UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY. [Reports - Open file series]

A RECONNAISSANCE OF HYDROGEOLOGIC CONDITIONS IN LEHIGH ACRES AND ADJACENT AREAS OF LEE COUNTY, FLORIDA

By

D. H. Boggess
and
T. M. Missimer

Open File Report

75-55

Prepared by the
U.S. GEOLOGICAL SURVEY
in cooperation with
THE FLORIDA DEPARTMENT OF NATURAL RESOURCES,
BUREAU OF GEOLOGY
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BOARD OF COUNTY COMMISSIONERS OF LEE COUNTY

Tallahassee, Florida
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A RECONNAISSANCE OF HYDROGEOLOGIC CONDITIONS IN LEHIGH ACRES AND ADJACENT AREAS OF LEE COUNTY, FLORIDA

By D. H. Boggess and T. M. Missimer

ABSTRACT

Lehigh Acres, a residential community with a population of about 13,500 and comprising an area of about 94 square miles (243 square kilometres) in the eastern part of Lee County, has been under development since 1954. Prior to development the area was poorly drained. By 1974, more than 150 miles (241 kilometres) of drainageways had been constructed to drain the area.

The water-bearing formations underlying Lehigh Acres include the water-table, sandstone, lower Hawthorn, and Suwannee aquifers. The water-table aquifer is usually not more than 30 feet (9 metres) thick; it contains water of relatively good quality, except for iron and color. Water levels in this aquifer probably have been affected by construction of drainage canals. The sandstone aquifer, used extensively throughout the area as a source of water supply usually contains water of good quality although the water is hard and in places may contain concentrations of dissolved solids and iron which exceed the recommended limits of the U. S. Public Health Service and the State of Florida for drinking water. The lower Hawthorn and Suwannee aquifers, usually encountered at depths between 440 and 850 feet (135 and 262 metres), contains water with relatively high concentrations of sodium, sulfate, chloride, and dissolved solids.

Three streams, the Orange River, Hickey Creek, and Bedman Creek and the canals connected to them, provide drainage of the area. Except for the Orange River, where the water is of good chemical quality, little is known of the water quality. Similarly, little information is available on stream discharge except for the Orange River where the average annual discharge was 41.1 cubic feet per second (11.6 cubic metres per second) between 1935-46.

Most lakes and ponds in Lehigh Acres are hydraulically connected to the water-table aquifer such that factors which affect one also affect the other. Theoretical drawdown curves indicate that the drainage canals may affect ground-water levels to a distance of 6,000 feet (1,800 metres) under certain conditions. Leeland Lake, the only known sinkhole lake in Lee County, is about 208 feet (64 metres) deep and contains water more nearly similar to the sandstone aquifer, although the lake may be hydraulically connected to both the water-table and sandstone aquifers.

INTRODUCTION

Lehigh Acres, a residential subdivision of about 94 square miles (243 square kilometres) located in the eastern part of Lee County, Florida (fig. 1) has been under development since 1954. Prior to development, much of the area was poorly drained: The water table was characteristically high and surface water filled shallow natural basins. In 1958, the East County Water Control District was formed to provide a network of canals for drainage of the area and to provide a water management system. More than 150 miles (241 kilometres) of drainage canals have been constructed to date (1974).

Fig. 1 near here

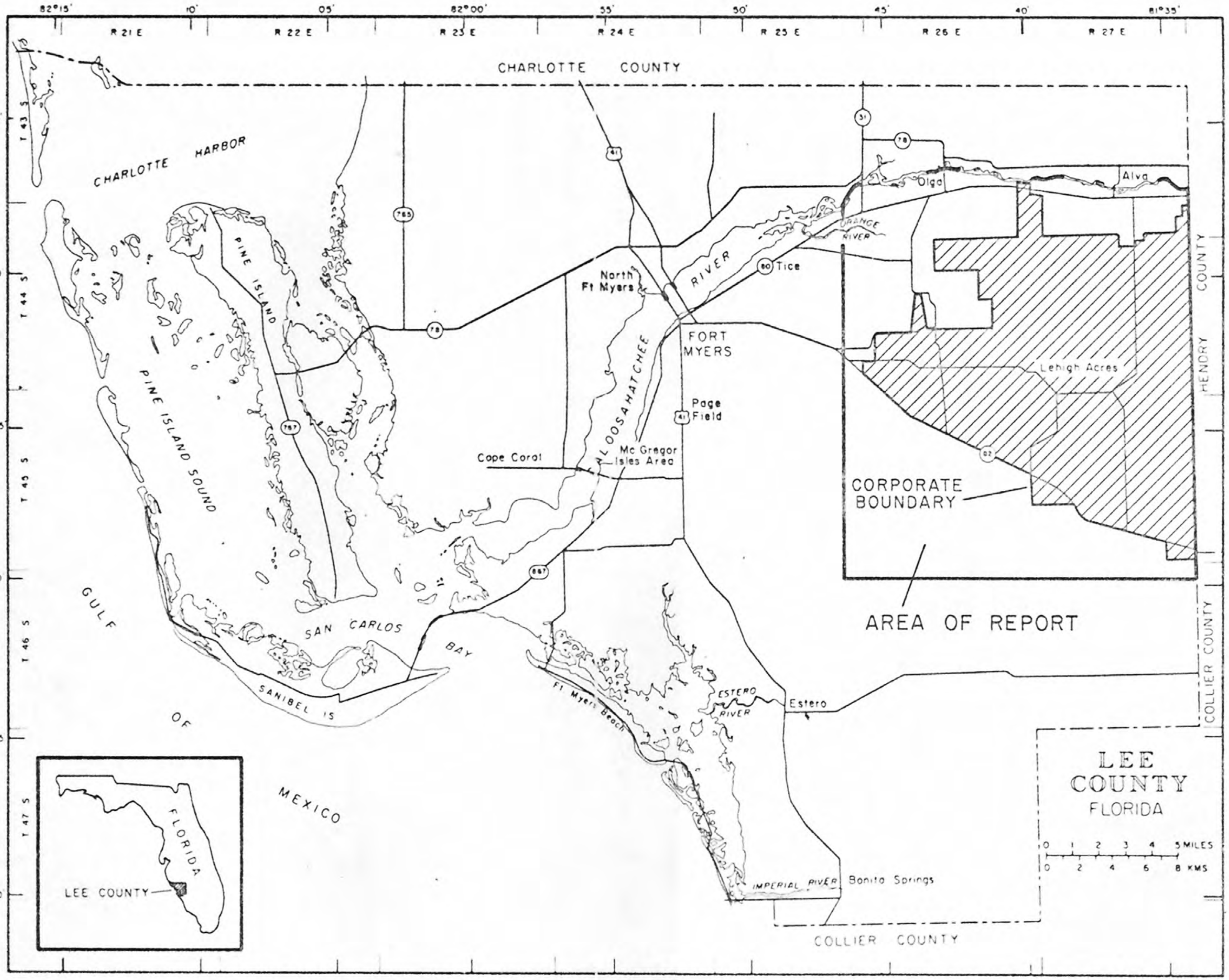

Figure 1.--Lee County, Florida showing area of investigation.

PURPOSE AND SCOPE

In April 1974, the Florida Department of Natural Resources requested that the U. S. Geological Survey compile a summary of available information on the geology and hydrology in the vicinity of Lehigh Acres. This summary would aid in the evaluation of the effects of existing and proposed drainage canals on flooding in adjacent areas, the conservation of water for present and future use, and the retention of existing natural vegetation and terrain feature both within and outside of the area of development. Specifically, requested information was on the lithology of geologic formations underlying the area, a description of the aquifers including quality of water contained therein and areas of recharge, a description of the confining layers, and a description of the surface-water hydrology including water quality.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the valuable advice and assistance of the late Dr. Robert O. Vernon and members of his staff in the Florida Department of Natural Resources. The continued support of the water-resources investigations in Lee County by the Lee Board of County Commissioners is greatly appreciated. Much of the information contained in this report resulted from these investigations. The authors also express their appreciation to the Mobil Oil Corporation for releasing most of the test hole information included in this report and to James A. Ruth of Gee and Jensen Consulting Engineers, Incorporated for providing the rainfall records from Lehigh Acres and other information on the municipal wells, canal systems, and bottom topography of Halfway Pond. James E. Gardner, of the Lehigh Acres Development Corporation, provided a map of corporate boundaries of Lehigh Acres and population estimates.

The report was prepared under the general supervision of Clyde S. Conover, District Chief and Thomas J. Buchanan, Subdistrict Chief of the Water Resources Division of the U. S. Geological Survey.

BASIC DATA

A summary of the basic data included in this report is given in table 1. This summary, grouped according to selected topics, provides a ready reference to the figures and tables on which the basic data are included. For the convenience of those readers more familiar with the metric (SI) system, most measurements in the report are shown in both English and metric units. A conversion table is also included for ease of reference (table 2).

Table 1 near here

Table 2 near here

Table 1.--Summary of basic data included in report.

Rainfall.................Lehigh Acres and Page Field, table 3.

Geology..................Geologic section, figure 4; geologic column, figure 5; descriptive logs, table 5.

Ground water.............Record of wells and test holes, table 4.

Water levels..........Water-table aquifer, figures 6-9.
Sandstone aquifer, figures 10-13.
Lower Hawthorn aquifer, figures 14-15.

Water quality........Chemical characteristics, table 6.

Surface water

Streams

Discharge.........Orange River, tables 7 and 8, figures 17-18.

Stage.............Bedman and Hickey Creeks, table 10.

Water quality.....Orange River, table 9.
Streams and canals, table 11.

Ponds and lakes

Water quality.....Leeland Lake, table 12.

Table 2.--English unit-metric unit conversion table.

Multiply English unit	By	To obtain metric unit
feet	0.3048	metres
inches	25.4	millimetres
miles	1.609	kilometres
square miles	2.590	square kilometres
gallons per minute	6.309×10^{-2}	litres per second
cubic feet per second	2.832×10^{-2}	cubic metres per second
gallons	3.785	litres

DESCRIPTION OF THE AREA

The report area is bounded on the north by the Caloosahatchee River and on the east by the Lee-Hendry County boundary. The western and southern boundaries were established to include all of the area within the corporate limits of Lehigh Acres (figure 2). Information on these areas adjacent to Lehigh Acres are included in the report.

The highest area in Lee County is in the southern part of Lehigh Acres where altitudes range from 30 to 35 feet (9 to 11 metres) above mean sea level (fig. 2). From this high, the land slopes to the north and west to the Caloosahatchee River where altitudes generally are less than 10 feet (3 metres). Most of the area under development is 15-30 feet (5-9 metres) above mean sea level.

Fig. 2 near here

Housing and commercial development is more heavily concentrated in the central part of Lehigh Acres although an extensive road and street network has been constructed throughout most of the area. The 1974 resident population is estimated at 13,500 persons with a seasonal variation of 1,000 persons (J. E. Gardner, written commun., 1974). Numerous access roads into Lehigh Acres have been constructed including those connecting with SR 80 to the north and SR 82 which traverses the southern and western boundaries of the development.

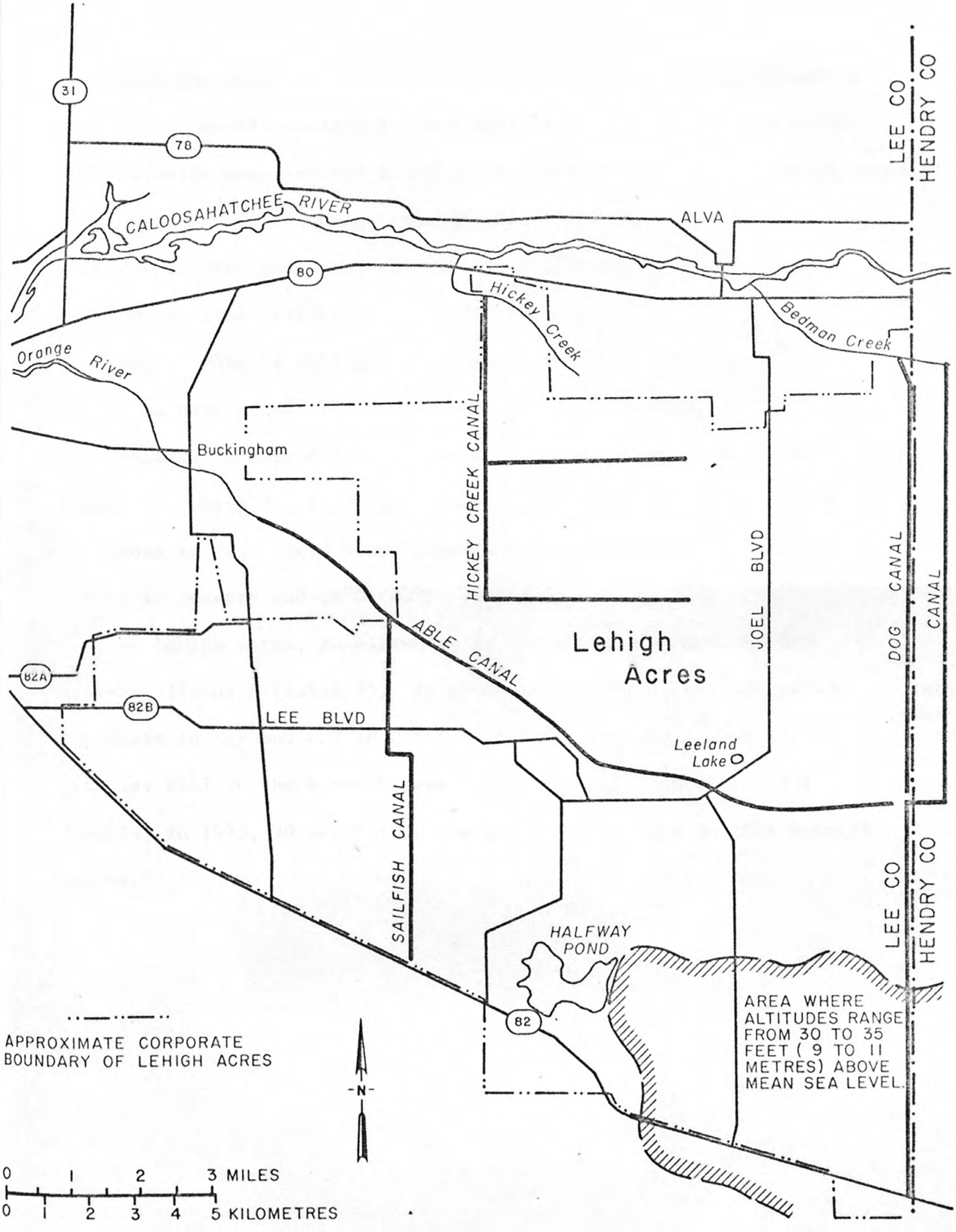

Figure 2.--Lehigh Acres showing names used in report.

Only one major natural drainageway, the Orange River, transects the area. Several smaller streams including Hickey Creek and Bedman Creek provide some natural drainage in the northern part of Lehigh Acres. These streams all discharge into the Caloosahatchee River. Numerous canals have been excavated throughout Lehigh Acres, most of which drain into the natural waterways.

The climate is subtropical; mean annual air temperature is 23°C (74°F) as determined from weather records at Page Field maintained by the National Oceanic and Atmospheric Administration. Temperature extremes in Lehigh Acres probably are similar to, although not identical to, those at Page Field where average monthly temperature is 18°C (64°F) in January and 28°C (83°F) in August.

In Lehigh Acres, as elsewhere in south Florida, wet and dry seasons alternate (table 3). As shown in the table, the wet season may begin in May and end in October, but in some years most of the rain may fall in the 4-month period June through September. For example, in 1973, 70 percent of the annual total fell in this 4-month period.

Table 3 near here

Table 3.--Comparison of rainfall records at Lehigh Acres and Page Field near Fort Myers, Florida, 1965-74
(Rainfall in inches. P.F. - Page Field, L.A. - Lehigh Acres).

Month	1965		1966		1967		1968		1969		1970		1971		1972		1973		1974	
	P.F.	L.A.	P.F.	L.A.	P.F.	L.A.	P.F.	L.A.	P.F.	L.A.	P.F.	L.A.	P.F.	L.A.	P.F.	L.A.	P.F.	L.A.	P.F.	L.A.
January	1.24	0.10	3.39	3.08	1.15	3.92	0.40	0.33	1.44	2.62	4.36	4.55	0.85	0.72	0.77	0.57	3.14	2.86	0.36	0.03
February	2.99	1.67	1.06	1.98	2.15	2.89	2.08	2.49	2.87	2.36	2.20	4.74	1.55	1.48	2.14	2.96	2.23	3.24	0.81	0.66
March	2.91	5.34	0.37	0.54	0.72	1.53	0.65	0.73	4.74	4.57	18.58	17.82	0.55	0.21	4.72	3.79	3.89	3.95	0.03	0.40
April	2.39	1.15	3.03	3.00	0.00	0.00	0.57	0.16	0.15	1.04	0.00	0.00	0.70	1.03	0.27	0.50	1.71	1.17	0.11	0.25
May	4.70	0.61	1.61	3.51	1.46	1.54	10.32	6.89	4.71	7.65	6.36	4.25	3.77	3.37	5.20	4.35	0.78	1.96	2.40	8.93
June	7.78	7.50	12.42	10.49	7.41	12.95	15.03	18.98	10.63	11.45	7.47	11.60	6.18	10.58	7.86	12.92	3.99	7.59	20.10	13.80
July	12.05	12.97	8.22	8.02	6.69	11.34	9.85	10.71	7.11	2.64	4.74	4.35	9.50	9.42	9.72	6.18	9.57	13.46	14.47	14.21
August	6.57	9.85	8.10	4.82	15.86	7.36	11.44	6.48	8.49	4.98	4.82	4.58	8.06	7.09	16.22	6.84	8.66	11.05	7.70	13.41
September	4.35	8.28	4.18	12.11	7.04	9.16	8.92	2.45	16.60	10.04	8.29	5.31	9.21	5.71	2.33	5.01	8.38	6.80	4.31	6.05
October	4.42	4.99	2.14	0.68	3.08	8.72	7.99	4.65	11.03	13.42	1.19	1.92	6.49	11.29	2.20	0.28	0.16	0.94	0.19	1.05
November	0.58	0.50	0.18	0.17	0.92	0.68	2.88	3.12	0.22	0.86	0.46	0.35	0.16	0.19	3.85	8.28	0.10	0.43	1.46	1.84
December	0.85	0.81	0.29	0.40	2.91	2.19	0.16	0.28	3.95	2.50	0.37	0.26	0.30	1.17	1.43	1.00	1.72	1.40	0.89	1.95
Total	50.83	53.77	44.99	48.80	49.39	62.68	70.29	57.27	71.94	64.13	58.84	59.73	47.32	52.26	56.71	52.68	44.33	54.85	52.83	62.58

Although Page Field and Lehigh Acres are only about 14 miles (23 kilometres) apart, monthly rainfall may differ substantially at the two stations. For example, in August 1972, 16.22 inches (412.0 millimetres) were recorded at Page Field, whereas 6.84 inches (173.7 millimetres) were recorded at Lehigh Acres. The difference in monthly rainfall amounts usually are related to thunderstorms which frequently occur in the afternoon during the summer months. Because the path of these thunderstorms commonly is erratic, rainfall may be substantial in some areas and elsewhere little or no rain may fall. The annual totals at the two stations also may vary widely. For example, in 1968 the difference was 18.02 inches (457.7 millimetres). In 1970, the difference was only 0.89 inch (22.6 millimetres). As reported by Boggess (1974, p. 8), these differences in annual totals are similar to those determined between Sanibel Island and Page Field. Based on the records in table 3, the average annual rainfall in Lehigh Acres is about 56 inches (1430 millimetres). The average for Page Field over the same period of record was about 55 inches (1400 millimetres).

WELL INVENTORY AND NUMBERING SYSTEM

Information on the depth, diameter, casing length, and other hydrologic and water quality data has been collected from 158 wells and test holes in Lehigh Acres and adjacent areas. Records from 96 of these wells and test holes on which more detailed information is available are summarized in table 4. The test holes were drilled for the collection of geologic information, whereas the wells were drilled primarily for water-supply purposes. In some cases, test holes were converted to wells by installing well casing. The wells shown in table 4 range in depth from 18 to 850 feet (6 to 262 metres). The test holes were drilled to depths ranging from 75 to 1,340 feet (23 to 412 metres). Well and test hole locations are shown on figure 3.

Table 4

Fig. 3 near here

A dual numbering system is used in table 4. The first column of numbers prefixed by L- (Lee County) indicates the numerical sequence in which the wells have been inventoried since collection of records began in 1935. This numbering system is used on figure 3 and throughout the report. The second series of numbers gives the location of the well or test hole to the nearest second of latitude and longitude. This numbering system is used for the data storage and retrieval system of the U. S. Geological Survey. The first six digits followed by the letter "N" show the latitude. The next seven digits show the longitude. The last digit following the period refers to the number of wells located within the same 1-second rectangle.

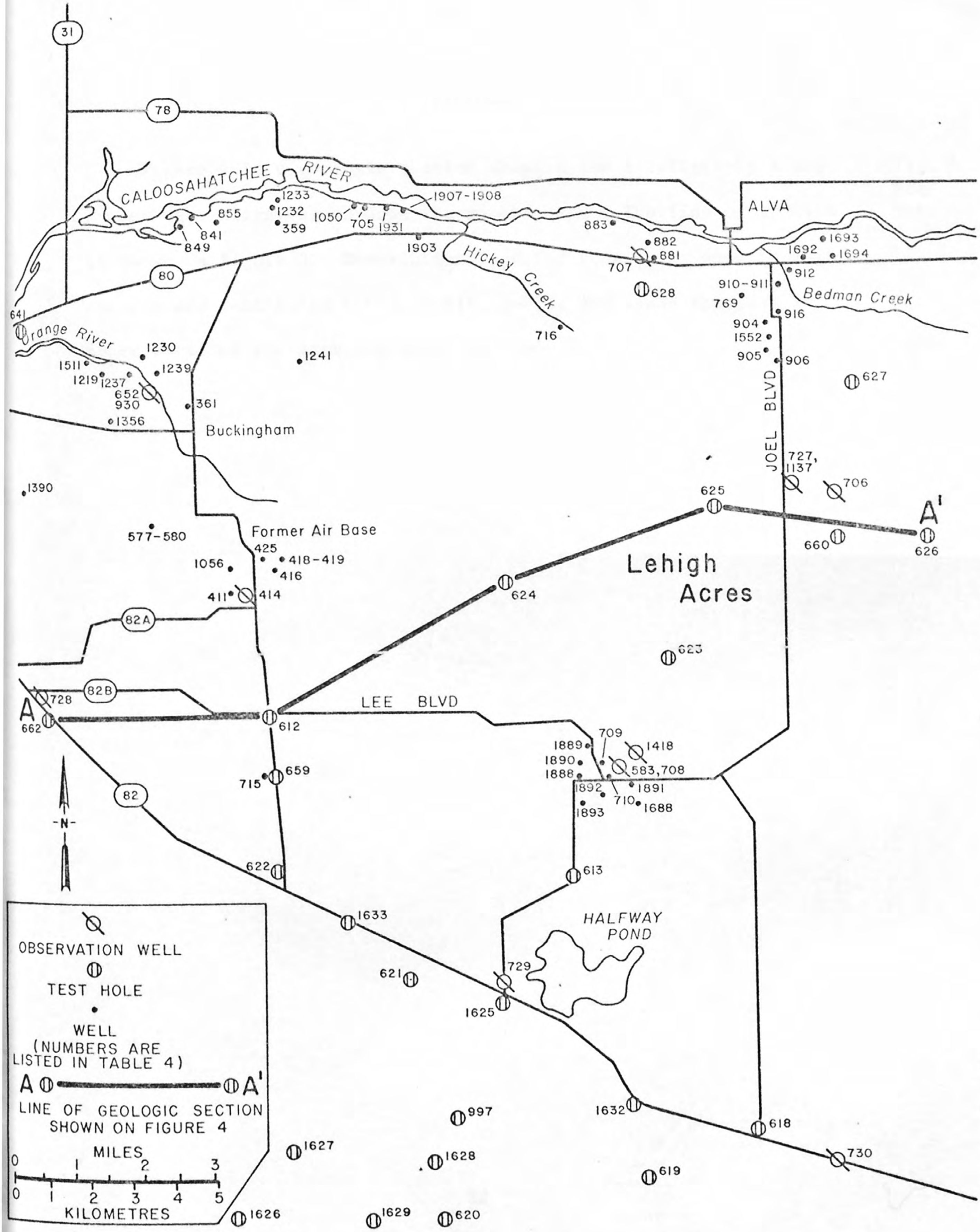

Figure 3.--Area of investigation showing location of wells and test holes.

GEOLOGY

Figure 4 is a geologic section showing the stratigraphy along a west-east alignment through the report area. The line of section is shown on figure 3. Descriptive logs for test holes used in this section and test holes L-613, L-618, L-628, and L-659 that are in other parts of the area are given in table 5.

Fig. 4 near here

Table 5

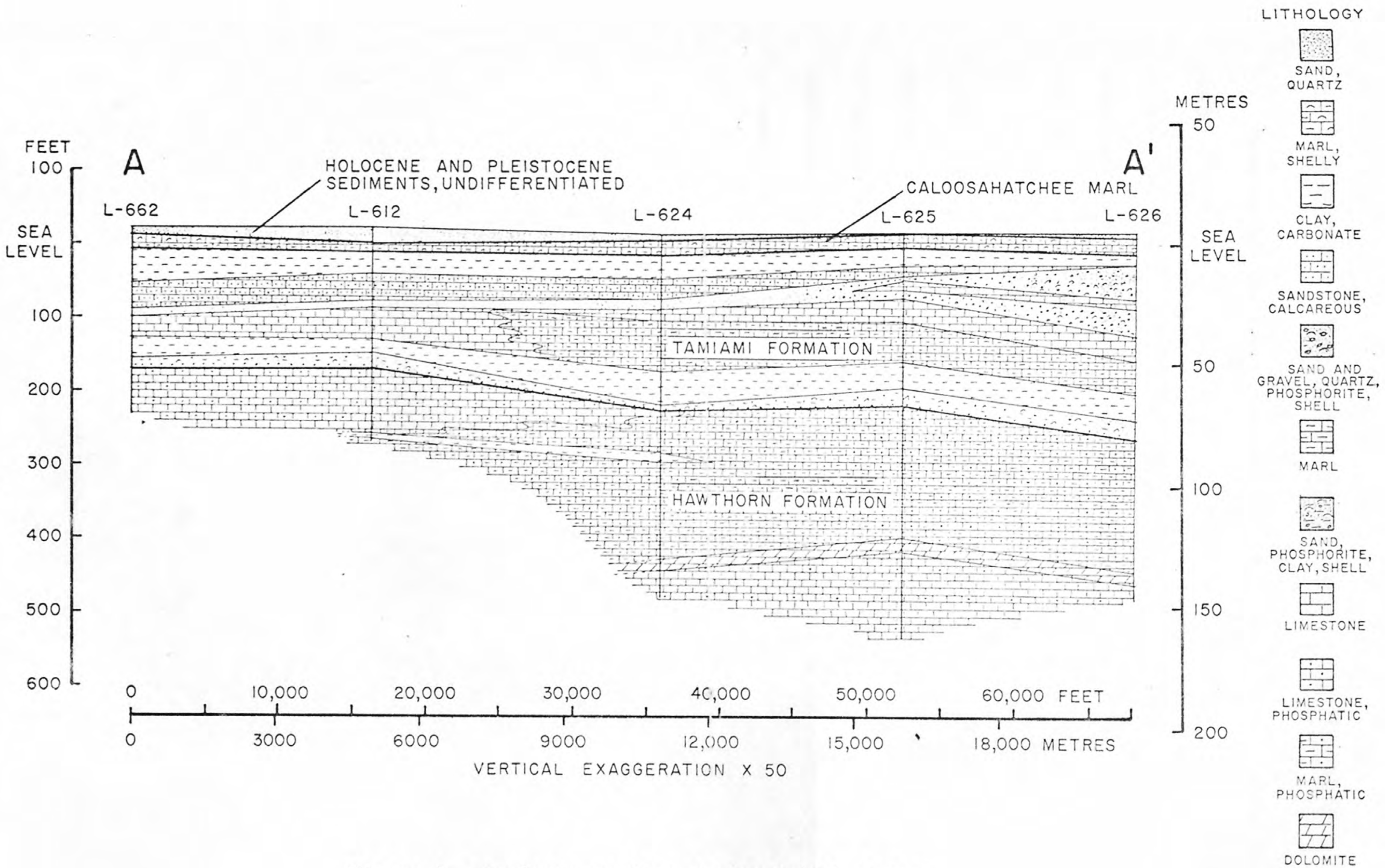

Figure 4.--Geologic section across Lehigh Acres.

(see fig. 3 for location of section)

Holocene and Plio-Pleistocene Sediments, Undifferentiated

Most of Lehigh Acres is mantled by a thin stratum of fine to medium grain quartz sand. Associated with these sediments are thin discontinuous beds of sandy limestone or calcareous sandstone. The sandy sediments seldom achieve a thickness of more than 20 feet (6 metres), and may be absent in places.

The Caloosahatchee Marl, consisting of yellow marly limestone or gray limestone, lies unconformably beneath the sand sediments, or may be exposed at the surface where no sand is present. The Fort Thompson Formation which, elsewhere in Florida unconformably overlies the Caloosahatchee Marl, apparently is not present in the area, possibly as a result of extensive subaerial erosion.

Tamiami Formation

The Upper Miocene sediments, consisting of carbonate clay, sandstone, unconsolidated quartz sand, phosphorite and quartz gravel, and limestone, underlies the Caloosahatchee Marl. The entire Upper Miocene stratigraphic sequence is assigned herein to the Tamiami Formation.

The Tamiami Formation increases in thickness from about 150 feet (45 metres) in the western part of Lehigh Acres to about 250 feet (75 metres) in the eastern part. Six different members within the Tamiami Formation have been traced across the area (fig. 4).

The uppermost member of the Tamiami Formation consists predominantly of light gray and green carbonate clay. It also contains some shell, quartz sand, and silt. Clay-size calcium carbonate particles make up about 80 percent of this member. As shown on figure 4, this upper carbonate clay member thins from the west to the east, and it is only 12 feet (4 metres) thick in test hole L-626 near the Lee-Hendry County line.

Beneath the upper carbonate clay member, a hard light gray calcareous sandstone member occurs as shown on figure 4. This member contains fine-grain quartz sand, shell, and phosphorite all lightly cemented together by microcrystalline carbonate cement. This member thins from the west to the east, and wedges out near the county line.

Beneath the calcareous sandstone member lie sediments consisting primarily of unconsolidated quartz sand with variable amounts of clay, shell, phosphorite, and quartz gravel. This member thickens considerably from the western part of the report area where it is about 20 feet (6 metres) thick, to the eastern part where it is about 100 feet (30 metres) thick (fig. 4). Coinciding with the increase in thickness, is a general increase in grain size of the sediments from clayey mostly fine quartz sand in the west to fine to medium and some coarse sand with shell and phosphorite gravel to the east. Lenticular sandstone also occurs within these deposits.

A fourth member consisting of white and tan limestone and gray marl immediately underlies the quartz sand member. This carbonate member thickens from 30 feet (9 metres) in the west to 80 feet (24 metres) in the east. In the western part of the area, it consists entirely of gray to white limestone. To the east, it undergoes a facies change and splits into two distinct lithologies. The upper part consists of tan limestone, whereas the lower and thicker part consists of gray marl with some shell and quartz sand.

A lower carbonate, clay member underlies the limestone-marl member. This fifth member consists largely of clay-sized carbonate sediments, with varying percentages of quartz sand, silt, shell, and phosphorite. The thickness ranges from about 30 to 50 feet (9 to 15 metres) with no general trend.

The lowermost member of the Tamiami Formation consists of gray clay, quartz sand, shell, limestone fragments, and a large amount of phosphorite. This zone represents erosional detritus and it mantles the underlying phosphatic carbonates throughout Lehigh Acres and adjacent areas. It ranges in thickness from about 20 to 40 feet (6 to 12 metres).

Hawthorn Formation

The Middle Miocene Hawthorn Formation lies unconformably below the Tamiami Formation. The top of this lithologically complex stratigraphic unit dips gently eastward across Lehigh Acres at an average slope of about 7 feet per mile (1.3 metres per kilometre).

In the western part of the area, the upper part of the Hawthorn Formation consists of moderately hard phosphatic limestone with varying percentages of shell and quartz sand. To the east, the upper part of the formation grades into a soft phosphatic marl facies, which contain some shell and quartz sand.

The Hawthorn Formation consists largely of phosphatic marl to as much as 400 feet (123 metres) below sea level (fig. 4 and table 5). The marl contains lenticular bodies of light gray carbonate clay, green carbonate clay, and gray shelly clay. The proportions of these constituents in the lenticular bodies change abruptly from place to place so that individual bodies cannot be traced over appreciable horizontal distances. The formation consists of hard light gray to tan dolomite strata at depths of 400 to 500 feet (120 to 150 metres) below mean sea level. These strata can be traced over most of the area. The Hawthorn consists of a series of interbedded hard phosphatic limestones and gray carbonate clays beneath the dolomite strata. These limestones and carbonate clays vary greatly in composition vertically and horizontally.

Pre-Hawthorn Formations

The Tampa Formation underlies the Hawthorn Formation conformably; the contact between the two is not easily recognized. The Tampa Limestone consists of phosphatic sandy limestone, marl, and carbonate clay, all of which closely resemble the materials of the Hawthorn Formation.

The Suwannee Limestone lies unconformably beneath the Tampa limestone and the contact between the two probably is in the depth range 650-750 feet (200-350 metres) below sea level. Because of the absence of phosphorite in the Suwannee Limestone, the Suwannee is distinguishable from the Tampa Formation.

The Ocala Group, similar in lithology to the overlying Suwannee Limestone, consists of tan limestone with some quartz sand, and clay. It contains characteristic microfossils.

AQUIFER CHARACTERISTICS AND WATER QUALITY

Four aquifers have been identified in Lehigh Acres. Included are the water-table, sandstone, lower Hawthorn and Suwannee aquifers. The stratigraphic position and associated lithology of these aquifers are shown on figure 5. A fifth water-bearing zone, the upper Hawthorn aquifer, underlies the western part of the report area, but is not present in the area of well L-660 (fig. 5). Fig. 5 near here

Chemical analyses made on 14 wells in Lehigh Acres and adjacent areas are given in table 6. Table 6 near here

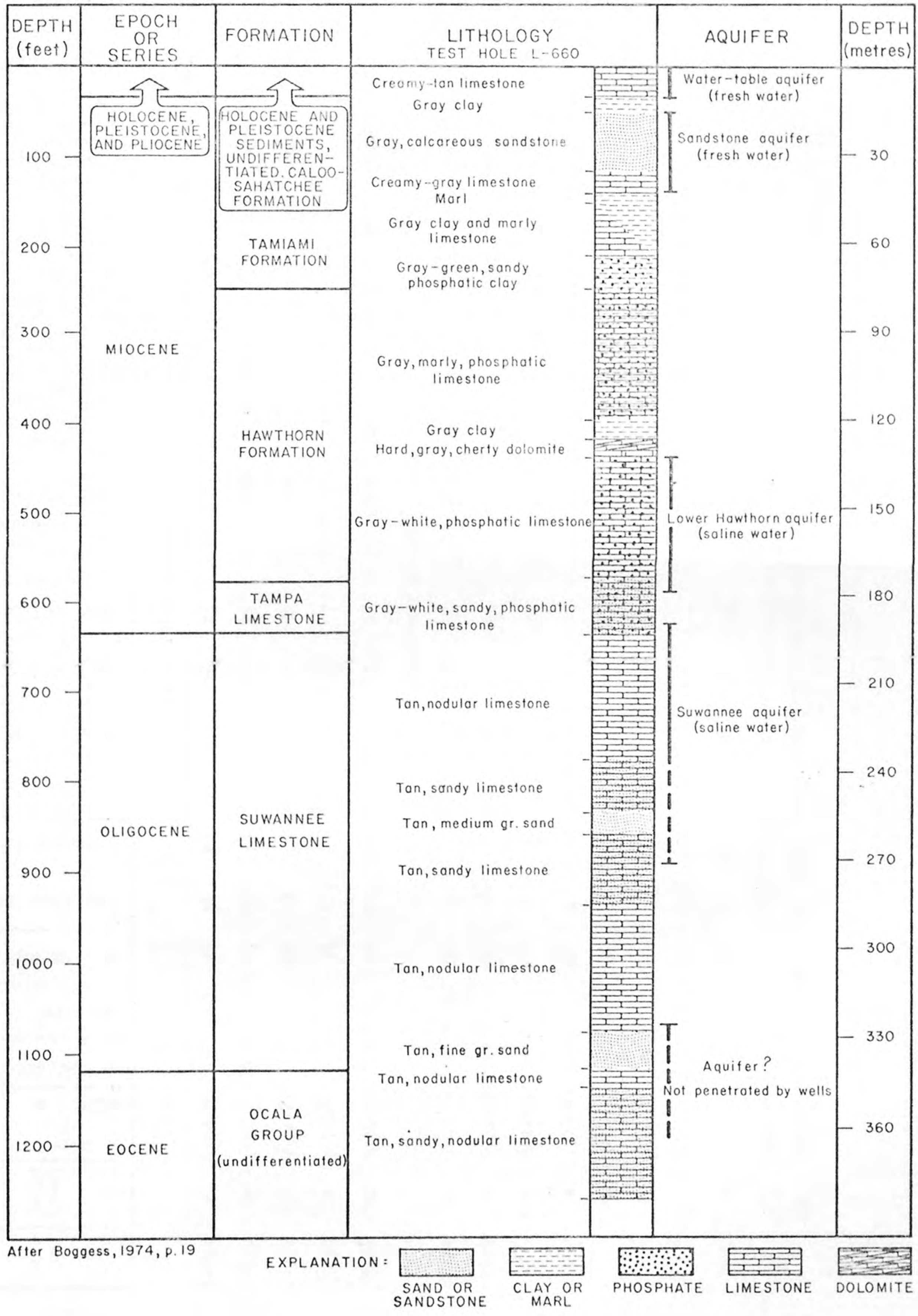

Figure 5.--Generalized geologic column showing lithology of test hole and aquifers underlying Lehigh Acres, on basis of L-660.

Table 6.--Chemical characteristics of ground water in Lehigh Acres and adjacent areas.
(Chemical constituents in milligrams per litre).

Well No.	Depth (Feet)	Date of Collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Strontium (Sr)	Sodium	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Bicarbonate (HCO_3)	Alkalinity as $CaCO_3$	Hardness as $CaCO_3$		Dissolved Solids		Specific conductance (micromhos at 25°C)	pH	Temperature (°C)	Color (plat.-cobalt units)
															Calcium-Magnesium	Non-Carbonate	Residue at 180°C	Calculated				
Water-table aquifer																						
L-707/1	21	4-10-74	54	0.93	80	26	.97	68	3.3	59	87	0.83	336	276	310	32	543	547	874	7.6	24	40
727	27	7-24-68	8.2		81	11	.64	19	.8	16	32	.2	280	230	248	18	324	308	530	7.3	24	40
729	27	7-29-68	9.3		94	5	.1	18	.3	.4	36	.1	296	243	255	12	344	310	550	7.2	24	50
730	19	8-2-68	9.8		88	2.2	.2	4.1	.6	3.2	7	.1	272	223	228	6	275	256	430	7.6	25	80
1137	20	4-11-74	7.3	1.7	78	9.1	.28	14	.6	7.7	21	.5	269	221	230	12	316	273	497	7.1	24	300
Sandstone aquifer																						
L-414	94	4-11-74	30	0.74	87	21	.42	36	2.1	0.5	59	.5	359	294	300	10	428	414	712	7.6	24	30
708	58	5-31-68	17	2.1	82	19	.32	82	1.6	33	162	.2	234	192	283	91	555	513	910	7.5	26	30
	58	5-9-74	18	.7	120	24	.46	110	2.9	68	190	.4	367	301	400	98	790	715	1180	7.3	26	
727	68	7-25-68	4.8		136	38	1.2	85	3.7	124	208	.3	314	258	498	240	841	799	1300	7.5	26	5
	68	4-11-74	2.8	.06	22	21	.13	7	3.9		170	.3	102	85	140	56	340	347	684	8.6	25	5
729	121	8-1-68	21		89	14	.2	58	1.7	30	75	.3	326	267	280	12	461	451	760	7.4	25	35
	121	4-19-74	5.9	.01	59	6.6	.19	26	1.1	2.3	45	.2	191	157	170	18		240	425	7.6	25	80
930/2	78	6-2-69	20		135	81	4.8	379	13	334	740	.7	164	135	676	541		1790	2900	7.9	25	5

/1 Analysis probably not typical because of effects of chemicals and fertilizers applied nearby.

/2 Analysis not typical except where upward leakage from deeper aquifers has occurred.

Table 6.--continued.

Well No.	Depth (Feet)	Date of Collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Strontium (Sr)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Bicarbonate (HCO_3)	Alkalinity as $CaCO_3$	Hardness as $CaCO_3$: Calcium-Magnesium	Hardness as $CaCO_3$: Non-Carbonate	Dissolved Solids: Residue at 180°C	Dissolved Solids: Calculated	Specific conductance (micro-mhos at 25°C)	pH	Temperature (°C)	Color (plat.-cobalt units)
											Lower Hawthorn and Suwannee aquifers											
L-359	650	3-6-73	14		110	92	22	500	21	350	920	1.5	148	121	680	560		2100	3600	7.9	28	5
425	780	3-23-46			87	78		392		359	615		182		538			1710	2770	7.4	29	4
652	598	6-2-69	13		89	88	18	386	19	296	720	1.4	168	138	605	467		1700	2800	7.9	26	3
	598	3-12-74	14	.21	82	74	20	430	21	310	720	1.3	130	107	530	430	1880	1740	2960		27	5
706	592	5-1-69	19		48	52	6.1	196	14	146	280	2.2	292	239	341	102	967	907	1500	8.1	28	3
	592	3-12-74	19	.06	41	46	6.0	220	17	170	270	2.0	290	238	300	61	936	934	1590	7.9	28	5
715	830	6-2-69	14		85	89	14	397	19	276	780	1.5	164	135	594	460		1760	2950	7.8	31	3
1688		3-22-73	14	.03	110	100	19	540	22	350	900	1.4	160	131	710	580		2100	3660	7.6	31	10
											Comparison of averages											
Water table/1			8.6		85	6.8	0.31	13.8	0.6	7.1	24	0.23	279	229	240	12	315	287	502	7.3	24	118
Sandstone/2			11.5	0.72	85	20.5	.42	58	2.5	43	130	.3	270	222	296	75	488	497	853	7.6	25	31
L.Hawthorn-Suwannee			15	.1	82	77	15	383	19	282	650	1.6	192	158	537	380	1261	1619	2729	7.8	28	5

/1 Excludes analysis for well L-707.

/2 Excludes analysis for well L-930.

Water-Table Aquifer

The water-table aquifer is the uppermost water-bearing formation in Lehigh Acres. The aquifer consists of sand and of the sandy and silty limestone of the underlying Caloosahatchee Marl where the sand and the limestone are hydraulically connected. The sand is highly permeable. The Caloosahatchee Marl, although generally low in permeability, locally transmits water readily because of the occurrence of large interconnected vugs within the formation. The thickness of the sand varies greatly as does the permeability of the Caloosahatchee Marl. For that reason the aquifer thickness is not uniform. Generally it is less than 30 feet (9 metres) thick. The water-table aquifer, where it includes the full thickness of the Caloosahatchee Marl is underlain by the relatively impermeable carbonate clay of the uppermost member of the Tamiami Formation.

The water-table aquifer is not a major source of water supply for domestic use in the report area. Because of its shallow depth, the aquifer is readily subject to contamination from the surface, or from the disposal of wastes. Most of the wells tapping the aquifer are used primarily for irrigation. The water-table aquifer is the principal source of water which sustains stream flow and lake levels during the dry season. The water level in the aquifer is a controlling factor in determining the character of the vegetation.

Fluctuations of Water Levels

As defined by Lohman and others (1972, p. 14), the water table is "that surface in an unconfined water body at which the pressure is atmospheric." This surface corresponds to the level at which water will stand in wells tapping an unconfined water body, the water-table aquifer. Variations in recharge and discharge to and from the aquifer result in a continuous change in altitude of the water table. Rainfall, the principle source of recharge, causes the water table to rise. Conversely, discharge by evaporation, transpiration, and base flow to streams causes the water table to decline. A more detailed description of the factors affecting the water table in Lee County are given by Missimer and Boggess (1974).

Wells tapping the water-table aquifer in Lehigh Acres and adjacent areas show a seasonal fluctuation of water levels similar to other parts of Lee County. These seasonal fluctuations resulting from variations in recharge and discharge factors are evident from the hydrographs of wells L-728, L-707, L-730, and L-1137 on figures 6-9. Figures 6-9 near here
Figure 6 illustrates the general relation between the principal source of recharge, rainfall, and water levels in well L-728 under virtually natural conditions. Water levels reach the highest annual position during the period of maximum rainfall and conversely, reach the lowest annual position during the period of minimum rainfall. Periods of unusually heavy rainfall or extended periods of deficient rainfall will result in water levels higher or lower than normal.

The rapid rise in water levels in all wells (fig. 6-9) in June-July 1974 resulted from unusually heavy rainfall of nearly 37 inches (940 millimetres) in May, June, and July 1974. Immediately prior to this period, water levels in these wells had reached the lowest position of record during the dry season, October 1973 through April 1974, when the cumulative total rainfall was about 4 inches (100 millimetres).

The water level in well L-707 (fig. 7) although showing a natural seasonal fluctuation, also is affected by pumping of nearby wells which causes a decline in the water level and by irrigation of crops near the well which results in a rise in water level. These effects which may occur either simultaneously or at different times results in an erratic variation in water levels.

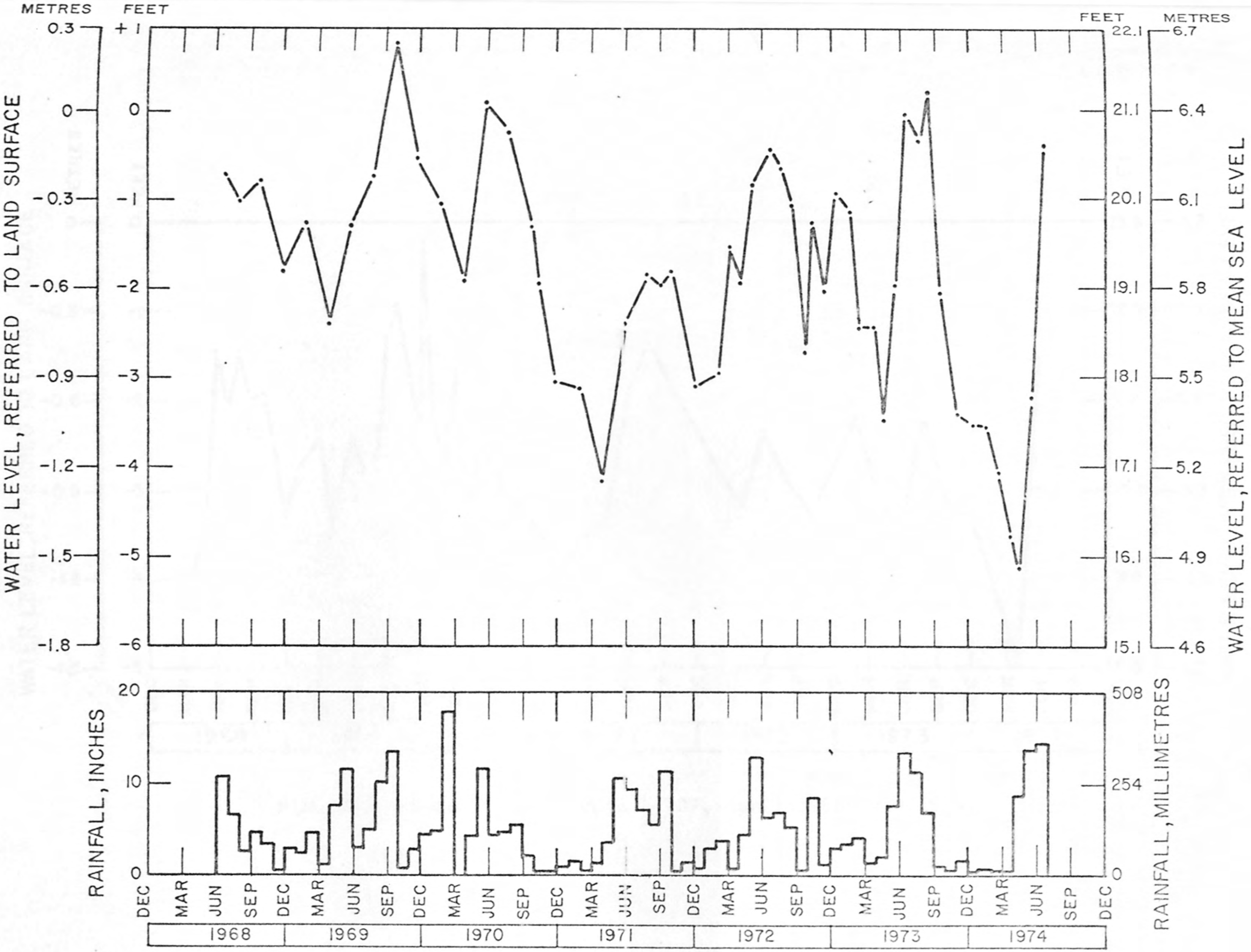

Figure 6.--Hydrograph of well L-728 and graph of monthly rainfall at Lehigh Acres, July 1968-July 1974.

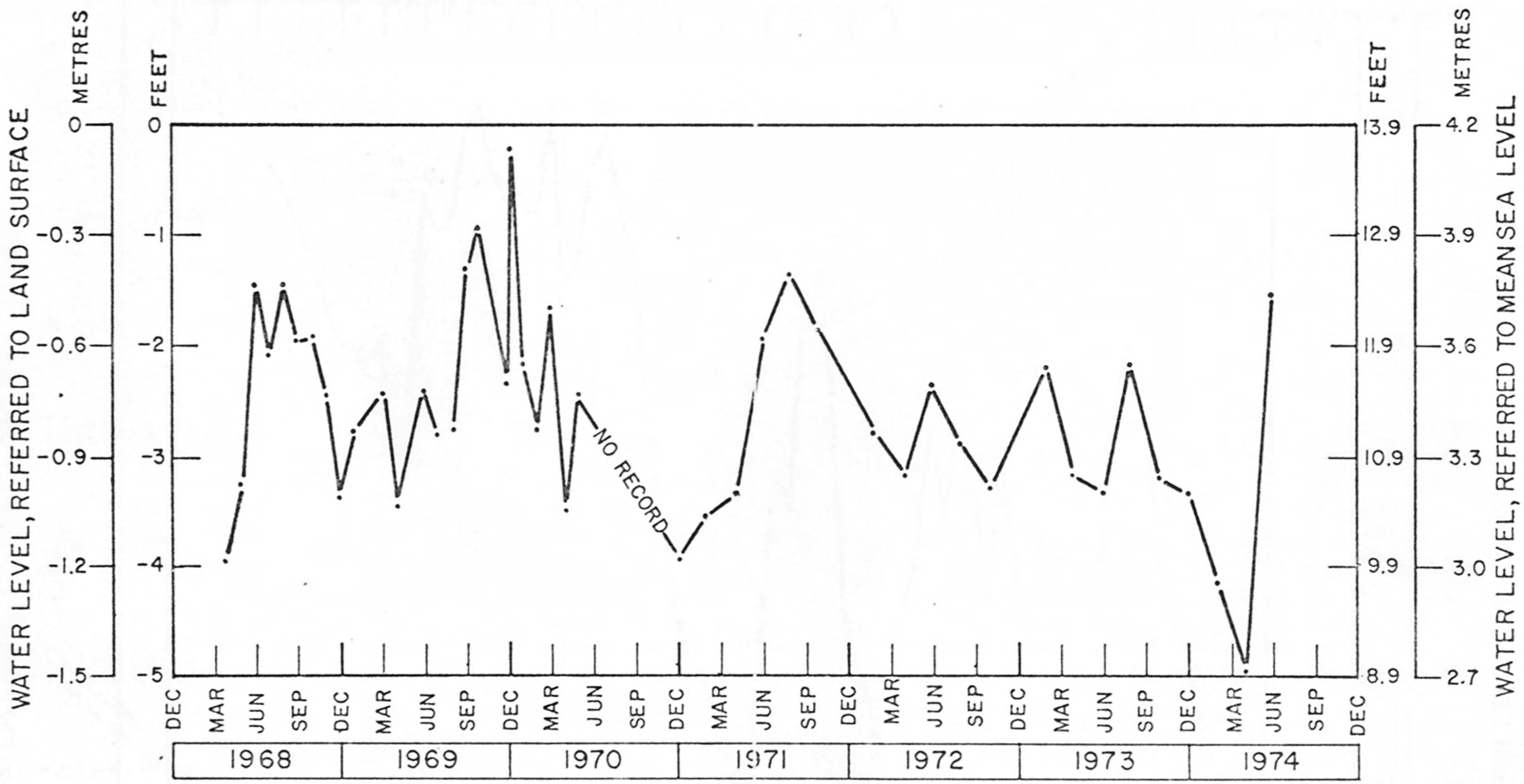

Figure 7.--Hydrograph of well L-707, April 1968-July 1974.

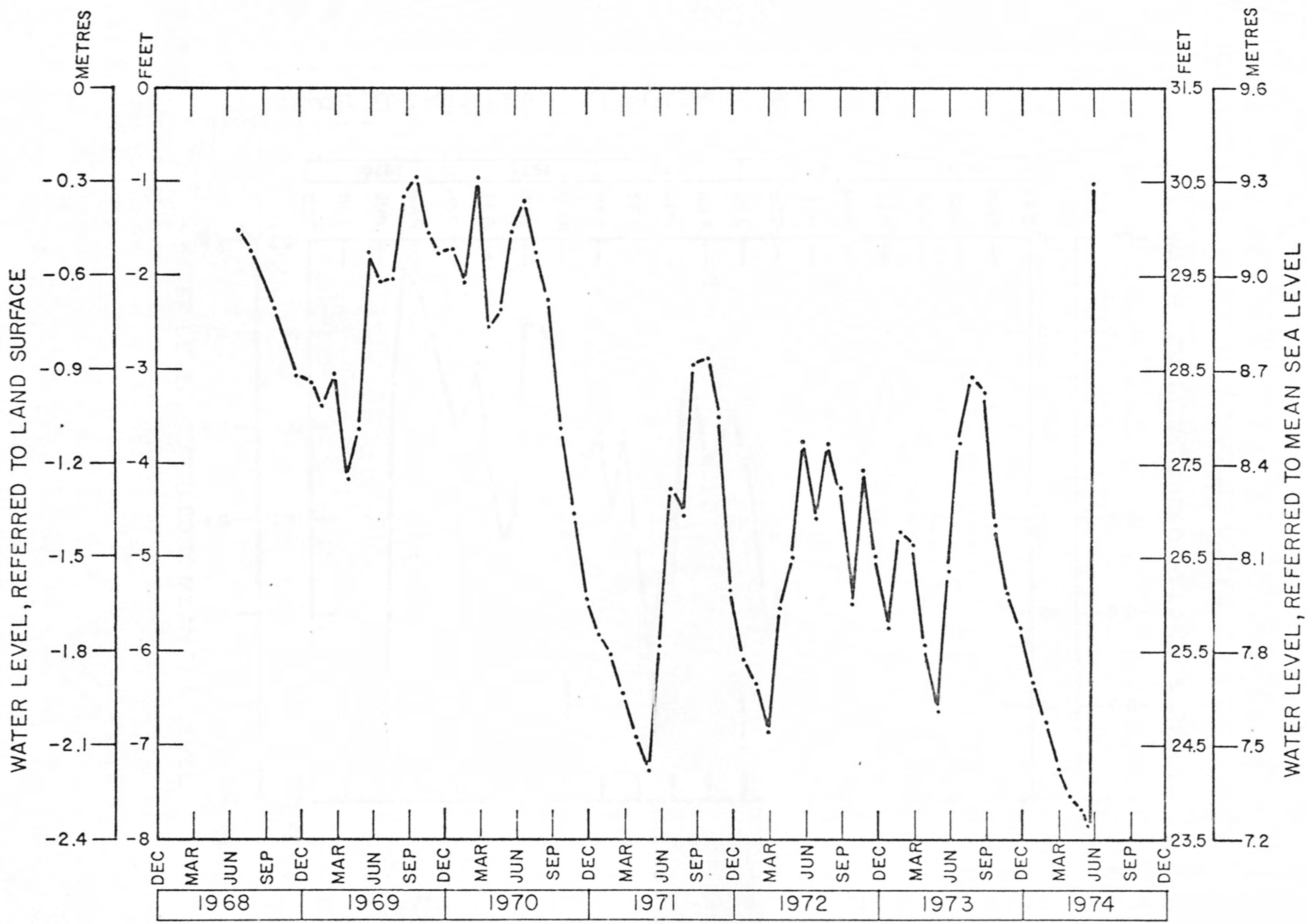

Figure 8.--Hydrograph of well L-730, July 1968-July 1974.

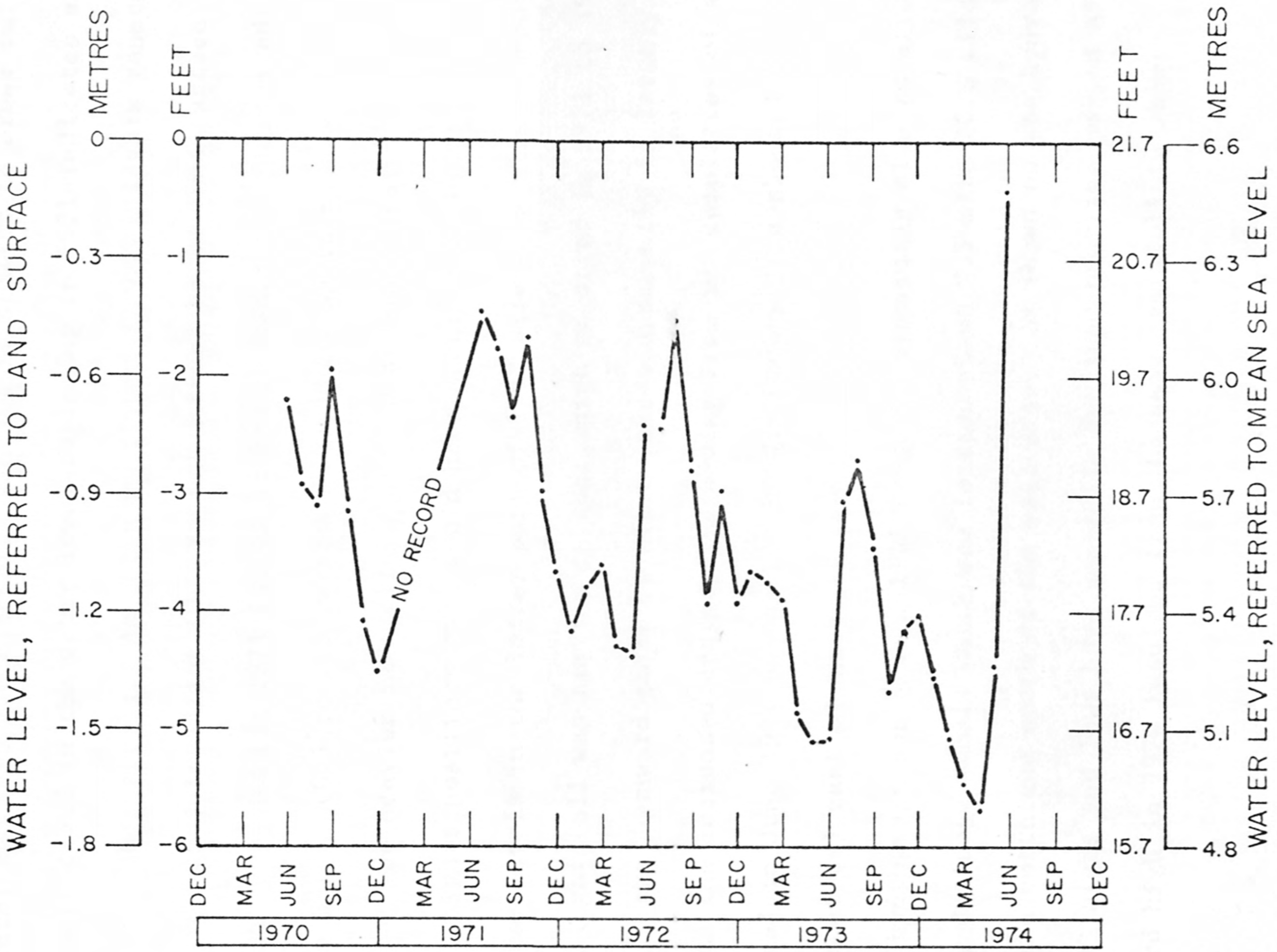

Figure 9.--Hydrograph of well L-1137, June 1970-July 1974.

The hydrograph for well L-730 (fig. 8) shows an unusual pattern of water-level fluctuations. Although the seasonal cycle resulting from natural recharge and discharge factors is similar to other wells, the downward trend in the water level beginning in 1971 indicates a response to other stress. As shown on figure 8, water levels generally fluctuated from 1 to 4 feet (0.3 to 1.2 metres) below land surface during 1968-70. During 1971-74, water levels generally fluctuated from 3 to 8 feet (0.9 to 2.5 metres) below land surface. As shown in table 3, the heavier rainfall in 1969-70 probably sustained water levels at higher positions than would have occurred otherwise. However, water levels in the latter part of 1968 also were high although the annual rainfall was similar to that which occurred in 1971 to 1972.

Thus, the downward shift in water levels apparently is largely related to the increased drainage resulting from the completion of a major canal in June 1971 on the Lee-Hendry County line about 1.5 miles (2.4 kilometres) east of the well site.

The hydrograph for well L-1137 (fig. 9) apparently also is affected by nearby drainage canals which are located about 0.5 mile (0.8 kilometre) both to the north and south of the well site. As shown on the hydrograph, the annual highs and lows have generally declined over the period of record. The record high in 1974 resulted from the heavy rainfall in June.

Water Quality

In general, water from the water-table aquifer is suitable for most purposes; the concentration of chemical constituents, except for color and iron are within the recommended limits for drinking water as established by the U. S. Public Health Service (1962, p. 7) and as adopted by the State of Florida. However, before water from this aquifer is used for domestic purposes, it should be checked for undesirable biological and chemical constituents. On the basis of four analyses in table 6, the dissolved solids are less than 400 mg/l (milligrams per litre), sulfate less than 10 mg/l, and chloride less than 30 mg/l. Although iron concentrations were determined for only two water samples, both exceeded the recommended limit of 0.3 mg/l. Other wells in Lehigh Acres apparently produce water with relatively high concentrations of iron as evidenced by red staining of walks and driveways in some parts of the area.

Sandstone Aquifer

The term "sandstone aquifer" as used herein refers to permeable members of the Tamiami Formation which are hydraulically interconnected. Included are the sandstone, sand, and limestone members described in the preceding section. Confined above and below by clay members in the Tamiami Formation, the aquifer is under slight artesian pressure. As shown on figure 4, the sediments comprising the aquifer attain maximum thickness near the Lee-Hendry County line and thin to the west.

The sandstone aquifer is the source of water for the public-supply system in Lehigh Acres and probably is used extensively throughout the area for individual domestic supplies and for irrigation. Of the wells listed in table 3, 49 tap the sandstone aquifer including the Lehigh Acres water-supply wells L-708, L-709, L-710, and L-1888 through L-1893. Most of the wells near Buckingham (L-411 through L-419) at the former Air Base also tapped the sandstone aquifer. Although little information is available on well yields from the sandstone aquifer, it is estimated that 200 gallons per minute (13 litres per second) can be obtained from properly constructed wells. Locally greater yields can be obtained.

Fluctuations of Water Levels

Water levels in wells tapping the sandstone aquifer fluctuate seasonally similar to wells in the water-table aquifer (fig. 10). The wells in figure 10 are in the northern part of Lehigh Acres and are less than 10 feet (3 metres) apart. Both hydrographs show a response to recharge and discharge factors. The water level in well L-727 is consistently lower than in well L-1137, which indicates that no direct hydraulic connection exists between the aquifers in the vicinity of these wells. The effects on water levels in well L-727 of the 1971 and 1974 droughts are shown on figure 10. The highest water level recorded in this well was about 18.4 feet (5.7 metres) above mean sea level, after the heavy rainfall in March 1970.

Fig. 10 near here

Inasmuch as water levels in the area of recharge to the sandstone aquifer must be as high or higher than in downgradient wells, the highest water level in well L-727 implies that land altitudes in the recharge area are at least about 19 feet (6 metres) above mean sea level. This excludes the possible loading effect on water levels at the well site resulting from water in storage in the overlying water-table aquifer.

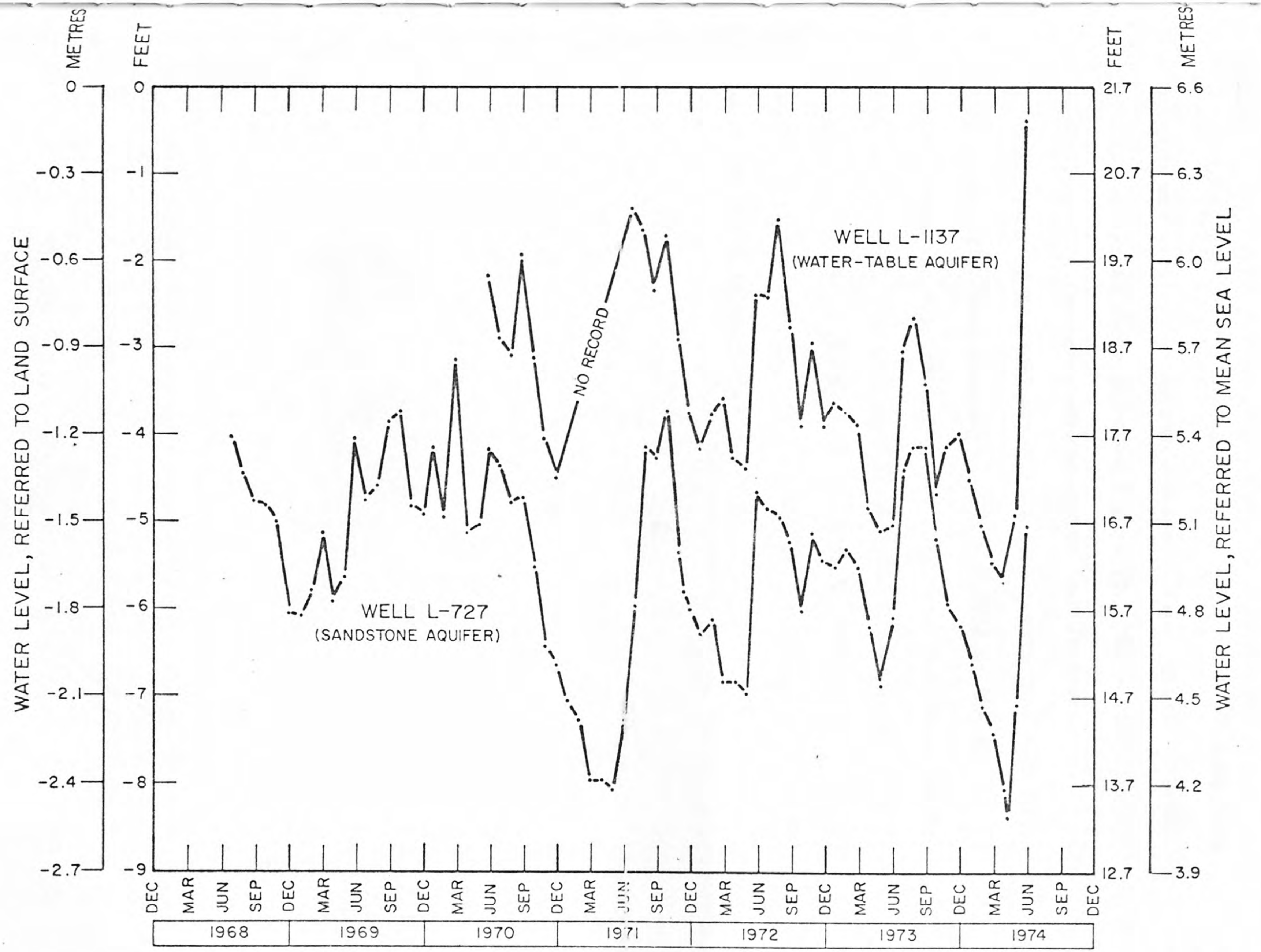

Figure 10.--Hydrographs of wells L-727 (August 1968-July 1974) and L-1137 (June 1970-July 1974).

The hydrograph for well L-414 (fig. 11) for which long-term records are available, indicates seasonal fluctuations of water levels similar to those shown on figure 10. The unusually low water levels in the early months of 1967 and 1968 were the results of heavy pumping for irrigation from well L-1056 (one-half mile to the northwest). This pumping was discontinued in the latter part of 1968 so that the fluctuations since then represent essentially natural changes. The droughts of 1971 and 1974 are reflected in the low water levels on the hydrograph in those years. The highest water level recorded in this well was 19.7 feet (6.1 metres) above mean sea level in July 1968.

Fig. 11 near here

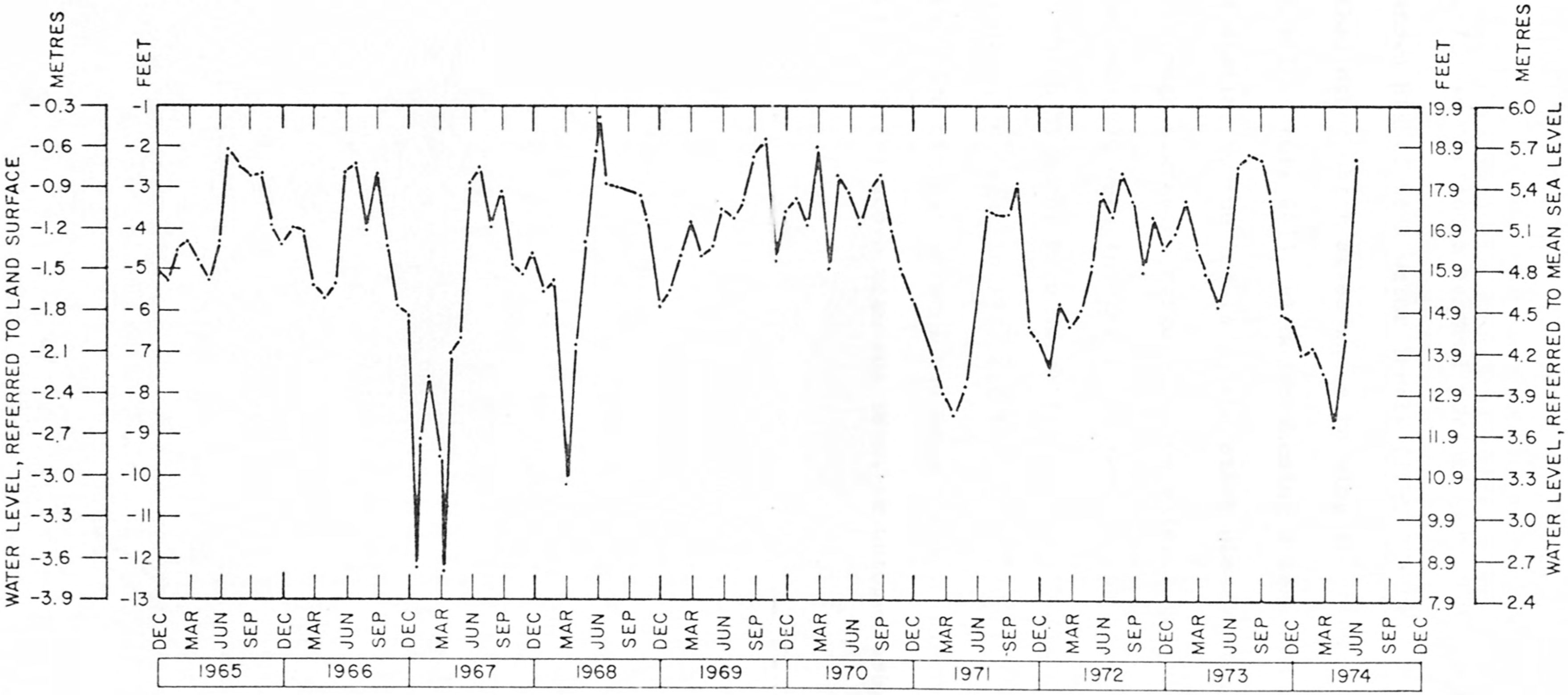

Figure 11.--Hydrograph of well L-414, January 1965-July 1974.

Well L-729 in the south central part of Lehigh Acres has consistently shown higher peak water levels (fig. 12) relative to mean sea level than other observation wells tapping the sandstone aquifer. The water level in this well, although showing a seasonal pattern of fluctuation similar to the levels in the other observation wells fluctuates through a greater range. The low water levels in the early part of 1969 and 1970 were in part the effects of pumping from wells in the area which have not been identified. As with the other wells, the effects of the drought in 1971 and 1974 are evident from the lower water levels. The highest water level recorded for this well was about 26.1 feet (8.0 metres) above mean sea level in October 1969.

Fig. 12 near here

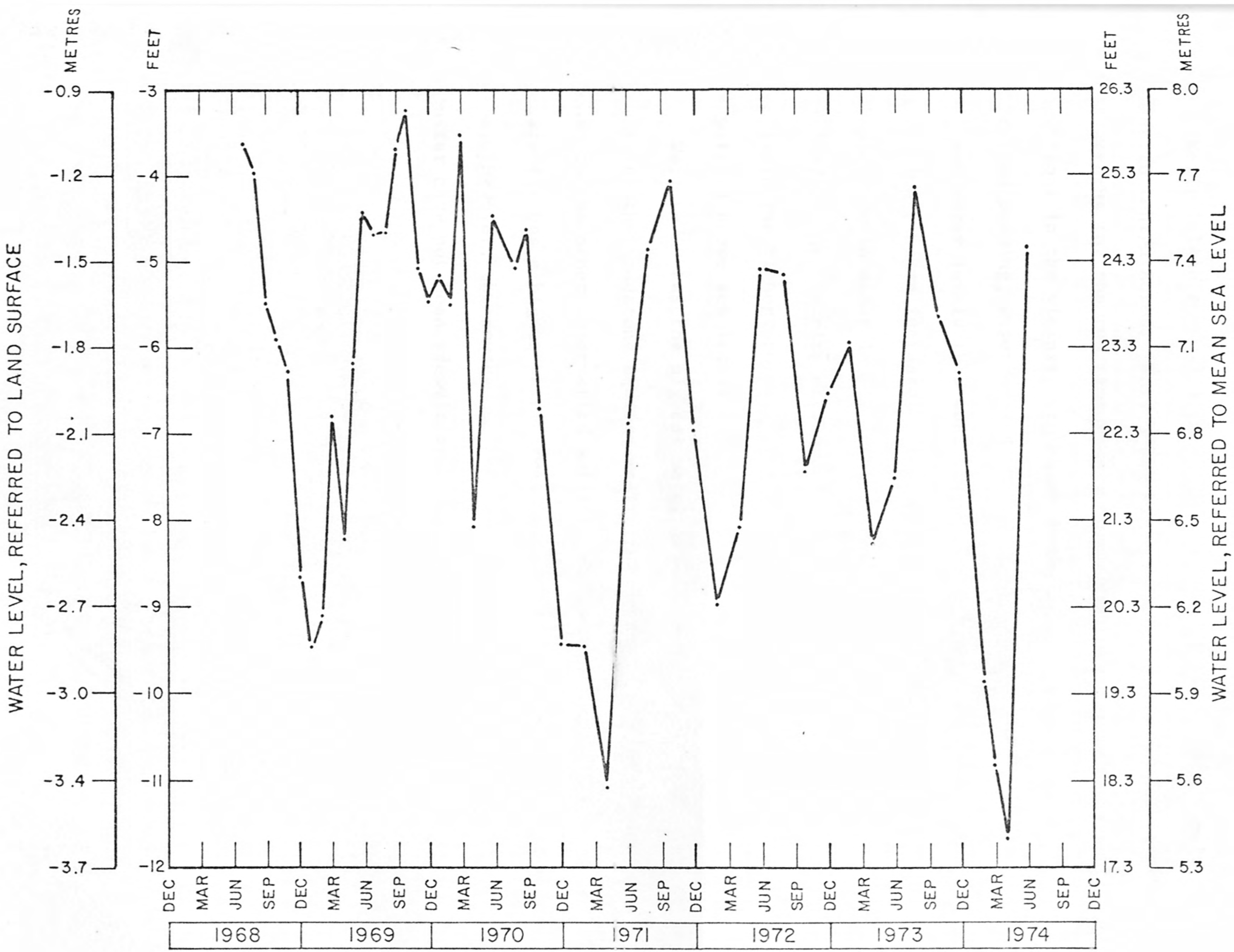

Figure 12.--Hydrograph of well L-729, August 1968-July 1974.

Wells L-1418 and L-583 (fig. 3) are near the wells that supply water to Lehigh Acres. Well L-583 was destroyed in 1971. The hydrographs for the two (fig. 13) indicate the general water-level conditions in the vicinity of Lehigh Acres' wells. The effect of sustained pumping, superimposed on the natural fluctuations results in lower water levels than would have occurred otherwise. A reduction in pumping plus an increase in recharge from rainfall can result in a rapid rise in water levels such as that which occurred in May and June 1974. Then, a rise of about 8.5 feet (2.6 metres) brought water levels to the highest point of record in well L-1418, nearly 20 feet (6 metres) above sea level.

Well L-729 has the highest water levels, referenced to mean sea level, of the sandstone aquifer wells, and levels become progressively lower in the other observation wells to the north. Well L-729 apparently has a higher water level because it is nearer the recharge area. However, the source and area of recharge to the sandstone aquifer have not been identified.

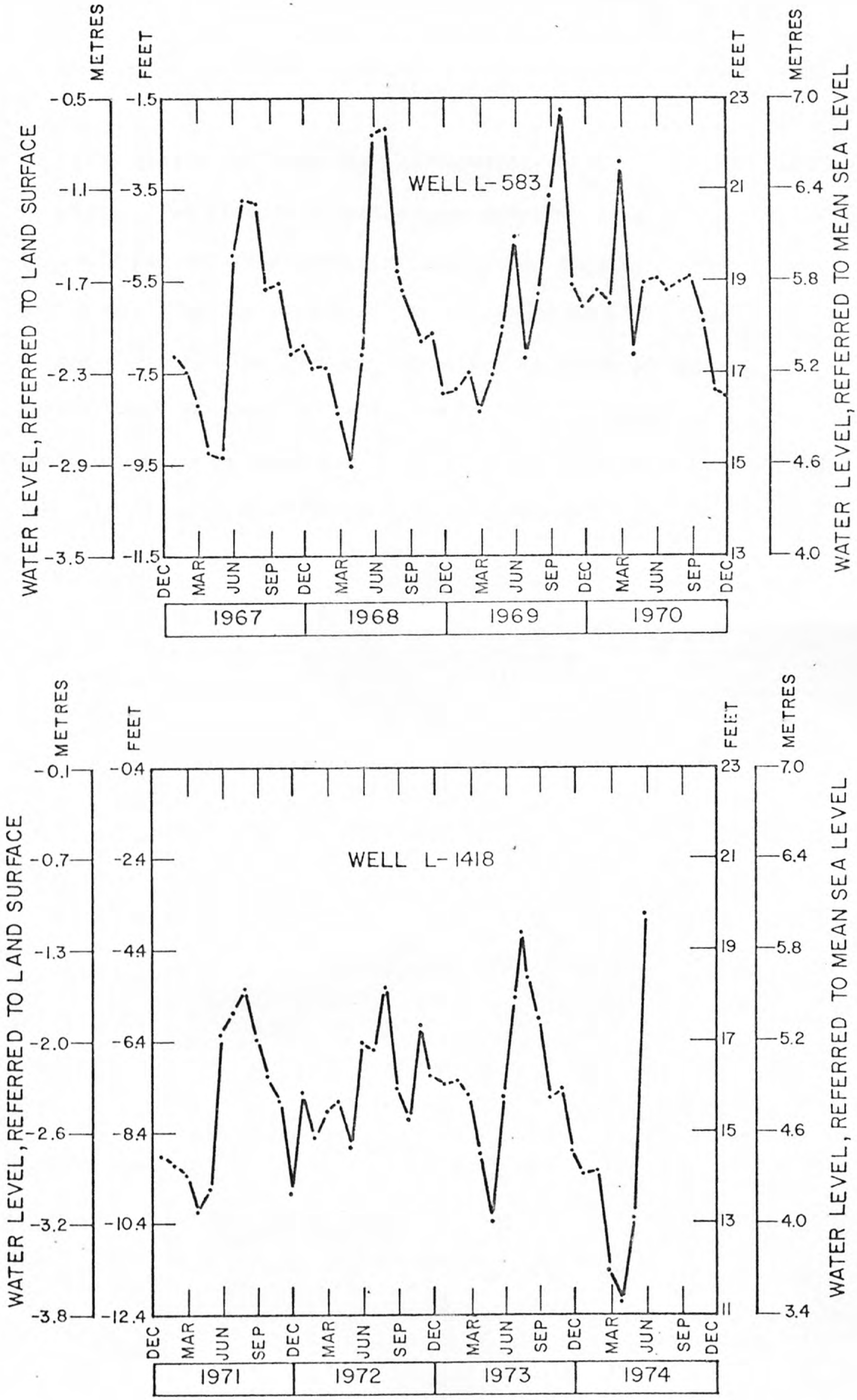

Figure 13.--Hydrographs of wells L-583 and L-1418, January 1967-July 1974.

Water Quality

The quality of water in the sandstone aquifer varies from place to place. The dissolved-solids concentration ranged from 240 to 799 mg/l and the chloride concentrations range from 45 to 208 mg/l (table 6). The water is hard averaging 296 mg/l in 7 samples typical of the aquifer. The iron concentration in three of the samples is great enough to cause staining. Otherwise the water is of relatively good quality. The sandstone aquifer usually contains more highly mineralized water than the water-table aquifer (table 6).

Lower Hawthorn and Suwannee Aquifers

Two water-bearing zones occur within the Hawthorn Formation in the western half of Lee County. The uppermost, the upper Hawthorn aquifer, is the principal source of public-water supply for Cape Coral, Pine Island, and Fort Myers Beach. This aquifer consists predominantly of limestone in the upper part of the Hawthorn Formation. Locally, upper Hawthorn sediments may yield water to wells in the report area.

The second water-bearing zone in the Hawthorn Formation, the lower Hawthorn aquifer, as defined by Sproul and others (1972, p. 9), includes the lower part of the Hawthorn Formation and the upper part of the Tampa Limestone. This artesian limestone aquifer is confined above and below by clay and marly limestone.

The Suwannee aquifer consists predominantly of tan limestone, or sandy limestone in the upper part of the Suwannee Limestone. Most likely, permeable beds in the lower part of the Tampa Limestone form part of the aquifer. Relatively impermeable beds above and below separate the Suwannee aquifer from the lower Hawthorn and those occurring at greater depths.

Because of lack of information on the lower Hawthorn and Suwannee aquifers in the report area, the characteristics of the individual aquifers can not be described. Therefore, they are combined in the following description of hydrologic and water quality parameters.

Wells tapping the lower Hawthorn and Suwannee aquifers range in depth from 440 to 850 feet (135 to 262 metres) (table 4). Most wells drilled to depths greater than 700 feet (215 metres), tap both aquifers. Average casing length of the nine wells for which casing lengths are known (table 4), is 214 feet (66 metres) which is about average for other wells tapping these aquifers in Lee County. The discharge by natural flow from wells tapping the lower Hawthorn and Suwannee aquifers in the area ranged from about 40 to 500 gallons per minute (3 to 30 litres per second).

Historically, water from the lower Hawthorn and Suwannee aquifers has been used primarily for irrigation of citrus groves, pasture lands, and truck crops. Most of the wells tapping these deeper aquifers are in northern part of the report area.

Fluctuations of Water Levels

Two observation wells, L-652 and L-706, tapping the lower Hawthorn aquifer are located in the report area (see fig. 4). In both, the artesian pressure is above land surface, to a maximum height of about 40 feet (12 metres) in well L-652 and about 30 feet (9 metres) in well L-706 (figs. 14-15). This is equivalent in altitude to about 47 feet (14 metres) in well L-652 and about 51 feet (16 metres) in well L-706. Levels in both wells fluctuate annually; the range of fluctuation for well L-652 is somewhat greater than for well L-706. This probably is the result of larger withdrawals from the aquifer in the vicinity of well L-652. Drought resulted in abnormally low water levels in the spring of 1971 and 1974.

Fig. 14-15 near here

As shown by Boggess (1974, p. 23) the artesian head of the lower Hawthorn and Suwannee aquifers is highest in the northeast part of Lee County and becomes progressively lower toward the coast. Thus, it is concluded that the general direction of water movement in these aquifers is to the southwest. The lower Hawthorn and Suwannee aquifers probably are recharged in the central highlands part of the state to the northeast from Lee County.

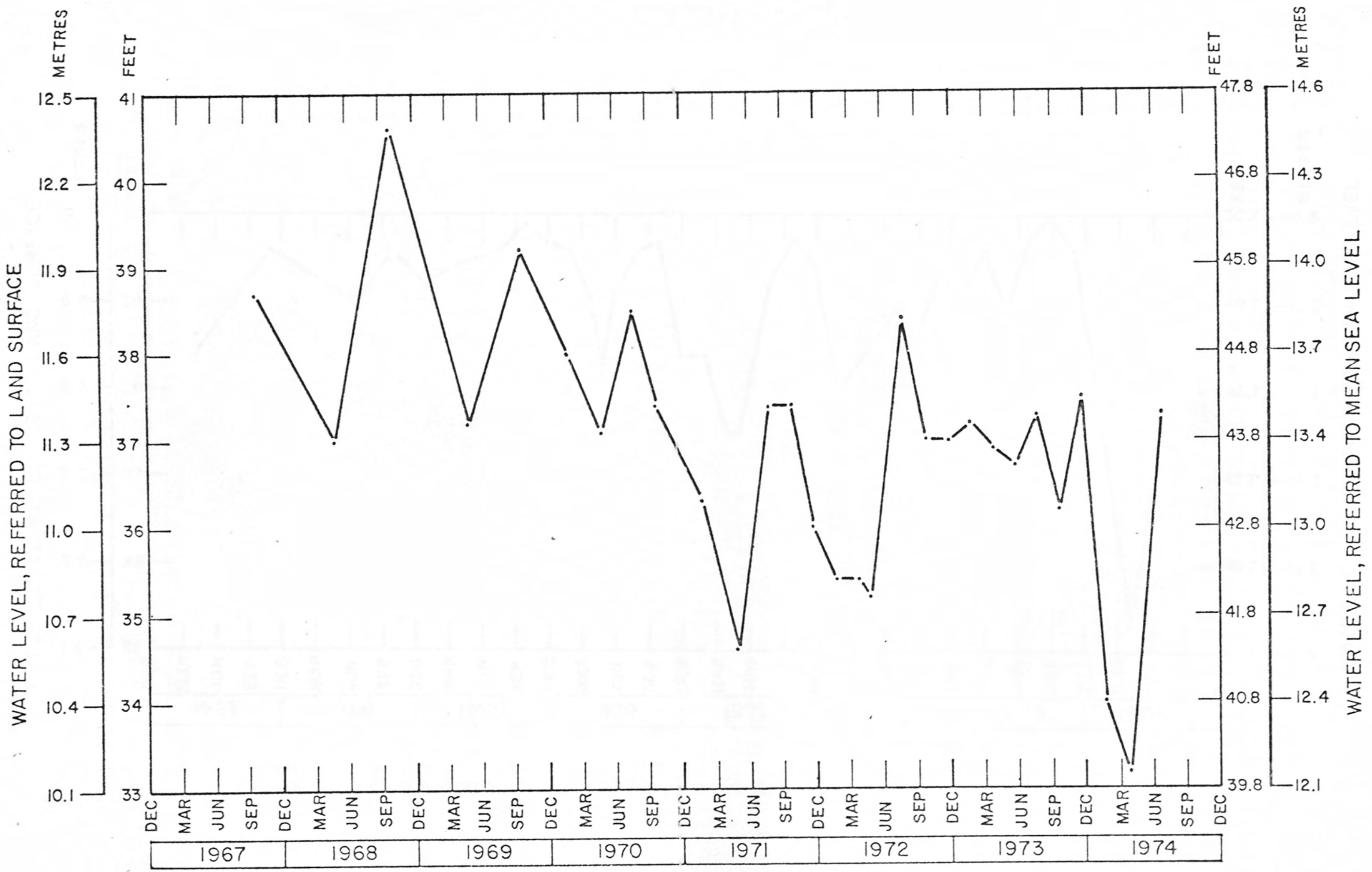

Figure 14.--Hydrograph of well L-652, April 1967 to July 1974.

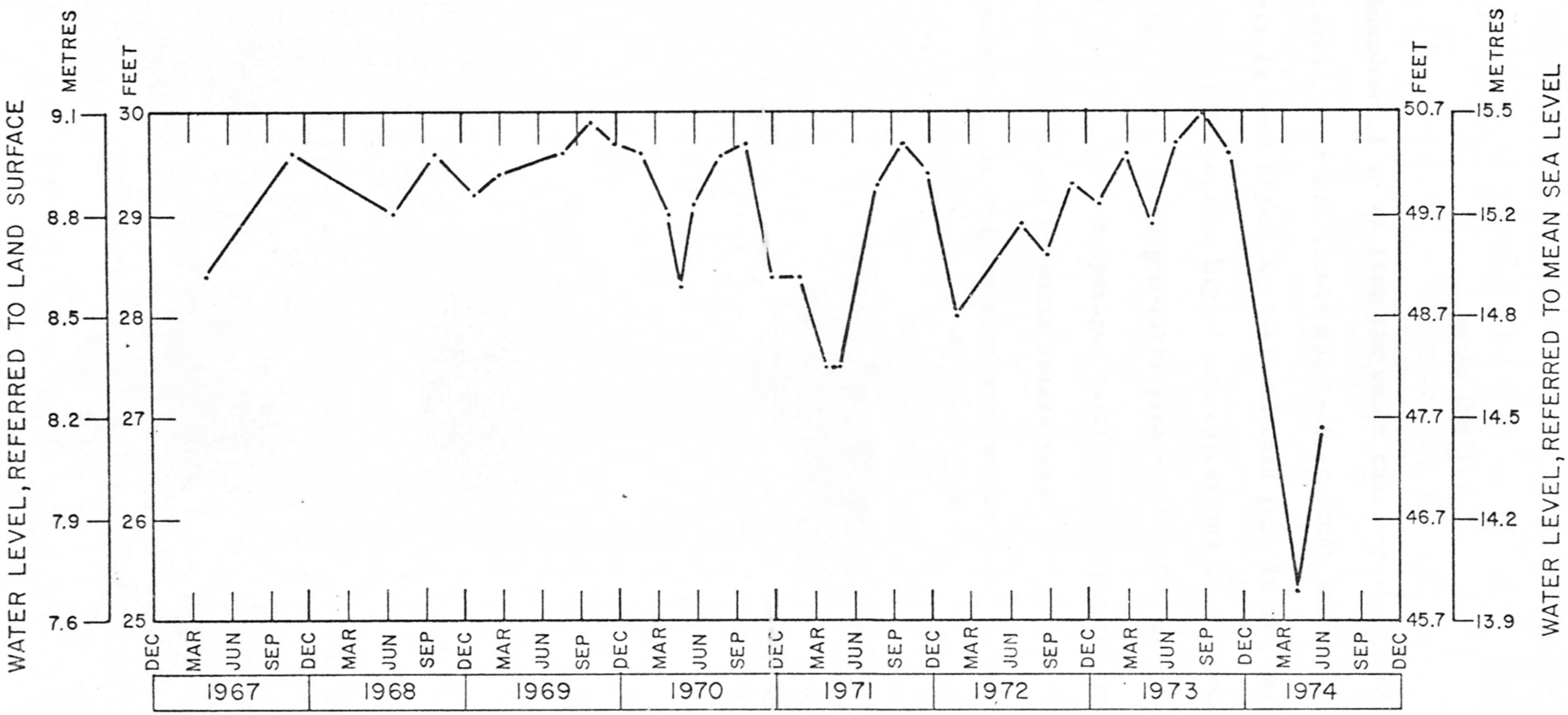

Figure 15.--Hydrograph of well L-706, April 1967 to July 1974.

Water Quality

Analyses of water from six wells that tap the lower Hawthorn and Suwannee aquifers (table 6), indicate that the water in these aquifers is more highly mineralized than that in the shallower aquifers. The chief difference is higher concentrations of sodium, sulfate, and chloride. Hardness is generally greater than 500 mg/l and the water has an odor typical of hydrogen sulfide. Because of the high dissolved-solids concentration of their waters (usually in excess of 1,000 mg/l), the lower Hawthorn and Suwannee aquifers are classified as saline-water aquifers.

SURFACE WATER

Three natural streams, the Orange River, Hickey Creek and Bedman Creek, drain most of the report area. Each of these streams discharge into the Caloosahatchee River. Since 1958, more than 150 miles (241 kilometres) of drains (canals) have been constructed by the East County Water Control District. These drains are connected to the natural streams. Figure 16 shows the location of the drains, surface-water sampling sites, and other monitoring stations.

Fig. 16 near here

Topographic maps define numerous shallow basins in the report area. Many of these basins contained water when these maps were prepared. The largest of the basins, Halfway Pond, is in the southern part of the report area. A small circular pond, Leeland Lake (fig. 16), is a sink-hole, the only one known in Lee County. This lake has been sounded to a depth of 208 feet (64 metres).

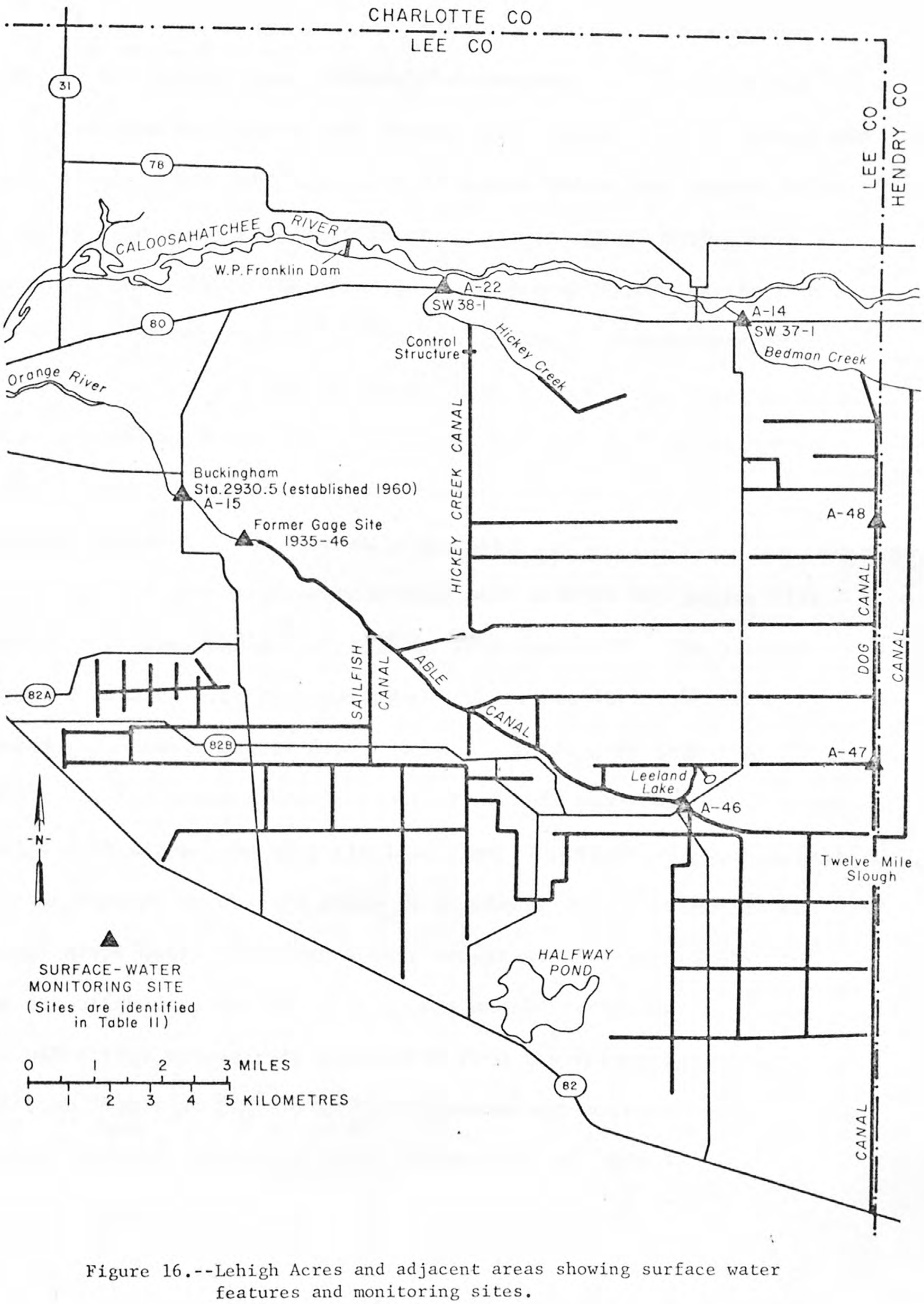

Figure 16.--Lehigh Acres and adjacent areas showing surface water features and monitoring sites.

Orange River

Orange River is the largest tributary to the Caloosahatchee River in the report area. Before the construction of canals the natural headwaters area of the Orange River was Twelvemile Slough and the drainage basin area was about 83 square miles (216 square kilometres). Since the construction of canals in Lehigh Acres, some change in the size of the drainage basin has occurred. Water from the former headwaters area in Twelvemile Slough is now diverted into drainage canals along the Lee-Hendry County line which discharge northward into Bedman Creek. The area involved in the change is upstream from a former stream gaging site located about 1. 5 miles (2.4 kilometres) southeast of Buckingham (fig. 16).

Stage and discharge measurements were made at the gaging site southeast of Buckingham from 1935 to 1946 (table 7). The average annual discharge over this period of record was 41.1 cubic feet per second (11.6 cubic metres per second). According to Kenner and Brown, 1956 p. 8, the average yearly runoff from this basin was 7.83 inches (198.9 millimetres) or slightly less than 15 percent of the rainfall.

Table 7 near here

No further records on stage or discharge were obtained on the Orange River until 1960 when a crest-stage partial record station was established at the existing bridge on the Buckingham Road about 1.2 miles (1.9 kilometres) downstream from the former gaging site. (Station 2930.5 on fig. 16). Miscellaneous measurements made at this station between 1960 and 1974 are summarized in table 8.

Table 8 near her

Table 7.--Monthly and yearly mean discharge from the Orange River near Buckingham, 1936-46.
(Discharge in cubic feet per second).

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1936	3.76	45.8	5.87	.04	.02	767	181	39.2	29.8	49.8	2.27	.044	92.8
1937	.022	.029	1.22	13.6	18.5	63.9	145	198	101	24.1	6.27	.727	48.0
1938	.433	.024	.010	.001	0	36.5	162	59.4	18.6	25.2	1.84	.020	25.3
1939	.020	.020	.007	18.0	6.14	242	173	278	172	17.8	3.95	.961	76.3
1940	10.8	31.0	11.8	9.76	.005	2.73	37.6	121	319	8.30	.055	.126	45.8
1941	8.65	46.9	25.0	96.1	4.63	34.4	232	46.8	159	14.8	2.74	.339	55.8
1942	9.10	2.52	5.65	29.8	1.86	31.2	23.9	16.2	94.3	4.72	.584	.410	18.3
1943	.360	.182	.058	1.05	5.60	119	250	50.1	73.0	68.5	8.00	3.92	48.6
1944	4.07	3.26	3.14	3.62	6.74	9.61	38.7	106	14.3	19.8	3.07	2.75	18.1
1945	3.07	1.35	.570	.174	.621	63.4	299	86.6	73.9	60.5	11.6	2.13	50.8
1946	1.32	.850	1.48	.090	1.98	7.67	27.8	134	60.3	34.2			

Table 8.--Miscellaneous stage and discharge records for the Orange River, 1960-74.
(Water stage in feet referenced to mean sea level)

Date	Water stage	Crest Stage /1	Discharge (cubic feet per second)
Sept. 11, 1960		8.50	1,630
Aug. 27, 1961		4.36	427
Sept. 21, 1962		9.65	2,180
Sept. 24, 1963		4.76	546
Sept. 6, 1964		4.64	529
Oct. 22, 1965		3.04	468
Sept. 9, 1966		3.31 (Hurricane tide)	
Aug. 16, 1967		3.29	490
July 9, 1968		5.93	1,000
June 19, 1972	4.94	4.94	395
Aug. 3, 1972	1.10		112
Apr. 6, 1973		3.21	
Sept. 12, 1973	1.60		275 Estimated
Jan. 29, 1974	0.29		
Feb. 27, 1974	-0.92		
Mar. 28, 1974	-1.21		
Apr. 30, 1974	-1.41		
June 26, 1974	4.78	6.78	818
June 27, 1974	4.92		

/1 Before 1968 the crest stage listed probably occurred on the date shown; after 1968 only the dates of inspection are shown and the crest stage listed occurred at some time between inspections.

During 1935-46 discharge from the Orange River equalled or exceeded 40 cubic feet per second (1 cubic metre per second) 20 percent of the time (fig. 17) and equalled or exceeded about 650 cubic feet per second (16 cubic metres per second) 1 percent of the time. Discharge of less than 3 cubic feet per second (0.1 cubic metre per second) has occurred for as long as 6.5 consecutive months (fig. 18).

Fig. 17 near here

Fig. 18 near here

The highest recorded discharge from the Orange River was 5,300 cubic feet per second (150 cubic metres per second) on June 15, 1936 with a corresponding stream stage of 15.11 feet (4.61 metres) above mean sea level. This is well above any of the recorded crest-stage measurements shown in table 8.

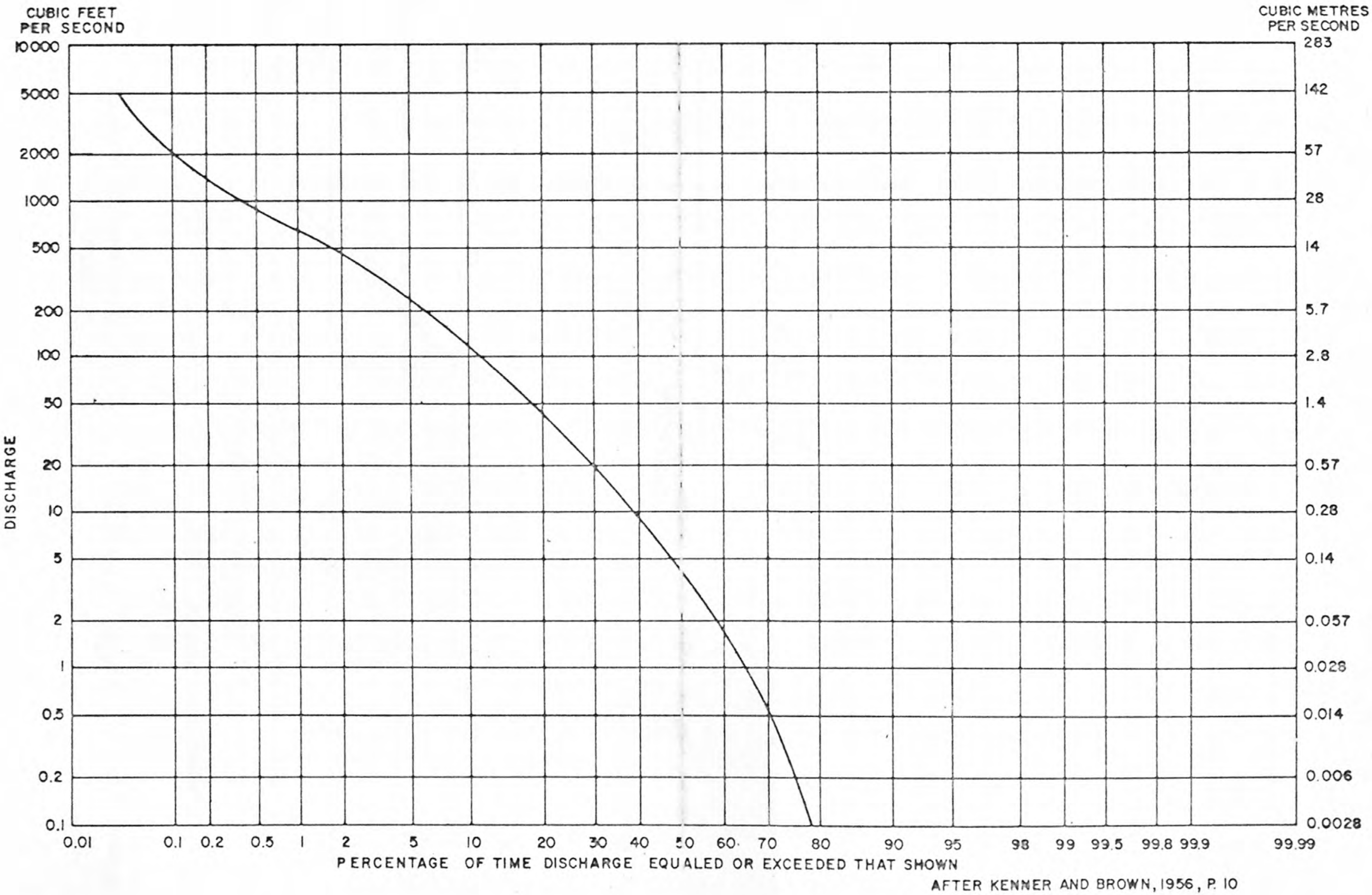

Figure 17.--Flow duration curve for Orange River, 1935-46.

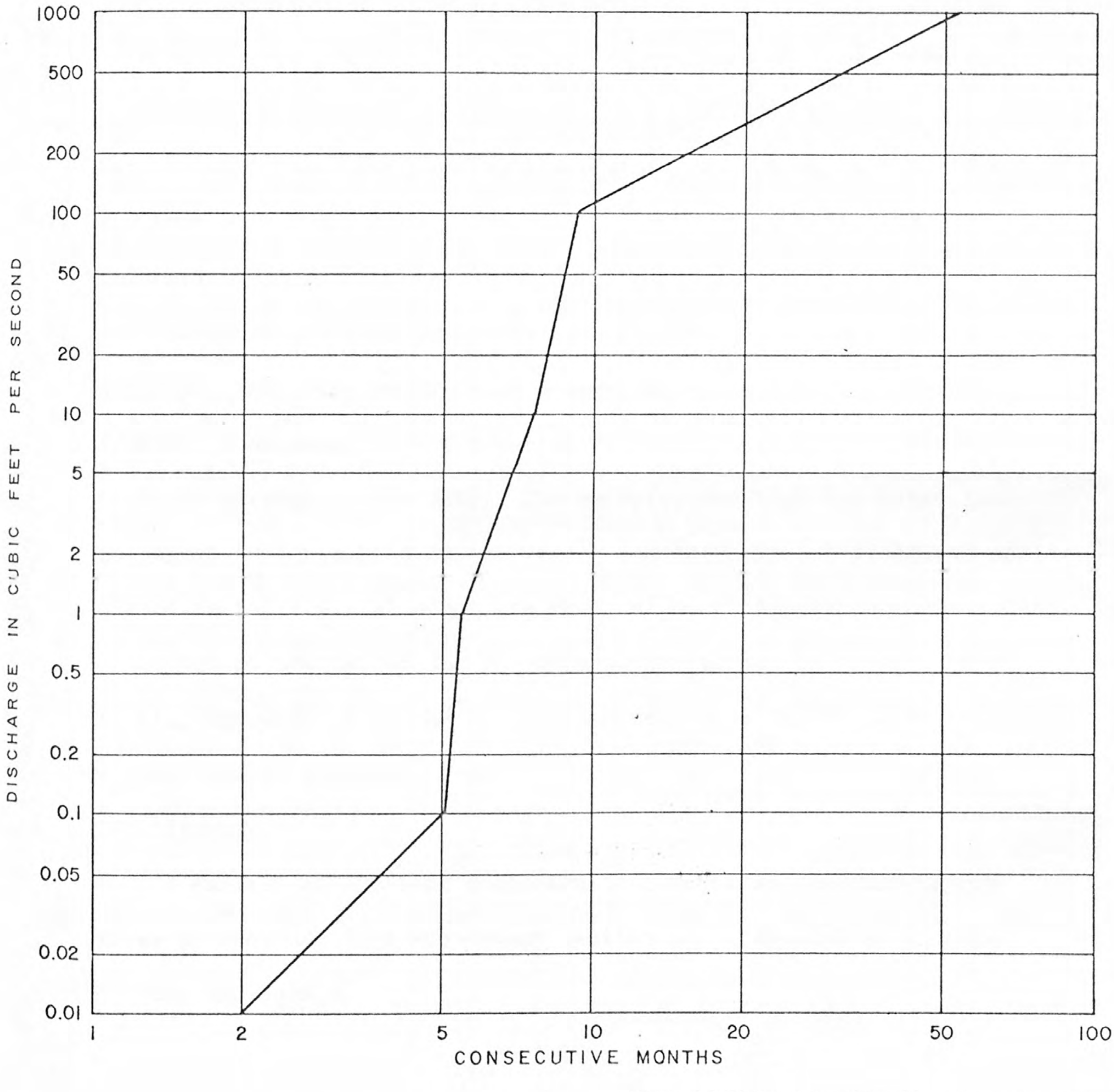

Figure 18.--Maximum period of deficient discharge for the Orange River, 1935-46.

Water Quality

Analyses of water collected from Orange River in 1939-70 are shown on table 9. The point of sample collection from 1939 to 1945 is about 1.2 miles (1.9 kilometres) upstream from the point where samples were collected during 1963-70. Tidal effects have been noted at the lower station which may account for the higher concentrations of sodium, potassium, sulfate, and chloride in samples collected there.

Table 9 near here

Generally, the water in the Orange River is of good chemical quality. Most samples of table 9 were collected during the dry season. A seasonal effect probably would be noted if samples were obtained throughout the year. For example, the high discharge rate in August 1944 resulted in the lowest concentration of dissolved solids listed in table 9. Although the chemical constituents in the samples collected do not exceed the recommended limits for drinking water, locally the water from the river is not suitable for drinking purposes without proper treatment because of other chemical and biological constituents.

A summary of nutrient concentrations in water from the Orange River is included in a subsequent section on water quality in other streams and canals.

Table 9.--Chemical analyses of water from the Orange River near Buckingham, 1939-70.
(Chemical constituents in milligrams per liter)

Date of Collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Bicarbonate (HCO_3)	Nitrate (NO_3)	Phosphate (PO_4)	Hardness as $CaCO_3$: Calcium-Magnesium	Hardness as $CaCO_3$: Non-Carbonate	Dissolved Solids: Residue at 180°C	Dissolved Solids: Calculated	Specific conductance (micro-mhos at 25°C)	pH	Color (plat.-cobalt units)
12-16-39			0.08	93	20	27		18	47		351			314			378	684		
2-3-44	4.2			82	14	7.1		13	35		262	0.2		262			280	574	7.9	37
4-6-44	4.2								38											
5-5-44	3.6			84	13	16		14	37		277	.6		263			301	662	7.6	38
8-22-44	38			36	5.5	4.6		5	16		116	.1		112			124	245	7.0	70
1-10-45	5.0								36									535		
5-3-45	.01								40									361		
11-18-63		6.5	.02	102	16	43	2.0	64	74		269	1.6		304	100		442	730	7.9	50
1-16-64		8.3	.02	101	12	43	1.5	57	77		268	.0		303	84		432	715	7.7	70
3-25-64		8.7	.01	96	22	50	1.4	63	90	0.3	274	.0		330	106	532		783	8.1	35
4-7-64		9.7	.19	98	15	54	1.4	64	95	.2	245	.1		307	106	538		783	8.5	45
5-16-66	21	8.4		97	14	56	1.6	58	98	.2	262	.7	0.11	300	85		463	890	8.2	40
5-11-67				94	16	59	1.0		110	.3	258							878	8.0	45
5-14-68		8.7	.23	96	15	54	2.0	70	115	.3	242	1.2	.30	302	103	539	482	822	7.7	50
5-18-70				90	11	28	1.2	42	46	.4	272			270	47	418	358	640	8.1	

Other Streams and Canals

Beginning in 1972, stream stage data (table 10) were obtained for Bedman Creek (SW 37-1) and Hickey Creek (SW 38-1) (fig. 16) either through direct readings or from crest-stage gages. Table 10 near here

The water stage in both Bedman and Hickey Creeks are controlled in part by the stage of the Caloosahatchee River upstream from the W. P. Franklin Dam which usually is maintained at about 3 feet (1 metre) above mean sea level. The water stage in Hickey Creek at gage SW 38-1 also is affected by the operation of a water control structure on Hickey Creek Canal.

During the period of record the highest observed stage in Bedman Creek was 5.81 feet (1.97 metres) above mean sea level, on June 19, 1972. The crest-stage gage indicated a previous higher level of 7.06 feet (2.18 metres) above mean sea level, which probably occurred earlier in June. A comparable high water stage did not occur at the gage site on Hickey Creek during June 1972 apparently as a result of the controlled release of water through Hickey Creek Canal.

Heavy rainfall of nearly 23 inches (580 millimetres) over Lehigh Acres in May-June 1974, resulted in a rise in stream stage throughout the area. The highest stage of Bedman Creek in June 1974 was several feet lower than previously recorded in June 1972. However, the highest stages recorded for Hickey Creek were in June 1974.

Table 10.--Stage records at Bedman Creek (SW 37-1) and Hickey Creek (SW 38-1), 1972-74.
(Water stage in feet referred to mean sea level)

SW 37-1	Water stage	Crest stage /1
June 19, 1972	5.81	7.06
Nov. 13, 1973	3.10	
Jan. 29, 1974	3.09	
Feb. 26, 1974	2.96	
Mar. 27, 1974	2.90	
Apr. 29, 1974	2.93	
June 27, 1974	4.36	4.37
SW 38-1		
June 19, 1972	3.09	
Nov. 13, 1973	3.15	
Jan. 28, 1974	3.14	
Feb. 26, 1974	3.04	
Mar. 28, 1974	2.89	
Apr. 30, 1974	2.84	
June 27, 1974	3.67	4.76

/1 Crest stage occurred at some time prior to date shown.

Water Quality

Nutrient concentrations were determined at six stream or canal sites in the report area as part of a regional sampling network and the analyses are listed in table 11. These sites are A-14 (Bedman Creek), A-15 (Orange River), A-22 (Hickey Creek), A-46 (Able Canal), and A-47 and A-48 (Dog Canal) (fig. 16). table 11 near here

The analyses of 1973 and 1974 (table 11) show that concentrations of phosphorus (PO_4-P), and ammonia nitrogen (NH_4-N) were higher in water from Dog Canal than from Bedman Creek. Conversely, for the same sampling dates Bedman Creek contained higher concentrations of nitrate nitrogen (NO_3-N) than Dog Canal.

The 1973 and 1974 analyses also show that water from the Orange River contained higher concentrations of phosphorus (PO_4-P) and nitrate nitrogen (NO_3-N) and lower concentrations of ammonia nitrogen (NH_4-N) than from Able Canal. The analysis of September 12, 1973 for Orange River may be anomalous. All streams analyzed were uniformly low in nitrite nitrogen (NO_2-N). Generally, the nutrient data do not accurately define the nutrient content throughout the entire stream systems or the range of concentration in nutrient content because of the small number of sampling sites and the frequency of sampling.

Table 11.--Nutrient concentrations in streams and canals in Lehigh Acres and adjacent areas, 1971-74.
(Analyses in milligrams per litre)

Station No.	Date	Phosphate (PO_4) as Phosphorus (P)	Ammonia (NH_4) as Nitrogen (N)	Nitrite (NO_2) as Nitrogen (N)	Nitrate (NO_3) as Nitrogen (N)
A-14 (Bedman Creek)	3-2-71	0.003	0.03	0.00	0.02
	9-20-71	.000	.03	.00	.02
	3-13-72	.000	.03	.000	.01
	1-17-73	.000	.06	.000	.04
	9-12-73	.000	.15	.000	.05
	1-14-74	.000	.06	.00	.08
A-15 (Orange River)	3-2-71	.108	.07	.00	.03
	9-20-71	.065	.03	.00	.04
	3-13-72	.000	.00	.000	.01
	1-17-73	.120	.08	.004	.04
	9-12-73	.040	1.2	.000	.02
	1-14-74	.010	.08	.00	.05
A-22 (Hickey Creek)	3-2-71	.013	.03	.00	.00
	9-20-71	.007	.03	.00	.01
	3-13-72	.000	.02	.000	.00
	1-17-73	.039	.06	.000	.07
	9-12-73	.012	.10	.000	.01
	1-14-74	.010	.07	.00	.01
A-46 (Able Canal)	1-17-73	.000	.03	.000	.07
	9-12-73	.006	.10	.000	.08
	1-14-74	.010	.16	.00	.10
A-47 (Dog Canal)	1-17-73	.028	.47	.000	.00
	9-12-73	.005	.20	.000	.00
	1-14-74	.020	.35	.00	.02
A-48 (Dog Canal)	1-17-73	.000	.06	.000	.00
	9-12-73	.003	.14	.000	.00
	1-14-74	.010	.27	.00	.02

Lakes and Ponds

Prior to development, numerous shallow basins were present throughout Lehigh Acres and adjacent areas. Nearly all of these basins contained water during the wet season. During very wet years, interbasin areas probably were flooded. Many of the basins probably contained water throughout the dry season of wet years. During extended periods of deficient rainfall, most basins were dry.

Water levels in nearly all of the ponds and lakes and in most reaches of streams and canals are coincident with and reflect the level of the water table. Thus, the water-table aquifer and the surface-water bodies are interdependent. Recharge or discharge factors which affect one also effect the other and water can move readily from the surface-water bodies to the aquifer or from the aquifer to the surface-water bodies.

After construction of the network of drainage canals in Lehigh Acres, most of the shallow basins were either filled with material excavated from the canals or were drained as the water table was lowered.

Halfway Pond

Halfway Pond (fig. 16) is the largest shallow natural pond in Lehigh Acres. Occurring in the area where the land is at highest altitudes, the base of the pond is about 26 feet (8 metres) above mean sea level at its deepest point (written commun., 1974, J. A. Ruth, Gee and Jenson, Consulting Engineers, Inc.). When completely full, the pond surface probably is about 30 feet (9 metres) above mean sea level.

During the 1973-74 dry season (October 1973-May 1974), the water level in Halfway Pond apparently declined about 5 feet (1.5 metres). By April 1974 the pond was almost dry. The water level in well L-730 (fig. 8) also declined about 5 feet (1.5 metres), from September 1973 into June 1974. The heavy rainfall in May and June 1974 caused the water level in Halfway Pond to recover to earlier levels and the water level in well L-730 to rise nearly 7 feet (3.1 metres).

Leeland Lake

Leeland Lake, formerly called Still Lake, is a funnel-shaped, nearly circular sink (fig. 16). It is the only known sinkhole lake in Lee County. In May 1943, the lake was sounded to a depth of 208 feet (64 metres) and was about 600 feet (185 metres) in diameter. Aerial photographs show that in April 1972 the diameter of the lake was only about 420 feet (130 metres). The decrease in diameter reflects a lower lake level.

Miscellaneous measurements of the lake stage indicate a seasonal range in fluctuation similar to the water table. Between October 30, 1969 and April 29, 1971, the lake stage declined about 5.6 feet (1.7 metres). Records for well L-728 (water-table aquifer) show a water-level decline of 4.9 feet (1.5 metres) over the same period. Between April 29 and June 28, 1974 the lake level rose about 6.2 feet (1.9 metres) and the water level in well L-1137 (water-table aquifer) rose 5.3 feet (1.6 metres) as a result of heavy rainfall in May and June.

The water in Leeland Lake is of good quality (table 12). The water is more nearly similar to water from the sandstone aquifer than from the water-table aquifer. The concentrations of most chemical constituents were higher in 1974 than in 1943, the greatest increase occurring in the sulfate concentration.

Table 12 near here

Table 12.--Chemical analyses of water from Leeland Lake.
(Chemical constituents in milligrams per litre)

	May 11, 1943 /1	Feb. 13, 1974
Silica (SiO_2)	6.7	9
Iron (Fe)	.03	.11
Calcium (Ca)	52	77
Magnesium (Mg)	9.9	22
Sodium (Na)	30	53
Potassium (K)	1.4	4.2
Bicarbonate (HCO_3)	192	165
Sulfate (SO_4)	6.3	120
Chloride (Cl)	52	93
Fluoride (F)	0.1	0.2
Dissolved solids	253	460
Hardness as $CaCO_3$		
Calcium-magnesium	170	280
Non-carbonate		150
Specific conductance		814
pH	7.1	7.1
Color	22	10

/1 Kenner and Brown, 1956, p. 68

Leeland Lake, because of its depth, could be hydraulically connected to both the water-table and sandstone aquifers. At the lake, the water-table aquifer probably extends to a depth of about 20 feet (6 metres) and the sandstone aquifer probably occurs between 60 and 120 feet (18 and 37 metres) below land surface.

Inasmuch as the water level in the water-table aquifer is several feet higher than the water level in the sandstone aquifer, water should move from the water-table aquifer into the lake and from the lake to the sandstone aquifer. The available evidence, however, indicates a lack of such movement. Temperature measurements made on May 11, 1943 showed a general decrease in temperature from 22°C (72°F) at 18 feet (5.5 metres) beneath the surface to 20°C (68°F) at a depth of 165 feet (51 metres). The distribution of chloride concentrations, ranging from 51 to 55 mg/l through the same depth interval, was relatively uniform. Measurements made on October 17, 1973 indicated the same general conditions as earlier, but a greater difference in temperatures with a decrease from 28°C (83°F) at a depth of 15 feet (4.6 metres) to 20.5°C (68°F) at a depth of 150 feet (46 metres).

EFFECTS OF CANAL CONSTRUCTION ON GROUND-WATER LEVELS

As previously described, the water levels in nearly all of the lakes and ponds and in most reaches of streams and canals in Lehigh Acres are directly coincident with the water table. This indicates that the water-table aquifer and the surface-water bodies are hydraulically connected and interdependent. Thus, recharge or discharge factors which affect one, also affect the other.

Numerous canals have been constructed in Lehigh Acres to drain the area. These canals perform two basic functions: (1) they provide a means for the rapid removal of water from the land surface and (2) they provide a means of removing water from the subsurface, from the water-table aquifer. This latter function is the subject of discussion in this section.

To demonstrate the possible effects of a major drainage canal on ground-water levels, a mathematical model was constructed by L. F. Land (U. S. Geol. Survey, Miami, written commun., 1974), based on the solution to a bank storage equation developed by Glover (1953). For a hydraulically connected surface- and ground-water system in equilibrium, the equation provides a solution for the position of the water table after the stage in a canal, river, or reservoir has been abruptly lowered.

For this model to apply correctly to a specific surface- and ground-water system, transmissivity, storage coefficient, aquifer thickness, and amount of water-table lowering at the canal must be accurately determined. Because aquifer characteristics are poorly defined for much of the Lehigh Acres area, application of the model to that area produced results that must be considered only as approximations. For purpose of analysis parameters for the Lehigh Acres area were estimated as follows: transmissivity, 20,000 gallons per day per foot (284 cubic metres per day per metre); storage coefficient, 0.15; aquifer thickness, 20 feet (6 metres); lowering of the water level at the canal, 10 feet (3 metres) below historic average.

Using these data, a family of drawdown curves was developed and these are shown on figure 19.

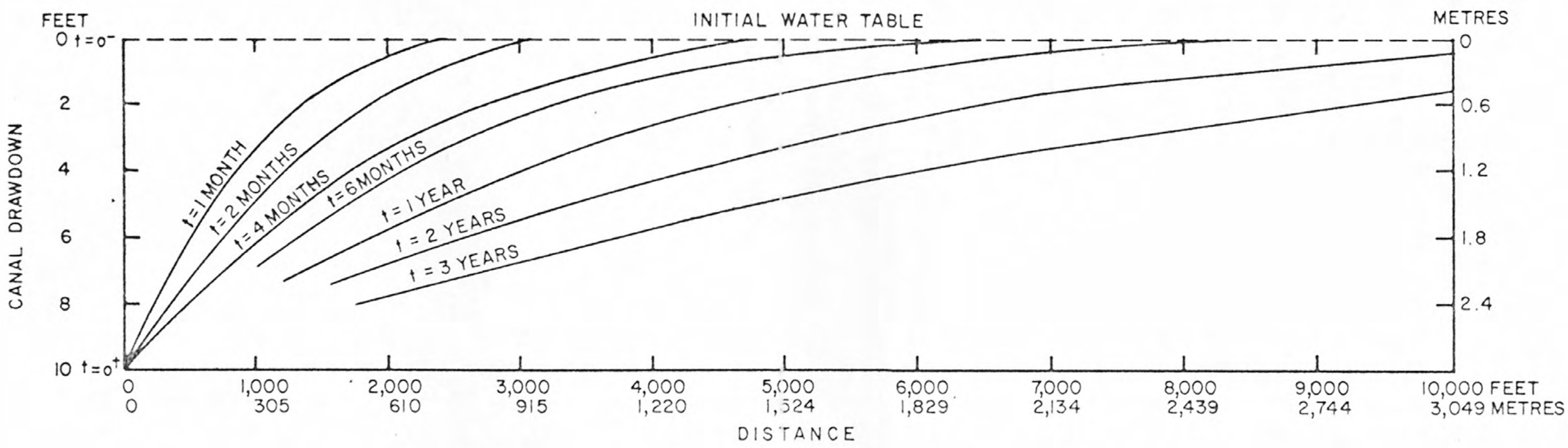

Figure 19.--Theoretical drawdown curves for a major canal in Lehigh Acres.

Each of the curves of figure 19 refers to a specific elapsed time. For example, a canal with an initial drawdown of 10 feet (3 metres), will in 2 months cause a lowering of the water table of about 5 feet (1.5 metres) at a distance of 1,000 feet (308 metres). In 4 months, the water table would be lowered about 1 foot (0.3 metres) at a distance of 3,500 feet (1,080 metres). This analysis assumes no recharge to the aquifer. According to Land (1974) "the water table probably builds up to a profile nearly equivalent to t=1 month during the rainy season and then decays to the t=6 months profile or slightly less by the end of the dry season. Using this hypothesis the canal would influence the water table for a distance of about 6,000 feet."

The curves may not represent existing conditions at any given locality in Lehigh Acres and provide no real information on the actual lowering of ground-water levels from canal construction in the area. They merely demonstrate the general profile or slope of the water table perpendicular to a canal draining the shallow aquifer and the magnitude of the distance that could be affected by a canal. They do not reflect the water table profile where two or more canals are present in the distance indicated on the figure.

FUTURE INVESTIGATIONS

As mentioned earlier in this report, only a summary of existing geologic and hydrologic data is presented. These data are not adequate to provide the background necessary to design programs for "optimum" management, control, and conservation of the available water resources. Geologic information is available for only a few deep (more than 500 feet or 150 metres) wells. The information is adequate for only a generalized understanding of the ground-water systems of Lehigh Acres. Too few water-level measurements (in wells) are available to prepare a potentiometric surface map from which hydraulic gradients in the aquifer and the direction of water movement can be determined. Specifically information is needed to define the source and area of recharge to the sandstone aquifer, to determine the hydraulic characteristics of the aquifers, the ground-water - surface-water relations with particular regard to the canals and to better define the chemical quality of water. Some of the information could be obtained as listed below:

1. A test drilling program would provide detailed information concerning the position, thickness, and other physical parameters of the sandstone aquifer and the position and thickness, of its confining layers.

2. A network of observation wells would provide at least part of the information needed to determine aquifer characteristics, to quantify recharge and discharge rates, and to delineate the areas where recharge occurs. Most of the wells of the network would have to be installed.

3. A network of water-quality monitoring sites for both ground-water and surface-water data points would provide a basis for evaluating seasonal changes in quality, and also the effects of base flow on streams and canals.

4. Stream discharge measurements at sites on the Orange River, Hickey Creek, and Bedman Creek and stage or crest stage gages on other streams would provide streamflow data needed for an evaluation of the quantity of water that could be salvaged for use.

The location of test holes, gaging sites and water-quality monitoring sites needed are shown on figure 20. Fig. 20 near here

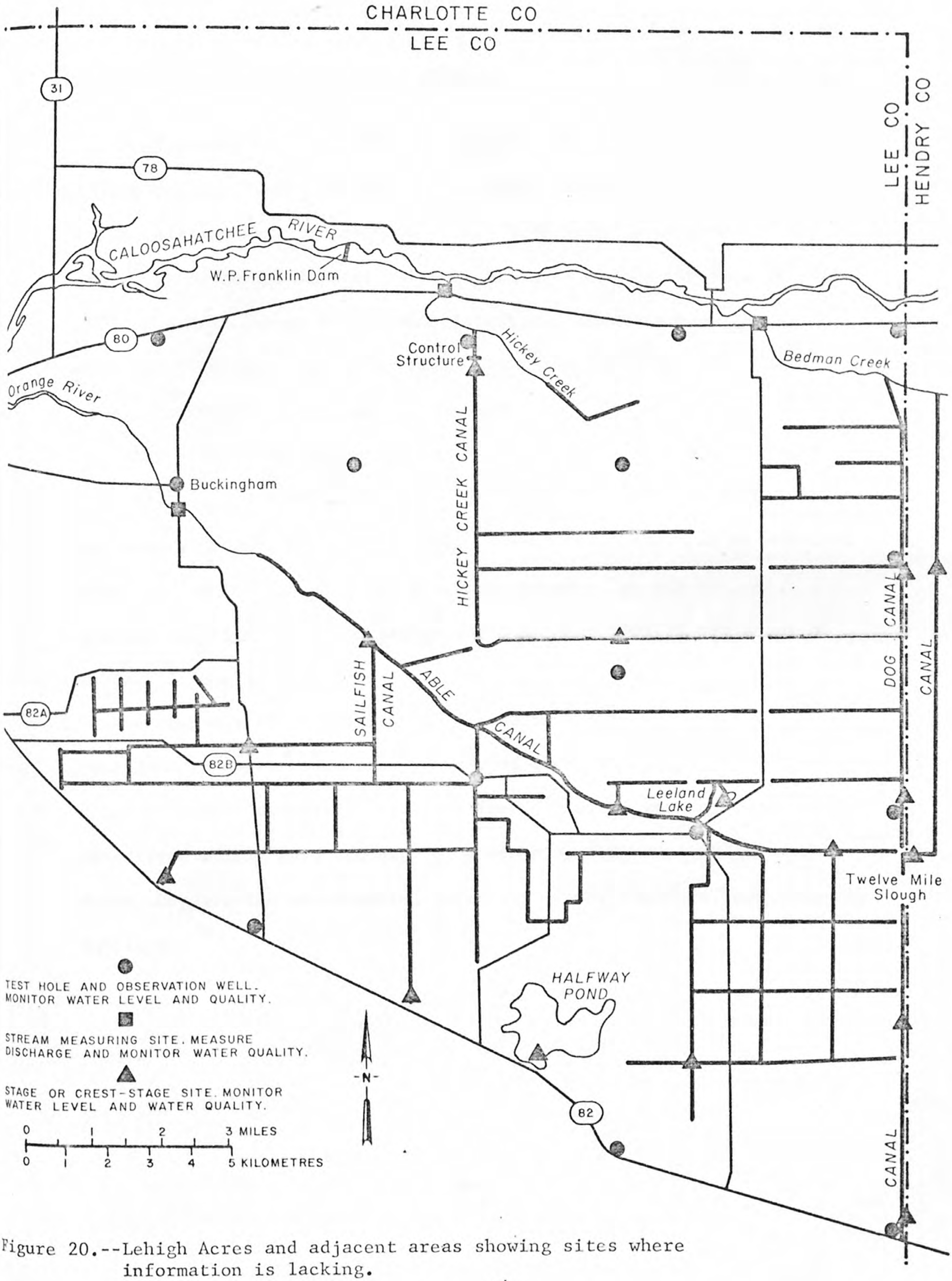

Figure 20.--Lehigh Acres and adjacent areas showing sites where information is lacking.

SUMMARY

Lehigh Acres, a residential community with a population of about 13,500 and comprising an area of 94 square miles (243 square kilometres) in the eastern part of Lee County, has been under development since 1954. Prior to development, much of the area was poorly drained. In 1958, the East County Water Control District was formed to improve drainage from the area and by 1974, more than 150 miles (241 kilometres) of drains (canals) had been constructed.

The climate is subtropical with a mean annual air temperature of 23°C (74°F), and average monthly temperature ranging from 18°C (64°F) in January to 28°C (83°F) in August. Rainfall in the area is seasonal with most of the annual total occurring between May and October. The average annual rainfall in Lehigh Acres between 1965-73 was about 56 inches (1430 millimetres).

Lehigh Acres is underlain to depths of about 1,200 feet (370 metres) by sediments consisting predominantly of sand, sandstone, limestone, dolomite, clay, and marl. At least four different aquifers have been identified within this sequence of sediments. In order of increasing depth they are the water-table, sandstone, lower Hawthorn, and Suwannee aquifers.

The water-table aquifer which occurs at shallow depths, usually is not more than 30 feet (9 metres) thick. Recharged by infiltration of rainfall, the water table fluctuates seasonally through a range dependent on natural recharge and discharge factors. Water levels in this aquifer probably have been affected by the construction of drainage canals. Water in the water-table aquifer usually is suitable for most purposes with concentrations of most chemical constituents, except iron and color, within the recommended limits for drinking water.

The sandstone aquifer, under slight artesian pressure, is the source of water for the public-supply system in Lehigh Acres and is used extensively throughout the area for domestic and irrigation water supplies. Water levels in the aquifer show a seasonal range in fluctuation similar to the water table. The areas of recharge to the aquifer have not been delineated. Water in the aquifer generally is of good quality although in places the water is hard, with dissolved solids and iron concentrations exceeding the recommended limits for drinking water.

The lower Hawthorn and Suwannee aquifers are at depths between 440 and 850 feet (135 to 262 metres). Wells tapping these aquifers usually flow at rates ranging from 40 to 500 gallons per minute (3 to 30 litres per second). The artesian head is as much as 40 feet (12 metres) above land surface, 51 feet (16 metres) above mean sea level. Recharge to these aquifers probably occurs to the north in the central highlands part of the state. They are classified as saline-water aquifers because the dissolved solids usually exceed 1,000 milligrams per litre. They yield water that is very hard and contains relatively high concentrations of sodium, sulfate, and chloride.

Three streams, the Orange River, Hickey Creek, and Bedman Creek, formerly provided natural drainage from the area. All of the drainage canals constructed since 1958 are connected to these streams. Between 1935-46 the average annual discharge from the Orange River was 41.1 cubic feet per second (11.6 cubic metres per second). The highest recorded discharge for the Orange River was 5,300 cubic feet (150 cubic metres) per second on June 15, 1936. Extended periods of little or no discharge occur. The effects of changes in the drainage basin on the flow regime of the Orange River have not been accurately defined.

Generally, the water in the Orange River is of good chemical quality. Information on the quality of water in other streams and canals is fragmentary: only several analyses for nutrient concentrations have been made. The results indicate higher concentrations of nutrients in the Orange River than at other sampling sites.

Most lakes and ponds in Lehigh Acres are hydraulically connected to the water-table aquifer. Thus, factors which affect one, also affect the other. In 1974, the water level in Halfway Pond the largest shallow pond in the area, apparently declined at a rate similar to well L-730 where the water table fell nearly 5 feet (1.5 metres). The pond, nearly dry in April 1974, recovered to a high level in July as a result of heavy rainfall in May and June.

Leeland Lake, the only known sinkhole lake in Lee County, is about 208 feet (64 metres) deep. The lake stage apparently fluctuates seasonally similar to the water table. The long-term range in fluctuation is about 6 feet (1.8 metres). Because of its depth, Leeland Lake may be hydraulically connected to both the water-table and sandstone aquifers. The water quality however, is more nearly similar to water from the sandstone aquifer.

Theoretical drawdown curves developed for conditions in Lehigh Acres, indicate that drainage canals could affect ground-water levels for a distance of 6,000 feet (1,800 metres). However, these theoretical curves provide no information on the actual water-level declines resulting from the construction of canals.

The available information on the hydrology and geology of Lehigh Acres and adjacent areas is inadequate for many purposes. Information is needed to define the source and area of recharge to the sandstone aquifer, to define the aquifer characteristics of transmissivity and storage, and to determine water quality. More detailed information is required to evaluate the effects of canal construction on ground-water levels and the flow regime and water quality of streams in the area.

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Abbreviations used in tables: Aquifers /1 WT(Water table), SS(Sandstone), LH(lower Hawthorn), Su(Suwannee).

Well number	Latitude-Longitude	Depth (feet)	Casing (feet)	Diameter (inches)	Land Surface altitude (feet)	Water level above (+) or below land surface (ft.)	Date	Yield gpm Flow-F	Temper-ature °C	Chloride mg/l	Date	Aquifer(s)	Remarks
L-359	264302N0814242.1	650	150	4.5	7	+31.7	9-44					LH	
						+37.5	8-69			900	8-69		See chem. anal.
361	264048N0814357.1			4	12	+39.7	9-44					LH?	
						+39.7	9-49						
						+37.5	8-54			765	3-52		
411	263828N0814322.1	90	60	8	21			168				SS	
414	263824N0814316.1	94	60	8	21					59	4-74	SS	Obs. well. See chem. anal.
416	263847N0814252.1	90	63	8	21			168				SS	
418	263855N0814247.1	93	60	8	22	5.68	1-46	168	25			SS	
419	263852N0814243.1	90	63	8	22			170		54	8-42	SS	
425	263849N0814301.1	780		6	21	+26.9	3-46		29	750	7-68	LH, Su	See chem. anal.
577	263917N0814433.1	145	95	8	17							SS	
578	263919N0814429.1	155	102	8	17	1.00	3-58					SS	
579	263920N0814435.1	115	98	8	17							SS	
580	263923N0814431.1	115	100	8	17							SS	
583	263623N0813807.1	50		4	24	10.73	12-66					SS	Obs. well
612	263702N0814255.1	300			24								Test hole
613	263500N0813846.1	360			29								Test hole
618	263148N0813616.1	600			30								Test hole
619	263112N0813746.1	540			30								Test hole

/1 Test holes usually contain no well casing and are open to all aquifers penetrated. Thus, the principal aquifer cannot be identified.

Table 4.--continued.

Well number	Latitude-Longitude	Depth (feet)	Casing (feet)	Diameter (inches)	Land Surface altitude (feet)	Water level above(+) or below land surface(ft)	Date	Yield gpm Flow-F	Temper-ature °C	Chloride mg/l	Date	Aquifer(s)	Remarks
L-620	263039N0814035.1	420			28								Test hole
621	263343N0814100.1	365			28								Test hole
622	263503N0814245.1	305			28								Test hole
623	263740N0813731.1	340			22								Test hole
624	263835N0813944.1	495			18								Test hole
625	263928N0813652.1	540			21								Test hole
626	263906N0813359.1	500			24								Test hole
627	264101N0813459.1	480			20								Test hole
628	264213N0813752.1	450			18								Test hole
641	264143N0814630.1	535	160	4	5				26	265		LH	
652	264101N0814430.1	598	188	6.5	7			F50	28	660	4-67	LH	Obs. well. See chem. anal.
						+38.7	11-67			715	11-67		
659	263613N0814250.1	1340			26								Test hole
660	263905N0813522.1	1260			24								Test hole
662	263653N0814556.1	255			22								Test hole
705	264320N0814134.1	94	80	4	10			F38	27	500	8-67	SS	
706	263943N0813543.1	592	140	6	21	+28.4	4-67	F67	28	285	4-68	LH	Obs. well. See chem. anal.
707	264235N0813753.1	21	18	4	14	3.99	4-68					WT	Obs. well. See chem. anal.
708	263625N0813808.1	58		6	24				24	164	2-69	SS	See chem. anal.
709	263623N0813824.1	70		6	25	19.7	12-66		25			SS	

Well number	Latitude-Longitude	Depth (feet)	Casing (feet)	Diameter (inches)	Land Surface altitude (feet)	Water level above(+) or below land surface(ft)	Date	Yield gpm Flow-F	Temper-ature °C	Chloride mg/l	Date	Aquifer(s)	Remarks
L-710	263609N0813820.1	70		6	25	21.6	12-66		26				
715	263612N0814254.1	830	110	6	26	+22.1	6-69			785	7-68	LH,Su	See chem. anal.
716	264148N0813854.1	800	86	6	12			F500	28	795	5-69	LH,Su	
727	263950N0813554.1	68	67	4	23	4.09	7-68	5	26	210	7-68	SS	Obs.well. See chem. anal.
728	263712N0814612.1	19	19	4	22	0 72	7-68	43	24.5			WT	Obs.well
729	263335N0813943.1	121	81	4	28	3.85	8-68	85	25	75	7-68	SS	Obs.well. See chem. anal.
730	263127N0813516.1	19	18	4	31	1.51	8-68	30	25	10	8-68	WT	Obs.well. See chem anal.
769	264212N0813628.1	70		6	12				23.5	480	8-68	SS	
841	264309N0814358.1	69	63	2	5				24	750	8-68	SS	
849	264302N0814408.1	69	63	2	5	+6.0	8-68		24	215	8-68	SS	
855	264309N0814401.1	78		2	5					675	8-68	SS	
881	264213N0813746.1	25	19	2	15	5.48	3-68	43		80	3-68	WT	
882	264243N0813742.1	56		2	13	0.0	3-68			400	11-68	SS	
883	264300N0813822.1	90	86	4	5			F20	23.5	650	11-68	SS	
904	264148N0813610.1	772		8	16	+23.9	5-69	F200	28.5	670	4-69	LH,Su	
905	264131N0813610.1	440		6	17	+30.5	5-69	F500	27	1180	4-69	LH	
906	264118N0813558.1			6	18			F150	28.5	840	3-69		
910	264214N0813602.1	600		6	13			F68	27.5	380	4-69	LH	
911	264212N0813601.1	650		6	14			F39	28	720	4-69	LH	
912	264223N0813553.1	850	650	6	10	+39.3	4-69	F500	29	1440	4-69	LH,Su	

Well number	Latitude-Longitude	Depth (feet)	Casing (feet)	Diameter (inches)	Land Surface altitude (feet)	Water level above(+) or below land surface(ft.)	Date	Yield gpm Flow-F	Temper-ature °C	Chloride mg/l	Date	Aquifer(s)	Remarks
L-916	264207N0813558.1	536	318	4	15			F45	28	1080	4-69	LH	
930	264102N0814430.1	78	64	2	9	+4.9	10-69	F6				SS	See chem. anal.
997	263158N0814023.1	420			30								Test hole
1050	264325N0814139.1	72		2	2	+4.5	3-70	F13	26	275	3-70	SS	
1056	263851N0814329.1	71		6	18	+5.0	4-70					SS	
1137	263532N0815922.1	20	20	4	23	2.09	6-70			21	4-74	WT	Obs. well. See chem. anal.
1219	264110N0814510.1	800		4	6			F40	27	800	8-69	LH, SU	
1230	264122N0814437.1	500		6	8	+29.5	8-69	F370	28	725	7-72	LH	
1232	264312N0814251.1	90		1 1/4	6				29	1020	8-69	SS	
1233	264316N0814246.1	90		1 1/2	6			F5	26	680	8-69	SS	
1237	264108N0814447.1	600		6	9	+19	8-69		27	760	8-69	LH	
1239	264109N0814425.1	86		2	6			F8	27	580	8-69	SS	
1241	264122N0814229.1			6	16	+34	8-69		27	860	8-69	LH	
1356	264033N0814506.1	660		4	11	+31	8-69	F160	28	700	8-69	LH	
1390	263943N0814630.1	540		6	19	+18	8-69	F200	28	900	8-69	LH	
1418	263630N0813753.1	62	55	8	24	9.00	1-71					SS	Obs. well
1511	264118N0814522.1	75	60	2	5					700	11-71	SS	
1552	264142N0813608.1	125	40		18							SS	
1625	263329N0813944.1	238	162	2	30			60		60	2-71	SS	
1626	263041N0814331.1	223		2	26			60		70	3-72	SS	

Table 4.--continued.

Well number	Latitude-Longitude	Depth (feet)	Casing (feet)	Diameter (inches)	Land Surface altitude (feet)	Water level above(+) or below land surface(ft)	Date	Yield gpm Flow-F	Temper-ature °C	Chloride mg/l	Date	Aquifer(s)	Remarks
L-1627	263133N0814237.1	230		2	26					70	3-72	SS	
1628	263129N0814040.1	255	130	2	28			45		80	5-71	SS	
1629	263039N0814134.1	246	82	2	26			60		40	9-71	SS	
1632	263209N0813757.1	239	110	2	36			60		110	2-71	SS	
1633	263425N0814150.1	244	89	2	29					120		SS	
1688	263554N0813754.1			5	26			F60	31	900	3-73	LH	
1692	264232N0813544.1	84	63	2	12					800	5-73	SS	
1693	264245N0813526.1	60	50	2	11			18		800	5-73	SS	
1694	264233N0813513.1	80	60	2	16					825	5-73	SS	
1888	263608N0813843.1	68	58.5	8	27							SS	
1889	263631N0813831.1	85	50	8	23							SS	
1890	263623N0813844.1	62	51	8	26							SS	
1891	263608N0813803.1	85	57	8	27							SS	
1892	263557N0813826.1	80	62.5	8	28							SS	
1893	263554N0813844.1	80		8	28							SS	
1903	264253N0814052.1	630	200	4	11					400	3-74	LH	
1907	264308N0814101.1	57	55	2	8	+1.5	3-74	F1	25	220	3-74	SS	
1908	264308N0814053.1	56		2	7				23.5	220	3-74	SS	
1911	264259N0814103.1	500	60	4	9							LH	
1931	264313N0814117.1	80	63	2	6				27	360	4-74	SS	

Table 5.--Descriptive logs of test holes in Lehigh Acres and adjacent areas.

L-612

Description	Depth (ft.)	Thickness (ft.)
Holocene and upper Pleistocene sediments, undifferentiated.		
Sand, quartz, medium to fine.	20	20
Caloosahatchee Marl.		
Limestone, light gray, clayey.	32	12
Tamiami Formation.		
Clay, gray and green.	62	22
Sandstone, and limestone, interbedded.	100	38
Sand, clayey.	110	10
Limestone, moderately hard.	152	42
Clay, dark gray-green.	170	18
Clay, sandy, dark gray, highly phosphatic.	192	22
Hawthorn Formation.		
Limestone, light gray-white, sandy, phosphatic.	291	99

Table 5.--Cont.

L-613

Description	Depth (ft.)	Thickness (ft.)
Holocene and upper Pleistocene sediments, undifferentiated.		
Sand, brown, white clay marl.	10	10
Caloosahatchee Marl.		
Limestone and clay, marl, white.	28	18
Tamiami Formation.		
Clay, gray and green, shell fragments.	42	14
Limestone, and sandstone, gray.	60	18
Limestone, gray.	75	15
Sandstone, gray, calcareous.	90	15
Same, some phosphorite, shell.	105	15
Sandstone, gray, quartz gravel, phosphorite, shell.	120	15
Limestone, tan, molds.	138	18
Clay, gray.	190	52
Clay, green.	222	32
Clay, dark gray, sandy, phosphatic.	255	32
Hawthorn Formation		
Limestone, gray-white, phosphatic.	360	105

Table 5.--Continued.

L-618

Description	Depth (ft.)	Thickness (ft.)
Holocene and upper Pleistocene sediments, undifferentiated.		
Sand, fine to medium, dark brown	10	10
Caloosahatchee Marl.		
Limestone, creamy tan, shell casts and molds.	35	15
Limestone, light gray, marly.	40	15
Tamiami Formation.		
Clay, tan to light gray.	58	18
Clay, green.	80	22
Limestone, gray, slightly sandy.	90	10
Sandstone, gray; calcareous shell fragments.	100	10
Same, some clay.	120	20
Clay, gray, interbedded with gray sandstone.	130	10
Clay, gray sandy, some sandstone.	140	10
Sand, fine to medium, dark gray, clayey.	260	120
Same with phosphorite.	284	24
Hawthorn Formation.		
Clay, light gray, sandy.	295	11
Limestone, gray-white, sandy.	300	5
Clay, light gray, sandy.	324	24
Limestone, tan; casts and molds.	340	16
Limestone, tan-light gray; clayey.	360	20
Limestone, tan, casts.	402	42
Clay, gray, limestone fragments.	480	58
Clay, phosphorite, gray clay, sandy.	520	40
Clay, dark gray, phosphorite, sandy.	562	42
Limestone, phosphatic, gray-white.	600	38

Table 5.--Continued.

L-624

Description	Depth (ft.)	Thickness (ft.)
Holocene and upper Pleistocene sediments, undifferentiated.		
Sand, brown, silt to medium.	8	8
Caloosahatchee Marl.		
Limestone, tan, marly, shelly, sandy.	10	2
Limestone, light gray to cream, some shell and quartz sand.	20	10
Limestone, light gray, phosphatic, shelly.	28	8
Tamiami Formation.		
Clay, light gray, oolitic, some sand.	30	2
Clay, light green, some shell and quartz sand.	46	16
Clay, light green, interbedded with soft tan limestone.	60	14
Sandstone, light gray, shelly, hard.	75	15
Same	87	12
Sand, quartz, light gray, fine to medium.	102	15
No sample, sandstone.	120	18
Clay, light gray, some shell.	135	15
Marl, light gray to white, limestone fragments.	150	15
Marl, same as above.	165	15
Marl, and limestone, shelly, some quartz sand and phosphorite.	180	15
Marl, light gray, sandy.	186	6
Clay, gray-green, sandy.	210	24
Same.	225	15
Clay, dark gray-green, highly phosphatic, sandy.	234	9
Hawthorn Formation		
Limestone, gray-white, phosphatic shelly, sandy.	255	15
Same.	270	15
Limestone, gray-white, interbedded with marl and hard gray limestone.	285	15
Limestone, gray-white, clayey, inter-bedded with marl.	296	11

Table 5.--Continued.

L-624 Cont.

Description	Depth (ft.)	Thickness (ft.)
Clay, green phosphatic, sandy.	310	15
Marl, gray-white, phosphatic, sandy, shelly.	339	29
Clay, light gray, some shell and quartz sand.	344	5
Limestone, gray-white, phosphatic, sandy, some marl.	360	16
Marl, gray-white phosphatic.	390	30
Marl, gray-white, phosphorite gravel.	405	15
Clay, light gray.	410	5
Marl, light gray, rock fragments, phosphatic.	420	10
Same.	424	4
Clay, light gray.	434	10
Limestone, gray, hard.	439	5
Marl, light gray, soft, phosphatic.	450	11
Marl, light gray to white, gray limestone fragments.	465	15
Marl, light gray.	480	15
Limestone, white, some sand, soft marly.	495	15

Table 5.--Continued

L-625

Description	Depth (ft.)	Thickness (ft.)
Caloosahatchee Marl.		
Limestone, light tan, shelly, sandy, marly.	10	10
Marl, white, shelly.	20	10
Tamiami Formation.		
Clay, light gray, some gypsum.	30	10
Clay, gray-green, some shell and quartz sand.	44	14
Sandstone, light gray, interbedded tan limestone.	58	14
Sand, gray, quartz gravel and pebbles.	62	4
Sandstone, gray, hard, calcareous.	82	20
Sand, gray, quartz and phosphorite gravel	86	4
Limestone, light tan to gray, interbedded sandstone; quartz and phosphorite gravel.	105	19
Limestone, light tan to gray, pelleted.	120	15
Clay, light gray, some quartz sand and shell.	135	15
Clay, light gray.	150	15
Clay, light gray sandy.	165	15
Clay, light gray.	176	11
Clay, gray-green, sandy, some shell.	188	12
Clay, dark gray-green, sandy, phosphorite gravel.	210	22
Clay, dark gray-green, sandy, shelly, phosphatic, coarse sand.	225	15
Clay, dark gray-green, rock fragments phosphorite gravel, sandy.	236	11
Hawthorn Formation.		
Limestone, white to light gray, sandy, some shell.	255	19
Marl, gray, shell, quartz sand, phosphorite.	270	15
Same.	285	15
Marl, gray, shelly.	300	15
Limestone, clayey, white to light gray, chalky.	315	15
Limestone, same as above..	330	15
Limestone, light gray to white, marly, some quartz sand.	350	20

Table 5.--Continued.

L-625 Continued

Description	Depth (ft.)	Thickness (ft.)
Clay, light gray.	360	10
Marl, white to light gray, sandy, shelly.	366	6
Clay, phosphatic, quartz sand, shell.	374	8
Marl, and interbedded soft limestone, sandy, shelly.	390	16
Clay, gray, marly, shell, quartz, phosphorite.	405	15
Clay, light gray to white.	414	9
Limestone, and dolomite, light gray-tan, hard.	434	20
Limestone, light gray, hard.	446	12
Limestone, interbedded soft and hard.	495	49
Limestone, white to light gray, some quartz sand and sand.	510	15
Same.	525	15
Limestone, light tan-white, very hard, pelleted.	540	15

Table 5.--Continued.

L-626

Description	Depth (ft.)	Thickness (ft.)
Holocene and upper Pleistocene sediments, differentiated.		
Sand, quartz, light brown, medium to very fine.	5	5
Caloosahatchee Marl.		
Limestone, tan to white, hard, sandy.	10	5
Limestone, light gray to tan, shell, quartz sand.	20	10
Tamiami Formation.		
Marl, white to light gray, some quartz sand and shell.	30	10
Clay, gray, fat.	42	12
Sand, quartz, phosphorite and quartz gravel, slightly clayey.	60	18
Shell, with light gray sand, some clay.	75	15
Shell, with light gray sand, quartz gravel and phosphorite.	90	15
Sandstone, light gray.	105	15
Sand, quartz, light gray, shelly, some gravel.	126	21
Sand and gravel; quartz, gray, phosphorite	140	14
Limestone, light gray to light tan, marly.	150	10
Limestone, light gray to light tan.	165	15
Same.	173	8
Clay, light gray, some quartz sand.	196	23
Clay, light gray, sandy, some shell.	210	14
Clay, and marl.	220	10
Clay, green, silty.	240	20
Clay, green, with quartz sand and shell.	255	15
Clay, gray-green, very phosphatic, sandy.	270	15
Same.	280	10

Table 5.--Continued.

L-626 Cont.

Description	Depth (ft.)	Thickness (ft.)
Hawthorn Formation.		
Marl, light gray-white, phosphatic, shell and quartz sand.	300	20
Same.	315	15
Marl, light gray, sandy, some shell and phosphorite.	330	15
Clay, gray, sandy.	340	10
Limestone, light gray, some phosphatic gravel, shelly, sandy.	345	5
Limestone, light gray to white.	364	19
Marl, white to light gray, slightly phosphatic.	375	11
Marl, white to cream.	390	15
Clay, light gray.	405	15
Clay green, very phosphatic, sandy.	420	15
Marl, cream, slightly sandy.	432	12
Clay, dark gray-green, phosphatic, sandy some shell.	450	18
Clay, light gray, phosphorite gravel.	462	12
Limestone, and dolomite, white and light brown.	480	18
Limestone, white to light gray, hard.	495	15
Limestone, white to light gray, shelly.	500	5

Table 5.--Continued.

L-628

Description	Depth (ft.)	Thickness (ft.)
Holocene and upper Pleistocene sediments, undifferentiated.		
Sand, dark brown, light gray clay; limestone, light and dark brown, sandy, clayey.	10	10
Caloosahatchee Marl.		
Limestone, creamy tan, shell fragments, clayey.	20	10
Limestone, creamy tan, clayey, shell, phosphatic.	30	10
Tamiami Formation.		
Clay, gray.	45	15
Clay, green, sandy.	56	11
Sandstone, gray, calcareous, phosphorite pebbles, some quartz, gravel.	75	9
Same, with shark's teeth, more gravel.	92	17
Sandstone, limestone, tan and gray, phosphorite pebbles.	105	13
Limestone, tan, shell molds.	121	16
Limestone, tan, some gray clay.	135	14
Limestone, gray-white, some gray clay.	164	9
Clay, green, some limestone.	180	16
Clay, green, sandy.	195	15
Clay, gray, sandy.	210	15
Clay, dark gray, sandy, phosphatic.	236	26
Hawthorn Formation.		
Clay, green, some limestone, phosphatic.	270	34
Clay, gray, some limestone, phosphatic.	330	60
Clay, gray, some phosphatic limestone.	390	60
Limestone, light gray; clayey.	405	15
Limestone, light gray, pure; some dolomite.	435	30
Same, some gray clay.	450	15

Table 5.--Continued

L-659

Description	Depth (ft.)	Thickness (ft.)
Caloosahatchee Marl.		
Limestone, creamy tan, sandy.	10	10
Limestone, creamy tan, (barnacles), shell casts.	20	10
Limestone, light tan, shell fragments.	30	10
Limestone, tan, shell fragments; clayey.	40	10
Tamiami Formation.		
Clay, dark gray, sandy; shell fragments.	50	10
Clay, green; shell fragments.	60	10
Sandstone, gray, calcareous; clayey.	70	10
No sample, sandstone to 120, limestone, gray clay below.	170	100
Clay, gray; shell and limestone fragments.	190	20
Clay, gray.	200	10
Clay, dark gray, sandy, phosphatic.	206	6
Hawthorn Formation.		
Limestone, tan, phosphatic, clayey.	230	24
Same.	250	20
Clay, gray, phosphatic.	260	10
Clay, gray, phosphatic, sandy.	270	10
Clay, gray, phosphatic.	290	20
Limestone, gray-white, phosphatic; clayey.	320	30
Clay, gray-white, phosphatic; limestone fragments.	420	100
Clay, gray-white, phosphatic; limestone fragments.	438	18
Limestone, phosphatic, clayey.	448	10
Clay, gray-white, phosphatic.	500	2
Clay, gray, phosphatic; limestone fragments.	530	30
Clay, gray, less phosphorite limestone fragments.	578	48

Table 5.--Continued.

L-659 Cont.

Description	Depth (ft.)	Thickness (ft.)
Tampa Limestone.		
Limestone, gray-tan, clayey.	590	12
Limestone, gray-tan, some phosphatic gray clay.	600	10
Limestone, gray-tan, phosphatic, sandy.	640	40
Same, some gray clay.	700	60
Limestone, gray-tan, some phosphorite.	720	20
Clay, gray-tan, phosphatic; limestone fragments.	738	18
Limestone, gray-tan, sandy.	780	42
Limestone, gray-tan, phosphatic; clayey.	800	20
Limestone, gray-tan, shell fragments (shark's teeth)	836	36
Suwannee (?) Limestone.		
Limestone, gray-tan.	860	24
Same; clayey.	880	20
Limestone, gray-tan.	920	40
Same, some sand.	940	20
Sand, fine to medium, tan; limestone fragments.	1040	100
Limestone, tan, sandy.	1060	20
Limestone, tan.	1080	20
Limestone, tan, sandy.	1094	14
Ocala Group (?)		
Limestone, tan, clayey.	1160	66
Limestone, tan.	1194	34
Limestone, tan; clayey.	1220	26
Limestone, tan.	1240	20
Clay, tan, sandy.	1260	20
Limestone, tan (shark's teeth 1300-1320)	1340	80

Table 5.--Continued.

L-662

Description	Depth (Ft.)	Thickness (Ft.)
Holocene and upper Pleistocene sediments, undifferentiated.		
Sand, quartz; tan to lt. brown, medium to fine.	6	6
Caloosahatchee Marl.		
Limestone, light tan to yellow, shell fragments.	20	14
Marl, light tan to white, shell.	30	10
Tamiami Formation.		
Clay, light gray, shell, slightly sandy.	40	10
Clay, light gray to light green, some shell, slightly oolitic.	50	10
Clay, green, silty.	75	15
Sandstone, limestone, light gray and tan, calcareous.	80	15
Sandstone, gray, hard.	90	10
Sandstone, light gray, calcareous, phosphorite pebbles.	105	15
Same, with some clay.	112	7
Sand, gray, clayey, some shell and phosphorite.	122	10
Limestone; light gray to white, sandy, molds and casts.	140	8
Limestone, same.	150	10
Clay, gray, phosphatic, some limestone fragments, shell.	165	15
Clay, dark gray-green, phosphatic.	180	15
Sand, dark gray, clayey, highly phosphatic.	192	12
Hawthorn Formation		
Limestone, light gray-white, sandy, phosphatic.	205	13
Limestone; light gray-white, phosphatic, slightly clayey.	225	15
Limestone, light gray-white, phosphatic shelly, some sand.	240	15
Limestone, light gray-white, same as above.	255	15

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