and southern Florida.

GENERAL HYDROGEOLOGY OF FLORIDA By Bernard J. Franks

INTRODUCTION

Ground water, readily available throughout most of Florida, is the primary source of drinking water for about 90 percent of the State's population. Florida has several ground-water reservoirs (aquifers) that yield large quantities of water to wells, and also has some of the world's largest springs. Virtually all of Florida is underlain by underground sources of potable water capable of yielding at least small quantities of water to wells. The principal source of ground water in Florida is the Floridan aquifer, which supplies most of the water used in the State. The Biscayne aquifer of southeast Florida, although limited in areal extent compared to the Floridan aquifer, is also a major source of ground water. The other principal aquifers are the sand-and-gravel aquifer of western Panhandle Florida, and smaller, surficial and intermediate-depth aquifers located beneath much of coastal

Purpose and Scope

As part of the Underground Injection Control (UIC) program, the State of Florida is required by the U.S. nvironmental Protection Agency (EPA) to designate the freshwater aquifers within its borders. The UIC program is part of Public Law 93-523, commonly referred to as the "Safe Orinking Water Act," which was passed by the U.S. Congress December 16, 1974, and was signed into law by President Gerald R. Ford. This act was the first major legislation to recognize that ground-water resources are critical to the entire

water-control issue. The UIC program has as its objective the protection of underground sources of drinking water from endangerment by the subsurface injection of fluids through well injection. The injected fluids may vary in water quality from potable water to hazardous waste. In particular, the UIC program requires the protection of ground-water sources containing less than 10,000 milligrams per liter (mg/L) dissolved solids, either as present or as possible future sources of drinking water. The purpose of this report is to define the areal and vertical extent of principal sources of ground water in Florida. Special emphasis is given to denoting those aquifers containing less than 10,000 mg/L dissolved solids, the criterion adopted by EPA for delineating present or future underground sources

of drinking water. The report was prepared by the U.S. Geological Survey as part of the statewide cooperative program with the Florida Department of Environmental Regulation (FDER). The report documents and summarizes available geologic, hydrologic, and selected water-quality data for the major aquifers in Florida. Altitudes and depths are given in reference to sea level, general term for 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 referred to as "mean sea level."

Florida is underlain mostly by limestone and dolomite strata capped by a discontinuous layer of surficial sands and clays (table 1). The principal unconfined aguifers in Florida include the Biscayne, the sand-and-gravel, and the surficial aguifer. The Biscavne aguifer in southeast Florida consists of upper Pliocene through Holocene sediments. The sand-andgravel aquifer, in westernmost Panhandle Florida, consists of middle Miocene through Holocene age sands, gravels, and clays. The presence of discontinuous clay lenses is reflected in local confined or semiconfined areas of the aquifer Surficial aquifers, generally comprised of Holocene and upper Tertiary sands exposed at land surface, include all unconfined water-bearing strata in the State other than the Biscavne aquifer and the sand-and-gravel aquifer. Surficial aquifers are located primarily along the east and southwest coastal areas and in south peninsular Florida. Parts of the Floridan aquifer at or near the surface (not covered by confining beds) also contain water under locally unconfined conditions. The principal aquifer is the Floridan aquifer, which ranges in age from late Paleocene through middle Miocene. Present throughout the State, the Floridan is comprised chiefly of limestone and dolomite interbedded with clay, sand, and marl. Other aquifers include several small confined systems in southwest Florida, primarily in the Tampa Limestone and

intermediate aquifers. used throughout Florida. More detailed stratigraphic and lithologic descriptions for each of the principal aquifers are included under the appropriate section in this report. HYDROGEOLOGY

Florida is in the Coastal Plain province, a region of plains and low hills in the South Atlantic-Gulf Region of the southeast United States (Cederstrom and others, 1979). The Floridan Plateau consists of a shelf or broad platform of marine and fluvial sediments which separate the deep waters of the Atlantic Ocean from the deeper parts of the Gulf of Mexico. The plateau boundaries are conventionally defined at a water depth of 50 fathoms (300 feet). The Peninsula of Florida, a geologically recent emergent part of the plateau, is characterized by widespread distribution of carbonate rocks and associated karst features, extensive marine terraces on the periphery surrounding a high central area, and much swampy land, particularly in the south. The geology of Florida has been summarized by numerous authors, including Matson and Sanford (1913), Cooke (1945), Puri and Vernon (1964), Vernon and Puri (1964), Bennison (1975), and Healy (1975).

All of Florida is underlain by deposits capable of yielding water to wells (fig. 1). These aquifers are comprised of permeable limestone, dolomite, and clastic material, and in much of the State yield abundant ground-water supplies (Stringfield, 1966). Water occurs under either confined (artesian) or unconfined (water-table) conditions. In some areas, particularly where supplies must come from the surficial and intermediate aquifers, well yields are low; in others, especially where the Floridan and Biscayne aquifers occur, hundreds and even thousands of gallons per minute of water can be obtained per well. Springs are common over much of the State, particularly in the northern half. More than 300 springs are known throughout Florida, discharging water primarily from the Floridan aquifer (Rosenau and others,

The Floridan aquifer underlies the entire State, crops out in north-central Florida, and supplies potable ground water to all but southernmost and westernmost Florida. It is part of the Tertiary limestone aquifer system of the Southeast United States. In southern Florida, the aquifer contains saline water, and water from the overlying Biscayne aquifer is used for local

The Biscayne aquifer is the primary source of drinking water for all municipal water supplies south of Martin County. The unconfined Biscayne is affected by a system of canals used for water-level control and flood prevention. These canals also serve as local sources of recharge. Highly permeable and vulnerable to contamination, the aquifer has been designated a "sole source aquifer" by the Environmental Protection Agency, qualifying it for special consideration in federally-financed activities. In the western panhandle, the sand-and-gravel aquifer is

the primary water source. Depending on local geologic conditions, the aquifer is either unconfined or artesian. Although the Floridan aquifer contains potable water over much of the area, in Panhandle Florida the overlying sand-and-gravel aquifer is used for most local needs. In addition to the Biscayne, the sand-and-gravel, and the Floridan aquifers, much of Florida is underlain by smaller surficial and intermediate depth aquifers. These local aquifers are generally extensively developed where a better supply is not available from one of the principal aquifers. The principal areas of development of these aquifers are in a narrow belt extending along the east coast, and in a wide belt extending southwest across the State in the vicinity of Lake Okeechobee The principal source of recharge to the ground-water systems in Florida is rainfall (Hughes and others, 1971) Average rainfall in Florida is about 53 inches per year ranging from about 40 inches in the Florida Keys to more than 64 inches along the southeast coast and inland in northwest Florida. Evapotranspiration losses range from about 33 to 49 inches annually. Runoff as represented by streamflow averages about 14 inches annually, but locally ranges from less than 5 inches to more than 30 inches (Hughes, 1978).

The total water withdrawn from Florida aquifers in 1980, the most recent complete record for State water use, was 3,758 million gallons per day (Mgal/d) (Leach, S. D., written commun., 1981). Most of this total were withdrawals for industrial use, irrigation, and thermoelectric power generation. Forty-four percent of 1980 water use, or 1,671 Mgal/d, was withdrawn for public supplies and rural domestic use. Of this amount, 1,361 Mgal/d was for public supply and 310 Mgal/d was for rural domestic use. Ground-water sources supplied about 87 percent of the total demand for public water supply and 94 percent of the rural domestic water use in 1980. A breakdown of ground-water use for public supply by aquifer for 1980 data was not available, but data from 1977 are

as follows (Healy, 1981):

		Aquifer	Mgal/d	Percent of total
		Biscayne	461	44
		Floridan	460	43
		Surficial and		
		intermediate	104	10
		Sand-and-gravel	34	3
2	for	nublic cupply were	calculated	from values renov

Data for public supply were calculated from values reported directly by personnel in municipal plants. Pumpage for rural domestic use was computed indirectly by multiplying the total number of people not served by a public supply system by a per capita use factor estimated from a nearby area where data

WATER QUALITY

Water quality varies significantly within the aquifers in Florida. Water in the Floridan aquifer generally is hard, low in iron, and has a neutral to slightly alkaline pH. In southeast Florida the Biscavne aquifer contains water that is very hard, more highly mineralized, and more alkaline than other water supplies in the State. Water in the sand-and-gravel aquifer in the western panhandle is characterized as soft, of low mineral content, and slightly acidic. The surficial and intermediate aquifers tend to contain water that is generally more variable in quality than the three major aquifers because they are comprised of more diverse lithologies and reflect local conditions. In general, the water in the surficial and intermediate aquifers is slightly alkaline, hard, and low in iron. Locally, the surficial and intermediate aquifers, particularly in southwest Florida, contain water that is high in iron.

A summary of selected chemical analyses of ground water in Florida is given in table 2. Because these data are taken primarily from drinking water supply wells which generally tap the upper parts of the aquifers, they are not representative of the deeper waters of the aquifers. Consequently, in the extreme values for particular constituents, such as chloride in areas of saltwater encroachment, table 2 may not represent the range of values indicated for the aquifers as detailed elsewhere in other sections of this report and in other sources. Nevertheless, these data are considered to be representative of water from most ground-water sites in Florida. More detailed discussions of significant water-quality parameters for each of these aquifers can be found in the appropriate

SELECTED REFERENCES Bennison, A. P. (compiler), 1975, Geological highway map of the Southeastern Region: American Association of

Petroleum Geologists, U.S. Geological Highway Map Series, Map 9. Cederstrom, D. J., Boswell, E. H., and Tarver, G. R., 1979, Summary appraisals of the Nation's ground-water resources--south Atlantic-Gulf Region: U.S. Geological Survey Professional Paper 813-0, 35 p. Cooke, C. W., 1945, Geology of Florida: Florida Geological Survey Bulletin no. 29, 335 p. Healy, H. G., 1975, Terraces and shorelines of Florida: Florida Bureau of Geology Map Series 71.

1981, Estimated pumpage from ground-water sources for

public supply and rural domestic use in Florida: Florida

Bureau of Geology Map Series 108.

Heath, R. C., and Conover, C. S., 1981, Hydrologic almanac of Florida: U.S. Geological Survey Open-File Report 81-1107, 239 p. Hughes, G. H., 1978, Runoff from hydrologic units in Florida: Florida Bureau of Geology Map Series 81. Hughes, G. H., Hampton, E. R., and Tucker, D. F., 1971 Annual and seasonal rainfall in Florida: Florida Bureau of Geology Map Series 40. Hughes, J. L., 1979, Saltwater barrier lines in Florida: Concepts, considerations, and site examples: U.S. Geo-

logical Survey Water-Resources Investigations 79-75 Hyde, L. W., 1975, Principal aquifers in Florida: Florida Geological Survey Map Series no. 16 (revised). Irwin, G. A., and Healy, H. G., 1978, Chemical and physical quality of selected public water supplies in Florida, August-September, 1976: U.S. Geological Survey Water Resources Investigations 78-21, 199 p. Matson, G. C., and Sanford, Samuel, 1913, Geology and ground waters of Florida: U.S. Geological Water-Supply

Miller, J. C., Hackenberry, P. S., and DeLuca, F. A., 1977,

Puri, H. S., and Vernon, R. O., 1964, Summary of the

report EPA-600/3-77-012, January 1977, 361 p.

Ground-water pollution problems in the southeastern

United States: U.S. Environmental Protection Agency

geology of Florida and a guidebook to the classic exposures (revised): Florida Geological Survey Special Publication no. 5, 312 p. Rosenau, J. C., Faulkner, G. L., Hendry, C. W., Jr., and Hull, R. W., 1977, Springs of Florida: Florida Bureau of Geology Bulletin 31, 461 p. Stringfield, V. T., 1966, Artesian water in Tertiary limestone in the southeastern states: U.S. Geological Survey Professional Paper 517, 226 p. Vernon, R. O., and Puri, H. S., 1964, Geologic map of

Florida: Florida Geological Survey Map Series 18.

ABBREVIATIONS AND CONVERSION FACTORS Factors for converting inch-pound units to International

System (SI) and abbreviations of units.

Multiply inch-pound units	By	To obtain metric (SI)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
gallon per minute	0.06309	liter per second

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the firstorder 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.

Table 2.--Median values and ranges of selected chemical analyses of ground water in florida

[Concentrations in milligrams per liter except where indicated. Minimum and maximum values in parentheses. Modified from Miller and others, 1977, p. 78; Irwin and Healy, 1978.]

Parameter	Sand-and-gravel aquifer	Floridan aquifer	Biscayne aquifer	Surficial and intermediate aquifers
Dissolved solids (residue at 180°C)	20 (10-370)	200 (80 - 800)	320 (60 - 500)	280 (17-7,210)
Hardness as CaCO ₃ (Ca, Mg)	5 (0-320)	150 (35-615)	200 (20-250)	150 (2-1,910)
Chloride (Cl)	3 (0-430)	10 (0-190)	30 (5-80)	20 (2-2,280)
Fluoride (F)	.1 (05)	.2 (0-1.7)	.4 (09)	.2 (0-3.1)
Sulfate (SO ₄)	1 (0-210)	5 (0-440)	20 (0-400)	20 (0-500)
Iron (Fe)	.2 (0-4.0)	.05 (02)	.2 (0-8.8)	.1 (0-6.4)
pH (units)	6.0	7.3	7.6	7.4

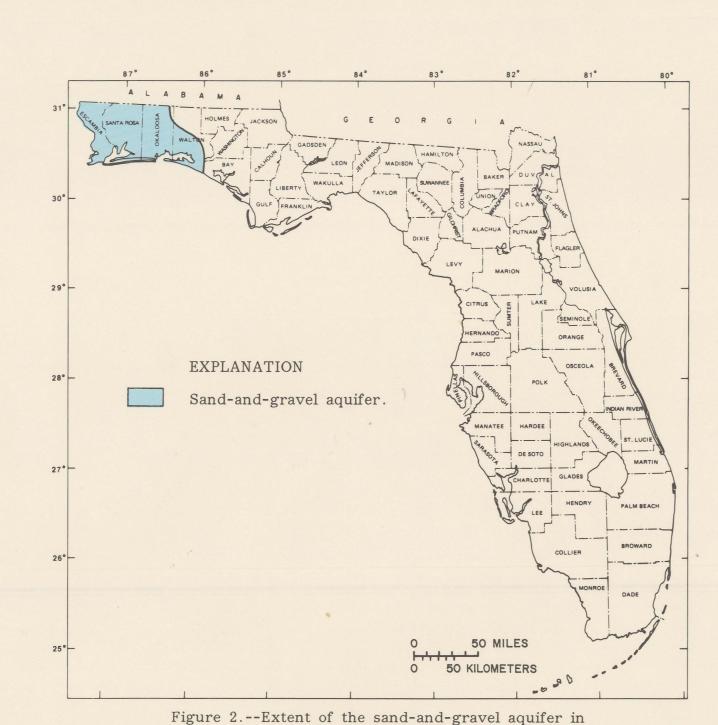


Figure 1.--Approximate areal extent over which the principal aquifers are the primary source of supply (modified from Stringfield, 1966; Hyde, 1975).

50 MILES

O 50 KILOMETERS

EXPLANATION

Floridan aquifer at or near surface

Floridan aquifer overlain by confin-

ing bed breached by sinkholes

Floridan aquifer in subsurface

Surficial aquifer and intermediate

Sand-and-Gravel aquifer

Biscayne aquifer

Cretaceous Upper Cretaceous

	Stratigraphic unit					
System	Series	Panhandle	Panhandle Penins		sula Aq	
Quaternary	Holocene and Pleistocene	Alluvium and terrace deposits		Pamlico Sand Miami Oolite		
				Fort Thompson Formation		Surficial -and-gravel
	Pliocene	Citronelle Formation	Alac	chua Tamiami ormation Formation	termediate	Stand-a
	Miocene	Pensacola Unnamed Alum Hawthorn Clay coarse Bluff Formation clastics Group				
		Tampa Limeston				
Tertiary	Oligocene	Chickasawhay Limestone Byram Formation Marianna Limestone			Floridan	
		Ocala Limestone			ori	
	Eocene	Lisbon-Tallahatta equivalents	Lake C	Park Limestone ity Limestone r Limestone	FIG	
	Paleocene	Tuscahoma through Clayton equivalents	Cedar	Keys Limestone		
0 1	TT O	TT 1.7	00	4 1		

Table 1.--Generalized stratigraphic units and principal aquifers in Florida

Table 3.--Generalized geologic column of the sand-and-gravel aquifer in western panhandle Florida

northwest Florida.

Series	Stratigr	Stratigraphic unit		Undifferentiated silt, sand, and gravel, with some clay.	
Holocene and Pleistocene	Alluvium and terrace deposits				
Pliocene	Citronelle Formation		er	Sand, very fine to very coarse and poorly sorted. Hardpan layers in upper part. Fossils scarce.	
Miocene	Unnamed coarse clastics	Choctawhatchee Formation Alum Bluff Group Shoal River Formation Chipola Formation	Aquife	Sand, shell, and marl. Fossil-bearing. Fossiliferous sand with lenses of silt, clay, and gravel (includes unnamed coarse clastics and Alum Bluff Group).	
Pensacola Clay conf				Dark-to-light gray sandy clay. Pensacola Clay stratigraphic unit is the base of water-bearing zone in southern half of a	
	Tampa Limestone and equivalents			Limestone and dolomitetop of the Floridan aquifer.	

SAND-AND-GRAVEL AQUIFER By Mary Cushman-Roisin and Bernard J. Franks

INTRODUCTION The sand-and-gravel aquifer is a wedge-shaped deposit composed of quartz sand and gravel interbedded with discontinuous layers of clay. The aquifer extends approximately from central Walton County west and north into Alabama and south to the Gulf of Mexico (fig. 2). It is the principal source of water in Escambia and Santa Rosa Counties, and is utilized as a secondary source in Okaloosa and Walton Counties. The aquifer extends from land surface to denths of more than 700 feet in northwest Escambia County. Thinning gradually to the north and east, the aguifer pinches out in central Walton County. The interbedded clay layers range from just a few inches to several tens of feet in thickness and vary laterally from lenses a few feet wide to continuous mappable units. Ground water in the sand-and-gravel aquifer occurs under both unconfined and artesian conditions, depending on the occurrence, persistence, and integrity of the

local confining layers. The sand-and-gravel aquifer has been studied as a part of several hydrologic investigations of northwest Florida (Musgrove and others, 1961; 1965; 1966; Dysart and others, 1977); as part of various countywide studies (Marsh, 1966; Barraclough, 1967; Pascale, 1974; Trapp and others, 1977); and in detail (Jacob and Cooper, 1940; Trapp, 1972; 1973; 1975; 1978; Barr and others, 1981; Pratt and Barr, 1982) The author gratefully acknowledges Murlene Clark and Walter Schmidt of the Florida Bureau of Geology, and Thomas Kwader, Douglas Barr, and Jeffry Wagner of the Northwest Florida Water Management District, for fruitful discussions and for use of unpublished geologic and hydrologic data on the sand-and-gravel aquifer.

The sand-and-gravel aquifer consists of surficial sedimentary deposits ranging in age from middle Miocene through Holocene (table 3). The top of the aquifer is land surface, with altitudes ranging from sea level near the coast to more than 200 feet above sea level in the north, where the topography is hilly and relief as much as 150 feet. In its northern extent, the aguifer is in direct hydraulic contact with the underlying Floridan aquifer. A thick clay confining layer underlies the southern part of the aguifer. The principal stratigraphic units included in the aquifer are the Alum Bluff Group and the Choctawhatchee Formation of Miocene age, the Citronelle Formation of Pliocene age, and undifferentiated alluvium and terrace deposits of Pleistocene and Holocene age. The base of the sand-and-gravel aquifer, in the southern

half of its extent, is generally considered to be the top of the Pensacola Clay, a low-permeability sandy clay underlying the Alum Bluff Group. Trapp and others (1977, p. 16) informally defined the "Pensacola Clay confining bed" as the material of relatively low permeability between the sand-and-gravel aquifer above and the Floridan aquifer below. Their definition encompasses material beyond the formal limits of the "Pensacola Clay" stratigraphic unit. In the northern extent of the aquifer, where the Pensacola Clay is absent, the base of the

sand-and-gravel aquifer is in contact with either the

"Pensacola Clay confining bed," or with the top of the Floridan

aquifer, which in this area is the Tampa Limestone (lower

Miocene) or its equivalent.

Figure 3 is a contour map of the base of the sand-andgravel aquifer, as defined above. Marsh (1966, fig. 16) and Barraclough (1967) present contours of the top of the Pensacola Clay in the vicinity of the city of Pensacola (Escambia County). Their contour maps, based largely on data from deep oil test wells, have been superseded by more recent detailed investigations. In particular, Barr and others (1981) map the altitude of the top of the Pensacola Clay in southern Okaloosa and Walton Counties; and Pratt and Barr (1982) map the base of the sand-and-gravel aquifer in southern, peninsular Santa Rosa County. These data have been supplemented by unpublished data made available by both the Florida Bureau Geology and the Northwest Florida Water Management

In general, the base of the aquifer has a regional slope to the west-southwest, from a maximum altitude of more than 100 feet above sea level in Walton County to a minimum of more than 700 feet below sea level in western Escambia County The tonguing of the contours in central Okaloosa and Santa Rosa Counties reflects the development of a thick section of Pensacola Clay at relatively shallow altitudes in the southern part of the mapped area. This map portrays general features of the base of the sand-and-gravel aquifer. Because the contact of the sand-and-gravel aquifer with either the "Pensacola Clay confining bed" or the Floridan aquifer is irregular, and data are sparse, local detail may differ from the altitudes indicated in figure 3. The generalized thickness of the sand-and-gravel aquifer is shown in figure 4. The aquifer is wedge-shaped, is locally more than 700 feet thick in western Escambia County, and gradually pinches out in central Walton County. Because of variations in relief, local data for a given well may differ from thicknesses estimated on the basis of this map. Maps of either the water table or the potentiometri

surface for the sand-and-gravel aquifer are generally not available; except for local areas. These include: southern Escambia County (Trapp, 1973, fig. 2), southern Okaloosa and Walton Counties (Barr and others, 1981), and southern, peninsular Santa Rosa County (Pratt and Barr, 1982). In many areas, multiple water levels have been observed corresponding to vertical zonation resulting from local confining beds within the aquifer. Perched water tables, the true water table, and one or more semiconfined potentiometric surfaces may all be present in an area. As reported in Dysart and others (1977, p. 34), the "complexity of the water levels has discouraged the preparation of potentiometric maps except where fairly detailed information is available." Recently, the sand-and-gravel aquifer has been locally differentiated into three zones -- a surficial (water-table) zone, an intermediate zone of relatively low permeability, and a main producing zone (Barr and others, 1981 p. 24). Because of problems (described above) in determining the upper surface of the aquifer, the saturated thickness at a given location may be significantly less than the total thickness estimated from this map. This is especially true in northeast Okaloosa County

and in central and southern Walton County. In these areas, saturated thickness is generally less than 50 feet, and the

sand-and-gravel aquifer is not a potential major source of

potable water.

WATER QUALITY Because the quartz-rich sediments which make up the

sand-and-gravel aquifer are practically insoluble, most water from the aquifer is soft and slightly mineralized. Selected water-quality data have been summarized in reports by Musgrove and others (1961), Barraclough and Marsh (1962), Pascale (1974), Dysart and others (1977), Irwin and Healy (1978), Barr and others (1981) and Pratt and Barr (1982). Following is a general discussion of the data presented in these reports and supplemental data from U.S. Geological Survey files. Dissolved solids concentrations in waters from the sandand-gravel aquifer are usually less than 50 mg/L, although values for water from wells near the coast occasionally exceed 500 mg/L, probably because of saltwater encroachment. Chloride concentrations are typically less than 10 mg/L, although

waters from coastal wells in a few locations sometimes have

chloride concentrations over 1,000 mg/L, indicative of mixing The pH of the water in the sand-and-gravel aquifer is usually slightly acidic (about 6.0), and hardness is usually Water in the upper part of the aquifer contains dissolved carbon dioxide, some of which is obtained from the atmosphere (in rainwater) and some of which originates from the aerobic decomposition of organic matter. Hydrogen sulfide is present locally in trace amounts, probably resulting from the anaerobic decomposition of organic matter in the aquifer. The quality of water in the aquifer is generally acceptable for drinking water, except for locally high iron content. In southern Escambia County, the concentrations of dissolved iron in the aquifer are highly variable, locally exceeding the

recommended drinking water limit of 0.3 mg/L.

Barr, D. E., Maristany, Agustin, and Kwader, Thomas, 1981 Water resources of southern Okaloosa and Walton Counties, northwest Florida--summary of investigation: Northwest Florida Water Management District, Water Resources Assessment 81-1. Barraclough, J. T., 1967, Ground-water features in Escambia

and Santa Rosa Counties, Florida: Florida Division of Geology Map Series 26. Barraclough, J. T., and Marsh, O. T., 1962, Aquifers and quality of ground water along the Gulf Coast of western Florida: Florida Division of Geology Report of Investiga-

tions 29, 28 p. Dysart, J. E., Pascale, C. A., and Trapp, Henry, Jr., 1977 Water-resources inventory of northwest Florida: U.S. Geological Survey Water-Resources Investigations 77-84,

Irwin, G. A., and Healy, H. G., 1978, Chemical and physical quality of selected public water supplies in Florida, August-September 1976: U.S. Geological Survey Water-Resources Investigations 78-21, 200 p. Jacob, C. E., and Cooper, H. H., Jr., 1940, Report on the ground-water resources of the Pensacola area, in Escambia County, Florida, with a section on the geology by Sidney A. Stubbs: U.S. Geological Survey Open-File Report FL-40001, 85 p., 4 figs.

Marsh, O. T., 1966, Geology of Escambia and Santa Rosa Counties, western Florida Panhandle: Florida Division of Geology Bulletin 46, 140 p. Musgrove, R. H., Barraclough, J. T., and Grantham, R. G., 1965, Water resources of Escambia and Santa Rosa

Counties, Florida: Florida Division of Geology Report of Investigations 40, 102 p. 1966, Water resources records of Escambia and Santa Rosa Counties, Florida: Florida Division of Geology Information Circular 50, 106 p. 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 Division of Geology Information Circular 30, 89 p. Pascale, C. A., 1974, Water resources of Walton County, Florida: Florida Bureau of Geology Report of Investiga-Pratt, T. R., and Barr, D. E., 1982, Availability and quality

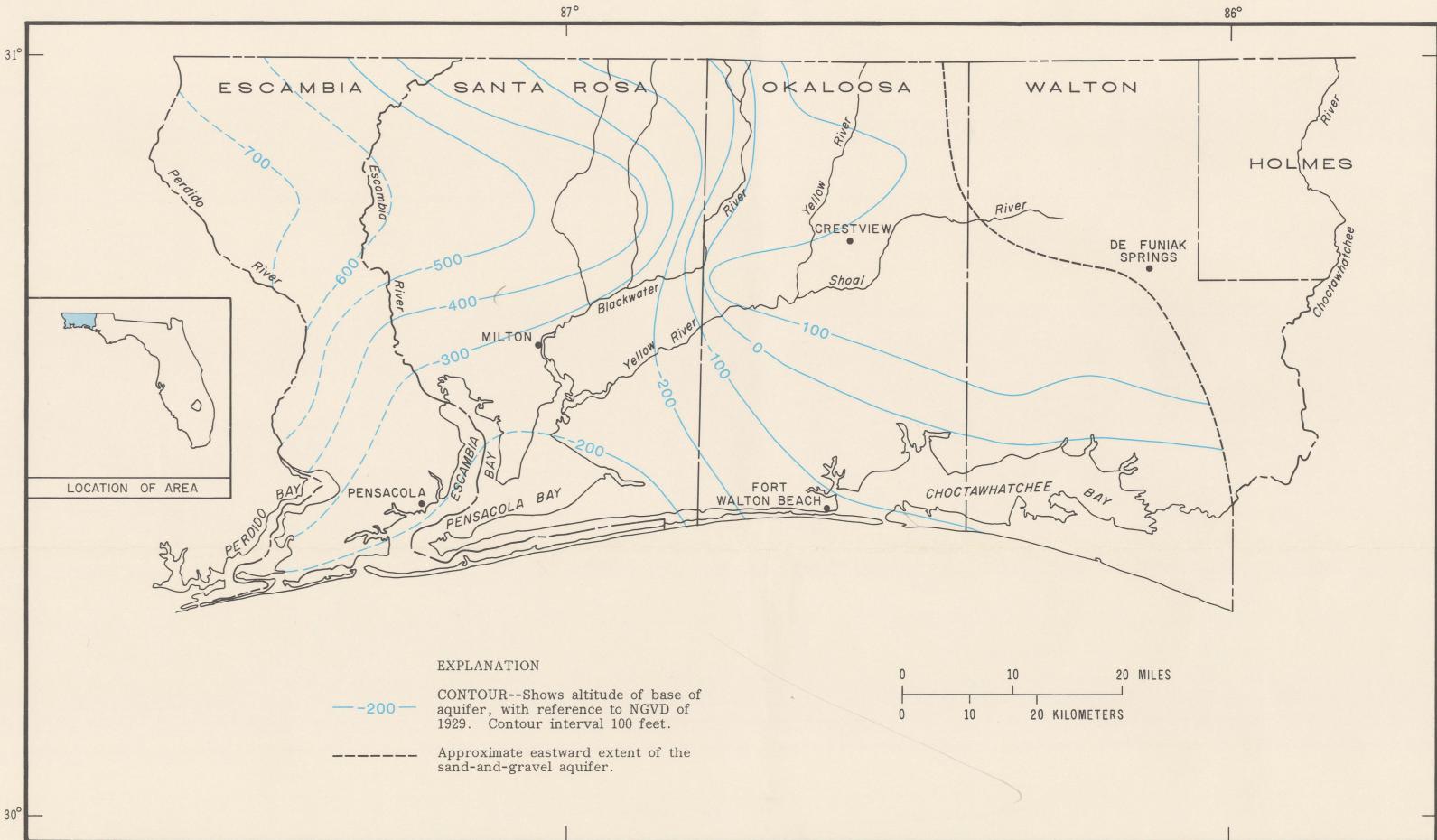
of water from the sand-and-gravel aquifer in southern Santa Rosa County, Florida: Northwest Florida Water Management District, Water Resources Special Report Trapp, Henry, Jr., 1972, Interim Report, June 1971, Availability of ground water for public-water supply in the Pensacola area, Florida: U.S. Geological Survey

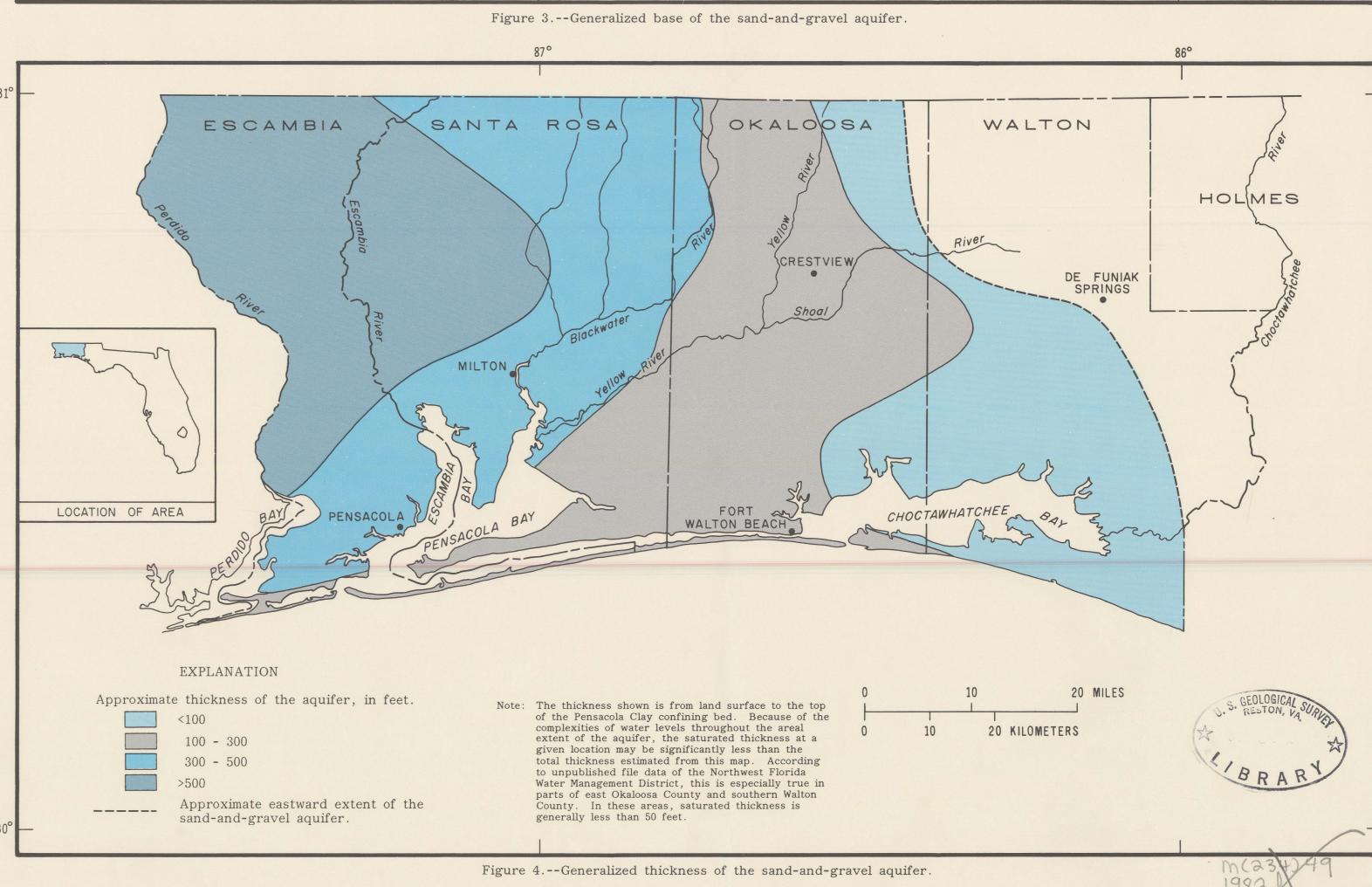
Open-File Report FL-72002, 56 p 1973, Interim report, July 1972, Availability of ground water for public-water supply in central and southern Escambia County, Florida: U.S. Geological Survey Open-File Report FL-72029, 40 p. 1975, Preliminary report, November 1973, Hydrology of the sand-and-gravel aquifer in central and southern Escambia County, Florida: U.S. Geological Survey Open-File Report FL-74027, 37 p. 1978, Preliminary hydrologic budget of the sand-andgravel aquifer under unstressed conditions, with a section

on water-quality monitoring, Pensacola, Florida: U.S.

Geological Survey Water-Resources Investigations 77-96,

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





m82-255

PRINCIPAL AQUIFERS IN FLORIDA

