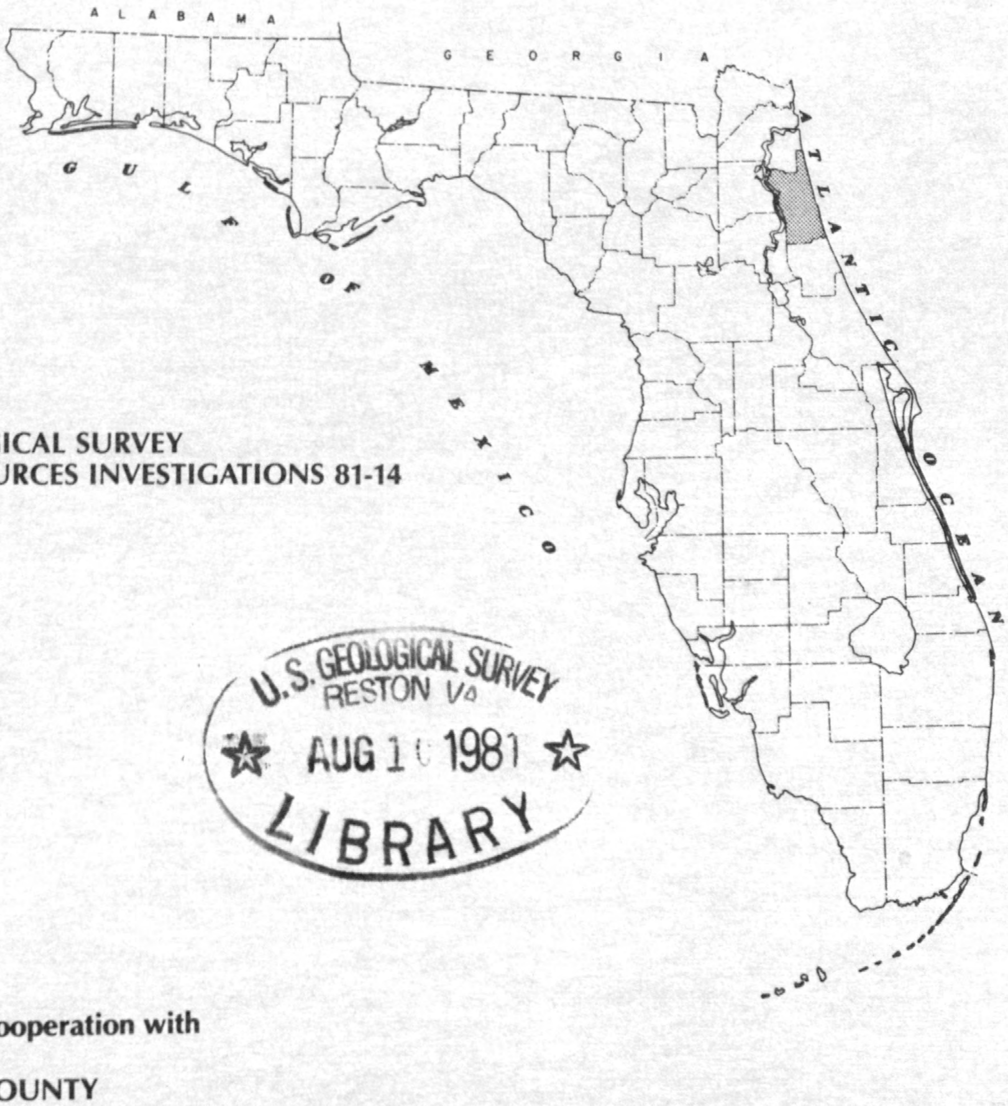
81-14 THE SURFICIAL AQUIFER IN EAST-CENTRAL ST. JOHNS COUNTY, FLORIDA 81-14

THE SURFICIAL AQUIFER IN EAST-CENTRAL ST. JOHNS COUNTY, FLORIDA



U.S. GEOLOGICAL SURVEY
WATER-RESOURCES INVESTIGATIONS 81-14

Prepared in cooperation with

ST. JOHNS COUNTY

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO.	2.	3. Recipient's Accession No.
4. Title and Subtitle THE SURFICIAL AQUIFER IN EAST-CENTRAL ST. JOHNS COUNTY, FLORIDA			5. Report Date May 1981
			6.
7. Author(s) E. C. Hayes			8. Performing Organization Rept. No. WRI 81-14
9. Performing Organization Name and Address U.S. Geological Survey, Water Resources Division 325 John Knox Road, Suite F-240 Tallahassee, Florida 32303			10. Project/Task/Work Unit No.
			11. Contract(C) or Grant(G) No. (C) (G)
12. Sponsoring Organization Name and Address U.S. Geological Survey, Water Resources Division 325 John Knox Road, Suite F-240 Tallahassee, Florida 32303			13. Type of Report & Period Covered
			14.

15. Supplementary Notes

Prepared in cooperation with St. Johns County.

16. Abstract (Limit: 200 words)

The surficial aquifer, a composite of confined and unconfined water-bearing zones overlying the Miocene Hawthorn Formation, is an important source of water in St. Johns County, FL. The water from wells open to the surficial aquifer generally meets quality standards, recommended by the U.S. Environmental Protection Agency, for public water supplies, except for concentrations of iron that for most wells are substantially greater than the recommended limit of 0.3 milligrams per liter. Data from 12 test wells drilled to the top of the Hawthorn Formation about 100 feet below land surface indicate that the productive zones and confining beds in the surficial aquifer are discontinuous. Test well yields from individual zones range from less than 1 to 42 gallons per minute from depths between 20 and 100 feet below land surface. The most productive zones were generally found in the Tillman Ridge area, about 10 square miles in the west-central part of the area of investigation. Analysis of an aquifer test on a well in the Tillman Ridge area indicates a transmissivity of about 6,500 to 7,000 feet squared per day. The best local source of good quality water for development of a relatively large water supply is in the vicinity of Tillman Ridge.

17. Document Analysis a. Descriptors

*Water supply, *Water quality, *Water resources, *Hydrology, Ground water, Aquifers, Wells

b. Identifiers/Open-Ended Terms

St. Johns County, St. Augustine, Florida

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
No restriction on distribution	Unclassified	25
	20. Security Class (This Page) Unclassified	22. Price

(See ANSI-Z39.18) See Instructions on Reverse OPTIONAL FORM 272 (4-77) (Formerly NTIS-35) Department of Commerce

THE SURFICIAL AQUIFER IN EAST-CENTRAL ST. JOHNS COUNTY, FLORIDA

By E. C. Hayes

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 81-14

Prepared in cooperation with

ST. JOHNS COUNTY

1981

UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, Secretary

GEOLOGICAL SURVEY

Doyle G. Frederick, Acting Director

For additional information write to:

U.S. Geological Survey
Suite F-240
325 John Knox Road
Tallahassee, Florida 32303

CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION FACTORS

For use of those readers who may prefer to use metric (SI) units rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Multiply	By	To obtain
inch (in)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.59	square kilometer (km^2)
cubic foot (ft^3)	0.0283	cubic meter (m^3)
foot squared per day (ft^2/d)	0.0929	meter squared per day (m^2/d)
million gallons (Mgal)	3,785	cubic meter (m^3)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
micromhos per centimeter (umho/cm)	1.000	microsiemens per centimeter (uS/cm)
degrees Fahrenheit (°F)	(°F-32)5/9	degrees Celsius (°C)

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "mean sea level."

GLOSSARY

Terms related to ground water and water quality, as used in this report, are defined below. A table for converting inch-pound units to the International System of Units (SI) is on page iv.

Aquifer is a formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Artesian aquifer is an aquifer which is saturated through the entire aquifer thickness and in which the hydrostatic pressure at the top of the aquifer is greater than atmospheric. The water in a well tapping an artesian aquifer stands above the top of the aquifer.

Confining bed is a body of "impermeable" material stratigraphically adjacent to one or more aquifers.

Confined aquifer is synonymous with artesian aquifer.

Milligrams per liter (mg/L) is a unit for expressing the concentration of chemical constituents in solution. Milligrams per liter represents the weight of constituent per unit volume of water.

Storage coefficient is the volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head.

Transmissivity is the rate at which ground water of the prevailing kinematic viscosity is transmitted through a unit width of an aquifer under a unit hydraulic gradient.

Unconfined aquifer is an aquifer that has a water table.

Water table is that surface in an unconfined ground-water body at which the pressure is atmospheric.

THE SURFICIAL AQUIFER IN EAST-CENTRAL

ST. JOHNS COUNTY, FLORIDA

By E. C. Hayes

ABSTRACT

The surficial aquifer, a composite of confined and unconfined water-bearing zones overlying the Miocene Hawthorn Formation, is an important source of water in St. Johns County, Florida. The water from wells open to the surficial aquifer generally meets quality standards recommended by the U.S. Environmental Protection Agency for public water supplies, except for concentrations of iron that for most wells are substantially greater than the recommended limit of 0.3 milligrams per liter. Data from 12 test wells drilled to the top of the Hawthorn Formation, about 100 feet below land surface, indicate that the productive zones and confining beds in the surficial aquifer are discontinuous. Test well yields from individual zones range from less than 1 to 42 gallons per minute from depths between 20 and 100 feet below land surface. The most productive zones were generally found in the Tillman Ridge area, about 10 square miles in the west-central part of the area of investigation. Analysis of an aquifer test on a well in the Tillman Ridge area indicates a transmissivity of about 6,500 to 7,000 feet squared per day. The best local source of good quality water for development of a relatively large water supply is in the vicinity of Tillman Ridge.

INTRODUCTION

Purpose and Scope

The area of investigation (fig. 1) is in the east-central part of St. Johns County, Fla. The coastal region of St. Johns County including the area of this investigation is rapidly increasing in population; however, a major limitation to growth in the area is the availability of potable water supplies. St. Augustine, the county seat and principal city in the area, obtains practically all its water supply from wells in the surficial aquifer, but the amount of water available is not sufficient for projected demands. The Floridan aquifer, which in many parts of Florida is capable of supplying abundant quantities of good quality water, underlies St. Johns County but contains saline water in much of the coastal region and southern half of the county. Thus the surficial aquifer offers the best potential for a local source of ground water to meet future water demands.

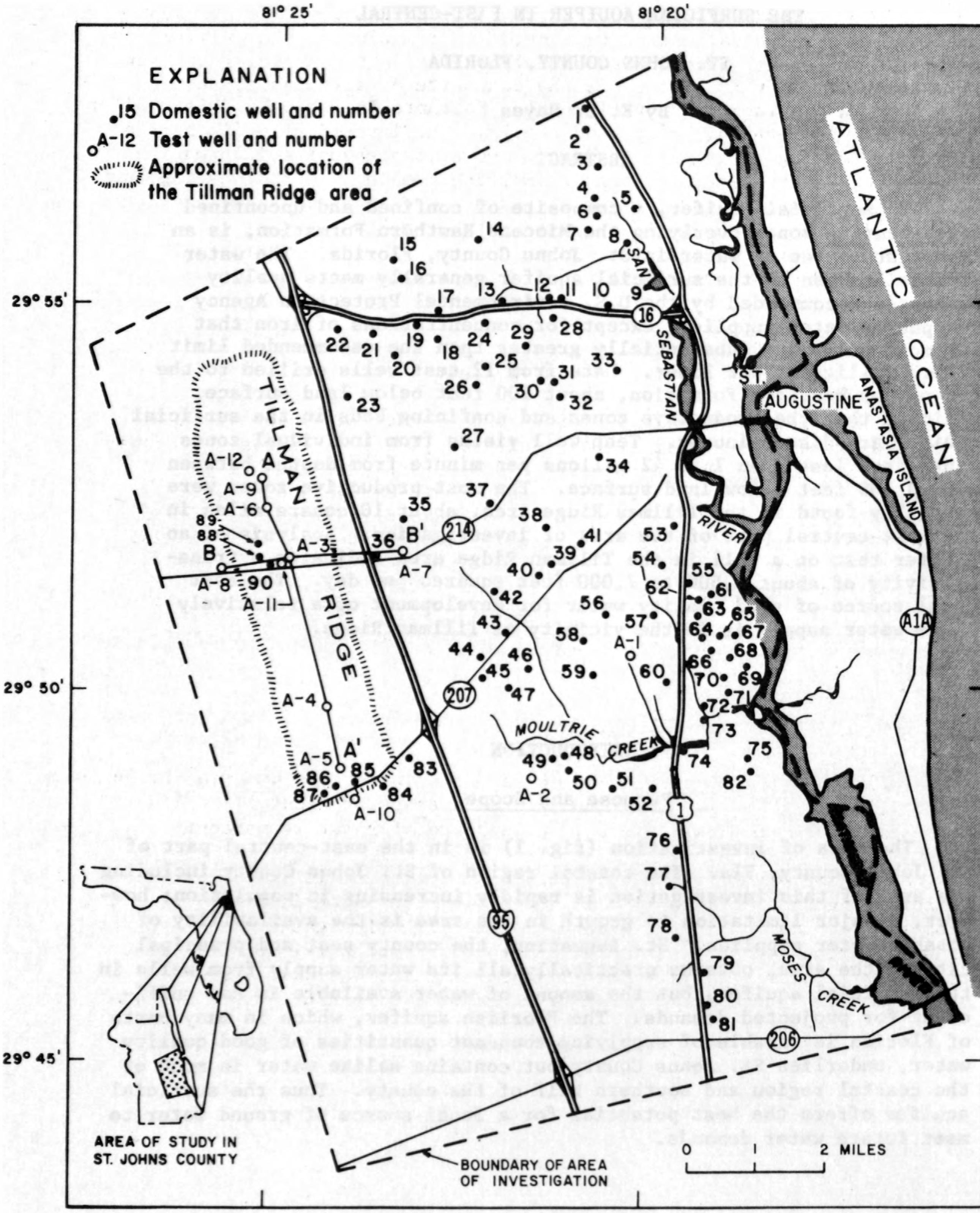


Figure 1.--Area of investigation, location of section A-A' and B-B', domestic wells inventoried, and test wells drilled during the investigation.

In 1977, the U.S. Geological Survey, in cooperation with St. Johns County, began an investigation to provide information on the availability and quality of water from the surficial aquifer. The surficial aquifer, as referred to in this report, is the composite of artesian and nonartesian water-bearing zones overlying the Hawthorn Formation. This aquifer includes layers of sand, clay, and shells. The investigation is part of the Survey's long-range plan to develop more comprehensive information for critical areas with pressing or emerging problems in the development and management of the total water resource. The investigation, completed in 1978, is summarized in this report. This report furnishes information on the physical characteristics and water quality of the surficial aquifer in the east-central part of St. Johns County.

Previous Investigations

The hydrology and geology of St. Johns County have been discussed in several reports. Fuller (1904), Sellards (1907), Sellards and Gunter (1910; 1913), and Matson and Sanford (1913) briefly describe the ground-water resources of St. Johns County. Investigative reports by Simons and Black (1927), Collins and Howard (1928), Stringfield (1936), Cooke (1945), Tarver (1958), Fairchild (1977), and Bentley (1977) also describe the water resources of the area. Only one report, Unklesby (1945), gives a detailed discussion of the surficial aquifer in the vicinity of St. Augustine. The most recent investigation of the geology and water resources of the county was made by Bermes and others (1963).

Water Use

In 1975, an average of about 36 Mgal/d of water was used in St. Johns County (Leach, 1978, p. 41). In 1977, an average of about 41 Mgal/d was used (Leach and Healy, 1980), an increase of about 14 percent.

Approximately 80 percent of the total water use in St. Johns County is for irrigation. Virtually all the irrigation water is withdrawn from the Floridan aquifer. However, most of the irrigated areas are outside the area of investigation. The municipal and rural domestic water use which is primarily from the surficial aquifer was 5.16 Mgal/d in 1975 and 5.56 Mgal/d in 1977, an increase of 0.5 Mgal/d (10 percent).

Location and Setting

The area of investigation includes approximately 130 mi^2 in the east-central part of St. Johns County, excluding the coastal barrier islands and the incorporated city of St. Augustine.

The major sources of income in the area are (1) tourism, (2) fishing and related industries, (3) agriculture, and (4) timber growing and harvesting for pulp production.

The climate is humid subtropical. Average temperature is 70° F and average annual rainfall is approximately 52 inches of which most occurs between June and October.

The relatively flat topography consists of a series of marine terraces that were formed by ancient seas standing at levels higher than at present. The terraces emerged when sea level dropped. Three of seven terraces recognized by Cooke (1945, p. 248) are within the area of investigation: the Talbot at 25-42 feet altitude, Pamlico at 10-25 feet, and Silver Bluff at 0-10 feet. The terraces slope gently eastward toward the Atlantic Ocean and westward toward the St. Johns River.

The Matanzas River and three of its tributaries, San Sebastian River, Moultrie Creek, and Moses Creek (fig. 1), drain the terraces to the east. The western edge of the area of investigation drains through swamps and small streams to the St. Johns River.

Method of Data Collection

Information on geology and ground-water resources in the area was obtained from published reports of the U.S. Geological Survey, from the files of St. Johns County, and from consulting engineers. Additional data were obtained by making an inventory of wells in the area of the investigation. As part of the inventory, water samples were collected from the wells. Evaluation of the data indicated areas where additional information was needed. Test wells were drilled at selected locations to define the lateral extent of the aquifer, and were pumped to determine yields of water-bearing zones. Wells inventoried in the investigation are numbered from 1 to 90 consecutively. All test wells drilled as part of the investigation are numbered consecutively and the numbers are preceded by the letter "A" to distinguish them from other wells.

Acknowledgments

This investigation was part of a cooperative water-resources program between St. Johns County and the U.S. Geological Survey. The assistance provided by the St. Johns County Commission and members of its staff is gratefully appreciated. Particular acknowledgment is expressed to J. L. Harrington, St. Johns County Administrator, for his support and suggestions during the investigation, and to Allen Nease, Planning Director, St. Johns County, for his assistance in selecting test well locations, obtaining permission to drill test wells, and scheduling drilling operations.

The cooperation and assistance of the following government agencies, firms, and individuals is especially appreciated: the Coastal Plains Regional Commission; the city of St. Augustine and their consultants, Black, Crow and Eidsness, a division of CH_2M Hill, who furnished valuable data and allowed an aquifer test at one of their wells; Container Corporation of America and Florida Lands Research and Development Corporation, who permitted test-well drilling on their property; George Doughty and Dennis Freeman, who drilled eleven test wells; William Wilson, who drilled one test well; and numerous well owners, who furnished information and permitted the collection of water samples from their wells.

GEOHYDROLOGY

Surficial deposits of Holocene and Pleistocene age in St. Johns County are underlain by undifferentiated marine deposits of Pliocene age. The latter are underlain in descending order by the Hawthorn Formation of Miocene age, the Ocala Limestone of late Eocene age, and the Avon Park and Lake City Limestones of middle Eocene age. During this investigation information was collected only for deposits overlying the Hawthorn Formation. A study of the geology of Flagler, Putnam, and St. Johns Counties was made by Bermes and others (1963). A summary of their description by Bentley (1977) has been modified for St. Johns County and is given in table 1.

The surficial aquifer in the area of investigation consists of formations of Holocene, Pleistocene, and Pliocene age ranging in depth from land surface to the top of the Hawthorn Formation, about 100 feet. These formations are composed of discontinuous and interbedded lenses of sand, shell, clay, and silty clay. Water in the aquifer occurs mainly under unconfined conditions. However, wherever a discontinuous relatively impermeable bed of well-cemented dark brown to black carbonaceous sand, called "hardpan" occurs, water in beds below the hardpan occurs under locally confined conditions. The aquifer is underlain by the Hawthorn Formation, which is continuous throughout the county. The Hawthorn serves as the lower confining bed for the surficial aquifer and as the upper confining bed for the Floridan aquifer. Sections A-A' and B-B' (figs. 1 and 2) show the general lithology in the Tillman Ridge area. Tillman ridge covers about 10 mi^2 in the west-central part of the area of investigation and extends north and south of Florida Highway 214 west of Interstate 95.

Table 1.--Geologic units and their water-bearing characteristics

[Modified from Bentley, 1977]

Geologic age	Geologic unit	Thickness 1/ (ft)	Lithology 1/	Aquifer	Water-bearing characteristics
Holocene and Pleistocene	Surficial deposits	20-90	Discontinuous sand, clay, and shell beds	Surficial aquifer	Locally supply moderate amounts of water to wells.
Pliocene	Undifferentiated marine deposits	20-100	Interbedded lenses of sand, shell, and silty clay		Yields moderate amounts of water to artesian and water table wells. Relatively impermeable clays which serve with those in Hawthorn Formation as confining beds for artesian water in Floridan aquifer.
Miocene	Hawthorn Formation	50-225	Phosphatic sandy clay and marl interbedded with phosphorite pebbles, phosphatic sand, and phosphatic sandy limestone		Yields small to moderate amounts of water to artesian wells. Clays and marls serve as confining beds for artesian water in underlying Eocene formations and basal, sand and limestone beds in Hawthorn Formation.
Late Eocene	Ocala Limestone	120-200	Homogeneous sequence of chalky and granular limestones	Floridan aquifer	Supplies large quantities of water to artesian wells and is the principal source of water in most of northeastern Florida. Yields saline water in the area of investigation.
Middle Eocene	Avon Park Limestone	170-235	Alternating beds of massive granular, and chalky limestone and dense dolomite		Yields saline water in the area of investigation.
	Lake City Limestone	230+			

1/ Variation within study area shown in more detail in figure 2 for the surficial aquifer.

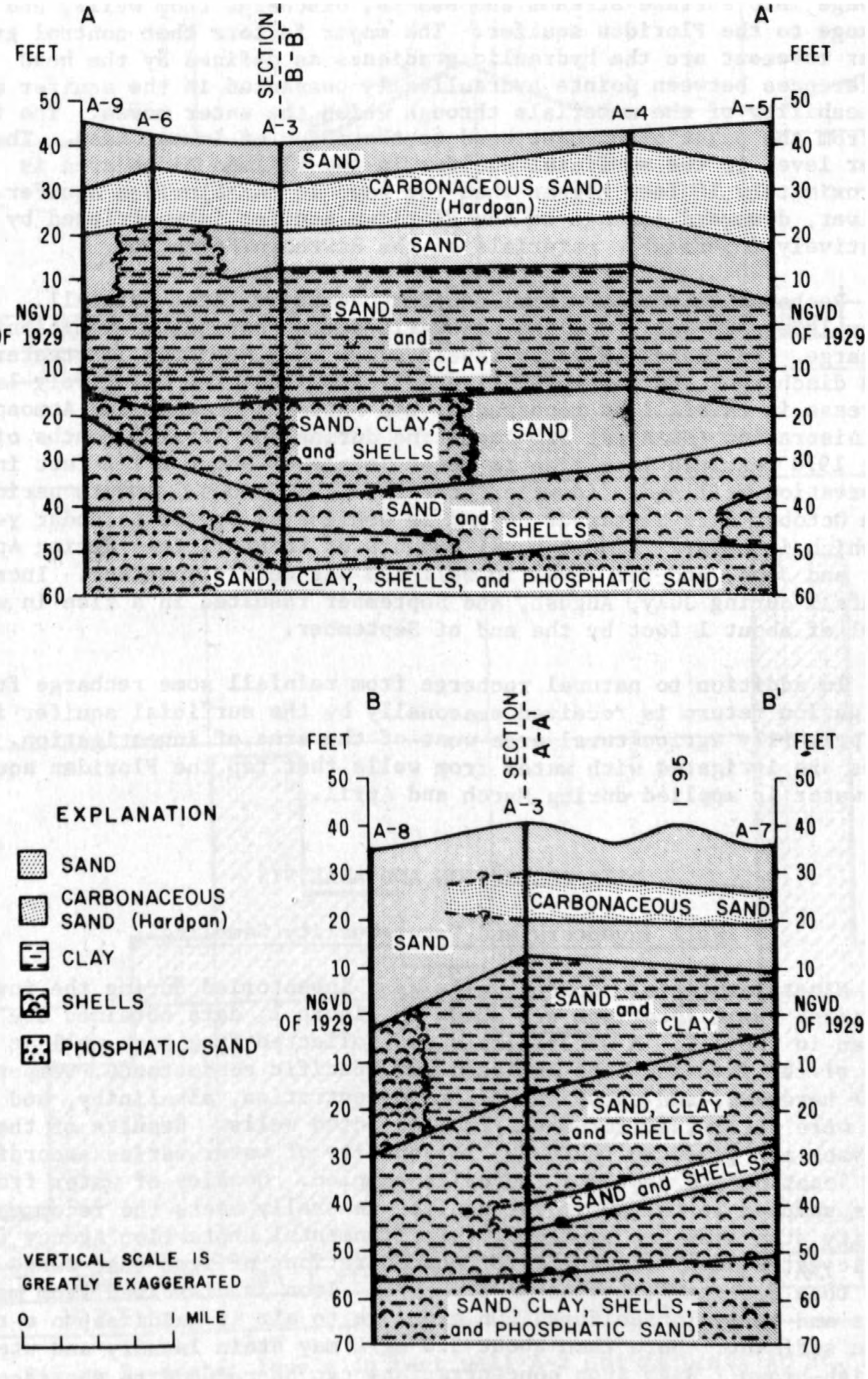


Figure 2.--Lithologic sections in Tillman Ridge area. Location of sections are shown in figure 1.

Discharge from the surficial aquifer occurs by evapotranspiration, seepage into surface streams and swamps, discharge from wells, and leakage to the Floridan aquifer. The major factors that control ground-water movement are the hydraulic gradients as defined by the head differences between points hydraulically connected in the aquifer and the permeability of the materials through which the water moves. The flow is from the point of highest head to the point of lowest head. The water level in the surficial aquifer in the Tillman Ridge area is approximately 10 feet higher than the head in the Floridan aquifer. However, downward leakage to the Floridan aquifer is restricted by the relatively impermeable materials of the Hawthorn Formation.

Recharge to the surficial aquifer occurs by local rainfall. Water levels in wells decline naturally during periods of deficient recharge. Increases in water levels occur when recharge is greater than discharge. For example, figure 3 shows that the relatively large increase in rainfall as reported by the National Oceanic and Atmospheric Administration (NOAA) at St. Augustine during the first 4 months of water year 1978 resulted in a rise in water levels of about 2 1/2 feet in observation well A-3. (A water year is a continuous 12-month period from October 1 to September 30 and is designated by the calendar year in which it ends.) Almost equal amounts of rainfall fell during April, May, and June, and the level in well A-3 was nearly constant. Increased rainfall during July, August, and September resulted in a rise in water level of about 1 foot by the end of September.

In addition to natural recharge from rainfall some recharge from irrigation return is received seasonally by the surficial aquifer in the primarily agricultural area west of the area of investigation. Crops are irrigated with water from wells that tap the Floridan aquifer. The water is applied during March and April.

DATA COLLECTION AND ANALYSIS

Well Inventory and Water-Quality Sampling

Ninety surficial aquifer wells were inventoried during the investigation. Well locations are shown in figure 1; data obtained are listed in table 2. A water sample was collected from each well at the time of the inventory and analyzed for specific conductance, temperature, total hardness, and chloride. Iron concentration, alkalinity, and pH, also were determined for water from selected wells. Results of the analyses are given in table 3. The quality of water varies according to both location and depth of the wells sampled. Quality of water from wells sampled in the surficial aquifer generally meets the recommended quality standards set by the U.S. Environmental Protection Agency for public water supplies except for concentrations of iron that range from less than detectable traces to 3.4 mg/L. Iron is dissolved from many rocks and soils in aquifers. On exposure to air it oxidizes to a reddish-brown sediment. More than about 3.0 mg/L may stain laundry and utensils reddish-brown. High iron concentrations can be reduced to the recommended limit of 0.3 mg/L (U.S. Environmental Protection Agency, 1977) by aeration or chlorination followed by filtration.

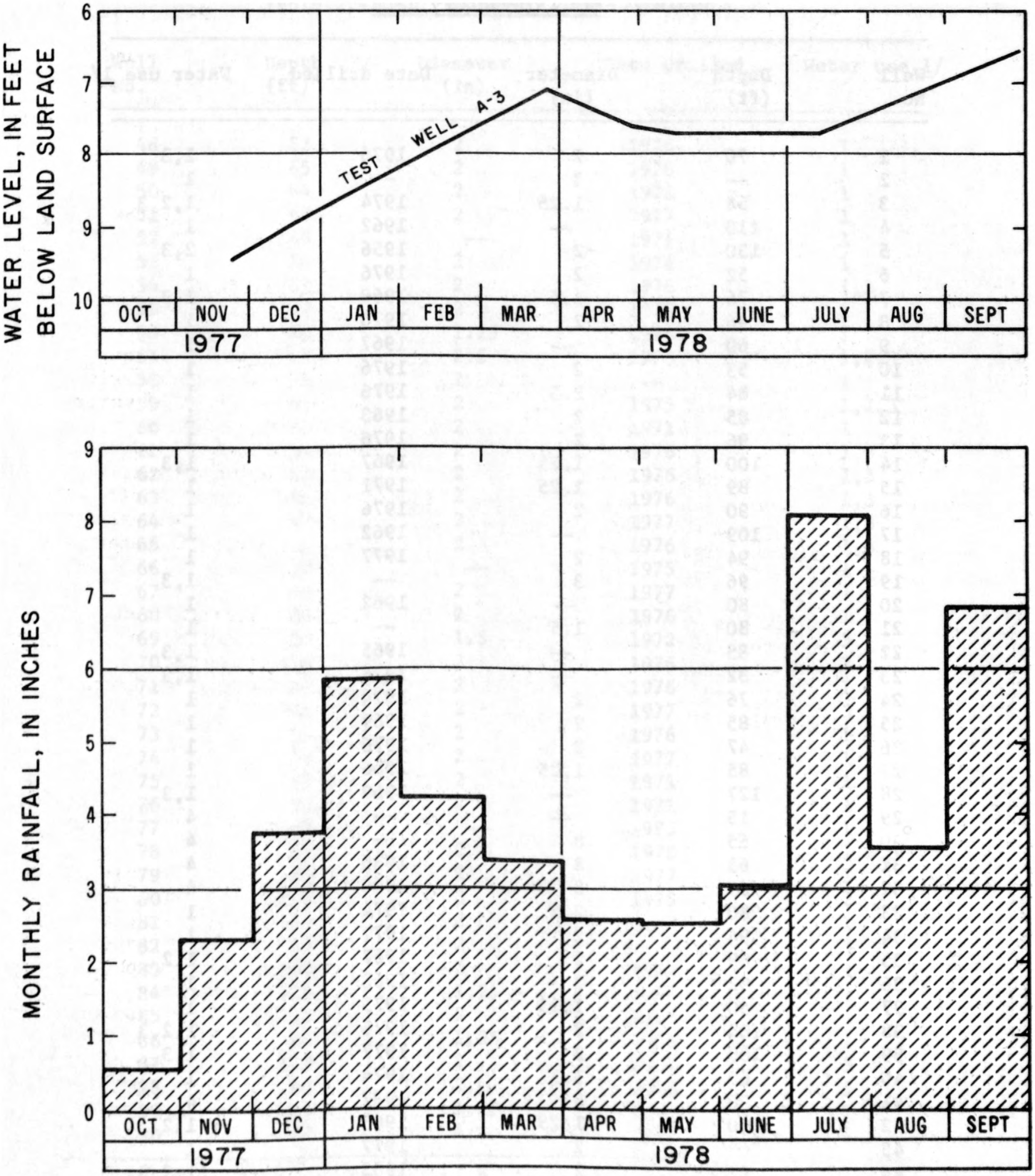


Figure 3.--Water levels in test well A-3 and rainfall at St. Augustine during water year 1978.

Table 2.--Well inventory data

Well No.	Depth (ft)	Diameter (in)	Date drilled	Water use 1/
1	70	2	1976	1,3
2	--	3	--	1
3	54	1.25	1974	1,2,3
4	110	--	1962	1
5	130	2	1956	2,3
6	52	2	1976	1
7	76	1.5	1960	1,3
8	96	2	1970	1
9	60	--	1967	1
10	53	2	1976	1
11	84	2.5	1976	1
12	85	2	1963	1
13	96	2	1976	1
14	100	1.25	1967	1,3
15	89	1.25	1971	1
16	90	2	1976	1
17	109	--	1962	1
18	94	2	1977	1
19	96	3	--	1,3
20	80	--	1962	1
21	80	1.5	--	1
22	85	--	1965	1,3
23	32	--	1976	1,3
24	76	2	1974	1
25	85	2	1969	1
26	47	2	1976	1
27	85	1.25	1966	1
28	127	--	1969	1,3
29	15	--	--	4
30	65	8	--	4
31	65	8	1930	4
32	65	8	1930	4
33	80	2.5	1974	1
34	94	2	1977	1
35	89	2	1967	1,2
36	92	2	1968	1
37	50	1.25	1975	1
38	105	2	1976	1,2,3
39	100	2	1977	1,3
40	60	1.5	1974	1
41	90	8	1937	4
42	80	1.25	1965	1,2
43	63	2	1977	1
44	97	2	1963	1,2,3
45	120	1.5	--	1,2,3
46	90	2	1975	1,3
47	--	--	1957	1

Table 2.--Well inventory data--Continued

Well No.	Depth (ft)	Diameter (in)	Date drilled	Water use 1/
48	57	2	1976	1
49	65	2	1976	1
50	64	2	1976	1
51	60	2	1977	1
52	40	--	1971	1
53	84	2	1976	1
54	63	2	1976	1,3
55	87	2	1976	1
56	80	1.25	1974	1
57	98	2.5	1976	1,2,3
58	75	2	--	1
59	90	2	1975	1,2,3
60	60	2	1971	1
61	57	2	1976	1,3
62	45	2	1976	1,3
63	65	2	1976	1,3
64	87	2	1977	1,3
65	58	2	1976	1,3
66	50	--	1975	1
67	60	2	1977	1
68	80	2	1976	1
69	80	1.5	1972	3
70	54	2	1976	1
71	64	2	1976	1
72	64	2	1977	3
73	56	2	1976	1
74	54	2	1977	1
75	61	2	1971	1
76	55	2	1971	1
77	85	--	1973	1
78	85	2	1970	1,2,3
79	81	2	1977	1
80	100	3	1975	2
81	69	2	--	1
82	97	2	--	3
83	103	3	1952	1
84	115	1.25	1964	1
85	115	2	1975	1
86	80	1.25	1955	1
87	110	2	1951	3
88	63	2	1976	1
89	84	1.25	--	1
90	87	4	1977	4

1/ 1, Domestic; 2, Livestock; 3, Irrigation; 4, Other.

Table 3.--Analyses of water samples collected during well inventory

Well No.	Specific conductance (umho/cm at 25°C)	Chloride (mg/L)	Total hardness (mg/L)	Temperature (°C)	Iron (mg/L)	Alkalinity as $CaCO_3$ (mg/L)	pH
1	700	28	330	23.0	--	--	--
2	730	41	330	20.5	--	--	--
3	810	53	310	22.0	--	--	--
4	770	37	330	22.0	--	--	--
5	650	28	240	22.0	--	--	--
6	740	38	350	21.5	--	--	--
7	810	43	370	22.0	--	--	--
8	740	36	330	22.5	--	--	--
9	760	49	330	22.2	--	--	--
10	800	56	330	--	--	--	--
11	890	63	370	24.0	--	--	--
12	870	63	250	23.0	--	--	--
13	780	48	300	22.5	--	--	--
14	1,400	200	480	22.5	--	--	--
15	620	20	270	23.0	--	--	--
16	580	14	270	22.0	--	--	--
17	730	41	340	--	--	--	--
18	720	39	340	24.0	--	--	--
19	700	26	320	23.0	--	--	--
20	700	31	320	24.0	--	--	--
21	770	35	330	22.5	--	--	--
22	680	31	300	23.0	--	--	--
23	240	--	--	21.0	--	--	--
24	880	55	380	22.0	--	--	--
25	770	32	290	--	--	--	--
26	810	45	370	--	--	--	--
27	800	41	380	22.5	--	--	--
28	840	58	360	--	--	--	--
29	840	25	360	--	--	--	--
30	920	30	460	21.0	--	--	--
31	1,200	30	620	20.5	--	--	--
32	1,000	38	500	20.5	--	--	--
33	810	48	370	23.0	--	--	--
34	860	55	340	22.0	--	--	--
35	850	55	360	21.8	--	--	--
36	780	48	320	21.7	--	--	--
37	840	75	350	22.0	--	--	--
38	630	41	270	21.5	--	--	--
39	710	27	350	22.0	0.8	--	--
40	750	32	360	21.8	--	--	--
41	840	40	390	21.0	--	--	--
42	710	33	300	23.0	--	--	--
43	710	29	330	22.0	--	--	--
44	720	34	330	23.0	--	--	--
45	720	42	320	23.0	.8	--	--
46	720	58	250	22.2	.7	340	7.2
47	160	--	--	21.5	--	--	--
48	620	18	240	21.7	--	--	--
49	590	18	230	22.0	.4	280	7.2

Table 3.--Analyses of water samples collected during well inventory--Continued

Well No.	Specific conductance (umho/cm at 25°C)	Chloride (mg/L)	Total hardness (mg/L)	Temperature (°C)	Iron (mg/L)	Alkalinity as $CaCO_3$ (mg/L)	pH
50	640	21	270	22.8	1.4	170	7.2
51	410	24	180	22.5	1.4	170	7.2
52	370	35	170	22.5	--	--	--
53	760	46	350	22.5	0	360	7.1
54	490	25	240	22.8	1.5	250	7.1
55	880	50	390	23.7	--	--	--
56	520	16	280	26.0	.7	280	7.1
57	480	20	250	22.2	.3	250	7.2
58	570	17	280	23.0	.4	290	7.2
59	640	24	340	24.0	.4	330	7.1
60	320	23	150	22.5	.3	140	7.4
61	570	30	290	23.0	--	--	--
62	540	24	280	21.5	--	--	--
63	300	23	140	22.5	--	--	--
64	560	52	260	22.0	--	--	--
65	540	33	250	22.0	--	--	--
66	550	38	280	22.0	--	--	--
67	480	21	250	22.0	--	--	--
68	520	41	250	22.2	--	--	--
69	420	30	190	23.0	--	--	--
70	370	68	180	23.5	--	--	--
71	320	28	140	23.0	--	--	--
72	410	28	190	23.0	--	--	--
73	380	28	180	22.5	--	--	--
74	180	13	80	26.0	.2	66	8.1
75	490	14	250	26.6	--	--	--
76	760	63	360	24.0	1.6	360	6.9
77	640	44	300	23.5	.6	290	7.2
78	690	60	280	26.0	1.6	300	7.0
79	170	--	--	26.0	1.4	9.5	5.1
80	730	78	290	23.0	1.3	290	7.0
81	760	65	270	24.0	--	--	--
82	1,200	180	370	26.0	--	--	--
83	780	58	360	21.7	1.7	--	--
84	540	42	280	22.0	1.4	--	--
85	640	31	290	22.0	.5	--	--
86	140	--	--	22.0	1.2	--	--
87	420	--	--	22.0	1.3	--	--
88	640	38	300	21.5	1.2	--	--
89	600	--	--	20.0	3.4	--	--
90	--	30	390	--	--	310	--
Maximum	1,380	200	620	26.6	3.4	360	8.1
Minimum	140	13	80	20.0	0	9.5	5.1

Test Drilling

Of the 12 test wells drilled for additional geologic and ground-water information, 9 were drilled on the Tillman Ridge and 3 to the east (fig. 1). Eleven of the wells are 2 inches in diameter and were drilled by the jet-percussion (jet-drive) method. The other well is 4 inches in diameter and was drilled by the hydraulic rotary-drilling method. Rock cuttings were collected from all of the test wells and examined to obtain geologic information needed to construct lithologic sections of the Tillman Ridge area. The sections are shown in figure 2. Water-quality and water-bearing characteristics of deposits were also determined from data gathered during and after the test drilling operations.

Water-bearing zones were test pumped during drilling operations by inserting a well screen into the jetted-out hole ahead of the well casing. A summary of information obtained at each test well is listed in table 4. Wells were drilled to the top of the Hawthorn Formation. Well depths ranged from 83 to 108 feet. Productive zones in the surficial aquifer were located at depths ranging from 20 to 100 feet. Yields of the water producing zones ranged from less than 1 to 42 gal/min. Well yields were lowest in areas where large amounts of clay and fine sand were present in the aquifer. Although yields were low from some of the wells in the Tillman Ridge area, most of the wells in which the yields of individual zones exceeded 20 gal/min were in the vicinity of Tillman Ridge.

Aquifer Test and Predicted Drawdown Distribution

An aquifer test was made using a 4 inch diameter production well in the Tillman Ridge area. The well (No. 90, fig. 1, table 2) was pumped with a portable suction pump at a rate of about 340 gal/min for approximately 8 hours. Water-level measurements were made in test wells A-11 and A-3, 55 and 550 feet, respectively, from the pumped well. A transmissivity of approximately 6,500 to 7,000 ft^2/d was determined from data obtained from the three wells. This value of transmissivity probably represents the more highly productive section of the ridge area. An aquifer with a transmissivity on the order of 1,400 ft^2/d or more can usually provide well yields adequate for industrial, municipal, or irrigation use, (Johnson, 1966, p. 102).

A valid storage coefficient could not be determined for the surficial aquifer from the aquifer test. Aquifer conditions change gradually from locally confined (artesian) to unconfined (water table) to the west of the test area. In addition, within the time of the 8-hour test, the presence of the hardpan layer within several feet of the water table resulted in retardation of drainage at the water table. Because of this, the aquifer responded like a confined aquifer rather than an unconfined aquifer during the short test. However, under longer pumping conditions, an unconfined response should prevail. Storage coefficients generally range from $1x10^{-5}$ to $1x10^{-3}$ for artesian aquifers and $5x10^{-2}$ to $3x10^{-1}$ for water table aquifers (Ferris and others, 1962, p.76, 78).

Table 4.--Information obtained from test wells drilled by U.S. Geological Survey during 1977-78

[Casing diameters, 2 inch, except 4 inch in A-12]

Well No.	Land surface altitude[1] (ft)	Total depth[2] (ft)	Casing depth[2] (ft)	Test information			
				Zone[2] (ft)	Water level[2] (ft)	Yield (gal/min)	Iron, dissolved (mg/L)
A-1	35	108	74	20-25	14.44	15	0.45
				74-99	13.88	7	--
A-2	35	99	74	41-46	6.40	12	.8
				62-67	9.56	4.5	--
				74-89	7.79	17	.45
A-3	41	99	77	67-77	9.82	42	.7
				77-78	10.42	15	.45
A-4	43	94	80	61-71	4.54	30	.9
				80-90	4.31	40	1.1
A-5	45	104	72	73-83	7.04	9	1.0
A-6	41	84	72	72-82	8.60	22	1.2
A-7	36	91	82	50-55	4.42	4	1.1
				82-90	1.34	25	1.0
A-8	35	105	70	47-52	2.47	35	.8
				70-80	3.82	1	--
A-9	45	100	83	62-67	3.39	6	--
				83-100	6.14	1	--
A-10	46	99	83	83-99	6.93	1	--
A-11	43	83	62	62-82	8.99	22	.8
A-12	43	90	69	69-89	7.08	30	1.0

[1]Estimated from topographic map.

[2]Depth below land surface.

Aquifer coefficients can be used to estimate or predict the drawdown in the aquifer at various distances from a pumped well and drawdown at any time in a well after pumping began. The distance-drawdown curves (fig. 4) were developed by using the transmissivity (7,000 ft^2/d) determined from the aquifer test, and selected pumping rates of 100, 200, and 300 gal/min for a pumping period of 180 days. The aquifer is expected to respond as a water table aquifer within this pumping period; therefore, a value of 0.2 was selected for the storage coefficient. Figure 4 shows that a single well pumping at a rate of 200 gal/min would produce drawdowns at a distance of 100 and 1,000 feet from the pumped well of approximately 3.2 and 1.2 feet, respectively. Other values of pumping rates and periods can also be selected to develop additional distance-drawdown relationships which are useful for estimating mutual well interferences.

CONCLUSIONS

The surficial aquifer is the principal source of freshwater in the area of investigation. The undifferentiated deposits of sand and shells contain freshwater that, if treated, could provide a reliable supply to help satisfy the future water demands of St. Johns County.

Data from twelve test wells drilled in the study area indicate that the confining beds and productive zones in the surficial aquifer are discontinuous. The area with the best water-supply potential is on Tillman Ridge in the west-central part of the area of investigation. Within this area of approximately 10 mi^2, individual zones in 2-inch wells produce as much as 42 gal/min from shell beds. Well yields are less in areas where large amounts of fine sand and clay are present in the aquifer. The less productive areas can also be utilized for water supplies by proper well construction and development.

A transmissivity of 7,000 ft^2/d determined from an aquifer test was used to develop distance-drawdown curves (fig. 4). A single well pumping at a rate of 200 gal/min would produce drawdowns of about 3.2 and 1.2 feet at a distance of 100 and 1,000 feet from the pumped well, respectively. Other values of drawdown at various distances for selected pumping rates can also be determined.

This information can be used to aid the county in future development of a water supply from the surficial aquifer. The Tillman Ridge area is probably the best source of good quality water that would be adequate for development of a relatively large water supply.

In order to further assess the county's water supplies, additional information is required. For example, information on the quantity and quality of water available from both the surficial aquifer and the Floridan aquifer in the remainder of the county could be provided by an expanded investigation. Also, a series of maps showing recharge areas, water-well yields, water-use information, and water-quality information would be useful to local agencies and potential developers as a planning tool to develop additional water resources.

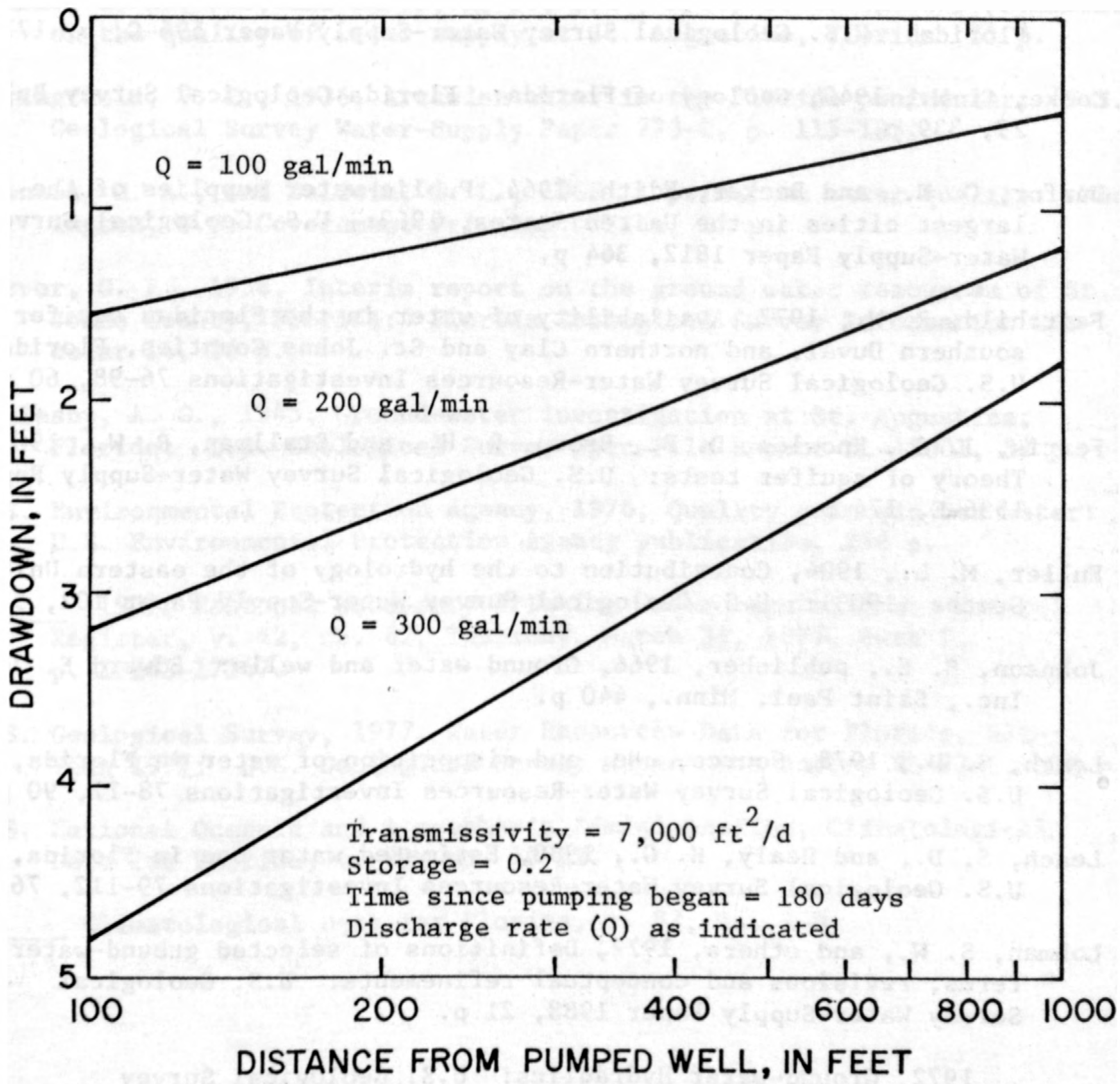


Figure 4.--Steady-state distance-drawdown curves for the surficial aquifer using selected aquifer characteristics.

SELECTED REFERENCES

Bentley, C. B., 1977, Aquifer test analyses for the Floridan aquifer in Flagler, Putnam, and St. Johns Counties, Florida, 1977: U.S. Geological Survey Water-Resources Investigations 77-36, 50 p.

Bermes, B. J., Leve, G. W., and Tarver, G. R., 1963, Geology and ground-water resources of Flagler, Putnam and St. Johns Counties, Florida: Florida Geological Survey Report of Investigations No. 32, 97 p.

Collins, W. D., and Howard, C. S., 1928, Chemical character of water of Florida: U.S. Geological Survey Water-Supply Paper 596-G, p. 177-233.

Cooke, C. W., 1945, Geology of Florida: Florida Geological Survey Bulletin 29, 339 p.

Durfor, C. N., and Becker, Edith, 1964, Public water supplies of the 100 largest cities in the United States, 1963: U.S. Geological Survey Water-Supply Paper 1812, 364 p.

Fairchild, R. W., 1977, Availability of water in the Floridan aquifer in southern Duval, and northern Clay and St. Johns Counties, Florida: U.S. Geological Survey Water-Resources Investigations 76-98, 60 p.

Ferris, J. G., Knowles, D. B., Brown, R. H., and Stallman, R. W., 1962, Theory of aquifer tests: U.S. Geological Survey Water-Supply Paper 1536-E, 174 p.

Fuller, M. L., 1904, Contribution to the hydrology of the eastern United States (1903): U.S. Geological Survey Water-Supply Paper 102, 552 p.

Johnson, E. E., publisher, 1966, Ground water and wells: Edward E. Johnson, Inc., Saint Paul, Minn., 440 p.

Leach, S. D., 1978, Source, use, and disposition of water in Florida, 1975: U.S. Geological Survey Water-Resources Investigations 78-17, 90 p.

Leach, S. D., and Healy, H. G., 1980, Estimated water use in Florida, 1977: U.S. Geological Survey Water-Resources Investigations 79-112, 76 p.

Lohman, S. W., and others, 1972, Definitions of selected ground-water terms, revisions and conceptual refinements: U.S. Geological Survey Water-Supply Paper 1988, 21 p.

______ 1972, Ground-water Hydraulics: U.S. Geological Survey Professional Paper 708, 70 p.

Matson, G. C., and Sanford, Samuel, 1913, Geology and ground waters of Florida: U.S. Geological Survey Water-Supply Paper 319, 445 p.

Sellards, E. H., 1907, Occurrence and use of artesian water: Agricultural Experiment Station Bulletin 89, p. 113

Sellards, E. H., and Gunter, Herman, 1910, The artesian water supply of eastern Florida: Florida Geological Survey 3rd Annual Report, p. 77-175.

_____ 1913, The artesian water supply of eastern and southern Florida: Florida Geological Survey 5th Annual Report, p. 103-306.

Simons, G. W., Jr., and Black, A. P., 1927, A report to the City Commission on the quality of water supply at St. Augustine, Florida: 51 p.

Stringfield, V. T., 1936, Artesian water in the Florida peninsular: U.S. Geological Survey Water-Supply Paper 773-C, p. 115-195.

Swenson, H. A., and Baldwin, H. L., 1965, A primer on water quality: Washington, U.S. Government Printing Office, 27 p.

Tarver, G. R., 1958, Interim report on the ground water resources of St. Johns County, Florida: Florida Geological Survey Information Circular 14, 36 p.

Unklesby, A. G., 1945, Ground-water investigation at St. Augustine, Florida: U.S. Geological Survey Open-File Report FL-45001, 57 p.

U.S. Environmental Protection Agency, 1976, Quality criteria for water: U.S. Environmental Protection Agency publication, 256 p.

_____ 1977, National secondary drinking water regulations: Federal Register, v. 42, no. 62, Thursday, March 31, 1977, Part I, p. 17143-17147.

U.S. Geological Survey, 1977, Water Resources Data for Florida, Water Year 1977: U.S. Geological Survey Water-Data Report FL-77-4, 578 p.

U.S. National Oceanic and Atmospheric Administration, Climatological Data for Florida, v. 81, no. 10-12.

_____ Climatological Data for Florida, v. 82, no. 1-9.

☆U.S. GOVERNMENT PRINTING OFFICE: 1981-740-127/26