THE SURFICIAL AQUIFER IN PINELLAS COUNTY, FLORIDA

By K. W. Causseaux

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Multiply	By	To obtain
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square foot (ft^2)	0.0929	square meter (m^2)
square mile (mi^2)	2.590	square kilometer (km^2)
gallon (gal)	3.785 0.003785	liter (L) cubic meter (m^3)
gallon per minute (gal/min)	0.00006309	cubic meter per second (m^3/s)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
gallon per minute per foot [(gal/min)/ft]	0.001152	cubic meter per minute per meter [(m^3/min)/m]

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By K. W. Causseaux

ABSTRACT

The surficial aquifer in Pinellas County is a potential source of water to augment the public supply that is presently imported from adjacent counties. The county accounts for 38 percent of the public supply consumption of ground water in the 11-county area of west-central Florida, and 68 percent of this water is imported from two adjacent counties. Because of continued population growth and dependence on outside sources of water, consideration of alternate sources of water is of prime importance. Use of the surficial aquifer for nonpotable uses such as lawn irrigation would reduce consumption of public water supply and supplement overall water resources of the county.

The surficial aquifer consists of sand or shelly sand and has a saturated thickness of more than 30 feet throughout most of the county. The aquifer is at least 40 feet thick along most of the Pinellas Ridge and more than 80 feet thick in the western part of the city of St. Petersburg. In most of the county, the aquifer is separated from the underlying Floridan aquifer by a confining bed that ranges in thickness from less than 25 feet in the north to about 100 feet in the south.

The water table ranges from near sea level along the coast to 80 feet above sea level along the Pinellas Ridge in the northern part of the county. The depth to water table is generally less than 5 feet below land surface, but ranges from at or near land surface along the coast and in flat, poorly drained areas to more than 10 feet in topographically high, well-drained areas. Seasonal fluctuations range from about 1 to 4 feet.

Pumping tests conducted at eight sites indicate that specific capacity per foot of screen for screened wells is less than 0.1 gallon per minute per foot of drawdown in some parts of the county. However, the well yield is sufficient in most of the county for lawn irrigation use. Potential yields of small diameter wells vary from 5 gallons per minute in the northern part of the county to more than 30 gallons per minute in the south.

The dissolved mineral content of water from the surficial aquifer varies greatly, but the water generally is of acceptable quality for most uses. Chloride concentrations are less than 100 milligrams per liter in most of the county and do not pose a problem for uses such as lawn irrigation. Concentrations of iron in the water range from less than 0.1 to 9.0 milligrams per liter and are high enough in parts of the county to cause staining.

INTRODUCTION

Pinellas County, on the west coast of central Florida (fig. 1), is the most densely populated county in Florida. The population of the county increased from about 375,000 in 1960 to about 728,000 in 1980. Continued population growth is expected because of increasing industrialization and the area's popularity for retirement living and tourism. By the year 2000, the population of the county is expected to exceed one million (University of Florida, 1982). Associated with continued growth will be an increasing demand for potable water.

Pinellas County is the largest user of water for public supply in west-central Florida. In 1981, the county used about 103 Mgal/d of ground water for public supply, or 38 percent of that used in the 11-county coastal area of west-central Florida. About 68 percent of this water was imported from well fields in neighboring Hillsborough and Pasco Counties. An alternative source of water would enable the county to reduce its dependency on imported water.

Pinellas County needs to develop additional or supplemental sources of water within its boundary to reduce withdrawals from the Floridan aquifer in adjacent counties. The Floridan aquifer in Pinellas County is a limited resource because of existing or potential saltwater intrusion. However, the surficial aquifer could be developed as a supplemental water resource.

Purpose and Scope

The U.S. Geological Survey, in cooperation with Pinellas County, began a 2-year investigation in 1980 on the hydrogeology of the surficial aquifer. Major objectives of the investigation were to determine (1) extent, thickness, and yield of the surficial aquifer; (2) depth to and seasonal fluctuations of the water table; (3) water chemistry of the surficial aquifer; and (4) potential of the surficial aquifer as a supplemental source of water, specifically as a source for lawn irrigation and other nonpotable uses.

This report presents the results of that investigation. It contains information on (1) the hydrogeology of the surficial aquifer, including hydraulic properties, saturated thickness, depth to the water table, and seasonal fluctuations of the water table; (2) chloride and iron concentrations of water in the surficial aquifer; and (3) description of the surficial aquifer's potential for development as a supplemental source of water. This information is based on data collected during this investigation and that obtained from unpublished data in the files of the U.S. Geological Survey, Pinellas County, the Southwest Florida Water Management District, the Florida Bureau of Geology, and private industry and from previously published reports.

Previous Investigations

The ground-water resources and geology of Pinellas County have been discussed in previous reports by the U.S. Geological Survey and the Florida Bureau of Geology. A report by Stringfield (1933) gives a general discussion of the

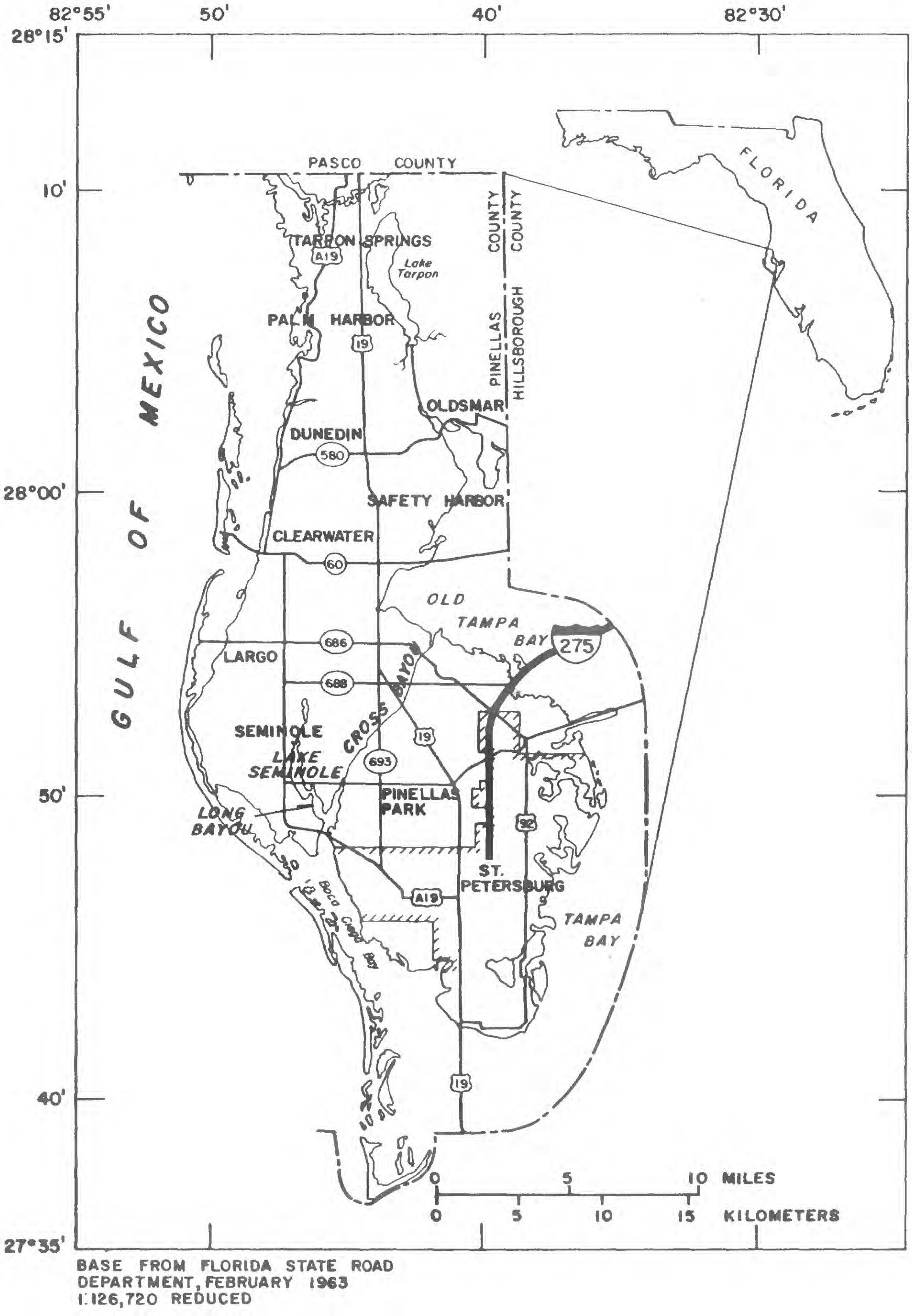

Figure 1.--Location of Pinellas County.

occurrence of ground water in the county and problems that need investigation. The geology of the area was described by Cooke (1945). Heath and Smith (1954) described the ground-water resources of Pinellas County, including a discussion on the hydrogeology of the surficial aquifer. Cherry (1966) discussed the chloride content of ground water at selected depth intervals within the county and noted that no significant saltwater encroachment had occurred during the period 1950 to 1963.

Cherry and others (1970) described the general hydrology of the middle-Gulf area that includes Pinellas County. Hickey (1981; 1982) discussed the hydrogeology of the surficial aquifer in Pinellas County in his reports on subsurface wastewater injection in the Tampa Bay area.

Several reports that describe the local hydrogeology and changes in the quality of ground water in the surficial aquifer caused by disposal of refuse and treated sewage at several sites in the county have been published by the U.S. Geological Survey and the Florida Bureau of Geology. These are included in the references at the end of this report.

DESCRIPTION OF AREA

Pinellas County has a total area of about 439 mi^2, of which 264 mi^2 is land. The mainland is about 32 miles long and ranges from 5 to 15 miles in width. The southern part of the county forms a peninsula that separates Old Tampa Bay and Tampa Bay from the Gulf of Mexico. The county has about 128 miles of coastline.

Topography and Drainage

Pinellas County lies in the nearly flat Gulf Coastal Lowlands physiographic division (Puri and Vernon, 1964, p. 13). According to Heath and Smith (1954, p. 6) and Vernon (1951, p. 16), the county is divided into the hilly uplands, a flat upland, and level lowlands (fig. 2).

The hilly uplands are dominated by the Pinellas Ridge that extends from Seminole northward to Palm Harbor. The ridge consists of gently rolling hills and closed drainage systems that contain small lakes and water filled sinkholes. Altitudes on the ridge range from about 40 to 100 feet above sea level. Numerous small creeks drain the eastern and western parts of the ridge.

The western slopes of the Pinellas Ridge are drained by Curlew, Stevenson, and McKay Creeks and other small streams that flow directly into the Intracoastal Waterway or the Gulf of Mexico. Small streams that drain the eastern slopes and flow into Old Tampa Bay include Allen and Alligator Creeks. Most of these streams have small drainage basins, short channel lengths, and are tidally affected in their lower reaches. The southeastern part of the ridge drains through Lake Seminole and Long Bayou into Boca Ciega Bay.

The flat upland area in the southern part of Pinellas County has low relief and a maximum altitude of about 50 feet above sea level. It is roughly circular in shape and has a diameter of about 5 miles.

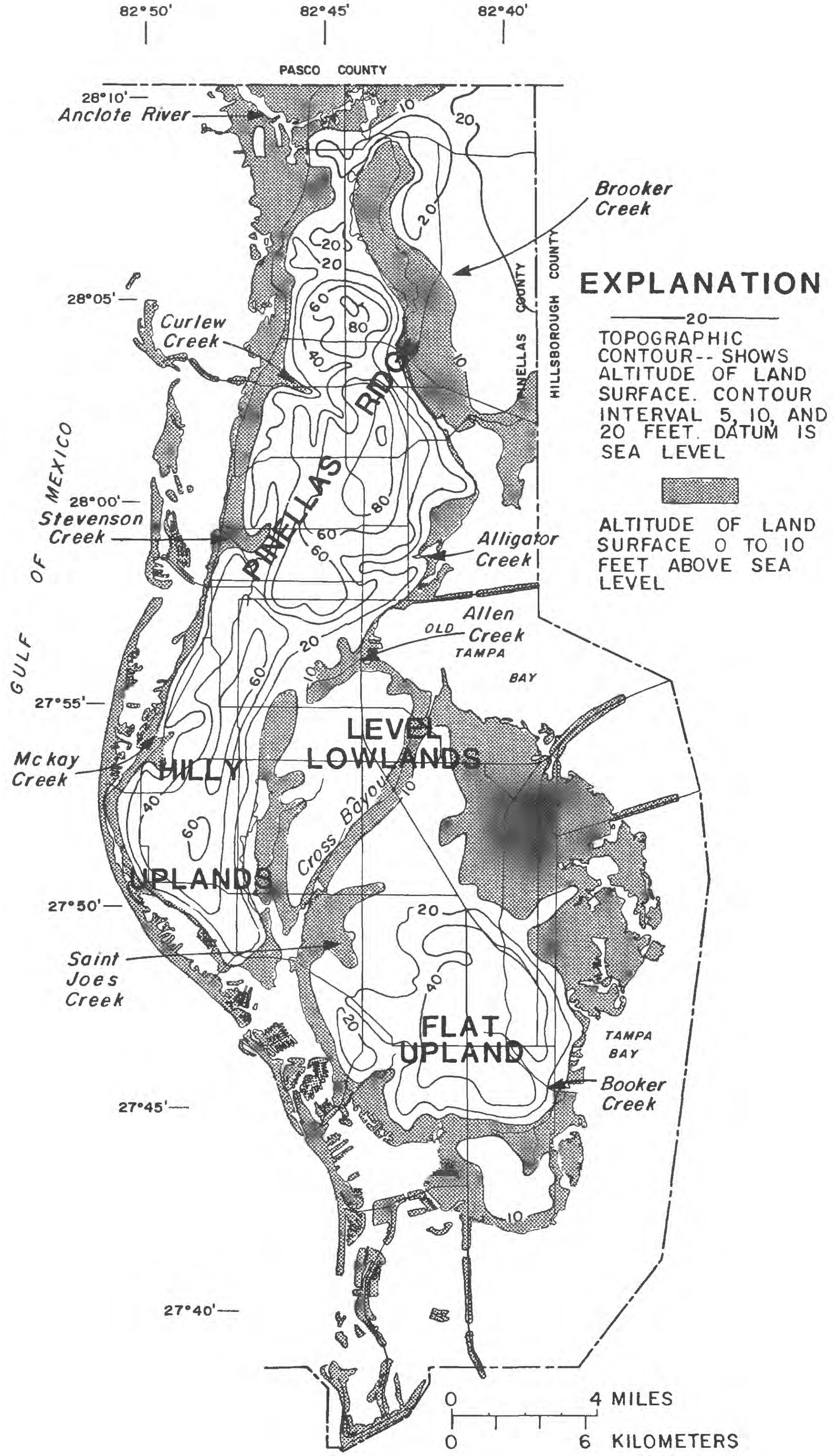

Figure 2.--Topography of Pinellas County (data from U.S. Geological Survey 7-1/2-minute quadrangle maps).

Level lowlands surround the flat upland and the hilly uplands. These lowlands are most extensive north and west of St. Petersburg and south and east of Lake Tarpon. The flat upland and level lowlands near St. Petersburg are separated from the Pinellas Ridge by Cross Bayou that drains the level lowlands north of Pinellas Park. Cross Bayou receives runoff from St. Joes Creek that drains the western part of St. Petersburg. Some runoff from the flat upland drains eastward through Booker Creek into Tampa Bay.

The northern part of the county is drained by the Anclote River. The river rises in south-central Pasco County and flows westward to the Gulf of Mexico. The river is tidally affected in much of its lower reach, and during periods of low flow, saltwater extends about 11 miles upstream into Pasco County (Coble, 1973). Brooker Creek drains the northeastern lowlands of the county. The creek rises in northwestern Hillsborough County and flows generally westward to Lake Tarpon.

Climate

The subtropical climate of the county is characterized by warm, humid summers and mild, relatively dry winters. The average annual rainfall for 1952-81 ranged from 51.6 inches at Tarpon Springs to 54.7 inches at St. Petersburg, but the annual rainfall is highly variable. For example, annual rainfall at St. Petersburg has ranged from 32.6 inches in 1966 to 87.6 inches in 1959. Annual rainfall was below average 8 of 12 years during 1970-81.

More than half of the annual rainfall occurs during the wet season of June through September, usually in the form of convective thunderstorms. From June through November, the county may be subjected to tropical depressions or hurricanes; associated with these storms is heavy rainfall that may exceed 15 inches in a relatively short period of time (3 to 5 days).

Evapotranspiration in Pinellas County is estimated to be 39 inches per year (Cherry and others, 1970, p. 71) and about 60 percent occurs from May to October. Average annual lake evaporation is estimated to be about 50 to 52 inches per year (Visher and Hughes, 1975).

HYDROGEOLOGIC FRAMEWORK

Pinellas County is underlain by a sequence of sedimentary rocks whose lithology and structure control the occurrence and movement of ground water. Table 1 shows the sequence of geologic formations and hydrogeologic units penetrated by water wells in Pinellas County. The principal rock types that underlie the county are (1) unconsolidated sand, clay, and marl and (2) limestone and dolomite. Sand, clay, and marl are the principal sediments in the upper part of the section in middle Miocene and younger rocks. Water in these deposits occurs in primary openings within the spaces between grains that comprise the deposits. Limestone and dolomite are the dominant rock types in the lower part of the section in lower Miocene to upper Eocene rocks. Water in these rocks occurs and moves principally in secondary openings, including joints, openings along bedding planes, and pores that commonly have been enlarged from solution by ground water.

Table 1.--Relation of geologic formations and geohydrologic units

[Modified from Heath and Smith (1954) and Hickey (1981)]

Geologic formation	Geologic age	Approximate thickness (feet)	Lithology	Geohydrologic unit
Undifferentiated surficial deposits	Pleistocene	0-90	Fine to medium sand, minor to abundant shell, gray to white, tan, phosphatic, some limestone.	Surficial aquifer
	Unconformity			
Hawthorn Formation	Middle Miocene	0-100	Calcareous clay or marl, sandy, greenish gray.	Confining bed
	Unconformity			
Tampa Limestone	Early Miocene	0-25	Stiff clay, dark green, with minor to abundant sandy limestone fragments.	
		75-150	Sandy limestone, fossiliferous, white to light tan, chert fragments.	Upper part of Floridan aquifer

All rock units underlying the county are permeable to some degree, but their water-yielding properties differ considerably. They have been classified hydrogeologically as aquifers or confining beds. An aquifer is a formation, group of formations, or part of a formation that contains sufficient permeable material to yield significant quantities of water to wells and springs. A confining bed is a body of impermeable material stratigraphically adjacent to one or more aquifers (Lohman, 1972).

In Pinellas County, two aquifers have been identified--the surficial aquifer and the Floridan aquifer (Parker and others, 1955; Hickey, 1981). The unconsolidated deposits of the surficial aquifer overlie sandy clay and marl of the Hawthorn Formation and Tampa Limestone of middle and early Miocene age, respectively. The sandy clay and marl comprise the upper confining unit of the Floridan aquifer. The thickness of the confining bed ranges from less than 25 feet in the northern part of the county to about 100 feet in the southern part (Hickey, 1981, p. 17). The confining bed restricts vertical movement of water between aquifers and generally causes the water in the Floridan aquifer to be under confined (artesian) conditions.

The top of the Floridan aquifer is considered by Hickey (1981, p. 10) to be the top of the persistent carbonate sequence below which clay, marl, and sand make up only a very small percentage of the rocks. The upper part of the aquifer probably is the Tampa Limestone. The base of the aquifer in Pinellas County is considered to be where intergranular gypsum first occurs in the limestone below a dark brown dolomite (Hickey, 1981, p. 18).

SURFICIAL AQUIFER

The surficial aquifer consists of Pleistocene deposits (Heath and Smith, 1954) of sand and shelly sand that range in thickness from a few feet along the Gulf Coast and northern part of the county to more than 90 feet in the extreme northeastern and southern parts of the county. These deposits vary in composition both laterally and vertically. In most areas, the sand and shelly sand of the surficial aquifer grade downward to a sandy clay or marl with some interbedding of clay. Near the surface, the sand commonly contains a mixture of organic material and silt that form a hardpan. This hardpan occurs at depths of about 5 to 10 feet and acts as a semiconfining bed that restricts the vertical movement of water. In some areas, a gray to white, sandy, phosphatic limestone forms the base of the surficial aquifer. In much of the Clearwater-Dunedin area, an organically rich, very fine-grained, dark brown to black sand occurs near the base of the surficial aquifer.

The saturated thickness of the surficial aquifer ranges from less than 20 feet to about 90 feet and is more than 30 feet thick throughout most of the county (fig. 3). The saturated thickness generally increases from 20 to 30 feet in the central part of the county in the Clearwater-Dunedin area to 50 to 60 feet in the northeast and to 50 to 90 feet in the south.

Hydraulic Properties

The hydraulic properties of the surficial aquifer vary greatly because of variation in types of material that comprise the aquifer; its physical characteristics, such as grain size and sorting; and thickness of the saturated zone. Little information is available on the hydraulic properties of the surficial aquifer; however, certain properties, such as hydraulic conductivity and specific yield, can be estimated by comparing the type of material with laboratory measurements of hydraulic conductivity and specific yield and aquifer tests run on similar materials in nearby areas.

The hydraulic conductivity of an aquifer is a measure of its capacity to transmit water and is defined as the volume of water that will move, in unit time under a unit hydraulic gradient, through a unit area of the aquifer measured at right angles to the direction of flow. Transmissivity, which is equivalent to the hydraulic conductivity multiplied by the saturated thickness of the aquifer, is defined as the rate at which water is transmitted through a unit width of aquifer under a unit hydraulic gradient. Specific yield is a measure of the water-yielding capacity of an aquifer and is defined as the ratio of the volume of water that a unit volume of aquifer will yield by gravity to the volume of the aquifer unit.

Estimates of hydraulic conductivity and range in specific yield of materials ranging from sand to gravel are shown in table 2. The hydraulic conductivity for a fine-grained sand is about 15 ft/d and for a medium-grained sand is about 50 ft/d. Assuming a saturated thickness of 20 feet and a hydraulic conductivity of 15 ft/d, an estimated transmissivity for a fine-grained sand would be 300 ft^2/d and for a medium sand would be 1,000 ft^2/d. The hydraulic conductivity for a coarse sand or fine gravel, similar to shelly sands found in Pinellas County,

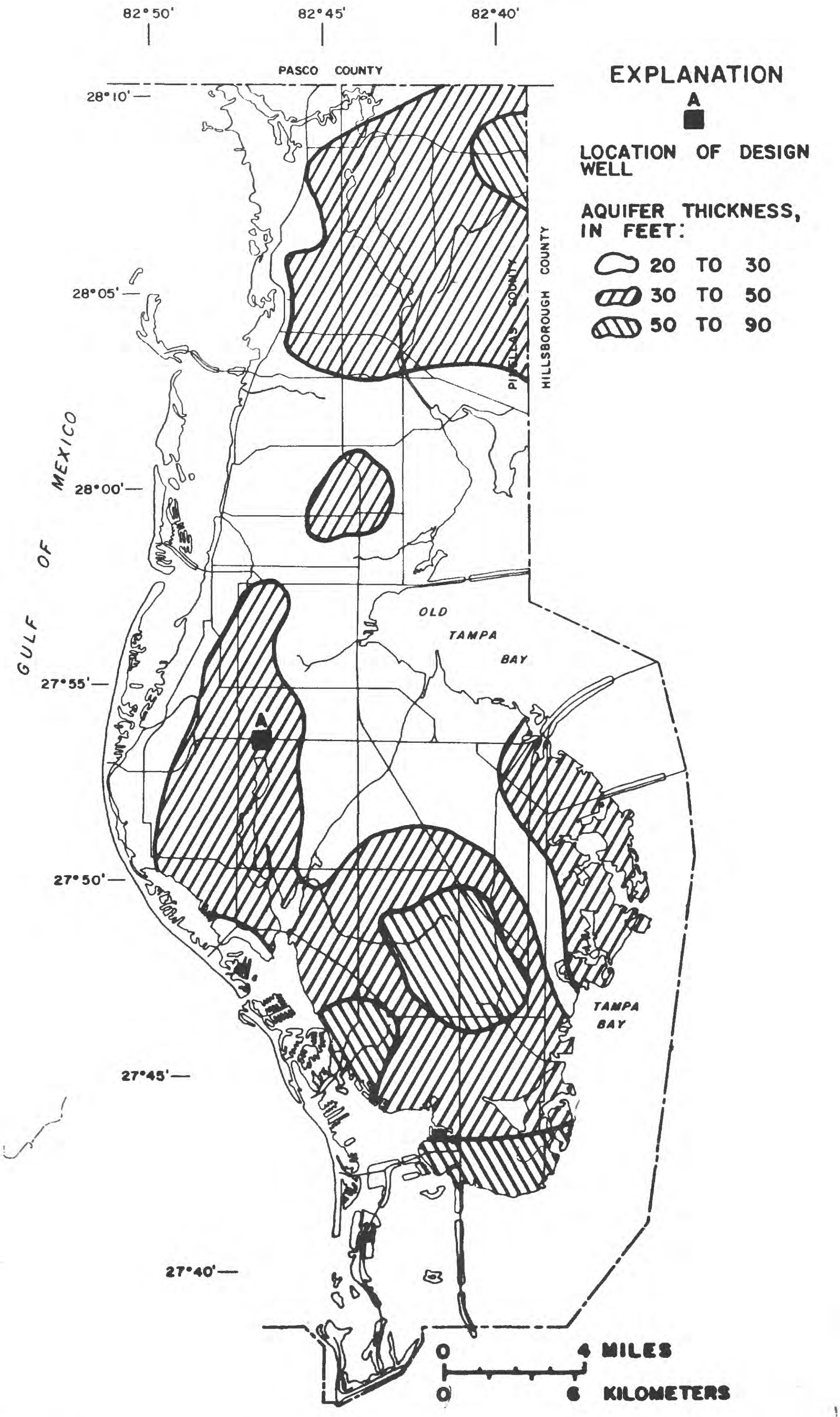

Figure 3.--Saturated thickness of the surficial aquifer, May 1982.

Table 2.--Estimates of hydraulic conductivity and specific yield for the surficial aquifer

Lithologic unit	Hydraulic conductivity[1/] (feet per day)	Specific yield[2/] (percent)
Sand:		
Fine to very fine	5	-
Fine	15	10-28
Medium to fine	30	-
Medium	50	15-32
Coarse to medium	100	-
Coarse	250	20-35
Gravel:		
Fine to coarse	900-1,000	12-35

1/ Lohman (1972, p. 53).

2/ Johnson (1972, p. D1).

ranges from about 250 to 900 ft/d (Lohman, 1972, p. 53). Assuming a thickness of 10 feet, the shelly sands would have an estimated transmissivity of about 2,500 ft^2/d to as much as 9,000 ft^2/d.

The specific yield of an unconfined aquifer generally is between 0.1 and 0.3. The average specific yield of an unconfined aquifer for long periods of draining is about 0.2 (Lohman, 1972, p. 8). The specific yield of a fine to medium sand ranges from about 0.15 to 0.30.

Based on an aquifer test conducted in the Clearwater area, the hydraulic conductivity of the surficial aquifer at depths of 10 and 20 feet was estimated to be about 180 ft/d (table 3). Assuming a saturated thickness of 10 to 20 feet, the estimated transmissivity would be about 1,800 to 3,600 ft^2/d.

Table 3.--Laboratory analyses of unconsolidated sediment samples from a test well in northeast Pinellas County

[Modified from Cherry and others, 1970]

Depth (feet)	Specific retention (percent)	Total porosity (percent)	Specific yield (percent)	Hydraulic conductivity (feet per day)
4.0-4.2	4.9	34.9	30.0	12
10-12	4.9	36.1	31.2	180
20-22	4.0	37.2	33.2	180
30-32	9.0	43.2	34.2	67
40-42	8.5	44.4	35.9	17

Aquifer testing of about 40 feet of sand, laminated sand, and sandy clay in northwestern Hillsborough County indicated a transmissivity range of about 270 to 430 ft^2/d and a specific yield of about 0.20 (Sinclair, 1977, p. 13). An estimated transmissivity of 1,900 ft^2/d and a specific yield of 0.29 were reported for a surficial aquifer composed of sand and clayey sand in Polk County (Hutchinson, 1977, p. 11). Wolansky (1978, p. 9) reported a transmissivity of 1,500 ft^2/d and a specific yield of about 0.2 for a 10- to 20-foot sandy shell bed in Charlotte County.

Specific Capacity

Specific capacity of a well is the rate of discharge of water from a well divided by the drawdown of water level within the well. The specific capacity of a well is affected by the construction of the well, its development, type of screen or cased perforation, and the pumping rate and length of flow up the casing, in addition to the hydraulic characteristics of the aquifer tapped.

Specific-capacity tests were conducted at eight sites in the southern half of Pinellas County. Each well had a 0.01-inch slotted screen that was 2 inches in diameter and about 3.6 feet long. The screen contained about 4 percent open area. Only the upper 10 to 20 feet of the aquifer was penetrated.

All wells had been partly developed during construction and, during the tests, were pumped at about 2 gal/min. For the purpose of comparing well-yield potential, test results were reported as specific capacity (in gallons per minute per foot of drawdown) per foot of screen. Values ranged from 0.06 to 0.26 (gal/min)/ft per foot of screen (fig. 4). Thus, for a 10-foot screen, the specific capacity would range from less than 1 to about 3 (gal/min)/ft of drawdown. The results of these tests are conservative because the open area of the screen was small, and the extent to which the well was developed was moderate.

Recharge and Discharge

The source of freshwater in Pinellas County is rainfall in the county or in adjacent areas. Part of the rainfall collects in topographic depressions, such as lakes and swamps, or enters stream channels and flows into gulf and bay waters. Some rainfall infiltrates into the soil and surficial aquifer where it eventually returns to the surface as streamflow, is lost through evapotranspiration processes, or leaks into the deeper Floridan aquifer. Most rainfall is lost to evapotranspiration.

A water budget (table 4) for Pinellas County was developed based on data collected in the county and on findings by Hutchinson (1984) for adjacent counties. It is assumed that there is no change in storage in the surficial aquifer. The average annual rainfall is 53 inches, of which 25 inches returns from land surface to the atmosphere as evapotranspiration and 6 inches flows directly out of the county as streamflow. The remaining 22 inches infiltrates to the surficial aquifer. Of the rainfall that reaches the surficial aquifer, 6 inches returns as ground-water discharge to streams, 14 inches is evaporated or transpired from the water table, and 2 inches leaks downward to the Floridan aquifer. Eventually, water from the Floridan aquifer discharges as pumpage or upward leakage along the coast.

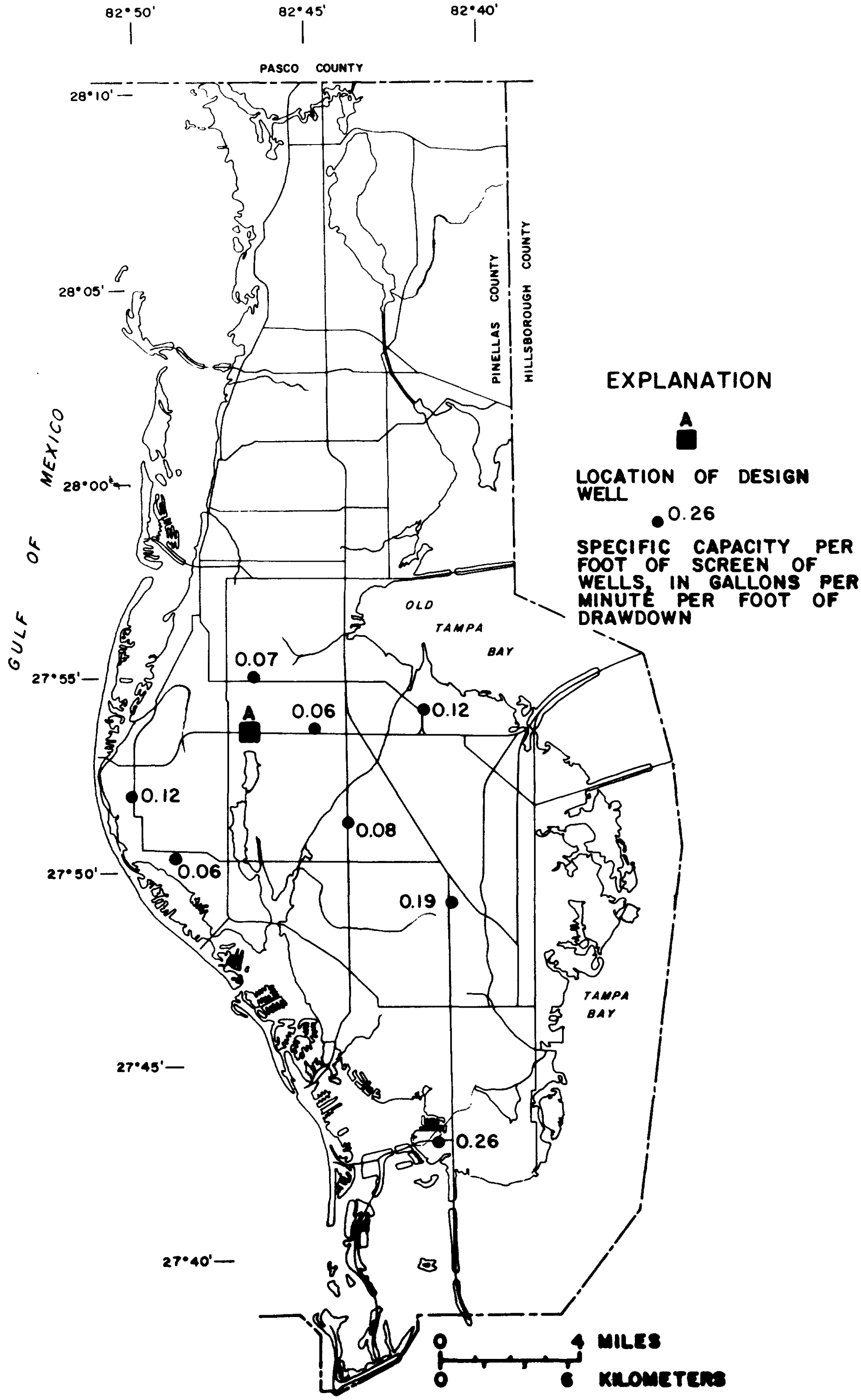

Figure 4.--Specific capacity of wells in the surficial aquifer.

Table 4.--Water budget for Pinellas County

Total rainfall	53 inches
Evapotranspiration from land surface	25 inches
Direct runoff to streams	6 inches
Recharge to surficial aquifer	22 inches
Evapotranspiration from water table	14 inches
Contribution to base streamflow	6 inches
Vertical leakage to Floridan aquifer	2 inches

Discharge data are available for four creeks in the north-central part of Pinellas County. These creeks lie in basins that have similar geology and topography and flow outward from the Pinellas Ridge area. The creeks drain a total area of about 33 mi^2 of which about 19 mi^2 has been gaged. The creeks have wide fluctuations in flow and periods of no flow when the water table declines below the stream bed. The average runoff ranges from 11 to 12 inches per year, which agrees with the 6 inches of storm runoff plus 6 inches of ground-water discharge to streams presented in the water budget.

In much of the county, recharge to the Floridan aquifer is probably more than 2 inches because average runoff is probably less than 11 to 12 inches. The recharge of 2 inches is consistent with Ryder's (1982) digital model of predevelopment flow in the Floridan aquifer. For each inch of infiltrating rainwater, approximately 4,600 Mgal of water is recharged to the surficial aquifer (based on 264 mi^2 of land area in the county).

Water in the surficial aquifer is unconfined, and its surface forms a water table that is free to rise and fall in response to recharge and discharge. The altitude and configuration of the water table are primarily controlled by the topography, hydrologic properties of the aquifer, and variations in recharge and discharge. Rises in the water table are caused by rainfall and seepage from lakes and streams when their stage is above the water table. More localized recharge to the aquifer occurs from the activities of man, such as agricultural, lawn, or golf course irrigation and septic-tank discharge. Declines in water table are caused by discharge from pumping and by natural discharge, such as seepage or spring discharge to surface-water bodies, evapotranspiration, and leakage to the underlying Floridan aquifer.

Water Levels

The water table of the surficial aquifer generally is a subdued reflection of the land surface. Figure 5 shows the altitude of the water table in May 1982 following the dry season (Barr, 1982). The water table is highest along the Pinellas Ridge, where it ranges from 20 to more than 80 feet above sea level, and in the flat upland area in the southern part where it ranges from about 20 to 40 feet above sea level. Elsewhere, the altitude of the water table generally is less than 20 feet above sea level. From these relatively high areas, ground-water flow is downgradient and perpendicular to the contour lines.

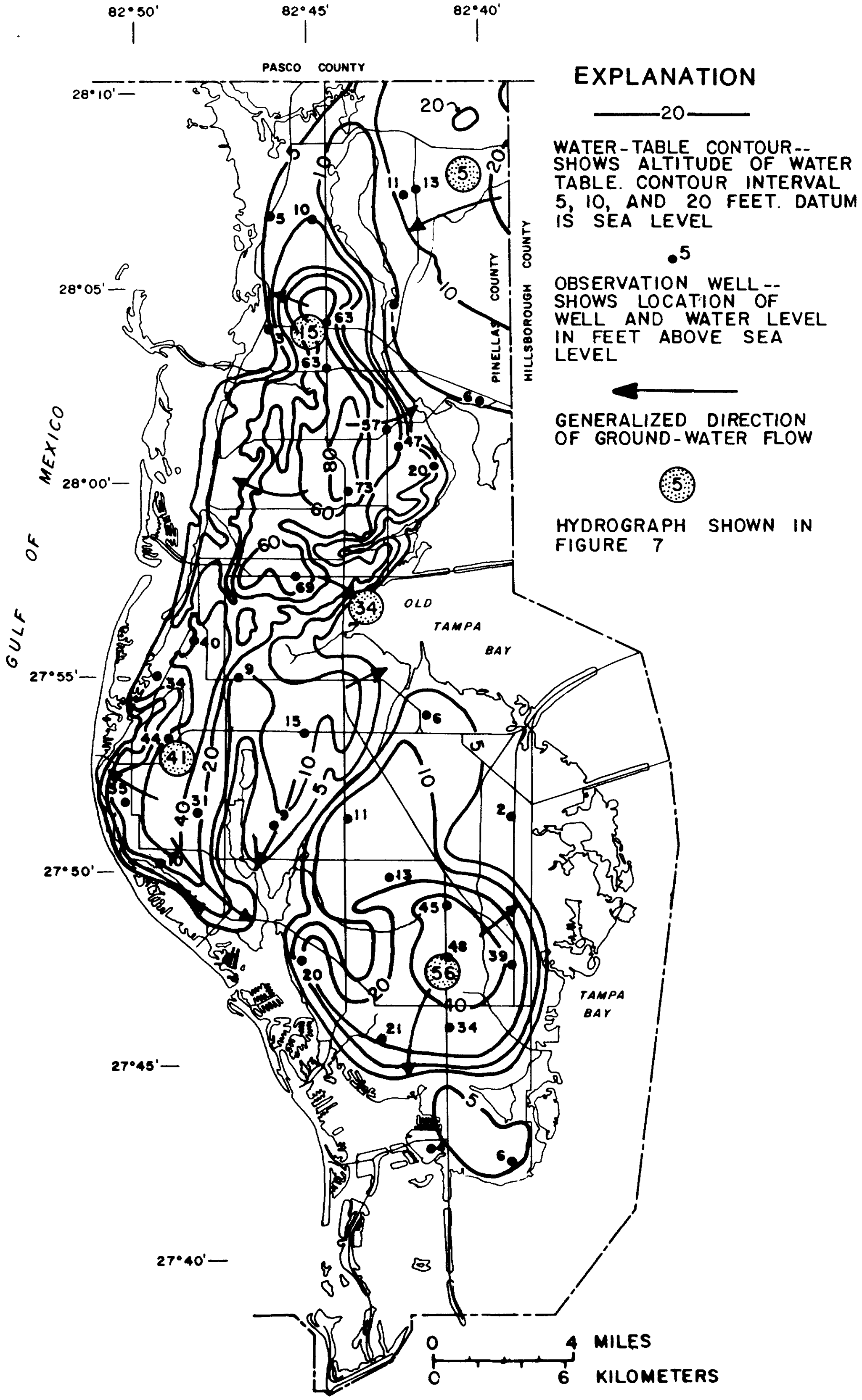

Figure 5.--Configuration of the water table of the surficial aquifer, May 1982 (from Barr, 1982).

The depth to the water table ranges from at or near land surface in the coastal and flat, poorly drained areas to about 10 feet below land surface in the topographically high areas (fig. 6). The water table is less than 5 feet below land surface throughout most of the county. In the Pinellas Ridge and flat upland areas, the water table is generally 5 to 10 feet below land surface.

Hydrographs of water levels from selected wells that tap the surficial aquifer are shown in figure 7. The water table is usually at its highest level in the fall at or near the end of the rainy season and at its lowest level in May or June at the end of the dry season. Seasonal fluctuations range from about 1 to 4 feet. Water levels in observation wells in Dunedin and Largo along the Pinellas Ridge fluctuated about 2 to 3 feet. Similar fluctuations were measured in a well in St. Petersburg in the flat upland area. Water-level fluctuations of 1 to 2 feet occurred in a well in Clearwater in the level lowlands near the coast.

Water Quality

Ground water in the surficial aquifer contains varying amounts of dissolved minerals that affect its quality and use. The mineral constituents and the degree of mineralization depend upon the quality of water recharged to the aquifer, the composition and solubility of the soil and rocks through which the water passes, and the duration of contact. In coastal areas of the county, water quality is affected by the mixing of relatively freshwater with seawater.

The source and significance of constituents and properties of ground water are discussed in detail by Hem (1970). Those constituents and properties that have a practical bearing on water use are summarized in "Water Resources Data for Florida--Water Year 1982" (U.S. Geological Survey, 1983).

The amount of dissolved minerals in the water is indicated by the dissolved-solids concentration. In Pinellas County, dissolved solids are comprised primarily of calcium, magnesium, sodium, bicarbonate, sulfate, and chloride. Specific conductance is the capacity of the water to conduct an electric current and is a measure of total mineral concentration. Water with a low dissolved-solids concentration is generally more suitable for most purposes than water with a high dissolved-solids concentration.

Chloride in ground water may be derived from several sources including intrusion of saltwater into the aquifer, solution of minerals containing chloride, and from activities of man, such as using slightly saline ground water from the Floridan aquifer for irrigation and maintaining lake levels. Chloride concentrations greater than 250 mg/L (milligrams per liter) are generally objectionable for public supply (U.S. Environmental Protection Agency, 1979) and for concentrations greater than 350 mg/L are objectionable for most irrigation uses (Edward E. Johnson, Inc., 1972).

Concentrations of chloride in water from selected wells that were sampled in February 1982 ranged from 5 to 1,400 mg/L (fig. 8). Concentrations were less than 50 mg/L in the northern part of the county and generally less than 100 mg/L in the southern part. Relatively high concentrations, exceeding 100 mg/L, were detected in water from three wells. Concentrations of 1,400 and 170 mg/L were detected in water from wells in low-lying coastal areas, and a concentration of 330 mg/L was detected in water from a well in a low-lying area northeast of Lake Seminole.

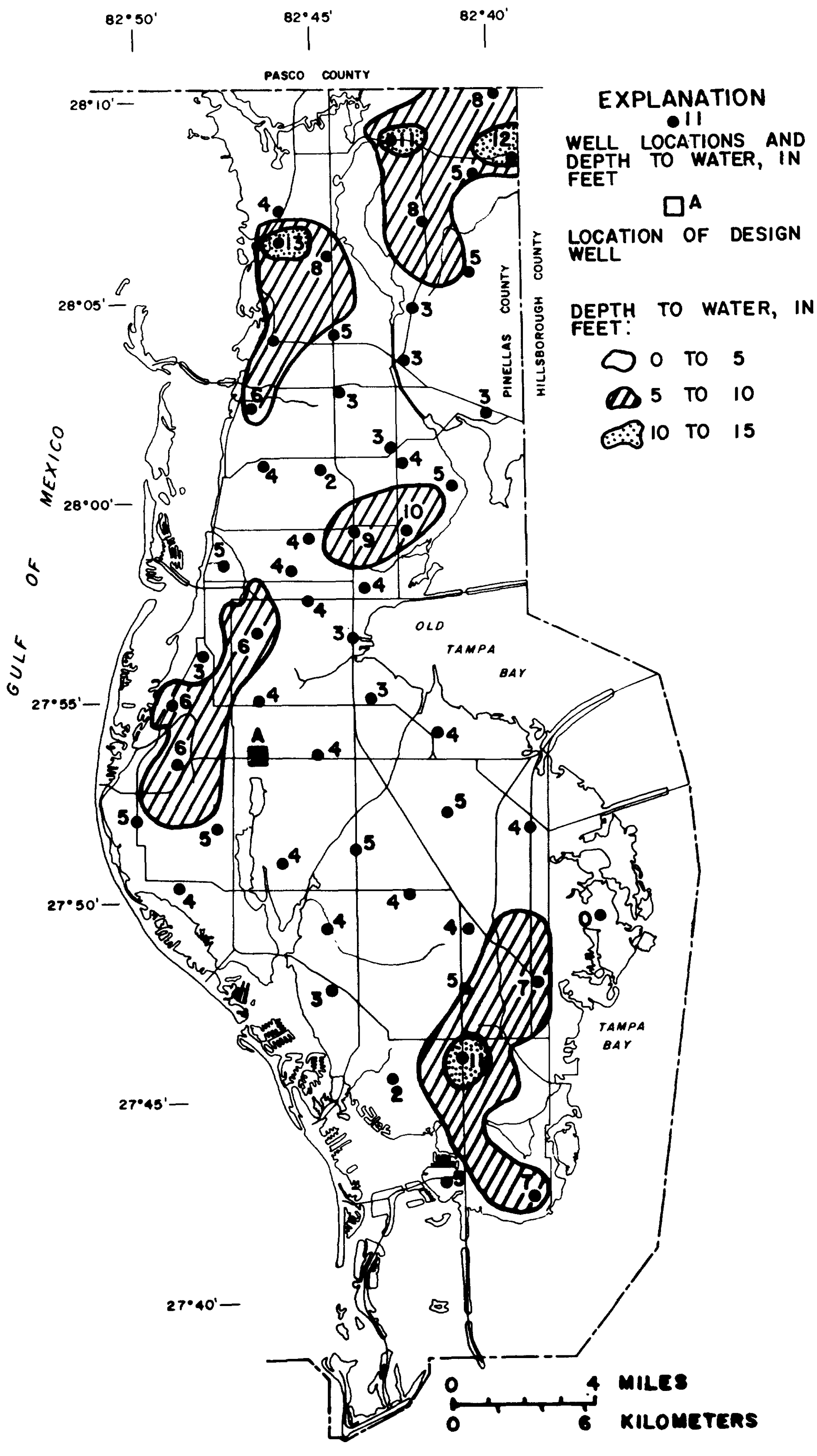

Figure 6.--Generalized depth to water in the surficial aquifer, May 1982.

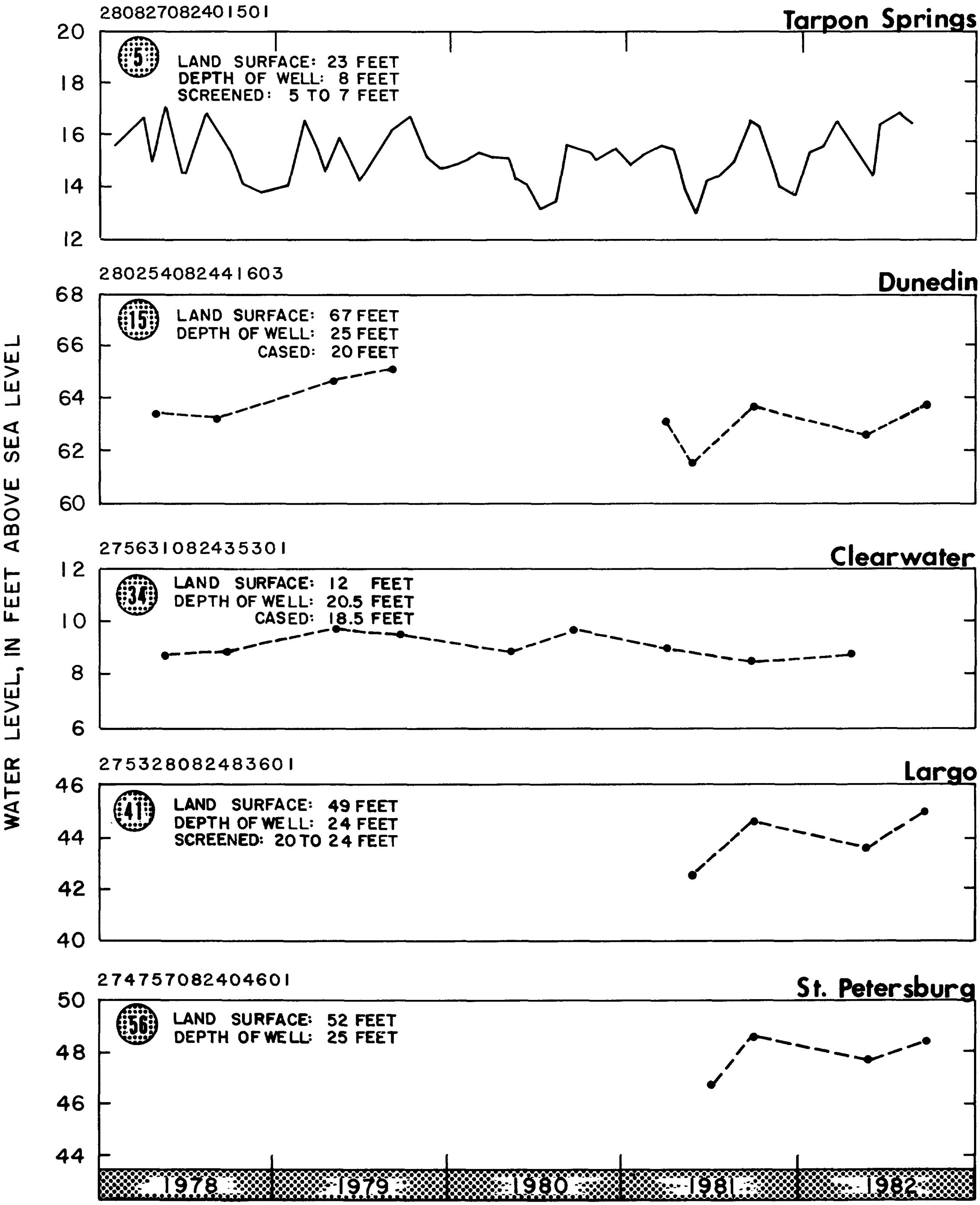

Figure 7.--Water levels in the surficial aquifer, 1978-82. (Location of wells are shown in figure 5.)

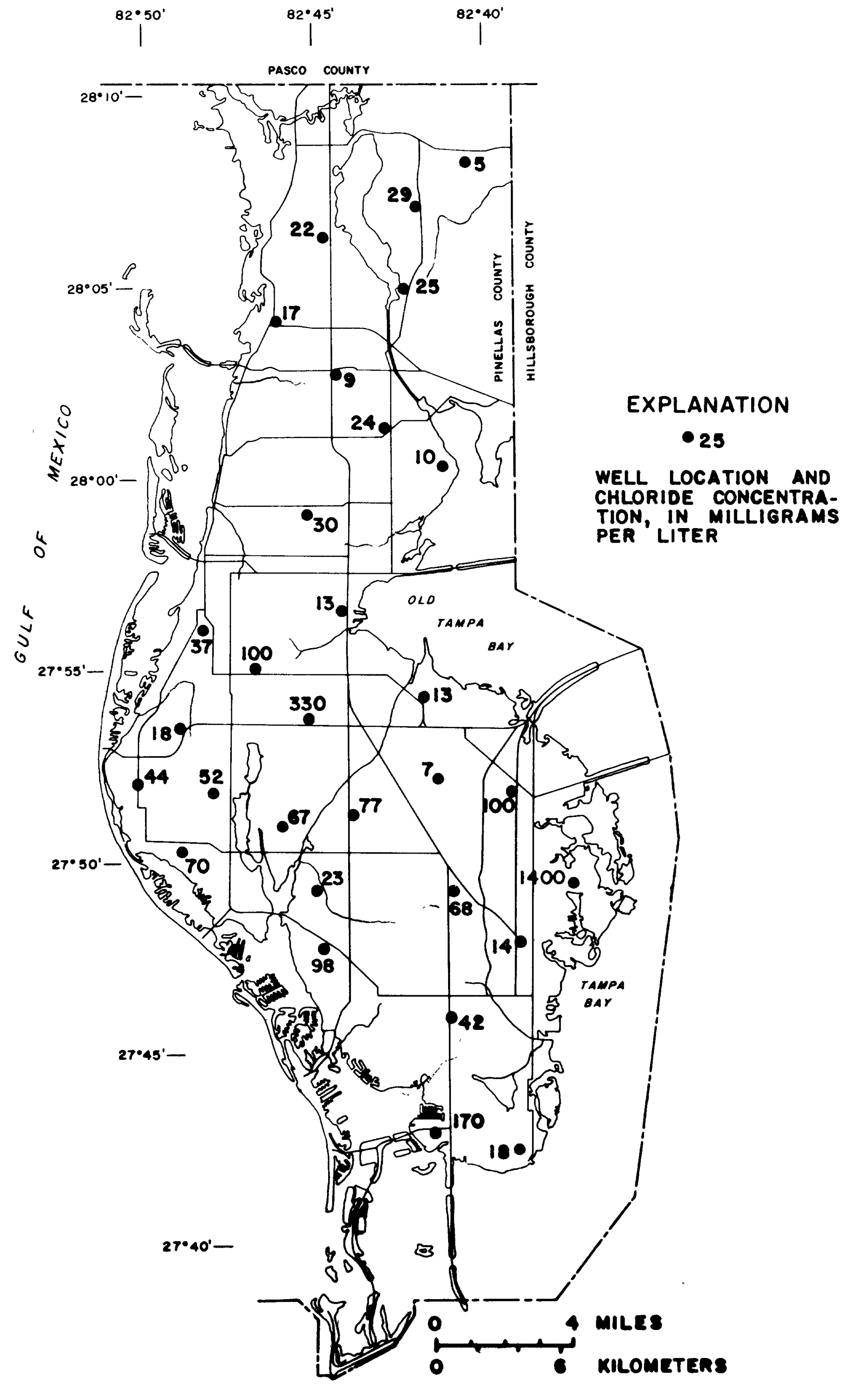

Figure 8.—Concentrations of chloride in surficial aquifer wells, February 1982.

Generally, concentrations of chloride throughout most of the county are less than the 250-mg/L recommended limit for public supply. Relatively high concentrations, exceeding 250 mg/L, generally occur in low-lying areas along the coast and near tidally affected streams and canals.

Iron in ground water is derived from the dissolution of rocks and soils in the aquifer. On exposure to air, iron in ground water oxidizes to a reddish-brown sediment. Concentrations in excess of 0.3 mg/L may stain laundry, utensils, and porcelain fixtures. Large quantities of iron cause unpleasant taste and favor growth of iron bacteria. Repeated use of such water for lawn irrigation can cause staining of sidewalks and buildings. High iron concentrations can be reduced to recommended limits of 0.3 mg/L (U.S. Environmental Protection Agency, 1979) by aeration or chlorination followed by filtration. Water that has iron concentrations of more than 1.0 mg/L can cause accumulation on well screens and restrict the flow of water.

Concentrations of iron in water from selected wells sampled in February 1982 ranged from less than 0.1 to 9.0 mg/L (fig. 9). Concentrations exceeding 0.3 mg/L, the recommended limit, occur throughout the county, and water from most wells had iron concentrations greater than 1.0 mg/L. The variability in iron concentrations is not related to any areal pattern. According to Hem (1970, p. 122), iron concentrations of 1.0 to 10 mg/L are a common occurrence, and significant differences may frequently be noted in wells that are in close proximity because of the wide distribution of geological materials that affect iron solubility.

Development

Development of ground water from the surficial aquifer is largely dependent upon the hydraulic properties of the aquifer, the saturated thickness of the aquifer, and the quality of water. Presently (1982), the surficial aquifer in Pinellas County is generally undeveloped as a source of water, although small volumes of water are used for rural domestic and livestock supply, lawn irrigation, and for heating and air conditioning.

Most wells tapping the surficial aquifer are 2 inches in diameter or less and range in depth from 20 to 50 feet. Most are finished as open hole, although some wells have some form of screen or slotted casing. In most parts of the county, wells yield 10 gal/min or less.

The surficial aquifer in Pinellas County has only limited use as a supplemental or alternative source of water for public, industrial, or agricultural supply. The aquifer is thin and heterogeneous, has low values of transmissivity, and has low yields to pumping wells. Near the coast and tidally affected streams, the aquifer is subject to saltwater intrusion and inundation by seawater during tidal flooding. However, throughout most of the county, the aquifer does have the potential as a dependable source of water for rural domestic and small irrigation supplies because it is readily recharged by rainfall.

The surficial aquifer is used as a source of water in nearby coastal counties where water from deeper aquifers is not potable. Several public supplies in the southern part of Sarasota County and in Charlotte County obtain some or all of their water from the surficial aquifer (Wolansky, 1978).

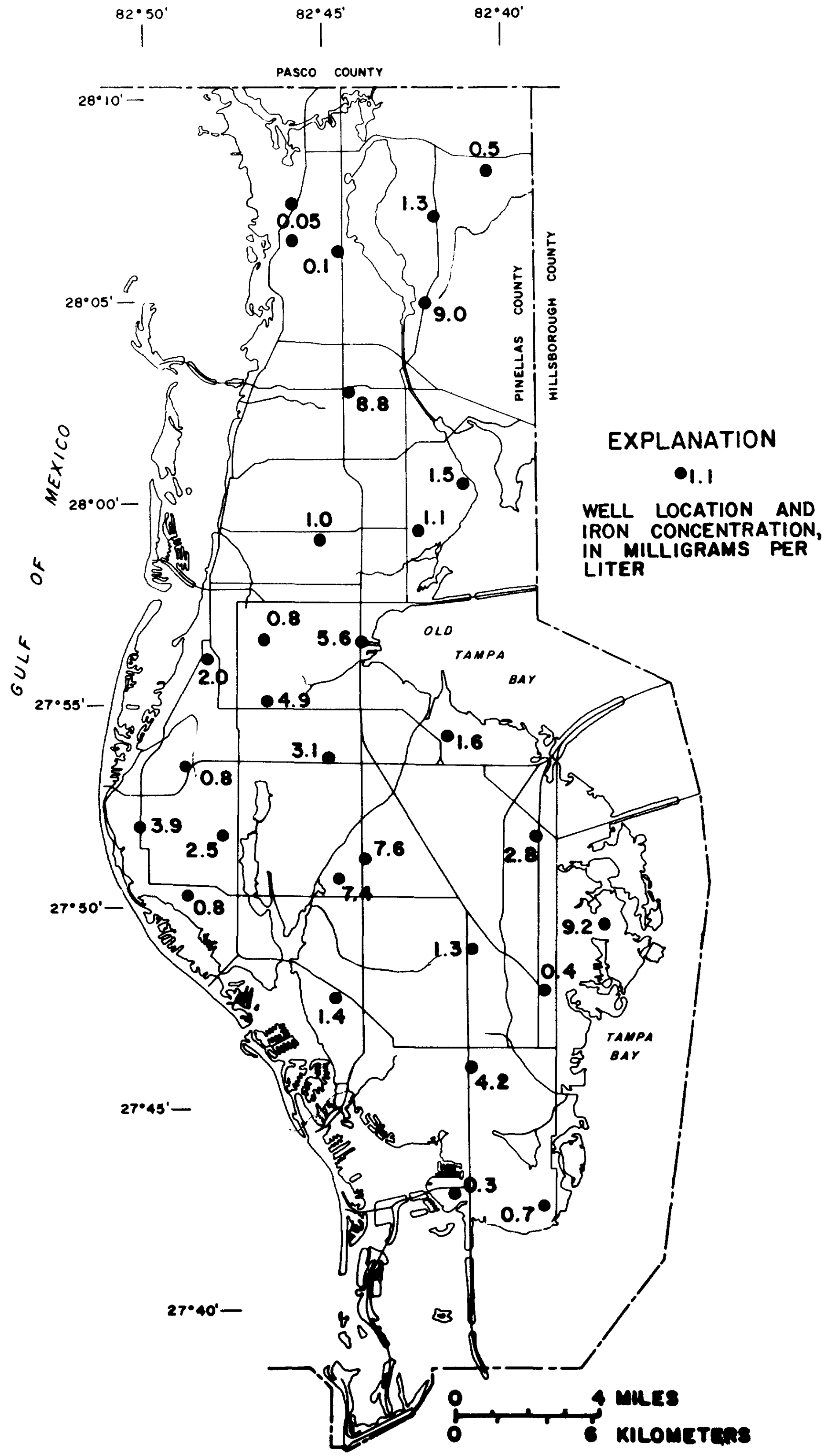

Figure 9.--Concentrations of iron in surficial aquifer wells, February 1982.

POTENTIAL YIELD OF SURFICIAL AQUIFER TO SMALL DIAMETER WELLS

Ground-water use for public supply is about 100 Mgal/d. Of this, an estimated 6 percent of the supply is used for lawn irrigation and other nonpotable uses (Duerr and Sohm, 1983). Most of these uses occur during the dry spring months when pumping from the Floridan aquifer in Pinellas County and adjacent counties is greatest. Development of the surficial aquifer for lawn irrigation and other nonpotable uses would reduce dependency on imported water during the dry season and reduce withdrawals from the Floridan aquifer within Pinellas County.

The determination of well depths and screen lengths for shallow-well construction in the surficial aquifer requires consideration of the depth to water table and thickness of the saturated aquifer. Centrifugal pumps, generally used for lawn irrigation wells, have maximum pumping lift capability of about 25 feet and a practical lift limit of about 22 feet. Thus, a shallow water table is essential for use of shallow-well lift pumps.

The saturated part of the aquifer must be thick enough to produce the desired yield to a well. The yield per foot of hole or screen increases with grain size and decreases with uniformity of grain size. Longer screens can be used in areas of low yield in cases where larger slot sizes cannot be used. Experience has shown that optimum well yield occurs when the length of slotted screen equals one-third to one-half the thickness of aquifer penetrated (U.S. Bureau of Reclamation, 1977, p. 51).

In most of Pinellas County, the depth to water during the dry season is less than 5 feet. Depths of more than 10 feet are found in only three small areas. In two of the areas--south St. Petersburg and the extreme northeast part of the county--the maximum depth to water is 12 feet, but there is the potential for high yield because the aquifer thickness is more than 50 feet in these areas. South of Tarpon Springs, a maximum depth to water of 13 feet occurs in an area where the aquifer is less than 30 feet thick. In this area, well production would probably be low. Generally, depths to the water table of about 5 feet provide favorable conditions for shallow-well productivity in the county.

The saturated thickness of the surficial aquifer is more than 30 feet in most of the county, which makes it suitable for the construction of small-yield wells. Two large areas where saturated thickness is less than 30 feet are in the coastal lowlands north of Pinellas Park and along a band of land that extends across the peninsula from Safety Harbor to Dunedin (fig. 3).

In areas where the aquifer is less than 20 feet thick, construction of multiple well points connected to a central distribution system may be necessary to sustain a small water system. Doubling the screen length by the use of a two-well system would provide almost a proportionate increase in yield, whereas doubling the well diameter will result in a 10 to 17 percent increase in yield (U.S. Bureau of Reclamation, 1977, p. 55).

The design of the well screen is requisite to efficient well performance. A properly designed screen combines a high percentage of open area with slot openings small enough to prevent sand from entering the well following development. Although percentage of open area has a significant influence on screen efficiency, the size of the opening is critical because its size is dictated by the particle size and uniformity of the sand comprising the aquifer. Data on particle size and distribution are sparse for Pinellas County. Analyses of sand size for four study areas show a range of 0.10 to 0.25 mm average diameter with the larger size occurring in the southern part of the county. Assuming that size distribution is generally uniform, slots should be designed to retain 30 to 50 percent of aquifer materials in the area adjacent to the screen. A slot size No. 10 that has a 0.25-mm opening would be suitable for much of the county, but a smaller size (for example, No. 6) may be required in some areas where the saturated zone is composed of fine to very fine sand.

Well depth is important in well construction and material costs. Two of the more common methods of constructing wells in the surficial aquifer are boring and jetting. Boring of small diameter wells is commonly undertaken with hand-turned or power augers. Depths to 50 feet can be accomplished by auger in clay and sand formations not subject to caving. The jetting method of well drilling uses the force of a stream of water to cut a hole in the ground. Depths to 50 feet can be achieved in most sandy formations.

After the hole is drilled and the screen and casing are set, it is necessary to develop the well to remove finer particles from the water-bearing zone near the screen. This can be accomplished by simple pumping or surging the system by turning the pump on and off or with a plunger. Surging can also be done with a compressed air line or water jet in the well.

Design of well depths and screen lengths can be approximated by using data given in this report. To illustrate use of these data, an example well installation is assumed to consist of a centrifugal pump capable of pumping up to 50 gal/min and a 2-inch well with a No. 10 slotted screen that has an open area of 7 in^2 per linear foot.

The data used in the example well design are from figures 3, 4, and 6. Data from these illustrations can be used to estimate the probable yield of a typical well drilled at any point in the county. For example, a well is to be drilled near the north end of Lake Seminole at point A in figures 3, 4, and 6. The site lies in the 30- and 50-foot saturated thickness zone on the aquifer thickness map (fig. 3), and the saturated thickness is estimated to be 42 feet. On the depth-to-water map (fig. 6), the site is shown to be in an area where the depth to water is less than 5 feet; so a depth of 5 feet is assumed. On the basis of pump tests of nearby wells (fig. 4), the design well is assumed to have a specific capacity of 0.10 (gal/min)/ft of drawdown per foot of screen. It is assumed the well is drilled through the entire saturated thickness to a depth of 47 feet. Since the well screen should not extend for more than half the saturated thickness, the screen length is assumed to be 21 feet; hence, the upper 26 feet of the well is cased. The pumping water level will be limited by a 22-foot lift capability, which gives a maximum drawdown of 17 feet. The theoretical yield of the well is the product of specific capacity per foot of screen, in gallons per minute per foot of drawdown, times allowable drawdown, in feet, times screen length, in feet. So, yield equals: 0.10 x 17 x 21 = 35.7 gal/min. If less yield is desired, the casing and screen lengths can be shortened.

SUMMARY

Pinellas County is a peninsula on the west coast of central Florida that separates Tampa Bay and Old Tampa Bay from the Gulf of Mexico. The county imports 68 percent of its public water supply from two adjacent counties. Because of continued population growth and dependence on outside sources of water, consideration of alternate sources of water is of prime importance. Use of the surficial aquifer for nonpotable use would reduce consumption of public water supply and supplement overall water resources of the county.

The surficial aquifer consists of fine- to medium-grained sand that grades downward from sand or shelly sand to sandy clay or marl with some interbedded clay. The deposits of sand range in thickness from 20 feet in northern coastal areas to 90 feet in the south. In most of the county, the aquifer is separated from the underlying Floridan aquifer by a confining bed that ranges in thickness from less than 25 feet in the north to about 100 feet in the south.

The hydraulic properties of the surficial aquifer vary greatly because of variations in lithology, physical characteristics, and saturated thickness of the aquifer. The transmissivity of the aquifer probably ranges from about 300 ft^2/d for the fine-grained, well-sorted sands to several thousand feet squared per day for the shelly sand. The specific yield for the surficial aquifer ranges from less than 0.1 to 0.3 and averages about 0.2.

The water table generally is a subdued reflection of land surface, ranging from near sea level along the coast to 80 feet above sea level along the Pinellas Ridge in the northern part of the county. The depth to water table is generally less than 5 feet below land surface, but ranges from at or near land surface along the coast and in the flat, poorly drained areas to more than 10 feet in topographically high, well-drained areas. Seasonal fluctuations range from about 1 to 4 feet.

Pumping tests conducted at eight sites indicate a potential yield of 0.06 to 0.26 (gal/min)/ft of screen. Yield from wells would be sufficient for many small uses in most of the county utilizing centrifugal pumps because of the shallow water table and large saturated thickness. Minimum potential yield ranges from 5 to 10 gal/min with 10 feet of drawdown in the northern part of the county to more than 30 gal/min in southern areas.

The dissolved mineral content of water from the surficial aquifer varies greatly; however, the water generally is of acceptable quality for most uses. It is low in mineral content, contains few impurities, and generally does not require treatment. Near the coast and tidally affected streams and marshes and in areas where saltwater intrusion has occurred, the water increases in mineral content and approaches that of seawater. Relatively high concentrations of chloride, exceeding 250 mg/L, occur in these areas. Iron concentrations varied greatly, ranging from less than 0.1 to 9.0 mg/L; concentrations exceeding 0.3 mg/L occurred throughout the county.

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