality.

6. Augment the observation well network utilizing information gained from the well inventory to provide density of ground-water level observation points required to establish and maintain minimum ground-water levels.

7. Augment the lake-level network to provide a basic network of "bench mark" lakes whose records can be used for estimating stage-duration curves for lakes through establishment of short-term measurement programs.

8. Define low-flow frequencies at existing gaging stations with short-term records by correlating them with records from long-term stations. The additional low-flow frequency data can be used to establish minimum flows at additional points on major streams.

9. Define natural low ground-water levels at observation wells with long-term records. This information on natural lows will be a major input to the establishment of minimum ground-water levels.

10. Define natural low levels for lakes with long-term stage records in terms of stage-duration. The information will be useful in the establishment of minimum lake levels.

11. Compile information pertinent to issuing permits to drill new wells, such as depth to salt water, existing areas of significantly lowered ground-water levels, and areas of poor-quality water, in an easily interpreted format. This compilation will provide a means of readily determining if a proposed well would be harmful to the water resources.

12. Using existing data on flow frequencies, provide preliminary estimates of surface-water availability needed for permitting new water use.

B. Intermediate Studies:

1. On the basis of existing stream-flow records and data from newly established stations (see A-1 above), define regional draft-storage data for various stream reaches.

2. Make detailed water-budget studies for the various basins of Figure 32.

3. Evaluate geologic and topographic characteristics of basins in terms of suitability for impoundments.

4. Make necessary streamflow measurements to quantify ground-water-surface-water relations.

5. Utilize ground-water-level data obtained from the observation well network and measurements of water levels in wells obtained during the well inventory (see A-5 above) to accurately define the configuration of the piezometric surface. Utilizing ground-water level contours and data on spring and ground-water discharge (see A-2 and B-4 above), construct and analyze ground-water flow nets. Flow net analyses will aid in locating ground-water divides, estimating aquifer transmissivity, and in quantifying recharge rates.

6. Define basin and channel characteristics (slope, cross sections, roughness, vegetative

types, and drainage density) of stream basins.

7. Obtain subsurface geological information through collection of well cuttings, geophysical logging and well-yield measurements during well drilling. The well permit function should provide for selection of pertinent wells.

8. Conduct test drilling programs in areas of insufficient subsurface data, including aquifer tests of the wells drilled.

9. On the basis of information gained through the investigations outlined in B-4, B-5, and B-7, define geometry, boundary characteristics of aquifer systems, including the hydraulic connection between aquifers and between aquifers and streams.

10. On the basis of water budgets and other studies, quantify evapotranspiration rates from the ground-water reservoirs as a function of the depth to the water table.

11. Quantify flow characteristics of streams in terms of flow frequencies, flow durations, and flood-flow frequencies for gaged and ungaged streams.

12. On the basis of data through investigations outlined in B-9, identify areas best suited to installation of artificial recharge facilities and connector wells. Conduct detailed site studies, including test drilling where necessary to evaluate recharge potential.

13. On the basis of laboratory analyses and on-site studies, evaluate ion exchange, adsorption and absorption capacities of surficial soils, subsoils, stream sediments, confining layers and aquifers.

14. Define suitability of areas for disposal of biodegradable liquid wastes by spray irrigation or land spreading; provide for water-quality monitoring at sites for such waste disposal.

15. Evaluate reaeration potential and other waste assimilation characteristics of streams.

16. Install water-quality observation wells to monitor the potential movement of salt-water into fresh-water aquifers.

C. Long Range Studies

1. Determine the feasibility of storing excess fresh water in deep saline-water aquifers. Using geologic studies as a basis, the investigation will allow a definition of potential zones through drilling, injection, and recovery of water.

2. On the basis of information from B-9 and B-10, design and fashion aquifer simulation models. Validate models utilizing data on water use and related ground-water level change as monitored by the observation well program.

3. On the basis of data from B-6 and B-11 design and fashion stream system simulation models; calibrate models on the basis of data obtained through streamflow and rainfall monitoring network.

4. On the basis of data from B-6 and B-15, fashion surface water quality models. Utilize data from the water-quality monitoring network to calibrate the models.

5. Utilizing data from B-9 and B-13, fashion geochemical models of aquifer systems.

6. Utilizing models of the types outlined in C-2, C-3, C-4, and C-5, assess the effects of proposed water uses or other developments on the water resources.

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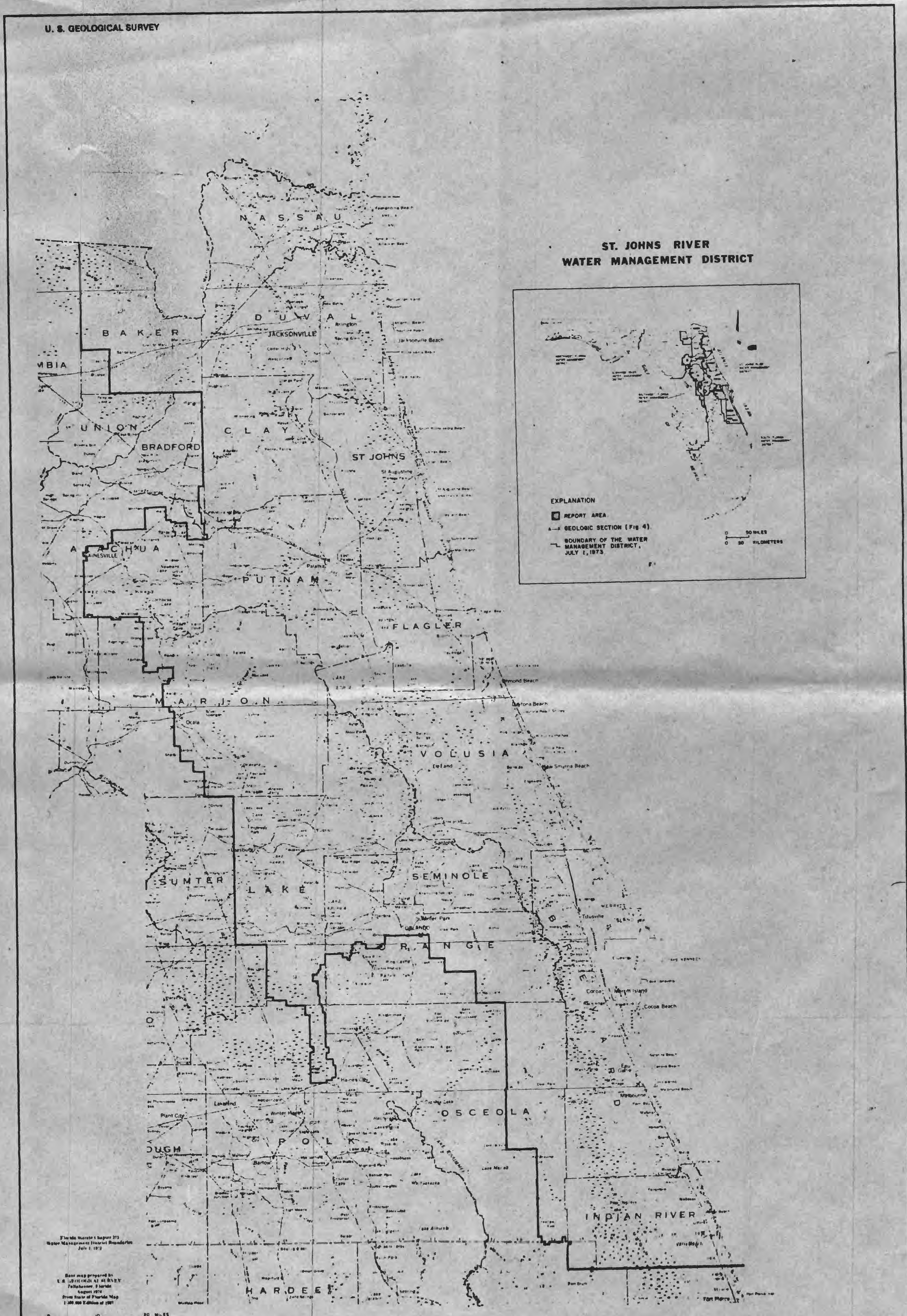

Figure 1.--Index map of water management districts in Florida.

75-44

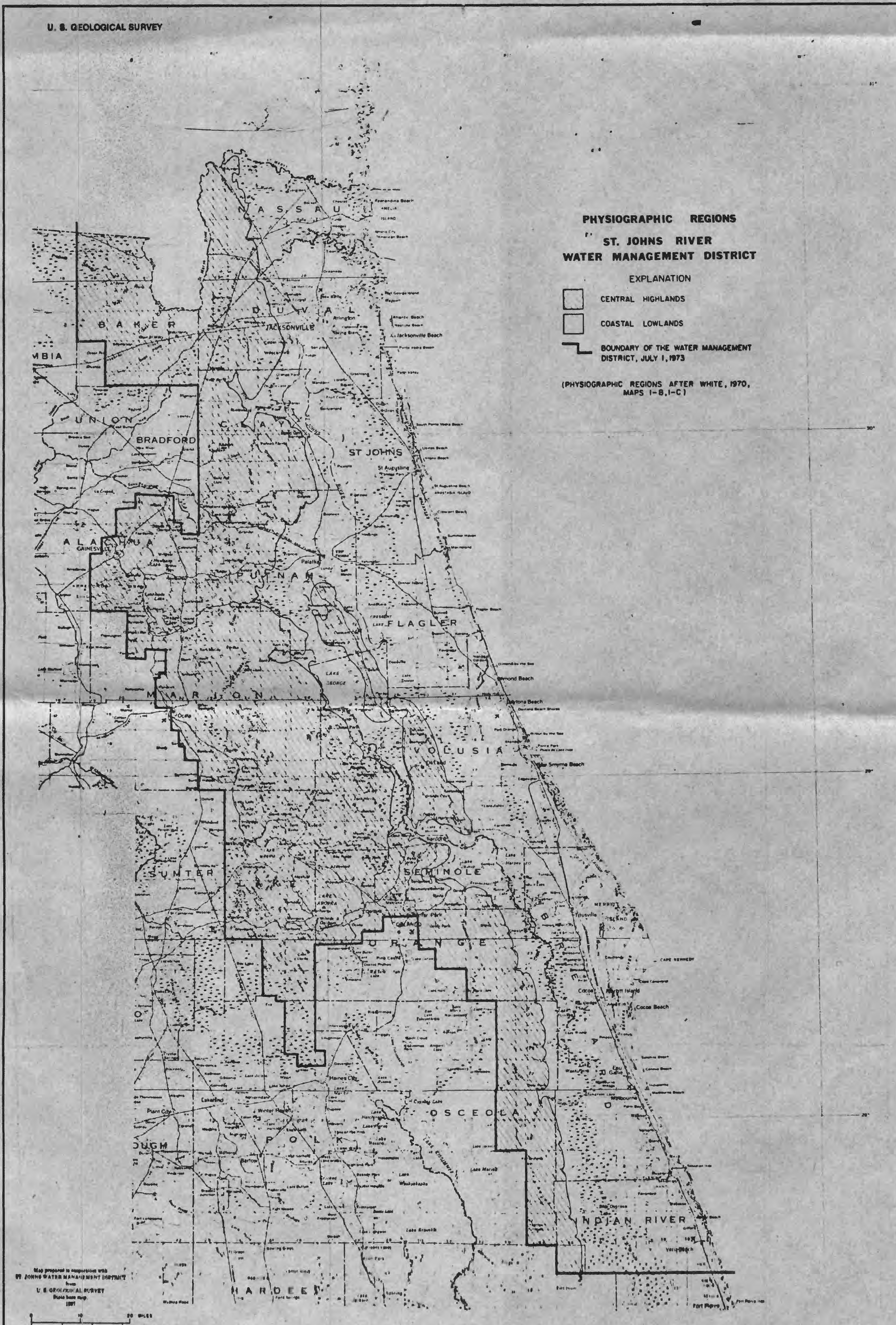

Figure 2. Physiographic regions in the St. Johns River Water Management District.

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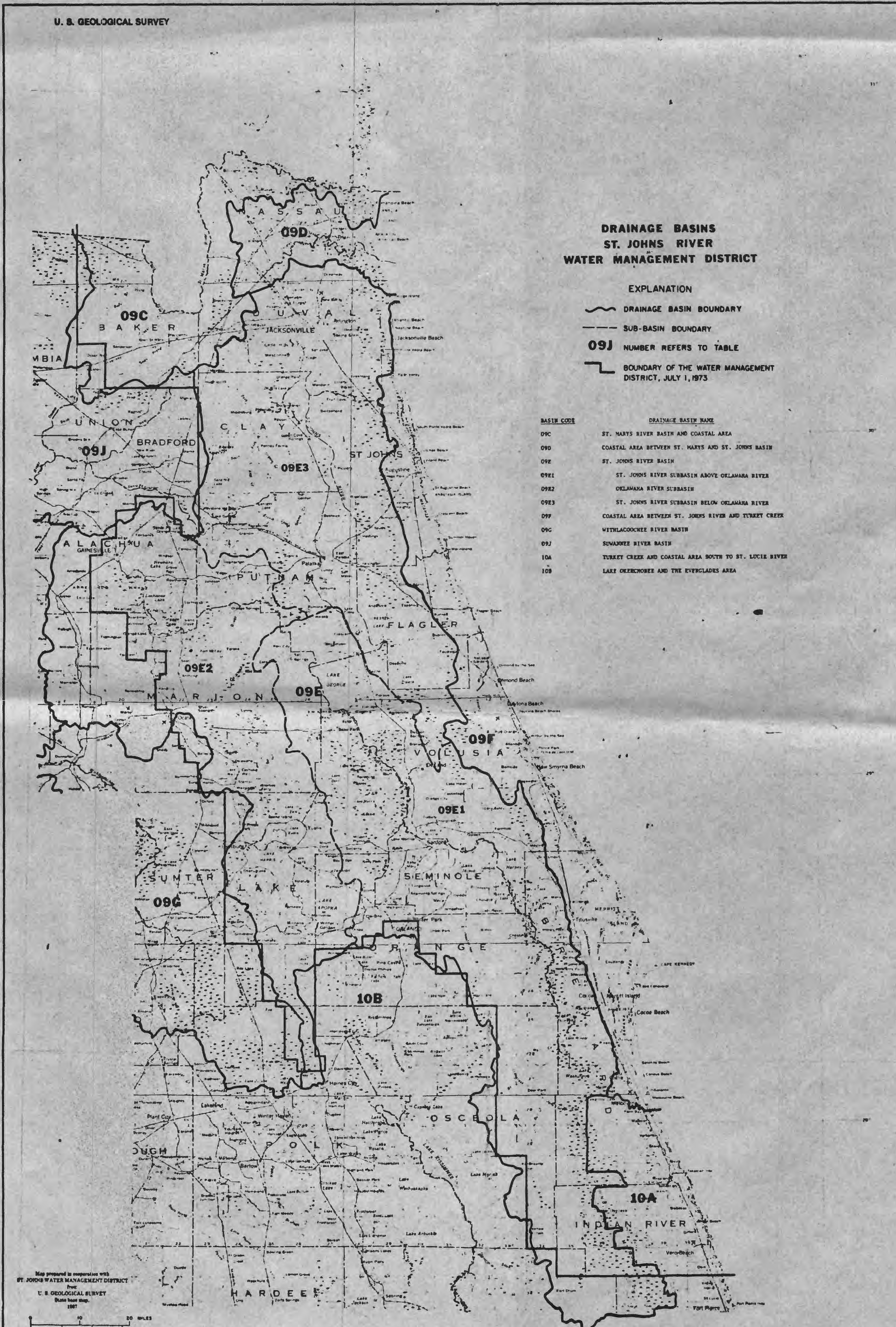

Figure 3.--Drainage basins in the District.

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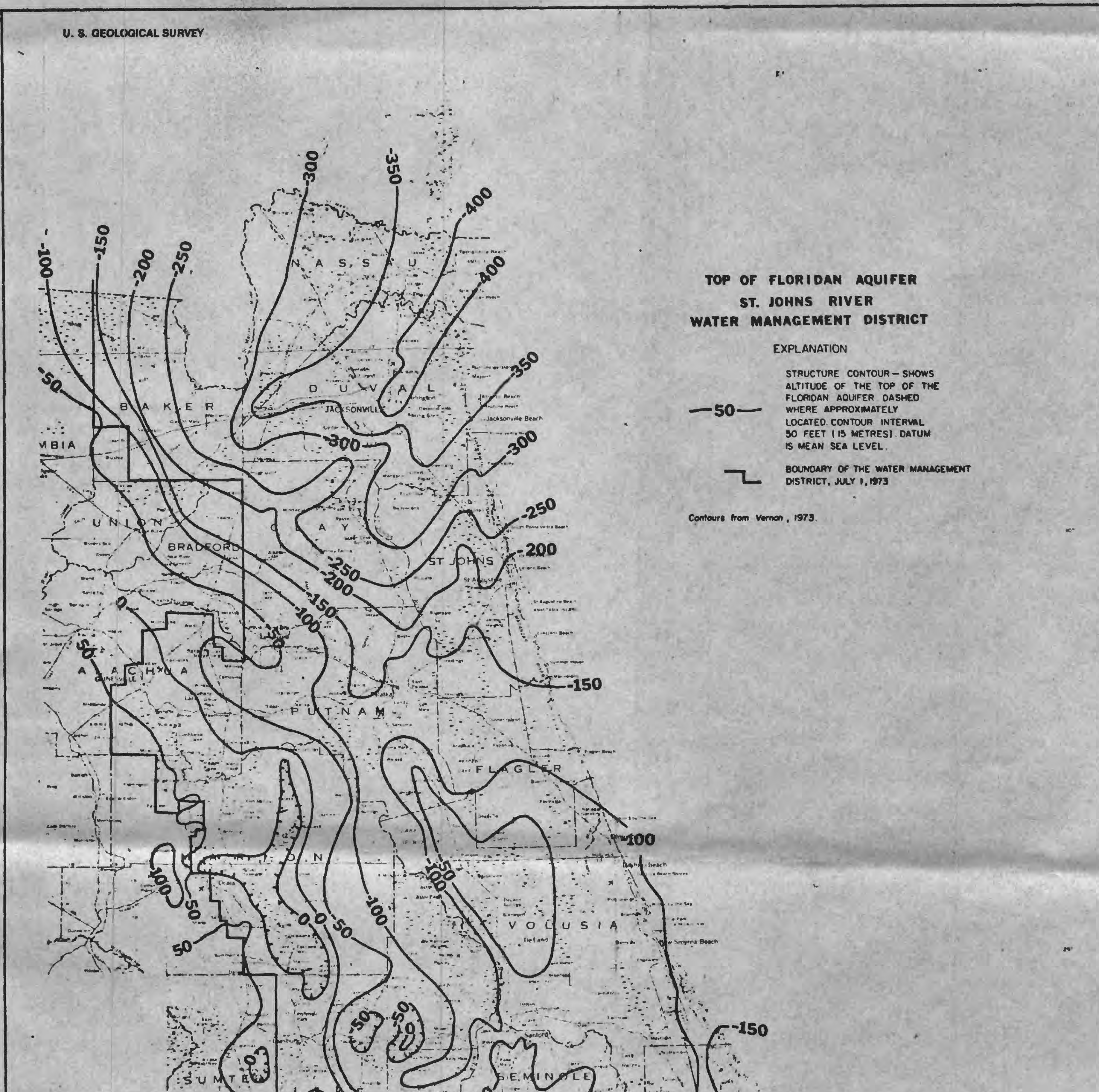

Figure 5.—Top of the Floridan aquifer.

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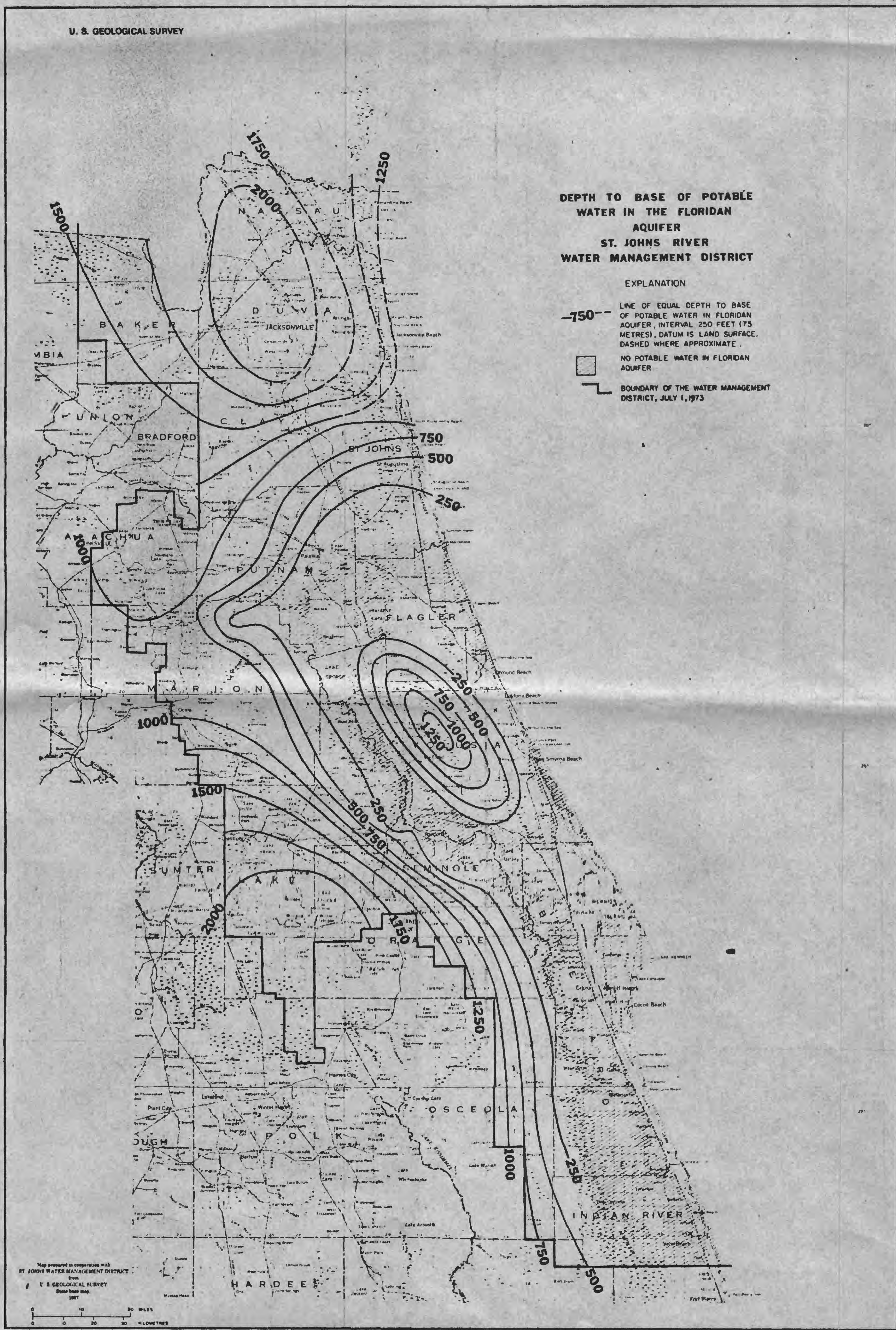

Figure 6.--Depth to base of potable water in the Floridan aquifer.

75-44

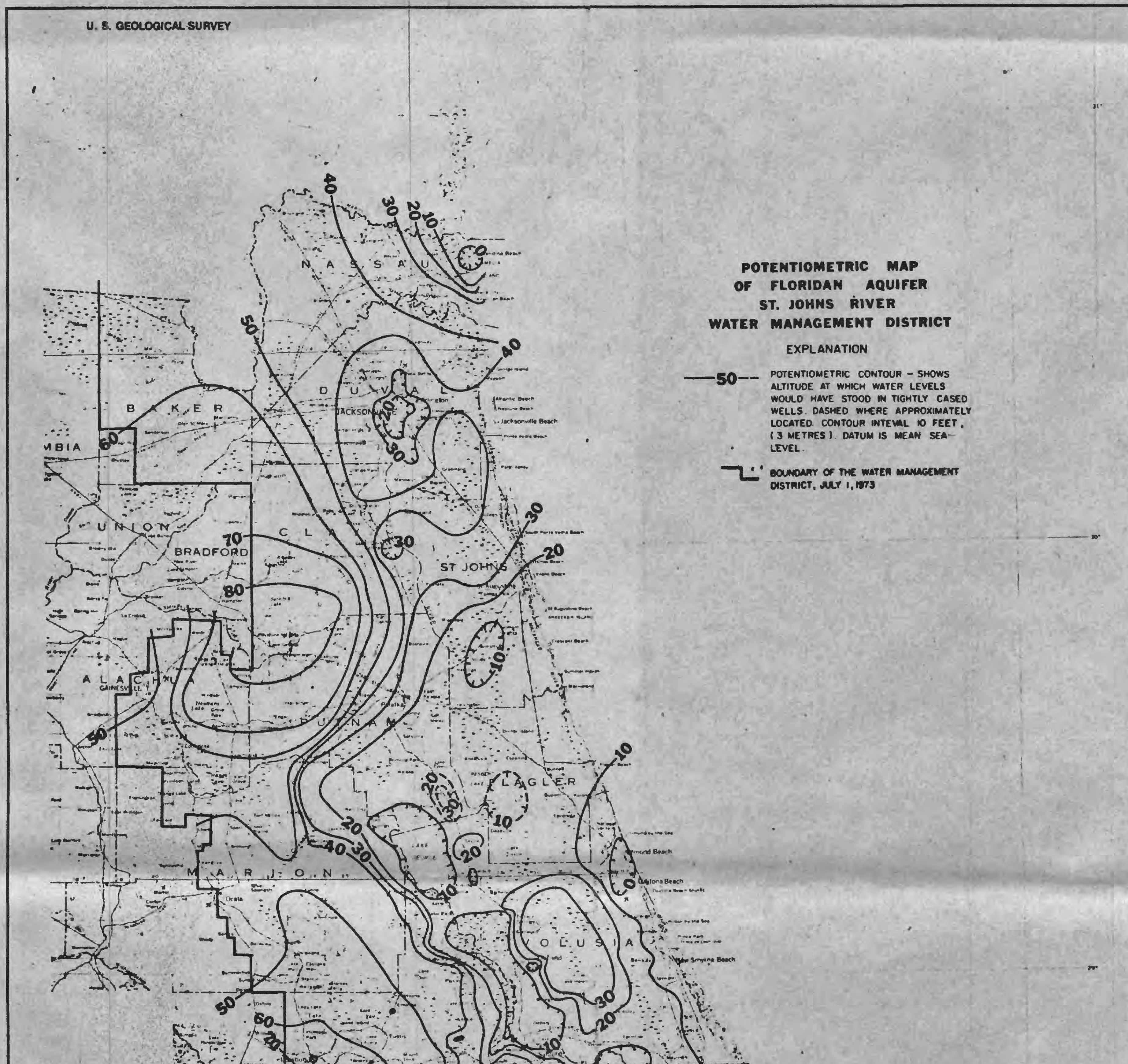

Figure 7.--Potentiometric map of the upper part of the Floridan aquifer, May, 1973.

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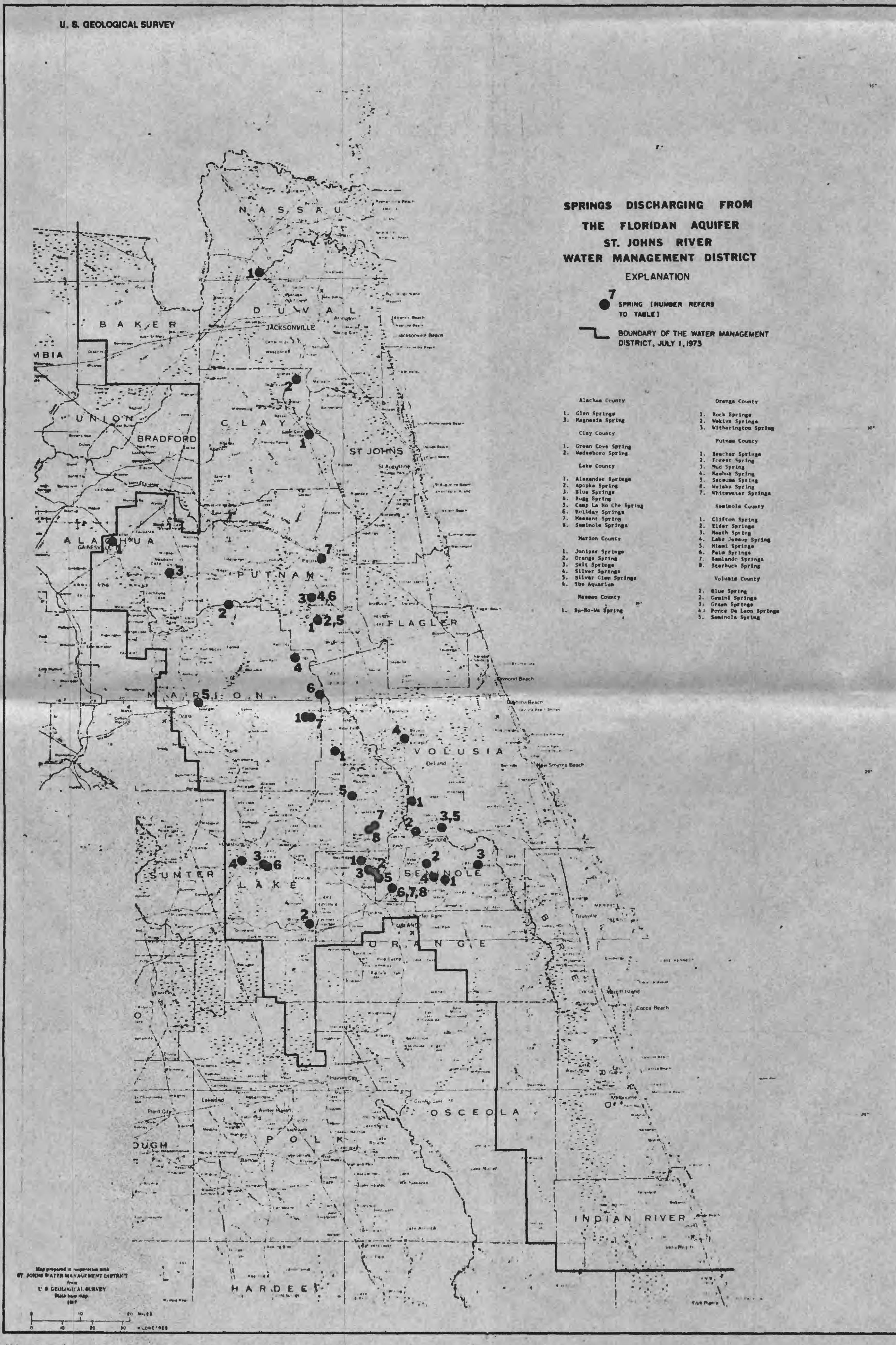

Figure 8.--Springs discharging from the Floridan aquifer.

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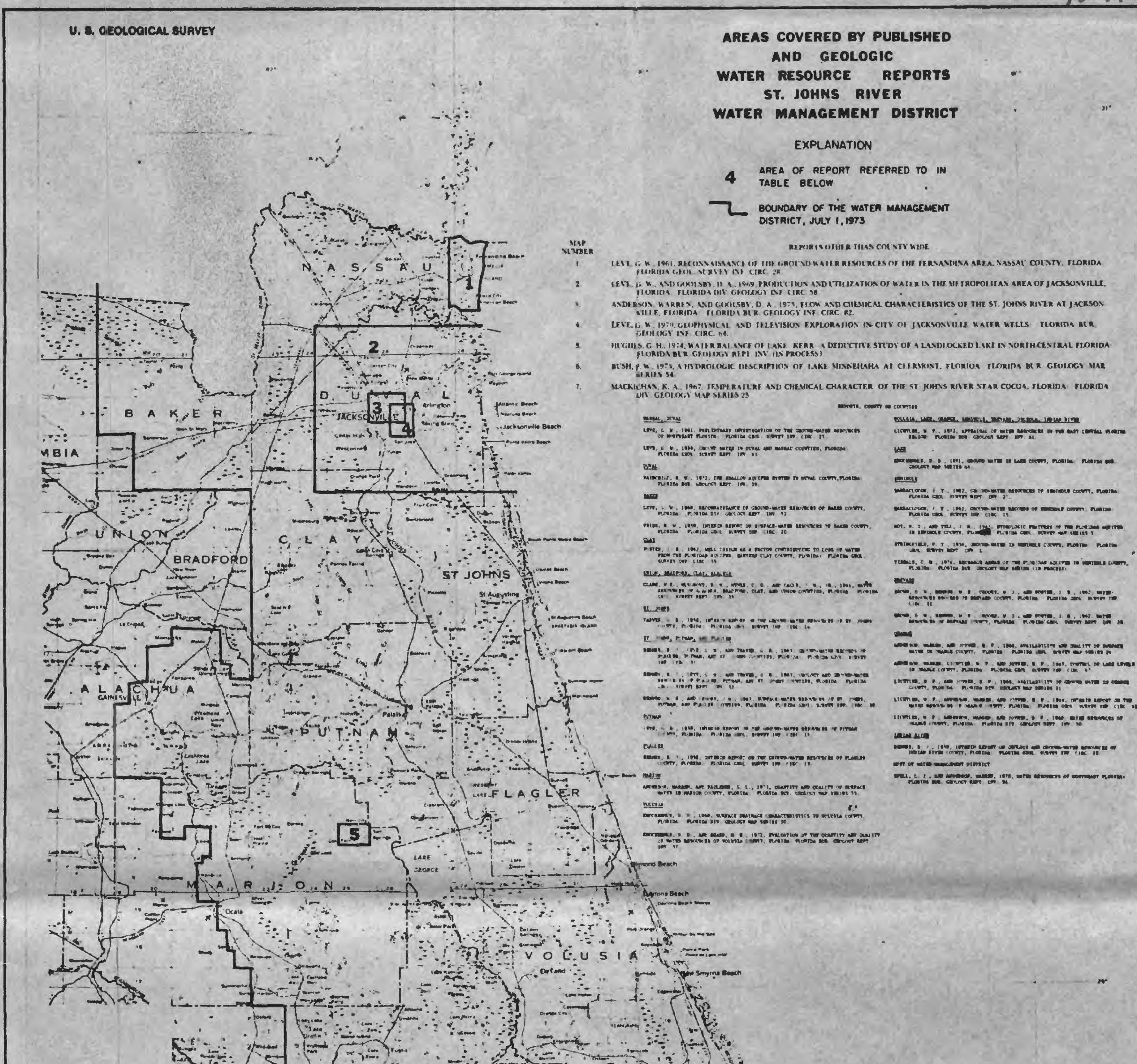

Figure 11.--Areas covered by published water-resource and geologic reports.

75-44

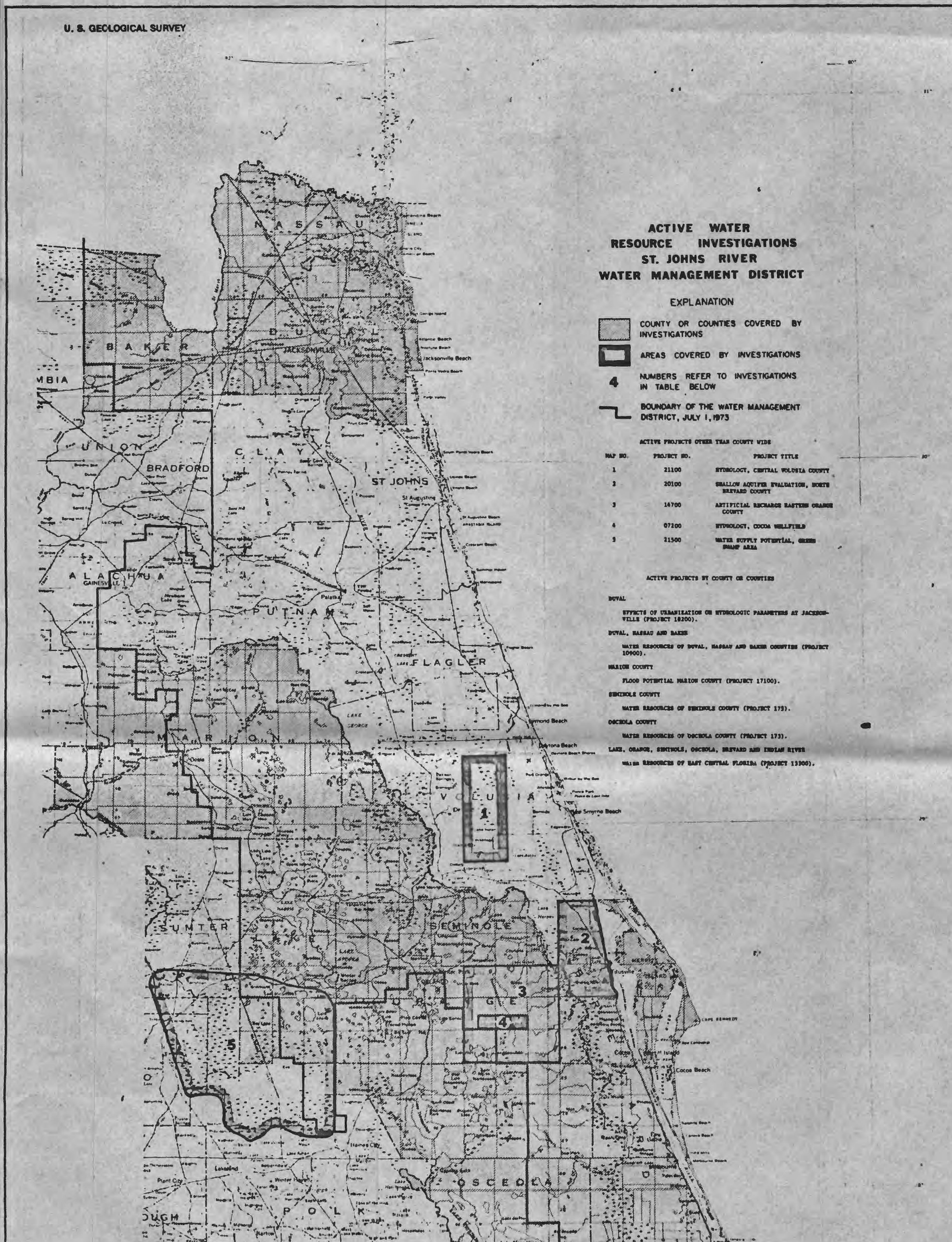

Figure 12.--Active water-resource investigations.

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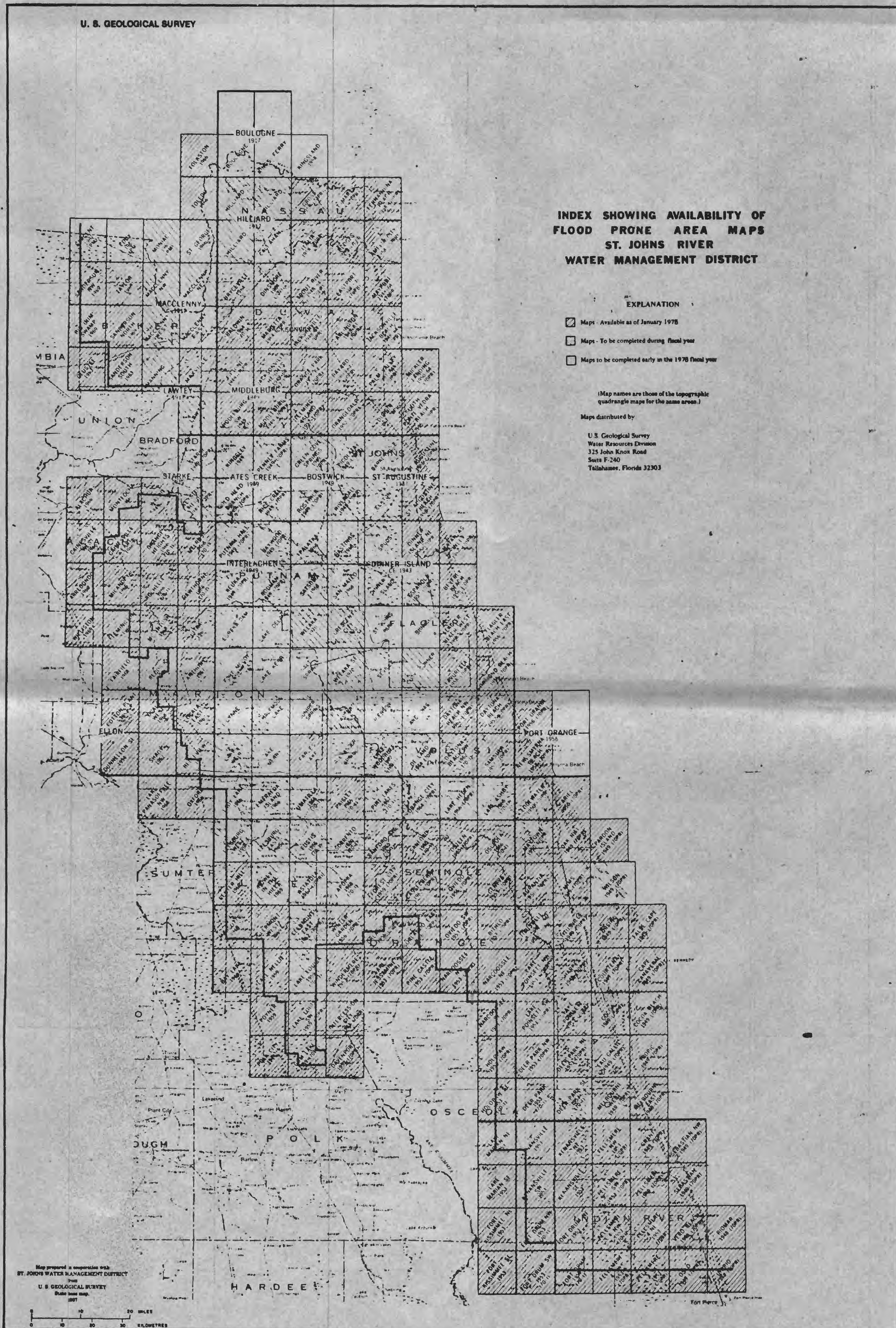
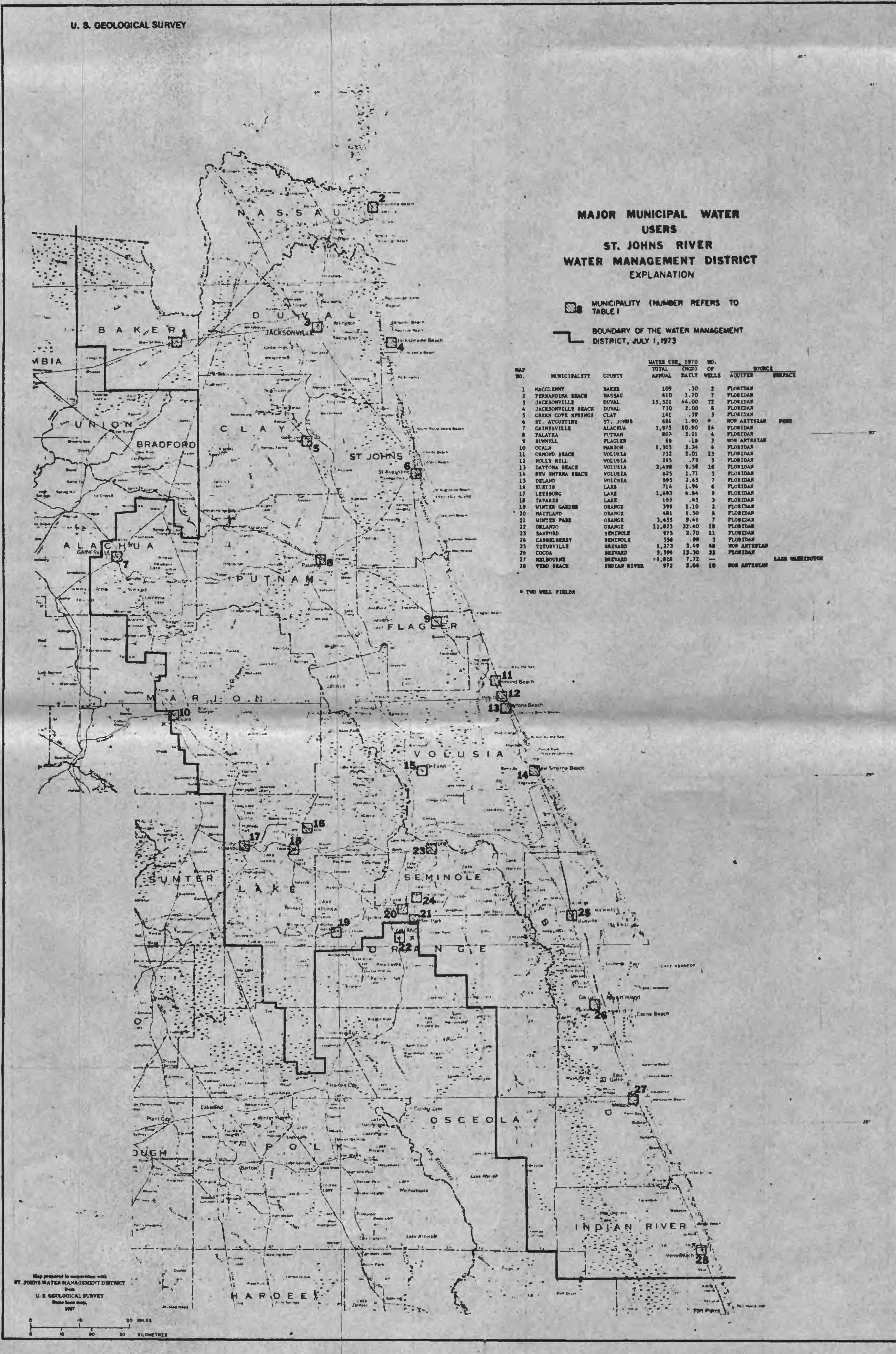


Figure 13.--Index map showing availability of flood-prone area maps.

1/5-44



MAJOR MUNICIPAL WATER USERS
ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

EXPLANATION

MUNICIPALITY (NUMBER REFERS TO TABLE)

BOUNDARY OF THE WATER MANAGEMENT DISTRICT, JULY 1, 1973

MAP NO.	MUNICIPALITY	COUNTY	WATER USE, 1970 TOTAL ANNUAL	(MGD) DAILY	NO. OF WELLS	SOURCE AQUIFER	SURFACE
1	MACCLENNY	BAKER	109	.30	2	FLORIDAN	
2	FERNANDINA BEACH	NASSAU	610	1.70	7	FLORIDAN	
3	JACKSONVILLE	DUVAL	15,521	44.00	72	FLORIDAN	
4	JACKSONVILLE BEACH	DUVAL	730	2.00	6	FLORIDAN	
5	GREEN COVE SPRINGS	CLAY	141	.39	3	FLORIDAN	
6	ST. AUGUSTINE	ST. JOHNS	694	1.90	*	NON ARTESIAN	POND
7	GAINESVILLE	ALACHUA	3,975	10.90	14	FLORIDAN	
8	PALATKA	PUTNAM	807	2.21	4	FLORIDAN	
9	BUNNELL	FLAGLER	66	.18	3	NON ARTESIAN	
10	OCALA	MARION	1,305	3.34	4	FLORIDAN	
11	ORMOND BEACH	VOLUSIA	732	2.01	13	FLORIDAN	
12	HOLLY HILL	VOLUSIA	265	.73	5	FLORIDAN	
13	DAYTONA BEACH	VOLUSIA	3,498	9.58	16	FLORIDAN	
14	NEW SMYRNA BEACH	VOLUSIA	625	1.71	5	FLORIDAN	
15	DELAND	VOLUSIA	895	2.45	7	FLORIDAN	
16	EUSTIS	LAKE	714	1.96	6	FLORIDAN	
17	LEESBURG	LAKE	1,693	4.64	9	FLORIDAN	
18	TAVARES	LAKE	163	.45	3	FLORIDAN	
19	WINTER GARDEN	ORANGE	399	1.10	2	FLORIDAN	
20	MAITLAND	ORANGE	481	1.30	6	FLORIDAN	
21	WINTER PARK	ORANGE	3,455	9.46	7	FLORIDAN	
22	ORLANDO	ORANGE	11,825	32.40	18	FLORIDAN	
23	SANFORD	SEMINOLE	975	2.70	11	FLORIDAN	
24	CASSELBERRY	SEMINOLE	358	.98	3	FLORIDAN	
25	TITUSVILLE	BREVARD	1,273	3.49	48	NON ARTESIAN	
26	COCOA	BREVARD	3,396	13.30	22	FLORIDAN	
27	MELBOURNE	BREVARD	2,818	7.72	—		LAKE WASHINGTON
28	VERO BEACH	INDIAN RIVER	972	2.64	10	NON ARTESIAN	

* TWO WELL FIELDS

Figure 14.--Major municipal water users.

75-44

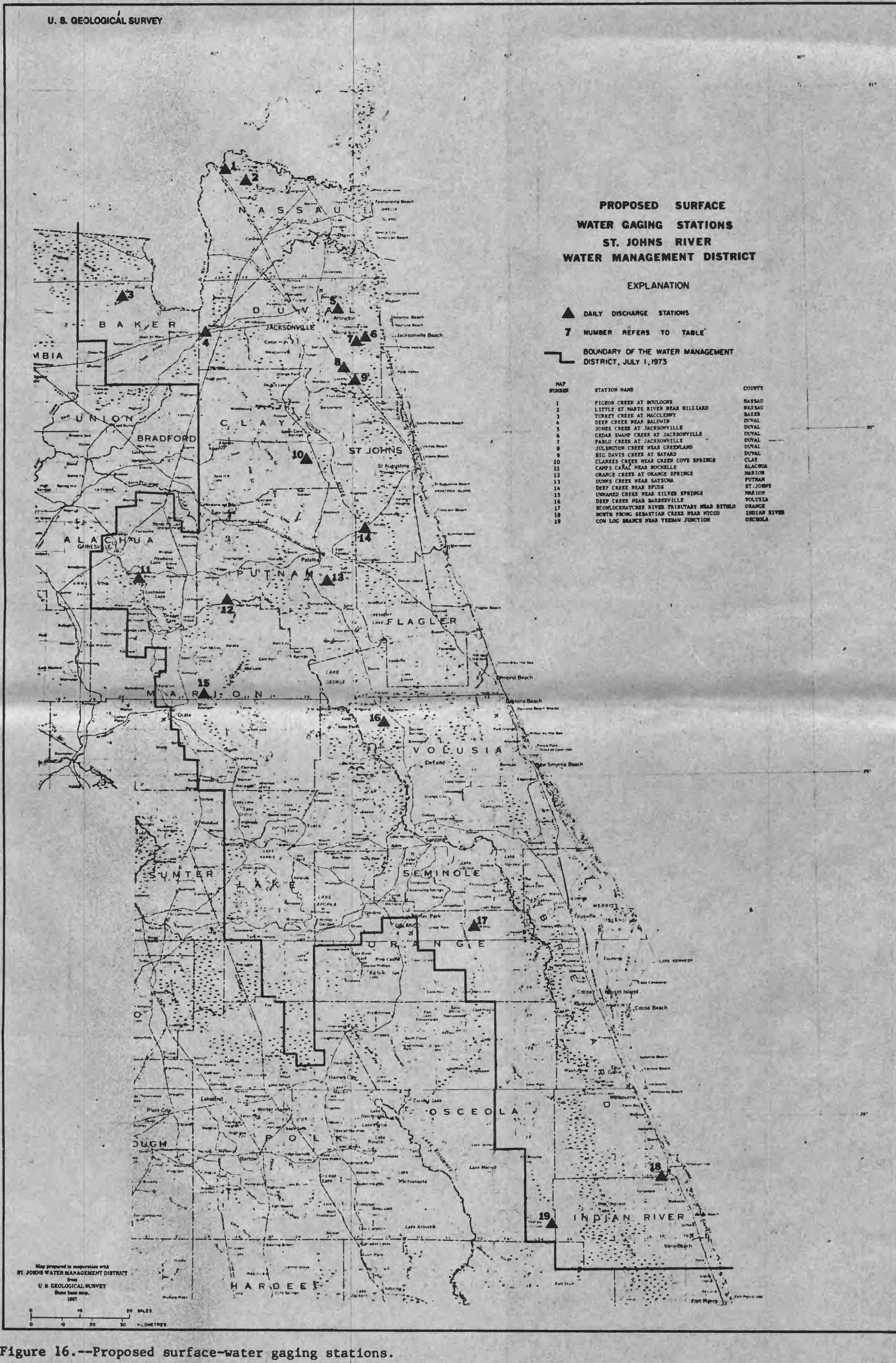


Figure 16.--Proposed surface-water gaging stations.

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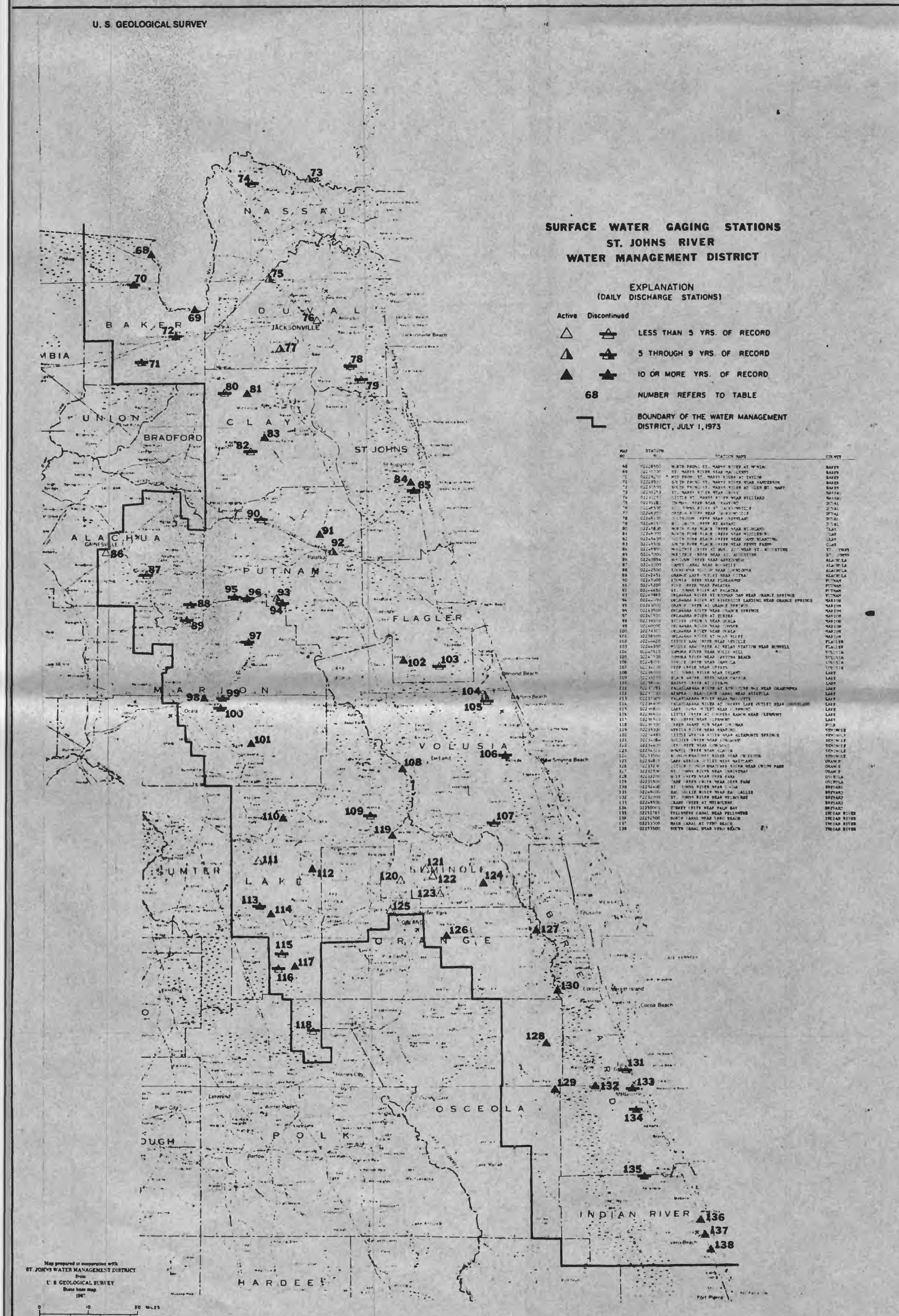

Figure 15.--Surface-water gaging stations.

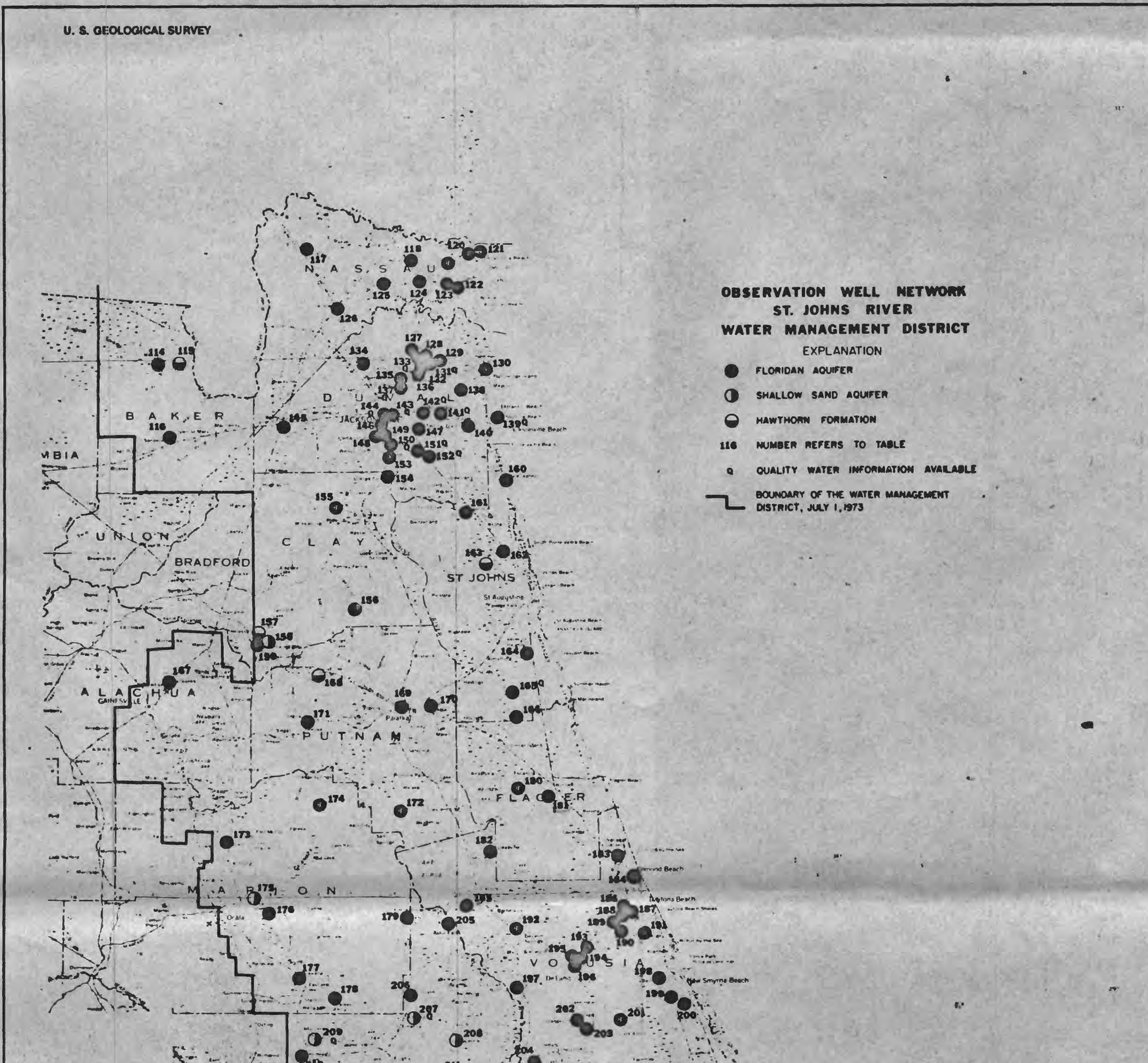

Figure 17.--Observation-well network.

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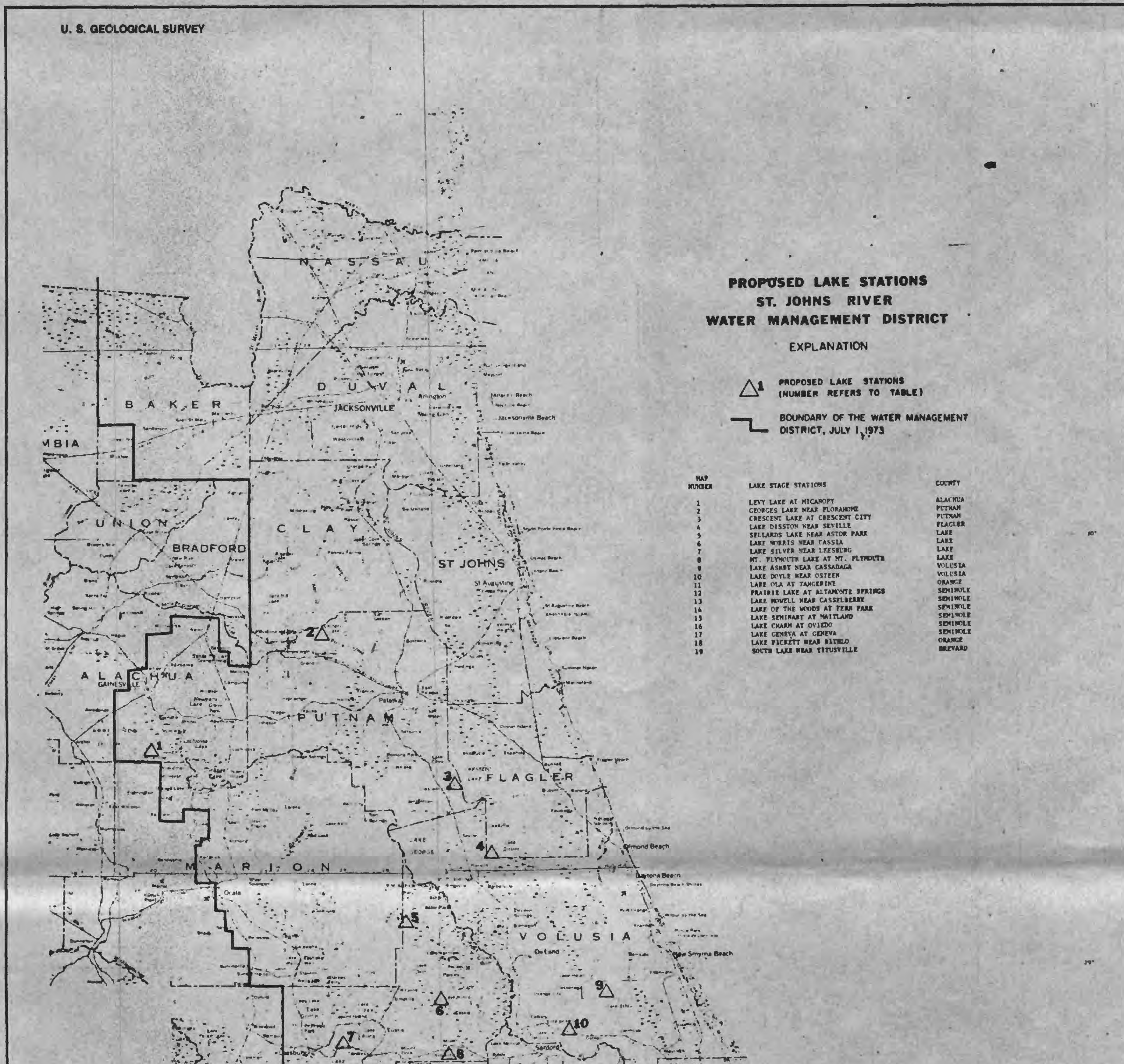

Figure 20.--Proposed lake stations.

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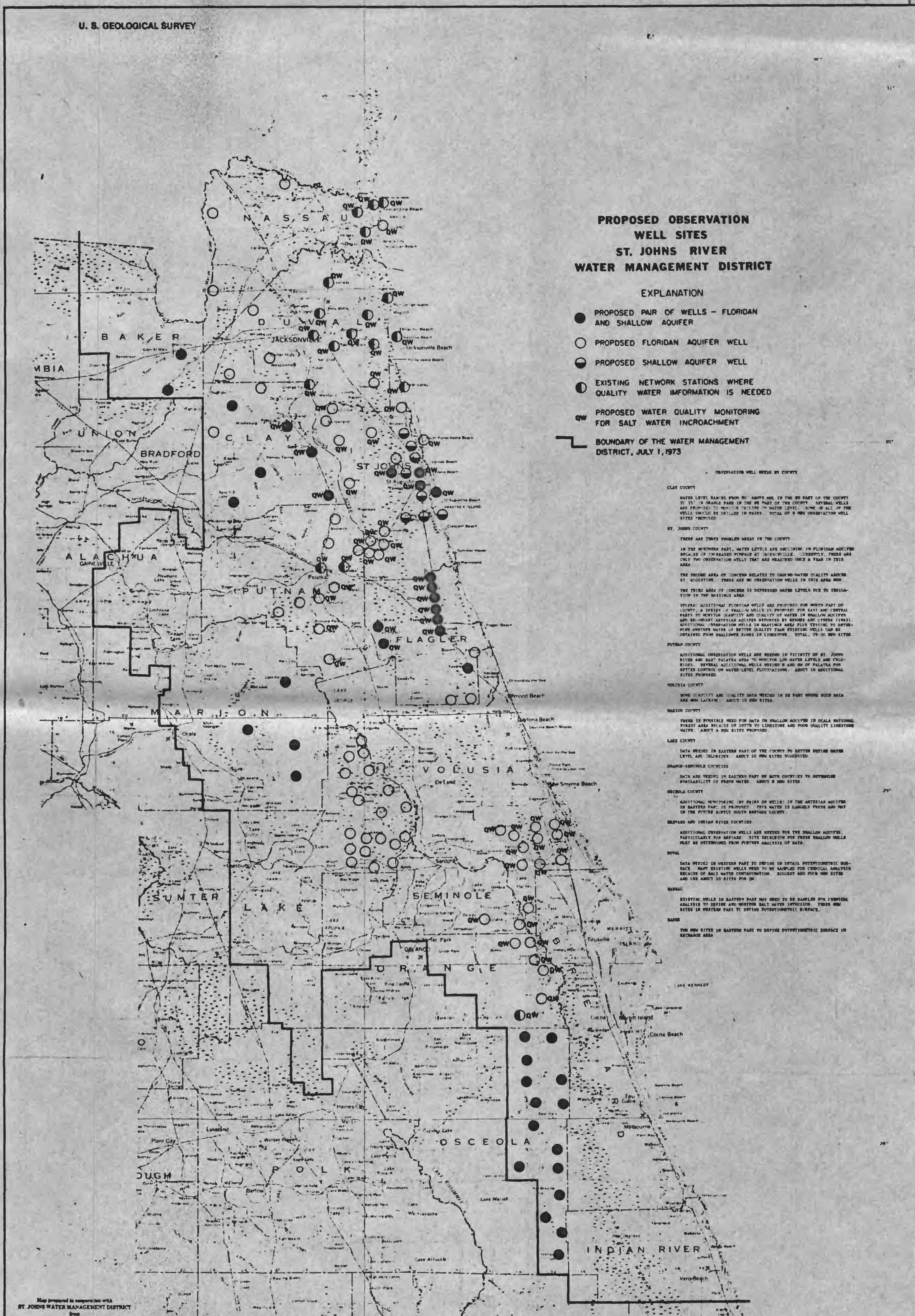

Figure 18.--Proposed observation-well sites.

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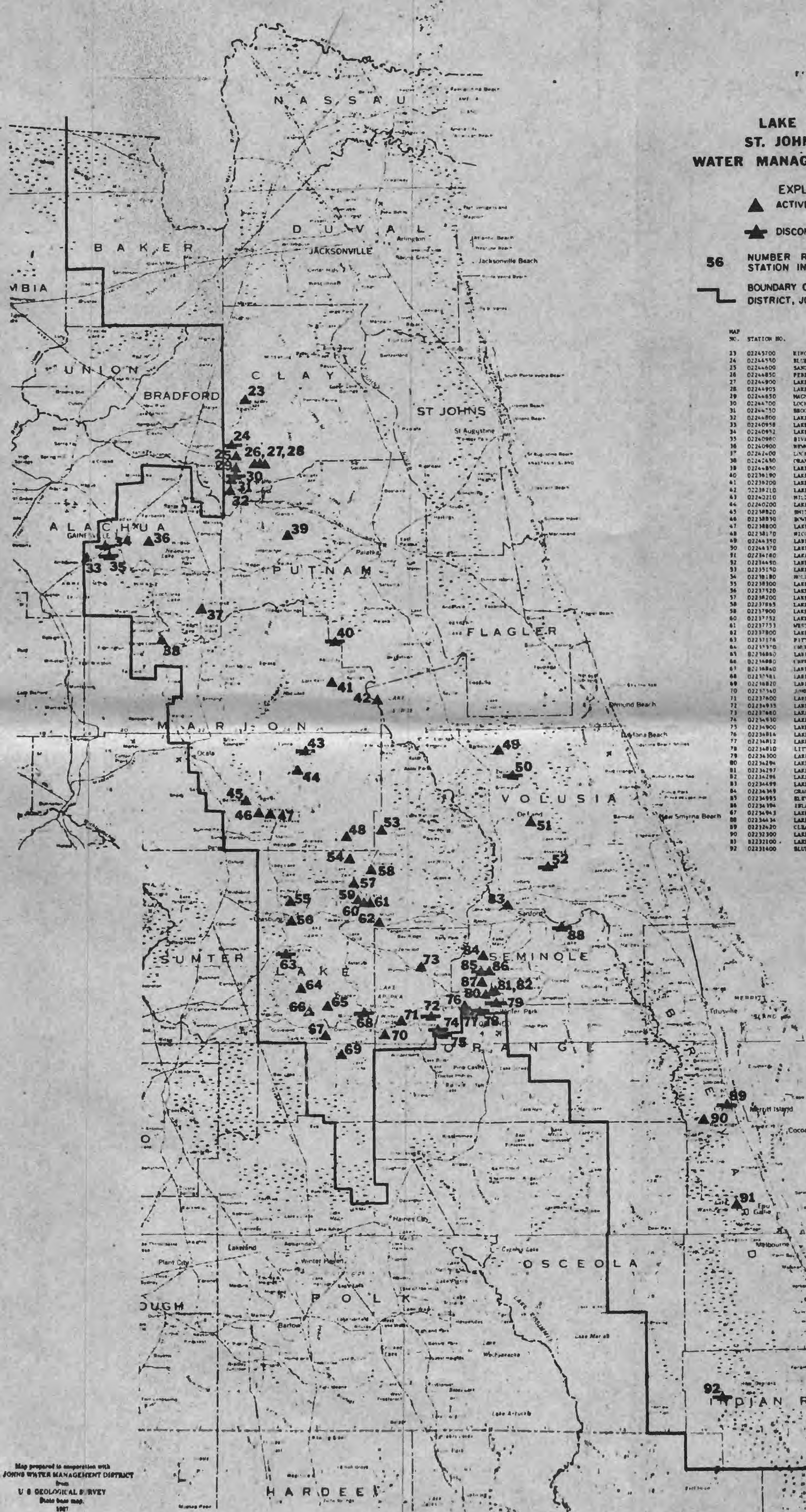
U. S. GEOLOGICAL SURVEY



LAKE STATIONS
ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT

EXPLANATION

▲ ACTIVE

DISCONTINUED

56 NUMBER REFERS TO LAKE STATION IN TABLE

BOUNDARY OF THE WATER MANAGEMENT DISTRICT, JULY 1, 1973

MAP NO.	STATION NO.	STATION NAME	DRAINAGE AREA	SURFACE AREA	COUNTY
23	02245700	KINGSLEY LAKE AT CAMP BLANDING	6.04	2.54	CLAY
24	02244550	BLUE POND NEAR KEYSTONE HEIGHTS	2.32	.31	CLAY
25	02244600	SAND HILL LAKE NEAR KEYSTONE HEIGHTS	11.0	1.95	CLAY
26	02244850	PEBBLE LAKE NEAR KEYSTONE HEIGHTS	0.19	0.01	CLAY
27	02244900	LAKE JOHNSON (LITTLE LAKE) NEAR KEYSTONE HEIGHTS	—	0.05	CLAY
28	02244905	LAKE JOHNSON (BIG LAKE) NEAR KEYSTONE HEIGHTS	6.37	0.76	CLAY
29	02244650	MAGNOLIA LAKE NEAR KEYSTONE HEIGHTS	14.6	0.31	CLAY
30	02244700	LOCH LOMOND NEAR KEYSTONE HEIGHTS	0.38	0.03	CLAY
31	02244750	BROOKLYN LAKE AT KEYSTONE HEIGHTS	17.6	.99	CLAY
32	02244800	LAKE GENEVA AT KEYSTONE HEIGHTS	35.5	2.73	CLAY
33	02240958	LAKE KANAPAHA AT ARREDONDO	—	—	ALACHUA
34	02240952	LAKE ALICE AT GAINESVILLE	1.96	0.11	ALACHUA
35	02240980	BIVANS ARM NEAR GAINESVILLE	4.84	0.41	ALACHUA
36	02240900	NEWNANS LAKE NEAR GAINESVILLE	110	9.20	ALACHUA
37	02242400	LOCHLOOSA LAKE AT LOCHLOOSA	—	—	ALACHUA
38	02243490	ORANGE LAKE AT ORANGE LAKE	1,000	35.7	ALACHUA
39	02244850	LAKE GRANDIN NEAR INTERLACHEN	3.72	0.35	PUTNAM
40	02236190	LAKE DELANCY NEAR EUREKA	14.0	0.00	MARION
41	02236200	LAKE KERR NEAR EUREKA	60.0	4.00	MARION
42	02236210	LAKE GEORGE NEAR SALT SPRINGS	3,760	70.0	MARION
43	02240210	MILLDAM LAKE NEAR LYNNE	28.0	0.40	MARION
44	02240200	LAKE BRYANT NEAR SILVER SPRINGS	8.10	1.20	MARION
45	02238820	SMITH LAKE NEAR CANDLER	—	—	MARION
46	02238830	BOWERS LAKE NEAR OKLAWAHA	—	—	MARION
47	02238800	LAKE WEIR AT OKLAWAHA	30.0	8.90	MARION
48	02238170	NICOTOON LAKE NEAR ALTOONA	23.0	0.90	MARION
49	02244350	LAKE WINONA NEAR DELAND	1.30	0.23	VOLUSIA
50	02244370	LAKE HIRES NEAR DELAND	2.10	0.11	VOLUSIA
51	02236160	LAKE WINNEMISSETT NEAR DELAND	1.10	0.28	VOLUSIA
52	02236450	LAKE DUPONT NEAR LAKE HELEN	2.48	0.40	VOLUSIA
53	02235150	LAKE DORR NEAR ALTOONA	30.0	2.70	LAKE
54	02238180	HOLLY LAKE NEAR UMATILLA	0.78	0.15	LAKE
55	02238300	LAKE GRIFFIN AT LEESBURG	850	16.0	LAKE
56	02237520	LAKE HARRIS AT LEESBURG	620	27.0	LAKE
57	02238200	LAKE YALE AT GRAND ISLAND	71.0	6.20	LAKE
58	02237865	LAKE UMATILLA AT UMATILLA	—	—	LAKE
59	02237900	LAKE EUSTIS AT EUSTIS	710	11.0	LAKE
60	02237752	LAKE DICIE AT EUSTIS	—	—	LAKE
61	02237753	WEST CROOKED LAKE NEAR EUSTIS	—	—	LAKE
62	02237800	LAKE DORA AT MOUNT DORA	240	5.70	LAKE
63	02237176	PITTS POND NEAR [illegible]	—	—	LAKE
64	[illegible]	[illegible] LAKE NEAR GROVELAND	—	—	LAKE
65	02236860	LAKE APSHAWA NEAR MINNEOLA	1.00	0.30	LAKE
66	02236880	CHERRY LAKE NEAR GROVELAND	160	0.60	LAKE
67	02236840	LAKE MINNEHAHA AT CLERMONT	140	3.77	LAKE
68	[illegible]	LAKE [illegible] AT [illegible]	81.0	21.0	LAKE
69	02236820	LAKE LOUISA NEAR CLERMONT	120	5.72	LAKE
70	02237340	JOHNS LAKE AT OAKLAND	40.1	[illegible]	ORANGE
71	02237600	LAKE APOPKA AT WINTER GARDEN	120	47.0	ORANGE
72	02234935	LAKE [illegible] NEAR OCOEE	0.31	0.04	ORANGE
73	02237680	LAKE FRANCIS NEAR PLYMOUTH	0.87	0.05	ORANGE
74	02234930	LAKE SHERWOOD NEAR ORLANDO	17.1	0.18	ORANGE
75	02234900	LAKE HERRICK NEAR ORLANDO	1.49	0.06	ORANGE
76	02234814	LAKE [illegible] NEAR MAITLAND	13.4	0.30	ORANGE
77	02234812	LAKE FAIRVIEW AT ORLANDO	3.73	0.63	ORANGE
78	02234810	LITTLE LAKE FAIRVIEW AT ORLANDO	1.27	0.13	ORANGE
79	02234300	LAKE MAITLAND AT WINTER PARK	19.3	0.71	ORANGE
80	02234294	LAKE CHARITY AT MAITLAND	—	—	ORANGE
81	02234297	LAKE HOPE AT MAITLAND	—	—	ORANGE
82	02234296	LAKE FAITH AT MAITLAND	—	—	ORANGE
83	02234499	LAKE MONROE NEAR SANFORD	2,580	15.7	SEMINOLE
84	02234369	GRACE LAKE AT LONGWOOD	—	—	SEMINOLE
85	02234995	ELEVENTH MILE POND AT ALTAMONTE SPRINGS	—	—	SEMINOLE
86	02234394	ISLAND LAKE AT LONGWOOD	—	—	SEMINOLE
87	02234943	LAKE ORIENTA AT ALTAMONTE SPRINGS	—	—	SEMINOLE
88	02234434	LAKE JESSUP NEAR SANFORD	130	13.0	SEMINOLE
89	02232420	CLEAR LAKE NEAR COCOA	0.30	0.02	BREVARD
90	02232300	LAKE POINSETT NEAR COCOA	1,272	8.71	BREVARD
91	02232100	LAKE WASHINGTON NEAR EAU GALLIE	1,025	6.72	BREVARD
92	02231600	BLUE CYPRESS LAKE NEAR FELLSMERE	409	10.2	INDIAN RIVER

Figure 19.--Lake stations.

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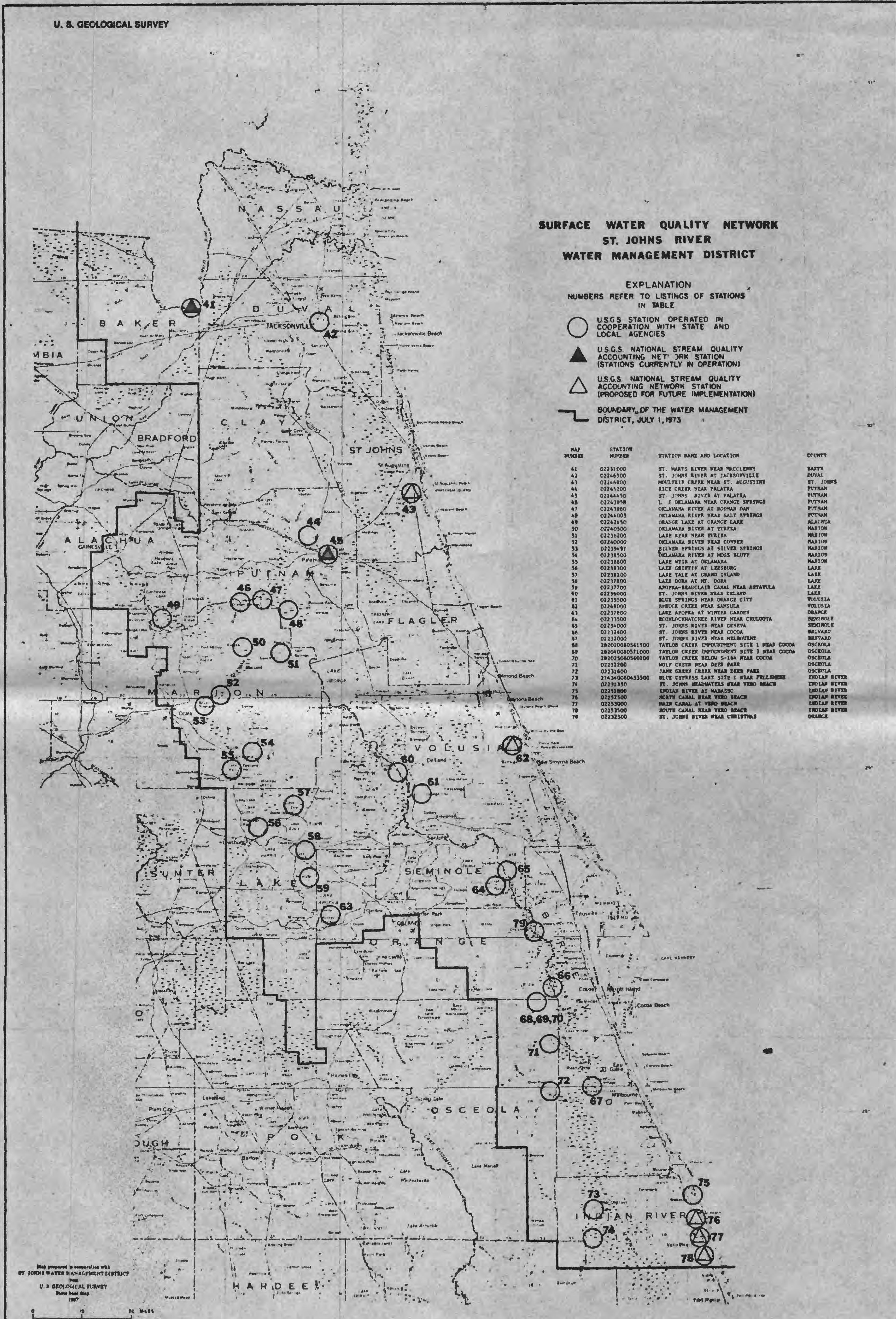
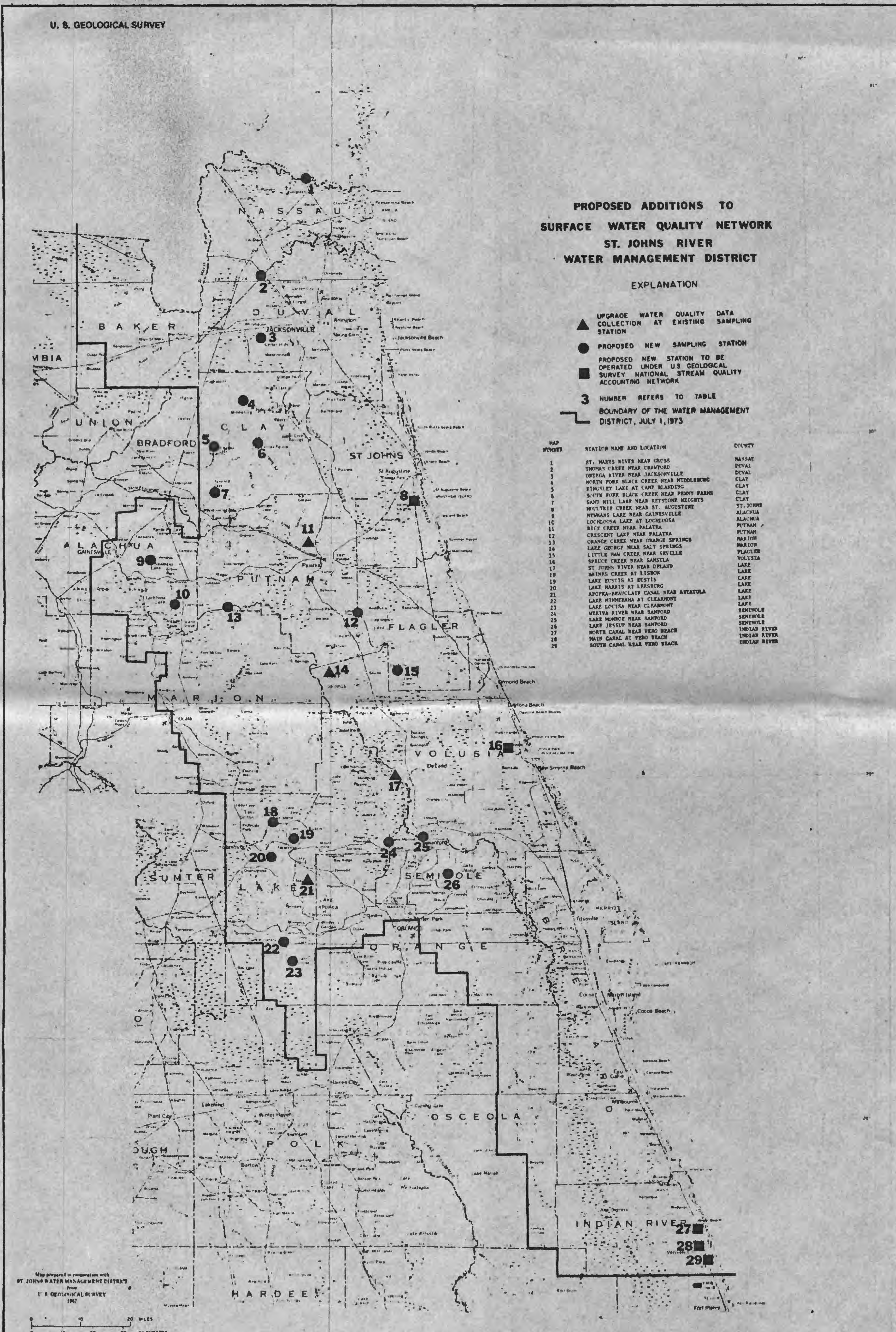


MAP NUMBER	STATION NUMBER	STATION NAME AND LOCATION	COUNTY
41	02231000	ST. MARYS RIVER NEAR MACCLENNY	BAKER
42	02246500	ST. JOHNS RIVER AT JACKSONVILLE	DUVAL
43	02246900	MOULTRIE CREEK NEAR ST. AUGUSTINE	ST. JOHNS
44	02245200	RICE CREEK NEAR PALATKA	PUTNAM
45	02244450	ST. JOHNS RIVER AT PALATKA	PUTNAM
46	02243958	L. E OKLAWAHA NEAR ORANGE SPRINGS	PUTNAM
47	02243960	OKLAWAHA RIVER AT RODMAN DAM	PUTNAM
48	02244005	OKLAWAHA RIVER NEAR SALT SPRINGS	PUTNAM
49	02242450	ORANGE LAKE AT ORANGE LAKE	ALACHUA
50	02240500	OKLAWAHA RIVER AT EUREKA	MARION
51	02236200	LAKE KERR NEAR EUREKA	MARION
52	02240000	OKLAWAHA RIVER NEAR CONNER	MARION
53	02239497	SILVER SPRINGS AT SILVER SPRINGS	MARION
54	02238500	OKLAWAHA RIVER AT MOSS BLUFF	MARION
55	02238800	LAKE WEIR AT OKLAWAHA	MARION
56	02238300	LAKE GRIFFIN AT LEESBURG	LAKE
57	02238200	LAKE YALE AT GRAND ISLAND	LAKE
58	02237800	LAKE DORA AT MT. DORA	LAKE
59	02237700	APOPKA-BEAUCLAIR CANAL NEAR ASTATULA	LAKE
60	02236000	ST. JOHNS RIVER NEAR DELAND	LAKE
61	02235500	BLUE SPRINGS NEAR ORANGE CITY	VOLUSIA
62	02248000	SPRUCE CREEK NEAR SAMSULA	VOLUSIA
63	02237600	LAKE APOPKA AT WINTER GARDEN	ORANGE
64	02233500	ECONLOCKHATCHEE RIVER NEAR CHULUOTA	SEMINOLE
65	02234000	ST. JOHNS RIVER NEAR GENEVA	SEMINOLE
66	02232400	ST. JOHNS RIVER NEAR COCOA	BREVARD
67	02232000	ST. JOHNS RIVER NEAR MELBOURNE	BREVARD
68	282020080561500	TAYLOR CREEK IMPOUNDMENT SITE 1 NEAR COCOA	OSCEOLA
69	282040080571000	TAYLOR CREEK IMPOUNDMENT SITE 3 NEAR COCOA	OSCEOLA
70	282025080560100	TAYLOR CREEK BELOW S-164 NEAR COCOA	OSCEOLA
71	02232200	WOLF CREEK NEAR DEER PARK	OSCEOLA
72	02231600	JANE GREEN CREEK NEAR DEER PARK	OSCEOLA
73	274340080453500	BLUE CYPRESS LAKE SITE 1 NEAR FELLSMERE	INDIAN RIVER
74	02231350	ST. JOHNS HEADWATERS NEAR VERO BEACH	INDIAN RIVER
75	02251800	INDIAN RIVER AT WABASSO	INDIAN RIVER
76	02252500	NORTH CANAL NEAR VERO BEACH	INDIAN RIVER
77	02253000	MAIN CANAL AT VERO BEACH	INDIAN RIVER
78	02253500	SOUTH CANAL NEAR VERO BEACH	INDIAN RIVER
79	02232500	ST. JOHNS RIVER NEAR CHRISTMAS	ORANGE

Figure 21.--Surface-water-quality network.



MAP NUMBER	STATION NAME AND LOCATION	COUNTY
1	ST. MARYS RIVER NEAR CROSS	NASSAU
2	THOMAS CREEK NEAR CRAWFORD	DUVAL
3	ORTEGA RIVER NEAR JACKSONVILLE	DUVAL
4	NORTH FORK BLACK CREEK NEAR MIDDLEBURG	CLAY
5	KINGSLEY LAKE AT CAMP BLANDING	CLAY
6	SOUTH FORK BLACK CREEK NEAR PENNY FARMS	CLAY
7	SAND HILL LAKE NEAR KEYSTONE HEIGHTS	CLAY
8	MOULTRIE CREEK NEAR ST. AUGUSTINE	ST. JOHNS
9	NEWNANS LAKE NEAR GAINESVILLE	ALACHUA
10	LOCHLOOSA LAKE AT LOCHLOOSA	ALACHUA
11	RICE CREEK NEAR PALATKA	PUTNAM
12	CRESCENT LAKE NEAR PALATKA	PUTNAM
13	ORANGE CREEK NEAR ORANGE SPRINGS	MARION
14	LAKE GEORGE NEAR SALT SPRINGS	MARION
15	LITTLE HAW CREEK NEAR SEVILLE	FLAGLER
16	SPRUCE CREEK NEAR SAMSULA	VOLUSIA
17	ST JOHNS RIVER NEAR DELAND	LAKE
18	HAINES CREEK AT LISBON	LAKE
19	LAKE EUSTIS AT EUSTIS	LAKE
20	LAKE HARRIS AT LEESBURG	LAKE
21	APOPKA-BEAUCLAIR CANAL NEAR ASTATULA	LAKE
22	LAKE MINNEHAHA AT CLEARMONT	LAKE
23	LAKE LOUISA NEAR CLEARMONT	LAKE
24	WEKIVA RIVER NEAR SANFORD	SEMINOLE
25	LAKE MONROE NEAR SANFORD	SEMINOLE
26	LAKE JESSUP NEAR SANFORD	SEMINOLE
27	NORTH CANAL NEAR VERO BEACH	INDIAN RIVER
28	MAIN CANAL AT VERO BEACH	INDIAN RIVER
29	SOUTH CANAL NEAR VERO BEACH	INDIAN RIVER

Figure 22.--Proposed additions to surface-water-quality network.

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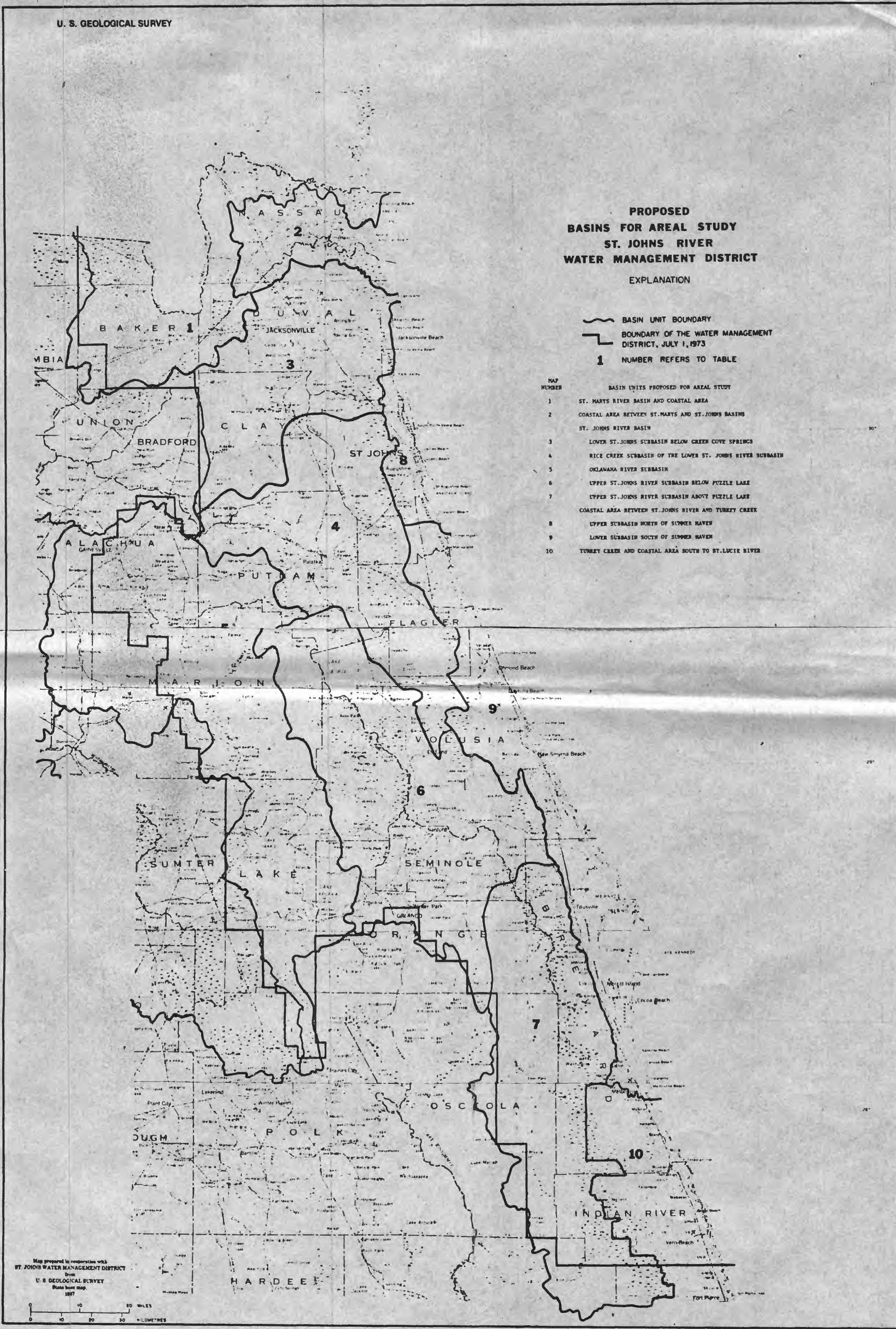

Figure 32.--Proposed units for areal investigations.