HYDROLOGY OF THE SAND-AND-GRAVEL AQUIFER,

SOUTHERN OKALOOSA AND WALTON COUNTIES,

NORTHWEST FLORIDA

By Larry R. Hayes, U.S. Geological Survey, and
Douglas E. Barr, Northwest Florida Water Management District

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 82-4110

Prepared in cooperation with the

NORTHWEST FLORIDA WATER MANAGEMENT DISTRICT

Tallahassee, Florida

1983

UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, Secretary

GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information
write to:

District Chief
U.S. Geological Survey
Suite 3015, Hobbs Federal Building
227 North Bronough Street
Tallahassee, Florida 32303

Copies of this report can be
purchased from:

Open-File Services Section
Western Distribution Branch
U.S. Geological Survey
Box 25425, Federal Center
Denver, Colorado 80225
(Telephone: (303) 234-5888)

CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION FACTORS

The inch-pound units used in this report may be converted to metric units (SI) by the following conversion factors:

Multiply inch-pound unit	By	To obtain metric (SI) unit
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
square mile (mi^2)	2.590	square kilometer (km^2)
foot per day (ft/d)	0.3048	meter per day (m/d)
square foot per day (ft^2/d)	0.0929	square meter per day (m^2/d)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
gallon per minute per foot [(gal/min)/ft]	0.207	liter per second per meter [(L/s)/m]

* *

Temperatures are converted from degrees Celsius (°C) to degrees Fahrenheit (°F) by the formula °F = 1.8 x °C + 32.

* *

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. NGVD of 1929 is referred to as sea level in the text of this report.

HYDROLOGY OF THE SAND-AND-GRAVEL AQUIFER, SOUTHERN OKALOOSA AND WALTON COUNTIES, NORTHWEST FLORIDA

By Larry R. Hayes and Douglas E. Barr

ABSTRACT

The sand-and-gravel aquifer is not a primary source of domestic or public-supply water in southern Okaloosa and Walton Counties because of the large quantities of high quality water available from the underlying upper part of the Floridan aquifer. Because the steadily increasing demands being placed on the Floridan aquifer have resulted in continuously declining water levels, increasing pumping costs, interference between wells, and a potential for saline-water intrusion, the development of the sand-and-gravel aquifer is becoming important. This report discusses the hydrogeologic characteristics, hydraulic properties, potential yield, and water quality of 1,000 square miles of the sand-and-gravel aquifer in southern Okaloosa and Walton Counties, northwest Florida.

The sand-and-gravel aquifer in southern Okaloosa and Walton Counties comprises sediments of late Miocene to Holocene age and ranges in thickness from about 10 feet in south-central Walton County to about 210 feet in southwestern Okaloosa County. The aquifer extends from land surface downward to the Pensacola Clay confining bed, which separates the sand-and-gravel aquifer from the upper part of the Floridan aquifer. Sand-and-gravel and Floridan aquifer test data and drill cuttings from the Pensacola Clay indicate that leakage through the Pensacola Clay confining bed is minimal.

In much of the area of investigation, the sand-and-gravel aquifer is differentiated into a surficial zone (water table) and a main producing zone (artesian). The fine to medium sand of the surficial zone is separated from the medium to coarse sand and fine gravel of the main producing zone by layers of clay, sandy clay, and clayey sand. These clayey sediments, when present, comprise the low permeability, or confining, intermediate zone. The surficial zone is recharged by infiltration of local rainwater; the main producing zone is recharged by leakage from the surficial zone in those areas where the sand-and-gravel aquifer is differentiated into the two producing zones.

The hydraulic properties of the aquifer vary considerably due to variations in lithology and thickness of the sediments. Most wells are capable of yielding 50 gallons per minute, and in most of southwestern Okaloosa County, yields of 500 to more than 1,000 gallons per minute can be obtained from wells of 6 inch or larger diameter. Despite locally low pH and high iron concentration, water obtained from the sand-and-gravel aquifer is suitable for most domestic, industrial, and irrigation uses and usually meets State and Federal requirements for public drinking-water supplies.

INTRODUCTION

Area of Investigation

The southern half of Okaloosa County (about 530 mi^2) and most of the southern half of Walton County (about 470 mi^2) in northwest Florida comprise the 1,000-mi^2 area of investigation (fig. 1). The area is bounded on the east by longitude 086°05'W., to the west by longitude 086°48'W. (the Okaloosa-Santa Rosa County line), to the south by the Gulf of Mexico, and to the north by latitude 30°43'N.

Okaloosa and Walton Counties have a humid, subtropical climate. The mean annual rainfall at Niceville is about 62 inches (U.S. Department of Commerce, 1931-78), which falls most abundantly in late spring or early summer (fig. 2). Rainfall varies with location; thunderstorms may yield several inches of rain in one location but only a trace of rain nearby. Winters are mild, with occasional frost occurring from November through February.

The area of investigation lies in two physiographic divisions (Puri and Vernon, 1964, p. 7-15): the Gulf Coastal Lowlands and the Western Highlands (fig. 3). The Gulf Coastal Lowlands region contains flat woods and swamps a few miles inland and sand dunes, beach ridges, and wave-cut bluffs along the coast. The Western Highlands region, which generally ranges in altitude from 50 to 200 feet above sea level, consists largely of sand hills cut by streams that have high base runoff and usually occupy deep, narrow ravines.

For a more detailed discussion of the rainfall, physiographic and geologic features, population growth, and water use in southern Okaloosa and Walton Counties, refer to Pascale (1974) and Trapp and others (1977, p. 10-22).

Wells tapping the upper part of the Floridan aquifer supply most of the water used in southern Okaloosa and Walton Counties. Thus, the sand-and-gravel aquifer, although utilized heavily farther west in Escambia County, is not a primary source of water in the area of investigation. A few domestic users tap the aquifer for lawn sprinkling, and it is used on a limited basis for irrigation and public supply. However, the sand-and-gravel aquifer has become important because the steadily increasing demands being placed on the Floridan aquifer have resulted in continuously declining water levels, increasing pumping costs, interference between wells, and a potential for saline-water intrusion.

Purpose and Scope

In July 1977, the U.S. Geological Survey and the Northwest Florida Water Management District undertook a cooperative investigation of the hydrogeology and water resources of southern Okaloosa and Walton Counties that was funded in part by both agencies as well as by the Regional Coastal Plains Commission.

This report presents those results of the investigation which pertain to the hydrogeology and availability and quality of water from the sand-and-gravel aquifer. It discusses the hydrogeologic characteristics, hydraulic properties, potential yield, and water quality of the aquifer. The information presented can be used by water-resource managers to evaluate the potential of the aquifer as a source of water within the framework of the total water-resources system of southern Okaloosa and Walton Counties.

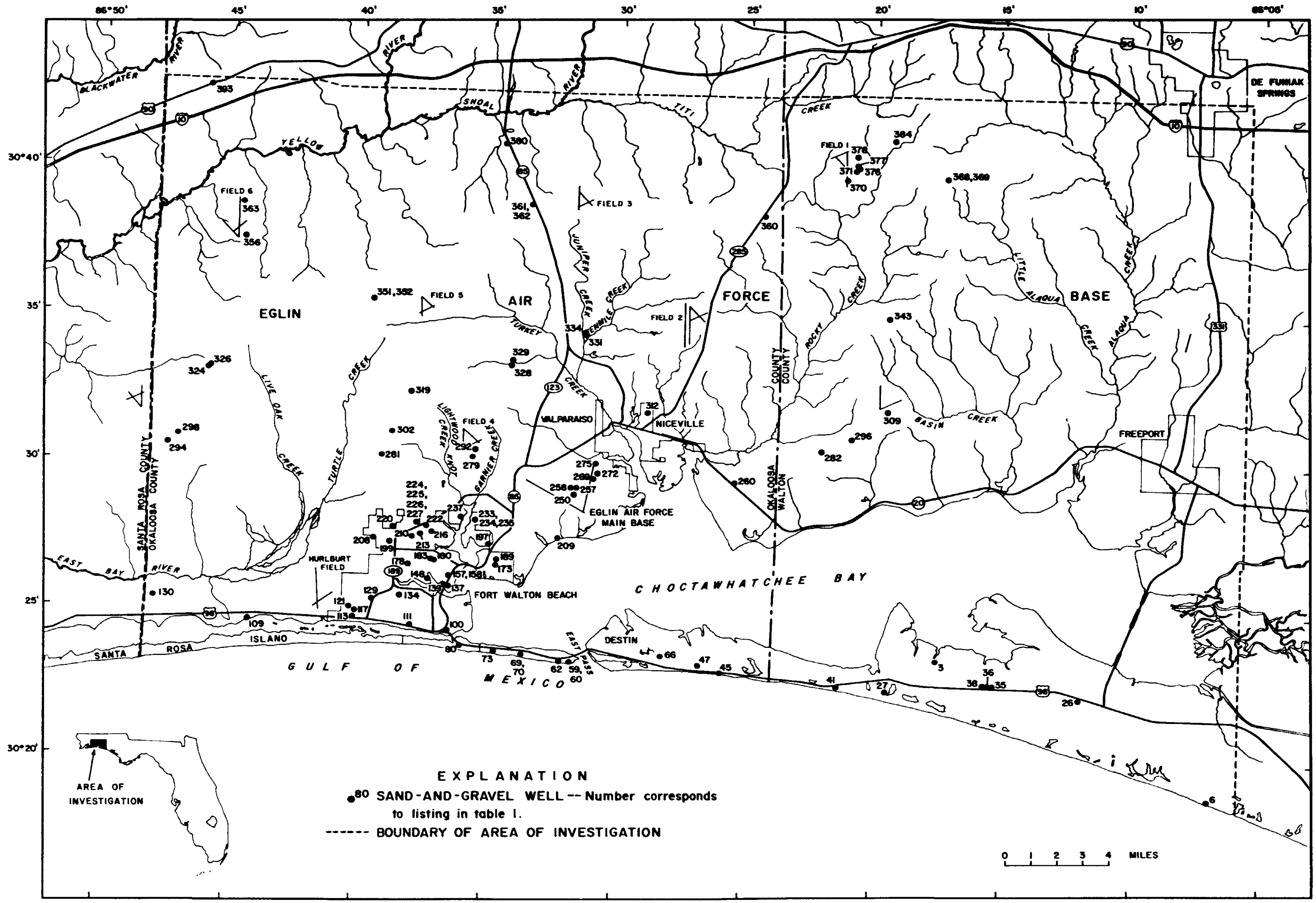

Figure 1.--Area of investigation and locations of selected sand-and-gravel wells, southern Okaloosa and Walton Counties.

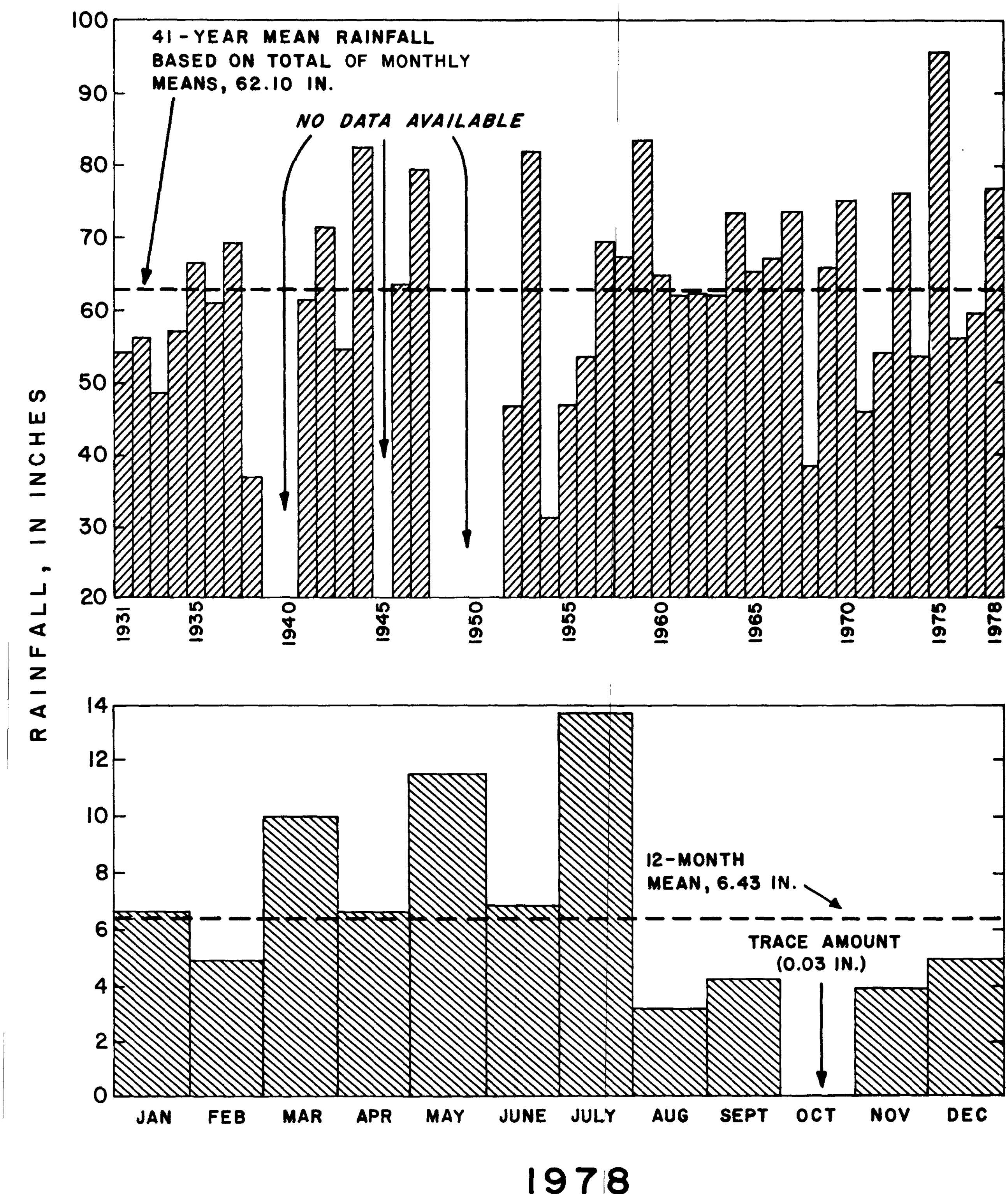

Figure 2.--Annual rainfall for calendar years 1931-78 and monthly rainfall for 1978 at Niceville, Fla.

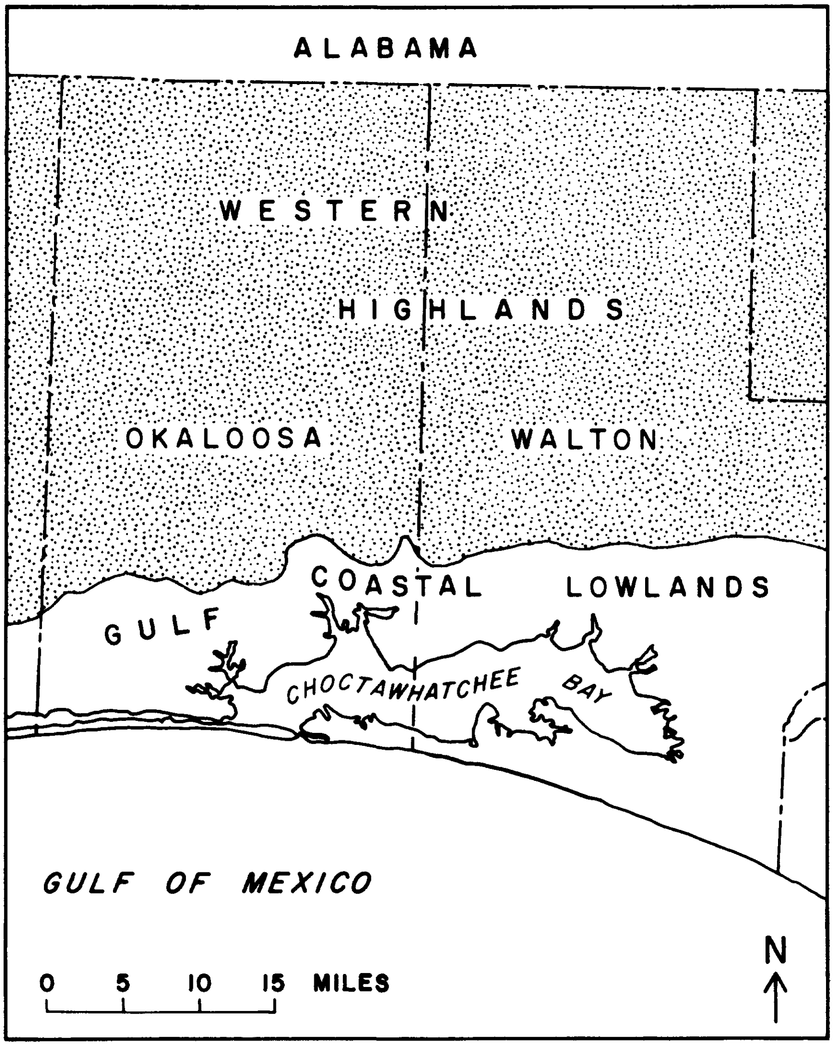

Figure 3.--Physiographic subdivisions of Okaloosa and Walton Counties. (From Puri and Vernon, 1964, p. 7-15. See also Pascale, 1974, p. 4; and Trapp and others, 1977, p. 12.)

Previous Investigations

Previous investigations of the ground-water resources of Okaloosa and Walton Counties were primarily concerned with the upper part of the Floridan aquifer. Consequently, the following cited reports often include only brief descriptions and discussions of the sand-and-gravel aquifer. Sellards and Gunter (1912, p. 105-110) describe the water resources, physiography, drainage, wells, and soils of Walton County, which originally included what is now Okaloosa County, and indicate several locations adjacent to Choctawhatchee Bay where flowing artesian wells could be drilled. Matson and Sanford (1913, p. 422-426) discuss the surface features, geology, and water supply of the Walton-Okaloosa County area. Barraclough and Marsh (1962) describe the system of aquifers and ground-water quality along the gulf coast from the Choctawhatchee River to the Perdido River (the western boundary between Florida and Alabama). Foster and Pascale (1971, p. 95) provide data on the streamflow, water quality, and ground-water levels in Okaloosa County and adjacent areas. Pascale's report on Walton County (1974) describes in detail the hydrogeologic characteristics, hydraulic properties, yield, and water quality of the upper part of the Floridan aquifer. He describes in less detail the hydrogeology of the sand-and-gravel aquifer. The results of an extensive investigation of the water resources of Okaloosa County and part of western Walton County were published in a report by Trapp and others (1977). Wagner and others (1980) give a comprehensive listing of basic hydrologic data for Okaloosa and Walton Counties.

Water-resources data in the State of Florida have been collected by the U.S. Geological Survey since 1930, generally in cooperation with agencies of the State, counties, or cities. These data have been published as U.S. Geological Survey Water-Supply Papers, as statewide data releases, and in project reports. Beginning with the 1975 water year, the report "Water Resources Data for Florida, volume 4, Northwest Florida" has been published annually; it contains ground, surface, and quality of water data for northwest Florida. More detailed information concerning U.S. Geological Survey water-resources data publications is available in each volume.

Data Collection

Table 1 gives the identification, location, and water use of 96 wells in southern Okaloosa and Walton Counties which served as sand-and-gravel aquifer data points in this investigation; figure 1 shows the locations of the wells. Much of the geological data were obtained as a result of close cooperation with commercial well drillers and their clients. Throughout the investigation, electric, natural-gamma, caliper, and temperature logs were run in selected wells (table 2). In areas where adequate information was not available, a test drilling program provided geophysical logs, as well as lithologic and hydrologic data. Thirteen sand-and-gravel wells were drilled under commercial contract, and three sand-and-gravel wells were drilled by the Red Horse Drilling Unit, Hurlburt Field, Eglin Air Force Base; all of the wells are listed in table 1. The electric, natural-gamma, and lithologic (driller and geologist) logs were used to delineate and correlate hydrogeologic units; the caliper logs were used to delineate borehole conditions. Geophysical logging was done by the U.S. Geological Survey and by the Northwest Florida Water Management District.

Water levels were measured at 3-month intervals in 27 wells, intermittently in 13, and 1 well was equipped with an hourly recording gage (table 2). Hydraulic data for the sand-and-gravel aquifer were obtained from 7 aquifer test sites (table 5) and 15 specific-capacity test sites (table 6).

Water samples were obtained from selected wells open to different depths in the aquifer and were analyzed to determine the chemical character of the water in the aquifer with respect to the producing zone tapped and areal location. Field determinations were made of pH, specific conductance, and temperature of the water from each well; samples were analyzed at the U.S. Geological Survey National Water Quality Laboratory-Atlanta, in Doraville, Ga. The data are summarized in table 8, partly illustrated in figures 11-14, and discussed in the "Water Quality" section. Owing to the sparsity of wells in some areas, water-quality data reported by Foster and Pascale (1971) and Pascale and others (1972) were utilized. These data probably accurately reflect the present water quality of the aquifer because (1) the sand-and-gravel wells from which the samples were obtained have been pumped at low rates and (2) the quality of ground water is not normally subject to rapid, significant changes.

Table 1.--Identification, location, and water use of selected sand-and-gravel wells in southern Okaloosa and Walton Counties

[Refer to text for an explanation of map location and Site ID numbering systems]

[Use of water notation: A, air conditioning; H, domestic; I, irrigation; P, public supply; U, unused]

MAP LOCATION NUMBER	SITE ID	LATITUDE AND LONGITUDE DEGREES-MINUTES-SECONDS	LOCAL NUMBER	OWNER	USE OF WATER
OKALOOSA COUNTY					
45	302246086254601	30 22 56 N 086 25 46 W	W-3607	UNKNOWN	U
47	302303086265001	30 23 14 N 086 26 25 W	CLAWSON TOWER	USAF EGLIN AFB	P
59	302317086313001	30 23 19 N 086 31 25 W	NCO BEACH CLUB 1	USAF EGLIN AFB	--
60	302317086313002	30 23 19 N 086 31 25 W	NCO BEACH CLUB 2	USAF EGLIN AFB	--
62	302319086322201	30 23 22 N 086 31 49 W	BLDG 8201,RDR SITE 2	USAF EGLIN AFB	--
66	302321086275202	30 23 32 N 086 27 53 W	DESTIN TW	NWFWMD	U
69	302328086333201	30 23 35 N 086 33 20 W	OBC,BLDG 8304,WELL 1	USAF EGLIN AFB	--
70	302328086333202	30 23 35 N 086 33 20 W	OBC,BLDG 8304,WELL 2	USAF EGLIN AFB	--
73	302334086344101	30 23 40 N 086 34 21 W	ABC, BLDG 8402, A-4	USAF EGLIN AFB	P
80	302343086354801	30 23 51 N 086 35 42 W	BLDG 8502, SITE A5	USAF EGLIN AFB	H
100	302416086362001	30 24 19 N 086 36 13 W	ICE PLANT AT FERRY	ICE PLANT	U
109	302431086435901	30 24 38 N 086 43 59 W	SCROGGIN	SCROGGIN, O O	H
111	302432086374301	30 24 32 N 086 37 41 W	SENIOR CITIZENS CTR	NWFWMD	I
113	302439086400501	30 24 48 N 086 39 54 W	TOOLE RESIDENCE	TOOLE, JAMES A	I
117	302443086400201	30 24 59 N 086 39 36 W	STASIAK RESIDENCE	STASIAK, R F	I
121	302446086400401	30 25 05 N 086 40 03 W	LAUR	LAUR, R C	I
129	302518086390902	30 25 18 N 086 39 09 W	ANCHORS RD SDGL TW	NWFWMD	U
130	302518086473801	30 25 21 N 086 47 44 W	RECEIVER ST,SITE A20	USAF EGLIN AFB	P
134	302529086380501	30 25 29 N 086 38 05 W	FWB MEMORIAL CEMTRY	NWFWMD	I
137	302536086360601	30 25 50 N 086 36 10 W	A W BROWN	BROWN, A W	I
139	302536086361802	30 25 50 N 086 36 22 W	BLOCK RESIDENCE	BLOCK, E B	A
148	302559086370201	30 26 03 N 086 37 01 W	THOMLINSON RESIDENCE	THOMLINSON, J	I
157	302608086361301	30 26 08 N 086 36 13 W	KELLY RESIDENCE	KELLY, CUSTER	I
158	302608086361501	30 26 08 N 086 36 15 W	WOOLWINE RESIDENCE	WOOLWINE, CLIFF	I
173	302629086342201	30 26 32 N 086 34 21 W	KRONMILLER RESIDENCE	KRONMILLER	H
178	302631086374802	30 26 31 N 086 37 48 W	GREEN ST SDGL TW	NWFWMD	U
180	302633086364101	30 26 40 N 086 36 46 W	KURKA RESIDENCE	KURKA, ROBERT	I
183	302635086364501	30 26 42 N 086 36 55 W	SCHERER RESIDENCE	SCHERER, GEORGE	I
189	302645086341702	30 26 45 N 086 34 17 W	SHALIMAR SDGL TW	NWFWMD	U
197	302708086344201	30 27 11 N 086 34 36 W	SIRNEY RESIDENCE	SIRNEY, JOHN A	I

Table 1.--Identification, location, and water use of selected sand-and-gravel wells in southern Okaloosa and Walton Counties--Continued

MAP LOCATION NUMBER	SITE ID	LATITUDE AND LONGITUDE DEGREES-MINUTES-SECONDS	LOCAL NUMBER	OWNER	USE OF WATER
OKALOOSA COUNTY -- Continued					
199	302711086383701	30 27 19 N 086 38 29 W	ADAMS RESIDENCE	ADAMS, GRANT	H
208	302726086390401	30 27 26 N 086 39 04 W	GREEN ACRES TW	NWFWMD	U
209	302727086314701	30 27 27 N 086 31 47 W	SCOUT CAMP BLDG 1701	USAF EGLIN AFB	P
210	302728086373402	30 27 28 N 086 37 34 W	FWB GOLF COURSE D	FT WALTON BCH, CITY OF	I
213	302735086371703	30 27 35 N 086 37 17 W	FWB GOLF COURSE C	FT WALTON BCH, CITY OF	I
216	302739086364902	30 27 39 N 086 36 49 W	FWB GOLF COURSE A	FT WALTON BCH, CITY OF	I
220	302747086382002	30 27 47 N 086 38 20 W	WRIGHT TEST-SHALLOW	USGS	U
222	302754086370102	30 27 54 N 086 37 01 W	FWB GOLF COURSE B	FT WALTON BCH, CITY OF	I
224	302758086370401	30 27 58 N 086 37 25 W	FWB BALLPARK WELL 11	FT WALTON BCH, CITY OF	I
225	302758086370402	30 27 58 N 086 37 25 W	FWB BALLPARK F	NWFWMD	U
226	302758086370403	30 27 58 N 086 37 25 W	FWB BALLPARK G	NWFWMD	U
227	302758086370404	30 27 58 N 086 37 25 W	FWB BALLPARK H	USGS	U
233	302804086351003	30 28 04 N 086 35 10 W	LONGWOOD SDGL TW A	NWFWMD	U
234	302804086351004	30 28 04 N 086 35 10 W	LONGWOOD SDGL TW B	USGS	U
235	302804086351005	30 28 04 N 086 35 10 W	LONGWOOD SDGL TW C	USGS	U
237	302810086354101	30 28 10 N 086 35 41 W	CAMP PINCHOT	USAF EGLIN AFB	--
250	302858086311601	30 28 58 N 086 31 16 W	BLDG 911	USAF EGLIN AFB	P
257	302914086311301	30 29 14 N 086 31 13 W	BLDG 916, AMMO AREA	USAF EGLIN AFB	U
258	302915086312401	30 29 15 N 086 31 24 W	ICA, BLDG 1218	USAF EGLIN AFB	P
260	302918086252002	30 29 26 N 086 25 00 W	BLUEWATER BAY SDGL	NWFWMD	U
269	302933086303201	30 29 33 N 086 30 32 W	BLDG 940	USAF EGLIN AFB	P
272	302942086302201	30 29 42 N 086 30 22 W	EMB, BLDG 936	USAF EGLIN AFB	U
275	303003086302701	30 30 03 N 086 30 27 W	MAIN N RUNWAY B945	USAF EGLIN AFB	U
279	303013086351602	30 30 13 N 086 35 16 W	NWFWMD S&G	NWFWMD	U
281	303014086351401	30 30 14 N 086 38 50 W	RANGE 71D	USAF EGLIN AFB	U
292	303044086351001	30 30 44 N 086 35 10 W	PISTOL RNG,BLDG 4060	USAF EGLIN AFB	U
294	303045086471101	30 30 38 N 086 47 11 W	RANGE 70, WELL 2	USAF EGLIN AFB	I
298	303054086464701	30 30 54 N 086 46 47 W	RANGE 70, WELL 1	USAF EGLIN AFB	I
302	303104086382201	30 31 04 N 086 38 22 W	RANGE 71, BLDG 9451	USAF EGLIN AFB	U
312	303158086274001	30 31 47 N 086 28 23 W	BALLPARK NICEVILLE	NWFWMD	I
319	303218086374801	30 32 18 N 086 37 48 W	RANGE 4A, BLDG 4964	USAF EGLIN AFB	U
324	303311086453901	30 33 11 N 086 45 39 W	HARP SITE BLDG 9400	USAF EGLIN AFB	--
326	303314086453701	30 33 14 N 086 45 37 W	METTS TWR, BLDG 1452	USAF EGLIN AFB	--
328	303321086334401	30 33 21 N 086 33 44 W	ROGUE CR NO 2	USGS	U
329	303330086334001	30 33 30 N 086 33 40 W	ROGUE CR NO 1	USGS	U

Table 1.--Identification, location, and water use of selected sand-and-gravel wells in southern Okaloosa and Walton Counties--Continued

MAP LOCATION NUMBER	SITE ID	LATITUDE AND LONGITUDE DEGREES-MINUTES-SECONDS	LOCAL NUMBER	OWNER	USE OF WATER
OKALOOSA COUNTY -- Continued					
331	303421086305001	30 34 21 N 086 30 50 W	TENMILE CR NO 2	USGS	U
334	303427086305301	30 34 27 N 086 30 53 W	TENMILE CR NO 1	USGS	U
351	303528086390901	30 35 28 N 086 39 09 W	COUPELAND SITE	USAF EGLIN AFB	P
352	303528086390902	30 35 28 N 086 39 09 W	COUPELAND WELL NO 2	USAF EGLIN AFB	U
356	303735086441101	30 37 35 N 086 44 11 W	FIELD 6	USAF EGLIN AFB	U
360	303820086241802	30 38 27 N 086 24 18 W	RAMER TOWER OLD WELL	USAF EGLIN AFB	U
361	303843086331101	30 38 43 N 086 32 59 W	DFT, BLDG 1433	USAF EGLIN AFB	H
362	303843086331102	30 38 43 N 086 32 59 W	OLD WELL, BLDG 1433	USAF EGLIN AFB	U
363	303843086441701	30 38 43 N 086 44 17 W	BLDG 6059, N FIELD 6	USAF EGLIN AFB	U
380	304040086341502	30 40 42 N 086 34 02 W	FORESTRY RESIDENCE	USAF EGLIN AFB	U
393	304237086453401	30 42 37 N 086 45 34 W	JACK JOHNS	JOHNS JR, JACK	H
WALTON COUNTY					
3	301717086233301	30 23 32 N 086 17 10 W	W W HUNTER	HUNTER, W W	H
6	301856086074301	30 18 56 N 086 06 31 W	N H WATERS	WATERS, N H	H
26	302214086120701	30 22 16 N 086 11 34 W	ENCO SERVICE STATION	MILLER, J D	H
27	302217086191801	30 22 16 N 086 19 05 W	T C RICE	RICE, T C	H
35	302231086150401	30 22 42 N 086 14 57 W	A HAUCK	HAUCK, A	H
36	302231086151201	30 22 45 N 086 15 06 W	MO-JO GAS STATION	ANTHONY, JAMES A	H
38	302231086153202	30 22 45 N 086 15 18 W	HOLLEY NO 2	HOLLEY, J A	I
41	302232086210001	30 22 37 N 086 21 01 W	WILLIAM LUBKEMAN	LUBKEMAN, WILLIAM	H
282	303020086214501	30 30 34 N 086 21 37 W	WINDHAM TOWER	USAF EGLIN AFB	--
296	303049086203702	30 31 00 N 086 20 30 W	WINDHAM TOWER - SDGL	USAF EGLIN AFB	U
309	303144086192201	30 31 55 N 086 19 05 W	RANGE 52, BLDG 8722	USAF EGLIN AFB	U
343	303456086191601	30 35 03 N 086 19 05 W	RANGE 52, BLDG 8738	USAF EGLIN AFB	U
368	303943086170201	30 39 48 N 086 16 52 W	SANDY MOUNTAIN TOWER	USAF EGLIN AFB	H
369	303943086170202	30 39 48 N 086 16 52 W	SANDY MTN TOWER OLD	USAF EGLIN AFB	U
370	303946086205701	30 39 43 N 086 20 45 W	BLDG 9500 FLD 1 R-72	USAF EGLIN AFB	U
371	303952086202701	30 40 00 N 086 20 26 W	FIELD 1, BLDG 9513	USAF EGLIN AFB	P
376	304005086203001	30 40 05 N 086 20 17 W	FIELD 1, BLDG 9531	USAF EGLIN AFB	U
377	304007086203801	30 40 12 N 086 20 21 W	FIELD 1, BLDG 9516	USAF EGLIN AFB	--
378	304023086203801	30 40 29 N 086 20 21 W	FIELD 1, BLDG 9522	USAF EGLIN AFB	P
384	304101086190201	30 40 58 N 086 18 53 W	FIELD 1, BLDG 9373	USAF EGLIN AFB	P

Table 2.--Geophysical and hydrologic data available for selected sand-and-gravel wells

Geophysical logs: C, caliper; D, driller; E, electric; G, geologist; J, natural-gamma; T, temperature.
Water-quality data: A, field analyses; B, standard complete analyses; M, analyses for all or most chemical constituents.
Measured or reported aquifer characteristics: F, discharge; W, water level; X, drawdown; Z, maximum available drawdown.
Computed aquifer properties: L, leakance; P, specific capacity; R, transmissivity; S, storage coefficient; Y, estimated potential yield.
Frequency of water-level measurements: H, hourly; I, intermittent; O, quarterly.

Map location number	Data available	Map location number	Data available	Map location number	Data available
Okaloosa County		Okaloosa County		Okaloosa County	
45	E, G,	121	A	197	A
47	B, F	129	B, E, F, G, J, P, R, W, O, X, Y, Z	199	A
59	A, F	130	B, F, W, I	208	B, D, E, F, J, P, R, W, O, X, Y, Z
60	B, F	134	B, D, F, G, J, P, W, O, X, Y, Z	209	B, F,
62	B, F	137	A	210	D, F, M, P, W, O, X, Y, Z
66	B, D, E, F, J, P, R, W, O, X, Y, Z	139	B	213	D, F, M, P, W, O, X, Y, Z
69	B, F	148	A	216	D, F, M, P, W, O, X, Y, Z
70	B, F	157	A	220	A, F, W, O
73	B, F	158	A	222	D, F, M, P, W, O, X, Y, Z
80	B, F	173	A	224	D, F, M, P, X, Y, Z
100	B, J, W, O	178	B, E, F, G, J, P, R, W, O, X, Y, Z	225	F, G, J, L, P, R, S, T, W, O, X, Y, Z
109	A	180	A	226	D, L, R, S, W, H
111	B, E, F, G, J, P, R, W, O, X, Y, Z	183	A		
113	A	189	B, D, E, F, J, P, W, O, X, Y, Z		
117	A				

Table 2.--Geophysical and hydrologic data available for selected sand-and-gravel wells--Continued

Map location number	Data available	Map location number	Data available	Map location number	Data available
Okaloosa County		Okaloosa County		Walton County	
227	W, O	302	B, F	3	A, W, I
233	B, E, G, J, W, O	312	C, J, T, W, O	6	A
234	G, J, L, R, S, W, O	319	B, F	26	A
235	G, J, W, O	324	B, F	27	A
237	B, F	326	B, F,	35	A
250	B, F, W, I	328	G	36	A
257	B	329	G, J, T, W, O	38	A
258	B, D, F, G, W, O	331	G, W, I	41	A, W, I
260	B, D, E, J, W, O	334	G, W, I	282	B, F
269	B, F	351	B, F, W, I	296	B, W, O
272	B, F	352	B	309	B
275	B, F	356	D, G	343	B, F, W, O
279	B, C, J, W, O	360	B, F	368	B, F, W, O
281	W, I	361	B, W, I	369	B, F
292	B, F	362	B, F	370	B, F
294	A, D, F, P, W, I, X, Y, Z	363	B, F	371	B, F, J, T, W, O
298	A, D, F, P, W, I, X, Y, Z	380	B, F	376	B, F, W, I
		393	A	377	F
				378	B, F, W, I
				384	B, F

Numbering System and Description of Wells

Two numbering systems are used to identify and locate test holes and well stations: a 1- to 3-digit map location number and the Ground-Water Site Inventory (GWSI) or Site Identification (ID) number. The map location numbers were assigned in order of increasing Site ID number. Gaps in the map location number sequence in table 1 usually represent wells open to the Floridan aquifer.

The Site ID number (table 1) consists of 15 digits that signify the latitude and longitude representing the location of the well. Thus, the first 6 digits denote the degrees, minutes, and seconds of north latitude; the next 7 digits denote the degrees, minutes, and seconds of west longitude; and the last 2 digits provide a sequential numbering system for stations located within a 1-second grid. Once assigned, a Site ID number does not change even if the latitude or longitude designation is changed. Hence, although the Site ID number is a unique number, it is not necessarily an accurate location indicator. The number can be used to both enter data into and retrieve data from computer storage. Consequently, any available historic data can be obtained from computer files by using the Site ID number. Inquiries regarding the availability of such data may be made to the U.S. Geological Survey, Tallahassee, Fla.

Table 3 provides the construction data, year completed, altitudes, and aquifer zone tapped for the 96 wells which served as data points in this investigation. The wells range in depth from 20 to 208 feet below land surface, but most are between 25 and 120 feet deep. Thirty-two of the wells listed in the table tap the surficial zone of the sand-and-gravel aquifer, with two possibly penetrating the intermediate zone. Fifty-eight of the wells listed tap the main producing zone. The zones tapped by the six remaining wells are unknown. Most of the domestic wells are 1.25 to 4 inches in diameter, whereas the municipal wells and Federal irrigation wells are 10 (with the exception of well 224) and 12 inches in diameter, respectively. The 16 test wells were cased and screened with PVC (polyvinyl chloride); other wells have standard steel casings and screens.

Table 4 lists the discharge from selected sand-and-gravel wells. Discharges range from 5 to 1,000 gal/min, and average 50 gal/min.

Acknowledgments

Appreciation is extended to the cities and many individuals who furnished information about their wells and permitted access to their land and equipment for measurements, geophysical logging, and water-quality sampling. Special thanks go to officials of the city of Fort Walton Beach, Eglin Air Force Base, and Okaloosa County for the use of their wells and pumping equipment, as well as for granting permission to drill test wells on their property.

The courtesies and help extended by the following persons are sincerely appreciated: George Imes, Ronald Bailey, Charles Ingram, and Rex B. Griffin, Jr., of the city of Fort Walton Beach; A. N. Southard of Eglin Air Force Base; James Thomason of Thomason Well Drilling; and the men of the Red Horse Drilling Unit, Hurlburt Field, Eglin Air Force Base.

Table 3.--Well construction data for selected sand-and-gravel wells

Depth of well: datum is land surface.

Altitude of land surface: values followed by the letter "L" were determined by leveling and are accurate to plus or minus 1 foot; other values were taken from topographic maps and are generally accurate to plus or minus 5 feet; datum is sea level.

Altitude of well bottom: datum is sea level.

Producing zone tapped: D, main producing zone; S, surficial zone; I, low permeability intermediate zone between the surficial and main producing zones. Refer to text for an explanation of how these zones are differentiated.

Map location number	Year completed	Depth of well (ft)	Altitude of land surface (ft)	Altitude of well bottom (ft)	Producing zone tapped	Casing length (ft)	Casing diameter (in.)	Screen length (ft)
				Okaloosa County				
45	1955	--	20	--	--	50	--	--
47	1954	26	--	--	S	--	--	--
59	1951	25	10	-15	S	--	4	--
60	1961	25	--	--	S	--	2	--
62	1965	--	--	--	--	--	2	--
66	1978	140	28	-112	D	120	4	20
69	1944	29	--	--	S	--	4	--
70	1944	28	--	--	S	--	2	--
73	1941	25	--	--	S	--	2	--
80	--	24	--	--	S	--	2	--
100	--	87	12	-75	D	--	8	--
109	1967	40	--	--	S	37	1.25	3
111	1978	120	12L	-108	D	100	4	20
113	1967	25	--	--	S	20	1.25	5

Table 3.--Well construction data for selected sand-and-gravel wells--Continued

Map location number	Year completed	Depth of well (ft)	Altitude of land surface (ft)	Altitude of well bottom (ft)	Producing zone tapped	Casing length (ft)	Casing diameter (in.)	Screen length (ft)
				Okaloosa County--Continued				
117	--	--	--	--	--	--	--	--
121	1967	--	--	--	--	--	--	--
129	1978	130	38L	-92	D	110	4	20
130	--	60	--	--	D	--	3	--
134	1978	130	33L	-97	D	110	4	20
137	--	--	--	--	--	--	--	--
139	1967	30	--	--	S	--	1.25	--
148	1961	25	--	--	S	21	1.25	4
157	1958	23	--	--	S	20	1.25	3
158	1967	25	--	--	S	22	1.25	3
173	1967	46	--	--	S/I	43	1.25	3
178	1978	80	19L	-61	D	60	4	20
180	1967	20	--	--	S	15	1.25	5
183	1957	35	--	--	S	25	1.25	10
189	1979	80	13L	-67	D	60	4	20
197	1965	25	--	--	S	20	1.25	5
199	--	38	--	--	S	33	2	5
208	1979	110	43	-67	D	90	4	20
209	--	20	--	--	S	--	4	--
210	1978	93	35	-58	D	72	10	20
213	1978	90	43	-46	D	69	10	20

Table 3.--Well construction data for selected sand-and-gravel wells--Continued

Map location number	Year completed	Depth of well (ft)	Altitude of land surface (ft)	Altitude of well bottom (ft)	Producing zone tapped	Casing length (ft)	Casing diameter (in.)	Screen length (ft)
			Okaloosa County--Continued					
216	1978	94	45	-49	D	73	10	20
220	1966	38	58	+20	S	23	2	15
222	1978	94	50	-44	D	73	10	20
224	1972	120	54L	-66	D	78	6	40
225	1978	120	54L	-66	D	80	4	40
226	1978	120	55L	-65	D	80	4	40
227	1978	25	55L	+30	S	20	2	5
233	1978	100	44L	-56	D	80	4	20
234	1978	100	44L	-56	D	80	2	20
235	1978	100	44L	-56	D	80	2	20
237	--	28	--	--	S	--	4	--
250	--	72	--	--	D	--	4	--
257	--	68	--	--	D	--	2	--
258	1954	86	69L	-17	D	76	6	10
260	1979	50	50L	0	D	30	4	10
269	1960	86	--	--	D	--	4	--
272	1943	70	--	--	D	--	4	--
275	1956	60	--	--	D	--	4	--
279	1978	160	87	-73	D	120	6	40
281	--	81	95	+14	D	71	4	10
292	1964	--	--	--	--	--	4	--

Table 3.--Well construction data for selected sand-and-gravel wells--Continued

Map location number	Year completed	Depth of well (ft)	Altitude of land surface (ft)	Altitude of well bottom (ft)	Producing zone tapped	Casing length (ft)	Casing diameter (in.)	Screen length (ft)
				Okaloosa County--Continued				
294	1966	193	118	-75	D	132	12	60
298	1966	193	124	-69	D	132	12	60
302	1953	110	--	--	D	100	4	10
312	1978	87	80	-7	D	60	6	27
319	1960	115	--	--	D	--	4	--
324	1960	170	--	--	D	--	4	--
326	--	140	--	--	D	--	2	--
328	1966	26	--	--	S	21	4	5
329	1966	91	--	--	D	86	4	5
331	1966	20	--	--	S	15	4	5
334	1966	35	--	--	S	30	4	5
351	1959	151	--	--	D	--	6	--
352	--	130	--	--	D	--	2	--
356	1942	208	136L	-72	D	168	6	40
360	--	60	--	--	S	--	2	--
361	1963	147	--	--	D	142	4	5
362	1958	130	--	--	D	--	2	--
363	1955	135	--	--	D	125	4	10
380	--	56	--	--	S	--	4	--
393	1965	106	186	+80	D	102	2	4

Table 3.--Well construction data for selected sand-and-gravel wells--Continued

Map location number	Year completed	Depth of well (ft)	Altitude of land surface (ft)	Altitude of well bottom (ft)	Producing zone tapped	Casing length (ft)	Casing diameter (in.)	Screen length (ft)
				Walton County				
3	1966	60	8	-52	D	58	2	2
6	--	60	30	--	D	57	2	3
26	1968	60	18	-42	D	56	1.25	4
27	1957	60	20	-40	D	57	2	3
35	1970	32	15	-17	S	29	1.50	3
36	1964	32	15	-17	S	30	1.25	2
38	1960	24	12	-12	S	22	1.25	2
41	1953	35	35	+11	S	22	2	2
282	--	65	72	+7	D	--	4	--
296	--	87	99	+12	D	--	2	--
309	--	47	97	+50	D	--	--	--
343	--	60	182	+122	D	--	4	--
368	1962	165	242	+77	D	155	4	10
369	--	90	242	+152	D	--	2	--
370	1953	108	220	+112	D	99	4	9
371	1953	104	230	+126	D	--	4	--
376	--	106	225	+119	D	--	4	--
377	1953	110	--	--	D	100	4	10
378	1953	95	235	+140	D	85	3	10
384	--	58	240	+182	S/I	--	2	--

Table 4.--Yield from selected sand-and-gravel wells

[Discharge in gallons per minute: M, measured; R, reported]

Map location number	Discharge	Map location number	Discharge	Map location number	Discharge
Okaloosa County		Okaloosa County		Okaloosa County	
47	10 R	213	350 M	326	15 R
59	40 R	216	350 M	351	150 R
60	10 R	220	80 R	360	30 R
62	5 R	222	350 M	362	5 R
66	50 M	224	200 R	363	14 R
69	27 R	225	50 M	380	10 R
70	18 R	237	100 R		
73	8 R	250	10 R	Walton County	
80	5 R	258	20 R	282	15 R
111	49 M	269	30 R	343	5 M
129	50 M	272	10 R	368	30 R
130	20 R	275	5 R	369	5 R
134	48 M	292	10 R	370	10 R
178	52 M	294	1,000 M	371	15 R
189	50 M	298	1,000 M	376	10 R
208	53 M	302	10 R	377	10 R
209	50 R	319	30 R	378	10 R
210	350 M	324	10 R	384	10 R

HYDROLOGY

Hydrogeology

Approximately 1,500 feet of sediment, ranging in age from middle Eocene to Holocene, compose the system of aquifers and confining beds in southern Okaloosa and Walton Counties. This stratigraphic sequence is divided into six hydrogeologic units, which in descending order are: the sand-and-gravel aquifer, the Pensacola Clay confining bed, the upper part of the Floridan aquifer, the Bucatunna Clay confining bed (Bucatunna Clay Member of the Byram Formation), the lower part of the Floridan aquifer, and the Claiborne confining bed. Only the sand-and-gravel aquifer and the Pensacola Clay confining bed will be discussed further in this report. For additional information on the geology of the area refer to Barraclough and Marsh (1962), Chen (1965), Marsh (1962; 1966), Pascale (1974), and Trapp and others (1977).

Pensacola Clay Confining Bed

Relatively impermeable sediments underlie the sand-and-gravel aquifer throughout most of southern Okaloosa and Walton Counties. Trapp and others (1977, p. 16) named these sediments the Pensacola Clay confining bed because "it corresponds approximately to the lower part of the Pensacola Clay of Marsh (1966, p. 54-68)." Trapp proceeded to define the Pensacola Clay confining bed as "the material of relatively low permeability between the sand-and-gravel aquifer above and the Floridan aquifer below. Sand-and-gravel and Floridan aquifer test data and drill cuttings from the Pensacola Clay indicate that leakage through the Pensacola Clay is minimal. It may include material older, younger, or beyond the limits of the lower Pensacola Clay stratigraphic unit."

The Pensacola Clay confining bed dips south-southwest at approximately 15 ft/mi; its depth below land surface ranges from about 10 feet in south-central Walton County to about 210 feet in southwestern Okaloosa County. Thickness ranges from 475 feet in southwestern Okaloosa County to less than 50 feet in parts of southeastern Walton County and averages about 150 feet in southern Walton County and about 350 feet in southern Okaloosa County.

Sand-and-Gravel Aquifer

The sand-and-gravel aquifer in southern Okaloosa and Walton Counties comprises sediments that range in age from late Miocene to Holocene. The aquifer covers all the land area and extends from land surface to the top of the underlying Pensacola Clay confining bed (fig. 4); it ranges in thickness from about 10 feet in south-central Walton County to about 210 feet in southwestern Okaloosa County (fig. 5). Figure 5 shows the thickness of the aquifer which was obtained by evaluating geophysical and lithologic logs of sand-and-gravel and Floridan aquifer wells that penetrate the aquifer. Floridan aquifer well data may be found in Wagner and others (1980, table 2, p. 34-43). Locations of the sand-and-gravel test holes are shown in figure 1.

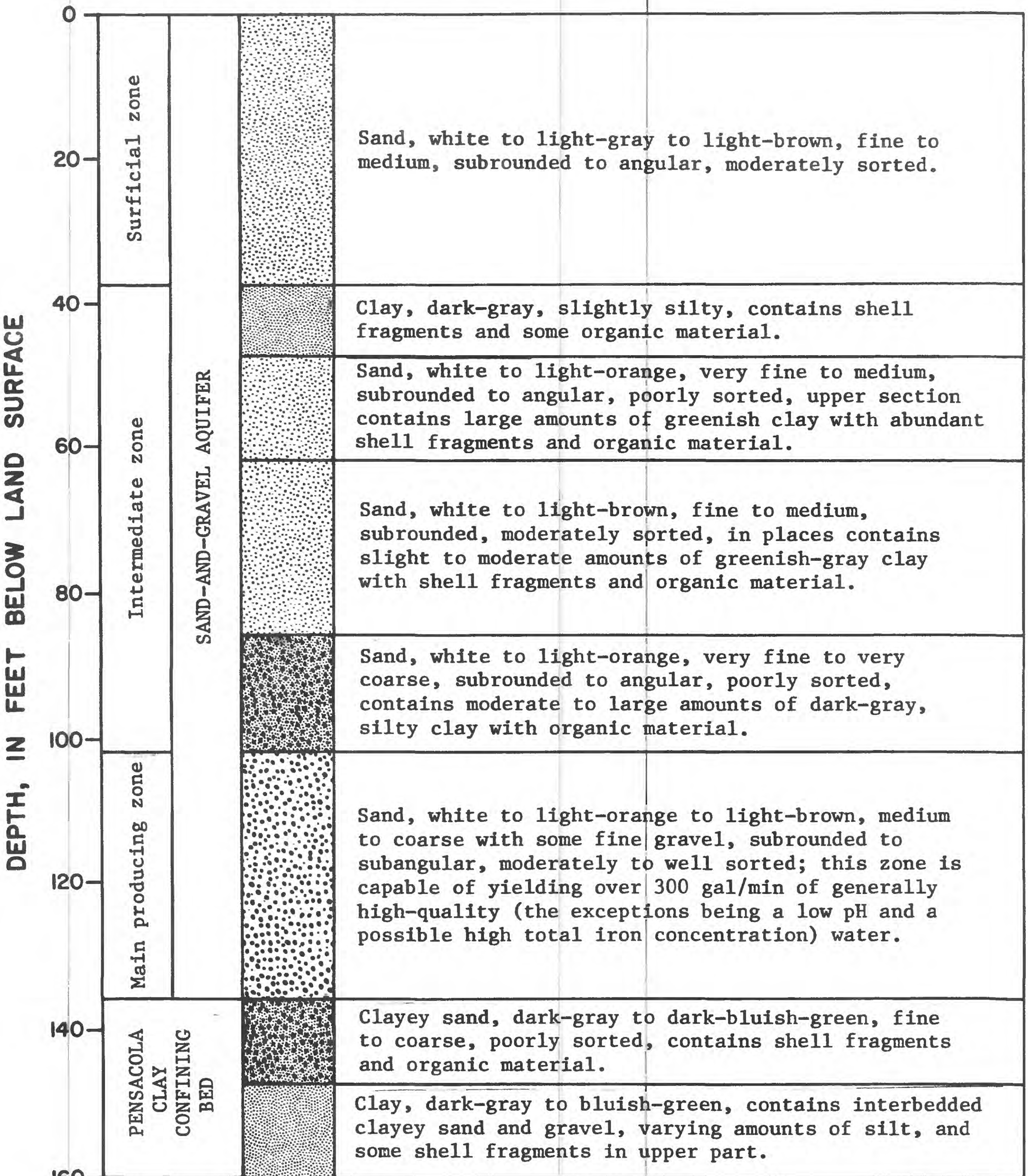

Figure 4.--Generalized stratigraphic description of the sand-and-gravel aquifer and the uppermost part of the underlying Pensacola Clay confining bed, Fort Walton Beach area.

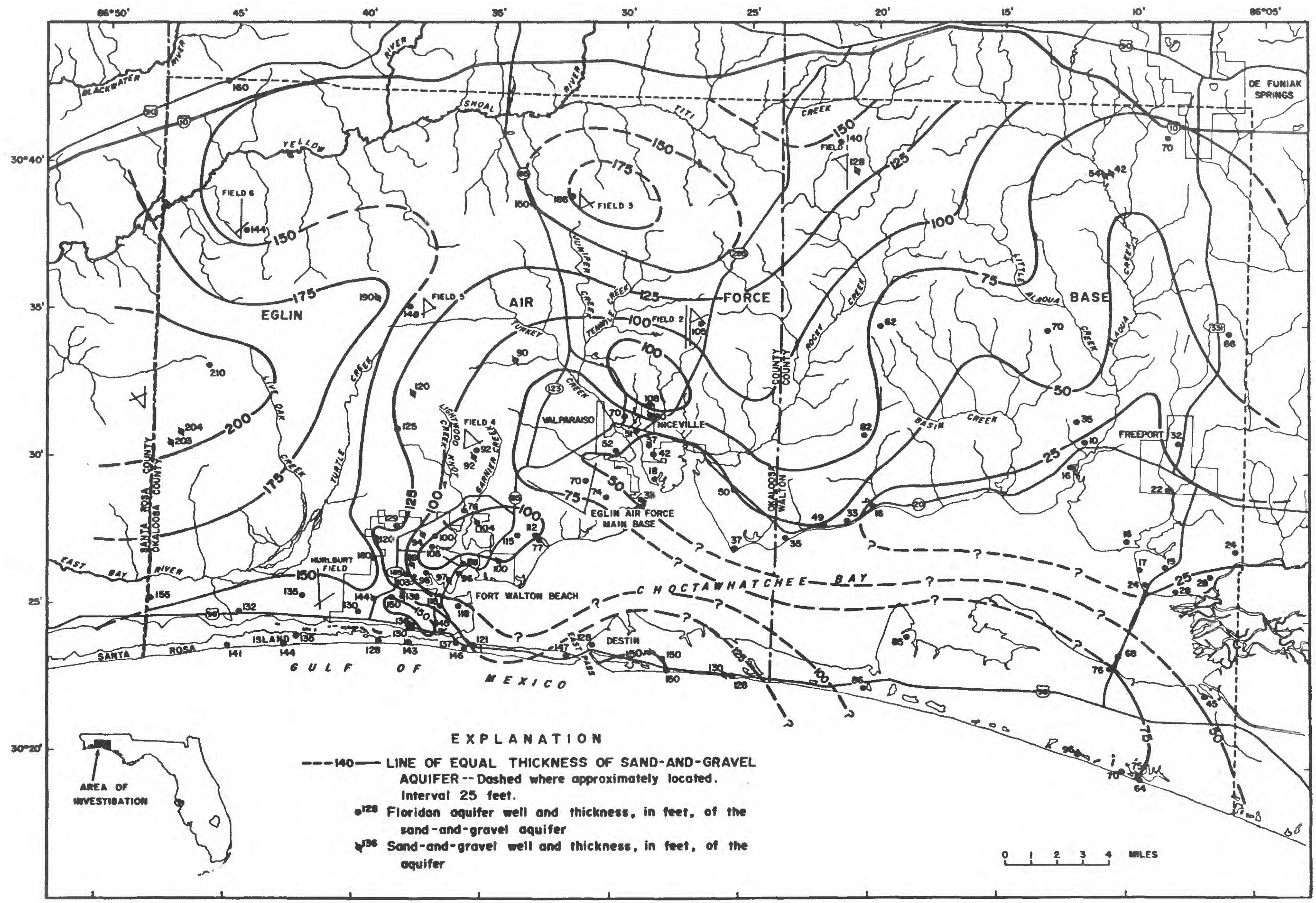

Figure 5.--Thickness of the sand-and-gravel aquifer.

Differences in lithology and hydraulic properties allow the sand-and-gravel aquifer to be divided into three hydrologic zones (fig. 4), which in descending order are: a surficial zone (water table), an intermediate zone of relatively low permeability, and a main producing zone (artesian). The surficial zone consists of white to light-gray to light-brown, fine to medium, moderately sorted sand and extends from land surface to a depth of 20 to 60 feet. Below the surficial zone are 10- to 65-feet-thick beds of clay, sandy clay, and clayey sand; the permeability of this intermediate zone varies widely, but is fairly low throughout most of the area. The main producing zone is usually the most permeable part of the aquifer; it consists of sand that is white to light orange to light brown in color, medium to coarse grained with some fine gravel, and moderately to well sorted. This zone includes the bottom 10 to 85 feet of the aquifer. The main producing zone usually functions as a confined (artesian) aquifer in that it is hydraulically separated from the surficial zone by the low-permeability intermediate zone. One or more of these zones may be absent where the aquifer is thin; for example, along the shore of Choctawhatchee Bay and in southeastern Walton County (fig. 5).

The overall permeability of the surficial and main producing zones varies in accordance with the areal variations in the lithology of their sediments. In southeastern Walton County these sediments consist largely of fine to medium sand with varying amounts of clay, and it is not always possible to differentiate the aquifer into the three hydrologic zones. The grain size of the sediments of the surficial and main producing zones increases to the west and the clay content becomes negligible. As a result, the permeability of the two zones increases from southeastern Walton County to southwestern Okaloosa County. Moreover, because they also increase in thickness from east to west, the transmissivity of each and the overall transmissivity of the entire sand-and-gravel aquifer correspondingly increase westward.

Hydraulic Properties

Aquifer Tests

To define the hydraulic properties of the main producing zone of the aquifer, seven sites were tested in the Fort Walton Beach area (fig. 6). Site 6 contained a production well and two observation wells open to the main producing zone, and one observation well open to the surficial zone. Site 7 contained a production well and observation well open to the main producing zone. The remaining five test sites contained only production wells open to the main producing zone. Observation and pumping wells open to the main producing zone were effectively fully penetrating and, consequently, partial penetration effects were not a problem.

The data obtained from multiwell test sites 6 and 7 were analyzed using a radial flow model for leaky confined aquifers developed by Hantush and Jacob (1955) and modified by Cooper (1963). The data obtained from the single-well test sites, at which the drawdown was measured in the pumped well, were analyzed using a straight-line method developed by Jacob (1950). The values of the hydraulic properties determined at multiwell test sites 6 and 7, the estimated transmissivity values obtained at single-well test sites 1-5, and other pertinent information are summarized in table 5.

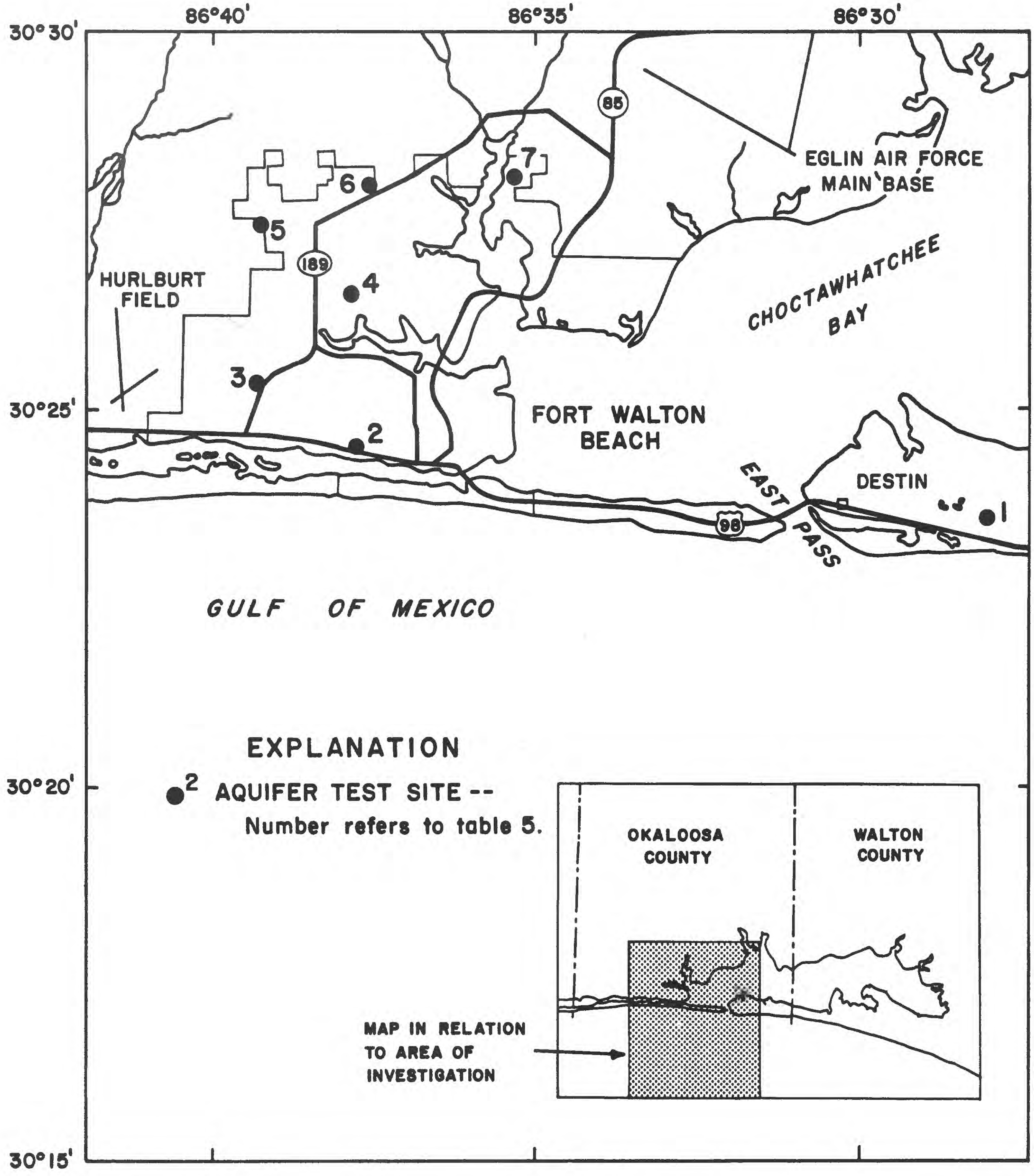

Figure 6.--Locations of the main producing zone aquifer test sites.

Table 5.--Summary of test results from the main producing zone aquifer

[The transmissivities obtained at single-well test sites 1-5 represent estimated values; refer to text for explanation]

Test site number	Map location number	Well discharge (gal/min)	Screen length (ft)	Method of analysis[1/]	Hydraulic properties: Transmissivity (ft^2/d)	Storage coefficient	Leakance K'/b' (d^{-1})
1	66	50	20	Straight line	2,500	--	--
2	111	49	20	Straight line	400	--	--
3	129	50	20	Straight line	2,000	--	--
4	178	52	20	Straight line	1,100	--	--
5	208	53	20	Straight line	700	--	--
6	224	382	40	--	--	--	--
	225		40	Leaky	6,200	$1.4x10^{-4}$	$1x10^{-2}$
	226		40	Leaky	5,400	$4.5x10^{-4}$	$1x10^{-2}$
	227		5	--	--	--	--
7	233	48	20	--	--	--	--
	234		20	Leaky	1,500	$1.9x10^{-4}$	$2x10^{-2}$

[1/] Straight-line method from Jacob, 1950. Leaky method from Hantush and Jacob, 1955; Cooper, 1963.

Figure 7 shows the plan and profile views of the well system utilized in the testing of site 6. The production well, 224, and two observation wells, 225 and 226, were each equipped with 40 feet of screen set adjacent to a clean, medium to coarse sand in the main producing zone. Drawdown in these observation wells reached a steady-state condition after 2 hours of pumping as a result of leakage through the confining intermediate zone. Well 227, with 5 feet of screen in the surficial zone, did not show the effects of pumping of the main producing zone. Figure 8 presents a logarithmic plot of drawdown versus time for observation well 226 (test site 6), which was located 150 feet from pumped well 224. The calculated values of transmissivity and storage coefficient are 6,200 ft^2/d and $1.4x10^{-4}$, respectively, for observation well 225 and 5,400 ft^2/d and $4.5x10^{-4}$, respectively, for observation well 226. The estimated leakance of the confining intermediate zone (K'/b', where K' and b' are the vertical hydraulic conductivity and thickness of the intermediate zone, respectively) is $1x10^{-2}$ d^{-1}.

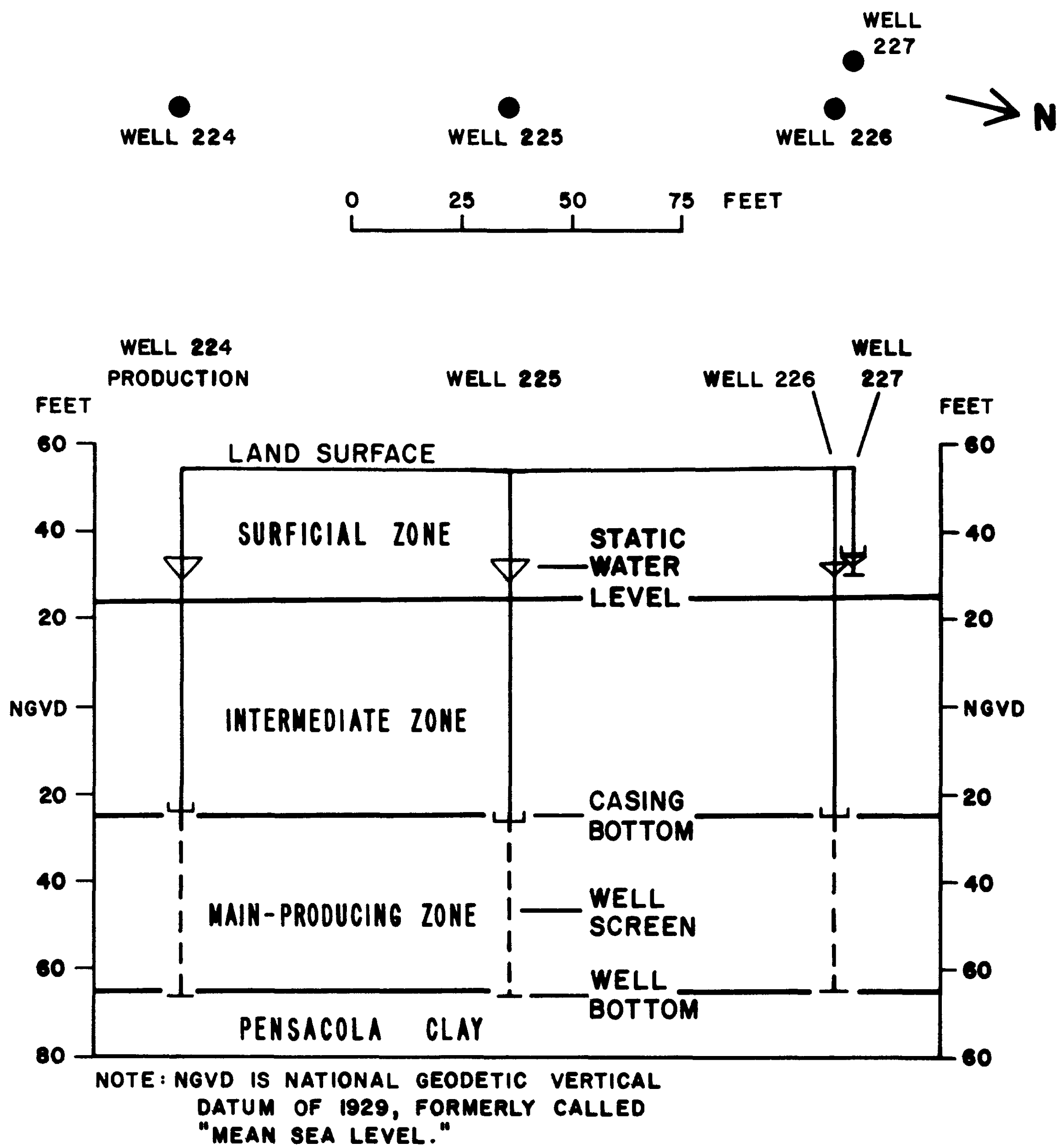

Figure 7.--Plan and profile views of wells at aquifer test site 6 in Fort Walton Beach ball park.

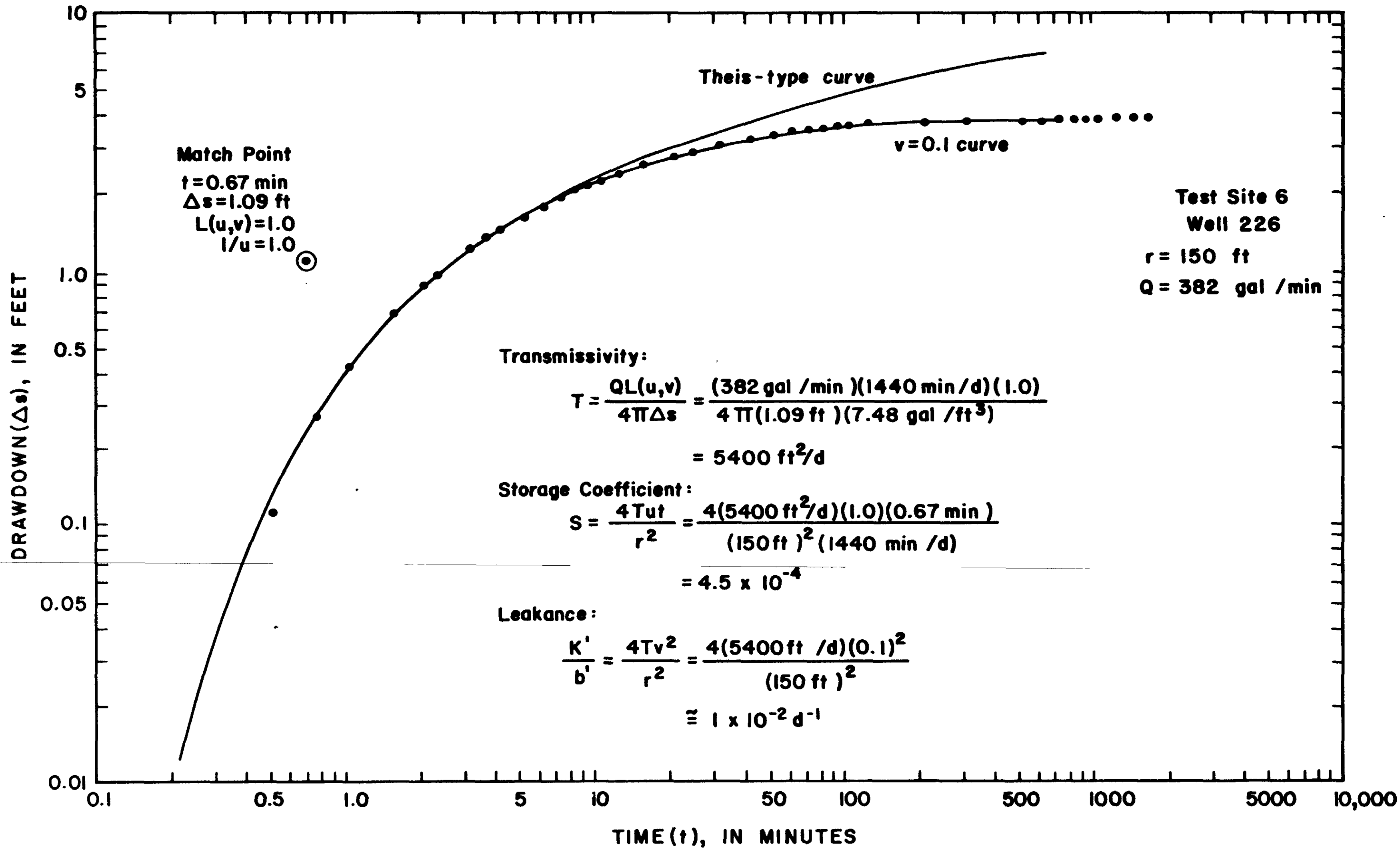

Figure 8.--Logarithmic plot of drawdown versus time for observation well 226, aquifer test site 6, in Fort Walton Beach ball park.

At test site 7, observation well 234 was 51 feet from well 233, the production well. The pumping rate was 48 gal/min. The time-drawdown curve for observation well 234 is similar to those obtained for observation wells 225 and 226 at test site 6. The calculated values of transmissivity and storage coefficient are 1,500 ft^2/d and 1.9×10^{-4}, respectively; the estimated leakance of the confining intermediate zone is 2×10^{-2} d^{-1}.

The five single-well tests were analyzed using Jacob's (1950) straight-line method. Because the method does not account for leakage through the confining bed, only data from the early part of the tests were used in their analyses. Transmissivity values obtained, consequently, are considered to be estimates because of the inaccuracies that arise from drawdown being measured in pumped wells, partial penetration effects, and well losses (Meyer, 1963; Lohman, 1972). The fact that the tests were analyzed in a consistent manner supports their use as indicators of the relative variations in the transmissivity of the main producing zone of the sand-and-gravel aquifer. As a means of approximating the accuracy of a Jacob straight-line analysis relative to an analysis by the Hantush-Jacob leaky aquifer method, the transmissivity of observation well 225, aquifer test site 6, was also determined by the straight-line method. Its 5,000 ft^2/d transmissivity is reasonably close to the 6,200 ft^2/d calculated using the Hantush-Jacob method and supports a qualified use of single-well test results.

The storage coefficient and leakance values determined from the aquifer tests confirm that the main producing zone can be treated as a leaky confined aquifer. Because the tests were only of the main producing zone, the applicability of the transmissivity values to the entire thickness of the sand-and-gravel aquifer is limited. Also, because of regional changes in lithology and thickness of the main producing zone, extrapolation of transmissivity outside of the area tested (Fort Walton Beach area) is not feasible.

Specific Capacity and Water Availability

The specific capacity of a well is the rate of discharge of water from the well divided by the drawdown of the water level in the well. It varies slowly with duration of discharge. Walton (1970, p. 311-326) and Lohman (1972, p. 52) discuss the effects of well construction, development, well-screen characteristics, and velocity and length of flow up the casing upon specific capacity.

Specific capacities were calculated for 15 wells open to the main producing zone (table 6). The specific capacities range from 1.3 to 125 but are generally less than 15 (gal/min)/ft. This range in values is largely the result of a combination of areal variations in the lithology and thickness of the saturated sediments and differences in well construction (Meyer, 1963). Table 6 shows that the high specific capacities were obtained for the larger diameter wells and particularly for wells in the area northwest of Fort Walton Beach (fig. 1); these wells also have correspondingly high estimated potential yields.

Estimated potential yield is the product of specific capacity and maximum available drawdown, that is, the static water level in a well drawn down to the top of the main producing zone. The estimated potential yields of these 15 wells range from about 100 to more than 10,000 gal/min, but generally fall in the range of 200 to 400 gal/min.

Table 6--Specific capacities and estimated potential yields of wells open to the main producing zone of the sand-and-gravel aquifer in southern Okaloosa County

Map location number	Well discharge (gal/min)	Pumping period (hour)	Draw-down (ft)	Specific capacity [(gal/min)/ft]	Maximum available draw-down (ft)	Estimated potential yield (gal/min)	Well and screen diameter (in.)	Screen length (ft)
66	50	5.4	10.4	4.8	78	374	4	20
111	49	2.7	36.4	1.3	80	104	4	20
129	50	3.2	18.5	2.7	76	205	4	20
134	48	4.0	23.8	2.0	65	130	4	20
178	52	0.5	12.2	4.3	36	155	4	20
189	50	1.4	14.0	3.6	44	158	4	20
208	53	2.3	17.8	3.0	67	201	4	20
210	350	12.0	24.0	15	24	360	10	20
213	350	12.0	30.0	12	19	228	10	20
216	350	12.0	22.0	16	24	384	10	20
222	350	12.0	20.0	18	24	432	10	20
224	200	8.0	16.0	12	50	600	6	40
225	50	0.5	8.0	6.2	52	322	4	40
294	1,000	9.0	10.0	100	85	8,500	12	60
298	1,000	8.0	8.0	125	82	10,250	12	60

The available data indicate that large volumes of water can be pumped from wells of 6 inch or larger diameter that are open to the main producing zone. The area north and northwest of Fort Walton Beach appears to be the most productive. As a result of well losses at high flow rates, maximum yields would probably be on the order of 500 to more than 1,000 gal/min. The yields of most of the wells in southeastern Okaloosa and southern Walton Counties would probably be more than 50 gal/min but less than those obtained in the Fort Walton Beach metropolitan area because the aquifer thins to the east. Where the aquifer is less than 50 feet thick (fig. 4), and is composed of mostly fine to medium sand, yields of 25 to 100 gal/min may be expected.

Water Levels

The scant historical data on the water-table in the surficial zone of the sand-and-gravel aquifer indicate that the water table is generally a subdued replica of the topography, being a few feet below land surface in much of the Gulf Coastal Lowlands region and 25 to 50 feet below land surface in much of the Western Highlands region. Rainfall readily infiltrates the unsaturated surficial sands and moves down to the water table (top of the saturated zone), where movement becomes predominantly lateral. Lateral flow continues until the water: moves up and is lost to evaporation and transpiration in areas where the water table is at or near land surface; discharges into streams, lakes, swamps, bays, or the Gulf of Mexico; is pumped to the surface through wells; or leaks down through the confining beds to recharge the main producing zone.

Water-level altitudes in the surficial zone usually are higher than the potentiometric surface of the main producing zone in most of the sand-and-gravel aquifer. Consequently, water moves from the surficial zone, by leakage, down through the confining beds and into the main producing zone. Aquifer tests indicate that this leakage is significant and probably represents the major source of recharge to the main producing zone. The March 1979 generalized potentiometric surface of the main producing zone (fig. 9) was developed using data from 27 observation wells; the locations of streams, lakes, swamps, and bays; and the relation of the potentiometric surface of the main producing zone to the potentiometric surface of the underlying Floridan aquifer except in areas where the Floridan is heavily pumped. The configuration of the potentiometric surface shows that water in the main producing zone discharges generally toward the Gulf of Mexico and Choctawhatchee Bay.

Figure 10 illustrates the combined effects of rainfall and pumping on the water level in a well open to the main producing zone. Although variations in the amount of rainfall produce corresponding variations in water level, the response is delayed. For example, the high rainfall in January and February 1979 was not fully manifested as higher water levels in well 226, Fort Walton Beach ball park, until late February. The small, short-term water-level fluctuations that occurred in April and May 1979 are attributed to the pumping of nearby ball park irrigation well 224.

Water Quality

This investigation, in agreement with previous studies (Pascale, 1974, p. 20-24; Trapp and others, 1977, p. 39-42), found that, with occasional exceptions, potable water can be obtained from the sand-and-gravel aquifer in southern Okaloosa and Walton Counties. Although pH may be as low as 4.5 and iron concentration may be as high as 4.3 mg/L (table 8), the water is usually suitable for domestic, industrial, and irrigation use meeting State and Federal requirements for public drinking-water supplies. Some chemical constituents or physical conditions of the water may be problems. For example, the concentration of hydrogen sulfide may be high enough to give the water a "rotten egg" odor and make it corrosive; water pumped from wells screened opposite clayey sand may have a turbid appearance due to the presence of colloidal clay; or wells close to the saline-water bayous and shorelines of the Gulf of Mexico and Choctawhatchee Bay may exhibit higher values of chloride, pH, and iron than wells located further inland. Investigation, however, has not shown saline-water contamination of the aquifer to be other than a local coastal problem.

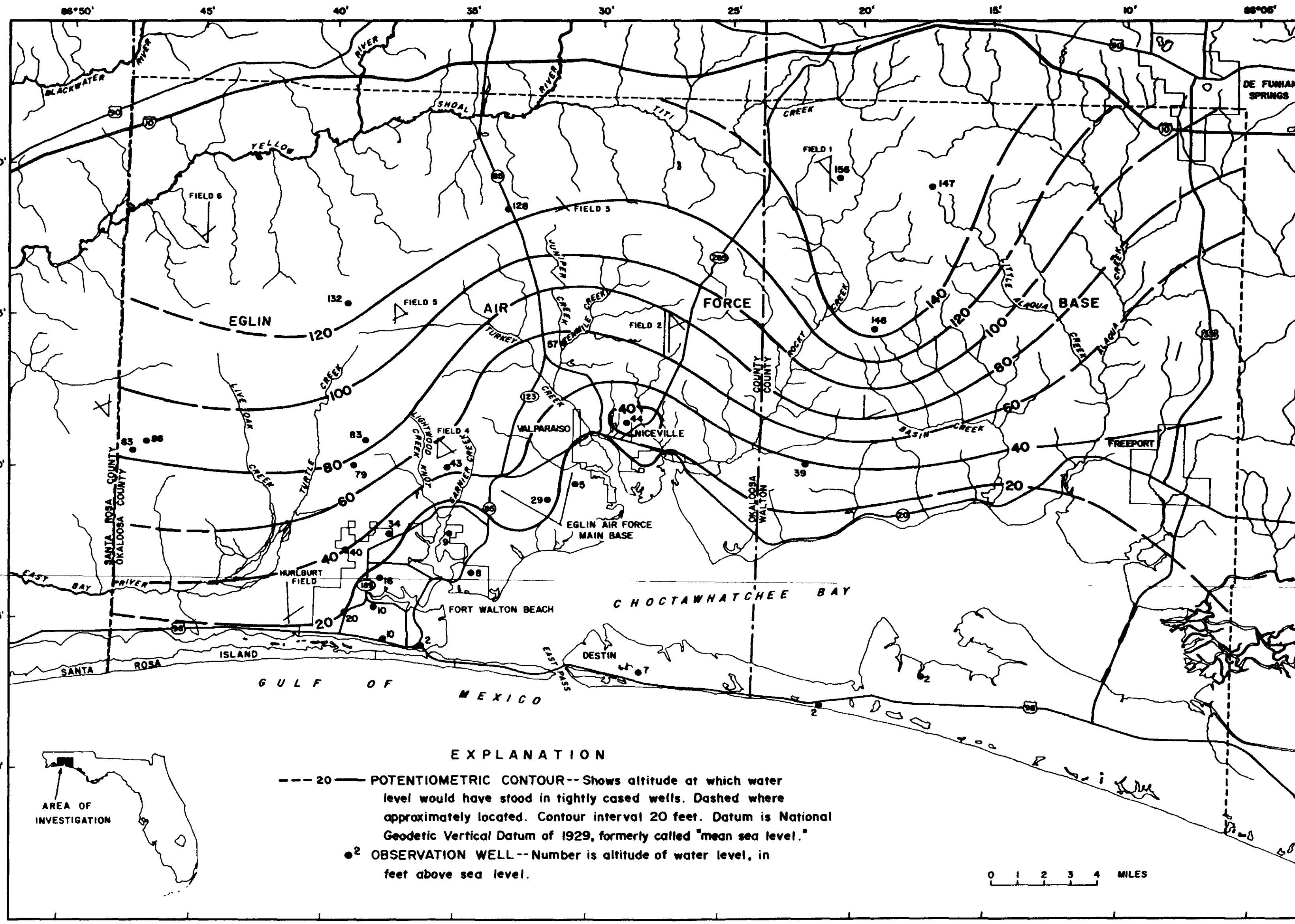

Figure 9.--Generalized potentiometric surface of the main producing zone of the sand-and-gravel aquifer in March 1979.

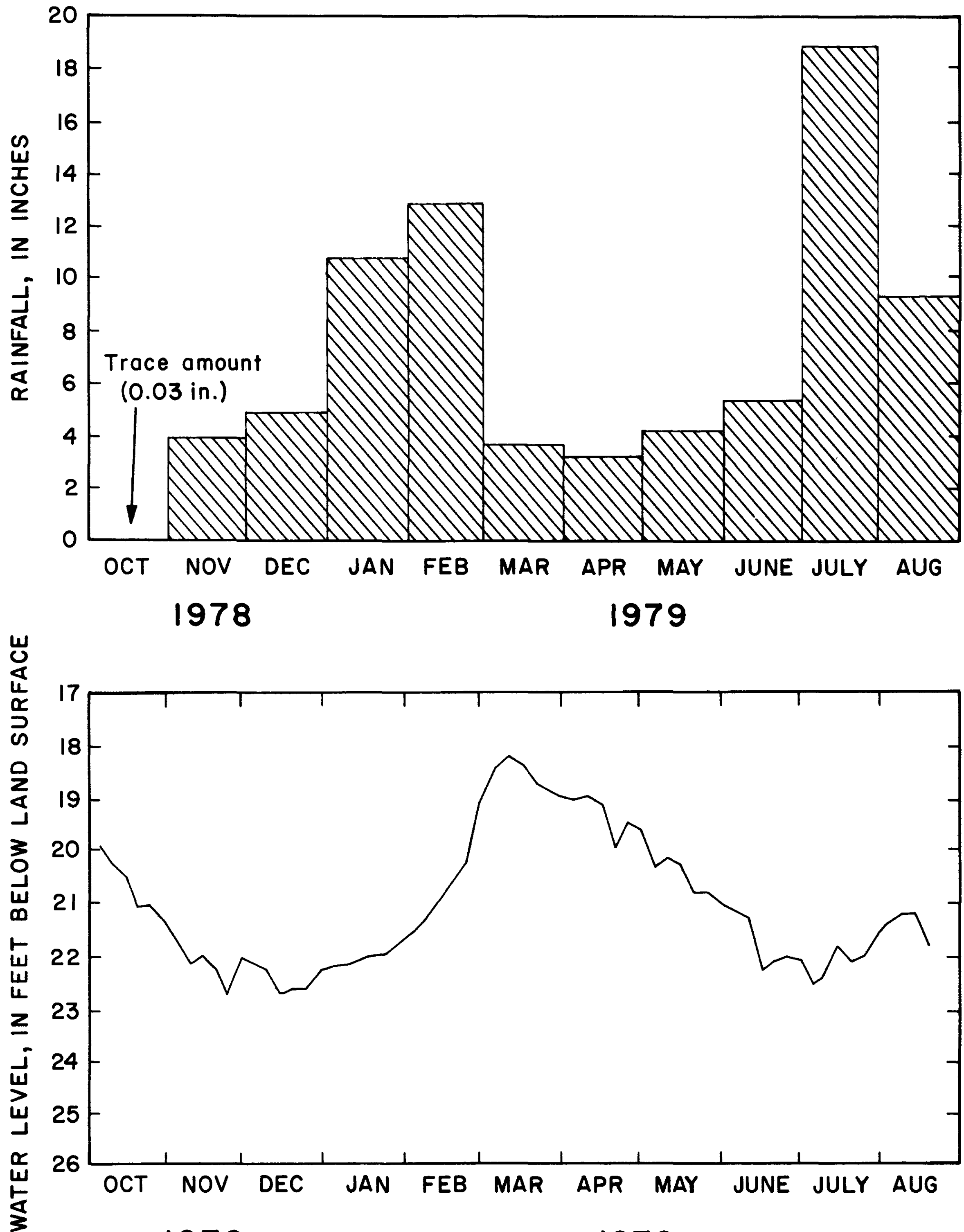

Figure 10.--Monthly rainfall at Niceville and hydrograph of average weekly water levels in well 226, October 1978 through August 1979.

Major inorganic constituents, as well as any constituents that might have attained the maximum contaminant levels established by the U.S. Environmental Protection Agency (EPA, 1975), were of primary interest (table 7). Although maximum contaminant levels have not been established for most major inorganic constituents, recommended maximum levels proposed by the EPA (1977) for several of them became effective on January 19, 1981. Effective November 1, 1981, all recommended EPA maximum contaminant levels are considered mandatory and legally enforceable in Florida (Florida Department of State, 1978).

Major Inorganic Constituents and Physical Properties

The chemical character and physical properties of aquifer water summarized in table 8 indicate that major inorganic constituent concentrations, hardness, and pH (range, mean, and standard deviation) may be greater for water from the surficial zone than for water from the main producing zone. The generally higher mean and greater variability of major inorganic constituent concentrations, hardness, and pH in water from the surficial zone may result from saline water from such surface sources as the Gulf of Mexico and Choctawhatchee Bay. The surficial zone is also more likely to be contaminated by sewage effluent and other pollutants derived from human activities because it is shallow and unprotected by an overlying confining bed.

As rainwater moves down through the upper soil zone it interacts geochemically with the sediments and organic material and becomes acidic. If decaying organic material is abundant the pH can become as low as 4.5 units. Saline-water contamination of an aquifer can result in higher than normal pH values, as illustrated by well 139 (figs. 1, 11, 12, and 13). Well 139 had a chloride concentration of 280 milligrams per liter (mg/L) and a pH of 7.5 units for the date mapped (July 10, 1967); the same sample also had an unusually high iron concentration (5.8 mg/L). These anomalous conditions were the result of heavy pumping, which allowed contamination of the well by nearby saline bay water (Foster and Pascale, 1971). Because these concentrations were considered to reflect anomalous conditions, the data were excluded from the statistical analysis in table 8. Similarly, although iron concentrations of 5.1 mg/L (fig. 13) have been reported (Pascale and others, 1974) for main producing zone wells 3 and 27, these values are also probably anomalous and were excluded from the statistical analysis.

Iron is an abundant and widespread constituent of the sediments that comprise the aquifer and is an essential element in both plant and animal metabolism. Organic wastes and plant debris present in the sediments of the aquifer contain considerable amounts of iron. Consequently, aquifer water with a pH of less than 7.0 units can contain iron at concentrations of as much as 5 mg/L. Iron concentrations in water from the surficial zone of the aquifer range from 0.02 to 4.3 mg/L and average 0.70 mg/L, and in the main producing zone the range is from 0.01 to 3.7 mg/L and the average is 0.54 mg/L (table 8 and fig. 13); hence, on the average, the iron concentration in both zones exceeds the maximum contaminant level of 0.3 mg/L recommended by the EPA (1977).

Table 7.--Maximum allowable contaminant levels recommended by the U.S. Environmental Protection Agency for selected chemical constituents in drinking water

[Data from the U.S. Environmental Protection Agency (1975)]

[Constituents in milligrams per liter except where noted]

	Maximum contaminant level
Arsenic (As)	0.05
Barium (Ba)	1.0
Cadmium (Cd)	.010
Chromium (Cr)	.05
Copper (Cu)	1
Lead (Pb)	.05
Manganese (Mn)	.05
Mercury (Hg)	.002
Selenium (Se)	.01
Silver (Ag)	.05
Zinc (Zn)	5
Dissolved solids	500
Color (platinum-cobalt units)	15
Foaming agents	.5
Odor (threshold odor number)	3
pH (units)	6.5-8.5
Corrosivity	non-corrosive
Endrin	.0002
Lindane	.004
Methoxychlor	.1
Toxaphene	.005
2, 4-D (dichlorophenoxyacetic acid)	.1
2, 4, 5-TP (Silvex)	.01
Chloride (Cl)	250
Fluoride (F)	1.4[1/]
Hydrogen sulfide (H_2S)	.05
Iron (Fe)	0.3
Nitrate (NO_3-N)	10.0
Sulfate (SO_4)	250
Combined radium 226 and 228 (picocuries per liter)	5
Gross alpha particle activity, including radium 226 but excluding radium and uranium (picocuries per liter)	15
Gross beta particle activity (millirems per year)	4

[1/] The maximum contaminant level for fluoride depends on the annual average of the maximum daily air temperature in the location of the water-supply system.

Table 8.--Range in major inorganic constituent concentrations and physical properties of water from the sand-and-gravel aquifer

[All of the water-quality data obtained at well 139, as well as the iron concentrations measured in wells 3 and 27, were excluded from the statistical analysis--see text for an explanation. Data for surficial zone (shallow wells) are based on 24 to 26 wells sampled; data for main producing zone (deep wells) are based on 47 well samples. With the exception of pH, all range, mean, and standard deviation values are in milligrams per liter.]

	Surficial zone			Main producing zone		
	Range	Mean	Standard deviation	Range	Mean	Standard deviation
Bicarbonate (HCO_3)	10-114	48	31	0-20	7	4
Calcium (Ca)	1.6-32	15	9.8	0-6.6	1.5	1.4
Chloride (Cl)	2.5-154	22	29	0-15	4.4	3.4
Dissolved solids (residue at 180°C)	16-428	106	83	6-106	29	18
Fluoride (F)	0-0.5	0.2	0.1	0-1.5	0.1	0.2
Hardness (total as $CaCO_3$)	7-105	50	32	1-23	7	5
Iron (Fe)	0.02-4.3	0.7	1.23	0.01-3.7	0.54	0.80
Magnesium (Mg)	0.4-5.7	2.7	2.9	0-2.1	0.7	0.5
Nitrate (NO_3)	0-20	1.7	4.6	0-8.8	1.4	2.4
pH (units)	5.7-7.7	--	--	4.5-6.9	--	--
Potassium (K)	0-4.8	1.2	1.1	0-2.6	0.4	0.4
Silica (SiO_2)	2.8-22	7.3	4.4	0.5-14	5.1	2.6
Sodium (Na)	1.7-80	13	15	0.8-15	3.3	2.7
Sulfate (SO_4)	0-64	11	15	0-14	2.0	3.0

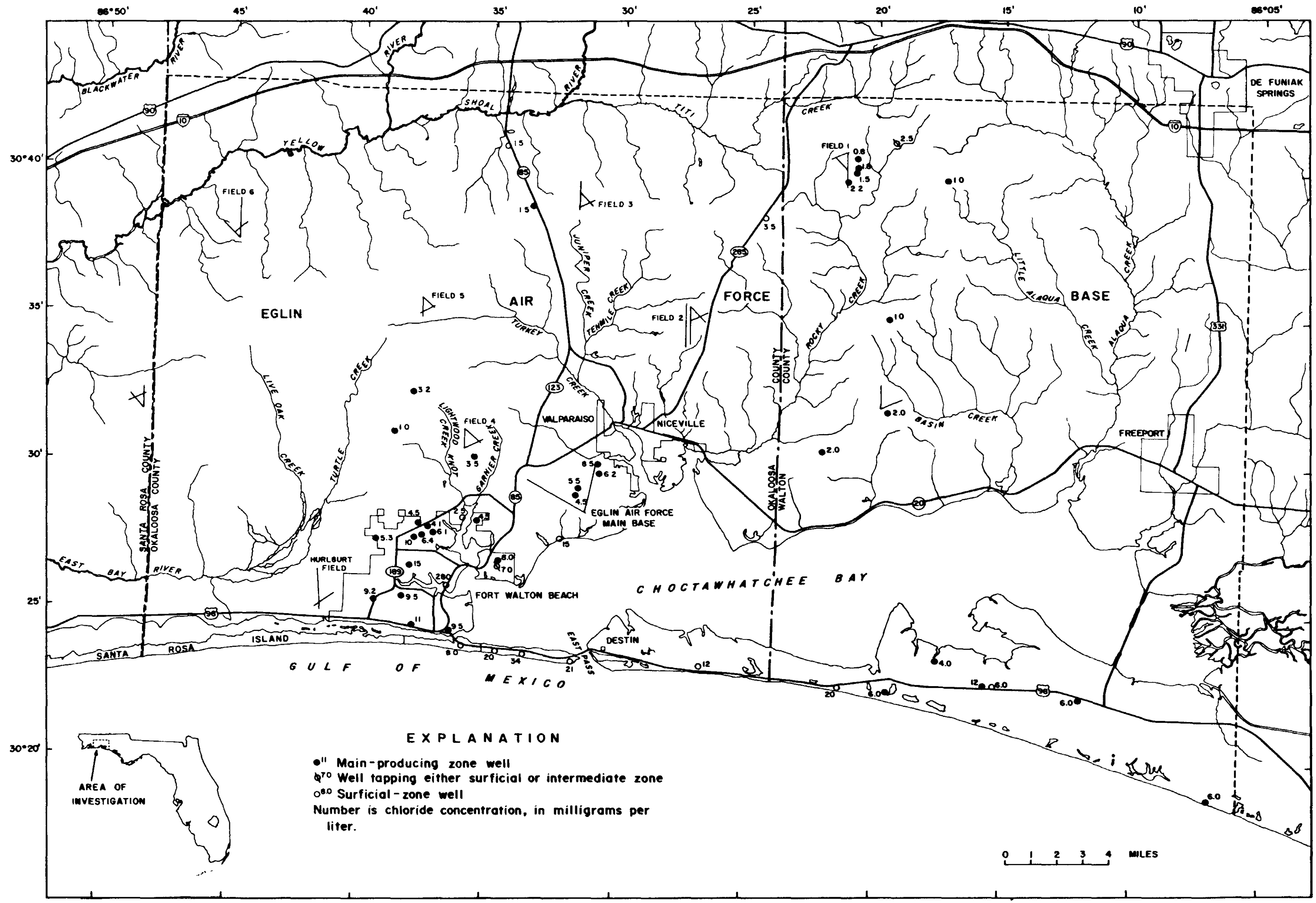

Figure 11.--Distribution of chloride in water from the sand-and-gravel aquifer, southern Okaloosa and Walton Counties.

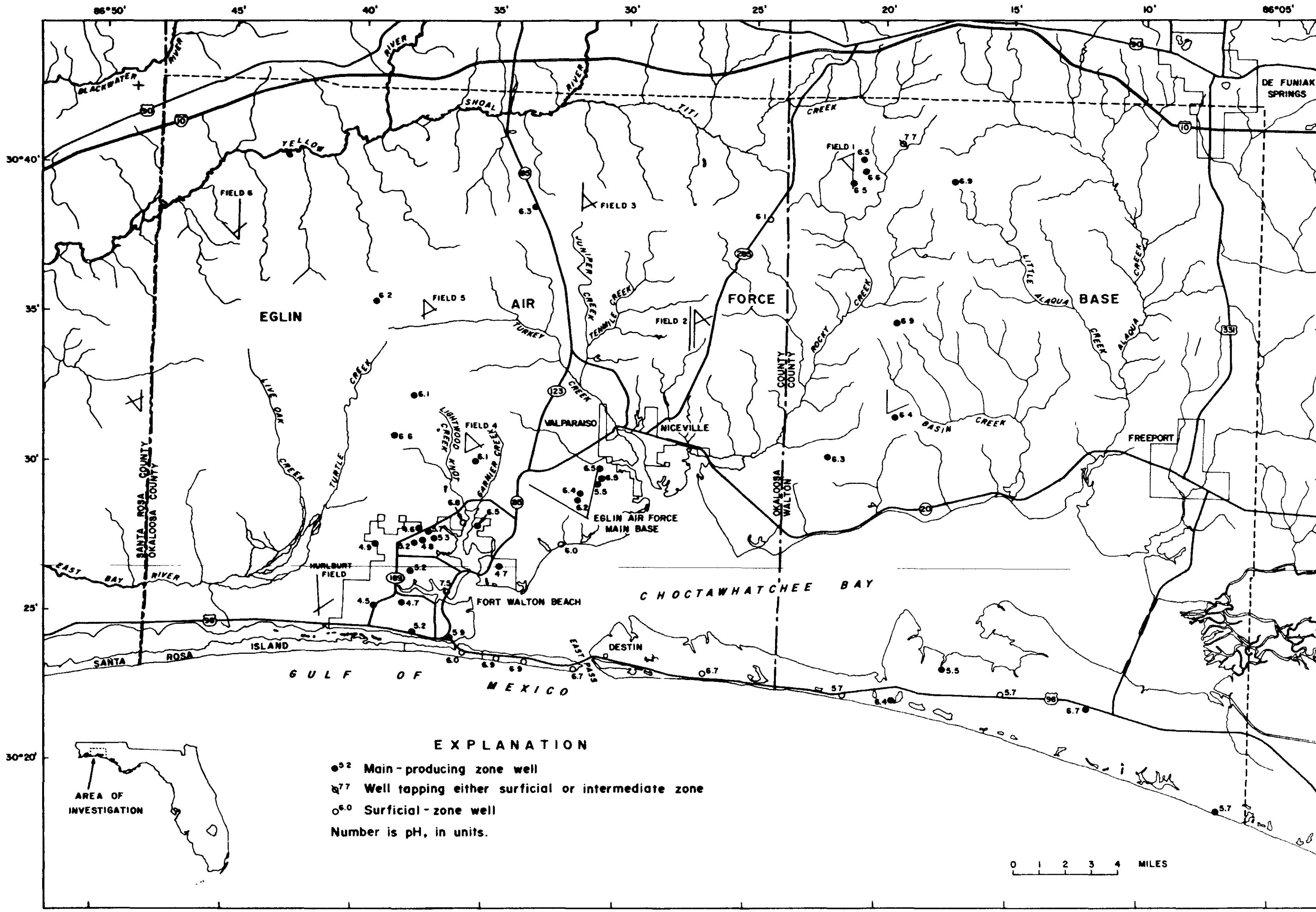

Figure 12--Distribution of pH values in water from the sand-and-gravel aquifer, southern Okaloosa County.

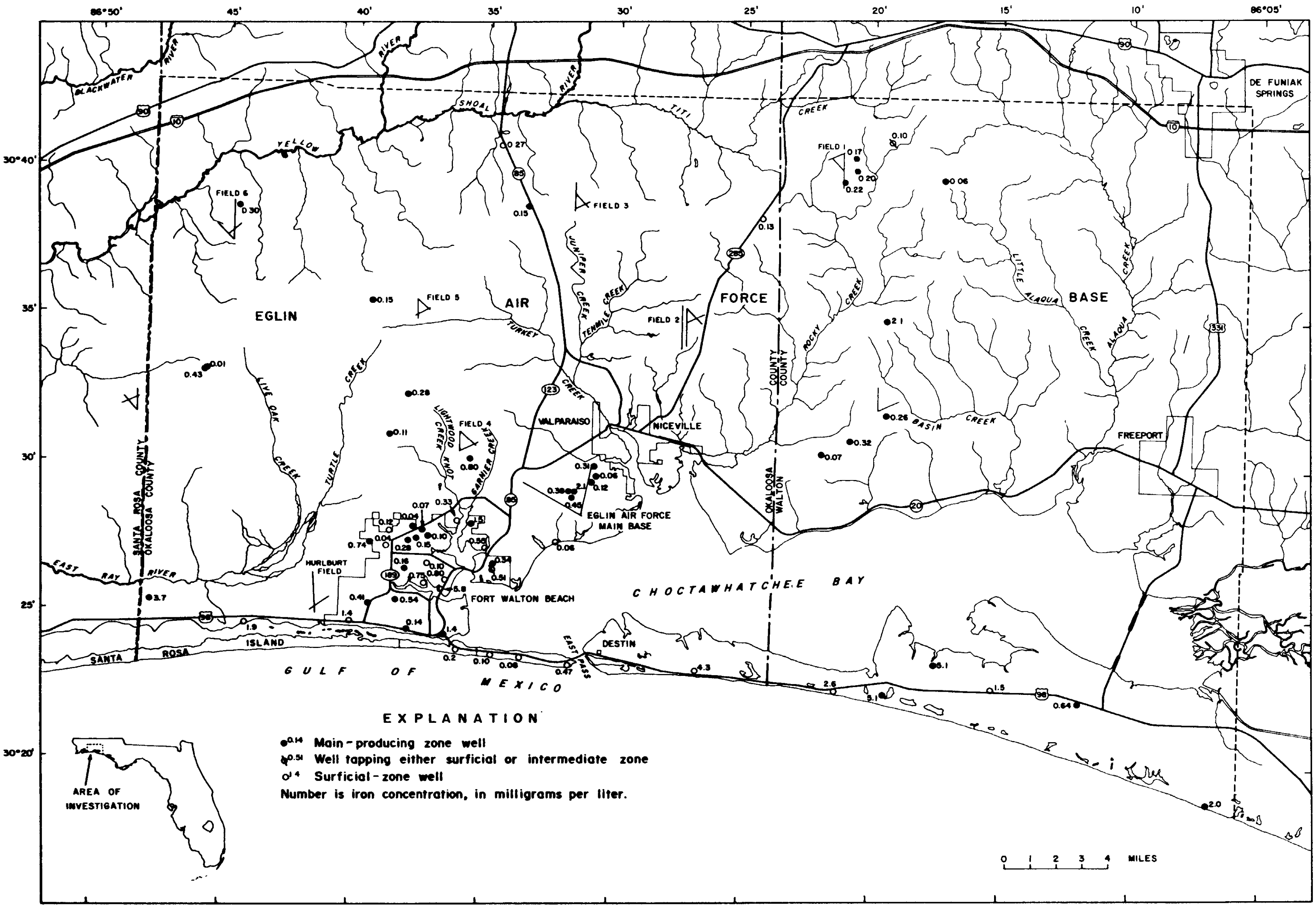

Figure 13.--Distribution of iron in water from the sand-and-gravel aquifer, southern Okaloosa and Walton Counties.

In some wells, the corrosion of the metal casing, screen, and pump may be the sole or partial source of the iron in the water; this has been considered a particularly good possibility in wells located near the coast because of the corrosive action of saline waters. In an effort to determine if metal well parts could be a significant cause of high iron concentrations, eight PVC-cased wells open to the main producing zone were sampled using a stainless steel submersible pump equipped with PVC discharge lines. The wells were clustered in the Fort Walton Beach area (fig. 13). A partial tabulation of the analytical results is given in table 9.

Table 9.--Iron, chlorides, and pH of wells cased with PVC and open to the main producing zone

Map location number	Total iron (mg/L)	Dissolved iron (mg/L)	Suspended iron (mg/L)	Chloride (mg/L)	pH (units)
111	0.140	0.030	0.110	1.0	5.2
129	.410	.350	.060	9.2	4.5
134	.540	.200	.340	9.5	4.7
178	.160	.050	.110	15.0	5.2
189	.340	.030	.310	8.0	4.7
208	.740	.400	.340	5.3	4.9
233	1.520	.120	1.400	4.5	5.6
279	.800	.010	.790	3.5	6.1

The analyses indicate that the aquifer water at six of the eight wells exceeded the maximum 0.3 mg/L total iron content recommended for public water supplies and show that the well and pump system are not necessarily the source of the high iron content of a well-water sample.

The iron concentration in water obtained from a single well may not be representative of the ground-water quality of the surrounding area, but samples obtained from several nearby wells containing high iron concentrations may be indicative of expected iron concentration in ground water in that area. Caution must be exercised, however, in predicting iron occurrence because of the number of conditions that can effect the level of iron concentration in ground water. Figure 13 illustrates the iron-concentration variability in water from the sand-and-gravel aquifer.

Trace Elements

Five wells open to the main producing zone in Fort Walton Beach were sampled for trace element content of the water (table 10). Barium, cadmium, chromium, selenium, and silver were not detected in any of the samples. Whereas two samples contained low lead concentrations, and one sample contained a low arsenic concentration, none contained any constituent in concentrations above maximum recommended contaminant levels (EPA, 1975; 1977).

Table 10.--Trace elements in water from the main producing zone

[Concentrations in micrograms per liter]

Element	Map location number				
	210	213	216	222	224
Arsenic	1	1	1	5	1
Copper	6	6	8	4	6
Lead	2	1	1	1	8
Manganese	20	20	10	10	10
Zinc	30	30	40	20	20

Organic Pesticide Compounds

The water from four of the five wells previously cited (210, 213, 216, and 222) were analyzed for the presence of pesticides, polychlorinated biphenyls (PCB), and polychlorinated naphthalenes (PCN). All were undetectable by the analytical methods utilized.

Nitrogen Species and Phosphorus

The same four wells in Fort Walton Beach that were sampled for pesticides were also sampled for the presence of nitrogen species and phosphorus (table 11). Nitrite was not detected. The average concentration of nitrate was 0.68 mg/L; none of the samples had concentrations that exceeded 10 mg/L, the maximum contaminant level established by the EPA (1975). The average concentration of ammonia plus organic nitrogen was 0.12 mg/L; total nitrogen was 0.80 mg/L; and total phosphorus was 0.28 mg/L.

Radionuclides

Radionuclide analyses were run on water from four wells (210, 213, 216, and 222) in Fort Walton Beach. Gross alpha particle activity ranged from 0.3 to 3.1 pCi/L (picocuries per liter), well below the maximum contaminant level of 15 pCi/L. Gross beta particle activity ranged from 0.6 to 2.3 pCi/L, well below the maximum contaminant level of 50 pCi/L. Whereas the method used does not give a biological dosage, the low activities detected indicate that radioactivity is probably less than the minimum biological dosage (table 7).

Table 11.--Nitrogen species and phosphorus in water from the main producing zone

[ND indicates concentration is less than the detection limit of 0.01 milligrams per liter]

[Concentrations in milligrams per liter]

	Map location number			
	210	213	216	222
Nitrate plus nitrite (as N)	0.54	1.10	0.83	0.25
Nitrate (as N)	.54	1.10	.83	.25
Nitrite (as N)	ND	ND	ND	ND
Ammonia plus organic nitrogen (as N)	.16	.14	.12	.04
Ammonia (as N)	.04	ND	ND	ND
Organic nitrogen (as N)	.12	.14	.11	.04
Total nitrogen (as N)	.70	1.24	.95	.29
Total phosphorus (as P)	ND	1.00	.10	ND
Orthophosphate (as P)	--	ND	ND	ND

SUMMARY AND CONCLUSIONS

The sand-and-gravel aquifer in the area of investigation consists of sand, sandy clay, clayey sand, and fine gravel and extends from land surface to the Pensacola Clay confining bed, which effectively separates it from the upper part of the Floridan aquifer. The aquifer ranges in thickness from about 10 feet in south-central Walton County to about 210 feet in southwestern Okaloosa County. Differences in lithology and hydraulic properties permit division of the aquifer into three hydrologic zones: the surficial zone, which extends from land surface to depths of 20 to 60 feet and consists of fine to medium, moderately sorted sand; an intermediate zone or confining bed 10- to 65-feet thick which consists of clay, sandy clay, and clayey sand; and the main producing zone, which comprises the bottom 10 to 85 feet of the aquifer and consists of medium to coarse, moderately to well sorted sand with some fine gravel. The main producing zone is the primary source of water for yields of 50 gal/min or more. One or more of these zones may be absent in locations where the aquifer is thin.

Aquifer tests of the main producing zone were conducted at seven sites in southern Okaloosa County. The transmissivity ranged from 400 to 6,200 ft^2/d; storage coefficients of $3.0x10^{-4}$ and $1.9x10^{-4}$ were obtained at two sites, and the leakance of the confining intermediate zone at these sites was about

$1x10^{-2}$ and $2x10^{-2}d^{-1}$, respectively. The test results are considered valid only for the individual sites because of variations in lithology and thickness of the aquifer, but the data may be considered conservative estimates for the sand-and-gravel aquifer.

Specific capacities were calculated for 15 wells open to the main producing zone; they ranged from 1.3 to 125 (gal/min)/ft, but are generally less than 15 (gal/min)/ft. The wide range in values is believed to be due to areal variations in transmissivity and differences in well construction.

Discharges from sand-and-gravel wells range from about 5 to 1,000 gal/min and average about 50 gal/min. Estimated potential yields based on existing well data, however, generally range from 200 to 400 gal/min and may exceed 10,000 gal/min for some wells. The highest estimated potential yields occur in southwestern Okaloosa County, where large volumes of water can be pumped from wells of 6 inch or larger diameter open to the main producing zone. Well losses that occur at high flow rates would probably limit actual yields to about 1,000 gal/min. The yields of wells in southeastern Okaloosa and southern Walton County would probably be less than those obtained in southwestern Okaloosa County because the aquifer thins and the sand becomes finer to the east. Where the aquifer is less than 50 feet thick and contains mostly fine to medium sand, yields no greater than 25 gal/min may be expected.

Water from the sand-and-gravel aquifer in southern Okaloosa and Walton Counties usually meets State and Federal requirements for public drinking-water supplies. Wells located along the saline-water bayous and shorelines of the Gulf of Mexico and Choctawhatchee Bay tend to exhibit higher chloride and iron concentrations; this is a local but not serious problem. The pH of water from the surficial zone ranges from 5.7 to 7.7 units and from 4.5 to 6.9 units in water from the main producing zone. Iron concentrations in water from the surficial zone range from 0.02 to 4.3 mg/L and from 0.01 to 3.7 mg/L in water from the main producing zone.

SELECTED REFERENCES

Barr, D. E., Maristany, A. R., and Kwader, Thomas, 1981, Water resource availability for development in southern Okaloosa and Walton Counties, northwest Florida: Northwest Florida Water Management District Water Resources Assessment 81-1, 41 p.

Barraclough, J. T., and Marsh, O. T., 1962, Aquifers and quality of ground water along the gulf coast of western Florida: Florida Geological Survey Report of Investigations no. 29, 28 p.

Chen, C. S., 1965, The regional lithostratigraphic analysis of Paleocene and Eocene rocks of Florida: Florida Geological Survey Bulletin 45, 105 p.

Cooper, H. H., Jr., 1963, Type curves for nonsteady radial flow in an infinite leaky artesian aquifer, in Shortcuts and special problems in aquifer tests (Ray Bentall, compiler): U.S. Geological Survey Water-Supply Paper 1545C, p. C48-C55.

Ellis, M. M., Westfall, B. A., and Ellis, M. D., 1948, Determination of water quality: U.S. Department of Interior, Fish and Wildlife Service, Research Report 9, 122 p.

Florida Department of State, 1978, Rules of the Department of Environmental Regulation, water quality standards, Chapter 17-22, in Florida Administrative Code: Tallahassee.

Foster, J. B., and Pascale, C. A., 1971, Selected water resources records for Okaloosa County and adjacent areas: Florida Bureau of Geology Information Circular no. 67, 95 p.

Hantush, M. S., and Jacob, C. E., 1955, Nonsteady radial flow in an infinite leaky aquifer: American Geophysical Union Transactions, v. 36, no. 1, p. 95-100.

Jacob, C. E., 1950, Flow of ground water, in Engineering Hydraulics (H. Rouse, ed.): New York, John Wiley and Sons, Chapter 5, p. 321-385.

Kirkor, Teodor, 1951, Protecting public waters from pollution in the USSR: Sewerage Works Journal, v. 23, 938 p.

Lohman, S. W., 1972, Ground-water hydraulics: U.S. Geological Survey Professional Paper 708, 70 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.

Maier, F. J., 1950, Fluoridation of public water supplies: Journal of the American Water Works Association, v. 47, pt. 1, p. 1120-1132.

Marsh, O. T., 1962, Relation of Bucatunna Clay Formation (Byram Formation, Oligocene) to geology and ground water of western-most Florida: Geological Society of America Bulletin, v. 73, p. 243-252.

______1966, Geology of Escambia and Santa Rosa Counties, western Florida Panhandle: Florida Geological Survey Bulletin 46, 140 p.

Matson, C. G., and Sanford, S., 1913, Geology and ground waters of Florida: U.S. Geological Survey Water-Supply Paper 319, p. 422-426.

Maxcy, K. F., 1950, Report on the relation of nitrite concentrations in well waters to the occurrence of methemoglobinemia: National Research Council, Sanitary Engineering and Environment Bulletin, Appendix D, 271 p.

Meyer, R. R., 1963, A chart relating well diameter, specific capacity, and the coefficients of transmissibility and storage, in Methods of determining permeability, transmissibility, and drawdown (Ray Bentall, compiler): U.S. Geological Survey Water-Supply Paper 1536-I, p. 338-340.

Musgrove, R. H., Barraclough, J. T., and Marsh, O. T., 1961, Interim report on the water resources of Escambia and Santa Rosa Counties, Florida: Florida Geological Survey Information Circular no. 30, 89 p.

Pascale, C. A., Essig, C. F., Jr., and Herring, R. R., 1972, Records of hydrologic data, Walton County, Florida: Florida Bureau of Geology Information Circular no. 78, 103 p.

Pascale, C. A., 1974, Water resources of Walton County, Florida: Florida Bureau of Geology Report of Investigations no. 76, 65 p.

Puri, H. S., and Vernon, R. O., 1964, Summary of the geology of Florida and a guidebook to the classic exposures: Florida Geological Survey Special Publication 5, revised, 312 p.

Sellards, E. H., and Gunter, Herman, 1912, The underground water supply of west-central and west Florida: Florida Geological Survey 4th Annual Report, p. 80-155.

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

Trapp, Henry, Jr., Pascale, C. A., and Foster, J. B., 1977, Water resources of Okaloosa County and adjacent areas, Florida: U.S. Geological Survey Water Resources Investigations 77-9, 83 p.

U.S. Department of Commerce, 1931-78, Climatological data, Florida annual summaries, 1931-78: National Oceanic and Atmospheric Administration, Environmental Data Service, Asheville, N.C.

U.S. Environmental Protection Agency, 1975, National interim primary drinking water regulations: Federal Register, v. 40, no. 51, March 14, p. 11990-11998 and no. 248, December 24, p. 59566-59588. See also, EPA-570/9-76-003, 159 p.

U.S. Environmental Protection Agency, 1977, National secondary drinking water regulations: Federal Register, v. 42, no. 62, Thursday, March 31, 1977, pt. I, p. 17143-17146.

U.S. Geological Survey, 1978, Water Resources Data for Florida, v. 4, northwest Florida, Water-Data Report FL-78-4, Tallahassee, Florida, 731 p.

Wagner, J. R., Lewis, Charles, Hayes, L. R., and Barr, D. E., 1980, Hydrologic data for Okaloosa, Walton, and southeastern Santa Rosa Counties, Florida: U.S. Geological Survey Open-File Report 80-741, 228 p.

Walton, W. C., 1970, Ground water resource evaluation: New York, McGraw-Hill, 664 p.