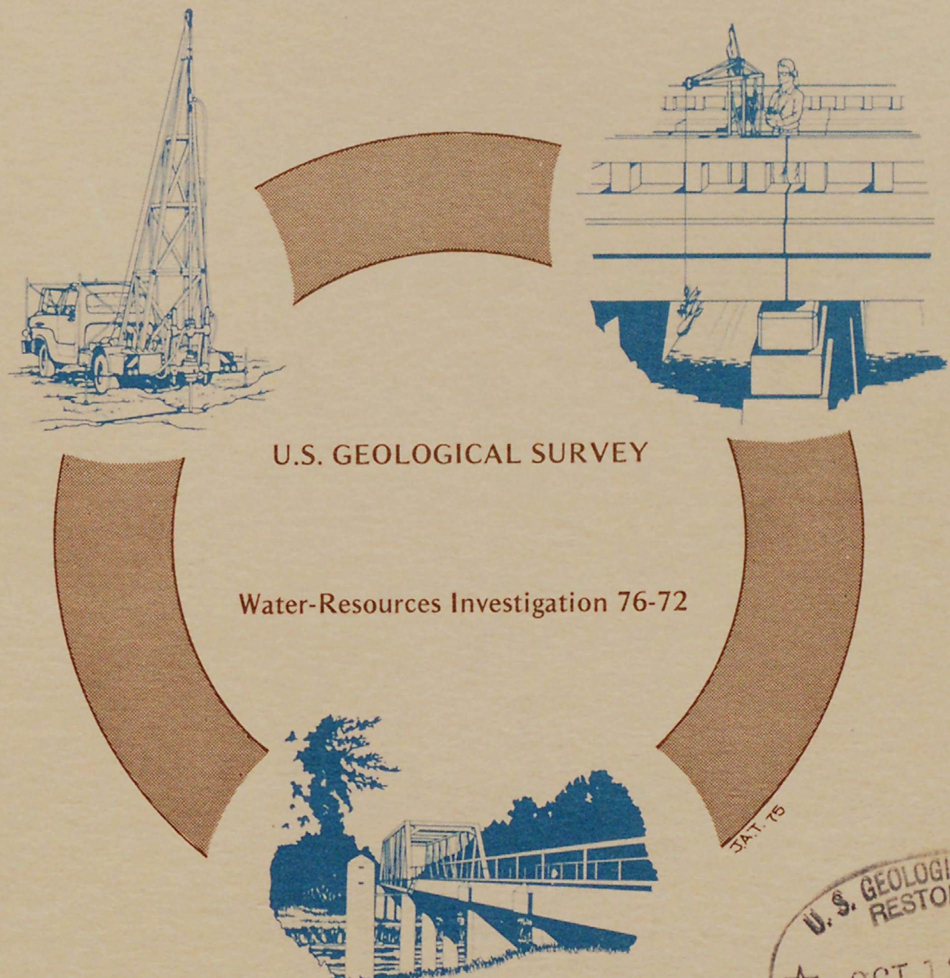
HYDROLOGY OF LAKE COUNTY, FLORIDA



U.S. GEOLOGICAL SURVEY

Water-Resources Investigation 76-72

Prepared in cooperation with the
BOARD OF COMMISSIONERS OF LAKE COUNTY, FLORIDA
OKLAWAHA BASIN RECREATION AND WATER CONSERVATION AND CONTROL AUTHORITY
BUREAU OF GEOLOGY, FLORIDA DEPARTMENT OF NATURAL RESOURCES;
and
BUREAU OF WATER RESOURCES MANAGEMENT,
FLORIDA DEPARTMENT OF ENVIRONMENTAL REGULATION

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16. Abstracts Lake County includes a 1,150 square-mile area consisting of ridges, uplands, and valleys in central-peninsular Florida. About 32 percent of the county is covered by lakes, swamps, and marshes. Water requirements in 1970 averaged about 54 million gallons per day. About 85 percent of the water was obtained from wells; about 15 percent from lakes. The Floridan aquifer supplies almost all the ground water used in Lake County. Annual recharge to the Floridan aquifer averages about 7 inches over the county; runoff averages 8.5 inches. The quality of ground and surface water in Lake County is in general good enough for most uses. Concentrations of dissolved solids in Floridan-aquifer water tend to be lowest in recharge areas and highest in discharge areas; however, the poor quality of Floridan-aquifer water in the St. Johns River Valley probably results from the upward movement of saline water along a fault zone. Surface water in Lake County is less mineralized than ground water, in general, but is more turbid and colored owing to organic compounds derived from flow through swamps.

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August 1976

UNITED STATES DEPARTMENT OF THE INTERIOR

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CONTENTS

ILLUSTRATIONS

ILLUSTRATIONS (Cont'd)

TABLES

HYDROLOGY OF LAKE COUNTY, FLORIDA

by

D. D. Knochenmus and G. H. Hughes

ABSTRACT

Lake County includes a 1,150 square-mile (2,980 square-kilometre) area consisting of ridges, uplands, and valleys in central-peninsular Florida. For the purpose of hydrologic discussions in this report, the County has been divided into eight geohydrologic areas: St. Johns River Valley, Marion Upland, Mount Dora Ridge, Oklawaha Chain of Lakes, Sumter Upland, Lake Wales Ridge, Palatlakaha Upland, and Green Swamp. Land-surface altitudes range from near sea level in the St. Johns River Valley to 312 feet (95 metres) above sea level. About 33 percent of the county is taken up by open undeveloped land, 32 percent by lakes, swamps, and marshes, 21 percent by agriculture, 12 percent by Ocala National Forest, and 2 percent by urban areas.

The county population in 1970 was about 69,000; water requirements averaged about 54 million gallons per day (2.4 cubic metres per second). Forty percent of the water was used for irrigation, 36 percent for industrial purposes--largely citrus processing--19 percent for public water supply, and 5 percent for rural domestic and livestock. About 85 percent of the water was obtained from wells; about 15 percent from lakes.

Annual rainfall in Lake County averages about 51 inches (1,300 millimetres). Although much of the annual rainfall is consumed by evapotranspiration, estimated to be 40 inches (1,020 millimetres), that part of the rainfall that is temporarily stored in lakes, streams, and aquifers provides the basis for a substantial water resource in Lake County.

The ground-water system in Lake County includes a clastic unit and a carbonate-rock unit. The clastic unit consists of a confining bed and a clastic aquifer. The confining bed of the clastic unit overlies the carbonate-rock unit, which is the Floridan aquifer. The clastic deposits are about 100 feet (30 metres) thick in general but range from 25 to 400 feet (8 to 120 metres); the confining bed ranges in thickness from zero to 100 feet (30 metres). The clastic aquifer has little potential as an important source of water in Lake County, but it is hydrologically important because it provides ample storage for water to recharge the Floridan aquifer. The Floridan aquifer supplies almost all the ground water used in Lake County.

Annual recharge to the Floridan aquifer ranges from zero to 14 inches (356 millimetres) and averages about 7 inches (178 millimetres). In general, recharge rates are largest in ridge areas and smallest in valley areas. St. Johns River Valley is basically an area of discharge as are the low parts of other valley areas. Floridan-aquifer water is discharged from eight known springs in Lake County, including Alexander Springs, which is one of Florida's 22 first-magnitude springs. The combined discharge from all the springs averages about 140 million gallons per day (6.1 cubic metres per second), more than half of which is contributed by Alexander Springs.

Runoff from Lake County averages 8.5 inches (216 millimetres) and ranges from 5.7 inches (145 millimetres) for the Oklawaha River basin to 16 inches (406 millimetres) for the St. Johns River Valley. The runoff includes an appreciable quantity of ground-water discharge from the clastic and Floridan aquifers, especially in the St. Johns River Valley. Runoff from the county is almost 9 times as great as the total water used in Lake County in 1970.

Lake County has 1,345 lakes with surface areas of 2.5 acres (1.0 hectares) or more. Lake Harris, wholly in the county, has a surface area of 27.6 square miles. The combined surface area of Lakes Apopka, Harris, Griffin, Eustis, Yale, Dora, Carlton, and Beauclair totals about 80 square miles (207 square kilometres) in Lake County, almost 7 percent of the county.

The quality of ground water in Lake County is in general good enough for most uses. Throughout most of the county, water from wells tapping the Floridan aquifer contains dissolved solids in concentrations less than 300 milligrams per litre. Concentrations of dissolved solids are slightly greater than 300 milligrams per litre in the Green Swamp, in the southwest corner of the county, and are substantially greater (643 to 945 milligrams per litre) in the St. Johns River Valley, and locally in the Marion Upland near Alexander Springs. Concentrations of dissolved solids in Floridan-aquifer water tend to be lowest in areas where recharge occurs, and highest in areas where discharge occurs; however, the poor quality of Floridan-aquifer water in the St. Johns River Valley probably results from the upward movement of saline water along a fault zone. The source of the saline water is unknown.

In general, water in the clastic aquifer is less mineralized than water in the Floridan aquifer. However, water withdrawn from wells tapping the clastic aquifer is likely to contain chemical constituents derived from man's activities near the wells. For example, concentrations of nitrate in water withdrawn from wells tapping the clastic aquifer were consistently higher for wells in citrus grove areas than for wells in non-grove areas.

Surface water in Lake County is less mineralized than ground water, in general, but is more turbid and colored owing to organic compounds derived from flow through swamps and marshes. Concentrations of dissolved solids usually are less than 100 milligrams per litre for those streams that do not receive an appreciable part of their water from the Floridan aquifer, such as Palatlakaha River and Big Creek; otherwise, dissolved-solids concentrations in streamflow may range from as little as 100 milligrams per litre at high flow to as much as 300 milligrams per litre at low flow.

In the many lakes of Lake County, the water quality varies considerably from lake to lake depending on whether the lakes gain water from or lose water to the Floridan aquifer, and also on whether the lakes contain waste products derived from man's activities in the lake basins. Of the lake waters sampled, those having the lowest concentrations of dissolved solids (as represented by specific conductance, 65 micromhos or less) are mostly in the forested area in the northeast part of the county; a few are scattered throughout other parts of the county. Those having the highest concentrations of dissolved solids (specific conductance, 200-400 micromhos per centimetre) generally contain chemical constituents derived from Floridan-aquifer water or from domestic, industrial, or agricultural waste products. Lakes in the Oklawaha Chain of Lakes have experienced frequent algal blooms that probably were caused by a high level of nutrients introduced by waste waters from farms on muck soils and from sewage treatment and industrial processing plants.

INTRODUCTION

Purpose and Scope

The investigation of the hydrology of Lake County was started in 1967 by the U.S. Geological Survey in cooperation with the Oklawaha Basin Recreation and Water Conservation and Control Authority (also called the Lake County Water Authority), the Lake County Planning and Zoning Commission, the Lake County Board of Commissioners, and the Florida Bureau of Geology. The area of investigation includes all of Lake County which is located in central-peninsular Florida, as shown in figure 1.

The purpose of the investigation was to inventory and appraise the water resources of Lake County and to provide part of the hydrologic information necessary for coordinated development of the resources of the county. In scope the investigation was to determine or describe: (1) the hydrologic cycle as it pertains to rainfall, evaporation, surface-water and ground-water in Lake County; (2) runoff characteristics of various drainage basins; (3) physical characteristics of lakes; (4) aquifer properties including recharge characteristics; (5) the availability and quality of surface- and ground-water resources; and (6) the effects of man-made stresses on the local hydrologic system.

As part of this investigation, which spanned 3 years, data-collection stations were established in the countv to measure rainfall, streamflow, lake levels, ground-water levels, and water quality. Twenty-nine test holes and numerous observation wells were drilled to obtain data on aquifer permeability and recharge potential. This report presents the results of the 3-year investigation.

Acknowledgments

The writers acknowledge the cooperation of residents and public officials who contributed information useful to the investigation and permitted access to wells to obtain water-level measurements and water samples. The support of Howard Young, Director of the Lake County Water Authority during the investigation, is especially appreciated. Others whose assistance was especially helpful are Gordon Hayes, Jr., County Engineer, who granted permission to drill test holes along the right-of-way of county roads; Jackson Haddox, County Agricultural Agent, who contributed information of agricultural water use; and Walter Shaffer, U.S. Soil Conservation Service, who made map information available prior to publication. The following well-drilling companies furnished well logs and permitted collection of rock cuttings and water samples: Central Florida Well Drillers, Lawrence Kilpatrick, Locke Well and Pump Company, Meridith Corporation, and Layne-Atlantic Company.

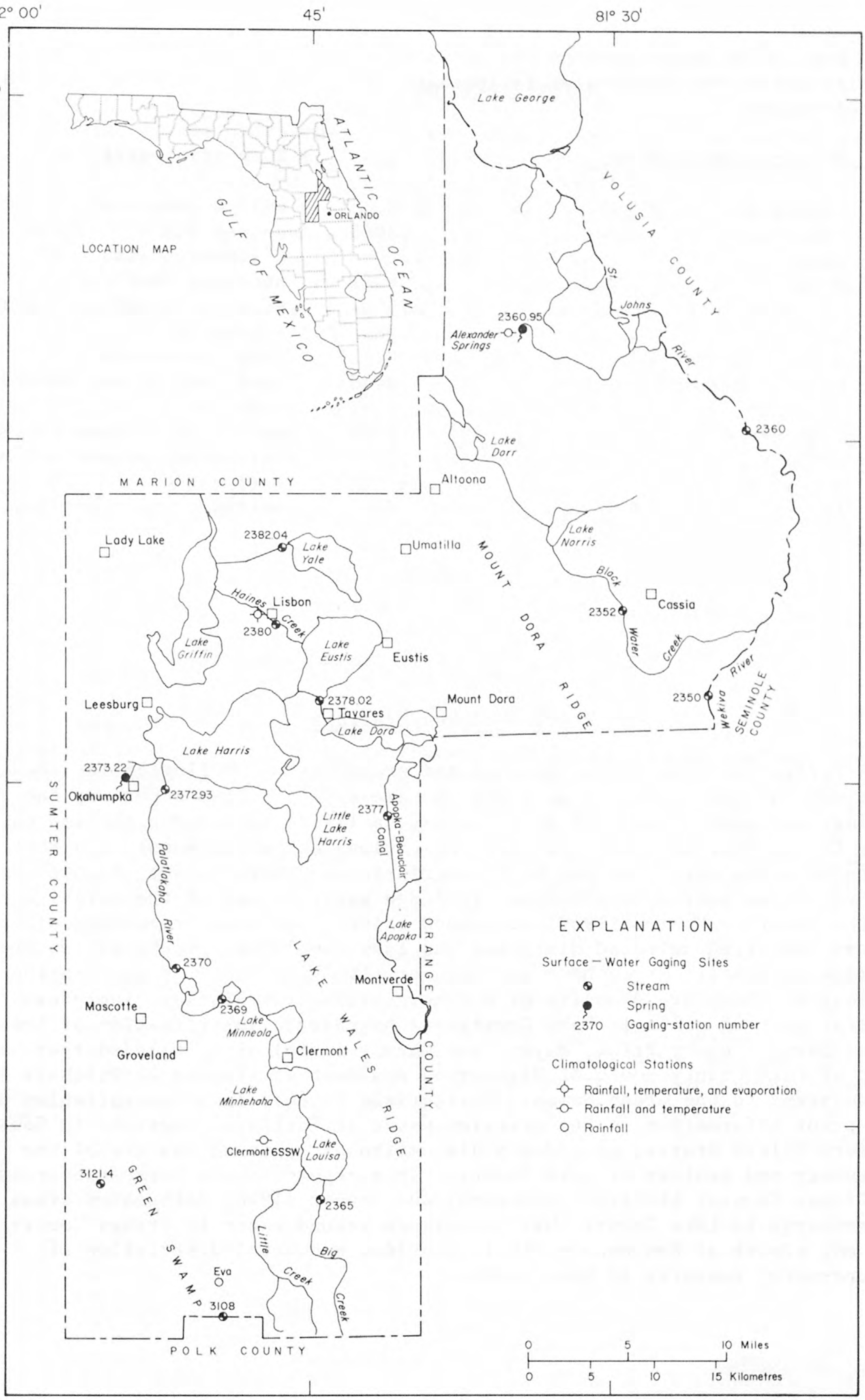

FIGURE 1.--LOCATION OF SURFACE-WATER GAGING SITES AND CLIMATOLOGICAL STATIONS IN LAKE COUNTY.

For use of those readers who may prefer to use metric units rather than English units, the conversion factors for the terms used in this report are listed below:

Multiply English unit	By	To obtain metric unit
inches (in)	25.4	millimetres (mm)
feet (ft)	.3048	metres (m)
miles (mi)	1.609	kilometres (km)
acres	.4047	hectares (ha)
square miles (mi^2)	2.590	square kilometres (km^2)
gallons (gal)	3.785	litres (l)
cubic feet (ft^3)	.02832	cubic metres (m^3)
million gallons per day (Mgal/d)	.04381	cubic metres per second (m^3/s)
feet per mile (ft/mi)	.1886	metres per kilometre (m/km)
gallons per minute per foot (gal/min)/ft	.2070	litres per second per metre (l/s)/m
feet squared per day (ft^2/d)	.0929	metres squared per day (m^2/d)

Previous Investigations

Earlier reports on the geology and ground-water of Florida include sections on Lake County or on parts of Lake County. In a report on the geology and ground-water of Florida, Matson (1913) included a section on Lake County that describes the general geology and water supply and that contains a few well logs and well descriptions. Cooke (1945), in his report on the geology of Florida, included descriptions of the stratigraphy in the county. Mohler (1960) discussed briefly the water resources of Lake County and cited selected discharge and lake-level hydrographs and water-quality analyses. Espenshade and Spencer (1963), in their report on the geology of phosphate deposits of northern peninsular Florida, included several logs of wells in Lake County. A hydrologic investigation of the Green Swamp area by Pride, Meyer, and Cherry (1966) also included that part of Lake County south of Highway 50 and west of Highway 27 which is in or adjacent to the Green Swamp. Stringfield (1966), in an assimilation of all prior information on the artesian water in Tertiary Limestone in Southeastern United States, provided a discussion of regional aspects of the hydrology and geology of Lake County. In a report of the water resources of Orange County, Lichtler, Anderson, and Joyner (1968) delineated areas of recharge in Lake County that contribute ground water to Orange County. The map report of Knochenmus (1971) provides a general description of ground-water features in Lake County.

Well-Numbering System

To catalog wells the Geological Survey uses a 16-character number that defines for each well the latitude and longitude of the southeast corner of a one-second quadrangle in which the well is located. The first six characters of the well number are digits that define the degrees, minutes, and seconds of latitude, in that order. The six digits defining the latitude are followed by the letter "N" which indicates north latitude for wells in the northern hemisphere. The seven digits following the letter "N" give the degrees, minutes, and seconds of longitude. The last digit, set off by a period from the rest of the number, is assigned sequentially to identify wells inventoried within the same one-second quadrangle. For convenient reference in this report, wells in Lake County also have been numbered serially beginning with 1 for wells tapping the Floridan aquifer and 1001 for wells tapping the clastic aquifer, as shown in table 1. Figure 2 shows the location of wells in Lake County for which geologic, water-level, or chemical quality data were available for use in this report

GEOGRAPHIC DESCRIPTION

Location and Extent

Lake County (fig. 1) comprises 1,150 square miles (2,980 km^2) in the heart of the citrus belt in central-peninsular Florida (Morris, 1965). Tavares, the county seat, is 35 miles (56 km) northwest of Orlando, one of the two large metropolitan areas in central Florida. The county is bordered by Polk County on the south, Sumter County on the west, Marion County on the north, and the Wekiva and St. Johns Rivers and Orange County on the east. Lake County, as the name implies, has numerous lakes which cover about 155 square miles (400 km^2) of the county area. The county also contains parts of two major topographic ridges: the Lake Wales and Mount Dora Ridges.

Climate

Lake County has a subtropical climate with hot humid summers and mild dry winters. The National Weather Service includes Lake County in the north-central climatic division of Florida. Generally more than half the annual rainfall occurs in the 4-month period June through September. Temperature, rainfall, and pan evaporation data are given in table 1-a.

Table 1.--Well-data-catalog numbers for selected wells in Lake County.

FLORIDAN AQUIFER

	Catalog number		Catalog number		Catalog number
1	282126N0814039.1	51	(a)	101	285056N0813231.1
2	282204N0814054.1	52	283711N0814201.1	102	(a)
3	282245N0814926.1	53	(a)	103	(a)
4	282331N0814932.1	54	283830N0814753.1	104	(a)
5	282441N0813956.1	55	283830N0815349.1	105	285129N0815451.1
6	282443N0814252.1	56	283910N0814331.1	106	(a)
7	282444N0814341.1	57	283944N0814750.1	107	(a)
8	282532N0815118.1	58	284014N0815114.1	108	285242N0812823.1
9	282638N0815129.1	59	(a)	109	285244N0814714.1
10	282640N0814705.1	60	(a)	110	285310N0815219.1
11	282643N0813954.1	61	(a)	111	(a)
12	282655N0815527.1	62	284129N0814142.1	112	285318N0813406.1
13	282711N0814211.1	63	284129N0814743.1	113	(a)
14	(a)	64	284135N0815655.1	114	(a)
15	282731N0815454.1	65	284210N0814623.1	115	285407N0813424.1
16	282746N0814301.1	66	284222N0815111.1	116	(a)
17	282823N0815004.1	67	284232N0815330.1	117	(a)
18	282825N0814235.1	68	284236N0814401.1	118	285425N0815504.1
19	282829N0814136.1	69	284258N0814957.1	119	285426N0813809.1
20	282833N0815442.1	70	284320N0814107.1	120	(a)
21	282852N0814249.1	71	284328N0815159.1	121	285452N0815632.1
22	282954N0814630.2	72	284328N0815214.1	122	285456N0812411.1
23	283024N0814335.1	73	(a)	123	285504N0814059.1
24	283045N0814831.1	74	284439N0814208.1	124	285545N0814006.2
25	(a)	75	(a)	125	(a)
26	283057N0815028.1	76	(a)	126	285548N)813227.1
27	283142N0814409.1	77	284445N0814621.1	127	285552N0815306.1
28	(a)	78	(a)	128	285618N0812552.1
29	283154N0815438.1	79	284516N0815729.1	129	(a)
30	283204N0815449.1	80	(a)	130	285645N0814924.1
31	283205N0815052.1	81	284728N0813222.1	131	(a)
32	283206N0814425.1	82	284757N0815430.1	132	285707N0814411.1
33	283214N0814144.1	83	284759N0815001.1	133	(a)
34	283214N0814148.1	84	284819N0814408.1	134	285722N0813605.1
35	283232N0813941.1	85	284822N0815206.1	135	285758N0813855.1
36	283247N0814001.1	86	284825N0815217.1	136	285827N0813314.1
37	283248N0814309.1	87	284826N0812546.1	137	285841N0813308.1
38	283301N0814459.1	88	284827N0814035.1	138	285930N0812242.1
39	283303N0814448.1	89	284834N0815237.1	139	290000N0813800.1
40	283305N0815140.1	90	284842N0815330.1	140	290013N0812559.1
41	283344N0815125.1	91	(a)	141	290050N0813016.1
42	283351N0814001.1	92	284856N0813830.1	142	290244N0813026.1
43	283359N0814115.1	93	284857N0815709.1	143	(a)
44	283432N0815306.1	94	(a)	144	290445N0813440.1
45	283439N0814513.1	95	284917N0813537.1	145	290700N0813550.1
46	(a)	96	(a)	146	290900N0813420.1
47	283530N0815145.1	97	284927N0814952.1	147	290951N0811355.1
48	283540N0814024.1	98	284943N0814125.1	148	291010N0813150.1
49	283612N0814952.1	99	(a)		
50	(a)	100	285047N0814011.1		

CLASTIC AQUIFER

1001	282245N0814926.2	1006	284054N0814819.1	1011	284953N0813932.1
1002	283324N0813927.1	1007	284113N0815236.1	1012	284958N0813925.1
1003	283536N0814051.1	1008	284213N0815245.1	1013	285425N0813234.1
1004	283634N0814023.1	1009	284512N0814415.1	1014	285432N0815346.1
1005	284054N0814814.1	1010	284856N0813506.1	1015	285613N0812552.1
				1016	285730N0814045.1

a Catalog number not assigned.

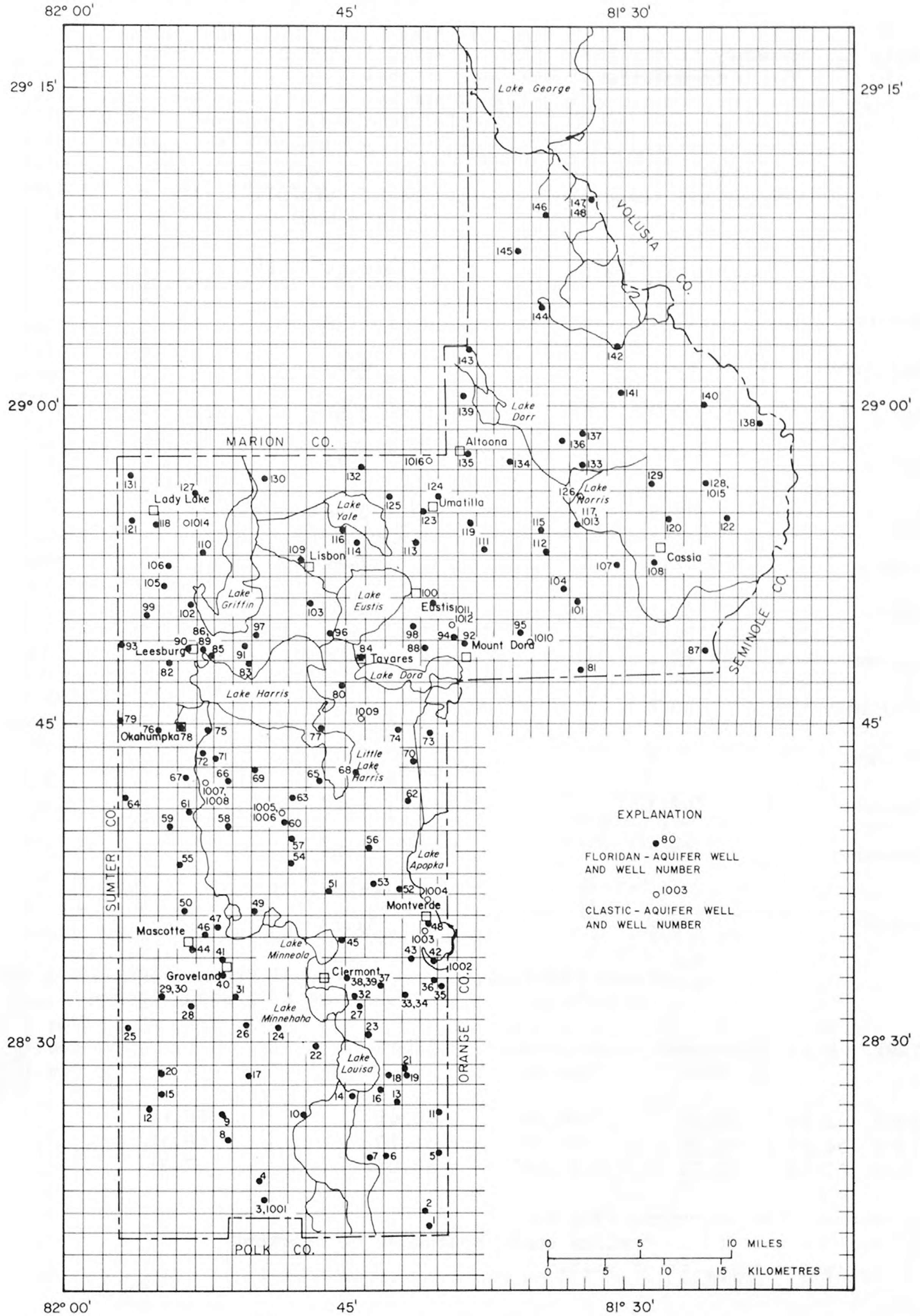

FIGURE 2.--LOCATION OF SELECTED WELLS IN LAKE COUNTY

Table 1a.--Summary of air temperature, rainfall, and pan evaporation data. (Data from National Weather Service).

	Average air temperature[a] (°F)	Normal rainfall[a] (inches)
	Clermont 6SSW[b]	Clermont 6SSW[b]
January	61.6	2.00
February	63.1	2.63
March	66.8	3.87
April	71.9	3.74
May	77.5	3.38
June	81.1	7.10
July	82.1	8.79
August	82.5	6.55
September	80.8	6.49
October	74.8	3.11
November	67.1	1.53
December	62.1	2.04
Annual	72.6	51.23

	Annual Rainfall (inches)				Annual evaporation from Class A pan at Lisbon, inches
Year	Eva	Clermont 6SSW	Alexander Springs	Lisbon	
1967	42.46	53.53	44.16	40.65	60.67
1968	54.45	53.39	62.25	51.70	58.42
1969	65.55	63.71	61.44[c]	53.07	57.31

a/ Average for 30-years, 1931-60.
b/ Weather station is 6 miles south-southwest of Clermont
c/ Estimated for part of year.

Temperature

The mean annual temperature in the north-central division is 72°F (22.2°C). January is the coldest month with a mean minimum temperature of 50°F (10.0°C); however, occasional below-freezing temperatures occur. The hottest months are July and August, each with a mean maximum temperature of 92°F (33.4°C). Lakes tend to moderate changes in temperature and, hence, during brief periods of below freezing temperatures, may be locally helpful in preventing damage to citrus groves.

Rainfall

Records of rainfall in Lake County have been collected by the National Weather Service (formerly the U.S. Weather Bureau) since 1890. The longest continuous record began in 1892 at a site (Clermont 6SSW) 6 miles (10 km) south and slightly west of Clermont. During the investigation National Weather Service rainfall stations at Lisbon, Eva, and Alexander Springs also were active. The location of the rainfall stations and other data collection stations in Lake County are shown in figure 1.

The long-term normal rainfall at the Clermont 6SSW station is 51.23 inches (1,300 mm) annually compared to the long-term average of 50.37 inches (1,280 mm) since the beginning of record. Rainfall at the Clermont 6SSW station (51 inches annually) is considered to be representative of the county as a whole.

Variations in rainfall at the Clermont 6SSW station also probably are representative of rainfall variations throughout the county. The annual rainfall at the Clermont 6SSW station ranged from 68.09 inches (1,730 mm) in 1959 to 32.28 inches (820 mm) in 1961, as shown in figure 3. Periods of outstanding deficiencies or excesses of rainfall are evident from the cumulative departure curve shown in figure 4. The longest dry period of record at the Clermont 6SSW station was from 1913 to 1918, when rainfall was deficient by 52 inches (1,320 mm). More recently the rainfall was deficient by 28.5 inches (720 mm) from 1961 to 1963. The wettest period of record was in 1957-60, when rainfall was excessive by 47 inches (1,190 mm).

The distribution of rainfall in Lake County varied considerably during the investigation. Rainfall in general was less than average in 1967, somewhat greater than average in 1968, and substantially greater than average in 1969 (table 1-a). The annual rainfall at the various stations ranged from 40.65 inches (1,030 mm) at Lisbon (1967) to 65.55 inches (1,660 mm) at Eva (1969). On basis of the cumulative frequency curve for rainfall at Clermont 6SSW, shown in figure 5, the annual rainfall would be expected to exceed 40 inches (1,020 mm) in 9 years out of 10, and to exceed 64 inches (1,630 mm) in only 1 year out of 20.

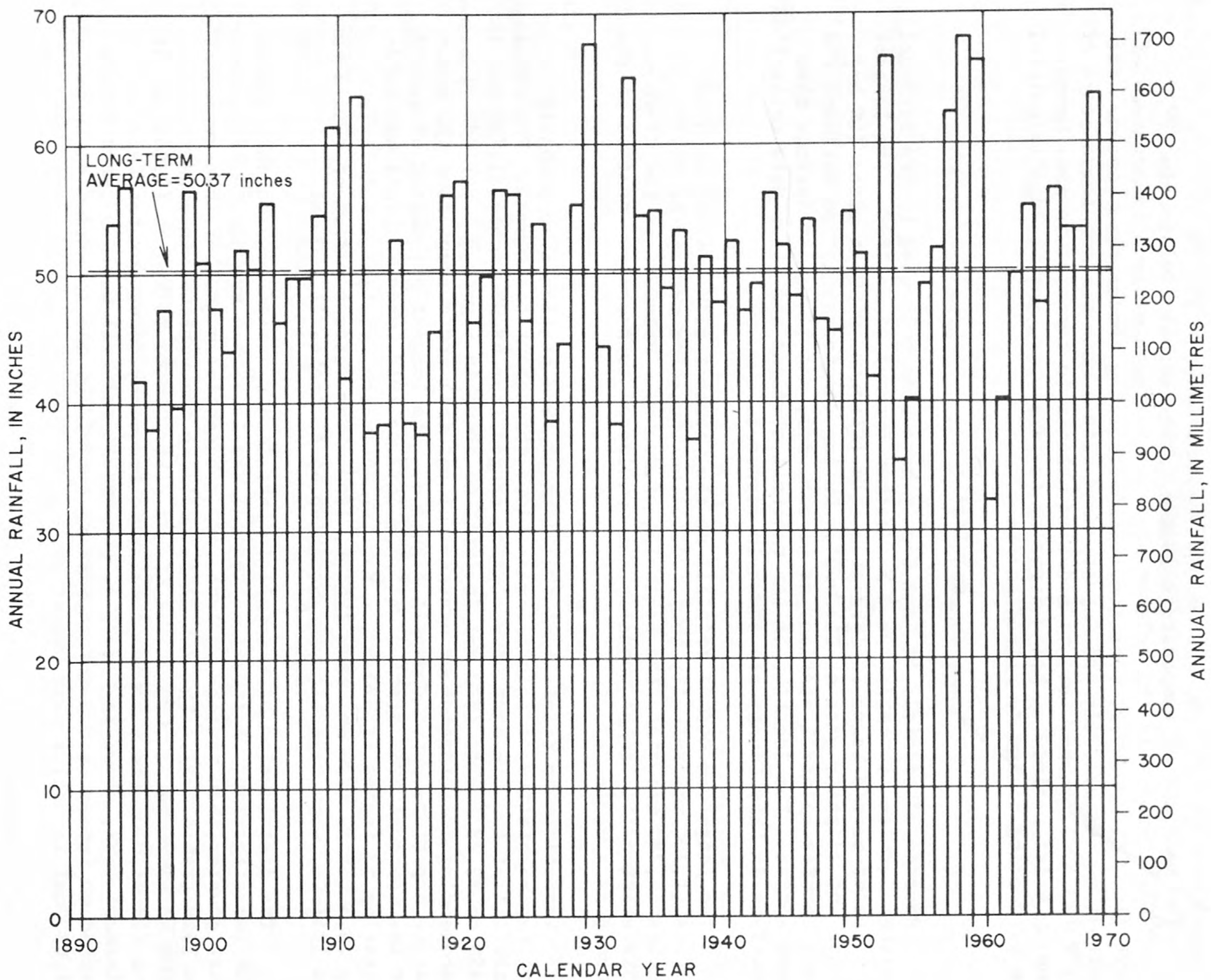

FIGURE 3.--ANNUAL RAINFALL (1893-1969) AT CLERMONT 6SSW RAINFALL STATION.

(DATA FROM NATIONAL WEATHER SERVICE)

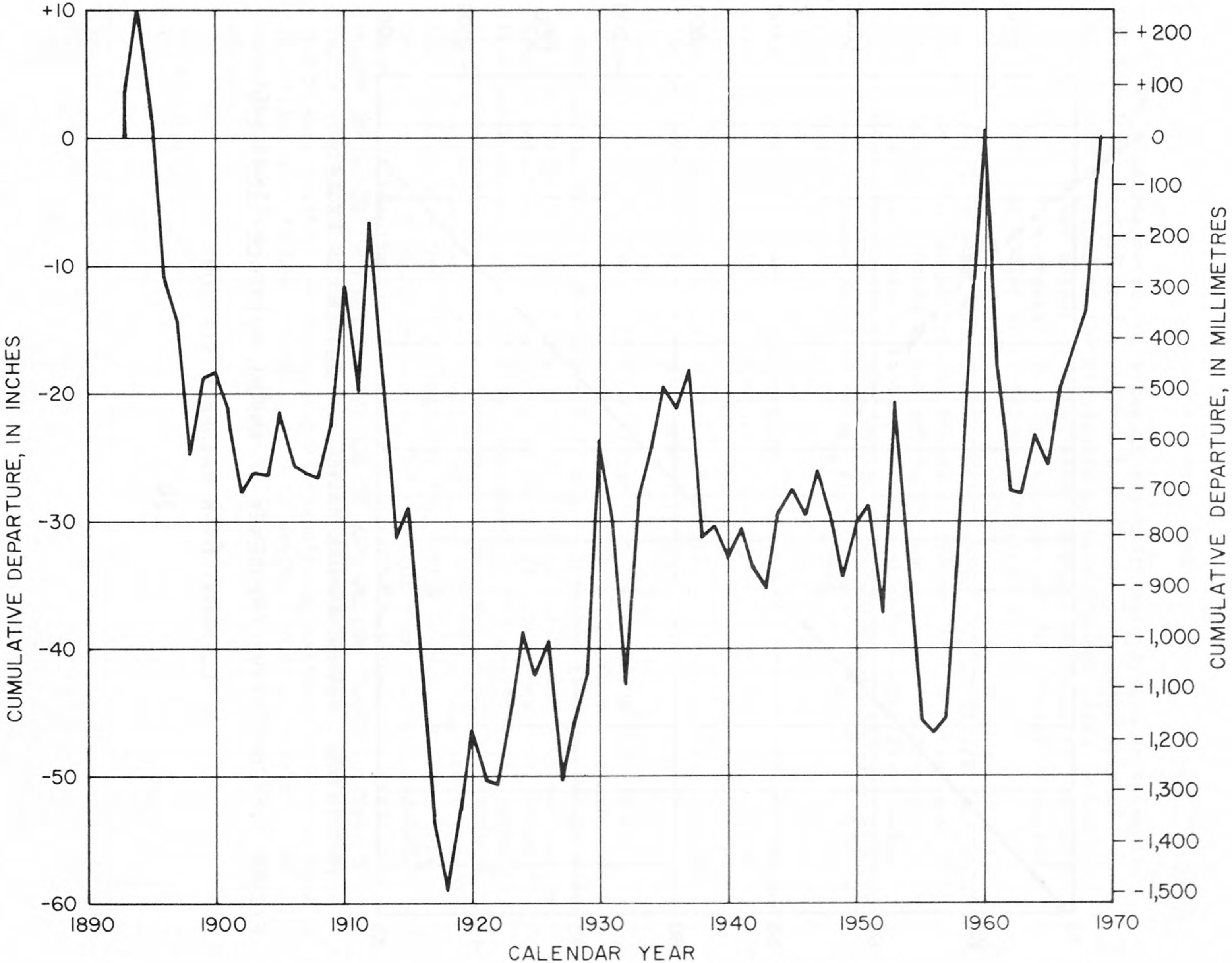

FIGURE 4.--CUMULATIVE DEPARTURE FROM LONG-TERM AVERAGE OF RAINFALL AT CLERMONT 6SSW RAINFALL STATION

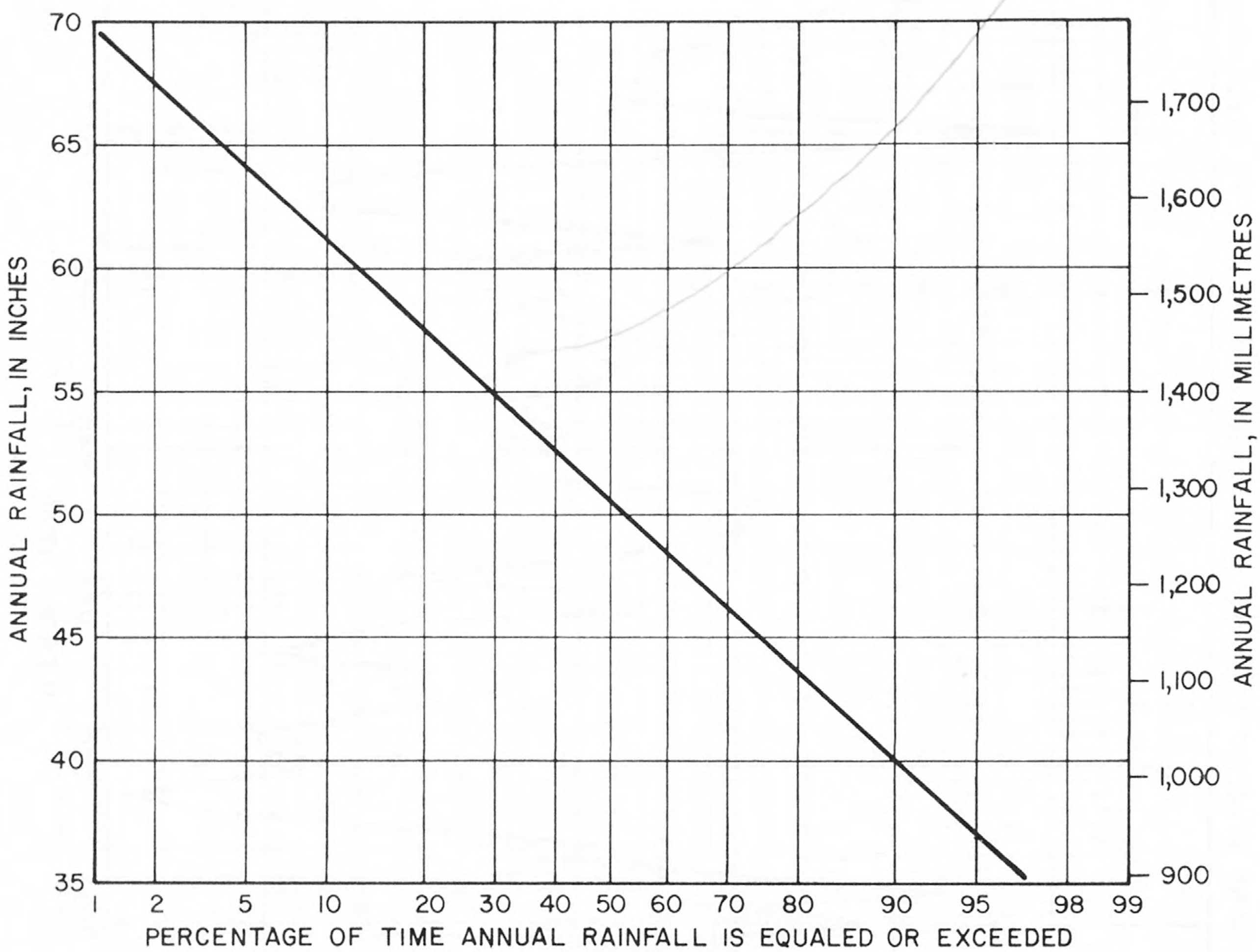

FIGURE 5.--CUMULATIVE FREQUENCY OF ANNUAL RAINFALL (1893-1969) AT CLERMONT 6SSW RAINFALL STATION

Evapotranspiration

The ultimate source of water in any hydrologic system is rainfall. In humid subtropical areas, such as Lake County, the major part of rainfall is returned to the atmosphere by evapotranspiration, which includes the water evaporated from land and water surfaces as well as that transpired by vegetation. The remainder of the rainfall runs off to surface water bodies or recharges subsurface reservoirs.

Evaporation maps (Kohler and others, 1959, pl.2) indicate that annual lake evaporation ranges from 46 inches (1,170 mm) in the northern part of Lake County to 48 inches (1,220 mm) in the southern part. Annual evaporation from a Class A pan at Lisbon, which is somewhat centrally located in the county, from 1960 to 1969 averaged 58.8 inches (1,490 mm). For an annual lake evaporation of 47 inches (1,190 mm) a coefficient of 0.80 is indicated for the Lisbon pan.

The seasonal variations in average monthly rainfall (1931-60) and pan evaporation (1960-69) at Lisbon are compared in figure 6. Monthly pan evaporation exceeds rainfall during the fall and spring months when the air temperature is relatively high. Rainfall generally equals or exceeds pan evaporation during the rainy summer months.

Annual evapotranspiration averages 42.6 inches (1,080 mm) in Kissimmee River basin (Langbein, 1955, p.512), which extends southward from Lake County to Lake Okeechobee, and 37.5 inches (950 mm) in the mid-Gulf area (Cherry and others, 1970, p. 77-79), which lies west and southwest of Lake County. Evapotranspiration in Florida tends to decrease from south to north and tends to increase with the availability of water at or near the land surface. Because Lake County is north of Kissimmee River Basin, evapotranspiration in the county would be expected to average less than 42.6 inches (1,080 mm) over the entire county. Because Lake County contains a higher percentage of wetlands than does the mid-Gulf area, evapotranspiration in the county would be expected to average more than 37.5 inches (950 mm) for the county as a whole. Thus, for Lake County as a whole, annual evapotranspiration is estimated to be 40 inches (1,020 mm). Within the county annual evapotranspiration could range from as little as 30 inches (760 mm) in areas having highly permeable soils and a low water table to as much as 48 inches (1,220 mm) from lakes and swamps.

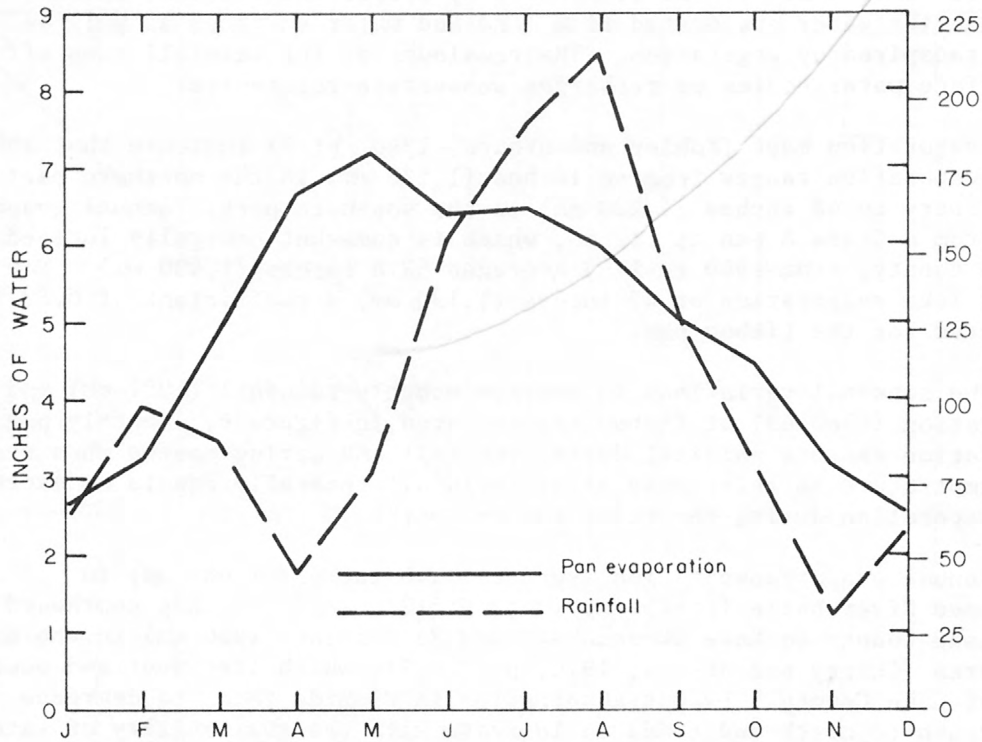

FIGURE 6.--AVERAGE MONTHLY RAINFALL AND EVAPORATION FROM A CLASS A PAN AT LISBON, FLORIDA. (DATA FROM NATIONAL WEATHER SERVICE)

Physiography

Lake County is in the Central Highlands topographic division of Cooke (1945). Within this division, Puri and Vernon (1964) described 25 landforms, 7 of which occur in Lake County, as indicated in figure 7. In general, the landforms are of three basic types: ridges, valleys, and uplands. All of these landforms are oriented approximately parallel to the Atlantic Coast, which implies a coastal origin.

Ridges, the first type, are characteristic of the Central Highlands and two of these -- the Mount Dora Ridge and the Lake Wales Ridge -- extend into or across the county. The Lake Wales Ridge is, in general, the higher of the two with hilltops in the central part 200 to 300 feet (61 to 91 m) high. One of the hilltops in Lake County, known locally as Sugarloaf Mountain, is 312 feet (95 m) high, the highest point in peninsular Florida. Three other hills in the Lake Wales Ridge are over 300 feet (91 m) high. In addition to their height, other characteristics of the ridges are deep lakes, closed lake basins, low water tables, and subsurface drainage. The altitude of the land surface and areas of internal drainage in the ridge areas are shown highly generalized in figure 8.

The Central Valley, of the second type of landform, terminates the northern end of the Lake Wales Ridge and separates it from the Mount Dora Ridge to the east. It is characterized by large lakes--for example, the Oklawaha Chain of Lakes--flat terrain, and relatively high surface runoff. In the Central Valley, water levels in shallow wells are at or only a few feet below land surface, and water flows from many deep wells.

Another valley landform is the St. Johns River basin which borders the northeastern edge of the county. Its physiographic characteristics are similar to those of the Central Valley.

The third type of landform is the upland, of which there are three in Lake County: Marion, Sumter, and Lake. For description of geohydrologic regions in this report, Lake Upland has been separated into the Palatlakaha Upland and the Green Swamp. Uplands are characterized by moderate altitudes and relief, numerous closed lakes which become connected during high water, shallow lakes, and moderate depths to the water table.

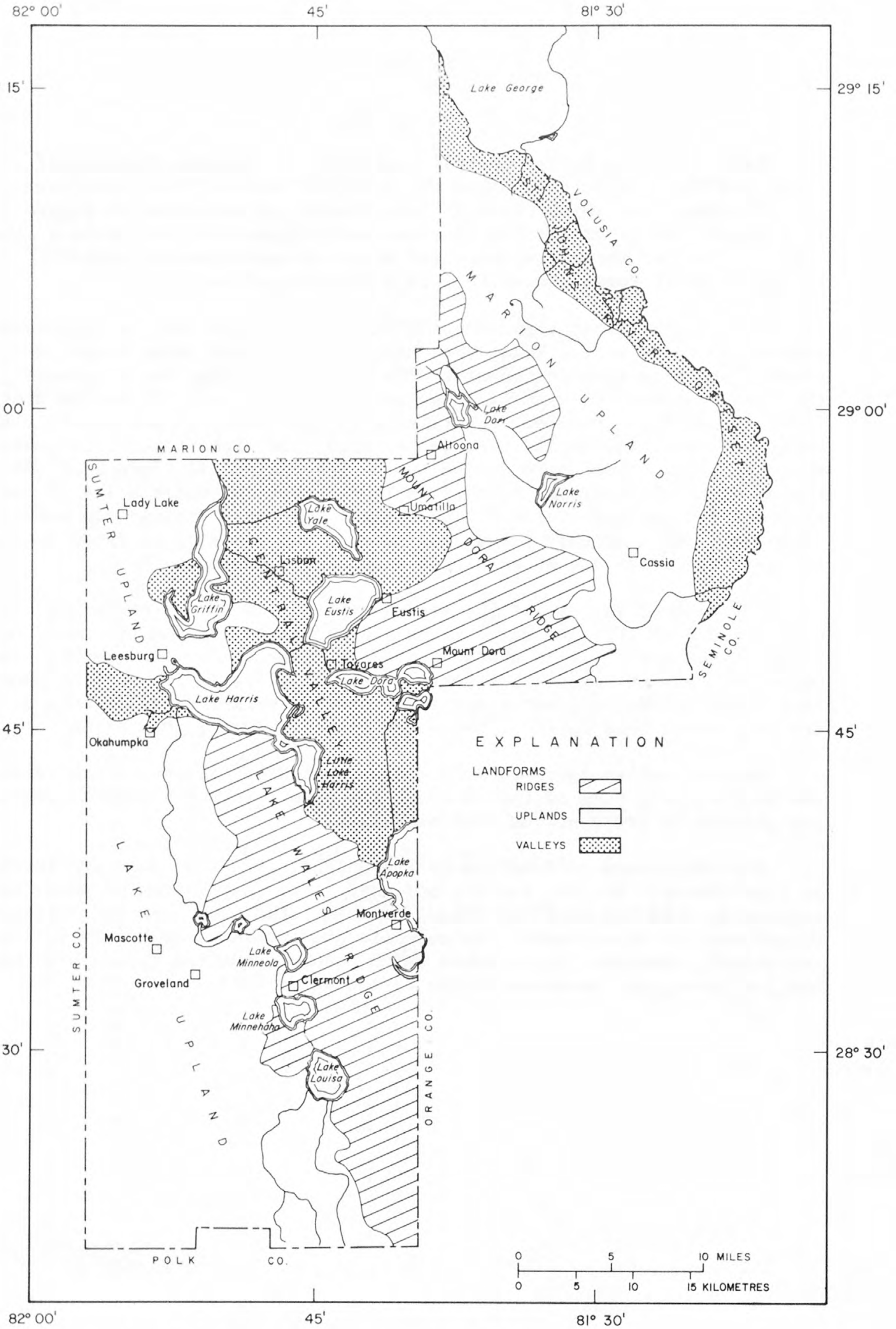

FIGURE 7.--LANDFORMS IN LAKE COUNTY (AFTER PURI AND VERNON,1964)

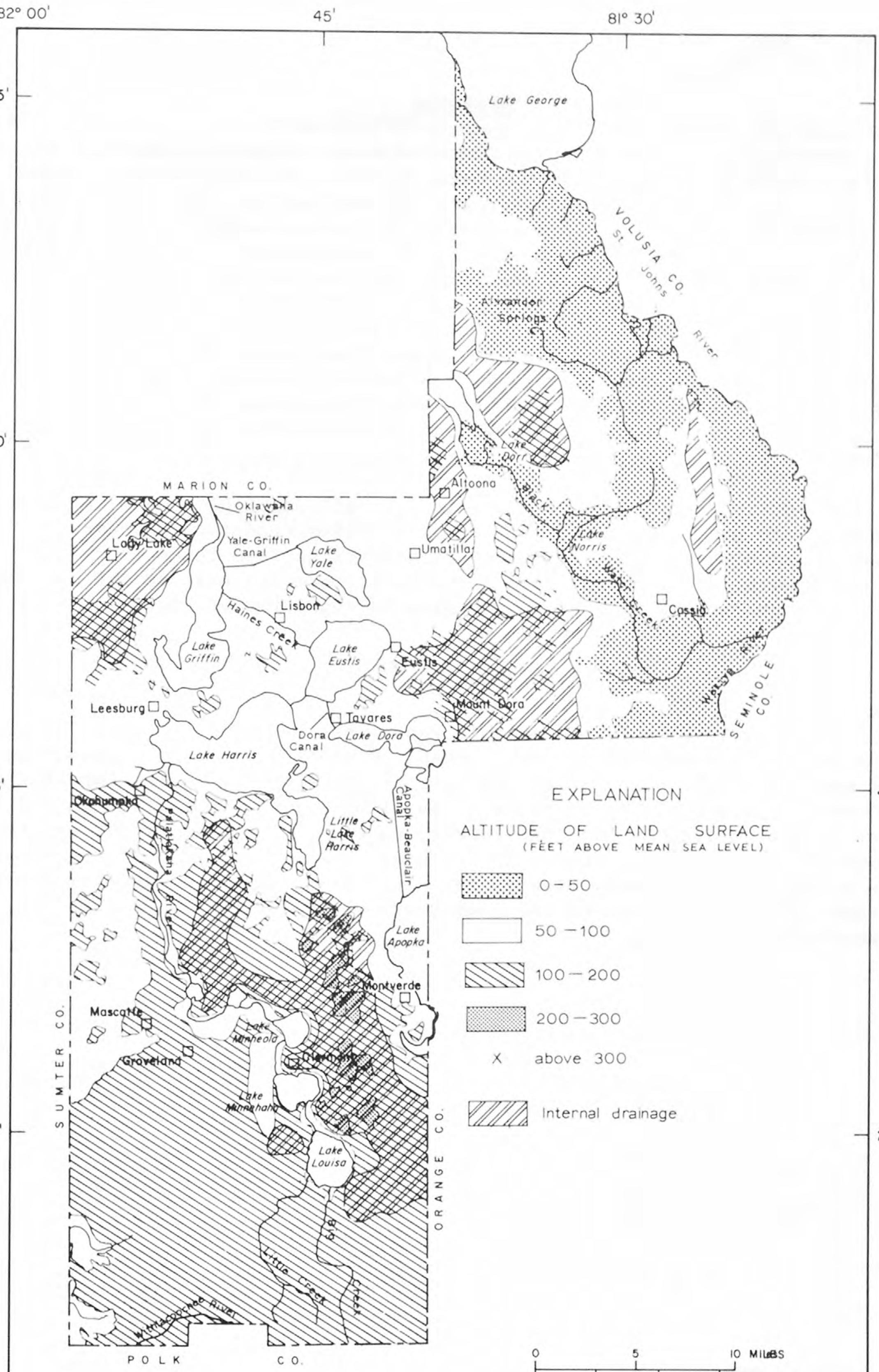

FIGURE 8.--TOPOGRAPHY AND DRAINAGE PATTERN OF LAKE COUNTY

Drainage

Lake County is drained by both surface and subsurface drainage systems. Surface drainage is mainly by the Oklawaha River and other tributaries to the St. Johns River, which flows north and empties into the Atlantic Ocean at Jacksonville, Florida. A small area in the southwestern part of the county drains to the Gulf of Mexico by way of the Withlacoochee River, and a small area in the southeastern part is drained by the Kissimmee River, which flows south to Lake Okeechobee.

The St. Johns River, Wekiva River, and Black Water Creek drain the northeastern part of the county (fig. 8). Black Water Creek flows southeast to its confluence with the Wekiva River, which then flows northeast to the St. Johns River. Black Water Creek and St. Johns River have about parallel alinements but flow in opposite directions.

The drainage system as a whole is not well developed and the stream channels are not deeply incised. Prior to widespread land development, stream channels existed only as high-water connectors between lakes or swamps. Channels were deepened and improved to facilitate drainage as the area developed. Flow through the Oklawaha Chain of Lakes is regulated by control structures.

Land Use

Land use in Lake County in this report has been classed as wet, open, agriculture, National Forest, and urban. Wetlands, including lakes, swamps, and marshes, cover about 32 percent of the county. Open land, consisting of wooded plots, unimproved pasture, rural homesites, roads, and unused land that is not wetland or National Forest, make up 33 percent of the county area. About 12 percent of the county is included in Ocala National Forest. Twenty-one percent of the county area is used for agriculture, mostly citrus groves. Cities take up 2 percent of the county area. The areas of land use are summarized in table 2.

Table 2.--Land use in Lake County, Florida.

Land Use	Area in square miles	Percent of total area
Open land	380	33
Wetland (including Lakes)	375	32
Agriculture	240	21
National Forest	135	12
Urban	20	2

Data from Lake County Agricultural Agent, Lake County Planning and Zoning Commission, and from U. S. Geological Survey and National Forest maps.

Water Use

In 1970 about 54 million gallons per day (2.4 m^3/s) were used in Lake County, as shown in table 3. Recreational and other non-consumptive uses of water were not included. Eighty-five percent of the water used was obtained from wells and 15 percent from lakes.

Of 12 municipal water supplies in the county, all obtain water from the Floridan aquifer. In 1970, these public supplies furnished 10 million gallons per day (0.4 m^3/s) to 42,000 people or about 60 percent of the county population. Leesburg, with 10 supply wells used the greatest amount of water, and Montverde, with one supply well, used the least. Private domestic wells were the source of water for about 27,000 people in Lake County in 1970. Rural water use was estimated on basis of a per capita use of 100 gallons (380 l) per day plus livestock use. Most of the irrigation use was to irrigate citrus groves. Almost 75 percent of the industrial water use was by citrus processing plants.

Soils

Knowledge of soil types is useful in water-resource investigations because in Florida permeable and well drained soils often are associated with areas of substantial ground-water recharge. Figure 9 is a generalized soils map showing the distribution of nine soil associations in Lake County, excluding that part of the county in Ocala National Forest. Data for the map were provided by the Soil Conservation Service, U.S. Department of Agriculture, prior to publication of the results of its soil survey of Lake County.

Soil associations are named for the two or three dominant soils in a given area. Brief descriptions of the soil associations appearing in figure 9 are as follows:

1. Paola-Pomello-Myakka Association: well drained soils on low sand ridges in northeast part of county; water table more than 60 inches (1,520 mm) below land surface.
2. Paola-Myakka Association: moderately to well drained soils on the lower slopes of low sand ridges in northeast part of county, generally down slope from soils of Paola-Pamello-Mayakka Association; water table 40 to 60 inches (1,020 to 1,520 mm) below land surface.
3. Astatula-Lake Association: well drained soils on high ridges and upland areas, occurring throughout much of the county; water table several feet below land surface.

Table 3.--Estimated water use in Lake County during 1970.

Type of use	Quantity used (million gallons per day)	Percent of total
Public supply (ground water)	10.0	19
Rural (domestic and livestock)		
Ground water	2.7	5
Surface water	.3	
Industrial (self supplied, ground water)	19.4	36
Irrigation		
Ground water	13.4	25
Surface water	7.7	15
Total	53.5	100

Note: Data from Pride, 1973, except that for rural use.

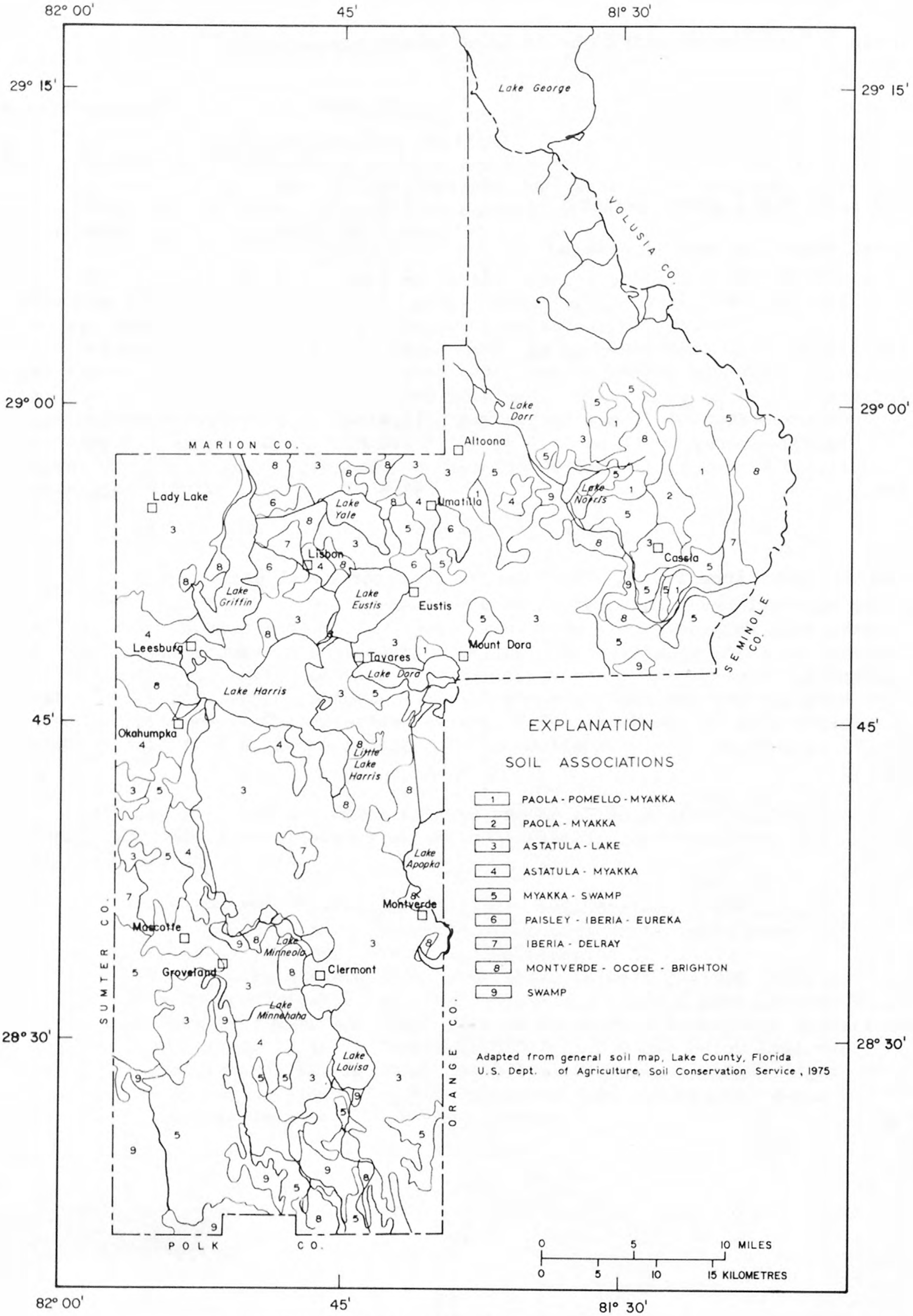

FIGURE 9.--GENERALIZED SOIL ASSOCIATIONS IN LAKE COUNTY

4. Astatula-Myakka Association: moderately to well drained soils on lower slopes of high ridges and uplands, generally down slope from soils of Astatula-Lake Association; water table generally within 60 inches (1,520 mm) of land surface.
5. Mayakka-Swamp Association: poorly drained soils on broad lowlands widely distributed throughout county; water table 10 to 30 inches (250 to 760 mm) below land surface.
6. Paisly-Iberia-Eureka Association: Poorly drained soils on broad lowlands of wet prairies in vicinity of Oklawaha chain of lakes; water table at or near land surface.
7. Iberia-Delray Association: poorly drained soils in low alluvial deposits of flood plains of St. Johns and Oklawaha Rivers; water table near land surface.
8. Montverde-Ocoee-Brighton Association: organic soils in low, level marsh or swamp land; well drained only where water table has been artificially lowered for agriculture.
9. Swamp Association: poorly drained soils in low areas subject to prolonged flooding.

GEOLOGY

Stratigraphy

The geologic history of the general area is described by Cook, C. W., 1945; Applin, Paul L., 1951; Vernon, R. O., 1951; Bishop, Ernest W., 1956; Applin, Paul L., and Applin, Esther R., 1965. Table 4 presents a generalized stratigraphic section of geologic formations occurring in Lake County. Geologic sections through the county are shown in figure 10.

According to Stringfield (1966, table 3, p. 31) the Lake City Limestone of middle Eocene age is the oldest formation of the Floridan aquifer. The deeper wells in Lake County obtain water from this formation (fig. 10). Overlying the Lake City Limestone is the Avon Park Limestone of middle Eocene age, the oldest formation exposed at the surface in Florida. Most high-yield wells in Lake County penetrate the Avon Park Limestone.

Overlying the Avon Park Limestone is the Ocala Group of Eocene age which consists of the Inglis, Williston, and Crystal River Formations. The Ocala Group supplies water for most of the domestic wells in Lake County. The Suwannee Limestone of Oligocene age, which overlies the Ocala Group, is an important part of the Floridan aquifer in some parts of Florida but is unimportant in Lake County.

The Hawthorn Formation of middle Miocene age ranges from zero to 100 feet (30 m) thick, and forms a confining bed for the Floridan aquifer. Overlying the Hawthorn Formation is the Citronelle Formation of Pliocene age. The Citronelle Formation makes up the lower part of the clastic aquifer and is a fairly well sorted sand which yields small quantities of water to wells for domestic supply.

Overlying the Citronelle Formation are Pleistocene deposits that in Lake County are commonly 100 to 200 feet (30 to 61 m) thick, but as much as 400 feet (122 m) of the deposits were penetrated in one well. The Pleistocene sediments are included in the clastic aquifer and have a

Table 4.--Generalized stratigraphic section of the geologic formations in Lake County, Florida [1]

Source of information includes Applin (1951), Vernon (1951), Puri (1957), Applin and Applin (1965), Stringfield (1966).

Era	System	Series	Stratigraphic Unit	Thickness (feet)	Lithology	Hydrologic Unit
Cenozoic	Quaternary	Holocene	Unnamed colluvial and aeolian deposits	0-15	Fine grained well-sorted sand.	Clastic aquifer
Cenozoic	Quaternary	Pleistocene	Unnamed alluvial and lacustrine deposits	0-400	Fine to medium grained quartz sand, organic sand and clay, peat, marl, fresh water limestone.	Clastic aquifer
Cenozoic	Tertiary	Pliocene	Citronelle Formation [1]	0-200	Marginal marine fine to course grained quartz sand containing a kaolinite matrix, variegated red and orange quartzite pebbles, cross bedded.	Clastic aquifer
Cenozoic	Tertiary	Miocene, Middle	Hawthorn Formation	0-100	Marine interbedded mixture of sand, clay and limestone; fine to course grained phosphatic sand, dark green to cream montmorillonitic clay, phosphorite pebbles, lenses of sandy dolomitic phosphatic limestone.	Confining bed
Cenozoic	Tertiary	Oligocene	Suwannee Limestone	0-25	Marine limestone, cream to white, soft, hard where silicified, porous.	Floridan aquifer
Cenozoic	Tertiary	Eocene, Upper	Ocala Group: Crystal River Formation	0-100	Marine limestone, cream to white, soft, chalky, fossiliferous, often a coquina of foraminifers.	Floridan aquifer
Cenozoic	Tertiary	Eocene, Upper	Ocala Group: Williston Formation	0-40	Marine limestone, cream to tan, hard, abundant micro-fossils.	Floridan aquifer
Cenozoic	Tertiary	Eocene, Upper	Ocala Group: Inglis Formation	0-50	Marine limestone, white to tan, dolomitic, fossiliferous.	Floridan aquifer
Cenozoic	Tertiary	Eocene, Middle	Avon Park Limestone	400-1000	Marine limestone, light gray to dark brown, soft to hard, fossiliferous, dolomitic, carbonaceous.	Floridan aquifer
Cenozoic	Tertiary	Eocene, Middle	Lake City Limestone	500-1000	Marine limestone, cream colored, dolomitic, fossiliferous and dolomite, brown, hard, minor amounts of gypsum and anhydrite.	Floridan aquifer
Cenozoic	Tertiary	Eocene, Lower	Oldsmar Limestone	400-600	Marine limestone, light brown, interbedded with brown crystalline dolomite, fossiliferous, contains chert and gypsum.	
Cenozoic	Tertiary	Paleocene	Cedar Keys Limestone	700-1200	Marine limestone, cream colored, fossiliferous, dolomitic, contains anhydrite.	
Mesozoic	Upper and Lower Cretaceous			2300-2700	Upper cretoceous marine limestones; lower cretaceous carbonats and evaporites grade into clastic rocks.	
Paleozoic and Pre-cambrian	Paleozoic or Precambrain			Coastal Plain Floor	North end of county, Paleozoic or Precambrian volcanic rocks.	
Paleozoic and Pre-cambrian	Precambrian (?)			Coastal Plain Floor	South end of county, Precambrian (?) granite.	

1/ The geologic nomenclature is that of the Florida Department of Conservation, Bureau of Geology except for the Citronelle Formation.

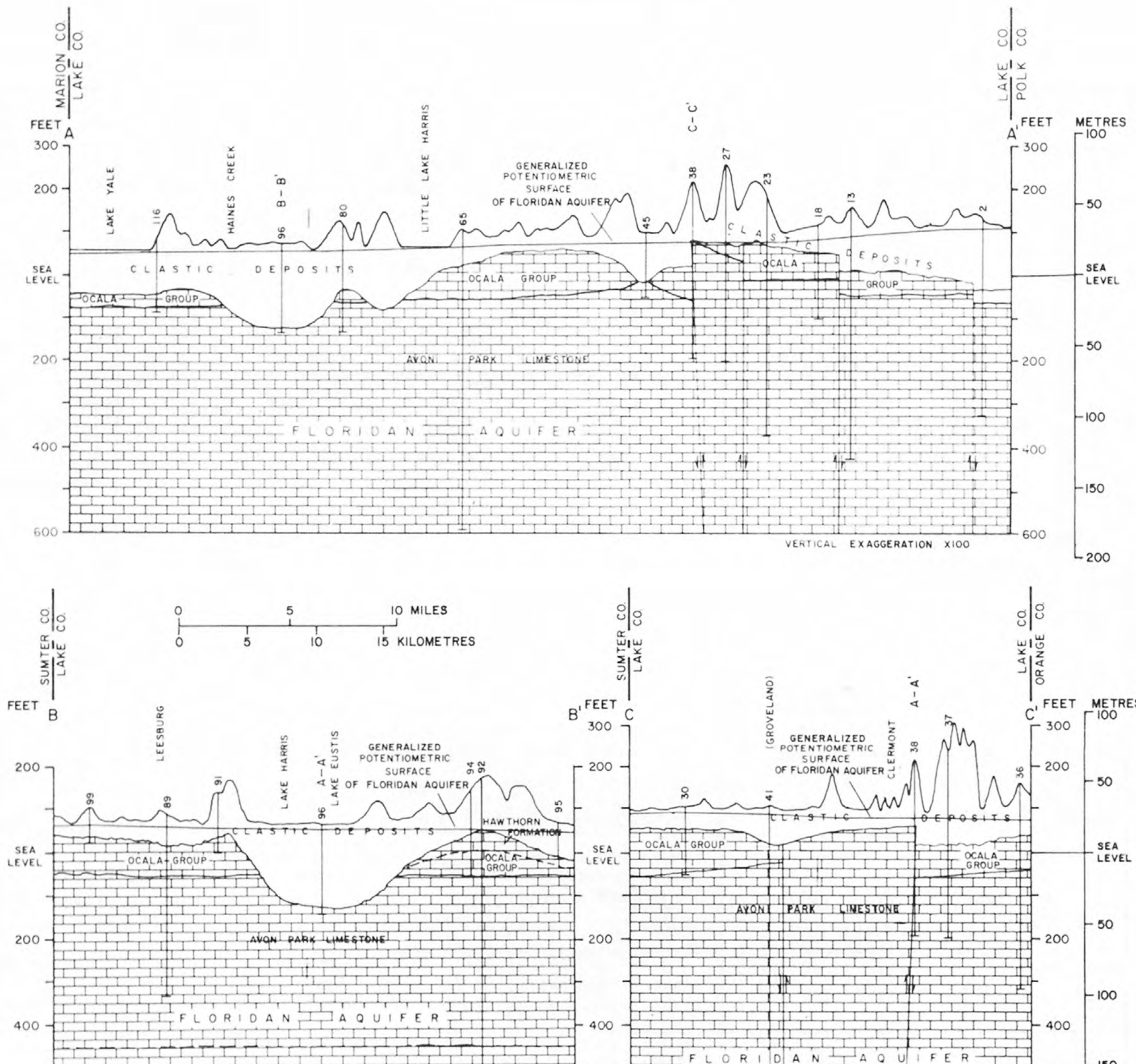

FIGURE 10.--GEOLOGIC SECTIONS THROUGH LAKE COUNTY

potential for greater well yields than the Citronelle Formation. A layer of colluvial and eolian sand of Holocene age covers the older formations to depths of 5 to 10 feet (1.5 to 3 m) in most of the county and to depths of 15 feet (4.6 m) in places.

The stratigraphic nomenclature used in this report conforms to the usage of the Florida Bureau of Geology except for the Citronelle Formation. It also conforms to the usage of the U.S. Geological Survey except for the Ocala Limestone which is referred to as the Ocala Group.

HYDROLOGY

Rainfall may be temporarily stored on the land surface in lakes, streams, or soil, but ultimately the rainfall is returned to the atmosphere by evaporation or moves to the ocean by surface and sub-surface drainage. The general pattern of water circulation is shown for Lake County in figure 11. The path that rainfall takes after reaching the land surface is determined largely by the geohydrologic characteristics of the area involved.

In Lake County the geohydrologic characteristics differ considerably between neighboring areas; hence, for purposes of discussing the hydrology of Lake County, the county has been divided into 8 geohydrologic areas, as shown in figure 12. The geohydrologic areas are almost identical to the landforms outlined in figure 7, the chief exception being that the Lake Upland landform has been subdivided into the Palatlakaha Upland and Green Swamp geohydrologic areas. The geohydrologic characteristics of the different areas are summarized in table 5.

Ground Water

As elsewhere in east-central Florida, the oldest formation penetrated by wells in Lake County is the Lake City Limestone of middle Eocene age. (Lichtler, 1972, p. 11). A generalized description of the hydrologic units at depth within Lake County is given in table 6. For purposes of discussion in this report, the sequence of materials from Holocene to Eocene is divided into a carbonate unit and a clastic unit. The carbonate unit is the Floridan aquifer and is comprised of the Ocala Group, and the Avon Park and Lake City Limestones. The clastic unit includes a lower part, which is a confining bed, and an upper part, which is the clastic aquifer. These relations are shown in table 6. The confining bed retards but does not prevent movement of water between the clastic aquifer and the Floridan aquifer.

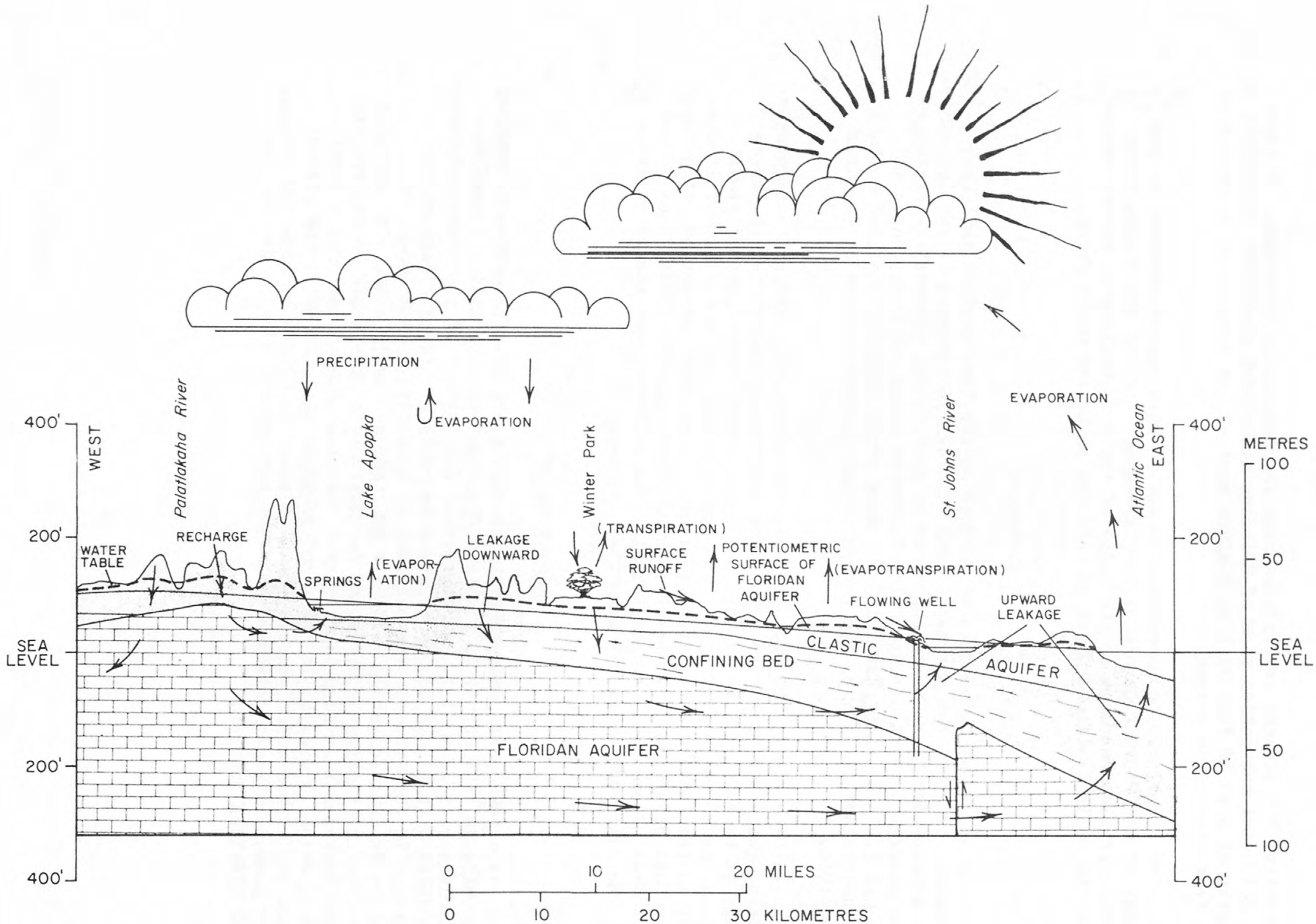

FIGURE 11.--ILLUSTRATION OF THE HYDROLOGIC CYCLE, LAKE COUNTY TO ATLANTIC OCEAN

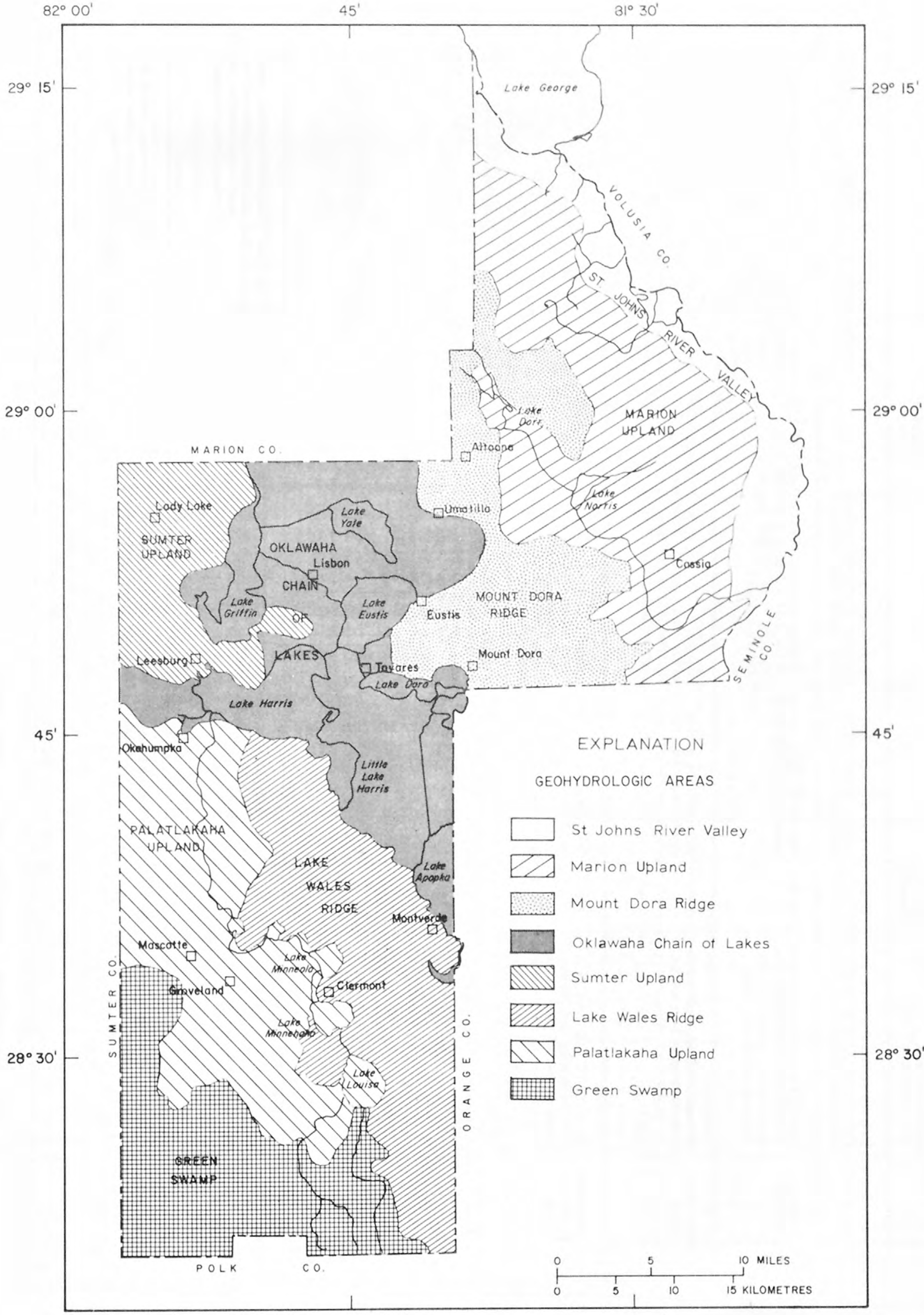

FIGURE 12.--GEOHYDROLOGIC AREAS IN LAKE COUNTY

Table 5.--Characteristics of geohydrologic areas in Lake County.

Geohydrologic Area	Topography	Annual surface runoff (inches)	Lakes	Ground-water levels	Depth to Floridan aquifer (feet)	Recharge to Floridan aquifer	Soil Association
St. Johns River Valley	Flat floodplain bounded by escarpment; 0 to 25 feet above sea level.	12-16	Large, shallow, few in number; connected to river system.	Clastic aquifer, near land surface; Floridan aquifer, at or above land surface.	100-200	None; area of natural discharge.	Montverde-Ocoee-Brighton; organic soil in low-level marsh or swampland.
Marion Upland	Low relief, moderately undulating, low hills separated by lakes and swamps; 25 to 100 feet above sea level.	8-12	Many small lakes interconnected at high water.	Clastic aquifer, 0 to 20 feet below land surface; Floridan aquifer, 0 to 25 feet below land surface.	25-200	Poor , mostly in sand hill areas along St. Johns River Valley; discharge in creek beds	Paola-Pomello-Myakka and Myakka-Swamp; well drained low sand ridges and poorly drained broad lowlands.
Mount Dora Ridge	Moderate relief, moderately high hills and lake basins; 75 to 185 feet above sea level.	4-8	Many small to medium sized lakes, mostly in closed basins.	Clastic aquifer, 0 to 50 feet below land surface; Floridan aquifer, 10 to 120 feet below land surface.	25-200	Fair; poor where water table is perched; hydraulic connection between lakes and Floridan aquifer is fair.	Astatula-Lake; well drained broad ridges interspersed with closed depressions.
Oklawaha Chain-of-Lakes	Large lakes separated by flat to highly undulating land; 55 to 165 feet above sea level.	4-8	Five large and many small lakes; levels of large lakes controlled by outlet structure.	Clastic aquifer, at or near land surface in areas of low relief; Floridan aquifer, above land surface in areas of low relief	100-200	Poor, except in few high areas.	Astatula-Lake and Montverde-Ocoee-Brighton; well drained broad ridges; level marshlands contain organic soil.
Lake Wales Ridge	High relief, undulating land surface; 75 to 310 feet above sea level.	0-4	Numerous small to medium size;fewer lakes in high areas.	Floridan aquifer, near land surface in areas of low relief, more than 200 feet below land surface under hills; clastic aquifer, about same as Floridan aquifer; Floridan aquifer is unconfined.	50-200	Good, both in lake basins and interlake basin areas.	Astatula-Lake; well drained broad ridges interspersed with closed depressions.
Sumter Upland	Moderate relief, moderately undulating; 55 to 185 feet above sea level.	0-4	Many small lakes in closed basins; few medium size lakes.	Floridan aquifer, near land surface in low areas, 50-100 feet below land surface under beneath hills; clastic aquifer, not known.	25-100	Good, greater in lake basins than in interlake areas.	Astatula-Lake; well drained broad ridges interspersed with closed depressions.
Palatlakaha Upland	Low to moderate relief; slightly undulating; 65-190 feet above sea level.	4-8	Many small lakes and swamps interconnected at high water.	Floridan aquifer, 5-20 feet below land surface in low areas, 20-50 feet under hills; Clastic aquifer, 0-5 feet above those of Floridan aquifer.	25-75	Fair, both in lake basins and in interlake basins.	Astatula-Myakka; moderately well drained uplands separated by poorly drained broad lowlands.
Green Swamp	Low relief, flat to slightly undulating; 95-130 feet above sea level.	4-8	Few lakes, wet areas are mostly swampland.	Floridan aquifer, at or slightly below land surface in low areas, as much as 40-50 feet below land surface in few high areas; clastic aquifer, 0 to 2 feet above those of Floridan aquifer.	25-75	Fair in areas where land surface is above potentiometric surface of Floridan aquifer.	Myakka-Swamp; broad lowlands with large swampy depressions.

Table 6.--Generalized description of hydrologic units in Lake County

Hydrologic Unit		HYDROLOGIC CHARACTERISTICS			GEOLOGIC NOMENCLATURE		
		Texture	Thickness and areal distribution (feet)	Water bearing property	System	Series	Stratigraphic unit
CLASTIC UNIT	CLASTIC AQUIFER	Well sorted fine sand	0-15 Mantles entire county except Oklawaha chain of lakes area	Generally above water table. Has high infiltration capacity.	QUATERNARY	HOLOCENE PLEISTOCENE	Undifferentiated colluvial and aeolian deposits.
		Well sorted fine to medium sand with clay strata	0-400 Mostly limited to St. Johns River valley and Oklawaha chain of lake area.	Generally saturated. Developed only for a few domestic water supplies in areas underlain by coarser grained material.			Undifferentiated alluvial and lacustrine deposits.
		Fine sand and fine clayey sand	0-200 Red clastics above water table, gray-green below water table. Thickest under Lake Wales ridge.	Mostly unsaturated. Water table located in lower part of unit. Conducts water from land surface to recharge Floridan aquifer.	TERTIARY	PLIOCENE	Citronelle Formation
	CONFINING BED	Clay and sand mixture with some stratification phosphatic	0-100 Thinnest under Lake Wales ridge area, thickens eastward.	Where thickest, acts as barrier to recharge and confines water in the underlying Floridan aquifer. Yields very little water to wells.		MIOCENE	Hawthorn Formation
CARBONATE UNIT	FLORIDAN AQUIFER	Limestone, white to tan, soft to hard, cavernous	0-100 Missing in Oklawaha chain of lakes area and in Clermont area.	Principal artesian aquifer yields large amounts of water to wells. Ocala group of limestone is highly productive but is limited because of its thickness. Most large yielding wells are open to the Avon Park Limestone. Few wells penetrate the Lake City Limestone, considered the bottom of the aquifer.		EOCENE	Ocala Group
		Limestone, dolomitic brown to gray, soft to hard, contains peat	400-1000				Avon Park Limestone
		Limestone, chalky, dolomite, dark brown, contains gypsum	500-1000				Lake City Limestone

Clastic Aquifer

The sandy material in the upper part of the clastic unit forms the clastic aquifer (table 6). This aquifer, except locally, has little potential as an important source of ground water. The mixture of clay and sand in the lower part of the clastic unit forms a confining bed that separates the clastic aquifer from the Floridan aquifer. The sandy materials of the clastic aquifer and the clayey materials of the confining bed have an important function in the hydrology of Lake County. Those parts of the unit that in the aggregate are permeable readily store water that infiltrates from the land surface and transmit it to the underlying Floridan aquifer as natural recharge. In areas where the infiltration rate is high, and where water is stored below the land surface and the root zone, both surface-water runoff and evapotranspiration are reduced. The clastic aquifer also acts as a large filter bed for purifying water before it recharges the Floridan aquifer.

Not everywhere in the clastic unit is the lithology of the confining ed or the clastic aquifer uniform. The unit incorporates a wide diversity of materials which from place to place differ greatly in thickness. In most of the geohydrologic areas, except the Oklawaha Chain-of-Lakes and the St. Johns River Valley, the clastic aquifer segment--except in the uppermost part--is clayey, to the extent that the permeability of the aquifer segment may be only slightly higher than that of the confining bed. In the Oklawaha Chain of Lakes the confining bed is thin and the aquifer segment occupies nearly the entire vertical range of the clastic unit. The sand of the aquifer is quite free of clay, although numerous clay strata are interbedded. Little is known of the nature of the clastic aquifer underneath the St. Johns Valley, but on basis of information obtained from outside the county, it may be much like that of the Oklawaha Chain-of-Lakes. In these areas where the aquifer segment occupies nearly the entire vertical range of the clastic unit, the clastic aquifer probably could be developed to yield water to wells at moderate rates. Presently (1974), no large-diameter wells tap the clastic aquifer, even where sand predominates. Generally, in drilling wells into the Floridan aquifer, the clastic aquifer is cased off.

Nearly everywhere in the county, the permeability of the confining bed is sufficiently less than that of the sandy or clayey materials above it that a water table is established whose distance below land surface depends on the quantity of water available for recharge, and the thicknesses and hydraulic conductivities of the aquifer and the confining bed. Generally, the configuration of the water table conforms in a subdued way to the configuration of the land surface so that it is lowest adjacent to a stream or lake and rises in altitude in proportion to the rise in land surface away from the stream or lake. However, in parts of Lake County, especially in the Lake Wales Ridge and Palatlakaha Upland areas, the configuration of the water table does not conform to the land surface, as is shown in figure 13.

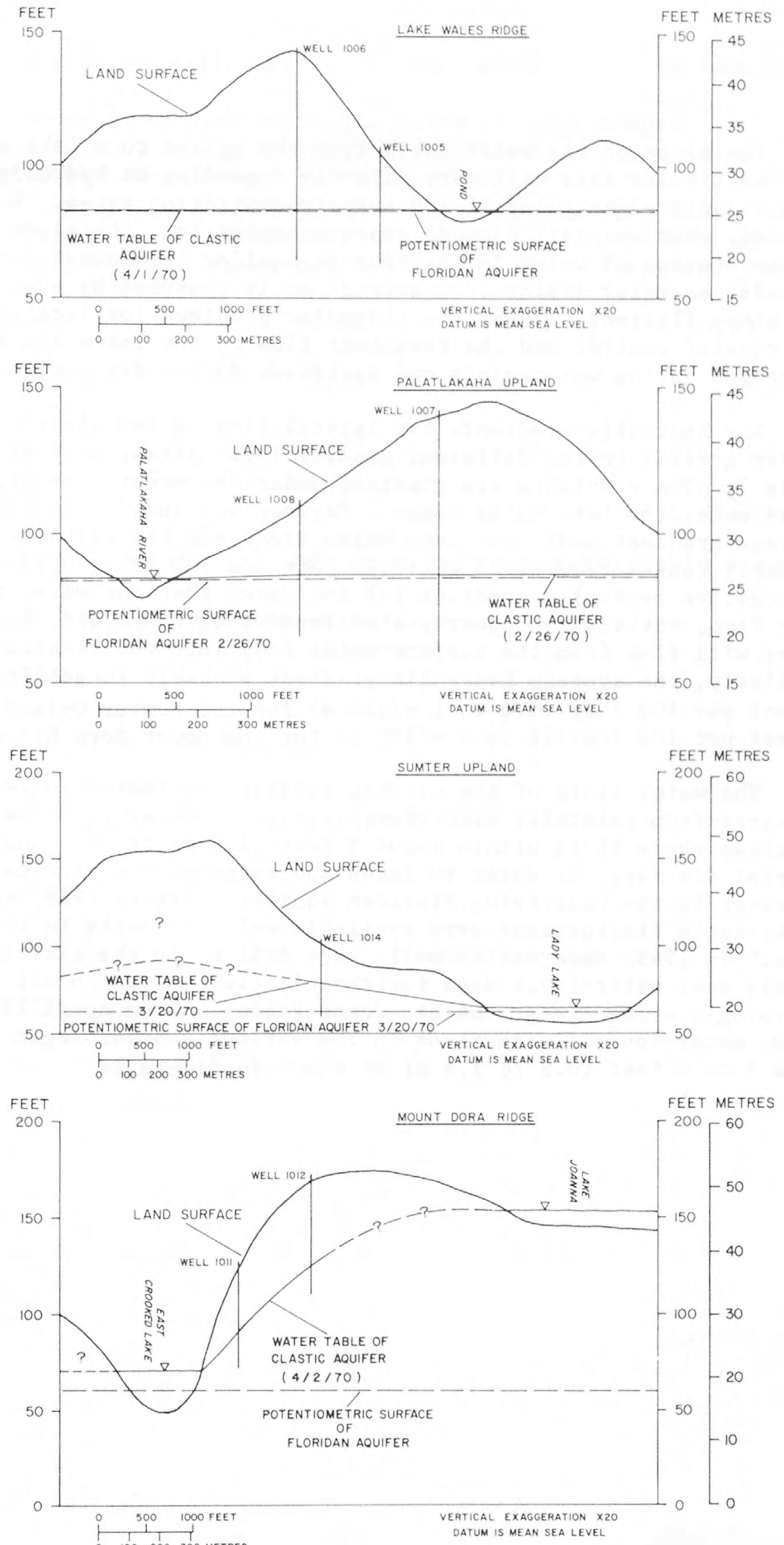

FIGURE 13.--GENERALIZED SECTIONS SHOWING TYPICAL WATER-LEVEL PROFILES IN FOUR GEOHYDROLOGIC AREAS.

The slope of the water table from the upland to a lake or stream at a particular site will vary slightly depending on hydrologic conditions, such as antecedent rainfall and evapotranspiration rates. During wet periods, when rainfall exceeds evapotranspiration, the slope steepens as the storage of water in the clastic aquifer increases; during dry periods, as water drains from storage or is consumed by evapotranspiration, the slope flattens. Thus, the hydraulic gradient for lateral flow in the clastic aquifer and the resultant flow to the lakes and streams increases during wet periods and decreases during dry periods.

The hydraulic gradients for lateral flow in the clastic aquifer differ greatly in the different geohydrologic areas, as indicated in table 7. The gradients are greatest under the Mount Dora Ridge and least under the Lake Wales Ridge. Between wet and dry periods, the average gradient under the Lake Wales Ridge and the Paltalakaha Upland probably ranges from -0.25 to +0.25 foot per 100 feet(-0.25 to +0.25 m/100 m). (A negative hydraulic gradient (-) indicates that the water table slopes away from, rather than toward, a surface-water body, and, hence, that water will flow from the surface-water body into the clastic aquifer.) Similarly, the average hvdraulic gradient probably ranges from 0.5 to 1 foot per 100 feet (0.5 to 1 m/100 m) for the Sumter Upland and 1 to 4 feet per 100 feet (1 to 4 m/100 m) for the Mount Dora Ridge.

The water table of the clastic aquifer fluctuates in response to recharge from rainfall, evapotranspiration of water from the water table in areas where it is within about 5 feet (1.5 m) of the land surface, lateral discharge of water to lakes and streams, and vertical discharge of water to the underlying Floridan aquifer. Before 1969, records of water-table fluctuations were available only for wells in the Green Swamp area. In 1969, observation wells were drilled in the clastic aquifer to obtain some water-level data for the clastic aquifer in all of the geohydrologic areas except the St. Johns Valley. From April 1968 to May 1970, water-level fluctuations in the various geohydrologic areas ranged from 3 to 6 feet (0.9 to 1.8 m) as shown in figure 14.

Table 7.--Measured hydraulic gradients for lateral flow in the clastic aquifer in selected geohydrologic areas of Lake County.

Geohydrologic area	Minimum gradient (feet per 100 feet)	Maximum gradient (feet per 100 feet)
Lake Wales Ridge	-0.28	0.33
Palatlakaha Upland	-.39	.14
Sumter Upland	.59	.77
Mount Dora Ridge	1.8	3.5

NOte: A negative gradient (-) indicates that the water table slopes from, rather than towards, a surface-water body.

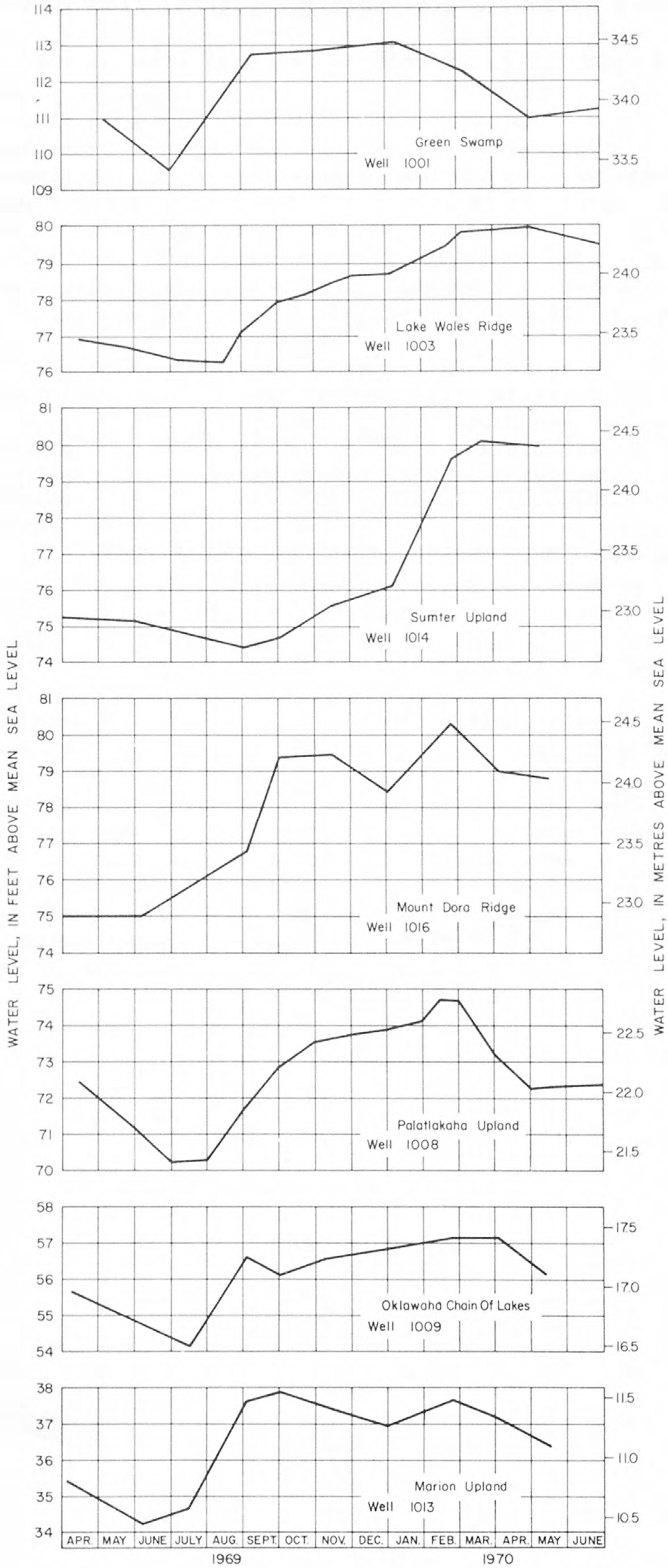

FIGURE 14.--HYDROGRAPHS OF WELLS TAPPING THE CLASTIC AQUIFER. (FOR LOCATIONS SEE FIG. 2.)

Where the water table is nearly flat, as in the Lake Wales Ridge, Palatlakaha Upland (fig. 13), for example, water moves through the clastic aquifer mostly downward to recharge the Floridan aquifer. Where the water table slopes more steeply toward surface-water bodies, as in the Sumter Upland and Mount Dora Ridge (fig. 13), for example, more of the water moves laterally to lakes and streams, and less moves downward to recharge the Floridan aquifer.

Water movement in unsaturated zone

The apparent rate of water movement from the land surface to the water table of the clastic aquifer was estimated for 3 storms, each of which occurred after long dry periods. The storms--occurring on December 10, 1969, February 3, 1970, and March 6, 1970, respectively--produced daily rainfalls ranging from 2.11 to 2.77 inches (54 to 70 mm) at neaby non-recording gages. The response of the water table of the clastic aquifer--as indicated by the rise in water levels in observation wells equipped with continuous water-level recorders--began from less than 24 hours to as much as 48 hours after the rainfall. Inasmuch as the time of the rainfall was not recorded, the time lag between the rainfall and the rise of the water table could not be determined precisely. If the water table began to rise on the day of the rainfall, the lag time was considered to be less than 24 hours; if the water table began to rise on the day following the day of the rainfall, the time lag was considered to be 24 hours; and, if the water table began to rise on the second day following the day of the rainfall, the time lag was considered to be 48 hours. On this basis, the apparent rate of movement of water through the unsaturated zone of the clastic aquifer ranged from 0.5 foot (0.15 m) per hour to slightly more than 1 foot (0.3 m) per hour in an area where the water table was 26 feet (8 m) below the land surface. These rates probably are representative of most areas in Lake County where the material in the unsaturated zone is fine to medium sand containing small quantities of clay. The time lag apparently varies with antecedent soil-moisture conditions and shorter time lags probably would have been indicated had the rainfalls not been preceded by such long dry periods. Similarly, shorter time lags might have been indicated had the magnitude and intensity of the rainfall been greater than it was for the selected storms.

Floridan Aquifer

Underlying the clastic unit in central Florida is the carbonate unit, a thick sequence of limestones and dolomitic limestones which forms the Floridan aquifer. In central Florida, the top of the Oldsmar Limestone (table 4) is considered to be the bottom of the Floridan aquifer. In an oil-test well in the southern part of Lake County the top of the Oldsmar Limestone was penetrated at a depth of about 2,000 feet (610 m). This probably represents the maximum thickness of the aquifer because it thins slightly toward the north.

The depth to the top of the Floridan aquifer and a generalized configuration of its surface are shown on figure 15. The depth is greatest in the vicinity of the Oklawaha Chain-of-Lakes (figs. 10, 12, and 15). The area of greatest depth is delineated by the minus 50-foot (15-m) contour on figure 15 and has the configuration of a buried stream valley. The clastic material in the "valley" is generally about 200 feet (60 m) thick but some wells have penetrated as much as 400 feet (120 m) of clastic materials before reaching the Floridan aquifer.

The Floridan aquifer is the source of most water (about 85 percent) for municipal, industrial, irrigation, and domestic supplies. The aquifer acts as a large reservoir which stores water, after recharge from the overlying clastic aquifer and before discharge through springs, seeps, and wells. In most places in Lake County, the Floridan aquifer is partly confined beneath the less permeable confining bed. In some parts of the county, the potentiometric surface of the Floridan aquifer is above the land surface. Where the potentiometric surface is above land surface, wells which tap the aquifer will flow. Such wells are called artesian flowing wells, and the areas in which they occur in Lake County are outlined in figure 16.

The potentiometric surface of an aquifer is defined by the level to which water will rise in tightly cased wells that penetrate the aquifer. The potentiometric surface fluctuates owing to variations in recharge to the aquifer and discharge from the aquifer. In Lake County the maximum recorded range of fluctuation of the Floridan aquifer is about 12 feet (3.7 m) in a well near Altoona, as shown in figure 17. Fluctuations in other wells for which long-term records are available range from 5.2 to 9.4 feet (1.6 to 2.9 m). The fluctuations in the water level of the Altoona well correspond, in general, to variations in rainfall. For example, the low levels in 1955-56 correspond with the less-than-average rainfall in 1954-56 and the peak level in 1960 corresponds with the greater-than-average-rainfall in 1959-60 (fig. 3 and 4).

The range of fluctuation of the potentiometric surface of the Floridan aquifer varies to some extent with geohydrologic areas, as shown in figure 18, which shows hydrographs for 5 wells tapping the Floridan aquifer in different geohydrologic areas. During 1968-69 the fluctuation in water level ranged from 4 feet (1.2 m) in the well in the Green Swamp area to slightly over 6 feet (1.8 m) in wells in the upland and ridge areas. The range of fluctuation of the potentiometric surface during 1968-69 in Lake County is shown generalized in figure 19. In general, fluctuations are largest in the ridge areas, which are the principal areas of recharge for the Floridan aquifer in Lake County. The range of fluctuation in the ridge areas to some extent may be affected by withdrawals of water from the Floridan aquifer to irrigate citrus.

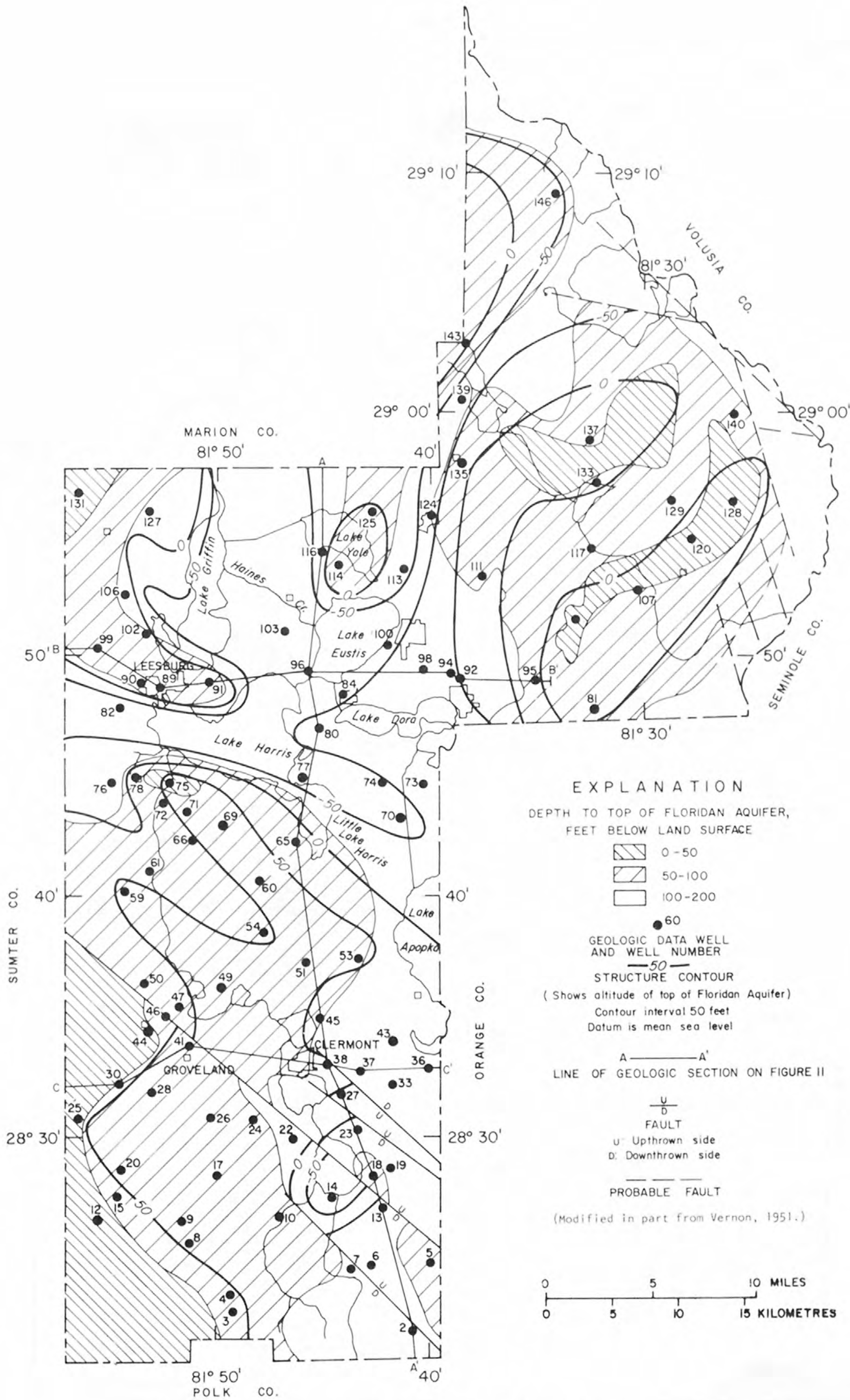

FIGURE 15.--DEPTH TO AND ALTITUDE OF TOP OF FLORIDAN AQUIFER IN LAKE COUNTY

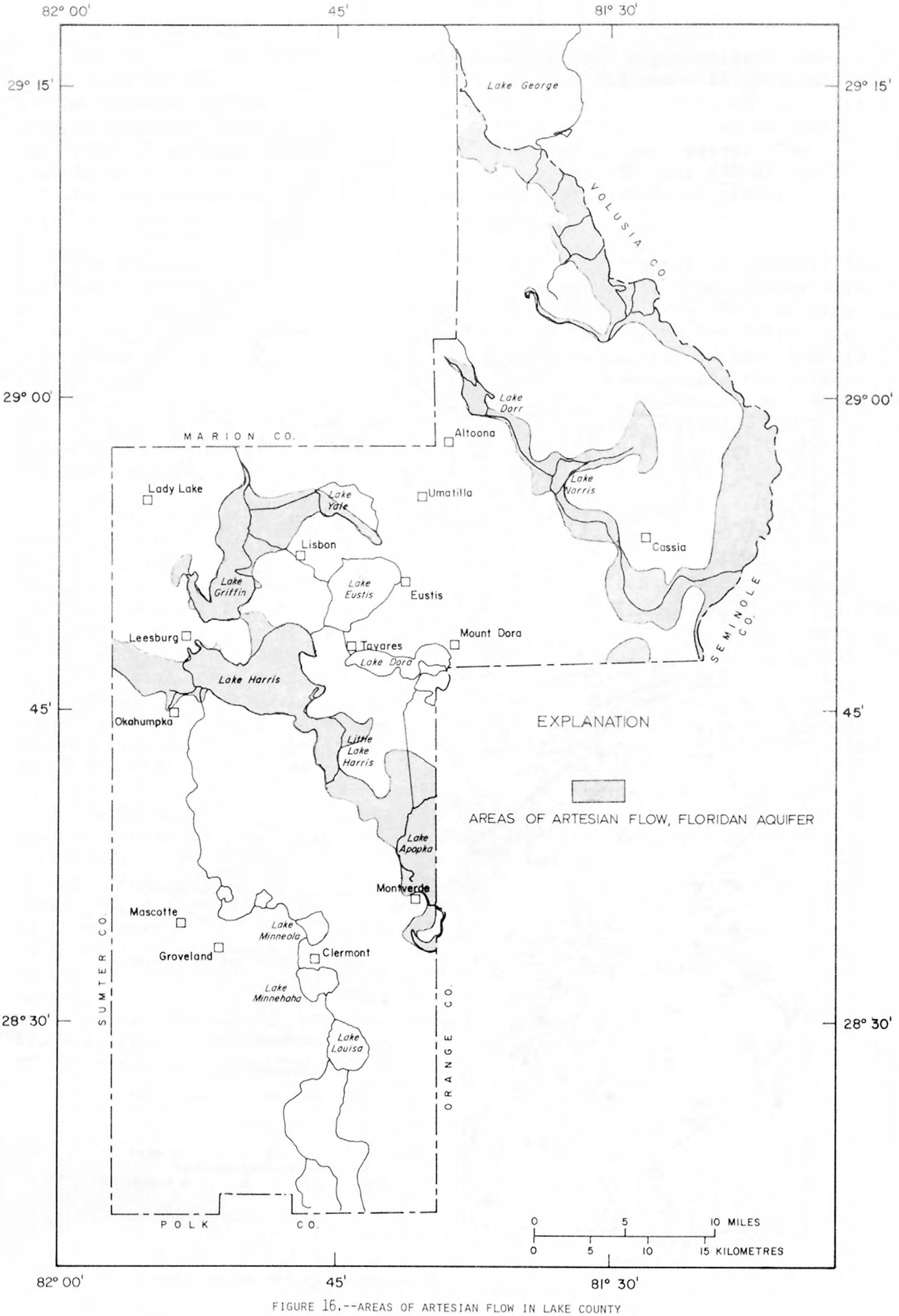

FIGURE 16.--AREAS OF ARTESIAN FLOW IN LAKE COUNTY

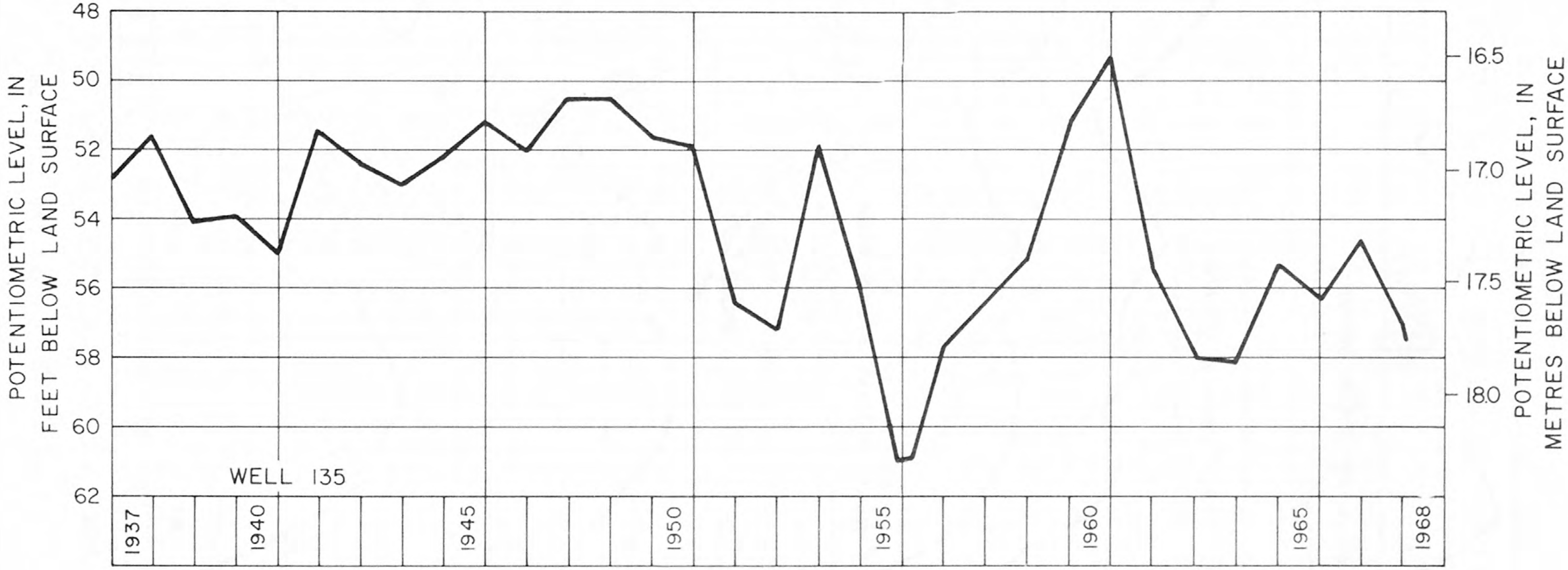

FIGURE 17.--HYDROGRAPH OF WELL TAPPING THE FLORIDAN AQUIFER IN LAKE COUNTY, NEAR ALTOONA.

(FOR WELL LOCATION SEE FIG. 2)

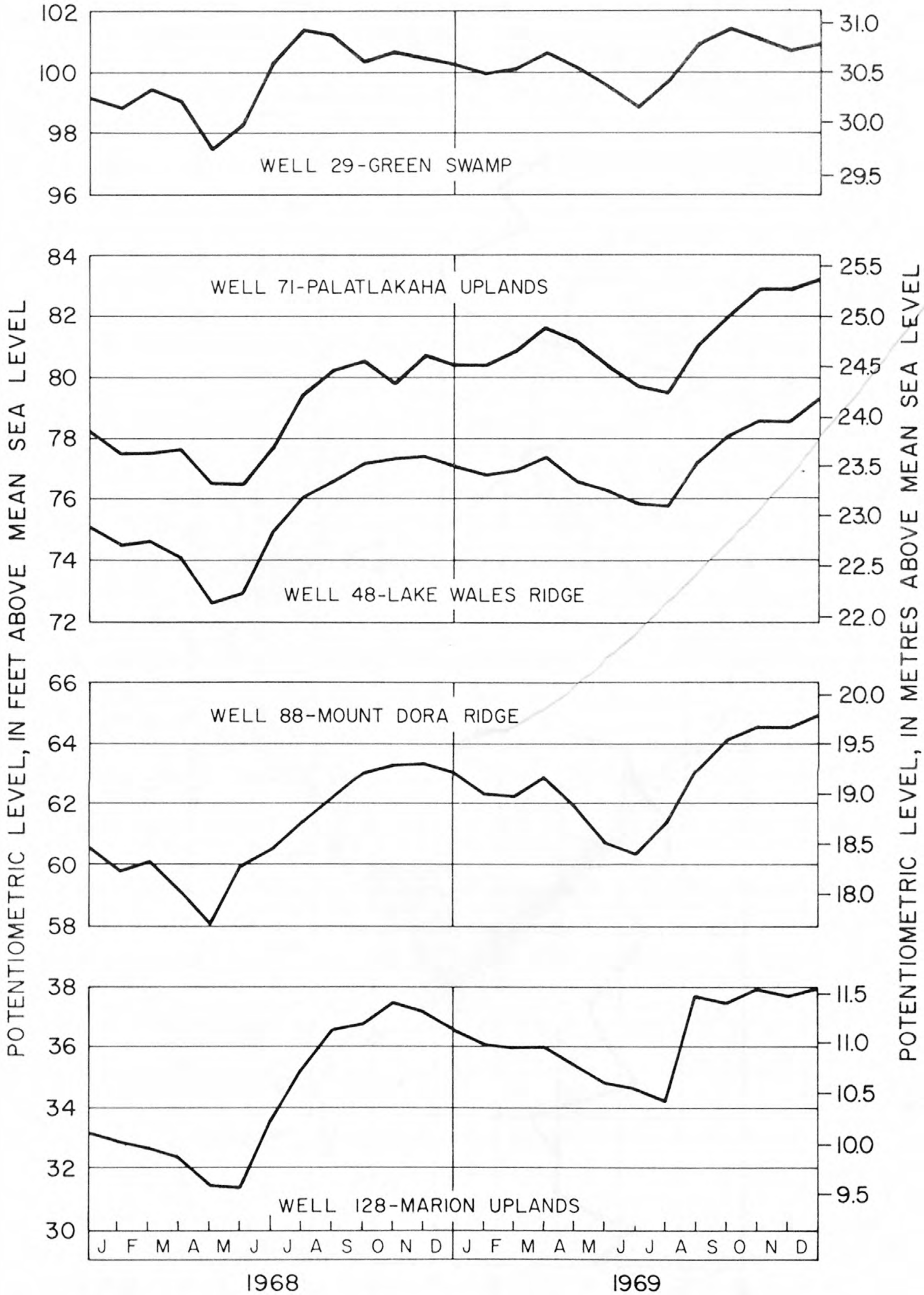

FIGURE 18.--HYDROGRAPHS OF WELLS THAT TAP THE FLORIDAN AQUIFER IN DIFFERENT GEOHYDROLOGIC AREAS OF LAKE COUNTY. (FOR WELL LOCATIONS SEE FIG. 2)

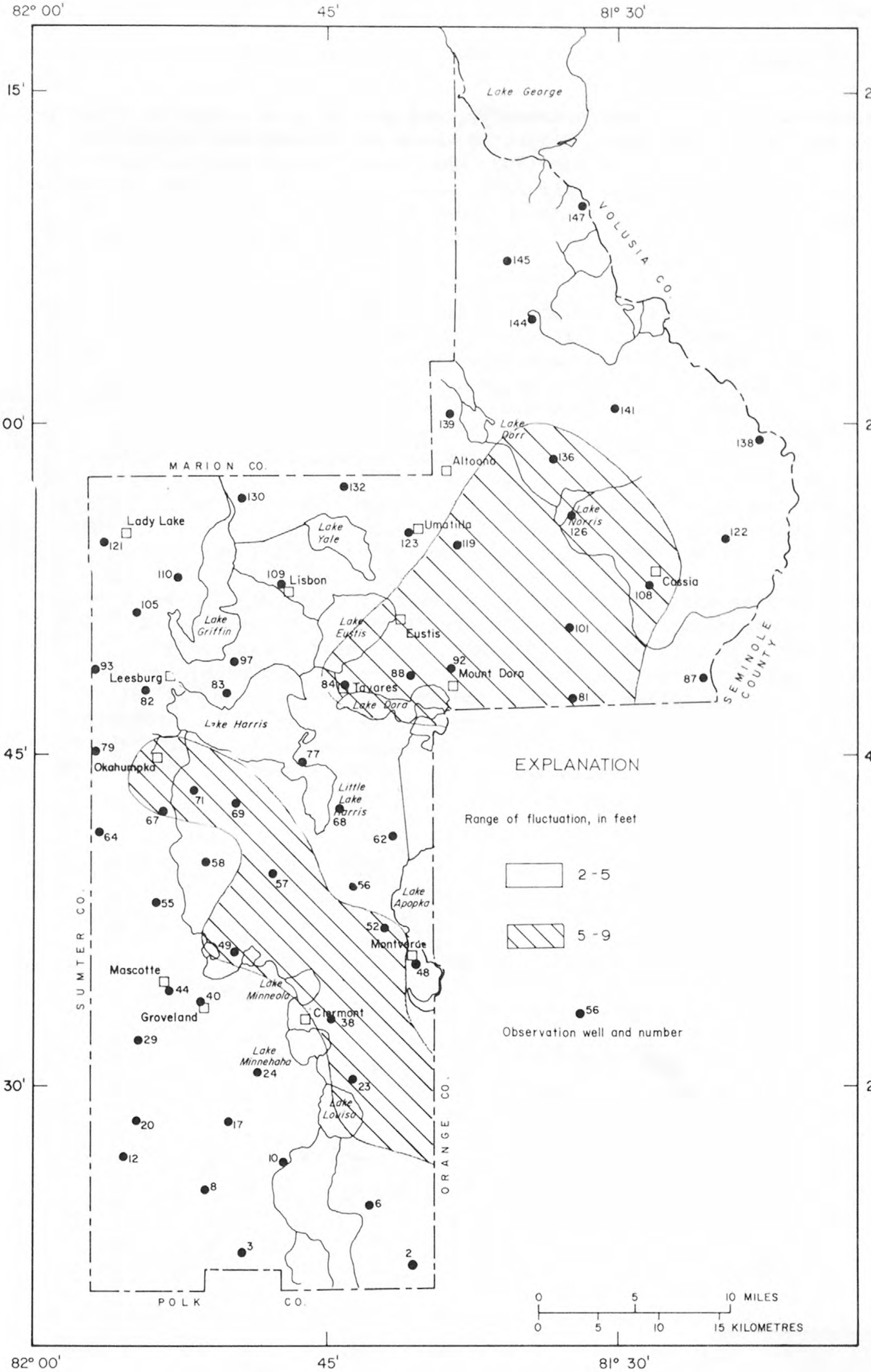

FIGURE 19.--RANGE OF FLUCTUATION OF WATER LEVELS IN WELLS TAPPING THE FLORIDAN AQUIFER IN LAKE COUNTY, 1968-69.

Ground-water levels vary seasonally, and generally are high in October-November and low in May-June. Figure 20 shows the potentiometric surface of the Floridan aquifer as of May 1968, when water levels were at their lowest for the investigation. Figure 21 shows the position of the potentiometric surface in October 1969, the highest during the investigation, and probably representative of the average position of the surface over the long term.

The potentiometric surface of the Floridan aquifer was about 5 feet (1.5 m) higher in October 1969 than in May 1968, but the configuration of the surface was about the same, as would be expected. The configuration of the surface indicates that, in general, ground water in the Floridan aquifer flows north and northeast from the south end of the county toward Marion County and the St. Johns River. Some ground water flows northwest toward the Withlacoochee River in Sumter County, some flows northeast into Orange County and some flows northward into Marion County. The ground-water divide that separates flow toward the Withlacoochee River from flow toward the St. Johns River (fig. 21) is also the divide between the flow toward the Gulf of Mexico and flow toward the Atlantic Ocean.

From the southeast corner of the county to the St. Johns River, the slope of the potentiometric surface of the Floridan aquifer (fig. 21) averages about 2.5 feet per mile (0.5 m/km). Locally the slope is considerably greater or less than the 2.5-foot-per-mile (0.5 m/km) average owing to differences in the thickness and permeability of the aquifer and in the rates of discharge from or recharge to the aquifer. The probable causes of local variations in the slope of the potentiometric surface are suggested for a few areas, beginning with the south end of the county. On

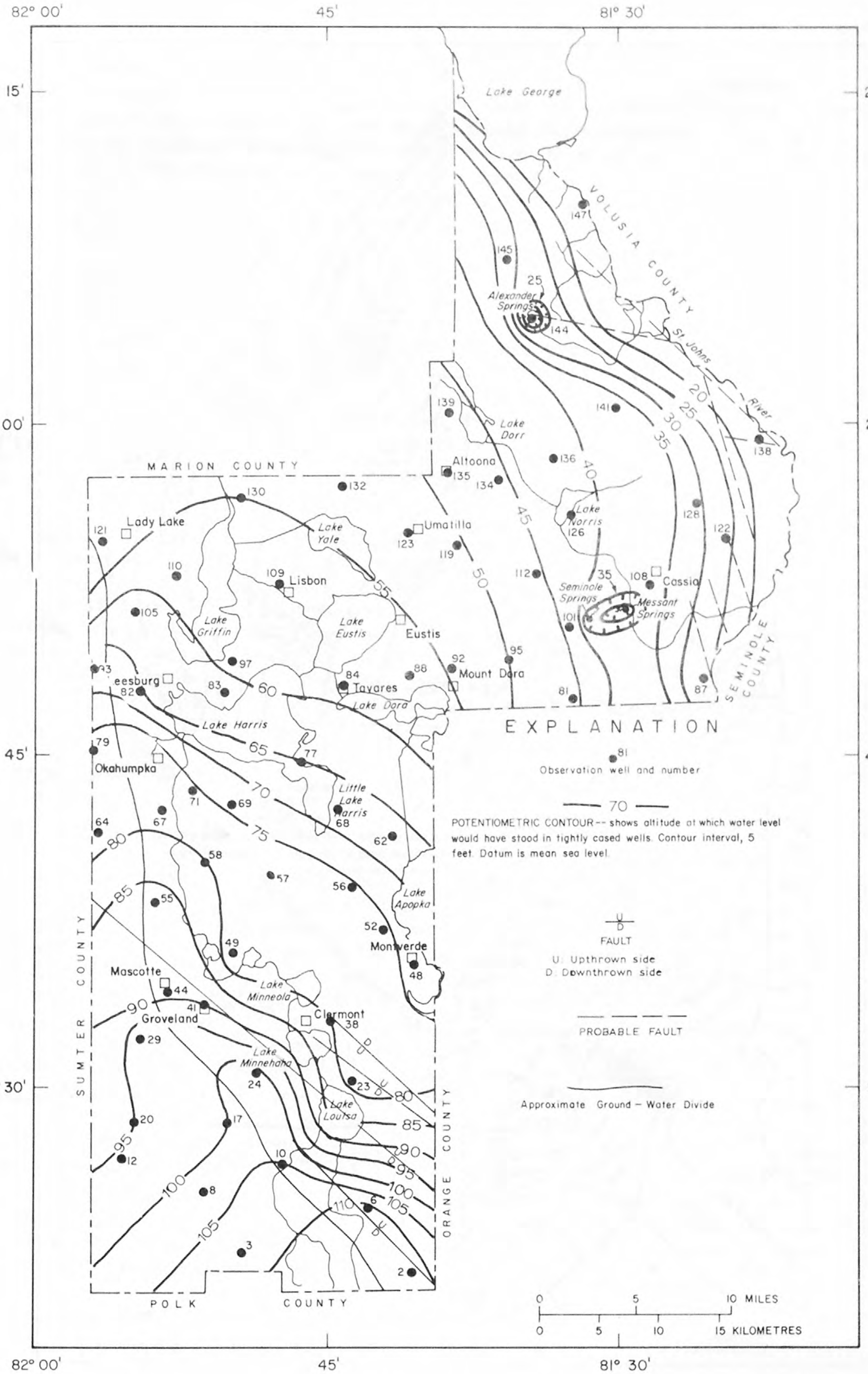

FIGURE 20.--POTENTIOMETRIC SURFACE OF THE FLORIDAN AQUIFER IN LAKE COUNTY DURING LOW WATER, MAY 1968

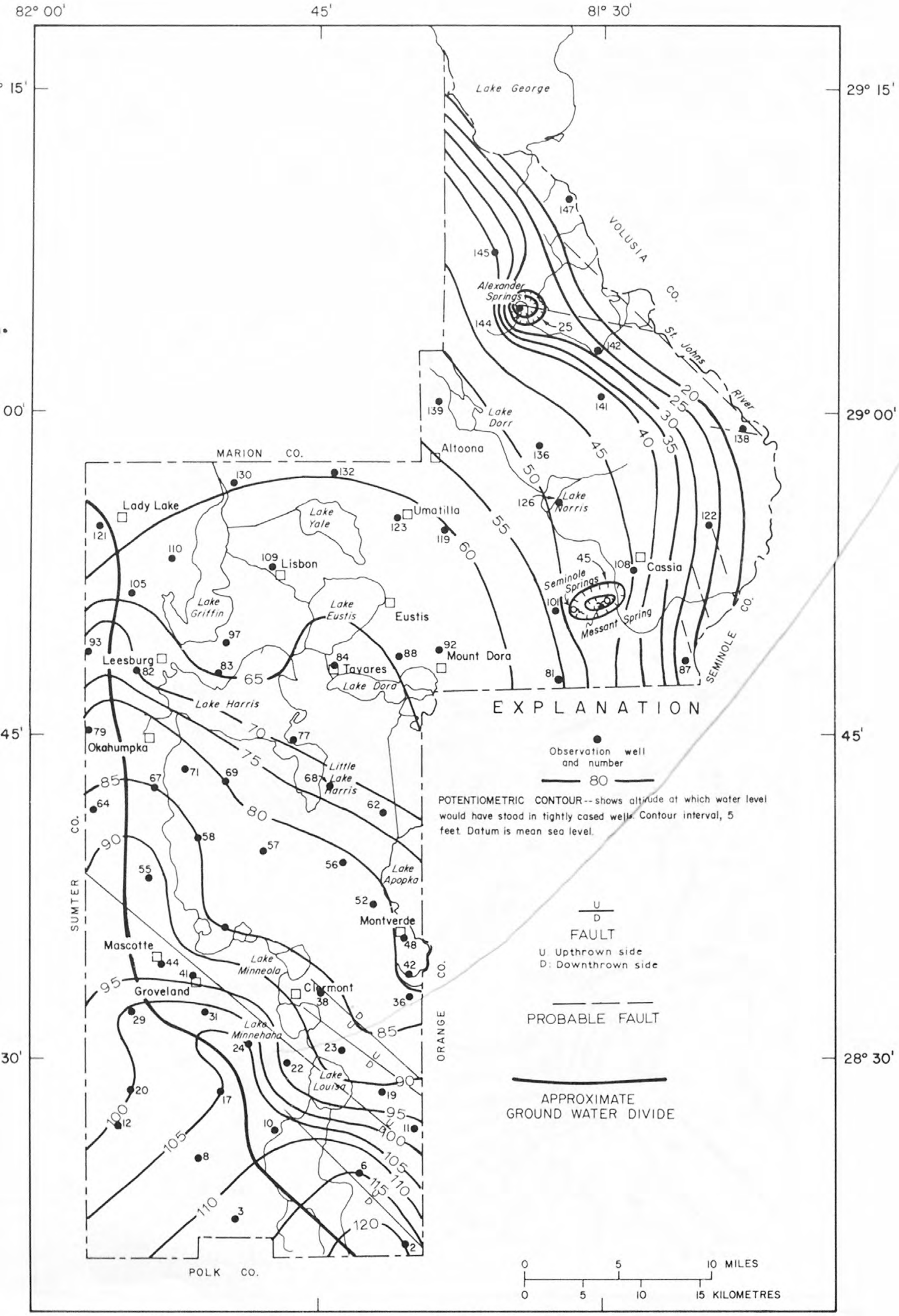

FIGURE 21.--POTENTIOMETRIC SURFACE OF THE FLORIDAN AQUIFER DURING OCTOBER 1969 WHEN WATER LEVELS WERE ABOUT NORMAL

the south side of Lake Louisa, where the potentiometric contours are shown to converge, the slope of the potentiometric surface averages about 8.5 feet per mile (1.6 m/km). The steep slope here probably reflects a decrease in aquifer permeability which is attributed to faulting and fracturing of the aquifer materials. The geologic structure in this area appears to act as a barrier that deflects ground-water flow to the west. Farther northward, between the 85- and 80-foot (26- and 24-m) contours (fig. 21) the slope of the potentiometric surface averages about 1 foot per mile (0.2 m/km). This decrease in slope probably results from the large quantity of recharge to the aquifer in this general area. Still farther northeast the increase in slope of the potentiometric surface to about 3 feet per mile (0.6 m/km) may reflect a thinning of the aquifer in the area of the large lakes. The steep slope of the potentiometric surface along the St. Johns River probably is caused by upward leakage from the Floridan aquifer with concentration of flow paths in the flow net. The large discharge of Alexander Springs causes a noticeable depression in the potentiometric surface in the northern part of the county.

Local differences in the permeability and thickness of the Floridan aquifer also are reflected in the yields of wells that tap the aquifer. Reported and measured yields of wells in Lake County of various sizes and depths ranged from 13 to 800 gallons per minute per foot [2.7 to 166 (l/s)/m] of drawdown. These values apply only to the upper part of the aquifer because even the large diameter wells penetrate only from 25 to 50 percent of the aquifer thickness. Well yields in the order of 200 gallons per minute per foot [41 (l/s)/m] of drawdown are fairly common in most parts of the county.

Transmissivity of the Floridan aquifer also ranges widely, as indicated by determinations of various investigators. For the upper part of the Floridan aquifer in Orange County, Lichtler and others (1968, p.137) suggest a transmissivity of 67,000 feet squared per day (6,200 m^2/d). (See Glossary.) From a test of the upper part of the Floridan aquifer in Volusia County, Wyrick (1960, p. 55-56) determined a transmissivity of 40,000 feet squared per day (3,700 m^2/d). In Marion County, Faulkner (1970) determined an average transmissivity of 2,090,000 feet squared per day (194,000 m^2/d) from a flow-net analysis of the Floridan aquifer near Ocala. For the eastern and northwestern parts of the Green Swamp, Pride and others (1966, p. 83-85) estimated the transmissivity of the Floridan aquifer as 40,000 and 62,000 feet squared per day, (3,700 and 5,800 m^2/d) respectively; transmissivity values from 3 pump tests in that part of the Green Swamp that is in Lake County ranged from 3,750 to 39,200 feet squared per day (350 to 3,600 m^2/d). The control wells used in the latter 3 pump tests penetrated only from 5 to 12 percent of the aquifer. In their study of the Green Swamp, Pride and others (1966, p. 84) concluded that the wide range in apparent transmissivity of the Floridan aquifer was caused by unequal penetration of the aquifer by the control wells, as well as by the local differences in the hydraulic conductivity of the aquifer.

On basis of the transmissivity determinations of the various investigators in adjoining areas, and also on well-yield data for Lake County, the transmissivity of the upper part of the Floridan aquifer probably averages about 40,000 feet squared per day (3,700 m^2/d) over the county.

Recharge to Floridan aquifer

The Floridan aquifer is recharged by water which moves downward through the clastic unit; that is, through the clastic aquifer and the confining bed. The rate of recharge varies with the hydraulic conductivity of the clastic unit and that in the Floridan aquifer. The hydraulic gradient is determined by the difference in levels of the water table of the clastic aquifer and the potentiometric surface of the Floridan aquifer and the thickness of the saturated materials of the clastic unit.

Annual rates of recharge to the Floridan aquifer were determined for the geohydrologic areas of Lake County on basis of estimates of the hydraulic conductivity, head difference, and saturated thickness of the clastic unit in each area. Recharge was computed separately for upland areas and for lake and swamp areas, and then weighted by area to obtain an average rate for each geohydrologic area. The following equation was used:

$$Q = 4,380 \quad \{A(K_u I_u) + B(K_l I_l)\}$$

wherein
- Q = recharge to Floridan aquifer, in inches per year;
- A = percentage of geohydrologic area in uplands;
- B = percentage of geohydrologic area in lakes and swamps;
- K_u = average vertical hydraulic conductivity of saturated zone of clastic unit under upland areas, in feet per day;
- K_l = average vertical hydraulic conductivity of saturated zone of clastic unit under lakes and swamps, in feet per day;
- I_u = vertical hydraulic gradient across saturated zone of clastic unit under upland areas, in feet per foot; and,
- I_l = vertical hydraulic gradient across saturated zone of clastic unit under lakes and swamps, in feet per foot.

The computed recharge to the Floridan aquifer ranged from 14 inches (356 mm) per year in the Lake Wales Ridge area to zero in the St. Johns River valley area as shown in figure 22. Of course, the St. Johns River Valley is entirely an area of ground-water discharge. The low rate of recharge shown for the Oklawaha Chain-of-Lakes area is partly due to areas of ground-water discharge from the Floridan aquifer in some of the lake basins. Natural discharge from the Floridan aquifer also occurs in some of the low parts of other geohydrologic areas. Computed annual recharge to the Floridan aquifer averaged 7 inches (178 mm) over the entire county, equal to about 383 million gallons per day (17 m^3/s).

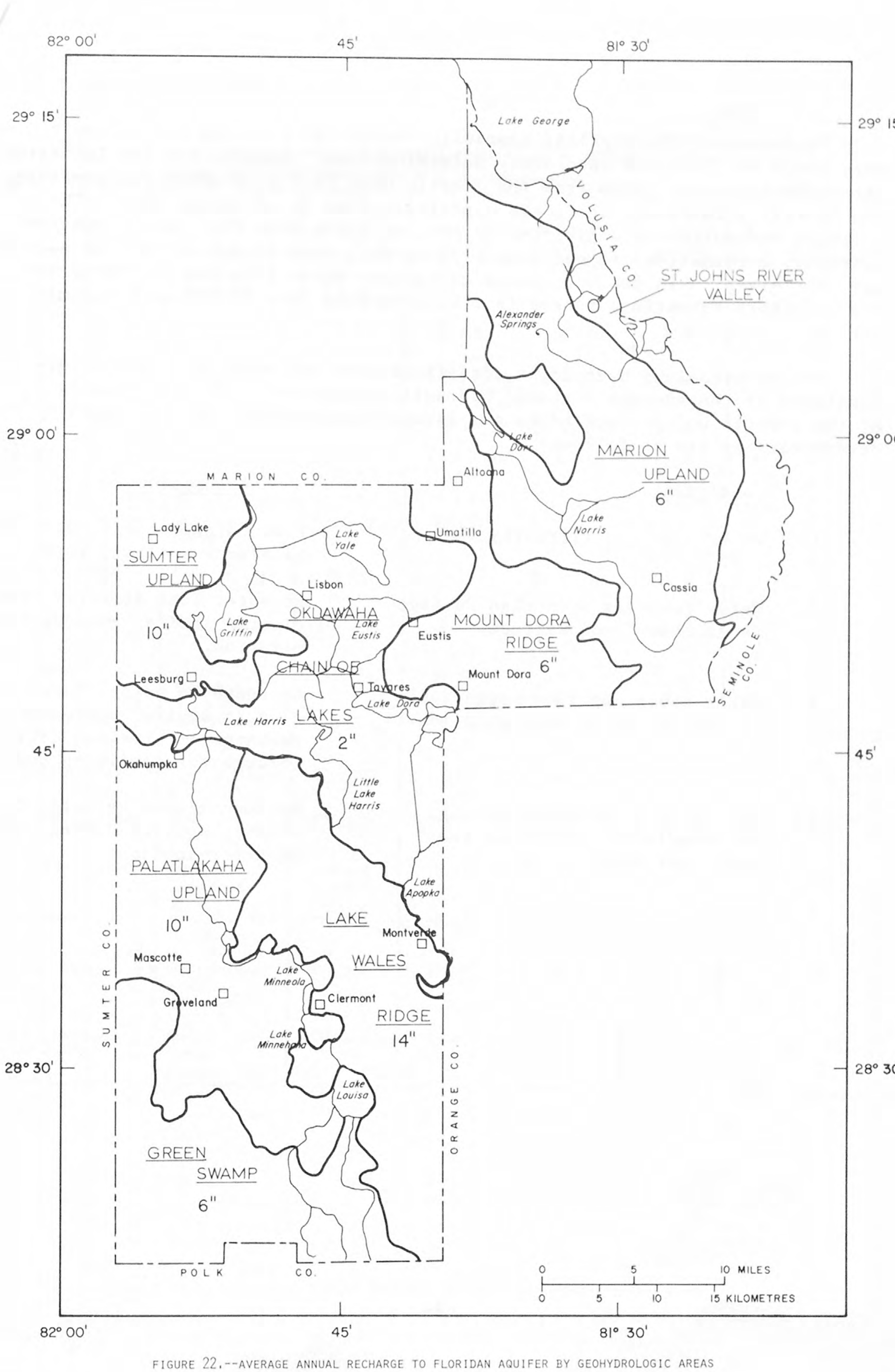

FIGURE 22.--AVERAGE ANNUAL RECHARGE TO FLORIDAN AQUIFER BY GEOHYDROLOGIC AREAS IN LAKE COUNTY (RECHARGE SHOWN IN INCHES.)

Estimates of the vertical hydraulic conductivity of the clastic unit were based on field and laboratory determinations. Samples for the laboratory determinations were taken from the clastic unit in places where the confining bed is fairly thick and where the clastic aquifer is of clayey sand. The vertical hydraulic conductivities of samples taken from the clastic aquifer (Citronelle Formation) ranged from 0.03 to 61.5 feet (0.009 to 18.7 m) per day, as given in table 8; those of samples taken from the confining bed (Hawthorn Formation) ranged from 0.01 to 0.53 foot (0.003 to 0.162 m) per day.

On two occasions hydrologic conditions were suitable for field determinations of the average vertical hydraulic conductivity of an entire section of the clastic unit. Conditions and assumptions pertinent to the field determinations are as follows:

	Conditions	Assumptions
1.	Water table is virtually flat.	Flow through the clastic aquifer is almost entirely vertical.
2.	Water table is more than 20 feet (6 m) below land surface.	No water lost directly from clastic aquifer by evapotranspiration.
3.	Water table declines appreciably during period of determination.	Decrease in water stored in clastic aquifer represents recharge to Floridan aquifer through the confining bed.
4.	Little or no rainfall during or immediately preceding the period of determination.	No appreciable recharge to clastic aquifer during period of determination.

Table 8.--Laboratory determinations of porosity, specific yield, and vertical hydraulic conductivity of samples taken from the clastic unit in Lake County.

Geohydrologic area	Geologic unit	Sample No.	Sample depth (feet)	Porosity (percent)	Specific Yield (percent)	Vertical Hydraulic Conductivity (feet per day)
Palatlakaha upland	Citronelle Formation	FTL 1/1	30-32	32.1	17.9	2.7
Sumter upland	Citronelle Formation	FTL 2/1	20-22	40.3	22.8	1.6
Sumter upland	Citronelle Formation	FTL 2/2	70-72	45.8	36.6	10.7
Mount Dora ridge	Citronelle Formation	FTL 4/1	35-37	41.2	22.4	.05
Mount Dora ridge	Citronelle Formation	FTL 6/1	40-42	35.5	22.8	61.5
Mount Dora ridge	Citronelle Formation	FTL 6/2	80-81	33.3	30.4	17.4
Lake Wales ridge	Citronelle Formation	FTL 7/1	30-32	38.2	28.2	6.7
Lake Wales ridge	Citronelle Formation	FTL 7/2	70-72	33.3	19.0	34.8
Lake Wales ridge	Citronelle Formation	FTL 8/1	35-37	33.6	24.8	2.0
Lake Wales ridge	Citronelle Formation	FTL 8/2	70-72	42.0	27.4	.26
Palatlakaha upland	Citronelle Formation	FTL 9/1	35-37	36.5	15.6	.03
Palatlakaha upland	Hawthorn Formation	FTL 1/2	76-77	32.9	18.1	.53
Mount Dora ridge	Hawthorn Formation	FTL 4/2	70-71	41.8	23.5	.01
Marion upland	Hawthorn Formation	FTL 5/1	30-32	52.4	30.7	.01
Oklawaha chain of lakes	Undifferentiated Alluvium	FTL 3/1	30-31	39.2	32.7	70.8
Oklawaha chain of lakes	Undifferentiated Alluvium	FTL 3/2	70-71	30.0	19.6	160

Values of hydraulic conductivity were computed by Darcy's equation expressed as follows:

$$K = q \cdot \frac{L}{\Delta h}$$

wherein K = vertical hydraulic conductivity of clastic unit, in feet per day;

q = recharge to Floridan aquifer (water-table decline times the specific yield), in cubic feet per square foot per day;

L = saturated thickness of clastic unit (water table to top of Floridan aquifer), in feet; and

Δh = head difference between water table of clastic aquifer and potentiometric surface of Floridan aquifer, in feet.

Field determinations of vertical hydraulic conductivity were made in the Lake Wales Ridge and Palatlakaha Upland areas. Conductivity values ranged from 0.1 to 2.3 feet (0.03 to 0.7 m) per day, as shown in table 9. These values are of the same general magnitude as the lower of the hydraulic conductivity values obtained from laboratory determinations (table 8). The lower laboratory values are therefore assumed to be more representative of the vertical hydraulic conductivity of the clastic unit as a whole than are the higher values. Conductivity values selected for use in determining the annual rates of recharge to the Floridan aquifer (fig. 22) ranged from 0.15 foot (0.046 m) per day in the Lake Wales Ridge area to 0.01 foot (0.003 m) per day in the Mount Dora Ridge and Marion Upland areas.

Springs

All the known springs in Lake County stem from the Floridan aquifer. Spring flow occurs at points where the potentiometric surface of the Florida aquifer is above the land surface and where the confining bed overlying the Floridan aquifer has been breached. Areas of potential spring flow are delineated in figure 16.

Largest of the eight springs known to exist in Lake County is Alexander Springs, which is listed by Rosenau and Faulkner (1974) as one of Florida's 22 first-magnitude springs, a term applied to springs that flow more than 65 million gallons per day (2.8 m^3/s). Estimated discharges of Alexander Springs and other springs in Lake County are listed in table 10. The annual discharge of springs in the county is estimated to average 140 million gallons per day (6.1 m^3/s). Annually this represents a runoff of 2.6 inches (66 mm) from the county area and accounts for about 30 percent of the 8.5-inch (216-mm) estimated runoff from Lake County. Spring discharge in the county is about 3 times larger than the quantity of ground water pumped from the Floridan aquifer in 1970. A more detailed description of most of the springs in Lake County is given by Ferguson and others (1947, p. 93-101).

Table 9.--Field determinations of vertical hydraulic conductivity of clastic aquifer.

Site	Location	Period of experiment	Rainfall during period (feet)	Water-table decline (feet)	Specific yield	Rate of recharge (q) represented by water-table decline (cubic feet per square foot per day)	Δh (feet)	L (feet)	$\frac{L}{\Delta h}$	K (feet per day)
Lake Wales Ridge	Lat 28°40' Long 81°48'	6/25/69 to 7/19/69	0.083	0.54	0.24	0.005	1.60	30	19	0.10
		4/15/70 to 5/22/70	.029	2.04	.24	.013	1.69	28	16	.21
Palatlakaha upland	Lat 28°42' Long 81°52'	4/15/70 to 5/21/70	.035	2.55	.24	.017	.30	40	133	2.3

Table 10.--Springs of Lake County

Name	Discharge			No. of meas.	Location	Remarks
		(million gallons per day)	(cubic feet per second)			
Alexander Springs	Average: Maximum: Minimum:	78 105 48	121 162 74.5	12	Five miles south of Astor Park in Ocala National Forest.	Chemical quality of water listed in table 17.
Apopka Spring		18	28	2(1971)	In Gourd Neck of Lake Apopka, 2 miles south of Montverde.	Spring orifice is submerged beneath lake surface.
Blue Springs		1.9	3.0	1(1972)	About 1 mile northwest of Yalaha.	
Bugg Spring	Average: Maximum: Minimum:	10 12 7	15 18.6 10.3	5	One-half mile northwest of Okahumpka.	Depth of spring is 176 feet; used for research by U. S. Navy. Chemical quality of water listed in table 17.
Messant Spring		16 12	24.6 18.4	1(1961) 1(1946)	Four miles northeast of Mount Plymouth; lat 28° 51'21", long 81°28'57".	Sometimes called Messinger Spring.
Seminole Springs	Average: Maximum: Minimum:	14 23 7	22.0 35.8 10.2	4	Two and one-half miles north of Mount Plymouth.	
Holiday Springs	Average: Maximum: Minimum:	2.6 3.1 1.9	4.0 4.8 3.0	4	South shore of Lake Harris, 0.3 mile northwest of Yalaha.	
Camp La-No-Che Spring		0.7	1.1	1	North shore of Lake Norris at Camp-La-No Che.	Spring orifice is submerged beneath lake surface.

Note: Average discharge is average of measured discharges; maximum and minimum discharges are the maximum and minimum of measured discharges.

Surface water

Virtually all of the water flowing in streams or stored in the many lakes of Lake County comes from rainfall in the county. Part of the water comes directly from rainfall on the surfaces of the streams and lakes, part of it comes from overland flow into the streams and lakes, and part of it is ground water discharges from the clastic and Floridan aquifers.

Streams

Almost one-half of the county is drained by the Oklawaha River basin which extends from Polk County at the south to Marion County at the north. The northeastern one-third of the county drains into the St. Johns River either directly or by way of Black Water Creek and Wekiva River. The remaining one-sixth of the county is drained by the headwaters of the Withlacoochee and Kissimmee Rivers. The various basins and sub-basins in the county are outlined in figure 23. Except for Big Creek, Little Creek, and Black Water Creek, the streamflow from the major basins and sub-basins in the county is regulated by control structures.

In the various stream basins and sub-basins in Lake County, the recorded annual runoff (per unit area) ranges from less than 5 inches (130 mm) for the Palatlakaha River near Groveland to more than 9 inches (230 mm) for Black Water Creek near Cassia, as shown in table 11. A study of runoff from stream basins in or near Lake County indicates that during the investigation (1967-69) runoff was less than average, and that, over the long term, runoff from Black Water Creek probably averages about 12 inches (300 mm). For the purpose of this report, the 12-inch (300 mm) unit runoff value is assumed to apply also to the 12-square-mile (31 km^2) area of Lake County that drains directly into Wekiva River.

The stream-gaging station, Withlacoochee River near Eva, is in Polk County just south of the Lake County line. Its drainage area includes part of the Green Swamp in the southwestern part of Lake County. The unit runoff at the Withlacoochee River near Eva station (table 11) probably is reasonably representative of the runoff from the headwaters of the Kissimmee River (fig. 23).

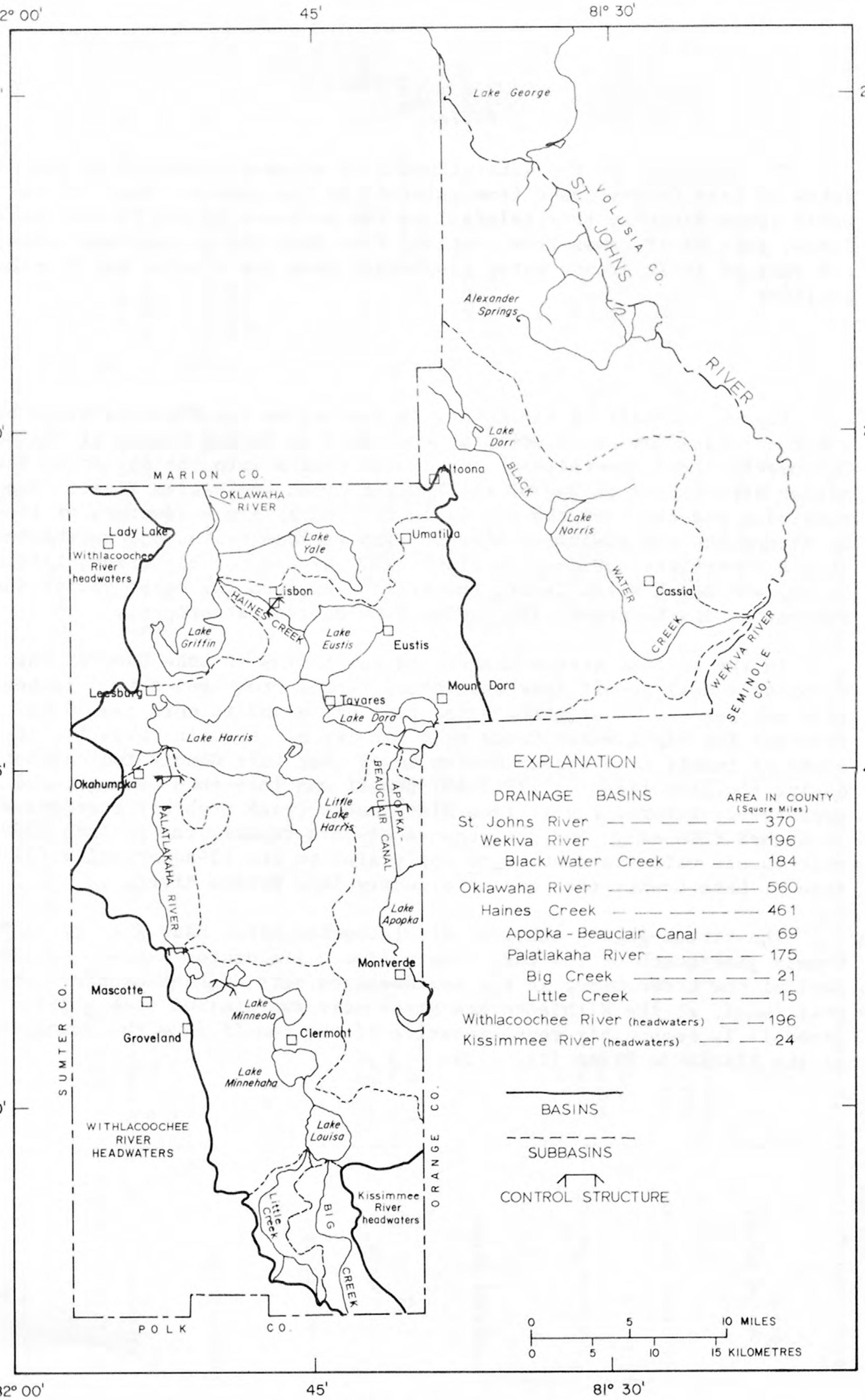

FIGURE 23.--DRAINAGE BASINS IN LAKE COUNTY

Table 11.--Streamflow data for selected gaging stations in or near Lake County.

Station number	Gaging station	Drainage area (square miles)	Years of record	Average discharge		Maximum recorded discharge		Minimum recorded discharge
				(cubic feet per second)	(inches per square mile)	(cubic feet per second)	date	cubic feet per second
3108.00	Withlacoochee River near Eva	130	1958-74	63.4	6.62	2,160	Mar. 17, 1960	0[b]
2352.00	Black Water Creek near Cassia	135	1967-69	93.0	9.20	749	Sept. 1, 1968	5.9[a]
2365.00	Big Creek near Clermont	68	1958-74	35.5	7.09	691	Sept. 13, 1960	0[b]
2369.00	Palatlakaha River at Cherry Lake Outlet near Groveland	165	1957-74	54.5	4.63	584	April 5, 1960	0[c]
2370.00	Palatlakaha River near Mascotte	180	1946-55	104	7.85	458	Oct. 4,5, 1945	0.2
2377.00	Apopka-Beauclair Canal near Astatula	184	1958-74	94.3	6.95	754	Mar. 19, 1960	0[c]
2380.00	Haines Creek at Lisbon	648	1942-74	285	5.97	1,350	Jan. 14,15,1970	66[d] 2[c]
2385.00	Oklawaha River at Moss Bluff	879	1943-55, 1967-74	351	5.42	1,630	Sept. 12, 1960	0[c]

a) Discharge from miscellaneous measurement on April 26, 1956.

b) No flow almost every year.

c) Flow controlled by dam.

d) Before regulation.

Note.--See figure 2 for location of gaging stations. The Withlacoochee River near Eva station is in Polk County, just south of the Lake County line. The Oklawaha River at Moss Bluff station is in Marion County about 9 miles north of the Lake County line.

Little streamflow data are available to estimate the runoff entering the St. Johns River directly from Lake County except for the occasional measurements of the flow from Alexander Springs, which presumably averages about 78 million gallons per day (3.4 m^3/s). The quantity of flow alone is equal to about 9.4 inches (239 mm) over the 174-square-mile (451-km^2) area that drains directly into the St. Johns River; however, additional water is discharged into the St. Johns River from the clastic and Floridan aquifers, and some overland inflow doubtless occurs. Thus, the total runoff to enter the St. Johns River from this 174-square-mile (451-km^2) area is estimated to be 16 inches (406 mm).

The gaging station, Oklawaha River near Moss Bluff, is in Marion County about 9 miles (14 km) north of the Lake County line, and its drainage area includes about 130 square miles (337 km^2) in Marion County. The unit runoff of the Oklawaha River decreases appreciably between Haines Creek at Lisbon and the Oklawaha River at Moss Bluff. Although the decrease in unit runoff may or may not occur uniformly with the increase in drainage area downstream from the Haines Creek station, it is assumed herein to do so; hence, the unit runoff of the Oklawaha River is assumed to be 5.7 inches (145 mm) at the county line. (An examination was made of the possibility that a discrepancy could arise because the records for Haines Creek at Lisbon and Oklawaha River at Moss Bluff do not cover the same time span. For the purpose of this report, the effect was insignificant. For the time span of the record for Oklawaha River at Moss Bluff, the unit runoff for Haines Creek at Lisbon was 6.11 inches (155 mm), compared to 5.97 inches (152 mm) as given in table 11.)

Thus, estimates of unit runoff from parts of the various stream basins in Lake County are summarized as follows:

Stream basin	Drainage area (square miles)	Unit runoff (inches)
Oklawaha River	560	5.7
St. Johns River	174	16
Headwaters of Withlacoochee and Kissimmee Rivers (combined)	220	6.6
Black Water Creek and Wekiva River (combined)	196	12
Total county	1,150	8.5

The estimated 8.5 inches (216 mm) of runoff from Lake County equals an average annual discharge of 465 million gallons per day (20 m^3/s).

Streamflow characteristics

Streamflow characteristics usually are portrayed by statistical relations, such as duration curves, which indicate the overall distribution of recorded flows within the range of magnitudes experienced, or flood and low-flow frequency curves, which indicate the probable frequency of occurrence of peak or low flows of specified magnitudes. For the most part, however, these relations have hydrologic significance only for natural streams. Fortunately, records of flow were obtained at a number of streams in Lake County for a considerable time before they were regulated in 1956. Thus, the natural streamflow characteristics can be established for several streams with a reasonable degree of reliability even though some of them are now regulated.

Flood-frequency curves indicate the probable recurrence interval of annual peak discharges of a given magnitude. Curves for Haines Creek at Lisbon, Palatlakaha River near Mascotte, Haines Creek at Lisbon, and Withlacoochee River near Eva are shown in figure 24. The flood-frequency curves for Haines Creek and Palatlakaha River are derived from data obtained before these streams were regulated. For a given recurrence interval, the peak discharges presumably would be slightly greater for Palatlakaha River near Mascotte than for Palatlakaha River at Cherry Lake outlet, near Groveland, because of the 15 acre (6 ha) increase in drainage area (table 11) between the two sites.

Prior to the regulation of flow in the Oklawaha River basin, the maximum recorded discharge of Haines Creek at Lisbon (1942-55) was 918 cubic feet (26.0 m^3) per second on January 3-4, 1954; since regulation (1956-74) the maximum recorded discharge of the creek has exceeded 1,000 cubic feet (28.3 m^3) per second several times, and was as much as 1,330 cubic feet (37.7 m^3) per second in 1958, 1,260 cubic feet (35.7 m^3) per second in 1960, and 1,350 cubic feet (38.2 m^3) per second in 1970. The extent to which these latter peaks were affected by regulation or channel modification is not known. However, 1960 was the second of two consecutive years of outstandingly great rainfall. In fact, the maximum recorded discharge at many of the long-term stream-gaging stations in or near Lake County occurred in 1960. In the absence of upstream regulation and channel modifications, the 1960 peak discharge of Haines Creek at Lisbon probably would have been the largest since 1942, at least, and possibly would have been the largest since the early 1900's. Whether the natural peak discharge of 1960 would have been appreciably greater or less than the recorded 1,260 cubic feet (35.7 m^3) per second is not known, but the natural peak of 1960 doubtless would have been considerably larger than the natural peak discharge of 1954.

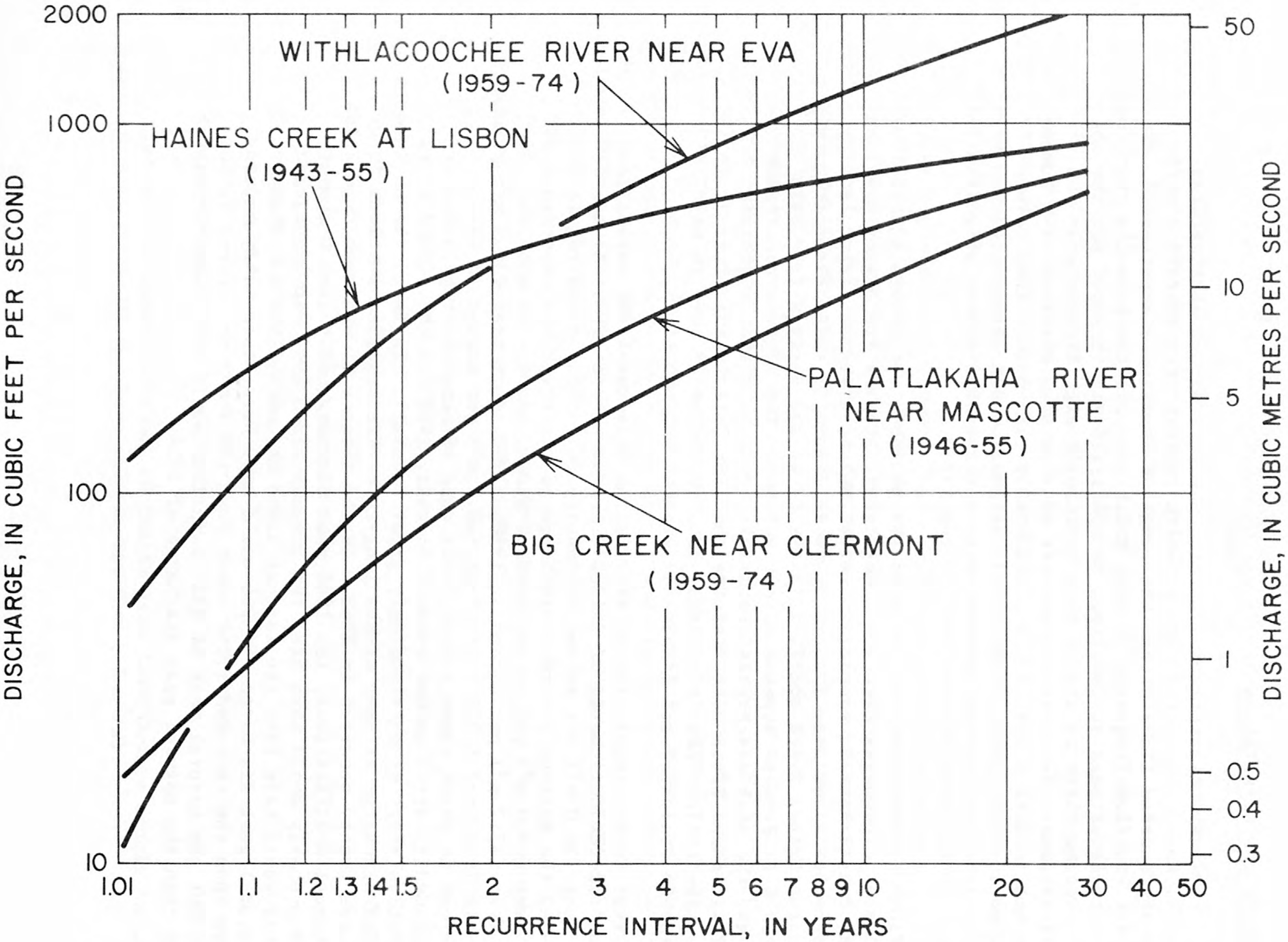

FIGURE 24.--FLOOD-FREQUENCY CURVES FOR STREAMS IN LAKE COUNTY. (CURVES FOR PALATLAKAHA RIVER AND HAINES CREEK REPRESENT CONDITIONS BEFORE REGULATION.)

Low-flow frequency curves show the probable recurrence interval of natural annual low flows of a given magnitude. Such curves are prepared to represent the lowest mean discharge for periods of a selected number of consecutive days, usually from 1 to 30 or more. In this report the lowest mean discharge for 30 days is used. Low-flow frequency curves for Big Creek near Clermont, Haines Creek at Lisbon, and Palatlakaha River near Mascotte are shown in figure 25. The curves for Haines Creek and Palatlakaha River are derived from data obtained before regulation of these streams began in 1956; hence, the curves for these two stations are no longer applicable. Low-flow frequency analyses are not applicable to streams subject to a high degree of regulation. The low-flow curve for Big Creek near Clermont is presently applicable because the flow of this stream is not regulated upstream from the gaging station.

Within the period of record, the duration curve for a particular gage site shows the percentage of time that the magnitude of streamflow was greater or less than a specified value. The variability of the streamflow is reflected in the slope of the curve. The flows of Big Creek near Clermont and the Withlacoochee River near Eva are highly variable; hence, the duration curves of these two streams have steep slopes, as shown in figure 26. The peak flows of these streams are several times larger than the mean yearly flow, and the streams go dry for many days in some years. The headwaters of these two streams are in the Green Swamp. Their channels have not incised deeply into the clastic aquifer and ground-water seepage into the streams ceases when the water table drops slightly.

The flat slope of the duration curve for the Wekiva River near Sanford indicates that the flow of this stream is not highly variable. The gaging station on the Wekiva River is upstream from the confluence of the Wekiva River and Black Water Creek. The flow of the Wekiva River at the gaging station is largely from springs in Orange and Seminole Counties. The duration curve for this station was included in this discussion to demonstrate the characteristic of a stream having a large ground-water inflow.

In variability, the flow of Black Water Creek near Cassia is intermediate between Wekiva River, at one extreme, and Big Creek and Withlacoochee River, at the other (fig. 26). The low flow is somewhat better sustained in Black Water Creek than in Big Creek and Withlacoochee River because of drainage from lakes and swamps and from the clastic and Floridan aquifers; however, the ground-water component is not as predominant in Black Water Creek at it is in Wekiva River. Inasmuch as the streamflow record for Black Water Creek spanned only 2 years, the duration curve for this creek was adjusted to a longer period on basis of long-term streamflow records for nearby stations.

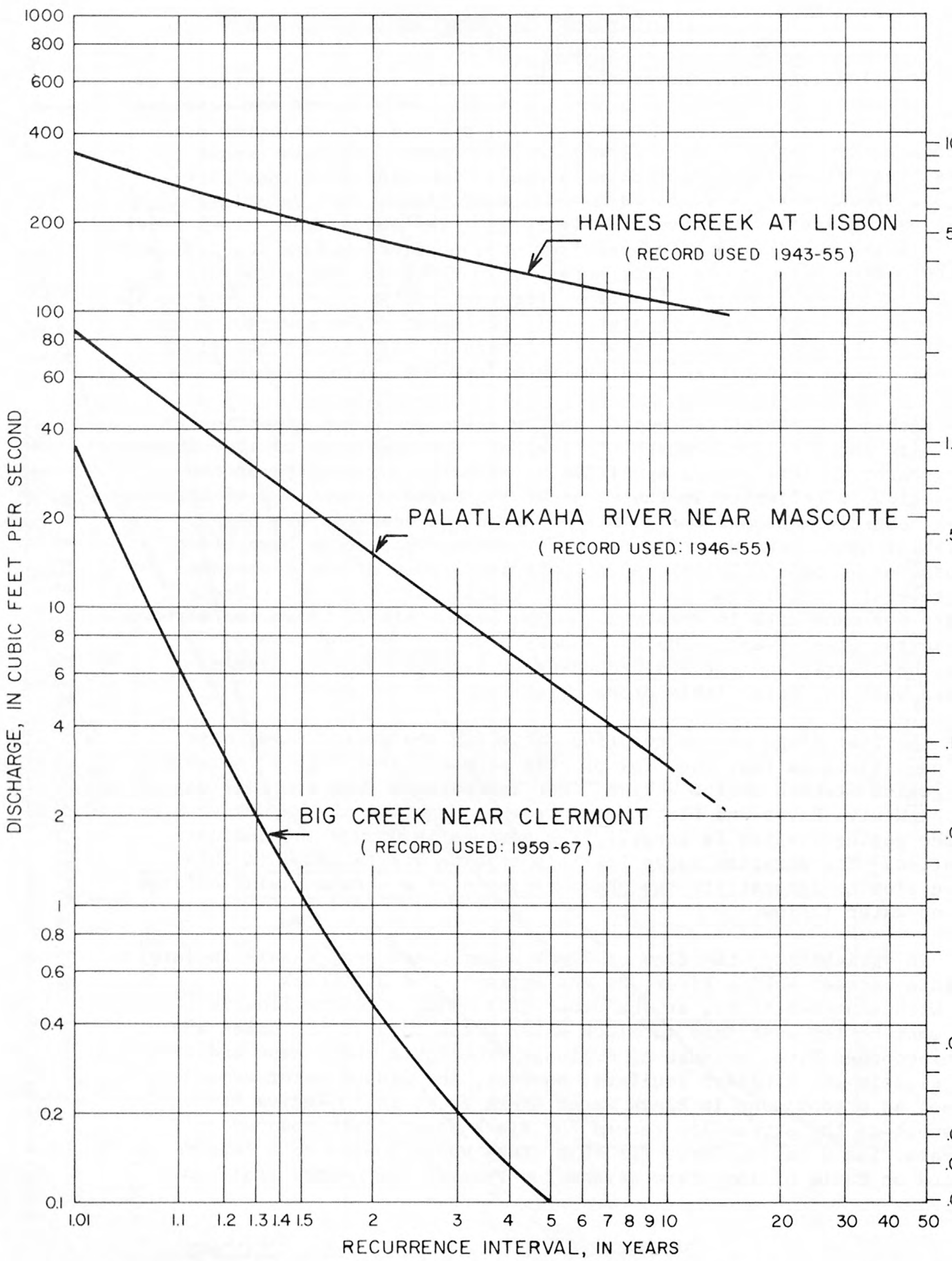

FIGURE 25.--FREQUENCY CURVES FOR UNREGULATED 30-DAY FLOWS OF HAINES CREEK, PALATLAKAHA RIVER, AND BIG CREEK.

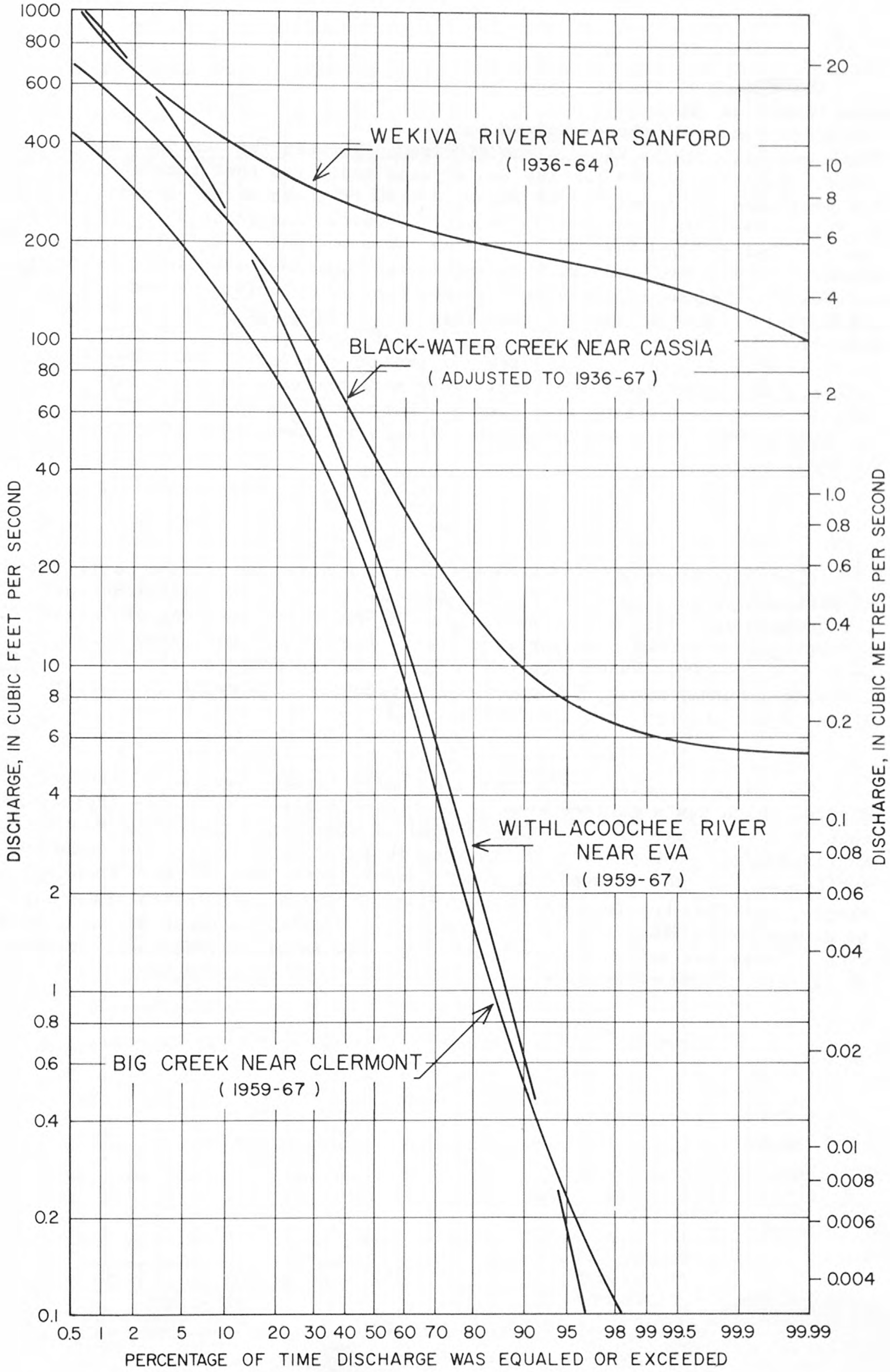

FIGURE 26.--FLOW-DURATION CURVES OF FOUR UNREGULATED STREAMS IN LAKE COUNTY

The effect of regulation of streamflow by control structures in Lake County is shown in figure 27, which shows duration curves of the monthly mean discharge before and after regulation began on Haines Creek and Palatlakaha River. The difference between the "before" and "after" duration curves for the two streams indicates that regulation has decreased the magnitude of the base flow of these streams, and has increased the magnitude of flood flows. However, the duration curves for the "before" and "after" periods probably would have differed in a somewhat similar way even without regulation. Without regulation, the natural flood flows of these two streams doubtless would have been appreciably higher in 1959-60 than they were during the period of record prior to 1956, and the recorded base flow of these streams probably would have been lower in the latter of the two periods because the droughts in recent years apparently were more extreme than they were during 1943-55. Nevertheless, from the pattern of daily discharges, it is obvious that the base flow of the streams at times is greatly reduced by regulation.

Lakes

Lake County has 1,345 lakes whose surface areas are 2.5 acres (1.0 ha) or more, based on a tabulation of lakes shown on U.S. Geological Survey topographic maps (7.5 minute series), or on Florida Department of Transportation county road maps for those areas where the topographic maps were lacking. Only about one-fourth the lakes are named on the U.S. Geological Survey maps. The general distribution of some of the larger lakes in Lake County is shown in figure 28.

The largest of the lakes that are wholly in Lake County is Lake Harris, which has a surface area of 27.6 square miles (71.5 km^2) including that of Little Lake Harris. Lake Apopka is almost twice as large as Lake Harris but about 80 percent of its area is in Orange County. The combined surface area of the Oklawaha Chain of Lakes--consisting of Lakes Apopka, Harris, Griffin, Eustis, Yale, Dora, Carlton, and Beauclair--totals about 80 square miles (207 km^2) in Lake County, or almost 7 percent of the county area. Lakes and swamps combined cover 373 square miles (966 km^2), or about 32 percent of the couny area.

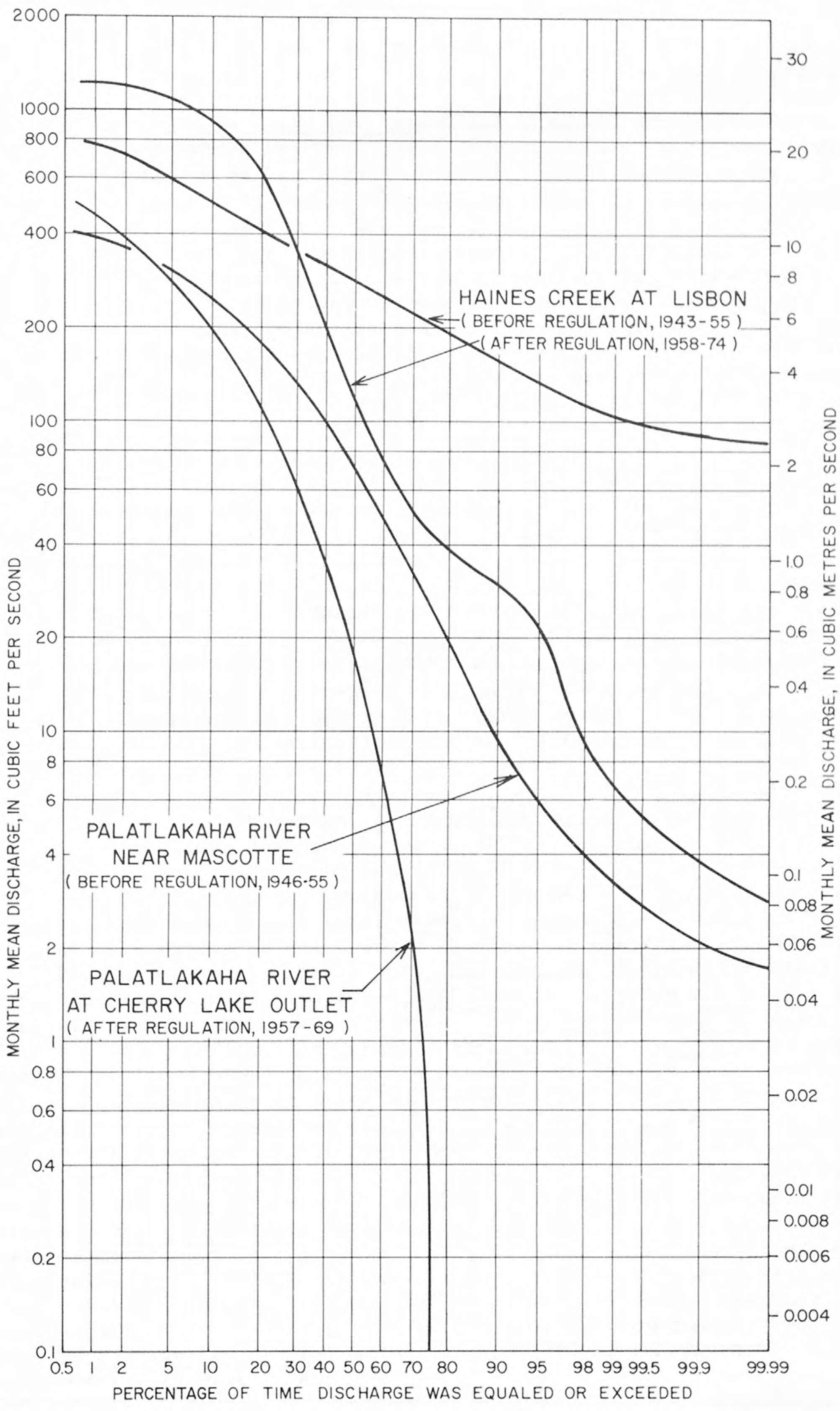

FIGURE 27.--DURATION CURVES OF MONTHLY MEAN DISCHARGE OF HAINES CREEK AND PALATLAKAHA RIVER BEFORE AND AFTER REGULATION.

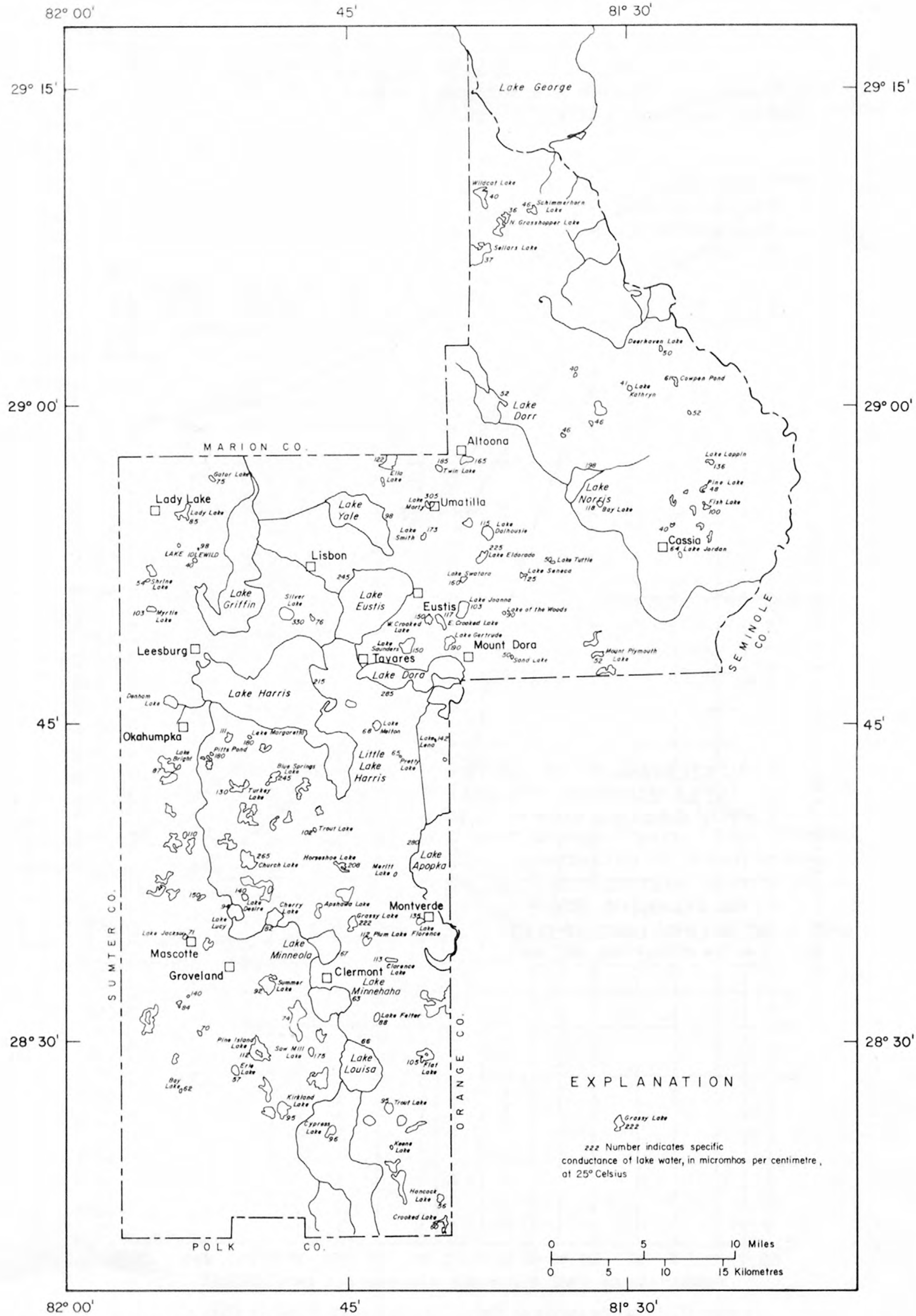

FIGURE 28.--AREAL DISTRIBUTION OF SOME OF THE LARGER LAKES IN LAKE COUNTY; VALUES OF SPECIFIC CONDUCTANCE OF LAKE WATER ARE INCLUDED FOR SELECTED LAKES.

The origin of most lakes in the county is related to sinkhole development in a covered karst terrane. The number and type of lakes that result vary with the geohydrologic area (fig. 12). In the Green Swamp and St. Johns River Valley areas, for example, the depressions are shallow, and swamps are the common feature rather than lakes. The Palatlakaha Upland area has a predominance of small shallow lakes, such as Pitts Pond whose bottom contours are shown in figure 29. These lakes are landlocked at medium and low water stages and have good hydraulic connection with the Floridan aquifer. In the Lake Wales Ridge area, deep sink lakes are predominant. A deep lake is represented by Lake Apshawa, whose bottom contours are in figure 30. Lakes in this area for the most part are entirely landlocked and have exceptionally good hydraulic connection with the Floridan aquifer. Landlocked lakes also predominate in the Sumter Upland and Mount Dora Ridge areas, and, because of greater relief, are generally deeper in the Mount Dora Ridge than in the Sumter Upland. The Marion Upland area has a variety of lake types, but many of the small lakes in this area are similar to Pitts Pond. Bottom contours of several lakes in Lake County have been mapped by Kenner (1964); bottom contours of lakes in the Oklawaha Chain of Lakes are shown by Bush (1974), who described the hydrology of these lakes in considerable detail.

Lake levels fluctuate naturally in response to variations in rainfall, evaporation, surface- and ground-water inflow and outflow. The net fluctuation owing to rainfall and evaporation over the long term in Florida is about the same for all lakes in the same general area (Hughes, 1974). Differences in the magnitude of lake-level fluctuations, therefore, relate primarily to the variability in the thickness and permeability of different types of materials beneath the land surface. In combination with the slope of the land surface, the thickness and permeability of materials determines the extent to which rainfall runs off the land surface or percolates down to the water table, and also determines the extent to which water from the clastic aquifer moves vertically down to the Floridan aquifer or moves horizontally into lakes and streams. The thickness and permeability of materials beneath the lake also determine the extent to which water can leak downward from the lake to the Floridan aquifer. Lakes which do not leak water to the Floridan aquifer in Florida will have a surface outlet because rainfall in general is greater than evaporation and the lakes receive some surface- and ground-water inflow. In general, the rate of leakage from a lake varies directly with the thickness and permeability of materials beneath the lake, and the range of lake-level fluctuation increases with increasing leakage. Another factor that contributes greatly to the magnitude of lake-level fluctuations is the relation between the lake level and the potentiometric surface of the Floridan aquifer. Lakes in recharge areas generally fluctuate more widely than do lakes in discharge areas. In hilly terrane, the relation between the lake level and the potentiometric surface can differ greatly over relatively short distances. Other things being equal, a lake that receives water primarily from surface-water inflow will have a greater range of fluctuation than one that receives water primarily from ground-water inflow. Of course, the magnitude of lake-level fluctuations can be altered by the manipulation of control structures.

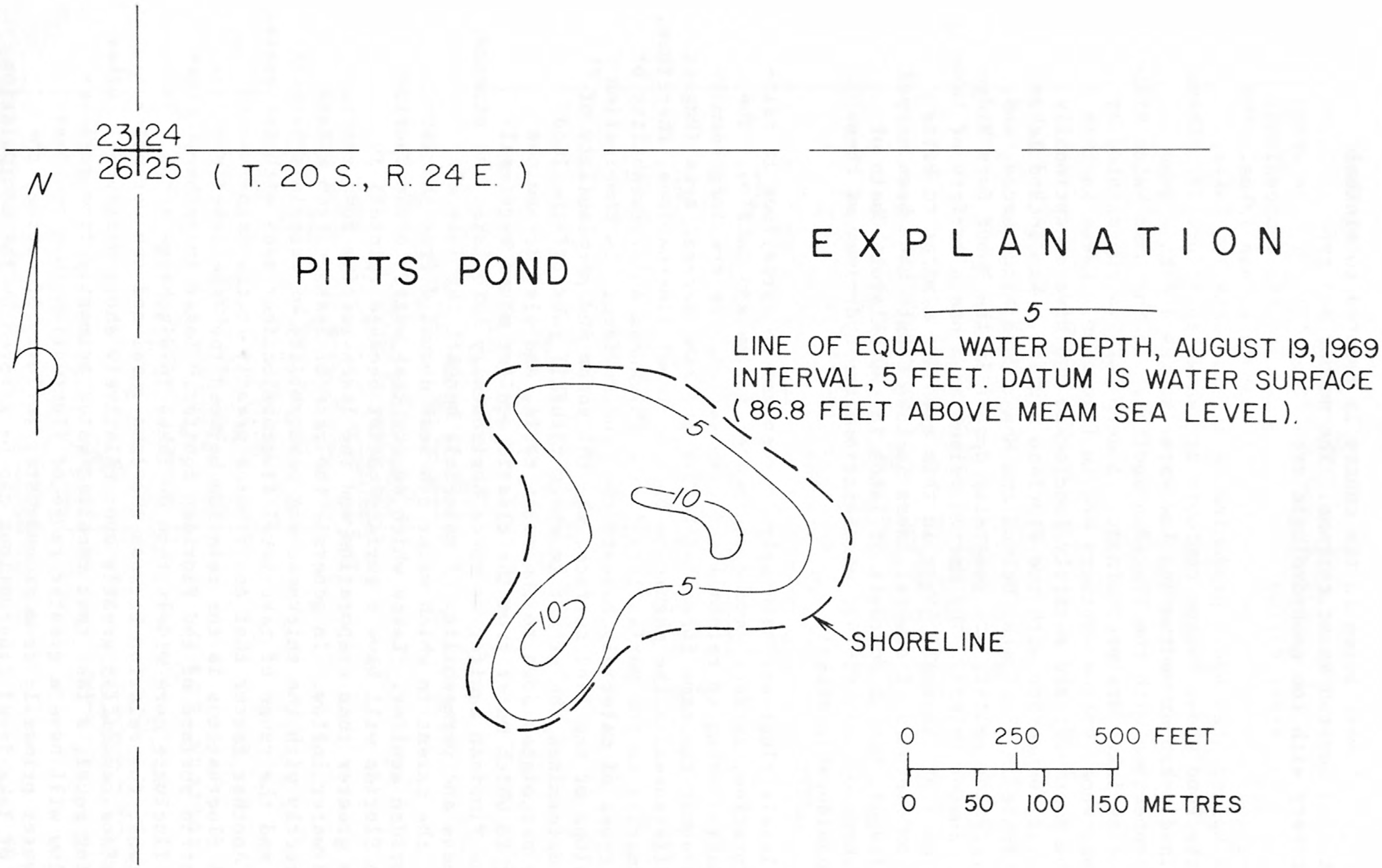

FIGURE 29.--BOTTOM CONFIGURATION OF PITTS POND NEAR OKAHUMPKA.

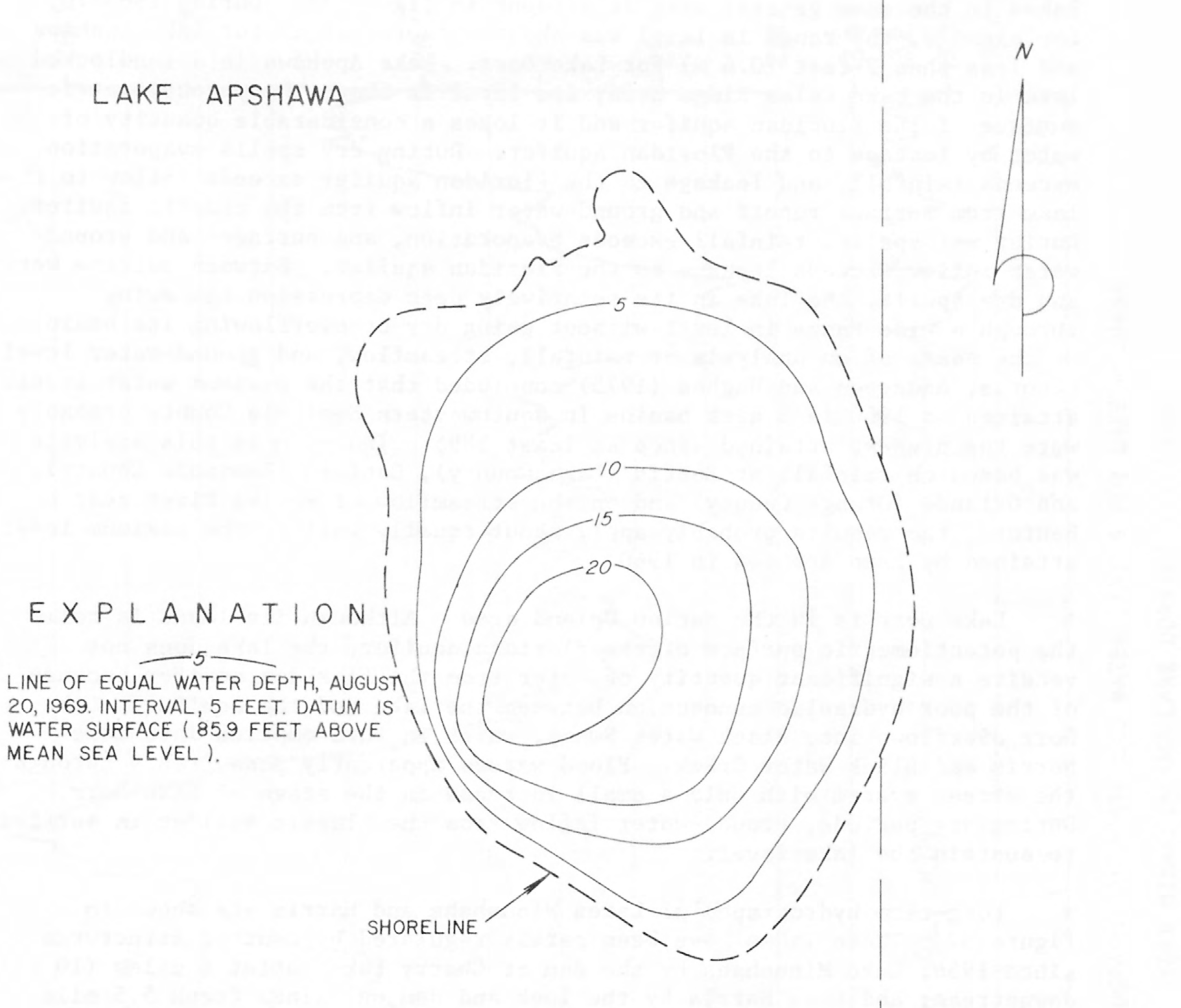

FIGURE 30.--BOTTOM CONFIGURATION OF LAKE APSHAWA NEAR MINNEOLA

That the magnitude of lake-level fluctuations can differ greatly for lakes in the same general area is evident in figure 31. During 1965-70, for example, the range in level was about 6 feet (1.8 m) for Lake Apshawa and less than 2 feet (0.6 m) for Lake Dorr. Lake Apshawa is a landlocked lake in the Lake Wales Ridge area; its level is above the potentiometric surface of the Floridan aquifer and it loses a considerable quantity of water by leakage to the Floridan aquifer. During dry spells evaporation exceeds rainfall, and leakage to the Floridan aquifer exceeds inflow to the lake from surface runoff and ground-water inflow from the clastic aquifer. During wet spells, rainfall exceeds evaporation, and surface- and ground-water inflow exceeds leakage to the Floridan aquifer. Between extreme wet and dry spells, the lake in its relatively deep depression can swing through a wide range in level without going dry or overflowing its basin. On the basis of an analysis of rainfall, streamflow, and ground-water level records, Anderson and Hughes (1975) concluded that the maximum water levels attained in 1960 in 3 sink basins in southwestern Seminole County probably were the highest attained since at least 1895. Inasmuch as this analysis was based on rainfall at Eustis (Lake County), Sanford (Seminole County), and Orlando (Orange County) and on the streamflow of Wekiva River near Sanford, the results probably apply about equally well to the maximum level attained by Lake Apshawa in 1960.

Lake Dorr is in the Marion Upland area. Although its level is below the potentiometric surface of the Floridan aquifer, the lake does not receive a significant quantity of water from the Floridan aquifer because of the poor hydraulic connection between the lake and the aquifer. Lake Dorr overflows into Black Water Swamp, which in turn empties into Lake Norris and Black Water Creek. Flood waters apparently pass freely through the stream system with only a small increase in the stage of Lake Dorr. During dry periods, ground-water inflow from the clastic aquifer is sufficient to sustain the lake level.

Long-term hydrographs of Lakes Minnehaha and Harris are shown in figure 32. These lakes have been partly regulated by control structures since 1956; Lake Minnehaha by the dam at Cherry Lake outlet 6 miles (10 km) downstream, and Lake Harris by the lock and dam on Haines Creek 5.5 miles (8.8 km) downstream. The effect of regulation is somewhat more evident in the hydrograph of Lake Harris than in that of Lake Minnehaha. This difference is partly due to the position of the lake surfaces with respect to the potentiometric surface of the Floridan aquifer. The surface of Lake Minnehaha is above the potentiometric surface of the Floridan aquifer. During dry spells when inflow to the lake dwindles to nothing, and the gates of the control structure are closed, the lake level continues to decline not only because of evaporation but also because of leakage through the lake bottom to the Floridan aquifer. Most of the surface of Lake Harris is below the potentiometric surface of the Floridan aquifer, and the lake apparently received more water from the aquifer (on the south side of the lake) than it loses to the aquifer (on the north side of the lake). During dry spells, when the control gates are closed, this net gain of water in the exchange between the lake and the Floridan aquifer helps to offset the loss of water by evaporation.

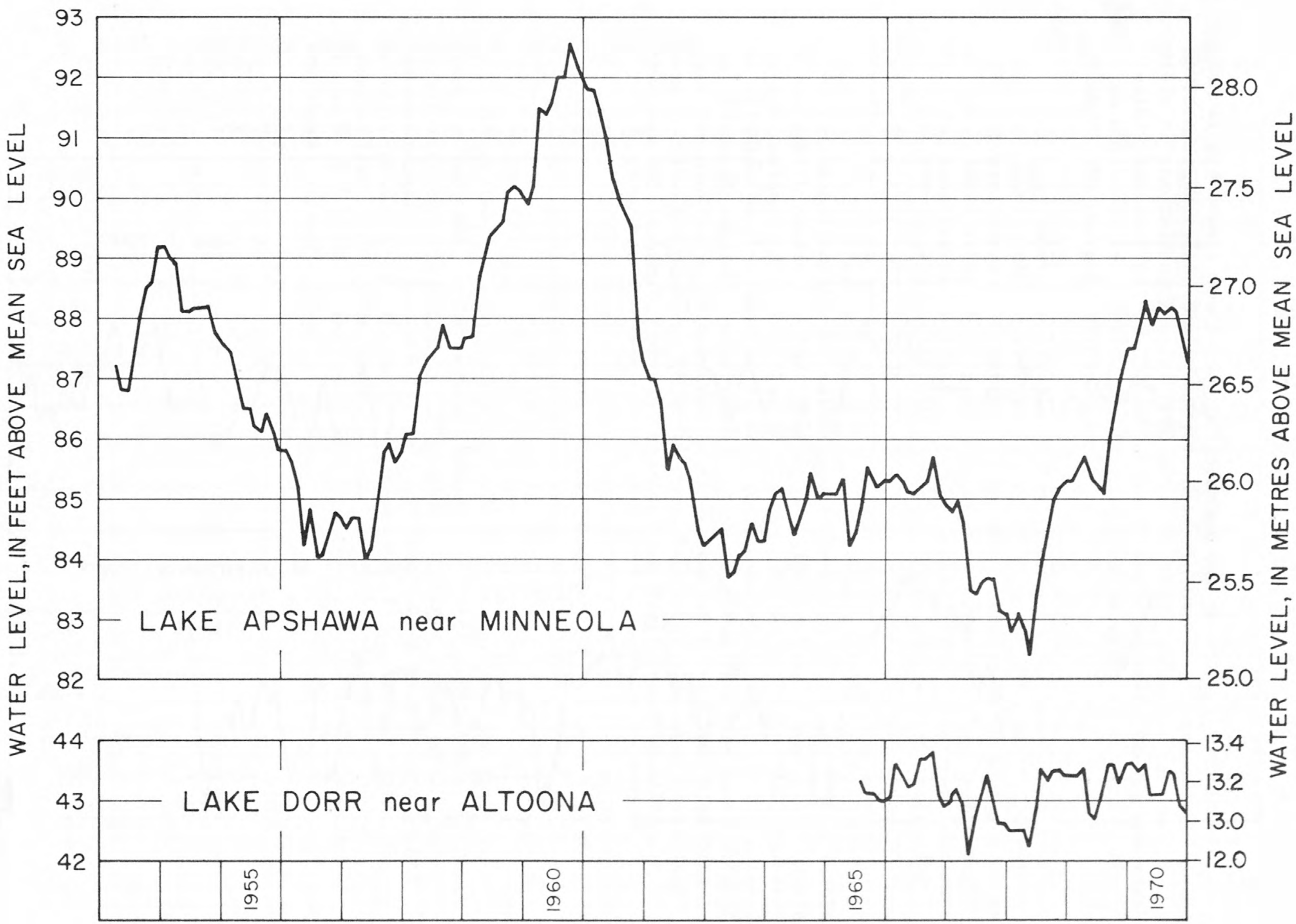

FIGURE 31.--HYDROGRAPHS OF MONTH-END WATER LEVELS FOR LAKE APSHAWA NEAR MINNEOLA AND LAKE DORR NEAR ALTOONA.

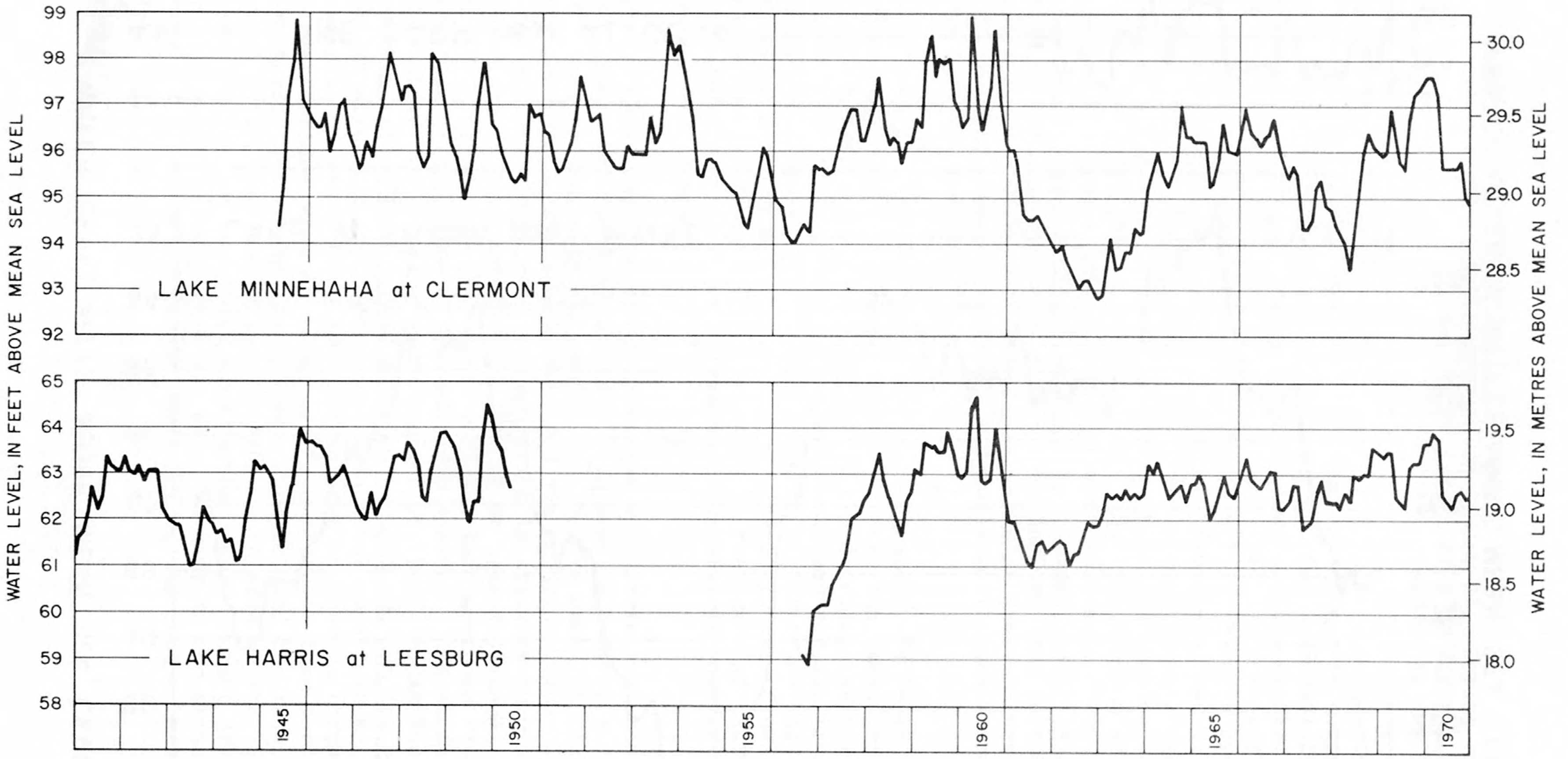

FIGURE 32.--LONG-TERM HYDROGRAPHS OF MONTH-END WATER LEVELS FOR LAKE MINNEHAHA AT CLERMONT AND LAKE HARRIS AT LEESBURG

Water-Budget Summary

It previously was noted that some of the ground water in Lake County moves northwest into Sumter County, possibly emerging in the Withlacoochee River or the Gulf of Mexico, some moves northeast into Orange County, possibly emerging in the St. Johns River or the Atlantic Ocean, and some moves northward into Mation County, possibly emerging in the downstream reach of the Oklawaha River.

For Lake County as a whole, annual rainfall and evapotranspiration were presumed herein to average 51 and 40 inches (1,300 and 1,020 mm) respectively. Annual runoff from streams in Lake County--which includes an appreciable quantity of ground-water discharge from the clastic and Floridan aquifers, especially in the St. Johns River Valley--was estimated to average 8.5 inches (216 mm). A water-budget analysis indicates that the quantity of water moving underground from Lake County into adjacent counties is 2.5 inches (64 mm).

This 2.5-inch (64 mm) value is extremely tenuous--and, hence, should be used with caution in any hydrologic analysis--inasmuch as it is determined as the residual of values that are subject to errors which are sizeable in relation to the residual value itself. Certainly, any or all of the estimates of rainfall, evapotranspiration, and runoff could be in error by an inch or so in either direction; hence, the sub-surface flow from Lake County into adjacent counties could be appreciably greater or less than the 2.5 inches (64 mm) indicated by the water-budget analysis.

Chemical Quality of Water

Ground-Water Quality

The quality of ground water in Lake County varies from place to place in both the clastic aquifer and the Floridan aquifer but in general is good enough for most uses. The chemical nature of the ground water was determined from samples collected from 11 wells tapping the clastic aquifer and 35 wells tapping the Floridan aquifer. Although most of these wells were sampled in 1968-71, a few were sampled in 1961-62. Analyses of the water samples are listed in table 12. Well locations are shown in figure 2.

Table 12.--Chemical analyses of water from wells in Lake County.

(Concentrations of chemical constituents in milligrams per litre)

Well number	Location	Date of collection	Depth of well (feet)	Temperature (°C)	Specific conductance (micromhos/cm at 25°C)	pH	Color	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Strontium (Sr)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nutrients						Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$
																			Nitrate (NO_3)	Nitrite (NO_2)	Ammonia as NH_4	Organic Nitrogen (N)	Total phosphorous as PO_4	Ortho phosphate (PO_4)		
FLORIDAN AQUIFER																										
3	282245N0814926.1	4/28/61	192	23.5	277	8.2	5	13	0.03	51	2.2	3.1	1.1	-	168	0.8	6.0	0.1	0.3	-	-	-	-	-	190	140
12	282655N0815527.1	3/22/68	465	22.0	520	7.3	20	10	3.1	102	2.4	7.2	1.6	0.06	329	1.2	14	.0	.1	-	-	-	-	.23	305	260
17	282823N0815004.1	3/6/68	400	24.0	209	7.9	10	5.3	-	38	1.0	3.6	.8	.06	122	.4	6.5	.1	.0	-	-	-	-	.09	119	100
21	282852N0814249.1	3/6/68	320	24.0	271	7.7	10	13	-	47	4.3	3.9	.7	.08	165	.4	8.0	.1	.1	-	-	-	-	.16	156	140
29	283201N0815450.1	3/28/62	160	-	360	7.4	4	11	.94	66	1.8	6.1	.4	-	208	.4	10	.2	.1	-	-	-	-	-	192	170
32	283206N0814425.1	5/21/68	-	-	188	7.1	20	9.6	.15	26	3.7	6.4	.5	.00	95	.0	11	.2	1.5	-	-	-	-	.12	110	80
39	283303N0814448.1	5/9/68	602	-	198	7.2	40	10	.21	27	5.0	6.3	.5	.00	106	.4	10	.3	1.0	-	-	-	-	.23	117	88
42	283351N0814001.1	1/15/68	420	23.0	200	7.8	0	9.6	.07	24	8.2	4.0	.7	.00	116	.0	8.0	1.3	.3	0.01	0.07	0.06	0.06	-	103	94
48	283540N0814024.1	1/10/68	180	24.0	160	7.8	0	6.2	.00	19	6.7	3.0	.5	.04	88	.0	5.0	.1	.1	-	-	-	-	-	88	75
54	283830N0814753.1	3/7/69	328	-	210	7.2	0	16	.08	31	5.2	4.6	.8	.12	122	1.6	10	.3	.0	-	-	-	-	-	136	99
57	283944N0814750.1	3/22/68	330	23.0	461	7.7	10	12	.39	80	3.0	8.5	.7	.04	295	1.2	15	.1	.1	-	-	-	-	.07	269	240
62	284129N0814142.1	1/15/68	69	22.0	222	7.5	0	27	1.4	21	10	8.8	2.9	.00	128	.4	6.5	1.3	.2	.00	.07	.31	.03	-	129	94
63	284129N0814743.1	3/7/69	200	-	335	7.8	0	11	2.0	62	2.0	6.2	1.0	.25	202	.8	11	.2	.0	-	-	-	-	-	208	160
66	284222N0815111.1	1/13/69	76	23.0	324	7.7	0	8.6	.17	65	1.2	5.6	.2	.00	192	.0	16	.1	.0	-	-	-	-	.04	186	170
71	284328N0815159.1	7/19/68	539	24.0	185	7.4	10	9.7	.05	28	2.7	4.0	.8	.00	94	4.4	6.5	.2	.0	-	-	-	-	.21	104	81
77	284445N0814621.1	3/22/68	200	24.0	272	7.8	5	12	.22	39	8.9	5.4	.8	.01	173	1.2	9.0	.1	.0	-	-	-	-	.50	162	130
87	284826N0812546.1	3/6/68	400	24.0	1530	7.6	5	12	-	110	32	164	3.8	2.4	146	218	305	.2	.0	-	-	-	-	.22	995	410
88	284827N0814035.1	7/18/68	271	24.0	270	7.5	0	35	.20	32	8.0	8.0	2.4	.20	160	.4	6.0	.4	.6	-	-	-	-	.00	170	110
97	284927N0814952.1	3/4/68	200	-	265	8.0	0	13	-	36	9.0	4.8	.8	.30	140	13	14	.1	.0	-	-	-	-	.08	152	130
105	285129N0815451.1	7/19/68	141	23.5	160	7.3	0	16	.07	15	7.1	3.2	2.9	.00	73	12	4.0	.3	.0	-	-	-	-	.25	102	66
115	285407N0813424.1	3/21/68	595	-	355	7.6	5	10	.00	48	12	4.8	.8	.75	126	67	8.0	.2	.0	-	-	-	-	.05	214	170
118	285425N0815504.1	3/4/68	131	22.0	310	7.4	5	10	-	39	15	3.9	.4	.07	190	2.4	8.0	.2	.0	-	-	-	-	.09	163	160
123	285504N0814059.1	3/22/68	156	22.0	418	7.7	15	22	1.4	56	16	12	2.2	.14	265	.8	11	.1	.1	-	-	-	-	.50	243	210
126	285548N0813227.1	3/6/68	165	22.0	238	8.0	5	10	-	30	9.1	3.9	.6	.42	112	21	7.0	.2	.0	-	-	-	-	.03	138	110
128	285618N0812552.1	7/18/68	124	23.0	300	7.6	0	7.7	1.6	43	6.5	4.2	.2	.01	176	.4	7.0	.2	.0	-	-	-	-	.21	160	130
130	285645N0814924.1	7/18/68	105	-	300	7.6	0	30	.37	34	11	10	2.7	.28	168	.4	9.0	.3	.0	-	-	-	-	.00	177	130
138	285930N0812242.1	3/21/68	140	23.0	1140	7.7	5	12	.16	73	23	128	4.0	.83	204	41	242	.1	.1	-	-	-	-	.06	643	280
144	290445N0813440.1	3/6/68	100	-	1190	7.8	5	8.8	-	51	23	157	4.3	.88	92	72	290	.1	.0	-	-	-	-	.16	708	220
146	290900N0813420.1	1/9/70	285	-	398	7.6	5	8.8	.64	77	6.5	3.8	.7	.00	260	0	7.0	.1	.0	-	-	-	-	-	241	220
148	291010N0813150.1	3/28/68	138	22.0	1440	7.3	10	11	.18	115	34	126	3.0	1.0	296	61	290	.1	1.2	-	-	-	-	.28	861	430
FLORIDAN AQUIFER (MUNICIPAL WELLS)																										
38	283301N0814459.1 (Clermont)	3/30/62	550	24.5	192	7.9	4	11	.01	25	5.7	5.3	.5	-	92	3.2	9.5	.1	3.8	-	-	-	-	-	112	86
40	283305N0815140.1 (Groveland)	3/13/62	593	23.5	255	7.8	2	11	.00	42	4.1	3.6	.5	-	142	1.6	6.5	.0	.1	-	-	-	-	-	148	120
86	284825N0815217.1	3/12/62	272	23.5	290	7.9	5	15	.04	45	6.7	6.0	1.2	-	164	2.8	10	.3	.1	-	-	-	-	-	172	140
85	284822N0815206.1 (Leesburg)	1/29/71	938	-	270	8.1	0	13	.01	40	8.6	4.6	.8	.05	160	.0	10	.0	.0	.01	-	-	.18	.09	195	136
92	284856N0813830.1 (Mount Dora)	3/12/62	752	23.0	260	8.0	5	8.7	.09	32	8.3	6.7	2.0	-	134	6.4	11	.2	.1	-	-	-	-	-	144	110
CLASTIC AQUIFER																										
1002	283324N0813927.1	3/1/68	8	-	570	6.2	40	15	-	52	23	7.5	18	.14	12	-	29	.2	115	-	-	-	-	-	-	220
1004	283634N0814023.1	3/1/68	6	-	515	6.8	40	4.6	-	58	12	9.8	17	.03	46	51	19	.2	148	-	-	-	-	-	400	190
1005	284054N0814814.1	3/20/70	42	23.0	75	6.3	10	6.7	.04	3.6	.8	5.0	.6	-	29	.0	6.5	.1	3.9	.02	.23	.38	.07	.01	47	13
1008	284213N0815245.1	3/20/70	44	24.0	86	6.1	5	6.4	.19	3.2	.9	7.9	.4	-	15	.0	4.8	.2	22	.02	.16	.26	.60	.37	57	12
1009	284512N0814415.1	4/2/70	26	22.0	210	6.1	5	3.8	.03	8.8	.7	6.0	9.2	.00	18	16	6.5	.1	41	.00	.17	.00	.05	.01	142	58
1010	284856N0813506	4/2/70	24	21.5	520	7.6	0	12	.03	48	28	23	1.4	.00	314	1.2	16	.6	.1	.01	.17	.26	.08	.05	282	240
1011	284953N0813932.1	4/2/70	55	24.0	520	6.3	0	8.3	.03	26	24	23	12	.12	26	42	24	.2	82	.32	.45	.00	.05	.05	371	160
1012	285425N0813234.1	4/3/70	33	23.5	103	6.6	20	6.8	.06	12	3.6	3.0	1.5	.00	50	4.8	6.5	.2	.0	.01	.28	.11	.16	.12	65	45
1014	285432N0815346.1	3/20/70	41	23.0	59	6.1	20	6.6	.04	3.2	1.1	3.5	.5	-	17	.0	4.2	.3	5.0	.06	.21	.57	.06	.01	44	13
1015	285613N0812552.2	4/2/70	30	21.5	67	6.6	5	4.3	.03	3.1	.9	2.8	.5	.00	23	.0	7.0	.1	1.2	.01	.20	.13	.92	.81	41	11
1016	285730N0814045.1	4/3/70	41	23.5	338	6.2	0	5.2	.04	10	24	7.1	1.5	.08	14	4.8	27	.1	123	.01	.22	.00	.01	.00	220	124

Floridan aquifer

The chemical nature of the Floridan aquifer water is indicated by figure 33. For most of the water samples from Floridan-aquifer wells, the bicarbonate ions make up more than half of the cations, and calcium and magnesium more than half the anions; hence, the water is a calcium-bicarbonate type. This is to be expected, of course, because of the comparative ease with which calcium and magnesium dissolve in water which contains a small quantity of carbon dioxide. As the water moves through the limestone aquifer, it continues to dissolve calcium and increases in mineralization and hardness.

Dissolved-solids concentrations of water samples from the Floridan aquifer range from 88 to 995 mg/l; hardness as calcium carbonate, ranges from 66 to 430 mg/l. Concentrations of dissolved solids are less than 300 mg/l throughout most of the county (fig. 34), but are considerably greater than 300 mg/l (643 to 945 mg/l) in the St. Johns River valley and locally near Alexander Springs in the Marion Upland, and are slightly greater than 300 mg/l in the southwest corner of the county in the Green Swamp.

Seemingly, therefore, concentrations of dissolved solids of water in the Floridan aquifer would be lowest in recharge areas and highest in discharge areas; and, to some extent, this occurs. For example, the samples of water having the lowest concentrations of dissolved solids (50 to 149 mg/l, fig. 34) for the most part were from wells in the Lake Wales Ridge area, where annual recharge to the Floridan aquifer averages 14 inches (356 mm) (fig. 20), and also from wells in the Palatlakaha and Sumter Upland areas, where the annual recharge averages 10 inches (254 mm). And, the samples having the highest concentrations of dissolved solids (greater than 600 mg/l) were from wells in the St. Johns Valley area, which is an area of discharge from the Floridan aquifer, and in the Marion Upland area near Alexander Springs, which is an important point of discharge from the Floridan aquifer.

Some inconsistencies are obvious, of course. Concentrations of dissolved solids in water from wells in some parts of the Lake Wales Ridge area, and, also in the Palatlakaha and Sumter Upland areas, are higher than those in water taken from wells in some parts of the Oklawaha-Chain-of-Lakes, Mount Dora Ridge, and Marion Upland areas, where the average annual recharge ranges from only 2 to 6 inches (50 to 150 mm). Such inconsistencies are to be expected because the ground-water system is complex, and conditions seldom are uniform throughout large areas, even within the same geohydrologic areas.

Another notable inconsistency occurs in the Marion Upland area where water from a well tapping the Floridan aquifer near Lake Norris had a dissolved solids concentration of only 138 mg/l. This well apparently taps a zone of good quality water in the upper part of the Floridan aquifer--possibly supplied by local recharge--because water that flows into the northern part of Lake Norris from Camp La-No-Che Spring has a dissolved solids concentration of 277 mg/l (table 13).

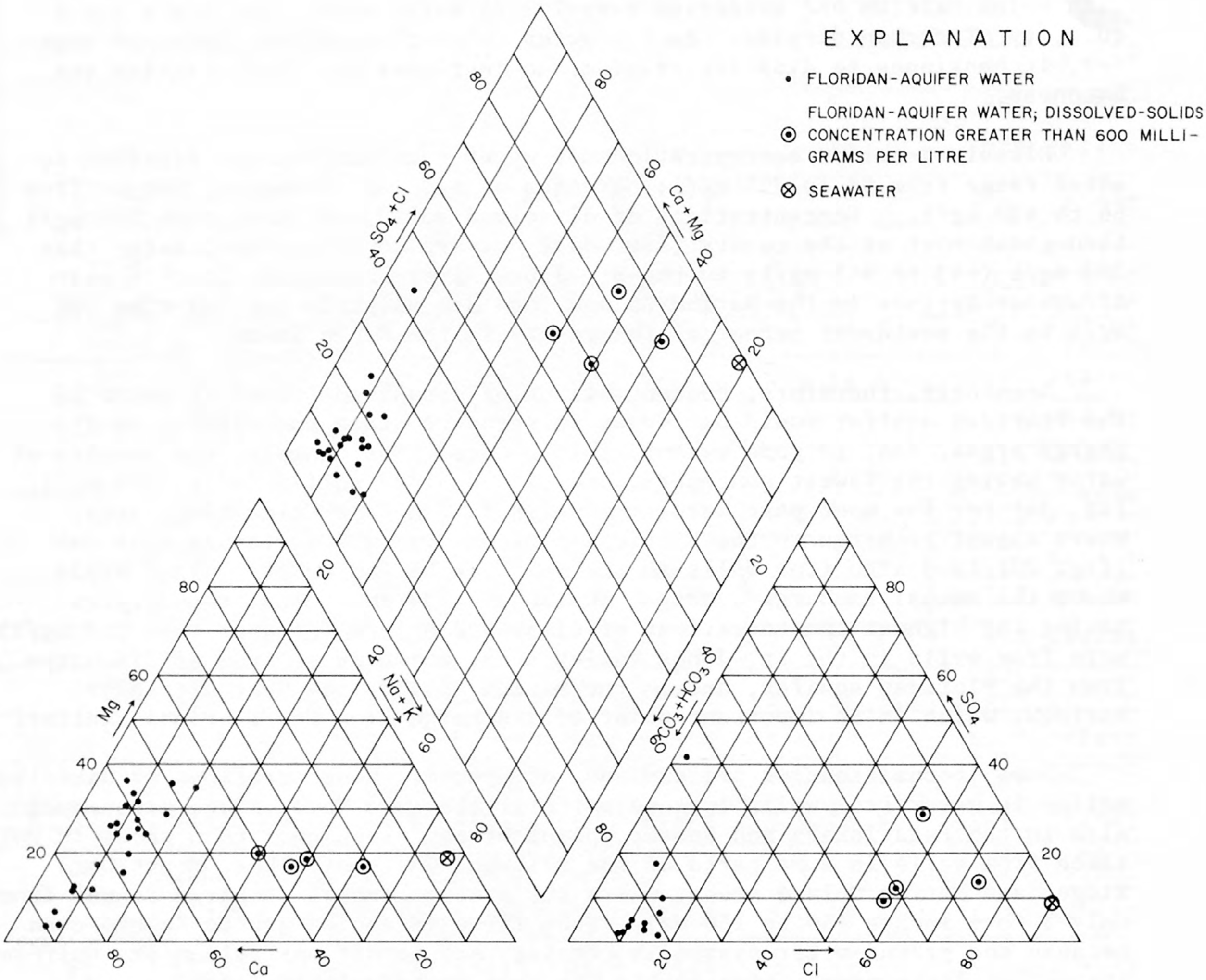

FIGURE 33.--PIPER DIAGRAM OF ANALYSES OF WATER FROM FLORIDAN AQUIFER

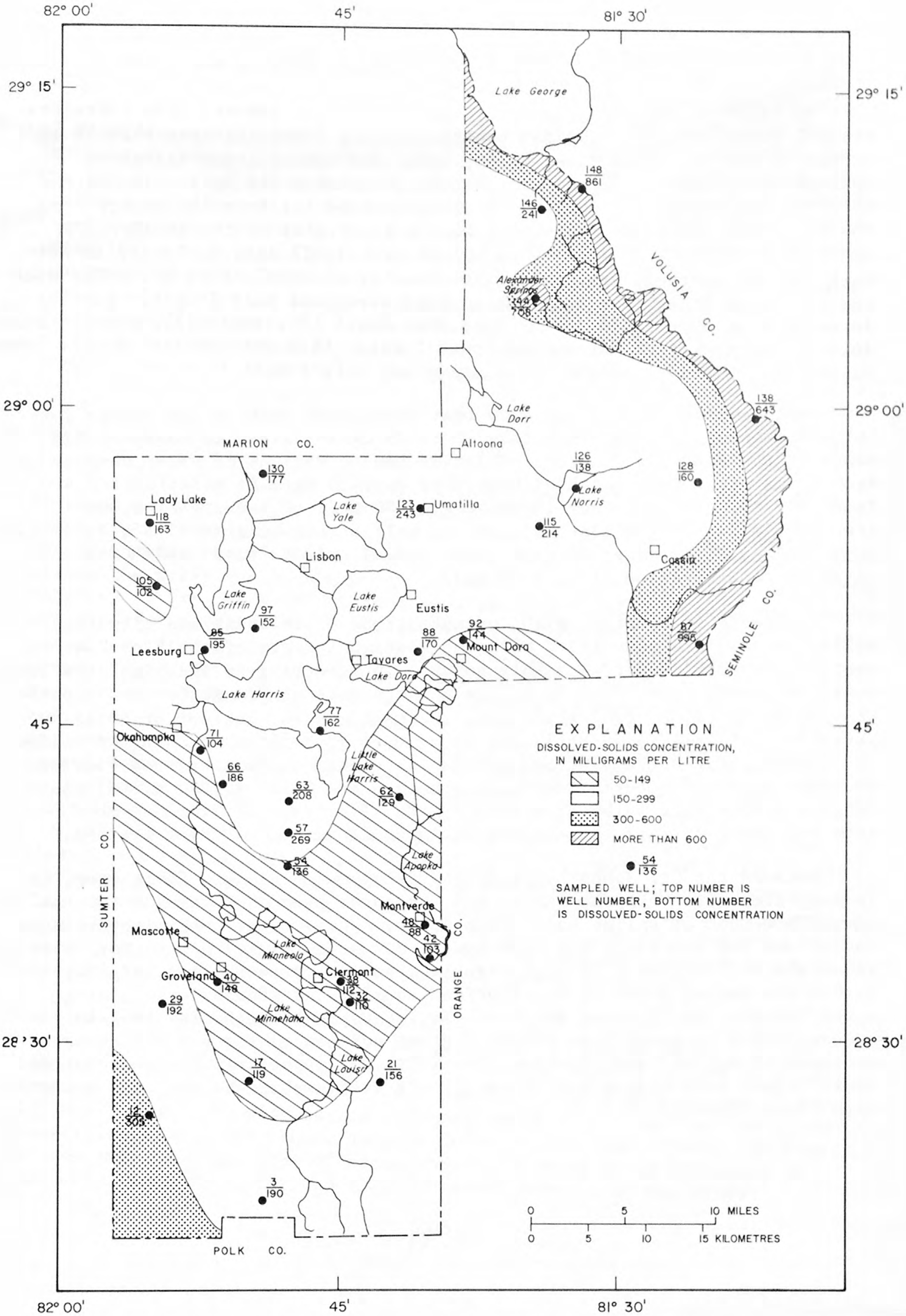

FIGURE 34.--CONCENTRATION OF DISSOLVED SOLIDS IN WATER FROM WELLS TAPPING THE FLORIDAN AQUIFER. (ANALYSES USED IN THE COMPILATION SPAN 1961-71; SEE TABLE 12.)

On basis of the chemical analyses in table 12, the chloride concentration of water from the Floridan aquifer in Lake County is less than 20 mg/l except in the St. Johns River Valley area, and locally near Alexander Springs in the Marion Upland area, where it exceeds 240 mg/l. The high chloride concentrations apparently do not extend far into the county from the St. Johns River, at least, not in the upper part of the aquifer. For example, in water from a 285-foot (87 m) well (well 146, table 12) in Astor Park, in the northeastern part of the county, about 2.5 (4.0 km) miles west of the St. Johns River, the chloride concentration was only 7 mg/l. Similarly, in water from a well 124 (38 m) feet deep (well 128, table 12), about 4 miles (6.4 km) northwest of Cassia and about 5 miles (8.0 km) west of the St. Johns River, the chloride concentration again was only 7 mg/l.

Ample evidence exists to show that throughout much of the county low chloride concentrations--less than 20 to 25 mg/l--extend to considerable depth in the Floridan aquifer. Chloride concentrations of water samples from an oil-test well south of Groveland were 20 mg/l at a depth of 1,400 feet (427 m), although they increased to 780 mg/l at a depth of 2,300 feet (701 m). Also, a 938-foot (286 m) well at Leesburg (well 85, table 12), which is cased to a depth of 600 feet (183 m), yields water which has a chloride concentration of only 10 mg/l.

Elsewhere in Florida, high concentrations of chloride and dissolved solids usually are associated with the lowermost parts of the Floridan aquifer and with deeper permeable zones. In referring to the high dissolved-solids concentration of water in the eastern part of Orange County, Lichtler and others (1968, p. 124) state that the high mineral content of artesian water in that area is probably due in part to incomplete flushing of saline water that entered the Floridan aquifer when the sea last covered Florida. In their study of Volusia County, Knochenmus and Beard (1971, p. 40) state "Highly mineralized water from deep in the (Floridan) aquifer may move into the upper part of the aquifer along fault planes or joint systems."

Because the St. Johns River Valley area extends along a fault zone, it is suggested here that the faults and fractures provide an avenue for the upward movement of saline water from depth. Whether the overall hydrologic conditions are favorable for such upward movement is not known. Nor is it known whether the water of high dissolved-solids concentration originates within the deeper parts of the Floridan aquifer, or from water-yielding zones beneath the Floridan aquifer. In the water of high dissolved-solids concentration (greater than 600 milligrams per litre) the sum of the percentages of sulfate and chloride ions (fig. 33) apparently is greater than would result from mixing a relatively pure calcium-bicarbonate type water with fresh seawater.

Besides the problem created by the high concentration of dissolved solids and chlorides in Floridan-aquifer water from wells, most of which are in the St. Johns River Valley area, other problems arise from the use of Floridan-aquifer water in Lake County. Problems associated with iron in concentrations greater than about 0.3 mg/l occur in a few places, and the occurrence of bacteria has been noted in some wells of the cities of Leesburg and Clermont. The source of bacteria is probably those sinkhole lakes that are now used as collection basins for street runoff. Most of these lakes have a good hydraulic connection to the Floridan aquifer. Leakage from these lakes could carry bacteria into the aquifer. Another water-quality problem is caused by hydrogen sulfide which appears in Floridan-aquifer water in the northeastern part of the county. The hydrogen sulfide probably results from sulfate reduction of gypsum (calcium sulfate) at depth in the aquifer.

Clastic Aquifer

Water in the clastic aquifer is less mineralized than water in the Floridan aquifer, in general, because the clastic sediments (sand and clay) are less soluble than limestone. However, the chemical quality of clastic-aquifer water varies considerably from place to place. In some places the water contains high concentrations of constituents derived from various sources, some natural and some related to man's activities. For example, water sampled from 2 shallow wells (wells 1002, 1004, table 12) one 6 feet (1.8 m) deep and one 8 feet (2.4 m) deep (table 12), both within 50 feet (15 m) of the shore of Lake Apopka in the vicinity of Montverde, contained extremely high concentrations of nitrate (115 and 148 mg/l), and also contained unusually high concentrations of calcium, magnesium, potassium, and (in one sample) sulfate. The source of these constituents is unknown; however, high concentrations of such constituents in shallow ground water often are associated with the use of commercial fertilizer.

Another sample that is not representative of native water in the clastic aquifer is that from a 26-foot (8 m) deep well (well 1009, table 12) tapping the clastic aquifer about 4 miles (6 km) south of Tavares. This sample had a dissolved-solids concentration of 142 mg/l owing mainly to a high concentration of nitrate (41 mg/l) but also to relatively high concentrations of potassium and sulfate. The chemical make up of water from this well probably is related to the surrounding land fill.

Of the remaining 8 analyses listed in table 12 (for the clastic aquifer), 5 are for samples from wells in citrus groves and 3 are for samples from wells in non-grove areas. Nitrate concentrations in these samples were consistently higher for wells in citrus grove areas (3.9 to 123 mg/l) than for wells in non-grove areas (0 to 1.2 mg/l). For other constituents, however, there is no consistent relation between the degree of concentration and type of area, which indicates great diversity in the conditions which influence the chemical make up of the water.

Springflow

Because the springflow in Lake County emerges from the Floridan aquifer, the chemical quality of the springflow is similar to that of water yielded by wells that tap the Floridan aquifer. The chemical quality of water does not vary appreciably for individual springs, but it does vary considerably from spring to spring. For example, as shown in table 13, the concentration of dissolved solids is fairly uniform for the several analyses of water from Alexander Springs; however, it is much higher for Alexander Springs than it is for either Bugg Spring or Camp La-No-Che Spring. Between Bugg Spring and Camp La-No-Che Spring, the difference in concentration of dissolved solids is due mainly to the difference in concentration of sulfate, which is markedly higher for Camp La-No-Che Spring than for Bugg Spring.

The chemical composition of water from Alexander Springs is similar to that of water from the well (well 144) that taps the Floridan aquifer near Alexander Springs (fig. 34, table 12) but the concentrations of most of the chemical constituents are slightly lower for Alexander Springs. This suggests that the proportion of water drawn from the uppermost part of the aquifer is slightly greater for the springs than it is for the 100-foot (30 m) deep well.

Surface-Water Quality

Surface water is generally less mineralized but is more turbid and colored than ground water. The lower mineralization is related to the shorter time that surface water is in contact with surrounding materials and to the lower solubility of minerals on the land surface as compared to those in the subsurface. Constituents which cause the color and turbidity of surface water are filtered out by the surficial materials through which water passes to reach the aquifers. Of course, surface-water bodies in areas where aquifers discharge water in many instances contain a high percentage of ground water. In such instances, the chemical nature of surface-water bodies will be similar to that of the ground-water inflow. The water quality of streams and lakes will be discussed separately herein, because of their individual characteristics and problems.

Streamflow

Chemical analyses of samples of streamflow taken at 5 sites in Lake County are listed in table 14. In chemical quality, the water in the Apopka-Beauclair Canal near Astatula is a calcium-bicarbonate type, as indicated by the circular diagram in figure 35, largely because it contains

Table 13.--Chemical analyses of water from selected springs in Lake County.

(Concentrations of chemical constituents in milligrams per litre)

Name	Date of collection	Discharge (gallons per day x10^6)	Temperature (°C)	Specific Conductance (micromhos/cm at 25°C)	pH	Color	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$
Alexander Springs	4/2/46	65	-	920	6.9	0	8.8	0.03	41	18	103	2.3	98	56	192	0.1	0.9	508	176
	4/23/56	88	23.5	988	7.8	5	9.4	.00	49	17	121	3.0	97	61	232	.1	.0	540	192
	11/16/60	80	23.5	813	7.5	5	8.1	.00	41	15	100	3.2	92	52	169	.2	3.0	436	164
	6/22/67	74	23.0	950	7.3	0	12	.00	40	18	115	3.3	92	58	210	.1	.1	525	174
Bugg Spring	4/19/46	11	23.5	259	7.4	5	9.0	.08	44	2.9	4.4	.2	146	2.0	6.6	.0	.3	140	122
	4/26/56	6.6	24.0	252	7.6	5	9.8	.06	48	1.5	4.0	.3	150	.0	8.0	.1	.1	146	126
	11/21/60	12	23.5	245	7.7	5	9.3	.00	44	2.4	4.2	.4	138	3.2	6.0	.1	.5	138	120
	6/23/67	7.8	23.5	262	7.4	0	9.6	.01	46	2.2	4.1	.5	149	1.6	7.0	.1	.4	147	124
Camp La-No-Che Spring	3/29/72	.7	24.0	420	8.0	5	11		48	14	7.2	.8	140	79	10	.3		277	180

Table 14.-- Chemical analyses of water from streams in Lake County. (Gaging-station locations shown in figure 1.)

(Concentrations of chemical constituents in milligrams per litre)

Period of record	Date of collection	Discharge (cubic feet per second)	Temperature (°C)	Specific conductance (micromhos/cm at 25°C)	pH	Color	Turbidity	Dissolved Oxygen (DO)	Biological oxygen demand (BOD)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)
Apopka-Beauclair Canal near Astatula (2377.00)															
1966-70															
Maximum			32.0	552	7.6	200	-	-	-	20	0.1	59	21	21	12
Minimum			14.0	340	6.7	20	-	-	-	1.9	.00	34	14	14	4.7
Average			22.5	433	7.3	70	-	-	-	7.7	.05	47	17	17	6.9
	9/18/68	349	28.0	372	7.6	50	-	-	-	9.3	.09	36	15	15	5.9
	8/4/69	59	26.0	552	7.1	200	80	2.2	4.3	-	-	-	-	-	-
	5/11/70	154	26.0	340	7.6	20	45	7.2	7.9	2.3	.04	42	14	15	4.7
Palatlakaha River at structure M-1, near Okahumpka (2372.93)															
1956-70															
Maximum			31.0	111	6.8	80	-	-	-	4.2	.35	12	1.9	10	1.9
Minimum			14.0	63	5.8	10	-	-	-	.0	.01	3.0	1.5	5.0	.5
Average			22.5	85	6.3	40	-	-	-	2.1	.09	5.8	1.7	7.3	1.2
	5/7/68	.07	22.0	111	6.8	10	-	-	-	2.2	.02	12	1.8	5.0	1.0
	8/9/68	51	28.0	72	6.4	50	2.2	7.2	.9	-	-	-	-	-	-
	5/12/70	96	25.5	63	6.6	80	3.5	-	-	.6	.27	4.4	1.7	6.9	.9
Haines Creek at Lisbon (2380.00)															
1956-70															
Maximum			31.5	303	8.6	40	-	-	-	4.2	.12	33	11	14	4.9
Minimum			13.0	210	6.7	5	-	-	-	.0	.00	27	6.3	9	.8
Average			23.5	280	7.2	20	-	-	-	1.3	.05	30	9.4	12	3.7
	4/29/68	3.0	26.0	302	7.2	20	-	-	-	.0	.02	32	9.5	13	3.5
	8/5/69	186	28.0	255	8.6	20	21	6.0	3.3	-	-	-	-	-	-
	5/11/70	696	28.0	210	7.6	20	30	6.3	6.9	1.7	.02	27	6.3	11	3.2
Big Creek near Clermont (2365.00)															
	8/19/58	5.9	25.5	59	5.4	240	-	-	-	2.5	.45	3.6	1.0	5.5	.1
	3/7/63	68	17.0	63	4.8	240	-	-	-	1.9	.27	3.6	.7	4.9	.4
	5/15/70	.8	26.5	75	5.3	280	8.0	-	-	2.6	-	4.9	1.6	7.2	.4
Black Water Creek near Cassia (2352.00)															
	4/26/56	5.9	23.5	258	6.9	45	-	-	-	6.3	.06	32	10	8.4	1.0
	5/12/66	53	21.5	168	6.7	200	-	-	-	8.9	.18	22	5.3	6.5	.2
	3/10/69	91	12.0	135	6.7	200	-	-	-	5.9	.14	17	4.1	5.5	.5
	10/3/69	400	25.0	88	6.6	280	-	-	-	6.3	.38	11	2.6	3.9	2.5

Period of record	Date of collection	Bicarbonate (HCO_3)	Sulfate (SO_4)	Cloride (Cl)	Fluoride (F)	Nutrients: Nitrate (NO_3)	Nutrients: Nitrite (NO_2)	Nutrients: Ammonia as NH_4	Nutrients: Organic Nitrogen (N)	Nutrients: Total phosphorus as PO_4	Nutrients: Ortho phosphate (PO_4)	Dissolved Solids: Residue at 180°C	Dissolved Solids: Sum of Ionic Constituents	Hardness as $CaCO_3$
Apopka-Beauclair Canal near Astatula (2377.00)														
1966-70														
Maximum		232	46	38	1.1	50	-	-	-	-	6.9	363	295	230
Minimum		135	19	26	.6	.0	-	-	-	-	.11	232	203	150
Average		185	25	32	.7	5.6	-	-	-	-	1.4	298	247	190
	9/18/68	154	23	27	.6	1.5	-	-	-	-	.26	276	210	150
	8/4/69	-	-	-	-	50	0.29	0.41	5.60	7.0	6.9	-	-	-
	5/11/70	160	20	34	.7	.0	.03	.13	.95	.9	.6	232	215	160
Palatlakaha River at structure M-1, near Okahumpka (2372.93)														
1956-70														
Maximum		46	6.4	18	.2	1.0	-	-	-	-	.04	72	58	40
Minimum		4.0	.0	9.0	.0	.0	-	-	-	-	.00	55	34	10
Average		18	4.1	14	.1	.3	-	-	-	-	.02	63	44	20
	5/7/68	46	1.8	11	.1	.5	-	-	-	-	.03	69	58	20
	8/9/68	-	-	-	-	.1	.00	-	-	.05	.00	-	-	-
	5/12/70	6.0	5.6	10	.2	.2	.03	.07	.65	.13	.07	65	34	20
Haines Creek at Lisbon (2380.00)														
1956-70														
Maximum		136	15	26	.5	6.0	-	-	-	-	.20	211	164	130
Minimum		94	9.0	17	.2	.0	-	-	-	-	.00	156	129	90
Average		120	12	23	.4	1.7	-	-	-	-	.04	187	154	110
	4/29/68	136	9.0	26	.4	1.6	-	-	-	-	.10	197	162	120
	8/5/69	-	-	-	-	.2	.00	.0	2.00	.11	.06	-	-	-
	5/11/70	94	14	19	.5	.0	.03	3.6	.14	.39	.20	156	129	90
Big Creek near Clermont (2365.00)														
	8/19/58	8.0	4.4	9.5	.1	.2	-	-	-	-	-	92	-	10
	3/7/63	2.0	3.2	12	.2	.9	-	-	-	-	-	88	-	10
	5/15/70	1.0	.8	13	.3	.2	.05	.18	1.0	.15	.07	103	-	20
Black Water Creek near Cassia (2352.00)														
	4/26/56	59	49	14	.1	.3	-	-	-	-	-	150	-	120
	5/12/66	45	28	12	.5	2.1	-	-	-	-	.09	108	-	80
	3/10/69	30	24	12	.4	.0	-	-	-	-	.00	139	-	60
	10/3/69	18	4.8	9.0	.4	.1	-	-	-	-	.06	119	-	40

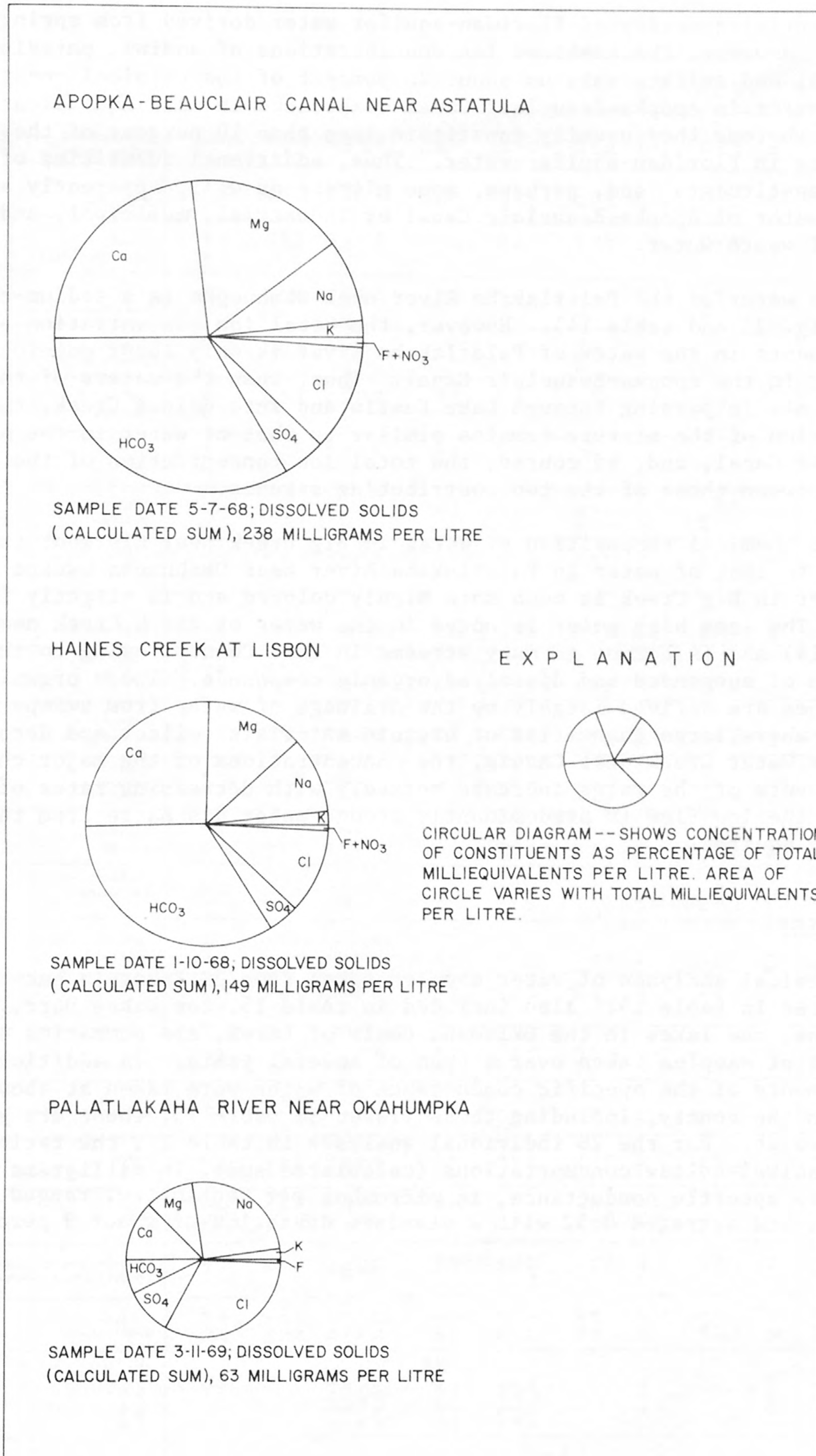

FIGURE 35.--CHEMICAL CHARACTERISTICS OF WATER FROM SELECTED STREAMS IN LAKE COUNTY.

a substantial quantity of Floridan-aquifer water derived from springs in Lake Apopka. However, the combined ion concentrations of sodium, potasium, chloride, and sulfate make up about 25 percent of the chemical constituents of the water in Apopka-Beauclair Canal (expressed in milliequivalents per litre), whereas they usually constitute less than 10 percent of the constituents in Floridan-aquifer water. Thus, additional quantities of these constituents, and, perhaps, some nitrate as well, apparently are added to the water of Apopka-Beauclair Canal by industrial, municipal, and agricultural waste water.

The water of the Palatlakaha River near Okahumpka is a sodium-chloride type (fig. 35 and table 14). However, the total ion concentration of chemical constituents in the water of Palatlakaha River is only about one-fourth that of water in the Apopka-Beauclair Canal. Thus, when the waters of these two streams mix in passing through Lake Eustis and into Haines Creek, the chemical composition of the mixture remains similar to that of water in the Apopka-Beauclair Canal, and, of course, the total ion concentration of the mixture falls between those of the two contributing streams.

The chemical composition of water in Big Creek near Clermont (table 14) is similar to that of water in Palatlakaha River near Okahumpka except that the water in Big Creek is much more highly colored and is slightly lower in pH. The same high color is noted in the water of Black Creek near Cassia (table 14) and is common to many streams in Lake County, owing to the presence of suspended and dissolved organic compounds. These organic substances are derived largely by the drainage of water from swamps and marshes where large quantities of organic materials collect and decompose. At Black Water Creek near Cassia, the concentrations of the major chemical constituents of the water increase markedly with decreasing rates of flow because the low flow is predominantly ground-water discharge from the Floridan aquifer.

Lake water

Chemical analyses of water samples taken from 28 lakes in Lake County are listed in table 15. Also included in table 15, for Lakes Dorr, Minnehaha, and lakes in the Oklawaha Chain of Lakes, are summaries of analyses of samples taken over a span of several years. In addition, field measurements of the specific conductance of water were taken at about 100 lakes in the county, including those listed in table 15; these are plotted on figure 28. For the 28 individual analyses in table 15, the ratio of the dissolved-solids concentrations (calculated sum), in milligrams per litre, to specific conductance, in micromhos per centimetre, ranged from 0.38 to 0.63, and averaged 0.52 with a standard deviation of about 9 percent. Thus, the

Table 15.--Chemical analyses of water from selected lakes in Lake County.

(Concentrations of chemical constituents in milligrams per litre)

Lake	Date of Collection	Temperature (°C)	Specific conductance (micromhos/cm at 25°C)	pH	Color	Dissolved oxygen (DO)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nutrients: Nitrate (NO_3)	Nutrients: Nitrite (NO_2)	Nutrients: Ammonia as NH_4	Nutrients: Organic Nitrogen (N)	Nutrients: Total phosphorus as PO_4	Nutrients: Ortho phosphate (PO_4)	Dissolved Solids: Residue at 180°C	Dissolved Solids: Sum of Ionic Constituents	Hardness as $CaCO_3$
Marion Upland																									
Schimmerhorn	8/8/68	30.0	45	5.0	0	-	0.6	0.00	0.8	0.8	4.7	0.4	0	3.2	6.0	0.1	0.0	0.04	0.04	-	0.10	0.00	27	17	6
Dorr	4/30/68	26.0	61	5.8	60	7.6	2.0	.10	2.0	1.2	6.4	.4	4	5.2	11	.1	.6	-	-	-	.18	-	52	31	10
(Summary of records) 1965-70, 8 analyses																									
Maximum		28.0	62	6.6	140	8.6	5.5	.16	3.8	3.2	6.4	.6	10	5.2	11	.3	.6	-	.08	.46	2.1	.11	59	32	17
Minimum		13.5	50	5.5	60	7.6	1.9	.04	1.6	.9	4.9	.3	0	2.9	6.8	.0	.0	-	.01	.07	.13	.00	47	28	10
Average		24.0	56	5.9	80	8.2	3.8	.09	2.2	1.4	5.5	.4	5	3.8	9.7	.1	.2	-	.04	.22	.60	.07	53	30	12
Kathryn	8/8/68	29.0	42	5.7	0	-	1.0	.03	1.1	.9	4.7	.2	1	3.2	8.5	.1	.3	.05	.05	-	.05	.00	32	21	6
Norris	8/8/68	34.0	226	6.9	240	-	10	.25	28	6.3	8.3	.5	35	52	16	.3	3.0	.16	.05	-	.05	.00	209	142	68
Pine	8/18/69	30.0	43	6.2	40	6.2	.9	.04	4.3	1.1	2.0	.3	12	4.8	5.0	.1	.2	.01	.00	.75	.02	.00	47	25	15
Fish	8/8/68	32.0	93	4.5	5	-	.5	.02	2.5	2.4	6.7	.3	0	19	10	.1	.2	.04	.05	-	.20	.00	51	42	16
Mount Dora Ridge																									
Mary	8/8/68	34.0	336	7.0	20	-	1.8	.03	14	13	26	8.3	68	39	39	.5	.3	.00	.05	-	.09	.00	212	175	90
Swatara	8/8/68	29.0	162	6.3	30	-	3.2	.04	5.2	7.0	11	7.4	18	26	23	.2	.6	.00	.04	-	.09	.01	114	93	42
Oklawaha Chain of Lakes																									
Silver	8/4/68	29.0	358	7.5	0	-	2.3	.02	19	8.6	38	.9	84	8.8	61	.2	1.1	.10	.23	-	.15	.01	212	181	83
Melton	8/4/68	30.0	72	5.4	0	-	1.0	.00	1.7	1.8	6.8	.9	0	9.6	12	.1	.3	.01	.10	-	.04	.00	41	34	12
Dora	4/30/68	27.0	410	7.9	30	10	.8	.05	41	16	18	7.1	168	23	38	.9	3.0	-	-	-	.26	-	294	231	168
(Summary of records) 1963-70, 8 analyses																									
Maximum		31.0	410	8.1	50	11	3.3	.32	41	16	19	7.1	168	26	38	.9	8.8	-	1.1	3.3	1.3	.67	297	231	168
Minimum		12.0	320	7.1	5	8.6	.2	.01	28	13	14	4.6	134	17	24	.4	.0	-	.00	.61	.26	.12	216	177	128
Average		-	366	7.6	20	-	1.3	-	38	14	17	6.1	153	22	29	.7	2.7	-	-	-	.72	.40	264	206	150
Apopka	5/8/68	23.0	380	7.5	70	10	3.6	.03	30	18	19	7.1	148	22	36	.3	1.1	-	-	-	.73	-	294	210	149
(Summary of records) 1924, 1959-70, 13 analyses																									
Maximum		30.5	391	8.4	70	16	15	.27	43	18	23	7.6	186	22	36	.6	28	-	.10	2.7	6.9	.73	294	234	169
Minimum		10.5	252	7.0	20	4.2	.4	.01	18	8.3	8.4	3.3	89	4.5	16	.2	.0	-	.03	.00	.00	.00	129	149	79
Average		-	341	7.4	30	-	4.5	-	33	13	16	5.4	141	17	25	.5	3.4	-	-	-	1.9	.19	235	193	137
Griffin	4/29/68	28.0	299	7.2	20	10	.0	.06	28	9.9	16	4.2	128	14	26	.4	.6	-	-	-	.54	-	207	162	110
(Summary of records) 1965-70, 7 analyses																									
Maximum		28.5	317	8.0	50	10	4.6	.11	38	9.9	16	4.2	138	15	26	.5	13	-	.17	.62	2.9	.42	220	177	134
Minimum		22.0	178	6.8	20	8.4	.0	.02	19	5.4	10	2.1	62	5.9	16	.2	.0	-	.12	.37	.19	.00	115	94	70
Average		-	273	7.3	30	-	2.2	-	30	8.2	14	3.5	118	11	21	.4	3.4	-	-	-	1.0	.28	184	152	109

Table 15.--Chemical analyses of water from selected lakes in Lake County.(continued)

(Concentrations of chemical constituents in milligrams per litre)

Lake	Date of collection	Temperature (°C)	Specific conductance (micromhos/cm at 25°C)	pH	Color	Dissolved oxygen (DO)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nutrients: Nitrate (NO_3)	Nutrients: Nitrite (NO_2)	Nutrients: Ammonia as NH_4	Nutrients: Organic Nitrogen (N)	Nutrients: Total phosphorus as PO_4	Nutrients: Ortho phosphate (PO_4)	Dissolved Solids: Residue at 180°C	Dissolved Solids: Sum of Ionic Constituents	Hardness as $CaCO_3$
Oklawaha Chain of Lakes (continued)																									
Eustis	4/30/68	27.0	300	7.5	50	8.9	.4	.04	33	9.4	14	3.7	130	12	25	.2	.5	-	-	-	.16	-	204	152	121
(Summary of records) 1966-70, 7 analyses																									
Maximum		30.5	300	7.5	50	11	1.8	.12	33	9.9	14	4.6	130	14	25	.5	5.1	-	.28	1.9	.87	.15	204	157	123
Minimum		13.5	250	6.8	10	7.3	.0	.02	27	7.6	10	2.8	103	10	17	.2	.0	-	.02	.36	.10	.00	157	130	102
Average		-	267	7.3	20	-	.8	-	30	8.5	11	3.5	112	12	20	.4	1.3	-	-	-	.40	.08	132	141	109
Yale	4/30/68	26.0	277	7.4	40	7.3	2.4	.03	23	8.4	20	3.8	114	3.1	30	.3	2.5	-	-	-	.10	-	173	150	92
(Summary of reocrds) 1965-70, 8 analyses																									
Maximum		26.0	280	8.1	100	7.3	5.4	.87	23	8.6	22	5.8	114	6.0	30	.4	2.9	-	.23	.99	3.3	.27	173	150	92
Minimum		12.0	160	6.6	10	1.3	.6	.01	11	3.2	13	1.7	38	2.4	23	.1	.0	-	.04	.27	.03	.00	109	86	41
Average		-	231	7.3	40	-	2.7	-	18	7.0	18	3.1	87	3.8	26	.2	1.0	-	-	-	.81	.16	147	123	75
Harris	4/28/68	28.0	250	7.3	10	8.2	1.0	.02	31	6.0	9.2	1.8	120	7.1	19	.3	1.2	-	-	-	.11	-	160	136	102
(Summary of records) 1965-70, 8 analyses																									
Maximum		28.5	250	8.8	40	8.9	2.6	.19	31	6.0	9.2	1.8	120	7.1	19	.3	3.1	-	.11	1.2	3.3	.14	164	136	102
Minimum		14.5	165	6.7	0	7.9	.0	.01	18	3.9	7.2	1.5	64	4.5	13	.1	.0	-	.05	.25	.05	.00	104	84	61
Average		-	211	7.5	10	-	1.1	-	27	5.0	8.0	1.6	94	6.1	14	.2	1.0	-	-	-	.66	.05	138	112	87
Sumter Upland																									
Lady	8/4/68	29.0	98	5.6	5	-	.7	.01	2.0	2.3	10	1.8	1	12	18	.2	.7	.00	.13	-	.14	.01	64	48	14
Palatlakaha Upland																									
Pitts Pond	8/19/69	30.0	182	6.8	20	6.3	.5	.03	24	2.3	9.0	1.2	72	4.4	18	.2	.2	.01	.00	1.1	.03	.00	124	94	70
Bright	8/6/68	32.0	93	5.4	20	-	1.7	.02	2.4	1.7	9.9	.9	0	10	18	.2	.5	.01	.06	- -	.09	.00	67	45	13
Turkey	8/9/68	31.0	134	6.1	10	-	.5	.01	3.7	3.6	14	3.6	10	14	26	.2	.5	.04	.04	-	.06	.01	92	71	24
Church	8/6/68	28.0	292	5.6	0	-	.8	.00	9.7	7.9	27	4.3	4	58	38	.2	.7	.01	.05	-	.14	.00	161	149	56
Minnehaha	10/15/68	26.0	65	5.5	90	-	1.7	.07	3.5	1.5	6.4	.6	6	4.8	12	.2	.4	-	.01	.59	.03	.00	60	34	14
(Summary of records) 1956-70,12 analyses																									
Maximum		33.0	83	6.5	160	8.0	2.3	.21	5.8	1.5	7.7	1.0	13	7.2	14	.4	2.3	-	.08	.59	8.8	.20	83	39	20
Minimum		11.5	42	5.5	30	7.0	.2	.04	2.4	.7	3.9	.3	2	.0	7.2	.1	.0	-	.01	.00	.01	.00	48	22	9
Average		23.0	65	5.9	100	-	1.2	-	3.2	1.3	6.3	.7	6	3.9	11	.2	.6	-	.04	.24	1.5	.04	62	31	13
Lake Wales Ridge																									
Apshawa	8/20/69	31.0	258	5.6	10	7.1	.6	.01	14	10	11	8.9	6	73	22	.2	.0	.01	.00	.14	.02	.00	173	143	76
Grassy	8/5/68	29.0	265	4.7	0	-	11	.00	11	7.3	20	4.1	0	55	34	.2	.2	.00	.06	-	.17	.00	157	143	58
Florence	8/21/69	31.0	150	6.7	10	9.1	5.0	.01	13	6.2	6.9	1.8	58	6.0	14	.3	.1	.01	.08	.98-	.03	.00	95	78	58
Flat	8/6/68	29.0	83	6.9	30	-	.0	.03	2.5	2.3	6.9	1.3	3	13	10	.2	.5	.02	.06	-	.10	.00	64	38	16
Hancock	8/6/68	29.0	62	5.0	70	-	1.7	.06	1.5	1.5	6.4	.3	0	4.8	14	.2	.7	.01	.02	-	.05	.00	54	31	10
Green Swamp																									
Bay	8/6/68	32.0	63	6.2	50	-	.3	.01	2.0	1.4	6.2	1.4	4	6.4	10	.2	.4	.00	.05	-	.08	.00	48	30	11

specific-conductance values provide the basis for a reasonable estimate of dissolved-solids concentration of water in the many lakes sampled. In instances where specific-conductance values are given for the same lakes in table 15 and figure 28, some descrepancies are evident. Determinations of specific conductance made in the field with a portable meter tend to differ slightly from those made from samples of the same water by use of conventional laboratory equipment and procedures.

Field determinations of the specific conductance of lake water ranged from 36 micromhos at North Grasshopper Lake, in northeast Lake County, to 330 micromhos at Silver Lake, in central Lake County between Lakes Griffin and Eustis. In general, lakes in the forest area of northeast Lake County have the lowest specific conductance of any group of lakes in the county, averaging 65 micromhos on basis of determinations for 20 lakes. Of the remaining lakes sampled, only 11 had specific conductance readings of 65 micromhos or less, and these are fairly well scattered in other parts of the county.

Other lakes having relatively low values of specific conductance are Lake Minneola, Minnehaha, and Louisa, in the southern part of the county near Clermont. The quality of water in these lakes is determined largely by inflow from the Green Swamp area through Big and Little Creeks. Moving down the Palatlakaha River through Cherry Lake and Lake Lucy, the specific conductance of lake water increases slightly; at Lake Harris it increases markedly, owing to an increase in calcium bicarbonate acquired as a result of ground-water inflow from the Floridan aquifer.

Ground-water from the Floridan aquifer also accounts for the relatively high specific conductance of water in Lake Norris (198 micromhos, fig. 28). Calcium bicarbonate and sulfate are the major constituents in the water of Lake Norris (table 15) and these are also the major constituents in the water of Camp-La-No-Che Spring (table 13) which discharges Floridan-aquifer water into Lake Norris.

The high specific conductance of water in Silver Lake (300 micromhos, figure 28) is caused primarily by relatively high concentrations of calcium, bicarbonate, sodium, and chloride (table 15). Silver Lake is landlocked. The Floridan aquifer is not a likely source of the calcium and bicarbonate in this lake water, because the lake level probably is always above the potentiometric surface of the Floridan aquifer in this area. However, the lake is surrounded by numerous residences and other developments, including Lake-Sumter Junior College; hence most of the sodium and chloride in the water, at least, probably are derived from or related to man's activities within the lake basin.

The most prevalent water quality problem associated with lakes in Lake County is that of nutrient enrichment which accelerates lake eutrophication. Nutrients such as nitrogen, phosporous, carbon, and other chemical elements stimulate the growth of algae. Frequent algal blooms decrease the recreational and esthetic value of lakes because of fish kills, noxious odors, and greatly increased suspended matter and organic decomposition.

Although the causes of algal blooms are not completely understood, they seem to occur in Lake County in water bodies where the average nitrate and orthophosphate concentrations exceed 1.0 and 0.1 mg/l, respectively. Frequent or constant algal blooms have been noted in Lakes Dora, Apopka, Eustis, and Griffin, for example. According to Bush (1974) the high level of nutrients in these lakes stem from nutrient rich waters pumped into Lake Apopka (and Apopka-Beauclair Canal) from muck farms and discharged into Lakes Yale, Dora, Eustis, Griffin and Apopka from sewage treatment and industrial processing plants. These practices are now prohibited by the Lake and Orange County Pollution Control Departments (Bush, 1974) and are being discontinued as alternate means of disposal are developed.

SUMMARY

Lake County comprises 1,150 square miles (2,880 km^2) in central-peninsular Florida. The climate is subtropical with hot humid summers and mild dry winters. Over the long term the annual rainfall averages about 51 inches (1,300 mm) over the county. During the investigation recorded rainfall ranged from 40.65 inches (1,030 mm) at Lisbon in 1967 to 65.55 inches (1,660 mm) at Eva in 1969. Annual evapotranspiration is estimated to average 40 inches (1,020 mm) for the county as a whole, and to range from as little as 30 inches (760 mm), in areas where the soil is permeable and the water table low, to as much as 48 inches (1,220 mm) from lakes and swamps.

Wetlands, including lakes, swamps, and marshes, cover about 32 percent of the county. Twenty-one percent of the county is for agriculture, mostly citrus groves. Open land, consisting mostly of wooded plots and unimproved pasture make up about 33 percent of the county. About 12 percent is included in Ocala National Forest.

In 1970 water use in Lake County averaged about 54 million gallons per day (2.4 m^3/s). Eighty-five percent of the water used was obtained from wells tapping the Floridan aquifer and 15 percent from lakes.

Landforms in Lake County are of three basic types: ridges, valleys, and uplands. Of the first type are Mount Dora Ridge and Lake Wales Ridge which extend into or across the county with hill tops rising generally 200 to 300 feet above sea level. The ridge areas are also characterized by deep lakes, closed lake basins, low water tables, and subsurface drainage. Lake Wales Ridge is separated from Mount Dora Ridge by the Central Valley, the second type of landform, which is characterized by large lakes--such as the Oklawaha Chain of Lakes--flat terrain, and relatively high surface runoff. The St. Johns River basin constitutes another important valley. Representing the third type of landform are the Marion, Sumter, and Lake Uplands, which are characterized by moderate altitudes and relief, numerous, mostly shallow, closed lakes, and moderate depths to the water table. The Lake Upland in this report is separated into the Palatlakaha Upland and Green Swamp.

The geohydrologic characteristics of Lake County are closely related to landforms, and, hence, are delineated by eight geohydrologic units which bear the same name and include the same area as the landforms previously described.

Surface drainage in Lake County is mainly by the Oklawaha River, which is fed by the Oklawaha Chain of Lakes and the Palatlakaha River in the southern part of the county. The Oklawaha River flows north into Marion County and empties into the St. Johns River, which in turn flows north to the Atlantic Ocean at Jacksonville. The St. Johns River forms the boundary for the northeastern part of Lake County and picks up water from the Black Water Creek and Wekiva River which drain most of the northeastern part of the county. The headwaters of the Kissimmee River extend northward into the southeastern part of the county and the headwaters of the Withlacoochee River extend into the western and southwestern parts of the county. The drainage system as a whole is not well developed; stream channels have been deepened and improved to facilitate drainage for land development. Flow through the Oklawaha Chain of Lakes is regulated by control structures.

The regulation of upstream lakes has altered the frequency distribution of streamflow in Haines Creek and Palatlakaha River. The effect generally has been to increase flood flows and decrease low flows in relation to the natural flows that would have occurred without regulation. The variability of streamflow, as reflected in the slopes of flow-duration curves, differs greatly for the unregulated streams in Lake County. Big Creek and Withlacoochee River have steeply sloping duration curves because their channels are not deeply incised and ground-water seepage into the streams ceases when the water drops slightly. The low flow of Black Water Creek is fairly well sustained by drainage from lakes, swamps, and aquifers; hence, the slope of its duration curve is only moderately steep. The duration curve of Wekiva River is gently sloping because its flow is amply sustained by springflow.

Annual runoff from parts of the various stream basins in Lake County is estimated to average 5.7 inches (145 mm) for the Oklawaha River, 6.6 inches (168 mm) for the headwaters of Withlacoochee and Kissimmee rivers, 12 inches (300 mm) for the Black Water Creek and Wekiva River, and 16 inches (410 mm) for the St. Johns River. For the county as a whole, annual runoff is estimated to average 8.5 inches (216 mm), which equals an average annual discharge of 465 million gallons per day (20 m^3/s). The quantity of runoff on the average is about eight times as great as the quanity of water used in Lake County in 1970.

The ground-water system in Lake County includes a clastic unit and a carbonate-rock unit. The clastic unit consists of a confining bed and a clastic aquifer. The confining bed of the clastic unit overlies the carbonate-rock unit, which the Floridan aquifer. The clastic deposits are about 100 feet (30 metres) thick in general but range from 25 to 400 feet (8 to 120 metres); the confining bed ranges in thickness from zero to 100 feet (30 metres). The clastic aquifer has little potential as an important source of water in Lake County, but it is hydrologically important because it provides ample storage for water to recharge the Floridan aquifer. The Floridan aquifer supplies almost all the ground water used in Lake County.

Recharge to the Floridan aquifer varies with the hydraulic gradient between water in the clastic aquifer and water in the Floridan aquifer, and with the thickness and vertical hydraulic conductivity of saturated materials in the clastic unit, including the confining bed. Consequently, recharge to the Floridan aquifer differs considerably among the various geohydrologic areas. The computed average annual recharge is 14 inches (360 mm) for the Lake Wales Ridge, 10 inches (250 mm) for the Sumter and Palatlakaha Uplands, 6 inches (150 mm) for the Green Swamp, Mount Dora Ridge, and the Marion Upland, 2 inches (50 mm) for the Oklawaha Chain of Lakes, and zero for the St. Johns River Valley. The average rate for the Oklawaha Chain of Lakes area is low partly because of discharge from the Floridan aquifer in some of the lake basins. The entire St. Johns River Valley area is an area of discharge rather than recharge. Natural discharge from the Floridan aquifer also occurs in some of the low parts of other geohydrologic areas. Computed annual recharge to the Floridan averages 7 inches (178 mm) over the entire county, equal to about 383 million gallons per day (17 m^3/s).

Floridan-aquifer water is discharged from eight known springs in Lake County, including Alexander Springs, which in one of Florida's 22 first-magnitude springs. The combined average discharge from all the springs is about 140 million gallons per day (6.1 m^3/s), more than half of which is contributed by Alexander Springs.

Lake County has 1,345 lakes whose surface areas are 2.5 acres (1.0 ha) or more. Of the lakes that are wholly in Lake County, Lake Harris, which has a surface area of 27.6 square miles (71.5 km^2) including Little Lake Harris, is the largest. Lake Apopka is larger, but most of it is in Orange County rather than Lake County. The combined area of the Oklawaha Chain of Lakes is about 80 square miles (207 km^2), almost 7 percent of the county area. The origin of most lakes in the county is related to sinkhole development in a covered karst terrane. The number and type of lakes vary with the geohydrologic areas. In the Green Swamp and St. Johns River Valley areas the depressions are shallow and swamps are the common feature rather than lakes. In the Palatlakaha Upland, most lakes are small and shallow, are landlocked at medium and low water states, and have good hydraulic connection with the Floridan aquifer. The Lake Wales Ridge area is characterized by deep sink lakes that for the most part are entirely landlocked and have exceptionally good hydraulic connection with the Floridan aquifer. Landlocked lakes also predominate in the Sumter Upland and Mount Dora Ridge areas, and, because of greater relief, are generally deeper in the Mount Dora Ridge than in the Sumter Upland. Lake levels fluctuate considerably between wet and dry spells, particularly in lakes in recharge areas which generally flcutuate more than those in discharge areas. The pattern of lake-level flcutuations on some lakes has been altered by the manipulation of control structures.

Throughout most of Lake County the quality of ground water is good enough for most uses. Water from the Floridan aquifer is a calcium-bicarbonate type. Dissolved-solids concentrations of water from wells tapping the Floridan aquifer usually are less than 300 mg/l. Dissolved-solids concentrations were slightly greater than 300 mg/l in water from wells in the Green Swamp area, and ranged from 643 to 954 mg/l in the St. Johns River Valley, and locally in the Marion Upland near Alexander Springs. Concentrations of dissolved solids tend to be lowest in areas where recharge occurs, and highest in areas where discharge occurs; however the poor quality of Floridan-aquifer water in the St. Johns River Valley probably results from the upward movement of saline water along a fault zone. The source of the saline water is unknown. The chemical quality of springflow is similar to that of water from wells that tap the Floridan aquifer in the area of the springs. Water in the clastic aquifer generally is less mineralized than Floridan-aquifer water, but its chemical quality varies from place to place mostly because of the diversity of chemical constituents derived from man's activities. Water from wells in citrus grove areas had higher nitrate concentrations than water from wells in non-grove areas. High concentrations of constituents often associated with the use of commercial fertilizers or with waste-disposal areas were found in the water from other clastic-aquifer wells.

Surface water in Lake County is likely to be colored or turbid because of organic compounds derived from flow through swamps and marshes; in general, however, surface water is less mineralized than ground water. Dissolved-solids concentrations usually are less than 100 mg/l for those streams that do not receive much water from the Floridan aquifer, such as Palatlakaha River and Big Creek. At time of low flow in streams that receive appreciable quantities of Floridan-aquifer water, dissolved-solids concentrations may reach as high as 300 mg/l.

The quality of lake water varies considerable from lake to lake depending on whether the lakes gain water from or lose water to the Floridan aquifer, and also whether the lakes contain waste products derived from man's activities in the lake basins. Lakes having the lowest concentration of dissolved solids (specific conductance, 65 micromhos per centimetre or less) are mostly in the forested area in the northeast part of the county. Those having the highest dissolved-solids concentrations (specific conductance, 200-400 micromhos per centimetre) contain Floridan-aquifer water or waste products from domestic, industrial, or agricultural areas. Waste waters from muck farms and sewage treatment and industrial processing plants probably have been the underlying cause of the frequent algal blooms experienced in the Oklawaha Chain of Lakes.

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GLOSSARY

AQUIFER--A formation, or group of formations, or part of a formation that is water bearing and will yield significant quantities of water to wells and springs.

CLASTIC--Pertains to rocks composed of fragmented material derived from pre-existing rocks and transported mechanically to its place of deposition.

CONFINING BED--A formation that is stratigraphically adjacent to one or more aquifers and has a permeability that is low in relation to the permeabilities of the aquifers.

EVAPOTRANSPIRATION--The overall loss of water by evaporation from land and water surfaces and by transpiration from plants growing thereon.

FAULT--A fracture in the earth's crust accompanied by a displacement of one side of the fracture with respect to the other and in a direction parallel to the fracture.

FORMATION--The ordinary unit of geologic mapping consisting of a large and persistent stratum of some one kind of rock.

GEOHYDROLOGY--The science dealing with subterranean waters.

HEAD (STATIC HEAD)--The height above a standard datum of the surface of a column of water that can be supported by the static pressure at a given point.

HYDRAULIC CONDUCTIVITY--Pertains to the volume of water that will flow through a cross section of unit area, measured at right angles to the direction of flow, of an isotropic porous medium under unit hydraulic gradient along the flow path. In this report values of hydraulic conductivity are expressed in units of cubic feet per square foot per day, which reduces to feet per day.

HYDRAULIC GRADIENT--The change in head per unit distance in a given direction.

HYDROLOGY--The science dealing with the properties, distribution, and circulation of water on the surface of the land, in the soil and underlying rocks, and in the atmosphere.

INFILTRATION--The movement of water from the land surface downward through the unsaturated zone to the water table.

KARST--A type of terrain, marked by sinkholes, in which the topography is chiefly formed by the dissolution of rock, usually limestone, by surface and ground water.

LITHOLOGY--Pertains to the description of rocks.

MILLIEQUIVALENTS--An equivalent concentration that results when the concentration of a chemical constituent in milligrams per litre is divided by the combining weight of the constituent involved. When expressed in milliequivalents per litre, the unit concentrations of all ions are chemically equivalent. If all the chemical constituents of a water sample are correctly determined, the total milliequivalents per litre of anions should exactly equal the total milliequivalents of cations.

PERMEABILITY--A property of a porous medium that relates to its capacity to transmit a fluid under a potential gradient.

POROSITY--The ratio of volume of interstices or voids in a rock or soil to its total volume.

POTENTIOMETRIC SURFACE--A surface which represents the static head of water in an aquifer. It is defined by the level in which water will rise in tightly cased wells penetrating the aquifer.

RUNOFF--The part of precipitation that appears in surface streams having reached the stream channel by either surface or subsurface routes.

SPECIFIC CAPACITY--The rate of discharge of water from a well divided by the drawdown of the water level in the well. Specific capacity usually is expressed in units of gallons per day per foot of drawdown.

SPECIFIC (ELECTRICAL) CONDUCTANCE--Pertains to the capacity of water to conduct an electrical current. It varies with temperature, ion concentration, and chemical composition of the water. In this report specific conductance is reported in units of micromhos per centimetre at 25°C.

SPECIFIC YIELD--The ratio of the volume of water that will drain by gravity from a saturated rock or soil to the volume of rock or soil.

STORAGE COEFFICIENT--The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head.

TRANSMISSIVITY--The rate at which water is transmitted through a unit width of aquifer under a unit hydraulic gradient. In this report transmissivity is expressed in units of cubic feet per lineal foot of aquifer per day, which reduces to feet squared per day.

WATER TABLE--The surface in an unconfined water body at which the pressure is atmospheric. It is defined by the level at which water stands in wells that penetrate the water body just far enough to hold standing water.

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