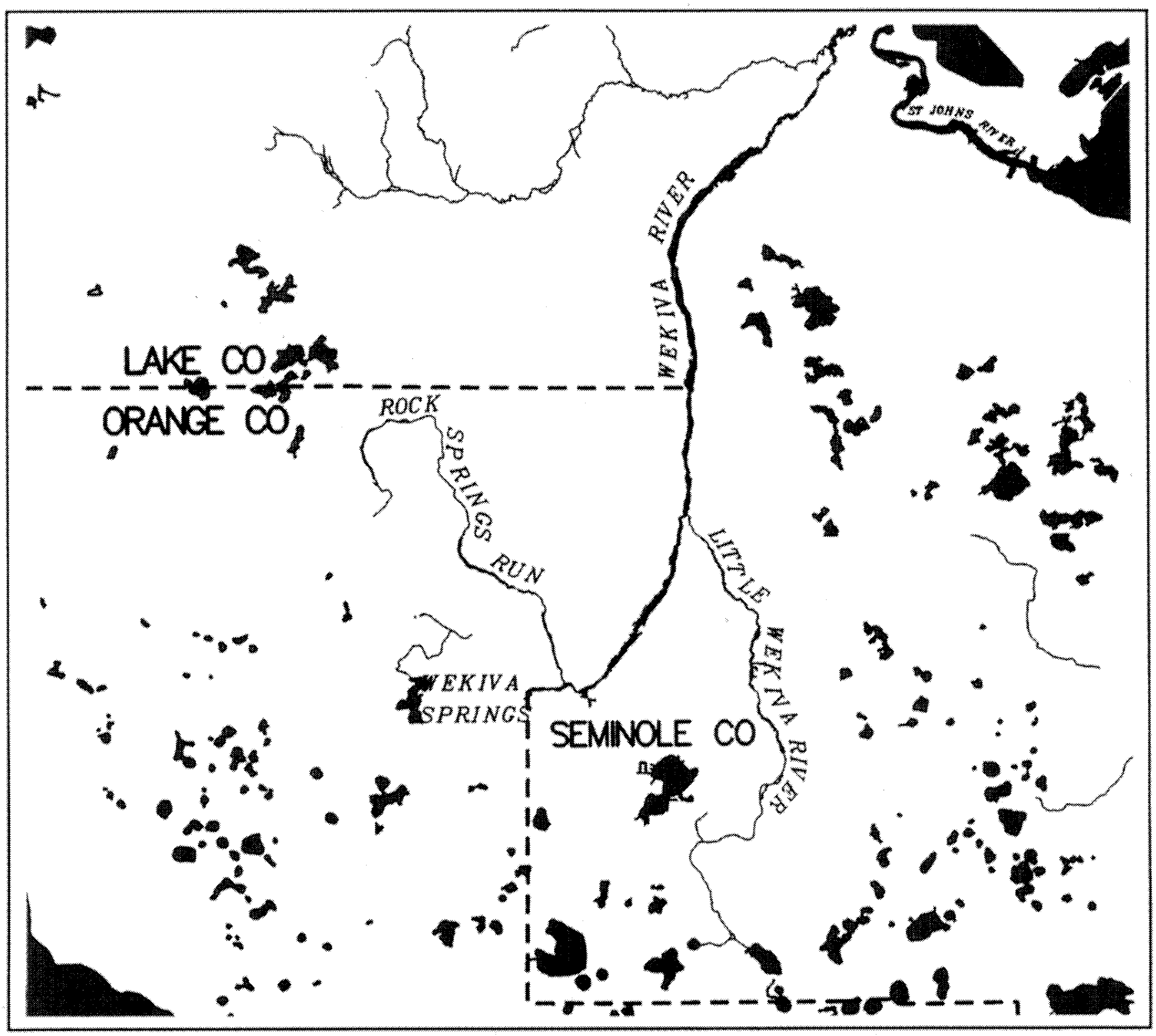
Technical Publication SJ 89-5

Water Quality Assessment of the Floridan Aquifer in the Wekiva River Basin of Orange, Lake, and Seminole Counties



St. Johns River Water Management District

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WATER QUALITY ASSESSMENT OF THE FLORIDAN AQUIFER IN THE WEKIVA RIVER BASIN OF ORANGE, LAKE, AND SEMINOLE COUNTIES

by

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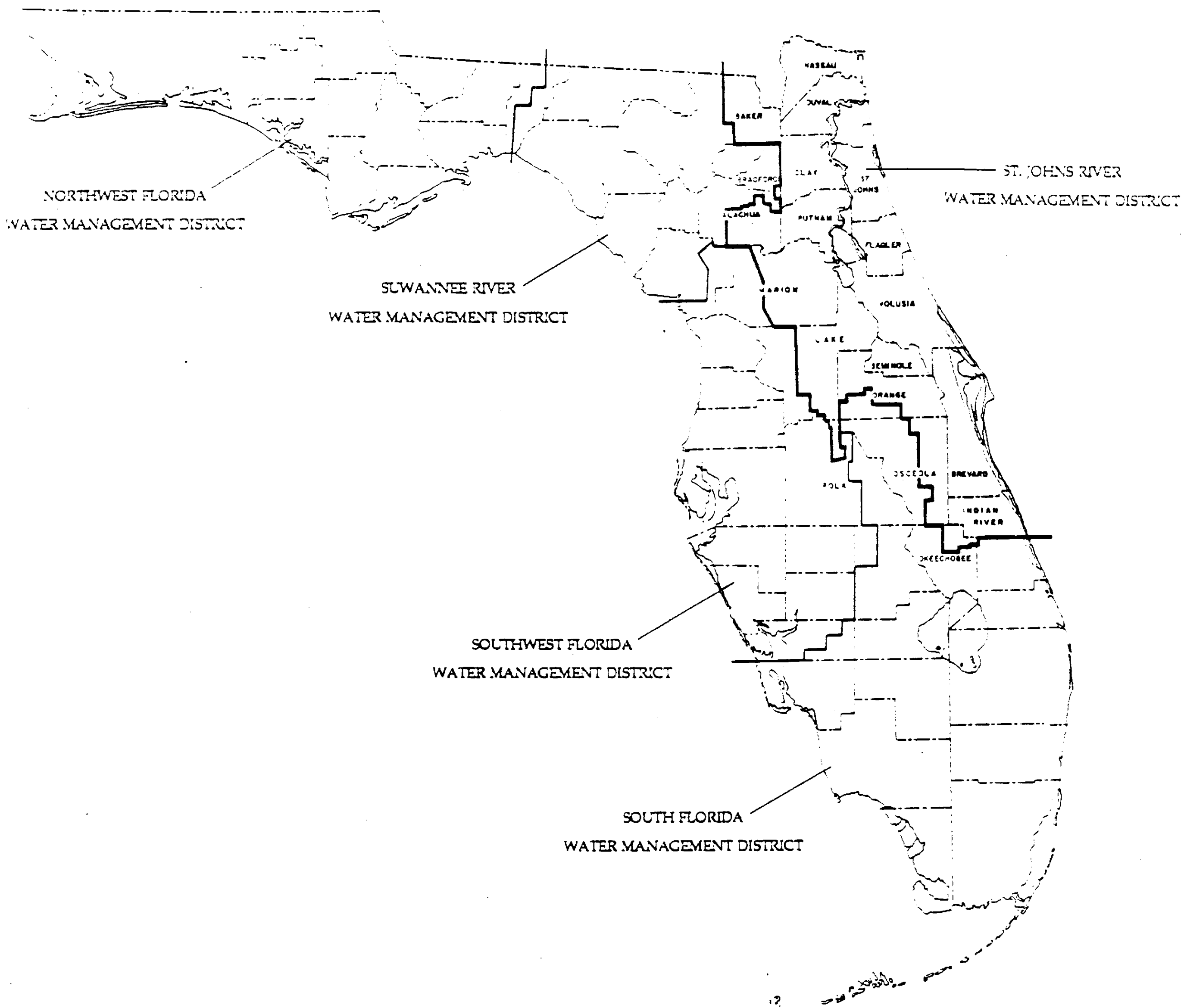
1989



THE ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

The St. Johns River Water Management District (SJRWMD) was created by the Florida Legislature in1972 to be one of five water management districts in Florida. It includes all or parts of nineteen counties in northeast Florida. The mission of SJRWMD is to manage water resources to insure their continued availability while maximizing environmental and economic benefits. It accomplishes its mission through regulation, applied research, assistance to federal, state, and local governments, operation and maintenance of water control works, and land acquisition and management. Technical reports are published to disseminate information collected by SJRWMD in pursuit of its mission.

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INTRODUCTION

The Governing Board of the St. Johns River Water Management District (SJRWMD) authorized a study of ground water quality changes in the Wekiva River basin to begin in 1986. This study was authorized in response to a request by the Friends of the Wekiva River, a local citizens group. The Friends of the Wekiva expressed concern that impacts from increased ground water demands, due to residential growth, may have caused saltwater encroachment within the Wekiva River basin (Friends of the Wekiva River, 1985).

This paper discusses the Floridan aquifer, the most significant source of water supply in the Wekiva River basin.

PURPOSE AND SCOPE OF STUDY

The purpose of this study is to determine the present condition of water quality in the Floridan aquifer in the Wekiva River basin. The study includes an evaluation of new and historical data concerning the response of chloride concentrations to seasonal fluctuations in the potentiometric surface of the Floridan aquifer. In addition, the study addresses changes in ground water quality since the water quality sampling reported by Tibbals (1977).

PREVIOUS INVESTIGATIONS

Stringfield (1934) and Stables (1937) reported on the ground water resources of Seminole County. A data report by Heath and Barraclough (1954) and an interpretive report by Barraclough (1962b) provided a reconnaissance of the ground water resources of Seminole County. Tibbals (1977) evaluated the effects of increased ground water withdrawals on the quantity and quality of water in the Floridan aquifer. The scope of each of these reports was county-wide or larger, thereby restricting the amount of detail that could be devoted to the ground water assessment of the Wekiva River basin.

METHODOLOGY

The following procedures were used:

- Data describing water quality and water levels were collected from previously published information. These data were added to the SJRWMD computer data base and used to produce water quality and lithologic contour maps.
- Wells used in Tibbals (1977) investigation were located. Additional wells were inventoried and geophysically logged.
- Water quality samples from Tibbals wells and the additional wells were collected and analyzed for chemical constituents in March and October of 1986.
- Public, industrial, and selected irrigation facilities that withdrew ground water in the study area were identified and monthly water use was tabulated (Marella pers. com. 1986).
- Measurements of the potentiometric surface of the Floridan aquifer were collected from published reports of the USGS. These data were used to construct change maps of the potentiometric surface of the upper Floridan aquifer in the study area.
- Each well in this study was assigned a letter indicating its county location followed by four digits. For example, well number L-0048, located in Lake County, was the forty-eighth well inventoried. A number based on latitude and longitude coordinates was also assigned to each well.

DESCRIPTION OF STUDY AREA

The Wekiva River basin, with a drainage area of more than 130 square miles, is located in east central Florida within Orange, Seminole, Lake, and Volusia counties (Figure 1). Its major tributaries are the Little Wekiva River, Rock Springs Run, and Blackwater Creek.

The land use in the eastern portion of the Wekiva River basin is predominantly urban residential. The southern portion is commercial. The western portion is primarily state-owned parks and preserves. Improved pasture and cleared land predominate along the northern reaches of the Wekiva River, though residential development is rapidly advancing northward.

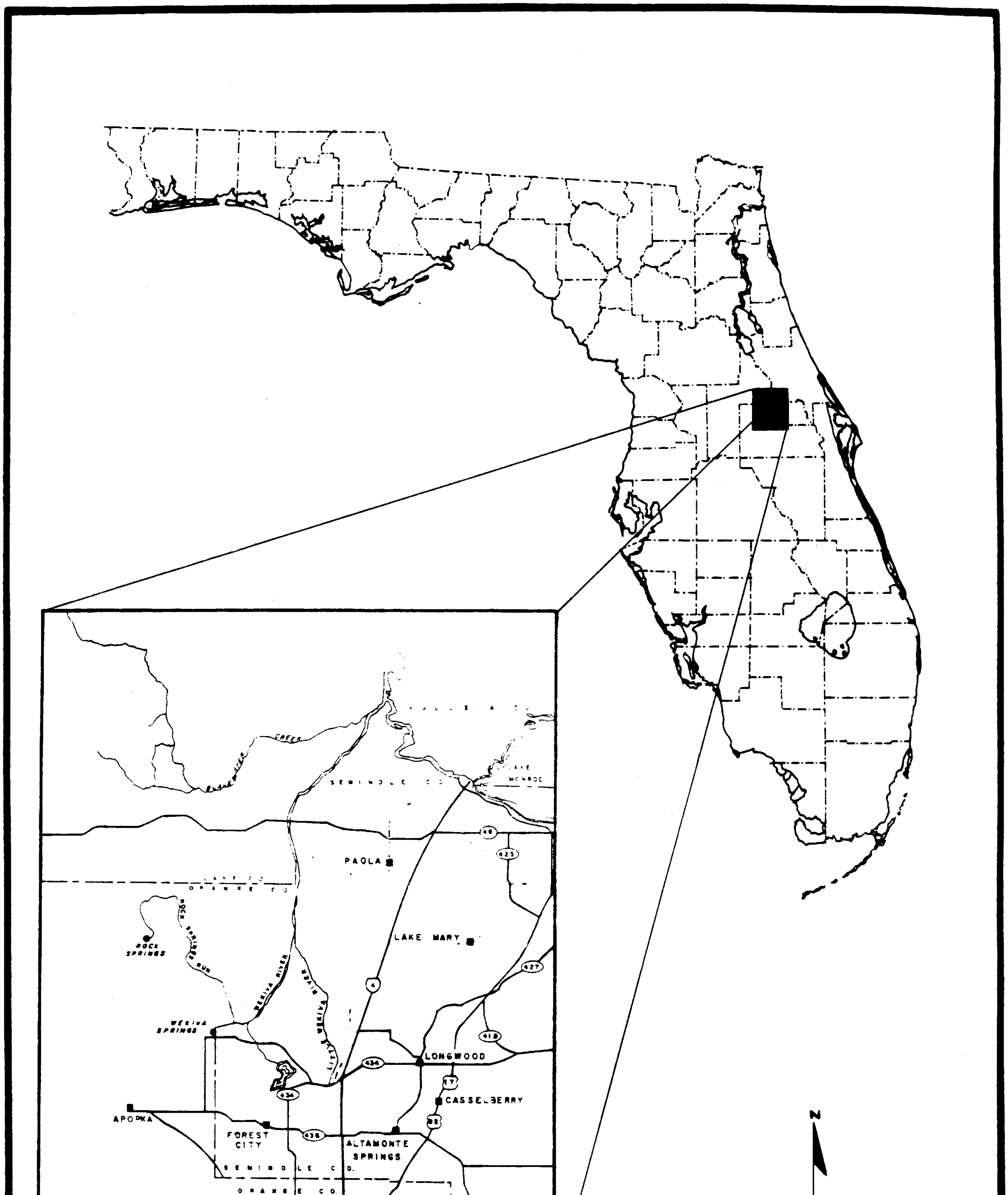

Figure 1. Location of the study area

WATER USE

The Floridan aquifer in the study area is used for public, domestic, and industrial supply and irrigation (Table 1, Figure 2). The irrigation facilities in Table 1 were selected from the district's Benchmark Farms Program, which is an agricultural irrigation monitoring program. They were selected to illustrate how water use for irrigation varied during 1986 in the study area.

Most of the wells sampled for this study were in park land or land where water is used largely for domestic supply. Because water use trends for public and domestic supply are generally very similar, it is assumed that self-supplied domestic use is similar to public supply use in the study area.

During 1986, the quantity of water withdrawn for public supply generally increased from January through May with peak water use of about 57 mgd occurring in May. From May through December, water withdrawn for public supply generally decreased (Figure 3). The quantity of water withdrawn for public supply was greater during the October sampling period (42 mgd) than during the March sampling period (36 mgd).

Industrial use decreased during 1986 from 5 mgd in January to 1 mgd in December. Most of this decrease resulted from the closing of a Coca-Cola plant at Forest City in July (Table 1). The quantity of ground water withdrawn for industrial use was smaller during the October sampling period (1 mgd) than during the March sampling period (5 mgd).

Irrigation from selected facilities increased during 1986 from 0.3 mgd in January to 0.6 mgd in December. Maximum irrigation from these facilities amounted to 1.5 mgd in May. The quantity of ground water withdrawn for irrigation from selected facilities was larger during the October sampling period (0.9 mgd) than during the March sampling period (0.8 mgd).

Assuming this pattern of ground water use for selected facilities is similar to the pattern of ground water use for the irrigation in general, more ground water was withdrawn during the October sampling period than during the March sampling period. Combining water withdrawn for public and industrial supply leads to the same conclusion. The quantity of ground water withdrawn for both public and industrial supply was 2 mgd larger during the October sampling period than during the March sampling period.

Table 1. Public, industrial, and selected irrigation facilities that withdrew ground water in the study area in 1986

Number	Latitude	Longitude	Facility	Use
1	283605	812148	Winter Park	Public Supply
2	283655	812249	Eatonville	Public Supply
3	283725	813000	Dol Ray Manor	Public Supply
4	283731	812137	Maitland	Public Supply
5	283739	811705	Consumer Howell	Public Supply
6	283800	812520	OCU-Riverside	Public Supply
7	283825	812208	Oakland Shores	Public Supply
8	283826	812242	Bretton Woods	Public Supply
9	283830	812027	English Estates	Public Supply
10	283844	812001	Indian Hills	Public Supply
11	283914	812933	Apopka Sheelor	Public Supply
12	283934	812420	Weathersfield	Public Supply
13	284009	812530	Lk Harriet Est	Public Supply
14	284024	812344	Apple Valle	Public Supply
15	284035	812130	Harmony Homes	Public Supply
16	284112	811815	Winter Spr. #3	Public Supply
17	284126	812243	Sanlando-Overst	Public Supply
18	284126	812811	OCU-Bent Oaks	Public Supply
19	284129	812446	Merideth Manor	Public Supply
20	284134	813038	Apopka Apk Terr	Public Supply
21	284136	813321	OCU-Plymouth Reg	Public Supply
22	284144	812555	Lake Blantley	Public Supply
23	284229	812243	Sanlando-Despin	Public Supply
24	284240	813036	Rock Springs MH	Public Supply
25	284242	811902	Winter Spg #2	Public Supply
26	284250	812602	Sanlando-Wekiva	Public Supply
27	284424	812044	Greenwood	Public Supply
28	284547	811706	Sanford-Aux Pl	Public Supply
29	284602	813104	OCU-Mt. Plymouth	Public Supply
30	284648	811920	Sanford Main Pl	Public Supply
31	284722	811812	Ravenna Park	Public Supply
32	285345	811845	WVU-Lake Marie	Public Supply
33	285445	811835	WVU-Terra Alta	Public Supply
1	283942	812510	Deep South Prod	Industrial
2*	283943	812502	Coca-Cola Forest City	Industrial
3	284130	813312	Coca-Cola Plymt	Industrial
4	284625	812105	Stromber Carl	Industrial
5	285031	811937	FPL-Sanford	Industrial
6	285209	811623	FPC-Turner	Industrial
1	283822	812948	Jacobson Nur.	Irrigation
2	283926	811835	Deer Run Golf	Irrigation
3	284123	812121	Rolling Hills	Irrigation
4	284419	812145	Bolling Nursery	Irrigation

* Plant closed July, 1986

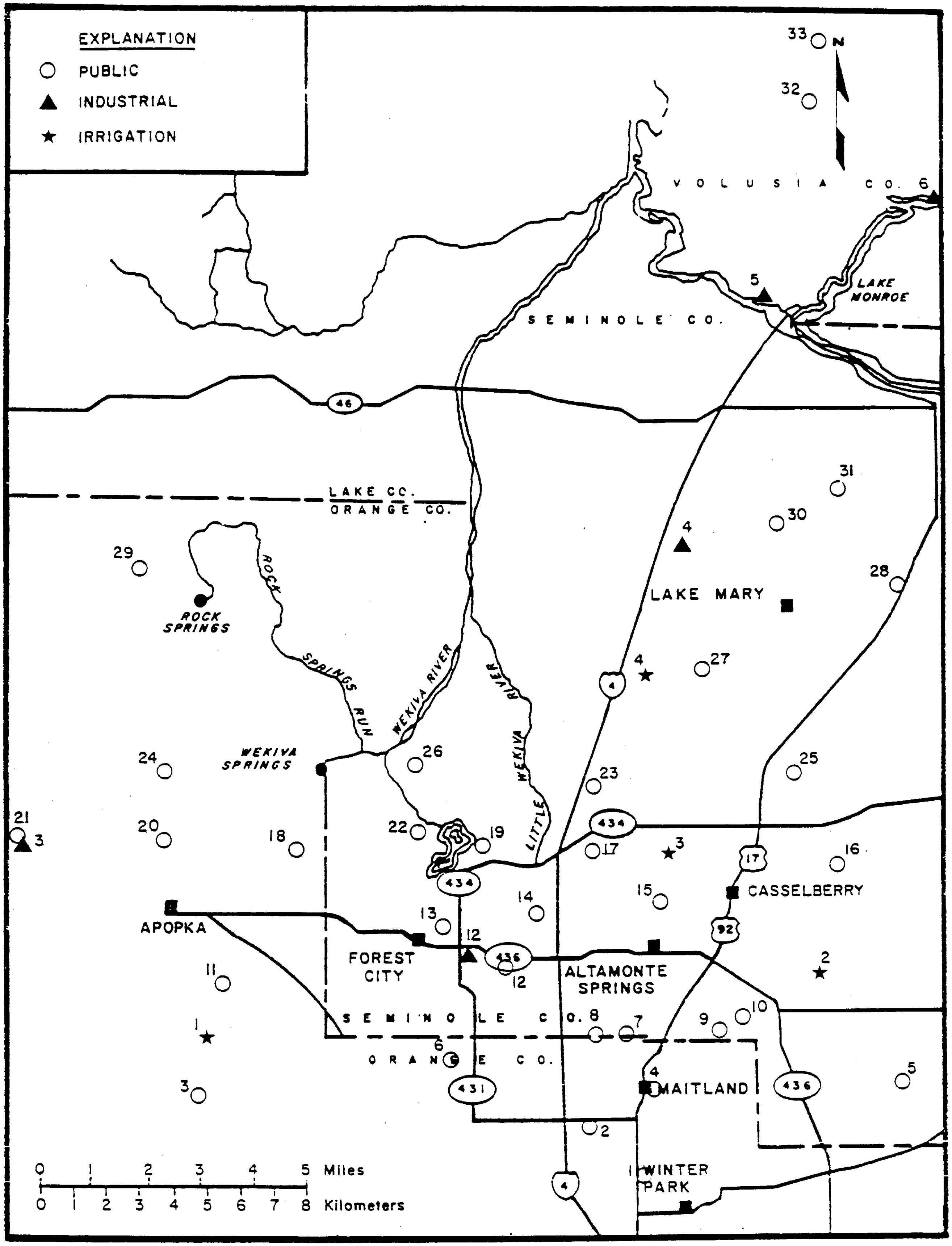

Figure 2. Location of public, industrial, and selected irrigation facilities, 1986 (Table 1)

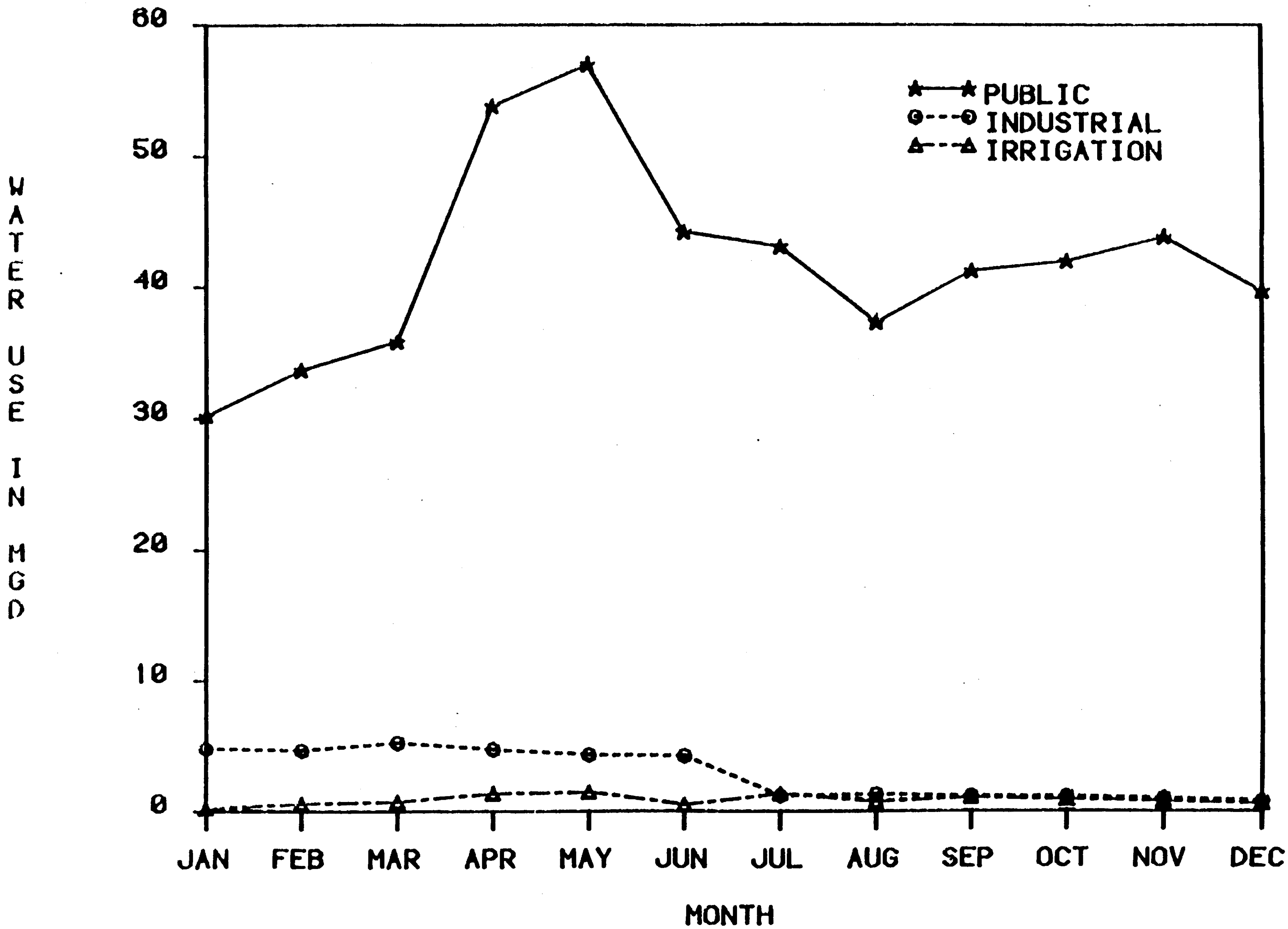

Figure 3. Water use in the study area in 1986

HYDROGEOLOGIC FRAMEWORK

The Wekiva River basin is underlain by several thousand feet of marine sedimentary rocks. The primary water-bearing sediments are composed of limestone, dolomite, silt, shell, and sand (Figure 4). Although all of the geologic units present in the basin yield some water to wells, their water-bearing characteristics are different. There are three aquifer systems in east-central Florida: the surficial aquifer, the intermediate aquifer system and the Floridan aquifer system. The surficial aquifer is not used as a primary water supply source because of its low yield. The two aquifers commonly penetrated by water supply wells in the Wekiva River basin are the intermediate and Floridan aquifers. The intermediate aquifer, consisting of permeable limestone lenses within the Hawthorn Group, provides a source of water for domestic wells.

FLORIDAN AQUIFER

In the study area the Floridan aquifer is composed of a thick sequence of interbedded limestones and dolomites. The formations which comprise the Floridan aquifer in descending order are the Ocala, Avon Park, and Oldsmar limestones. The lower part of the Avon Park Limestone contains a low permeability layer which according to Tibbals (1981) serves to separate the Floridan aquifer into an upper and lower permeable unit. The upper unit includes the basal member of the Hawthorn Group, the Ocala Limestone, and the upper part of the Avon Park Limestone. The lower unit consists of the lower part of the Avon Park Limestone and the Oldsmar Limestone.

The majority of water supply wells in the Wekiva River basin are completed into the Ocala Limestone. Casings for these wells are either set in the Hawthorn Group or at the top of the Ocala Limestone. In the study area, few wells have been drilled into the lower formations beneath the Ocala Limestone.

The Ocala Limestone consists of soft white-cream to tan fragmented limestone. In the lower portion of the Ocala Limestone, a higher percentage of dolomitic limestone occurs. The elevation of the top of the Ocala Limestone ranges from 26 ft above mean sea level (msl) near Rock Springs to 125 ft below msl southwest of Apopka (Figure 5). The thickness of the Ocala Limestone ranges from about 20 ft in the northern area of the Wekiva River basin to 112 ft near Lake Mary (Figure 6).

AGE	FORMATION	AQUIFER	THICKNESS	DESCRIPTION
LATE AND POST MIOCENE	SURFICIAL MATERIAL	SURFICIAL AQUIFER	34 ft. to 139 ft.	Sand, Clay, and Coquina
MIOCENE	HAWTHORN GROUP	INTERMEDIATE AQUIFER AND CONFINING UNIT	25 ft. to 150 ft.	Sand, Clay, Limestone, and Dolostone, mostly phosphatic
			3 ft. to 32 ft.	Basal Hawthorn: Dolostone, sandy, phosphatic, hard
EOCENE	OCALA LIMESTONE	FLORIDAN AQUIFER	20 ft. to 112 ft.	Limestone, relatively pure Coquina, bio- and foraminiferal-
			9 ft. to 57 ft.	Lower Ocala: Limestone, dolomitic, coquinoid
	AVON PARK LIMESTONE		150 ft. to 330 ft.	Limestone and Dolostone with Peat (disseminated and as beds) or Clay beds
				Avon Park: Dolostone, very hard, low porosity zone

Figure 4. Typical hydrostratigraphic column in the Wekiva River area

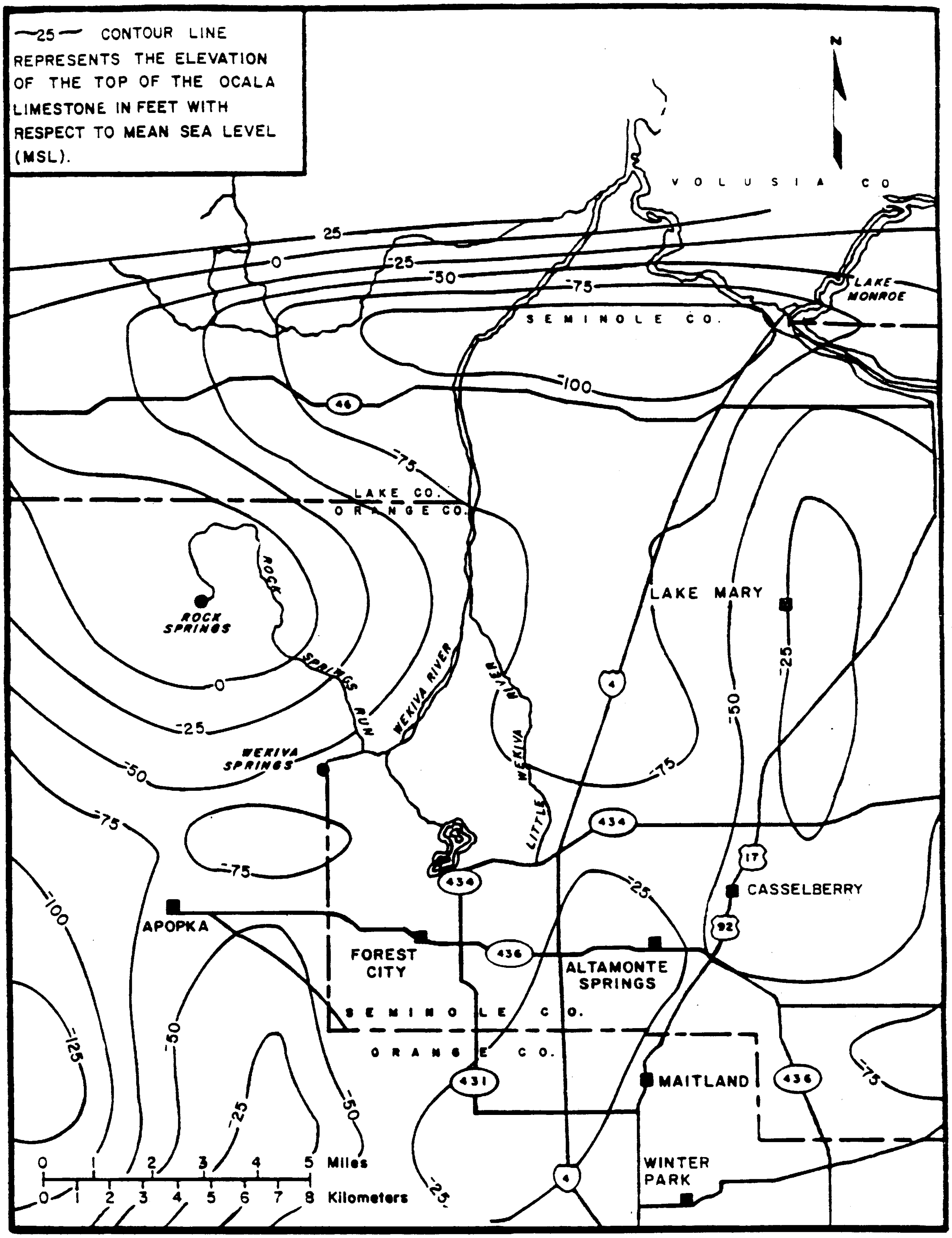

Figure 5. Top of the Ocala Limestone

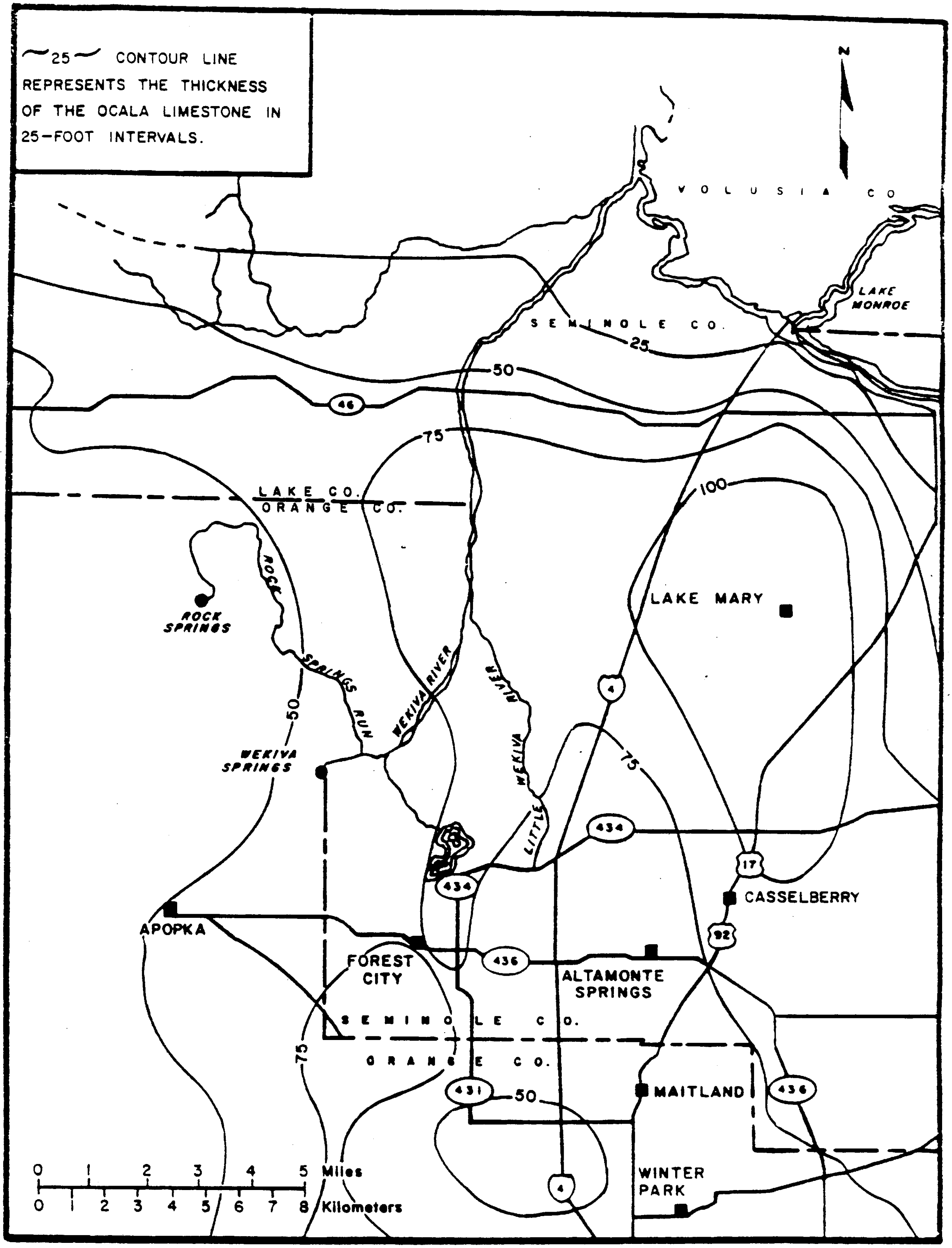

Figure 6. Thickness of the Ocala Limestone

The Hawthorn Group acts as a confining unit for the Floridan aquifer. The Hawthorn Group consists of two units. The upper unit consists of clay and marl and the lower unit of sand and limestone. The Hawthorn Group occurs throughout the Wekiva River basin. Elevation of the Hawthorn ranges from 75 ft above msl west of the Wekiva River to 25 ft below msl north of the Wekiva River near the St. Johns River (Figure 7). The Hawthorn's maximum thickness is 150 ft north of Apopka. The Hawthorn decreases in thickness to 25 ft east of the Wekiva River near Lake Mary (Figure 8).

Several faults and fracture patterns have been mapped by Vernon (1951) (Figure 9). These geologic features may affect the permeability of the limestone units. The presence of these features within the Wekiva River basin area could provide an avenue for the upward migration of saline water from deeper zones in the Floridan aquifer into the Ocala Limestone.

POTENTIOMETRIC SURFACE

The Floridan aquifer in the study area is under artesian pressure. The potentiometric surface is defined by the level to which water will rise in a tightly cased well penetrating the aquifer. Observed potentiometric levels can be used to illustrate the direction of ground water flow. Ground water flows from areas of higher pressure to areas of lower pressure. Water moves in a path perpendicular to lines of equal potentiometric pressure.

The potentiometric surface of the upper permeable unit of the Floridan aquifer in the study area in May 1986, was highest in the southwestern area of the basin where water levels of 50 ft above msl occurred (Figure 10). This area is a recharge area for the Floridan aquifer (Figure 11). During this same time, the potentiometric surface decreased to the northeast where water levels were below 15 ft above msl. Lows in the May 1986 potentiometric surface occurred at Rock and Wekiva springs and at the headwaters of the Little Wekiva River where both Palm and Sanlando springs occur. Water levels at Rock and Wekiva springs and at the headwaters of the Little Wekiva River were below 30, 20, and 30 ft above msl respectively. The springs, Rock Springs Run, Wekiva River, and Little Wekiva River occur in discharge areas for the Floridan aquifer (Figure 11).

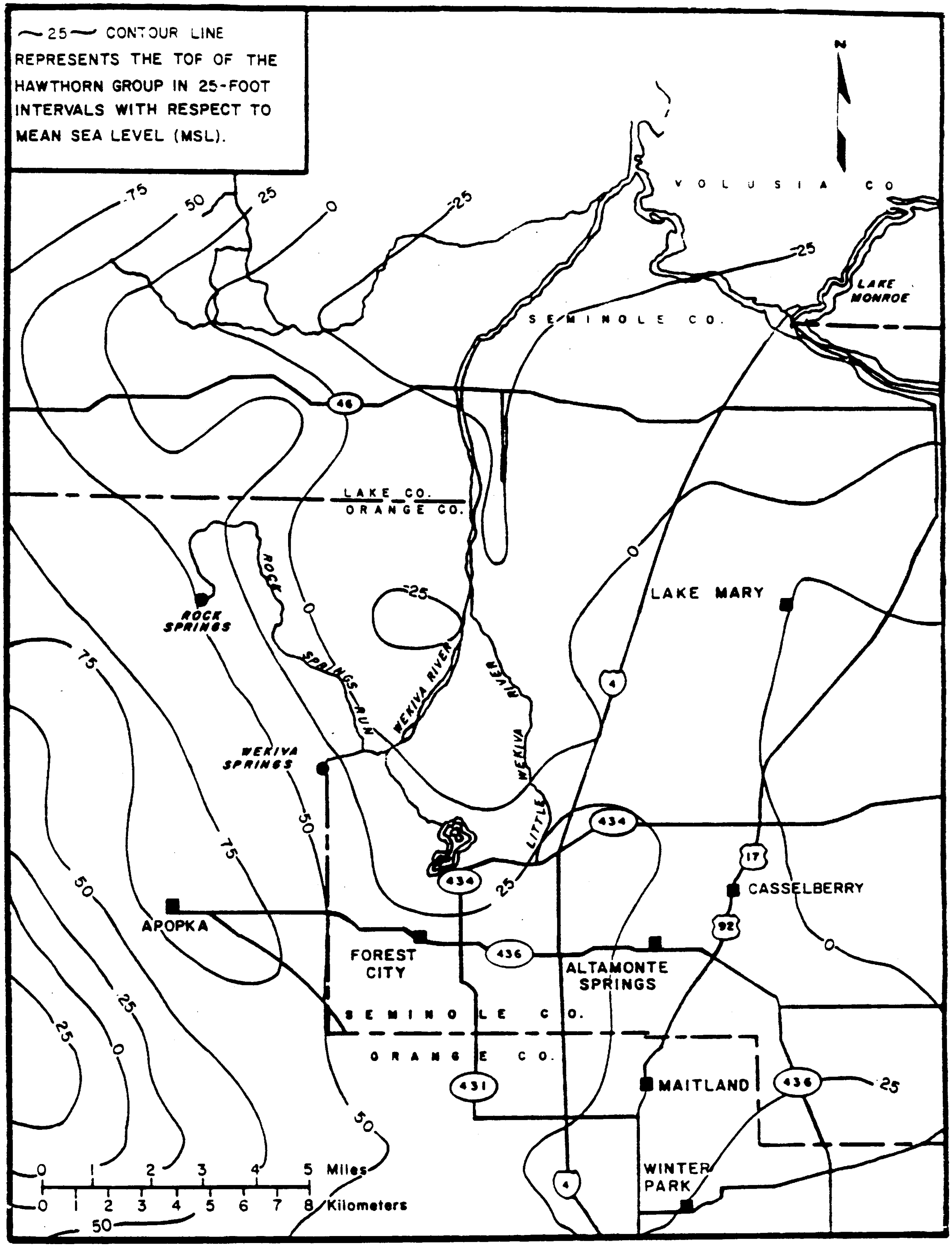

Figure 7. Top of the Hawthorn Group

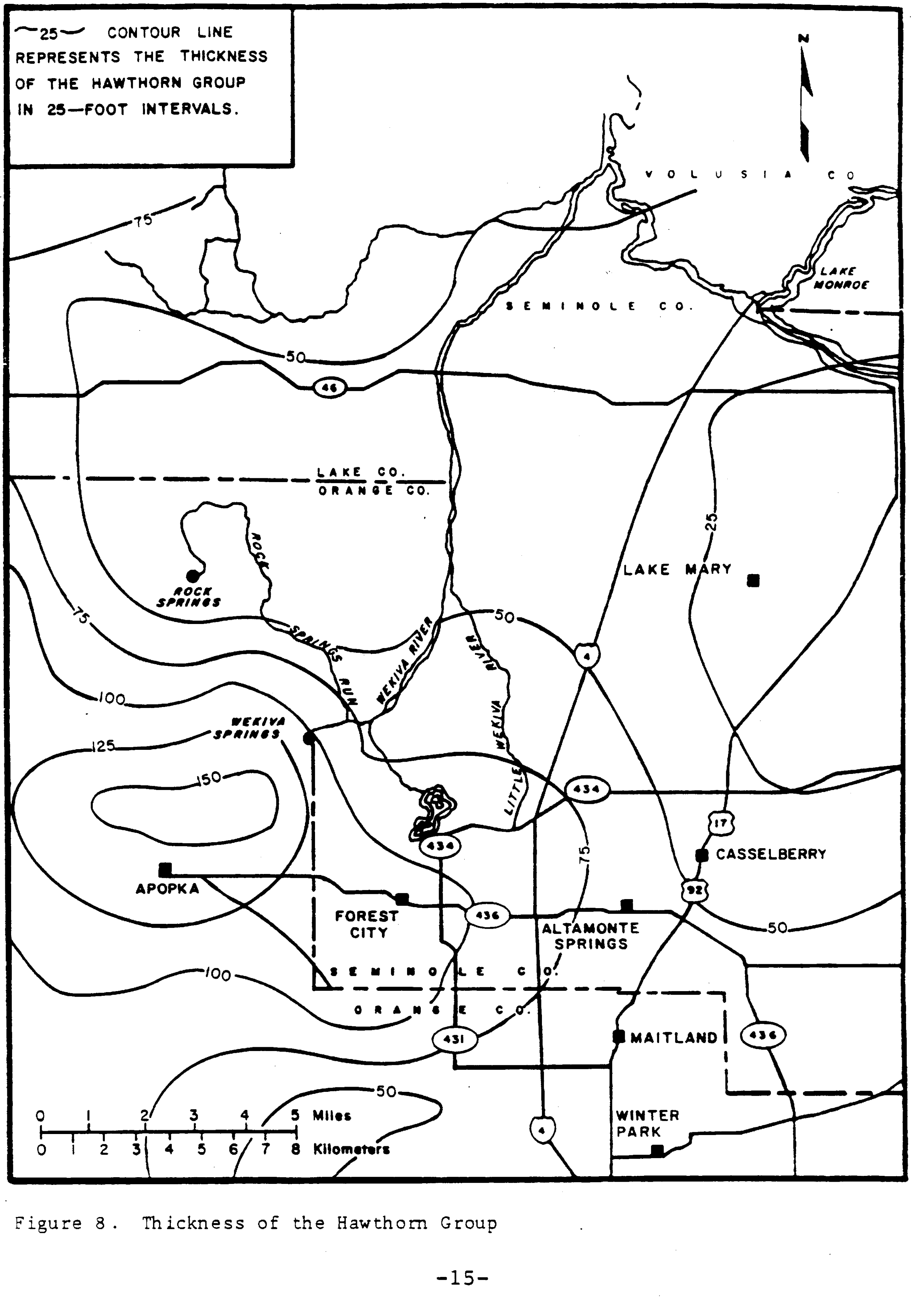

Figure 8. Thickness of the Hawthorn Group

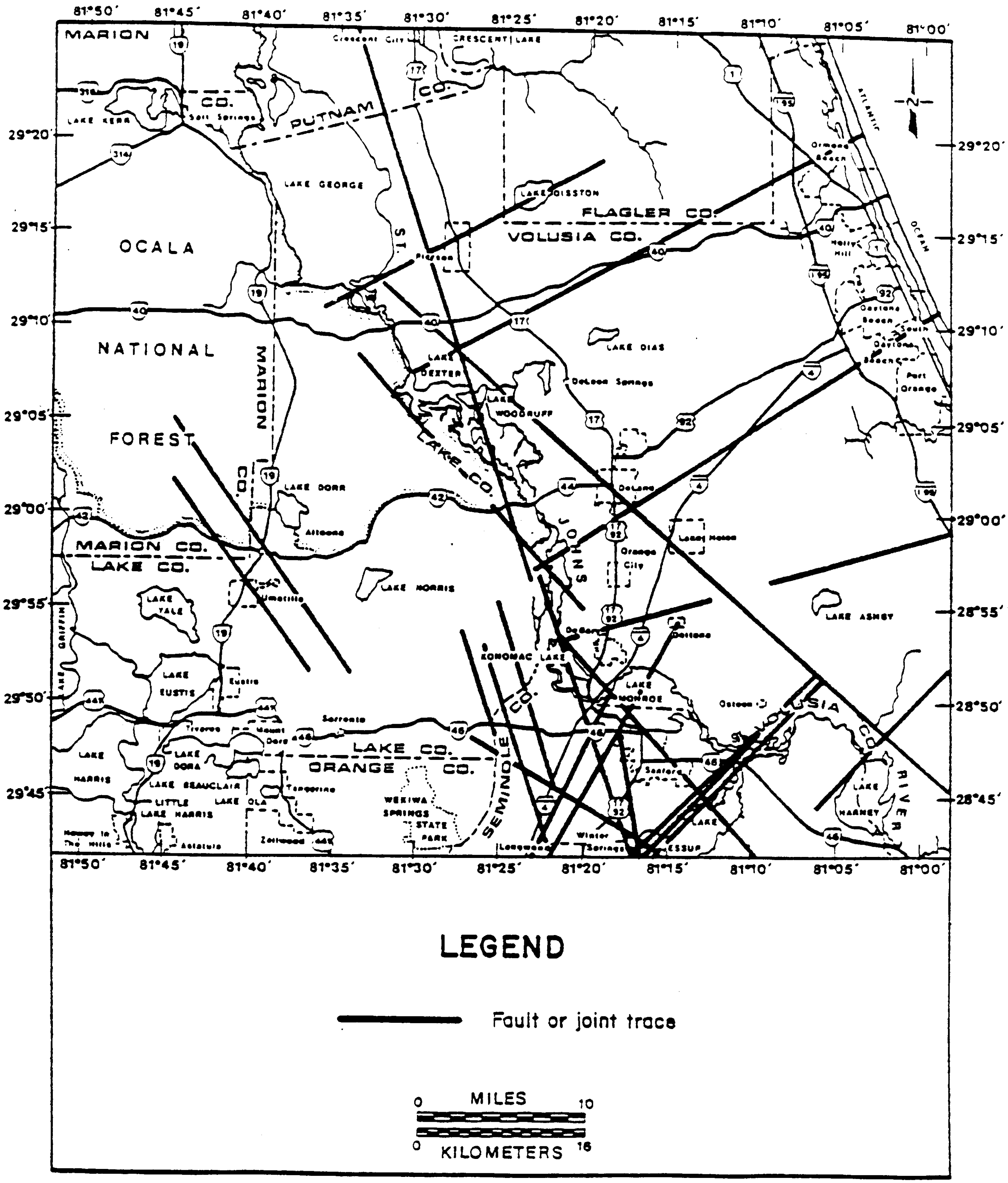

Figure 9. Location of faults and joints in Volusia, Orange, Lake, and Seminole counties (Vernon 1951)

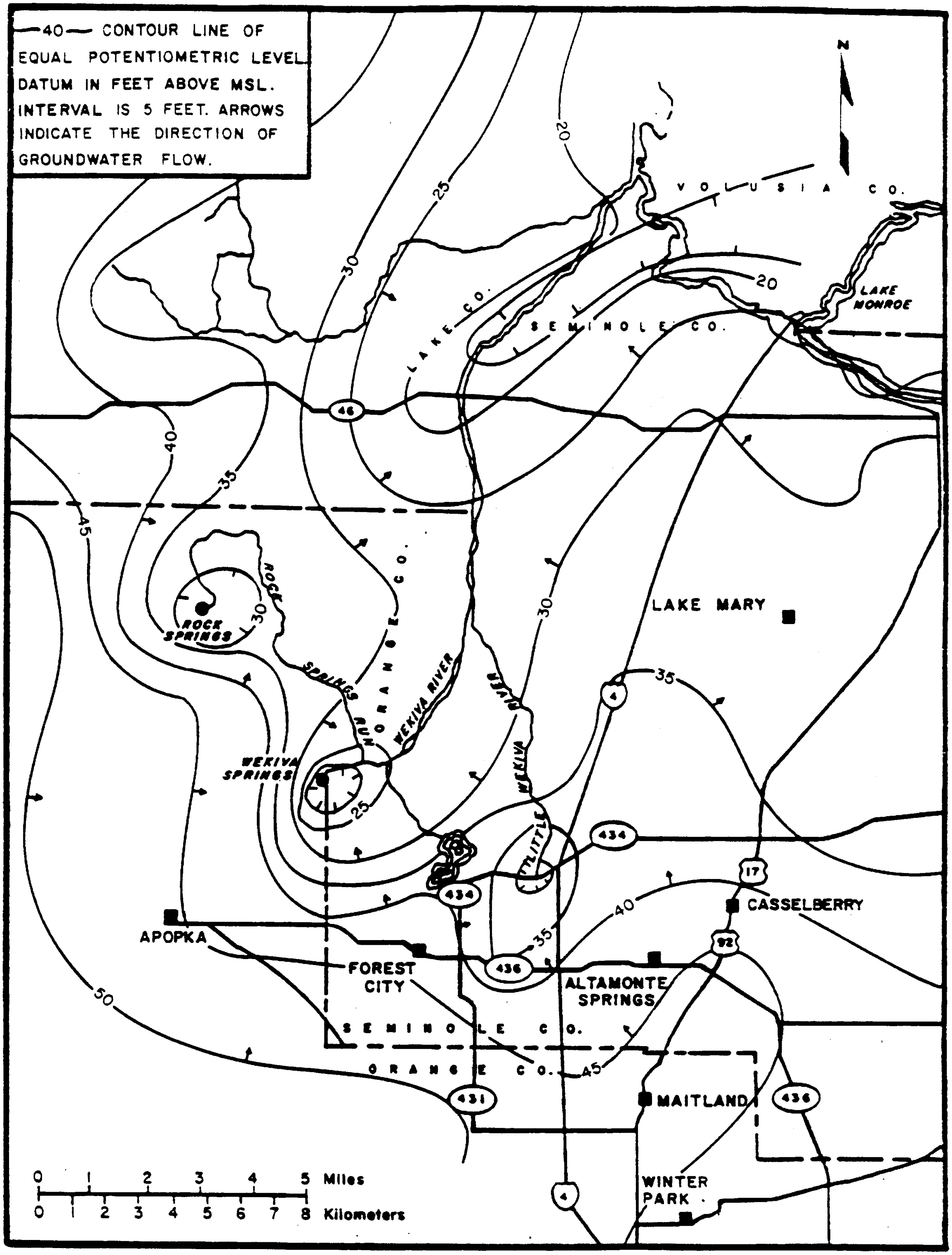

Figure 10. Potentiometric surface of the upper Floridan aquifer in the study area in May 1986 (from Schiner 1986)

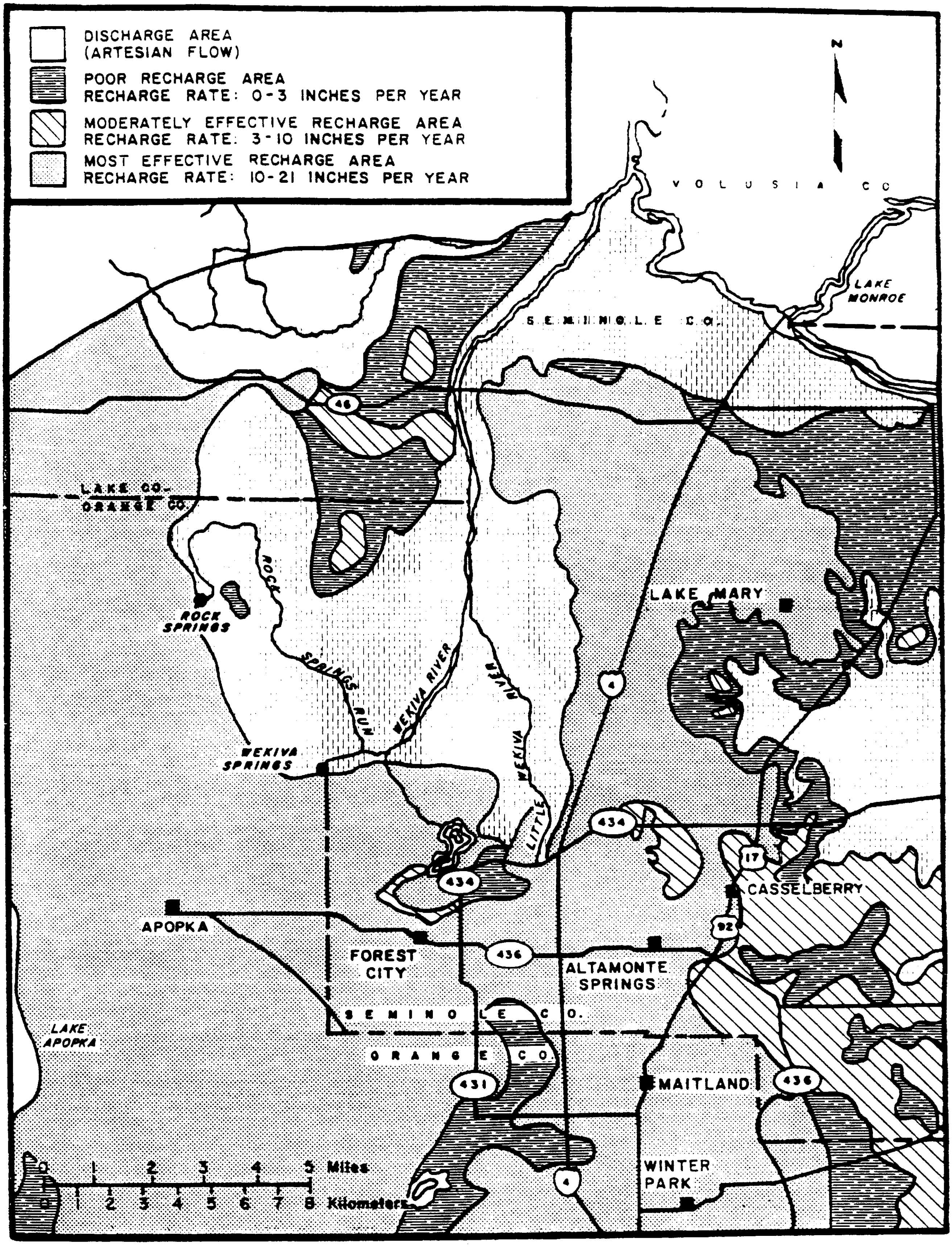

Figure 11. Areas of recharge and discharge for the upper Floridan aquifer (modified from Tibbals 1977)

Seasonal Fluctuations

The potentiometric surface fluctuates both seasonally and annually in response to recharge from rainfall and discharge from pumping wells or springs. In general, the seasonal fluctuation in the potentiometric surface of the Floridan aquifer within the study area is approximately 5 ft. The seasonal low typically occurs during the month of May as a result of the lack of rainfall during the fall, winter, and early spring, and because ground water withdrawals are typically greatest during April and May (Figure 3). The seasonal high is usually observed in September and results from increased amounts of recharge from frequent rainfall during the summer and decreased water use. Figure 12 shows the changes in the potentiometric surface of the upper permeable unit of the Floridan aquifer in the study area between May and September 1986. The largest increase occurred between Altamonte Springs and Winter Park and amounted to between 5 and 6 ft. Along Rock Springs Run, the Wekiva River, and the Little Wekiva River, the increase was less than 3 ft. In this area wells were sampled for water quality in March and October 1986.

Hydrographs (Figure 13) for three Floridan aquifer wells in the study area (Figure 14) illustrate the seasonality of water level fluctuations. The maximum recorded annual water level fluctuations are 6.00 ft at L-0006 between August 1972 and May 1986, 3.39 ft at L-0037 between May 1974 and May 1986, and 3.64 ft at S-0037 between May 1974 and September 1986. Recorded low and high water levels are 17.80 and 24.60 ft above msl at L-0006, 20.38 and 24.97 ft above msl at L-0037, and 11.03 and 15.05 ft above msl at S-0037. However, no long-term decline is evident at these wells. In 1986 water level fluctuations at L-0006, L-0037, and S-0037 were smaller than those observed for the period of record for the same wells.

Water level fluctuations between April 1972 and September 1986 and between June 1961 and September 1986 in Floridan wells OR-0058 near Wekiva Springs and OR-0170 near Rock Springs respectively (Figure 15 and 16) show no long-term decline in water levels. The large drop in water levels reported at OR-0058 in 1985 is probably due to a reporting error. Excluding this value, the mean water level at OR-0058 is 20.81 ft above msl; the standard deviation (the spread of values about the mean) is 0.61; and the 90 percent confidence interval varies about the mean from 20.62 to 21.01 ft above msl. At OR-0170, the mean water level is 34.70 ft above msl, the standard deviation is 1.56; and the 90 percent confidence interval about the mean varies from 34.29 to 35.10 ft above msl. Low water levels occurred at OR-0170 in 1977 and 1982 and either correspond to or follow periods of below normal rainfall.

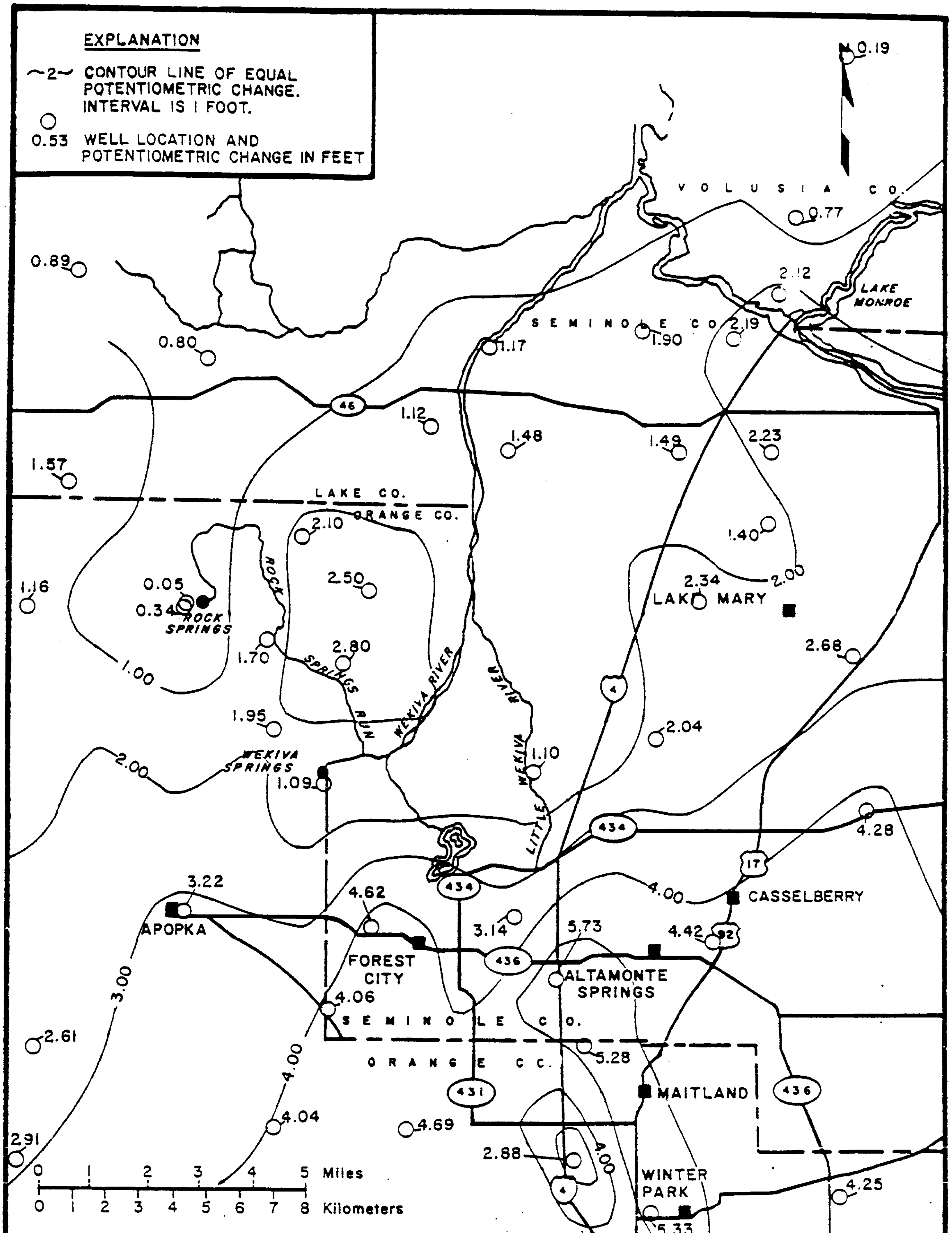

Figure 12. Change in the potentiometric surface of the upper Floridan aquifer between May and September 1986

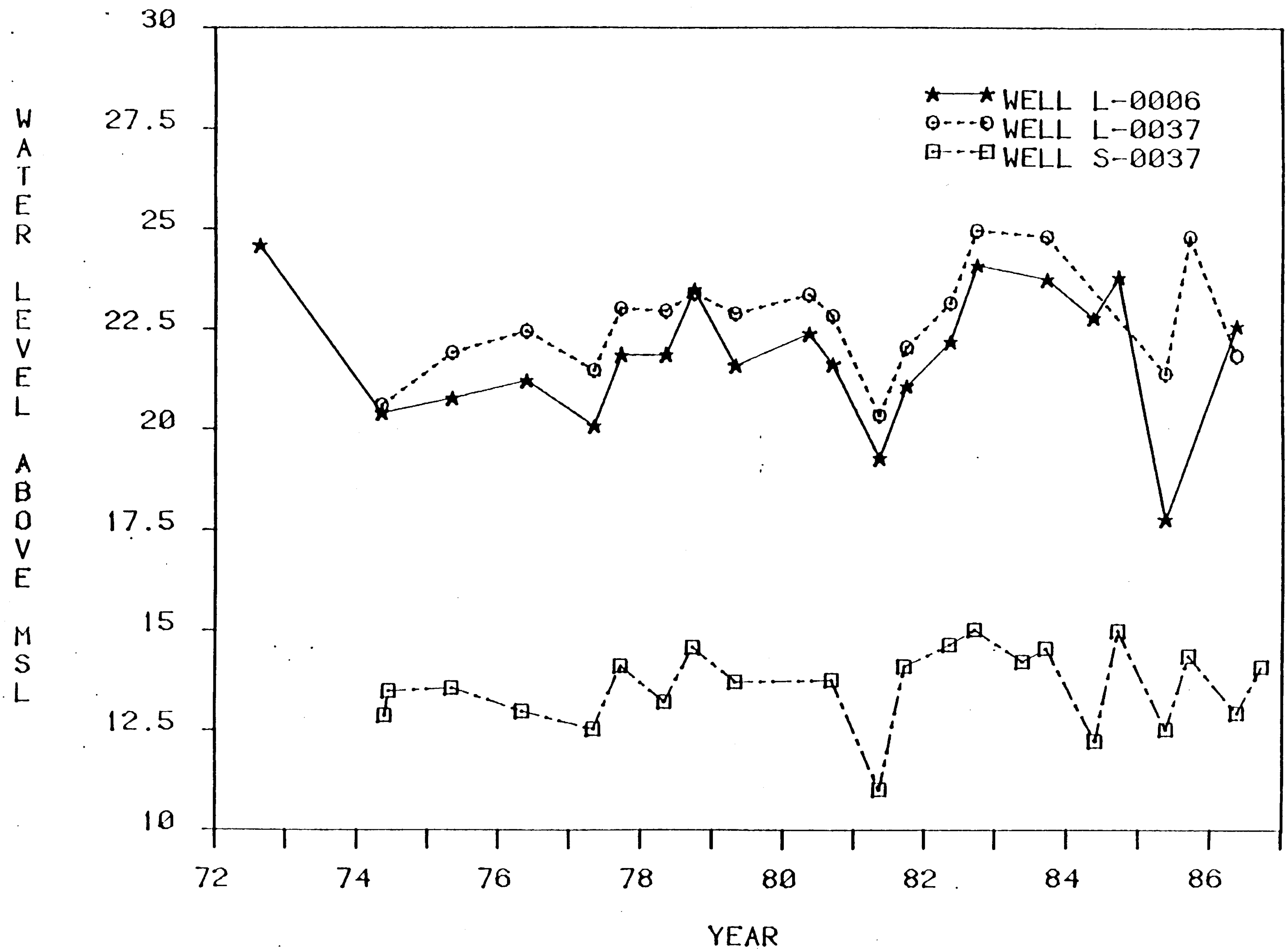

Figure 13. Water level in wells L-0006, L-0037, and S-0037

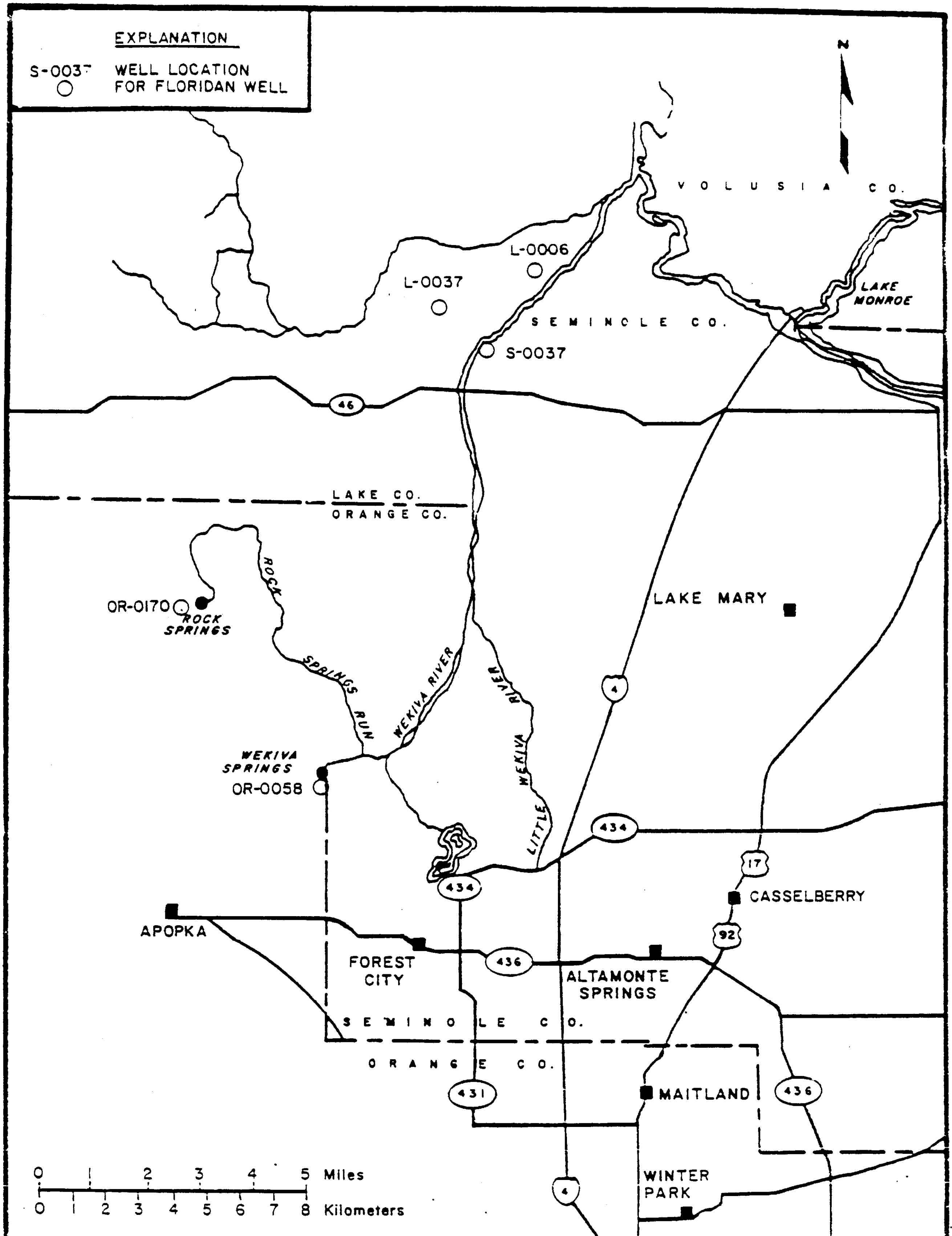

Figure 14. Location of Floridan aquifer wells L-0006, L-0037, S-0037, OR-0058, and OR-0170

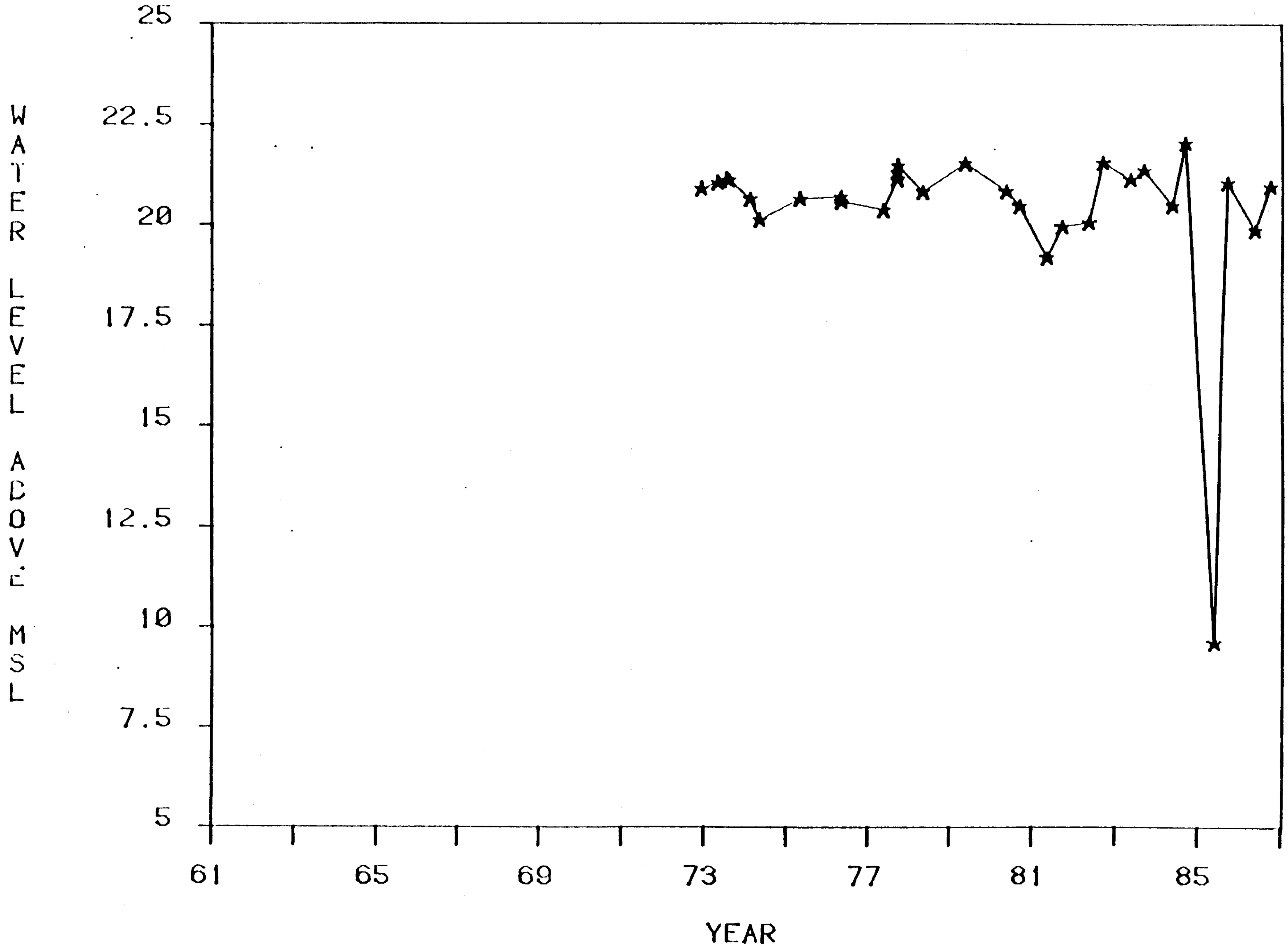

Figure 15. Hydrograph for well OR-0058 near Wekiva Springs

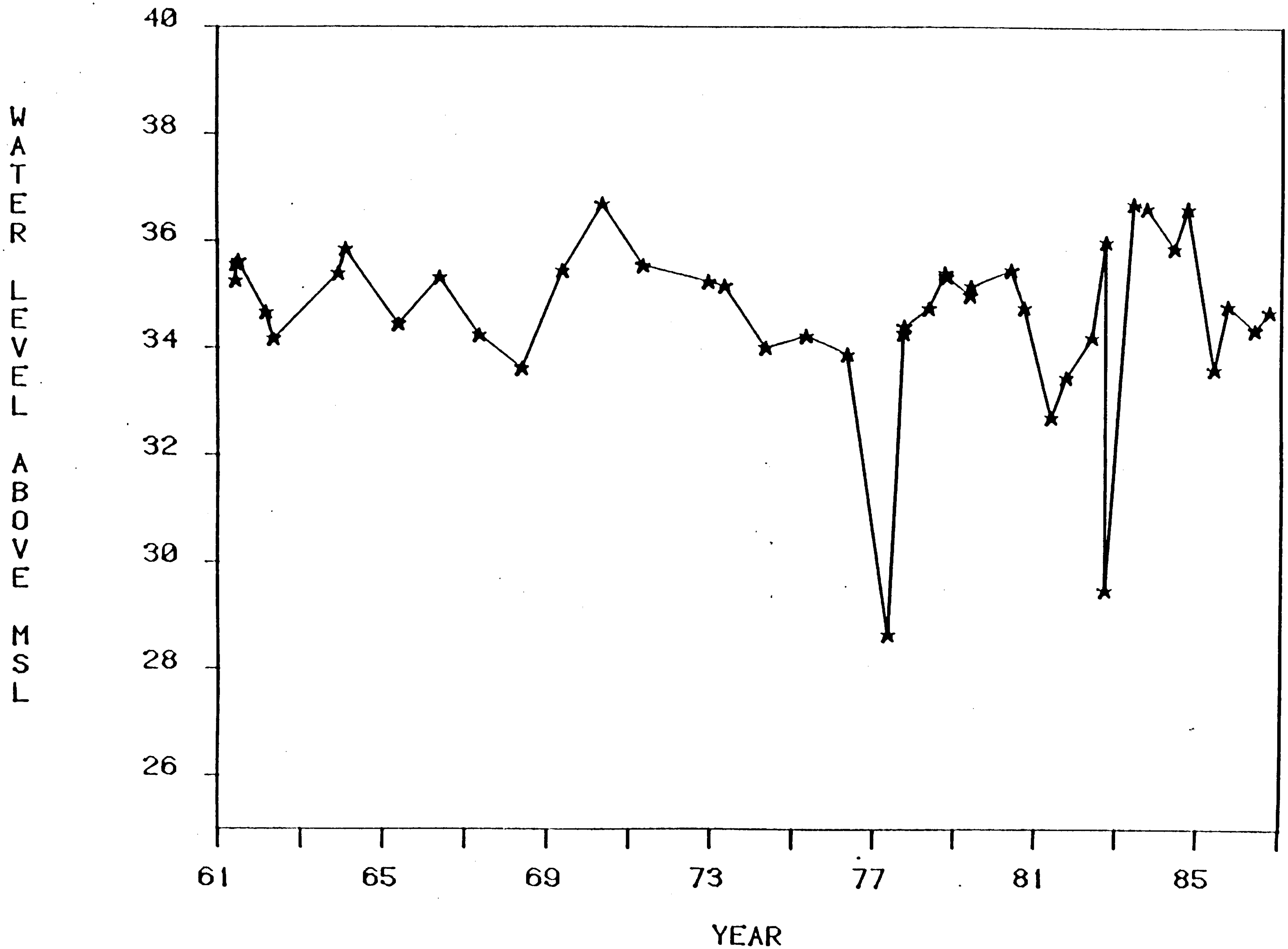

Figure 16. Hydrograph for well OR-0170 near Rock Springs

Long-Term Fluctuations

Changes in the potentiometric surface over extended periods of time may provide some insight into water level trends. Johnston and others (1980) described the potentiometric conditions of the Floridan aquifer in 1936 (Figure 17). This map was prepared from water levels collected in the early 1930s. This map is intended to show the best estimate of the "averaged" potentiometric surface. In comparison with the potentiometric map prepared in 1973 (Figure 18), water level declines range from 5 to 20 ft. Declines in the potentiometric surface could be the result of a general decline in rainfall as well as an increase in the regional withdrawal of ground water for various uses. Since 1961 rainfall at Orlando has averaged 47.95 in., or 2.93 in. below the 92-year mean. Rainfall has exceeded the mean rainfall (50.88 in.) for the period 1892 through 1984 (Jenab, Rao, and Clapp 1986) only 30 percent of the time.

The decline in the potentiometric surface of the Floridan aquifer in the study area averaged 2.0 ft between May 1973 and May 1986 (Figure 19). In a few areas, the potentiometric surface increased during this period. At Rock Springs and Wekiva Springs the potentiometric surface declined 0.82 and 1.2 ft respectively during this period. However, hydrographs of nearby wells (Figures 15 and 16) illustrate that there is no long-term decline at either spring. The largest decline in the potentiometric surface, 4.3 ft, occurs to the north of Wekiva Springs and east of Rock Springs (Figure 19).

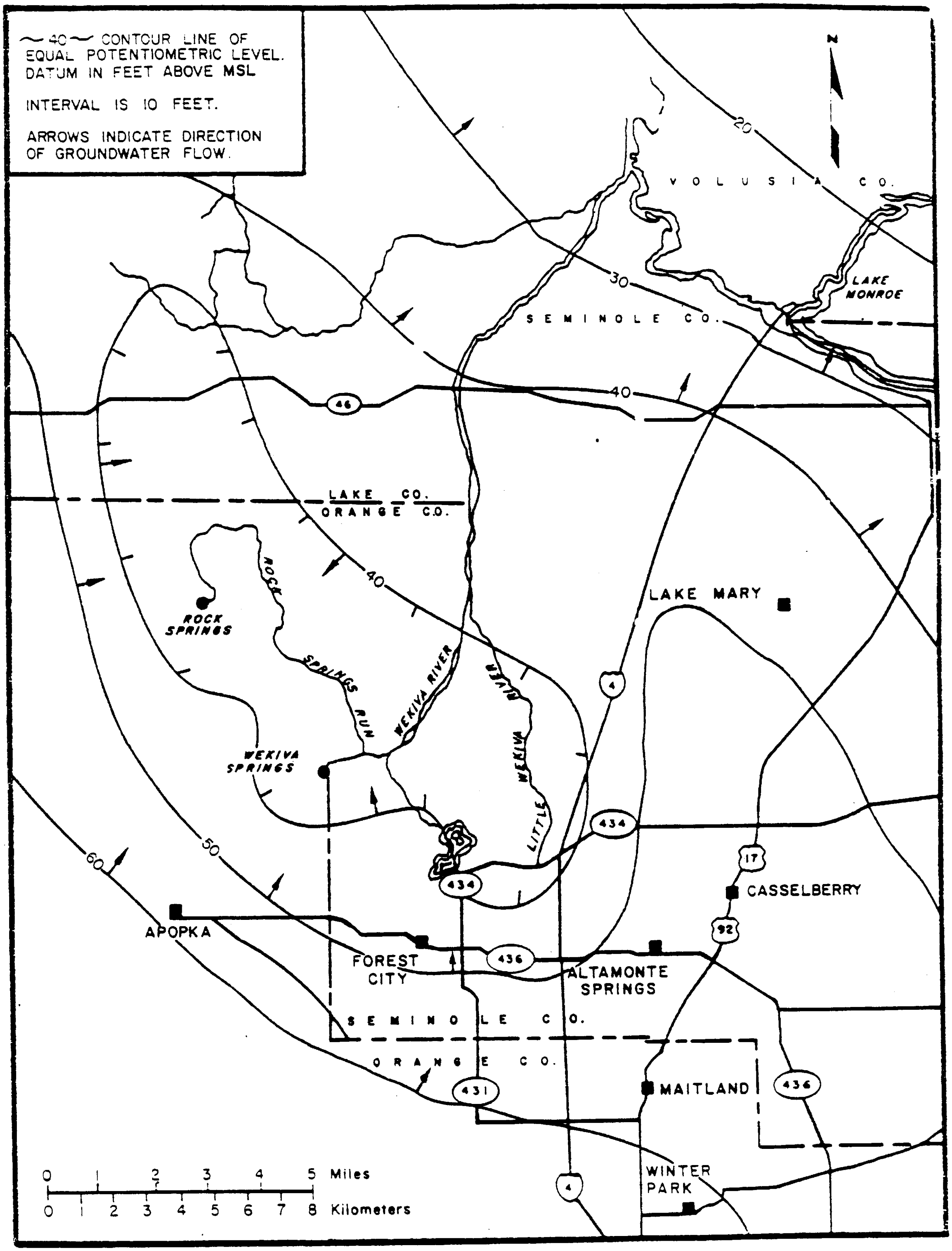

Figure 17. Estimated potentiometric surface for the tertiary limestone aquifer in 1936, compiled by Richard H. Johnston et al. (1980)

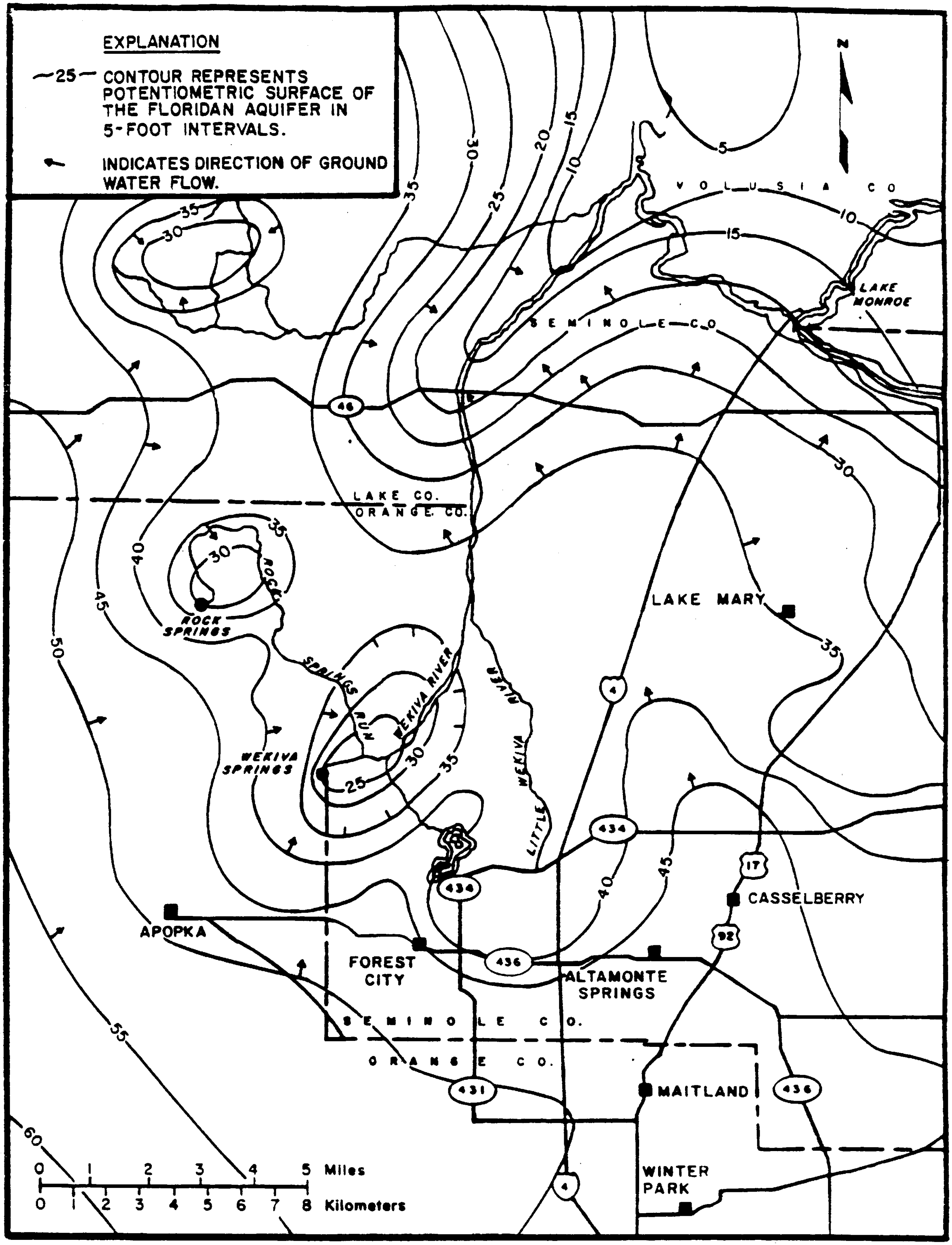

Figure 18. Potentiometric surface of the upper Floridan aquifer, May 1973 (from Tibbals 1977)

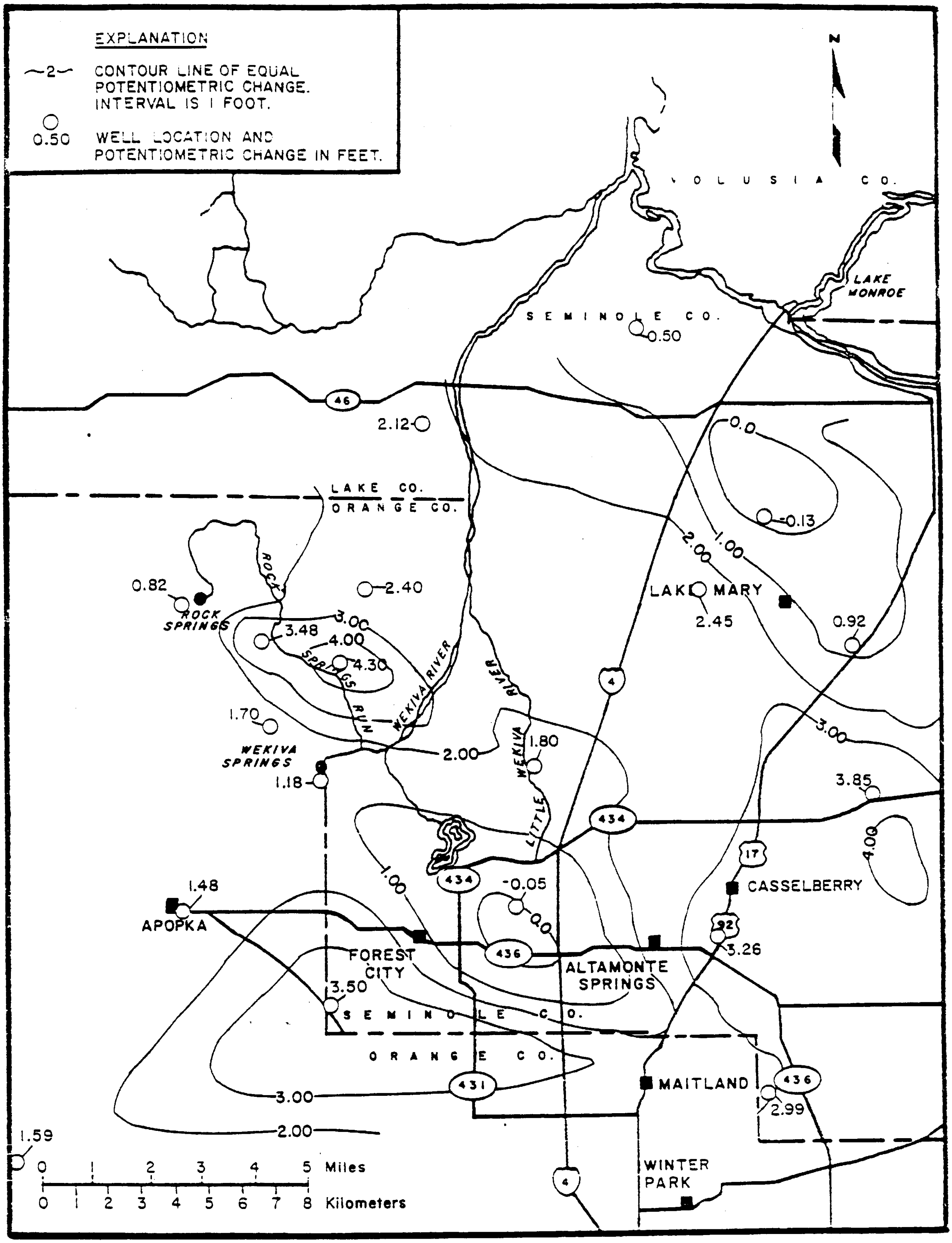

Figure 19. Change in the potentiometric surface of the upper Floridan aquifer between May 1973 and May 1986. Negative values indicate increases in water levels.

WATER QUALITY

The mineral content of ground water is dependant on the quality of water which enters an aquifer in the form of recharge, the composition of the aquifer media, and the duration of time the water is in contact with that media. Ground water quality can be affected by mixing with waters of differing quality, such as laterally intruded seawater in coastal areas and connate water (water trapped in the rocks during deposition) found in inland areas.

During this study 30 water samples were collected from wells which tap the Floridan aquifer (Table 2). These samples were collected from the wells after the wells had been purged. The majority of samples collected were from domestic supply wells. The water samples were analyzed for major ions including total dissolved solids (TDS), pH, specific conductivity, and temperature. Water samples were collected from the same wells in March and in October of 1986.

Table 3 shows the concentrations of chloride, hardness, sulfate, and iron for all wells sampled during March and October 1986 and between April 1973 and July 1974. Water from the wells sampled ranged from fresh for water used for domestic purposes to brackish for water used for irrigation. In March 1986 concentrations ranged from 4 to 1810 mg/l for chloride, 80 to 1245 mg/l as $CaCO_3$ for hardness, 4 to 540 mg/l for sulfate, and 50 to 3020 μg/l for iron. The U.S. Environmental Protection Agency (EPA) recommends a maximum chloride and sulfate concentration of 250 mg/l and an iron concentration of 300 μg/l for public drinking water. (The State of Florida has adopted 250 mg/l as a primary drinking water standard for chloride for public water supplies. Chapter 17-550 F.A.C.).

Hardness is caused by polyvalent cations, primarily calcium and magnesium, and is expressed as the equivalent quantity of calcium carbonate. Water is classified as soft if its hardness ranges between 0 and 75 mg/l as $CaCO_3$, hard for 150 to 300 mg/l as $CaCO_3$, and very hard for values above 300 mg/l as $CaCO_3$ (EPA 1976). No recommended potable water limit for hardness has been established by the EPA.

CHLORIDE CONCENTRATION

Chloride is a major dissolved constituent of most natural water. Chlorides found in ground water are derived from several different sources. Within the Floridan aquifer the predominate sources of

TABLE 2. Wells sampled in the Wekiva River study area

County	Well Owner	Well ID	LAT	LONG	SSTTRRQQ	Case DEP	Well DEP	Well DIA	Elev LSD	Elev msl	Aquifer	Well Type
Lake	Wekiva Falls	L-0048	284740	812517	1 33192900	80	120	24.00		20.00	CONFINED	RECREATION
	Wekiva Falls	L-0049	284740	812517	2 33192900	58	107	14.00		20.00	CONFINED	RECREATION
	Woodard	L-0073	284747	812515	1 33192900	75	130	2.00		32.00	CONFINED	DOMESTIC
	Pete Dorton Barn	L-0047	284753	812621	2 321929NE	80	133	10.00		27.00	CONFINED	UNUSED
	Mock	L-0076	284800	812523	1 28192900	60	131	2.00		43.00	CONFINED	DOMESTIC
	Lewis Gun Range	L-0046	284805	812637	1 301929SE	100	190	3.00		63.00	CONFINED	DOMESTIC
	Ray	L-0074	284839	812537	1 29192900	75	130	2.00		45.00	CONFINED	DOMESTIC
	Shorr	L-0075	284840	812533	1 28192900	80	235	2.00		46.00	CONFINED	DOMESTIC
	Major Realty	L-0038	284933	812558	1 201929NE	78	92	4.00	49.00	1.20	CONFINED	TEST
	Major Realty	L-0037	285028	812533	1 00192900	105	360	4.00	1.00	41.02	CONFINED	TEST
	Major Realty	L-0032	285057	812432	1 00192900	96	125	4.00	2.00	23.00	CONFINED	TEST
	Major Realty	L-0006	285106	812348	1 001929NE	101	103	4.00	15.00	16.90	CONFINED	TEST
Orange	Fla Wekiva Preserve	OR0035	284429	812720	1 192029NW	91	94	3.00	22.00	22.00	CONFINED	UNUSED
	Fla Wekiva Preserve	OR0054	284541	812652	1 072029SW	90	94	2.00		28.00	CONFINED	UNUSED
	Fla Wekiva Preserve	OR0067	284635	812753	1 012028SW	74	84	2.00		33.00	CONFINED	FIRE
	Fla Wekiva Preserve	OR0060	284636	812618	1 07202900	75	120	2.00			CONFINED	DOMESTIC
	P. Dorton-Hollywood	OR0061	284652	812519	1 04202900	60		10.00		30.00	CONFINED	IRRIGATION
Seminole	Nydam	S-0058	284300	812356	1 27202900	40	120	2.00		15.00	CONFINED	DOMESTIC
	Rock	S-0057	284317	812345	1 27202900	45	120	2.00		15.00	CONFINED	DOMESTIC
	Rodgers	S-0088	284804	812450	1 28192900	90	150	2.00		17.00	CONFINED	DOMESTIC
	Jett	S-0089	284806	812439	1 28192900	125	150	2.00		46.00	CONFINED	DOMESTIC
	Harris	S-0090	284807	812430	1 27192900	130	150	2.00		53.00	CONFINED	DOMESTIC
	M.Seckinger Resid	S-0091	284829	812459	1 28192900	75	160	2.00		25.00	CONFINED	DOMESTIC
	M.Seckinger Pasture	S-0092	284835	812443	2 28192900	80	120	2.00		30.00	CONFINED	DOMESTIC
	Morman Gary	S-0093	284838	812501	1 28192900	75	120	2.00		32.00	CONFINED	DOMESTIC
	LA Smith	S-0094	284839	812433	1 28192900	80	120	2.00		58.00	CONFINED	DOMESTIC
	Ranger N Dwelling	S-0098	284902	812419	1 30192200	110	130	2.00		53.00	CONFINED	DOMESTIC
	WN Hoffman	S-0095	284906	812505	1 39192900	-	40	2.00		30.00	CONFINED	DOMESTIC
	Fernandez C.M.	S-0037	284945	812442	1 39192900	-	41	2.00	11.03	12.03	CONFINED	UNUSED
	Wekiva River Haven	S-0097	285001	812423	1 39192900	110	120	4.00		23.00	CONFINED	DOMESTIC

TABLE 3. Chloride, hardness, sulfate, and iron concentrations in sampled wells for the period April 1973 to July 1974, March 1986, and October 1986

COUNTY	WELL OWNER	WELL ID	LAT	LONG	Chlorides mg/l Apr 73-Jul 74	Chlorides mg/l Mar 86	Chlorides mg/l Oct 86	Hardness mg/l Apr 73-Jul 74	Hardness mg/l Mar 86	Hardness mg/l Oct 86	Sulfate mg/l Apr 73-July 74	Sulfate mg/l Mar 86	Sulfate mg/l Oct 86	Iron μg/l Apr 73-Jul 74	Iron μg/l Mar 86	Iron μg/l Oct 86
Lake	Wekiva Falls	L-0048	284740	812517	240	296	300	370	400	-	200	210	230	0	50	20
	Wekiva Falls	L-0049	284740	812517		312	300		390	-		210	210		-	-
	Woodard	L-0073	284747	812515		352	340		440	-		225	220		50	60
	Dorton's Barn	L-0047	284753	812621		57	71		190	-		50	57		188	540*
	Mock	L-0076	284800	812523		244	220		370	-		190	190		50	120
	Lewis Gun Rng	L-0046	284805	812637		61	81		220	-		70	80		150	50
	Ray	L-0074	284839	812537		368	340		460	-		245	230		111	1000
	Shorr	L-0075	284840	812533		256	240		400	-		200	180		50	170
	Major Realty	L-0038	284933	812558	282	176	220	420	308	-	165	145	150	210	452	430
	Major Realty	L-0037	285028	812533	111	61	-	378	330	-	68	50	-	0	137	-
	Major Realty	L-0032	285057	812432	2160	-	750	576	-	-	130	-	200	0	-	70
	Major Realty	L-0006	285106	812348	2310	672	740	576	540	-	265	245	230	100	77	380
Orange	Fl Wek. Pres.	OR0035	284429	812720	40	45	77	156	150	-	45	18	50	20	50	10
	Fl Wek. Pres.	OR0054	284541	812652	200	208	220	324	900	-	180	145	160	30	50	60
	Fl Wek. Pres.	OR0067	284635	812753		57	40		270	-		150	160		50	20
	Fl Wek. Pres.	OR0060	284636	812618		176	190		330	-		365	220		50	20
	P. Dorton-Hollywood	OR0061	284652	812519		280	270		390	-		210	210		50	140
Seminole	Nydam	S-0058	284300	812356		82	90		210	-		65	97		50	10
	Rock	S-0057	284317	812345		93	110		240	-		100	120		61	10
	Rodgers	S-0088	284804	812450		23	150		-	-		8	47		59	20
	Jett	S-0089	284806	812439		6	8.5		100	-		10	4.7		2630	30
	Harris	S-0090	284807	812430		4	13		80	-		12	11		128	100
	M. Seckinger-Res.	S-0091	284829	812459		304	320		410	-		190	190		50	60
	" - Pasture	S-0092	284835	812443		6	15		130	-		4	5.2		3020	3400
	Gary Morman	S-0093	284838	812501		370	370		450	-		225	220		153	1400
	LA Smith	S-0094	284839	812433		5	82		130	-		15	40		60	100
	Ranger N. Dwelling	S-0098	284902	812419		11	21		130	-		14	26		50	20
	WN Hoffman	S-0095	284906	812505		363	420		460	-		-	240		157	100
	Fernandez, C.	S-0037	284945	812442	1100	720	700	500	545	-		205	140	50	121	250
	Wekiva River Haven	S-0097	285001	812423		1810	2000		1245	-		540	580		50	60

chloride are the solution of evaporite minerals when present in the aquifer media and/or mixing of connate water or laterally intruded seawater with fresh water.

Chloride is a conservative element and therefore is relatively free from the processes of ion exchange, adsorption, and biological activity. Thus, chlorides can be used to map the occurrence of saline water as well as to locate the areas where waters of different salt contents mix.

Figure 20 shows chloride concentrations of water from the upper permeable zone of the Floridan aquifer in March 1986. Generally, the highest concentrations of chloride are in the discharge areas along the Wekiva River. East of the Wekiva River chloride concentrations change very rapidly from less than 50 to more than 250 mg/l as the Wekiva River is approached.

Seasonal Fluctuations

Chloride concentrations in water withdrawn from the sampled wells ranged from 4 to 1810 mg/l in March and 8.5 to 2000 mg/l in October. However, chloride concentration, in water from most of the sampled wells was less than 425 mg/l. A comparison of chloride concentration data for March and October (Figures 20 and 21) showed an increase in the size of the 100-250 mg/l chloride region and a movement southward in October. The area within the 250 mg/l isochlor, however, remained approximately the same.

Chloride concentrations in 19 of the 30 wells sampled increased from March to October 1986 (Table 3). The increases ranged from 4 to 190 mg/l and represent 1 to 1540 percent of the March values. The largest percentage increase is from a well where the chloride concentration increased from 5 to 82 mg/l and probably reflects inaccurate data. Increases in chloride concentration were not confined to wells with a specific concentration range but occurred in wells with concentrations of (1) less than 25 mg/l, (2) 25-100 mg/l, (3) 101-250 mg/l, (4) 251-1000 mg/l, and (5) 1000-4000 mg/l. Tibbals (1977) used the same groupings in his study. The number of wells in each range where chlorides increased is six, five, three, four, and one respectively. The largest percentage increase in chloride concentration occurred in wells where chlorides were less than 25 mg/l.

Chloride concentrations decreased in 8 of the 30 wells sampled (Table 3). The declines ranged from 10 to 28 mg/l and represent 2.8 to 30 percent of the March values. Chloride concentrations decreased in six wells in the 251-1000 mg/l range and in two wells in the 101-250 mg/l range. Of the remaining three wells that were sampled, two were only sampled once. Chloride concentrations (370 mg/l) in the third well did not change between March and October.

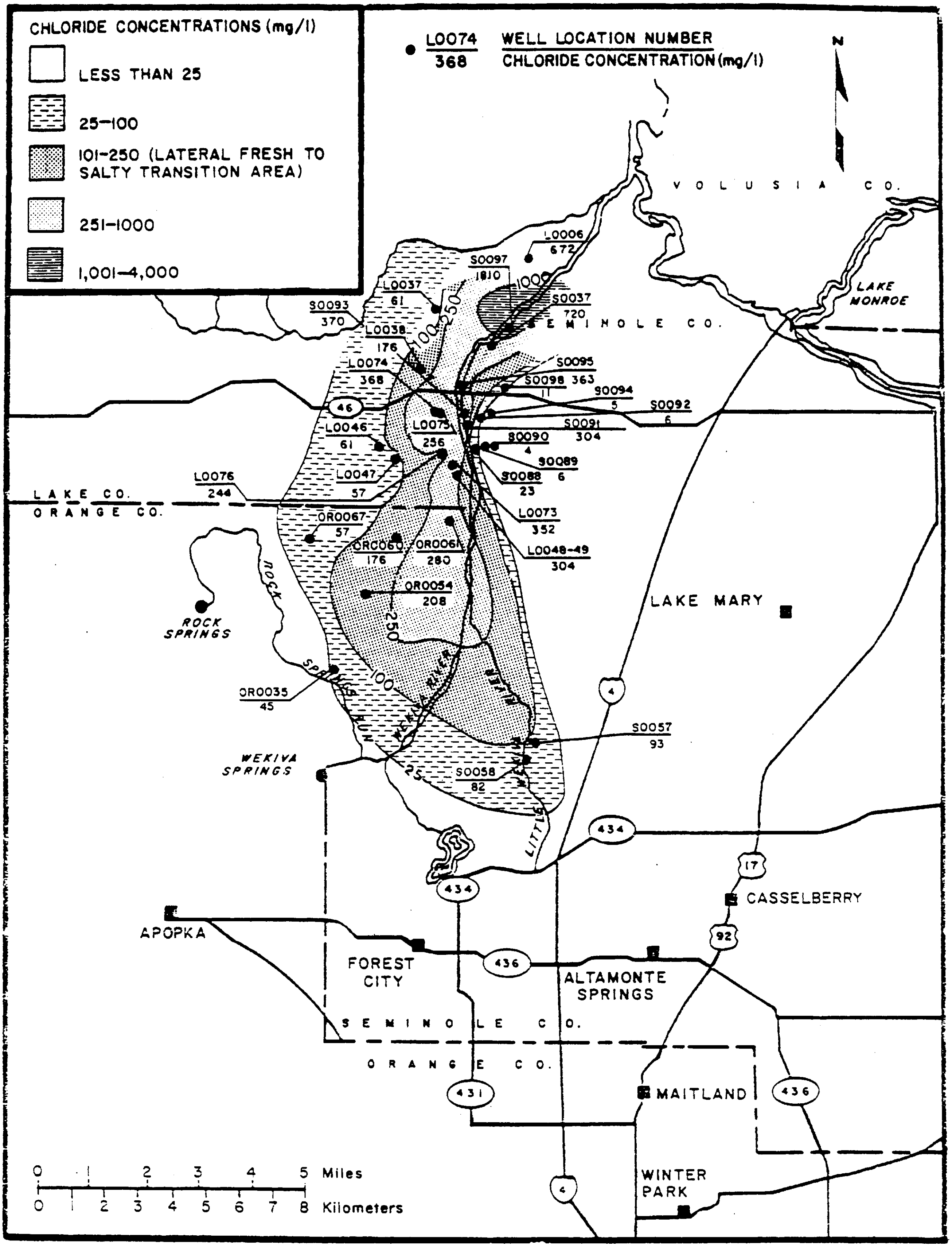

Figure 20. Chloride concentrations in water from the upper Floridan aquifer in the Wekiva River area, March 1986

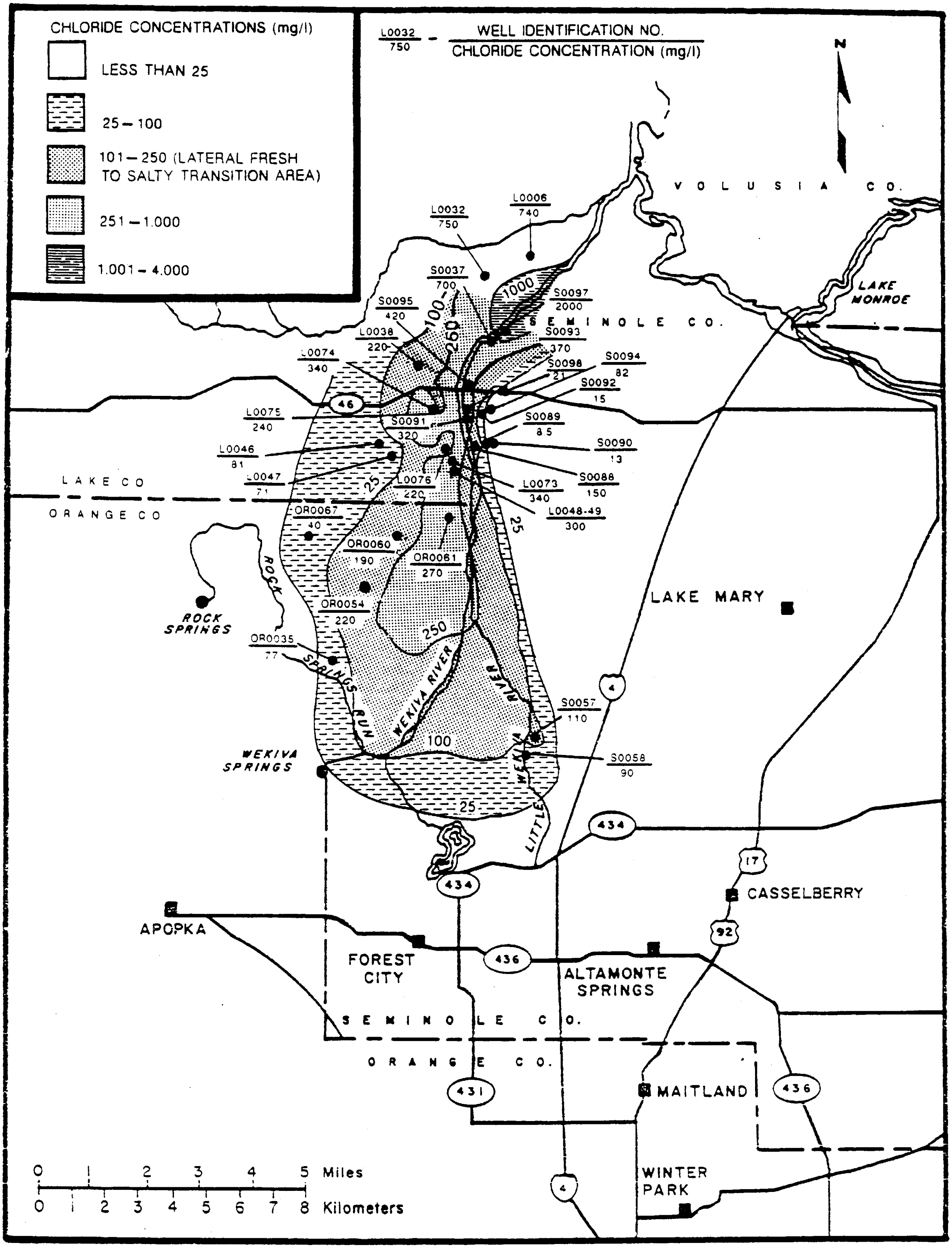

Figure 21. Chloride concentrations in water from the upper Floridan aquifer in the Wekiva River area, October 1986

Generally chlorides decrease when potentiometric levels rise and increase when potentiometric levels fall. However, a direct comparison with water levels is not possible because both water level measurements and ground water sampling were neither synchronous nor from the same well. In fact, the potentiometric surface in the Floridan aquifer in the sampled area was 0-3 ft higher in September than in May.

There was a larger mean chloride concentration in October than in March. The mean and standard deviation for chloride concentration in wells where chloride concentrations were less than 425 mg/l were 157 and 136 mg/l in March and 175 and 129 mg/l in October respectively. The mean chloride concentration was 18 mg/l larger in October than in March. Most of this difference occurred in wells where the chloride concentration was between 101 and 250 mg/l in October. Chloride concentrations above 425 mg/l were not included in the above statistics because these values are statistically considered to be outliers.

Long-Term Trends

In an effort to evaluate long-term changes in water quality for the study area, eight wells sampled by Tibbals (1977) during the period of April 1973 to July 1974 were located and resampled for water quality analysis. Chloride concentrations in the Floridan aquifer for the period of April 1973 to July 1974 were above 250 mg/l along the Wekiva River in Lake and Seminole counties (Tibbals 1977). In Orange County, the area adjacent to the Wekiva River had chloride concentrations between 101 and 250 mg/l (Figure 22). The extent of the area where chlorides are greater than 250 mg/l is the main difference between the chloride maps for April 1973 to July 1974 (Figure 22) and March 1986 (Figure 20). The increase in the size of this area in March 1986 is due to the sampling of well OR-0061, which was not sampled previously. Its chloride concentration was 280 mg/l in March 1986. There was no other change in the distribution of chloride concentrations although wells with chloride concentrations greater than 250 mg/l showed marked declines in concentration and wells with chloride concentrations less than 250 mg/l showed some increases.

As shown in Table 3, five of the eight wells sampled showed declines in chloride concentration, three of the other wells showed increases. The declines ranged from 50 to 1638 mg/l and represented 35 to 71 percent of the former values. Four of the five wells where chloride concentrations decreased had chloride concentrations greater than 250 mg/l. The remaining well had a chloride concentration of 111 mg/l.

Chloride concentrations increased in three wells where concentrations during the period April 1973 to July 1974 were less than 250 mg/l. The increases were 5, 8, and 56 mg/l and represented 13, 4, and 23 percent of the former values respectively. Only the last increase was statistically significant.

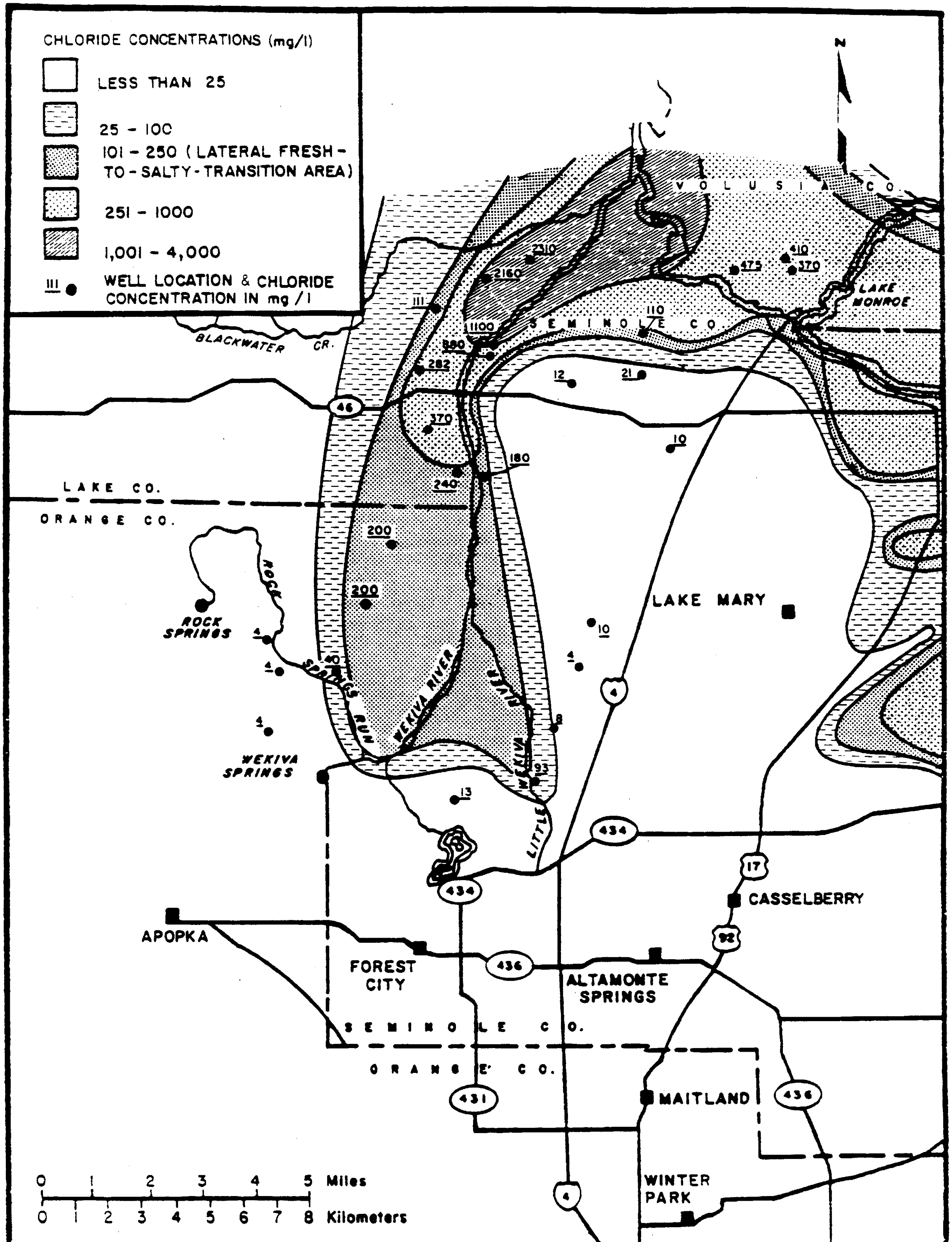

Figure 22. Chloride concentrations in water from the upper Floridan aquifer in the Wekiva River area, April 1973 to July 1974

CLASSIFICATION OF WATER TYPES

Figure 23 shows a trilinear diagram (Piper 1944 and Frazee 1982) for the water quality data collected during March of 1986. The water type or classification depends on the relative chemical composition of both anions and cations in the sample. As such, it is different from classifications based solely on chloride concentration. Fresh waters are indicated by the dominance of calcium and bicarbonate. These waters plot to the left side of the trilinear diagram. Samples plotting to the left contain less than 25 mg/l of chloride and sulfate and generally tend to be located on the east side of the Wekiva River, in or near the most effective recharge areas. Connate waters are indicated by dominant sodium-calcium-chloride-sulfate. Water quality located to the right side of the trilinear diagram indicates connate water. Typically, connate waters have high concentrations of chloride and total dissolved solids and are generally located in discharge areas. Transitional and transitional connate type waters have relative chemical compositions lying between fresh and connate. These waters result from the mixing which occurs between connate and fresh water in this area. Transitional waters are found in the moderate to poor recharge areas (Figure 24).

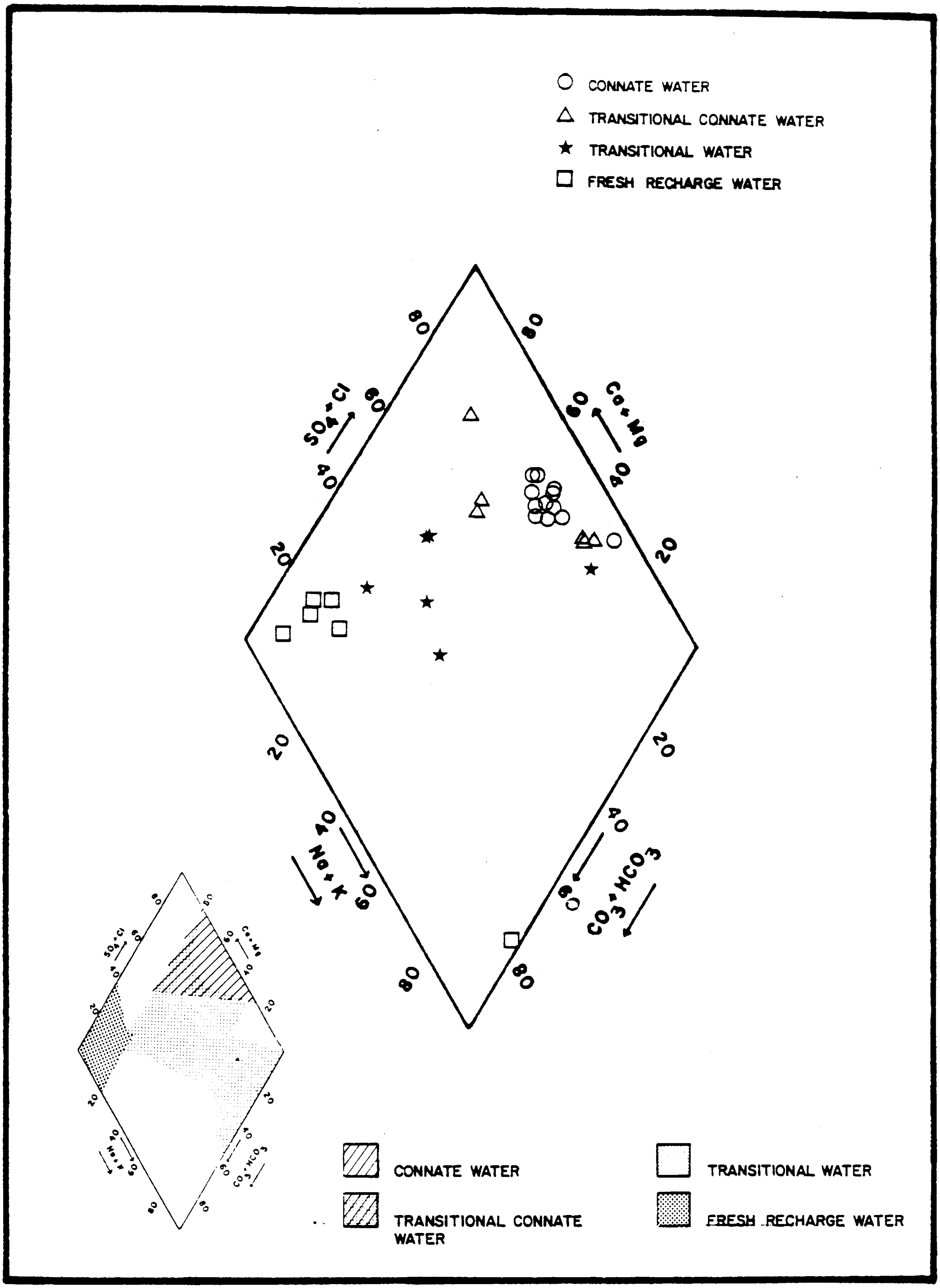

Figure 23. Piper trilinear diagram of water chemistry from wells in the Wekiva River area

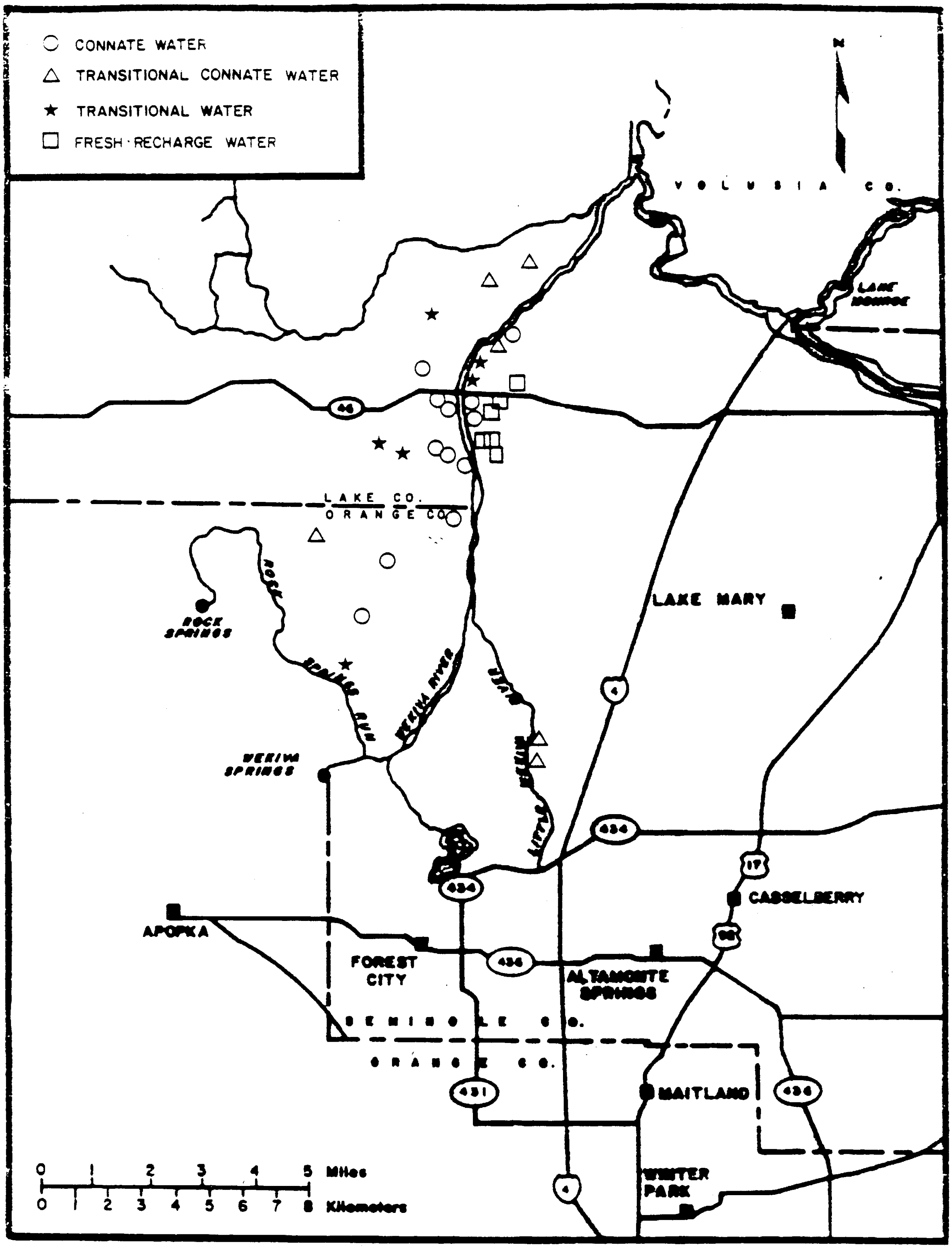

Figure 24. Water type and location of sampled wells in the Wekiva River area

SUMMARY

The Wekiva River basin is situated in an area where portions of the Floridan aquifer contain salt water. Piper trilinear analysis of the water indicates these waters are transitional connate and connate water.

Tibbals (1977) evaluated the effects of increased ground water withdrawals on the quantity and quality of water in the Floridan aquifer in Seminole County. Eight wells used in Tibbals (1977) study were located and resampled during this study.

Thirty wells were sampled and analyzed for major ions and metals in March and October 1986. The mean chloride concentration of the wells sampled in 1986, where chloride concentration was below 425 mg/l, was 18 mg/l higher in October than in March 1986. Most of the difference is due to the chloride concentration of wells located in the region where concentrations varied between 101 and 250 mg/l. Tibbals (1977) called this region a "lateral freshwater-salty water transition area." He postulated that the vertical position of the zone of diffusion between fresh and salty water is at the top of the Floridan aquifer in this region and that the chloride concentration of wells in this region would probably vary seasonally. Coincident with an increase in chlorides is higher water use during the October sampling period than during the March sampling period. Water withdrawn for public supply in the study area was 6 mgd greater during the October sampling period than during the March sampling period (Marella pers. com. 1988). Water quality samples were collected from wells for self-supplied domestic use. Presumably, water withdrawn for self-supplied domestic use is similar to the trend of water withdrawn for public supply in the study area. The higher chlorides in October compared to March may be due to increased ground water withdrawals during the October sampling period.

In Seminole County, Tibbals (1977) observed a slight increase in chloride concentration in the Floridan aquifer between samples collected in 1951 and 1956 and samples collected in 1973 and 1974. The increase occurred in areas where chloride concentrations varied between 101 and 250 mg/l. Variations in chloride concentrations may be related to the vertical movement of the freshwater/saltwater interface (Tibbals 1977).

The majority of wells sampled in the Wekiva River basin are completed into the Ocala Limestone. Casings for these wells are either set in the Hawthorn Group or at the top of the Ocala Limestone. The remainder of the well is completed as open hole.

The potentiometric surface of the Floridan aquifer was 1-5 ft lower in the area where wells were sampled for water quality in May 1986 than May 1973. However, no long-term decline is evident in the hydrographs for five wells in the study area (Figures 13, 15, 16). To determine if any long-term changes in chloride concentration occurred within the study area, chloride concentrations in March 1986 were compared to chloride concentrations for the period of April 1973 to July 1974 (Tibbals 1977). Comparing the two isochlor maps, the 101-250 mg/l area decreased and the 251-1000 mg/l area increased for samples collected in March 1986. The change in March 1986 (Figure 20) as compared to April 1973 to July 1974 (Figure 22) is probably not due to movement of the freshwater/saltwater interface but rather to better definition of this area as a result of the increased number of wells sampled. One well, OR-0061, where the chloride concentration was 280 mg/l in March 1986 was not sampled previously.

In the eight wells common to both sampling periods (Table 3), chloride concentrations in seven of the wells either did not change significantly or substantially decreased. However, four of the five wells in which chloride concentrations decreased still remained above the 250 mg/l chloride level and the area of potable water (chloride less than 250 mg/l) did not significantly increase in size.

Changes in chloride concentration are likely to occur in areas where the lateral and vertical chloride concentration gradient is large. The former occurs where regions of differing chloride concentrations are close together such as along the eastern side of the Wekiva River (Figures 20, 21, and 22).

Withdrawals from the Floridan aquifer may enhance this process. Not only do withdrawals lower water levels in the immediate vicinity of pumping wells, but they create a diffuse zone of higher chlorides beneath pumping wells which results from the mixing of waters at the freshwater/saltwater interface. The movement of this interface is dependent on many factors, such as the depth of the well, the pumping rate, the duration of pumping, the depth of the interface, and the difference in density of water across the interface.

Additional studies are needed to define the processes governing water quality variation in the Wekiva River area. This study establishes a framework upon which additional investigations can build.

CONCLUSION AND RECOMMENDATIONS

This study demonstrates that water levels fluctuate seasonally in the Wekiva River basin, but there has been no long-term water level decline, and water quality has not changed significantly in the last decade.

In order to manage the fresh ground-water resource for future supplies it will be essential to monitor and manage withdrawals in the Wekiva River basin. Suggestions for future research include:

- Mapping the depth of the freshwater/saltwater interface throughout the region through a geophysical and test drilling program.
- Conducting large-scale deep well pumping tests to establish quantitative characteristics of the Floridan aquifer.
- Establishing periodic monitoring of surface water discharge and quality from local springs.
- Developing a model capable of predicting changes in chloride concentrations within the Floridan aquifer for managing future withdrawals.
- Establishing a permanent monitoring network for sampling ground water levels and quality on a periodic basis to determine the effectiveness of water management strategies.
- Developing well construction guidelines for domestic and public supply wells in the Wekiva River basin using the water quality findings of this study.

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