Land Use, Water Use, Streamflow Characteristics, and Water-Quality Characteristics of the Charlotte Harbor Inflow Area, Florida

United States Geological Survey Water-Supply Paper 2359–A

Prepared in cooperation with the Florida Department of Environmental Regulation

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Chapter A

Land Use, Water Use, Streamflow Characteristics, and Water-Quality Characteristics of the Charlotte Harbor Inflow Area, Florida

By K.M. HAMMETT

Prepared in cooperation with the
Florida Department of Environmental Regulation

U.S. GEOLOGICAL SURVEY WATER-SUPPLY PAPER 2359

HYDROLOGIC ASSESSMENT OF THE CHARLOTTE HARBOR ESTUARINE SYSTEM

DEPARTMENT OF THE INTERIOR
MANUEL LUJAN, Jr., Secretary

U.S. GEOLOGICAL SURVEY
Dallas L. Peck, Director

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CONVERSION FACTORS

For use of readers who prefer to use metric (International System) units, conversion factors for inch-pound units used in this report are listed below:

Multiply inch-pound unit	By	To obtain metric unit
inch (in.)	25.4	millimeter (mm)
inch per year (in/yr)	25.4	millimeter per year (mm/yr)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
nautical mile (nmi)	1.852	kilometer (km)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
square mile (mi^2)	2.590	square kilometer (km^2)
acre	0.4047	hectare (ha)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic foot per second per day [(ft^3/s)/d]	0.02832	cubic meter per second per day [(m^3/s)/d]
cubic foot per second per year [(ft^3/s)/yr]	0.02832	cubic meter per second per year [(m^3/s)/yr]
gallon (gal)	0.003785	cubic meter (m^3)
gallon per minute (gal/min)	0.00006309	cubic meter per second (m^3/s)
gallon per day (gal/d)	0.003785	cubic meter per day (m^3/d)
gallon per day per acre [(gal/d)/acre]	0.003785	cubic meter per day per acre [(m^3/d)/acre]
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
million gallons per year (Mgal/yr)	3,785.0	cubic meter per year (m^3/yr)
pound per acre (lb/acre)	1.121	kilogram per hectare (kg/ha)
pound per acre per year [(lb/acre)/yr]	1.121	kilogram per hectare per year [(kg/ha)/yr]
ton, short	0.9072	megagram (Mg)
ton per day (ton/d)	0.9072	megagram per day (Mg/d)
ton per day per year [(ton/d)/yr]	0.9072	megagram per day per year [(Mg/d)/yr]
ton per day per square mile [(ton/d)/mi^2]	0.3503	megagram per day per square kilometer [(Mg/d)/km^2]
ton per year per square mile [(ton/yr)/mi^2]	0.3503	megagram per year per square kilometer [(Mg/yr)/km^2]

Temperature in degrees Fahrenheit (°F) can be converted to degrees Celsius (°C) as follows:

$$°C = (°F - 32)/1.8$$

Sea level: In this report, "sea level" refers to the 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 Sea Level Datum of 1929.

Additional Abbreviations	
microsiemens per centimeter at 25° Celsius	µS/cm
milligram per liter	mg/L

Land Use, Water Use, Streamflow Characteristics, and Water-Quality Characteristics of the Charlotte Harbor Inflow Area, Florida

By K.M. Hammett

Abstract

Charlotte Harbor is a 270-square-mile estuarine system in west-central Florida. It is being subjected to increasing environmental stress by rapid population growth and development. By 2020, population in the inflow area may double, which will result in increased demands for freshwater and increased waste loads.

The Charlotte Harbor inflow area includes about 4,685 square miles. The Myakka, the Peace, and the Caloosahatchee are the major rivers emptying into the harbor. About 70 percent of the land in these three river basins is used for agriculture and range. In the coastal basin around Charlotte Harbor, about 50 percent of the total land area is devoted to commercial or residential uses. Water use in the inflow area is about 565 million gallons per day, of which 59 percent is used for irrigation, 26 percent for industry, 11 percent for public supply, and 4 percent for rural supply.

Total freshwater inflow from the three major rivers, the coastal area, and rainfall directly into Charlotte Harbor averages between 5,700 and 6,100 cubic feet per second, which is more than 3,500 million gallons per day. A trend analysis of about 50 years of streamflow data shows a statistically significant decreasing trend for the Peace River stations at Bartow, Zolfo Springs, and Arcadia. No significant trend has been observed in the Myakka or the Caloosahatchee River data. In the Peace River, the decrease in flow may be related to a long-term decline in the potentiometric surface of the underlying Floridan aquifer system, which resulted from ground-water withdrawals. It is not possible to determine whether the trend will continue. However, if it does continue at the same rate, then, except for brief periods of storm runoff, the Peace River at Zolfo Springs could be dry year-round in about 100 years.

Of the 114 facilities permitted to discharge domestic or industrial effluent to waters tributary to Charlotte Harbor, 88 are in the Peace River basin. Phosphate ore and citrus processing account for most of the industrial effluent. Several locations in the headwaters of the Peace River have been significantly affected as a result of receiving wastewater effluent. The Peace, the Myakka, and the Caloosahatchee Rivers transport more than 2,000 tons per day of dissolved solids, more than 17 tons per day of nitrogen, and about 6 tons per day of phosphorus.

By 2020, the population in the inflow area is expected to increase by more than 500,000 people. They will require an additional 76 million gallons per day for water supply. The increased population will produce an additional 60 million gallons per day of domestic wastewater, which could result in an additional 3 tons per day of nitrogen and 0.65 ton per day of phosphorus. More than 150 square miles of land will be converted to urban uses, which will produce another 0.25 ton per day of nitrogen from urban runoff. These increased nutrient loads can be expected to occur concurrently with decreased freshwater inflow.

Manuscript approved for publication, August 5, 1987.

INTRODUCTION

Charlotte Harbor, which is a coastal plain estuarine system in southwestern Florida (fig. 1), is a vital resource of the State and the Nation. It is the second largest estuarine system in Florida and one of the most productive for commercial and sports fisheries. Its waters and surrounding lands provide food and habitat for about 40 endangered and threatened wildlife species (Florida Department of Natural Resources, 1984).

Rapid population growth and development within the Charlotte Harbor inflow area (fig. 2) are increasing the environmental stress on the estuarine system. By 2020, more than 500,000 new residents may live in the area that drains into the harbor. Industrial and agricultural development also may increase. Along with growth and development, demand for freshwater will increase, as will urban, agricultural, and industrial wastes. The inflow of good-quality freshwater is essential to the integrity and the health of the estuarine system. Freshwater, however, may be withdrawn or diverted from the rivers and the streams that flow into the estuary at the same time that wastewater discharges are increasing.

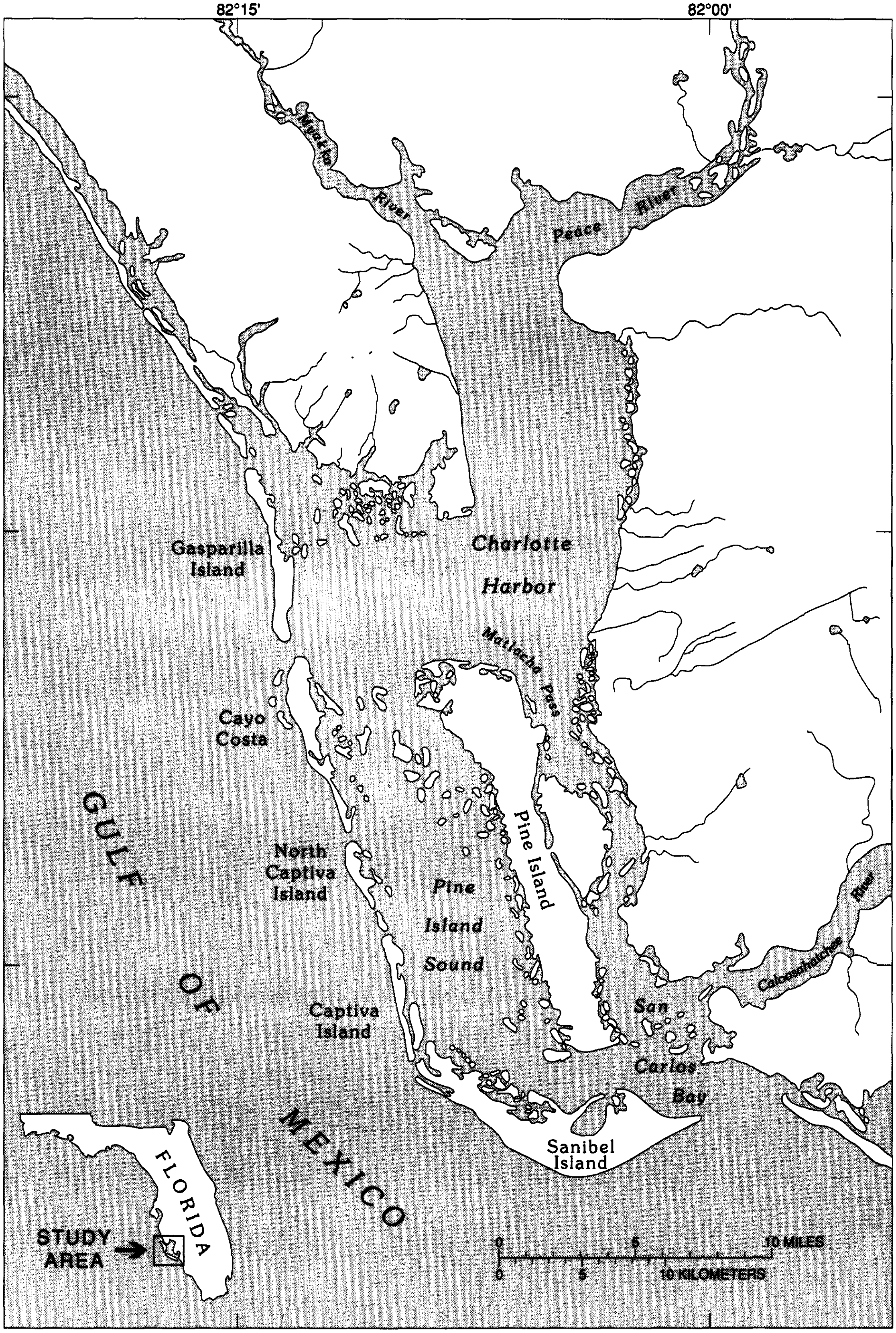

Figure 1. Charlotte Harbor estuarine system.

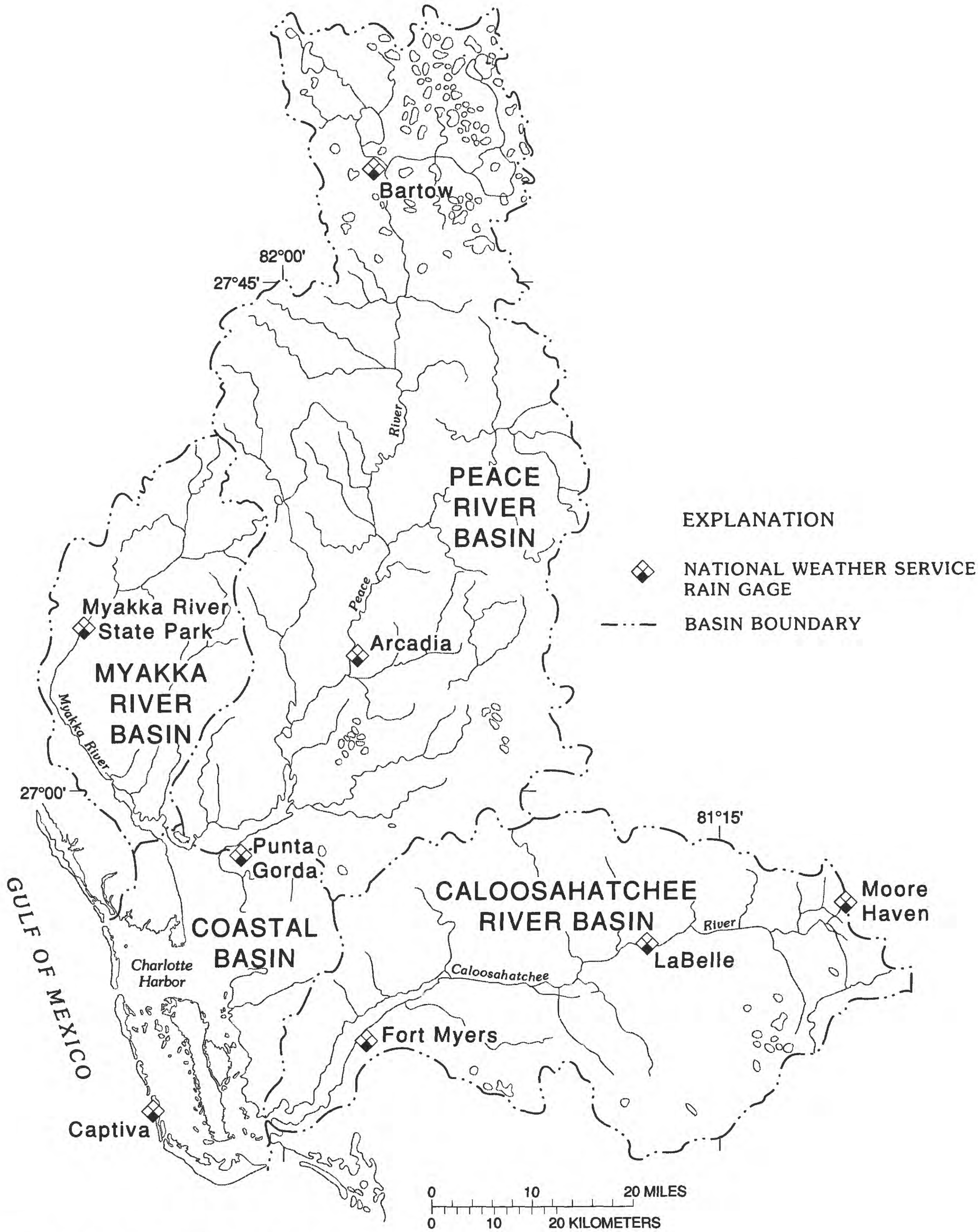

Figure 2. Charlotte Harbor inflow area.

In 1980, the Governor of Florida established a committee of representatives from local, regional, State, and Federal agencies to evaluate the course of action that Florida should take to protect the Charlotte Harbor estuarine system. At the request of that committee, the U.S. Geological Survey (USGS) developed a plan of study and, in 1982, began a 7-year multidisciplinary assessment of the estuary and its inflow area in cooperation with the Florida Department of Environmental Regulation. This report describes land use, water use, streamflow characteristics, and water-quality characteristics in the inflow area and discusses how these may change as a result of projected growth and development. Subsequent reports are planned that will include descriptions of hydraulic and salinity characteristics in the tidal river, salinity distributions in the harbor, nutrient loads and their effects on phytoplankton productivity, origins and distribution of radium isotopes in the estuary, attenuation of light in estuarine waters, and circulation and flushing in the harbor. The techniques developed for this study and the resulting information will have broad applications not only to Charlotte Harbor, but to other estuarine systems.

Purpose and Scope

This report has the following objectives:

1. To describe land use, water use, streamflow, and river water quality in the Charlotte Harbor inflow area;
2. To discuss some of the relations among land use, water use, streamflow, and river water quality; and
3. To present potential changes in land use, water use, streamflow, and river water quality that result from increasing growth and development.

To accomplish these objectives, previously published studies were reviewed for information, and data were compiled from many divers sources. The compilation and analyses of data are based on the following time frames: land use (1972–73 and 1984), water use (1975 and 1980), streamflow (through 1984), and water quality (through 1985). Statistical procedures, such as frequency, trend, and regression analyses, and graphical techniques were used to evaluate and interpret the data.

Acknowledgments

Several governmental agencies provided help and information for this study, including the Tampa Bay, the Central Florida, and the Southwest Florida Regional Planning Councils; the South and the Southwest Florida Water Management Districts; planning agencies for Polk, Hardee, De Soto, Manatee, Sarasota, Charlotte, and Lee Counties; the Florida Department of Natural Resources Marine Research Lab; the Florida Department of Environmental Regulation; and the U.S. Army Corps of Engineers.

Land-use data for 1984 were compiled at the University of Florida under the direction of John Alexander and by using software written by James Hatchitt. Lou Tyson and Henry Graham, residents of Hardee County, assisted in locating the springs at Zolfo Springs. William Bradford of the Florida Department of Environmental Regulation compiled the information on discharges of domestic and industrial effluent in the Charlotte Harbor inflow area.

DESCRIPTION OF STUDY AREA

The Charlotte Harbor estuarine system (fig. 1) consists of Charlotte Harbor proper, Pine Island Sound, Matlacha Pass, San Carlos Bay, and the tidal reaches of the Myakka, the Peace, and the Caloosahatchee Rivers. For purposes of this study, the inflow area (fig. 2) consists of the Myakka, the Peace, and the Caloosahatchee River basins and the coastal area and islands that drain directly into the harbor. The estuary has a surface area of about 270 mi^2. The inflow area is about 4,685 mi^2.

Climate

The climate of the study area is subtropical and humid. Average temperature is about 72 °F. Temperatures range from an average of about 80 °F during the summer to about 60 °F in December and January. Freezing temperatures occur occasionally. Temperatures for the coastal areas are moderated by the Gulf of Mexico, and temperature extremes occur most frequently inland. Annual rainfall averages about 52 in.; more than one-half occurs from June to September during localized thundershowers and squalls. Rain during fall, winter, and spring is usually the result of large frontal systems and tends to be broadly distributed rather than localized. The period from October through February is characteristically dry; November is the driest month at most stations. The months of April and May also are characteristically dry; low rainfall in April and May coincides with high evaporation and generally results in the lowest streamflows, lake stages, and ground-water levels of the year.

Figure 3 shows departures from average annual rainfall for the eight National Weather Service stations shown in figure 2. Palmer and Bone (1977) discussed rainfall patterns within the Southwest Florida Water Management District. They found that at 10 of 14 sites in west-central Florida, rainfall from 1961 to 1976 was the lowest of any 16-year period since 1915. At three National Weather Service stations in the southern part of the study area (Fort Myers, La Belle, and Moore Haven), rainfall patterns do not show a deficit during the same period.

Tropical cyclones produce the most severe weather conditions in the study area. The high tides and heavy rain associated with these storms can produce coastal and

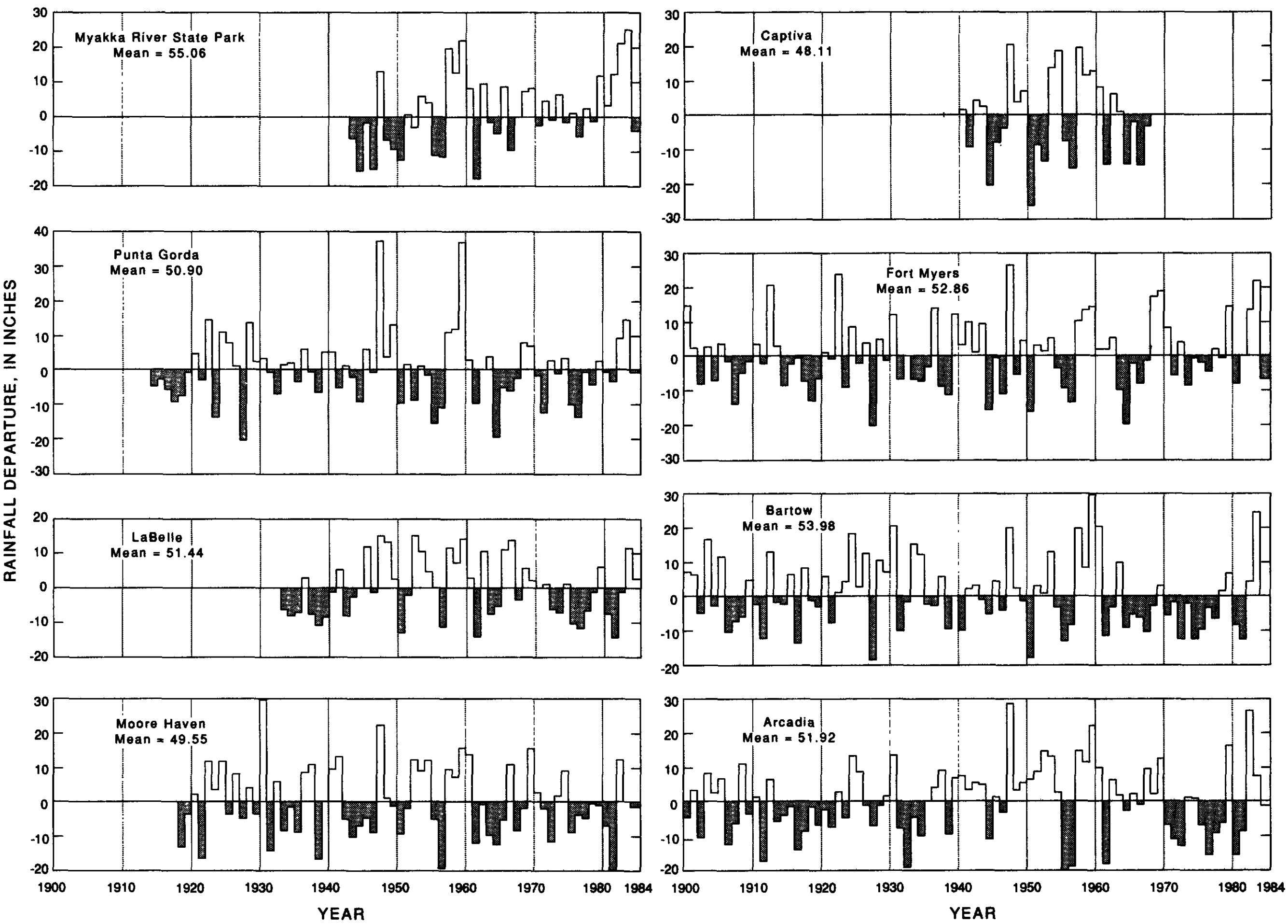

Figure 3. Departure from average annual rainfall at eight National Weather Service stations, 1900–84.

riverine flooding. These storms have the potential for changing the physiography of the harbor and the coastal basin. In the past, some of the barrier islands have been completely overtopped, and passes into the harbor have been opened or closed. The heavy winds and the tide action associated with hurricanes and tropical storms also stir up bottom sediments that significantly affect water quality in the estuary.

Ho and others (1975) analyzed the frequency of tropical storms and hurricanes for the period 1871–1973. On the average in the Charlotte Harbor area, more than two landfalling tropical storms or hurricanes occur per 100 years per 10 nmi of coast; for example, along 30 nmi of coast near Charlotte Harbor, six to seven tropical storms or hurricanes are expected to make landfall during 100 years. The probability of a storm exiting near Fort Myers is greater than at any other place along the Gulf Coast. Near Charlotte Harbor, about one exiting storm occurs per 100 years per 10 nmi of coast.

The information in table 1 is compiled from hurricane tracking charts for 1871–1980 (Neumann and others, 1981), the U.S. Army Corps of Engineers (1961c), and the "Mariners Weather Log" published by the National Oceanic and Atmospheric Administration (1985). Table 1 includes landfalling and exiting hurricanes, as well as storms that had tracks passing only over water or over land.

The records for storms before 1886 are not adequate to distinguish between tropical storms and hurricanes. Therefore, some of the events listed in table 1 that occurred before 1886 may not have been full-fledged hurricanes. The Saffir-Simpson Scale rates hurricane intensity from 1 to 5; 1 is the most moderate storm, and 5 is the most severe. Neumann and others (1981) provided a detailed description of storm classification criteria and the Saffir-Simpson Scale categories. It was not until 1950 that North Atlantic hurricanes were given names.

Except as noted above, table 1 includes only those storms that were hurricanes when they passed within 50 mi of Charlotte Harbor. Storms that passed the study area as tropical storms or depressions and were later upgraded to hurricane status are not included. Of the 26 hurricanes listed in table 1, about three-quarters occurred in September and

Table 1. Hurricanes that have passed within 50 miles of Charlotte Harbor, 1871–1984

[No hurricanes passed within 50 miles of Charlotte Harbor between 1967 and 1984]

Year	Date	Storm name	Saffir-Simpson scale	Remarks
1873	September 26–October 9	---	---	Landfall at Punta Rassa; 14-ft tide.
1876	October 12–22	---	---	
1878	July 1–3	---	---	
	September 1–13	---	---	Stationary near Punta Rassa, September 8–10.
1881	August 16–18	---	---	
1885	October 8–13	---	---	May have been just a tropical storm.
1888	August 14–24	---	---	
1891	August 18–25	---	---	Moved westward across the State.
1894	September 18–30	---	---	Landfall south of Fort Myers.
1896	October 7–16	---	---	
1898	August 2–3	---	---	
1903	September 10–12	---	2	Moved westward across the State.
1910	October 11–18	---	3	
1925	November 30	---	1	
1926	September 12–21	---	4	Came overland from Miami; entered gulf at Fort Myers; 12-ft tide at Sanibel.
1928	September 10–18	---	4	Passed near Lake Okeechobee.
1929	September 23–30	---	3	
1935	September 1–5	---	5	Passed about 25 mi offshore in gulf.
1941	October 4–7	---	2	
1944	October 12–19	---	3	Landfall near Sarasota; 7-ft tide at Boca Grande overtopped island.
1945	September 11–17	---	3	
1946	October 6–7	---	1	
1947	September 4–19	---	4	
1950	September 2–5	Easy	3	
1960	September 1–12	Donna	4	Passed over Fort Myers and Punta Gorda.
1966	June 7–9	Alma	2	

October. Only one scale 5 storm, the "Labor Day Hurricane" of 1935, passed near Charlotte Harbor. The 1926 storm and Hurricane Donna in 1960 were the most severe direct hits. The last hurricane to pass within 50 mi of the harbor was Hurricane Alma in 1966.

In addition to the hurricanes listed in table 1, more than 25 tropical storms or depressions passed within 50 mi of Charlotte Harbor. Most of these storms and depressions also occurred in September and October. Several of these entered land around Charlotte Harbor.

Storm surges and tides are considered to be the most damaging forces in hurricanes, but tropical cyclones are also capable of producing rains that may affect the area for days or weeks. Heavy rains, even from storms passing more than 100 mi away, may lead to abnormally high streamflows. Over a 3-day period in 1972, Hurricane Agnes, which was 200 mi offshore, dumped more than 5 in. of rain on Fort Myers, Punta Gorda, and Myakka River State Park. In June 1974, a subtropical storm that passed about 100 mi north of Charlotte Harbor produced over 9 in. of rain at Fort Myers and over 12 in. at Punta Gorda.

Hydrogeology

The geology of the study area has been described in many publications. Topography, physiography, and geomorphology were presented in Cooke (1939), White (1958, 1970), Puri and Vernon (1964), and Healy (1975). Stratigraphy was discussed in Matson and Sanford (1913), Cooke (1945), and Puri and Vernon (1964). More recently, the Florida Bureau of Geology published an environmental geology map series—Knapp (1980), Lane (1980), and Lane and others (1980). More detailed information on the hydrogeology of the study area was provided by Du Bar (1958), Klein and others (1964), Stewart (1966), Sutcliffe (1975), Wilson (1977), Wedderburn and others (1982), Brown (1982, 1983), and Wolansky (1983).

The hydrogeologic designations in table 2 are somewhat different from those used by earlier authors (Wolansky, 1983, p. 13). The thickness of the strata varies throughout the study area, but table 2 is generally descriptive of the sedimentary layers and the principal water-bearing units. In the upstream sections of the Peace and the

Table 2. Generalized stratigraphic section and hydrogeologic description of the study area
[Modified from Wolansky, 1983]

Series	Stratigraphic unit	Hydrogeologic unit	Thickness (ft)	Lithology
Holocene Pleistocene	Undifferentiated sediments	Surficial aquifer system	0– 60	Nonmarine, light-gray to yellow, fine- to medium-grained quartz sand; underlain by marine terrace deposits of sand and marl, including clay, shell, and peat deposits.
Pliocene	Caloosahatchee Marl		0– 50	Shallow marine, gray, tan, or cream, unconsolidated, sandy marl, marl, and shell beds; hard, sandy limestone; some phosphate.
	Bone Valley Formation		0– 20	Mostly nonmarine, very light gray to gray, clayey sand and sandy clay that has lenslike beds of light-gray, fine- to medium-grained quartz sand that has a considerable amount of land vertebrate fossil fragments, some marine fossil fragments, phosphate nodules, and quartz pebbles.
	Tamiami Formation	Confining unit Tamiami–upper Hawthorn aquifer	0–150	Shallow marine, green to gray, sandy, calcareous clay, gray marl, gray sandstone, and slightly consolidated tan to light-gray limestone; all units contain some phosphate.
Middle Miocerne	Hawthorn Formation	Confining unit	200–400	Marine, interbedded layers of buff, sandy, clayey, phosphatic limestone and dolomite; gray, fine to medium sand; gray to greenish-blue sandy clay that has abundant phosphate nodules.
Lower Miocene	Tampa Limestone	Lower Hawthorn–upper Tampa aquifer Confining unit	150–300	Marine, white to light-gray, sandy, often phosphatic, clayey limestone, silicified in part, that has many molds of pelecypods and gastropods; often interbedded with light-gray clay and sandy clay. A residual mantle of green to greenish-blue, calcareous clay is often developed.
Oligocene	Suwannee Limestone		200–300	Marine, cream to buff, often soft, granular limestone composed of loosely cemented foraminifers.
Upper Eocene	Ocala Limestone	Floridan Aquifer system	200–300	Marine, white to cream, often soft and finely granular limestone, grading near the bottom into tan limestone that has beds of grayish-brown dolomite.
Middle Eocene	Avon Park Formation		901–1,200	Marine, cream to tan, soft to hard, granular to chalky, highly fossiliferous limestone interbedded with grayish-brown to dark-brown, highly fractured dolomite; some carbonaceous and clayey zones; some intergranular gypsum and anhydrite near the bottom in places.
		Lower confining unit		Marine, cream to tan, slightly carbonaceous and cherty limestone and grayish- to dark-brown dolomite; both have varying amounts of intergranular gypsum and anhydrite.

Myakka River basins, the Floridan aquifer system is the primary source of ground-water supply. Nearer the coast and in much of the Caloosahatchee River basin, the Floridan aquifer system is highly mineralized. In these areas, the surficial aquifer system and intermediate Hawthorn aquifer are the primary sources of ground-water supply.

For the Myakka River basin (fig. 4), characteristics of the ground-water system have been described by Flippo and Joyner (1968). Artesian ground-water contributions to the Myakka River in the reach between Myakka City and Lower Myakka Lake are negligible. Upper and Lower Myakka Lakes appear to be solution features, thereby offering the possibility of hydraulic connection with the underlying aquifers. The lakes and the river channel, however, appear to be underlain by rather impermeable clays. Warm Mineral Springs and Little Salt Spring (fig. 4) are sources of highly saline ground water in the lower reaches of Big Slough Canal. Other smaller springs of this type in the area may be filled with debris and, therefore, are not noticeable at ground surface. Drainage from agricultural lands irrigated by using ground water is, at times, an appreciable part of low flow in the sloughs in the basin.

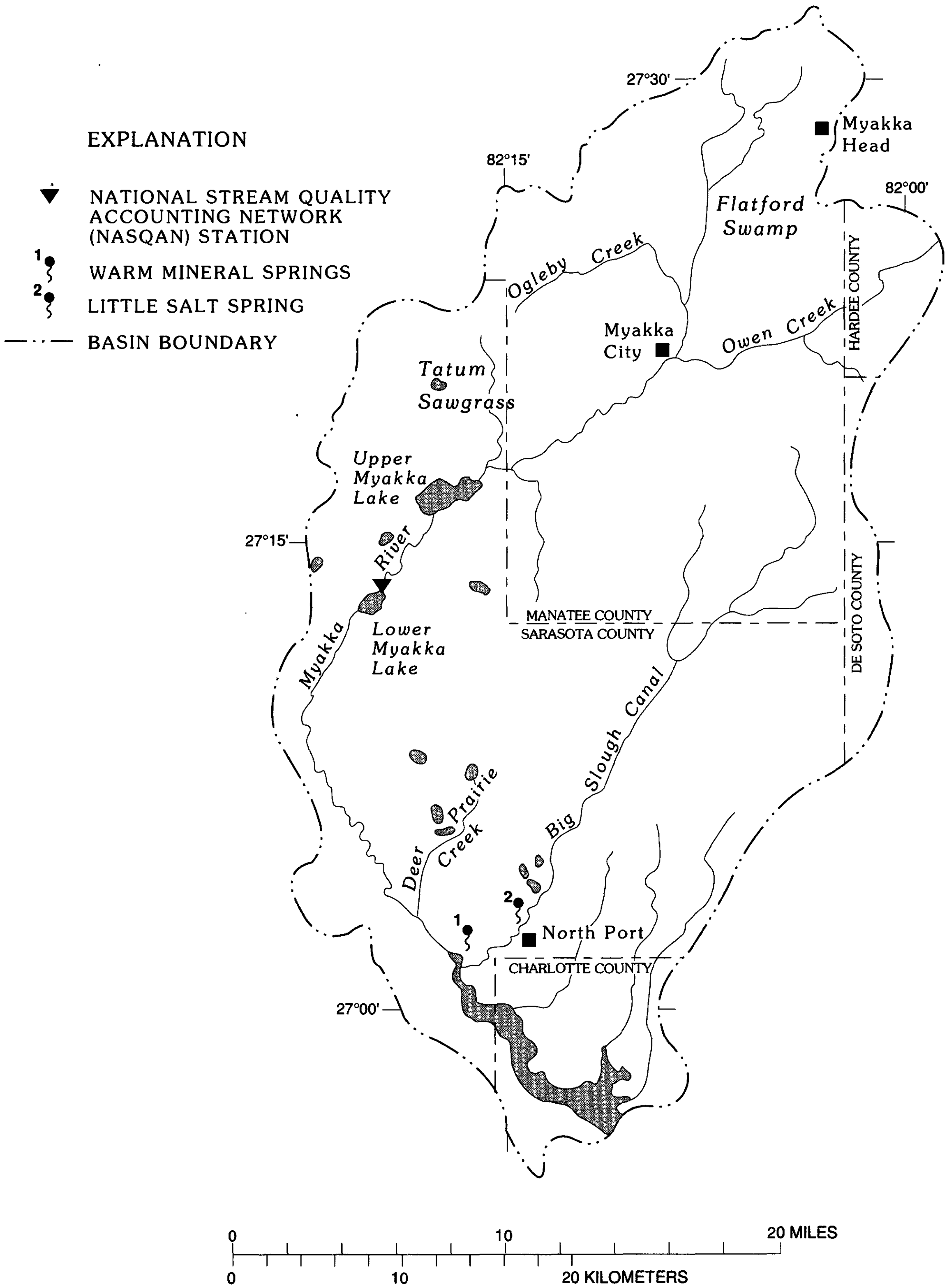

Figure 4. Myakka River basin.

For the Peace River basin (fig. 5), several investigations have described the ground-water system and its relation to the river and to the tributary streams. Based on data collected before 1960, Stewart (1966) reported a general zone of upward leakage from the intermediate Hawthorn aquifer and the Floridan aquifer system into Saddle Creek and the Peace River in Polk County. In Hardee and De Soto Counties, Wilson (1977) described the

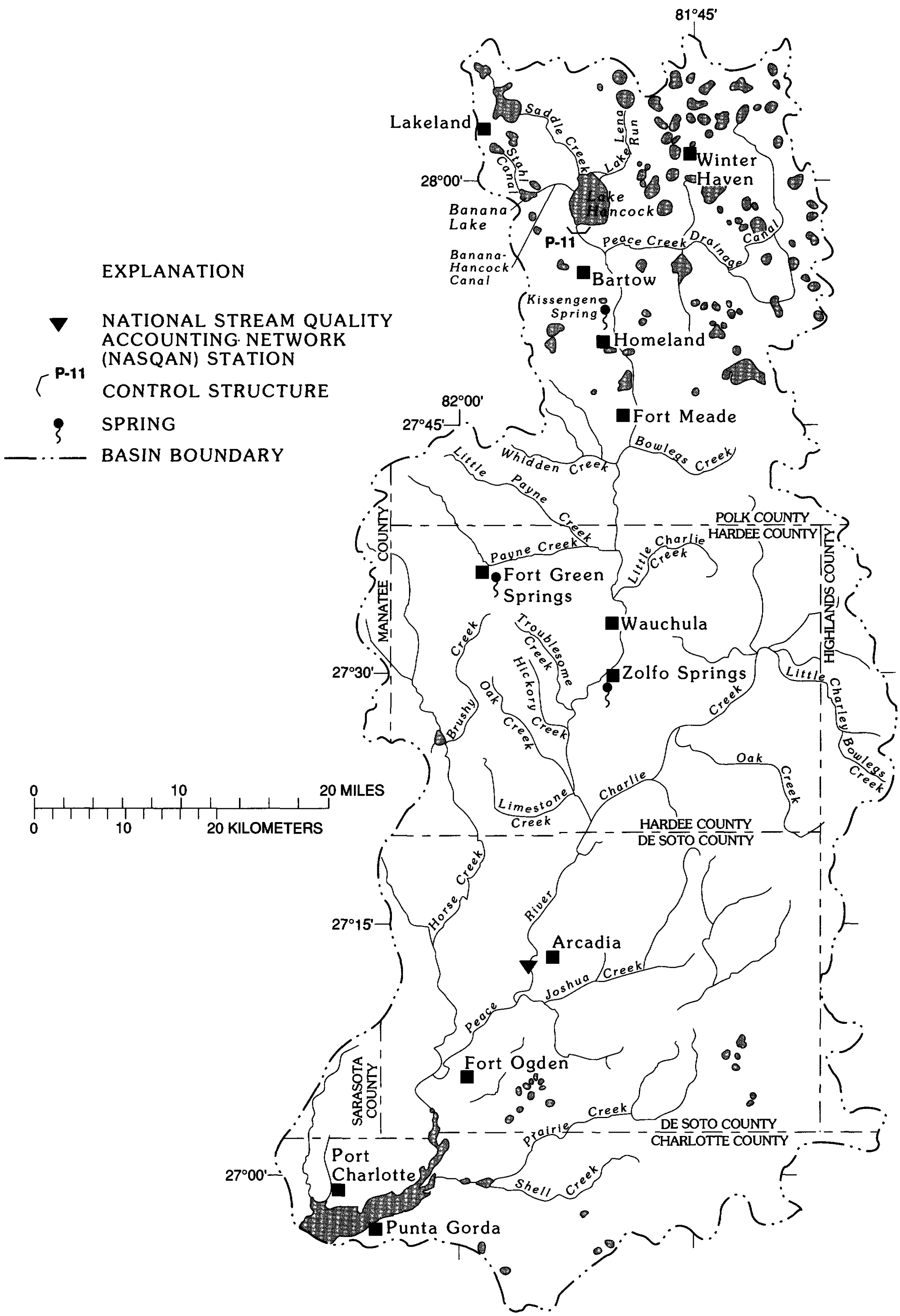

Figure 5. Peace River basin.

river valleys of the Peace and its tributaries as areas of artesian flow. Artesian springs and seeps are found at Zolfo Springs and Fort Green Springs, but discharge from the springs has not been measured. Wilson concluded, however, that the hydraulic connection between the Peace River and the underlying Floridan aquifer system in Hardee and De Soto Counties is poor. The springs probably originate in the intermediate Hawthorn aquifer, and the river derives much of its base flow from the surficial aquifer system.

Kissengen Spring (fig. 5), which is 4 mi southeast of Bartow, was the first known major spring to cease flowing in Florida because of ground-water withdrawal from wells (Rosenau and others, 1977). Peek (1951) attributed the cessation of flow to pumping from the Floridan aquifer system. The flow of the spring had remained fairly steady at about 20 Mgal/d from 1898 to 1934. A downward trend began in 1934 and continued until flow completely ceased in 1950. This downward trend in springflow corresponded to a downward trend in the potentiometric surface of the Floridan aquifer system. According to Kaufman (1967), an actual reversal of hydrologic conditions now may make it possible for water to move from the Peace River and the surficial aquifer system to the Floridan aquifer system.

During a field reconnaissance in April 1985, the entire flow (estimated to be less than 10 ft^3/s) of the Peace River south of Bartow was observed to be disappearing into a limestone crevice in the streambed. The same phenomenon was observed in spring 1981. The Miocene Hawthorn Formation outcrops along the Peace River channel in this area (Hutchinson, 1978). The observed hydraulic connection would, therefore, be with the intermediate Hawthorn aquifer.

In the Caloosahatchee River basin (fig. 6), only the surficial aquifer system is hydraulically connected to the stream system (Klein and others, 1964; Wedderburn and others, 1982). The banks and the riverbed along most of the reach downstream from Ortona Lock, structure S–78 (fig. 6), are composed of relatively impermeable clay and marl, which tend to prevent lateral or downward seepage from the river channel. The Caloosahatchee River is a major discharge area for ground water from the surficial aquifer system. Wedderburn and others (1982) showed gradients toward the river from the north, northwest, south, and east during wet and dry seasons.

Tidal canals and streams in the coastal area surrounding Charlotte Harbor derive their flow from surface runoff and the surficial aquifer system. Construction of canals and ditches has had a pronounced effect on the water level in the surficial aquifer system. Sea-level canals transport saltwater inland and, at the same time, cause existing freshwater in the surficial aquifer system to drain off into the canals. The deep tidal canals at the eastern end of Sanibel Island (fig. 1) have permanently lowered the water table (Clark, 1976). Canals have allowed saltwater intrusion in the surficial aquifer system in Charlotte County (Sutcliffe, 1975).

Topography and Drainage

The Myakka River basin (fig. 4) drains an area of 602 mi^2 (Foose, 1981). The river originates in northeastern Manatee County near Myakka Head and flows about 50 mi in a southerly direction through Manatee, Sarasota, and Charlotte Counties to Charlotte Harbor. Land-surface elevations range from about 115 ft above sea level at the headwaters to sea level at the mouth. The upper reaches of the river have a slope of about 5 ft/mi, but near the mouth, the slope is less than 1 ft/mi. Away from the stream channels, the topography is very flat. In some of the lower reaches of the river, the flood plain is up to 3 mi wide (Hammett and others, 1978). During low flows, the river is affected by tide more than 10 mi upstream from the mouth.

Marshes and swamps within the Myakka River basin provide large storage areas for surface water. A large surface depression, which is known locally as the Flatford Swamp, is found in the headwaters near the confluence with Ogleby Creek. Tatum Sawgrass is a large diked marsh about 5 mi southwest of Myakka City. Upper and Lower Myakka Lakes lie in a topographically low area near the east-central part of the drainage basin.

Between 1925 and 1965, most of the major sloughs in the Myakka River basin were deepened for drainage purposes. In 1941, a low concrete dam was built at the outlet of Upper Myakka Lake (Flippo and Joyner, 1968); several years earlier, an earthen dam was built at the outlet of Lower Myakka Lake. The dams were designed to be low-water controls to prevent the lakes from going dry in times of drought. The earthen dam washed out, and, as a result, Lower Myakka Lake went completely dry in 1945.

During the late 1950's and 1960's, much of the area around the mouth of the Myakka River in Charlotte County was channelized. Some channels were dredged to produce waterfront homesites, others were dredged for drainage. Seawalls and bulkheads were built along many of the channels. In the area north of Port Charlotte, a series of weirs act as saltwater barriers in the canals and gradually increase water levels to 15 to 20 ft above sea level.

The Peace River basin (fig. 5) has a drainage area of 2,350 mi^2 (D.W. Foose, USGS, written commun., 1986). The river has its headwaters among a group of lakes in northern Polk County. Saddle Creek and the Peace Creek Drainage Canal join near Bartow to form the Peace River. The river then flows southward for about 75 mi through Polk, Hardee, De Soto, and Charlotte Counties. Land-surface elevations range from over 200 ft above sea level near the headwaters to sea level at the mouth.

Many of the lakes in the headwaters area are linked by systems of canals. In some, flow between lakes is continual; in others, flow occurs only under high-water conditions. Fixed or operable control structures have been constructed on many lake outlets.

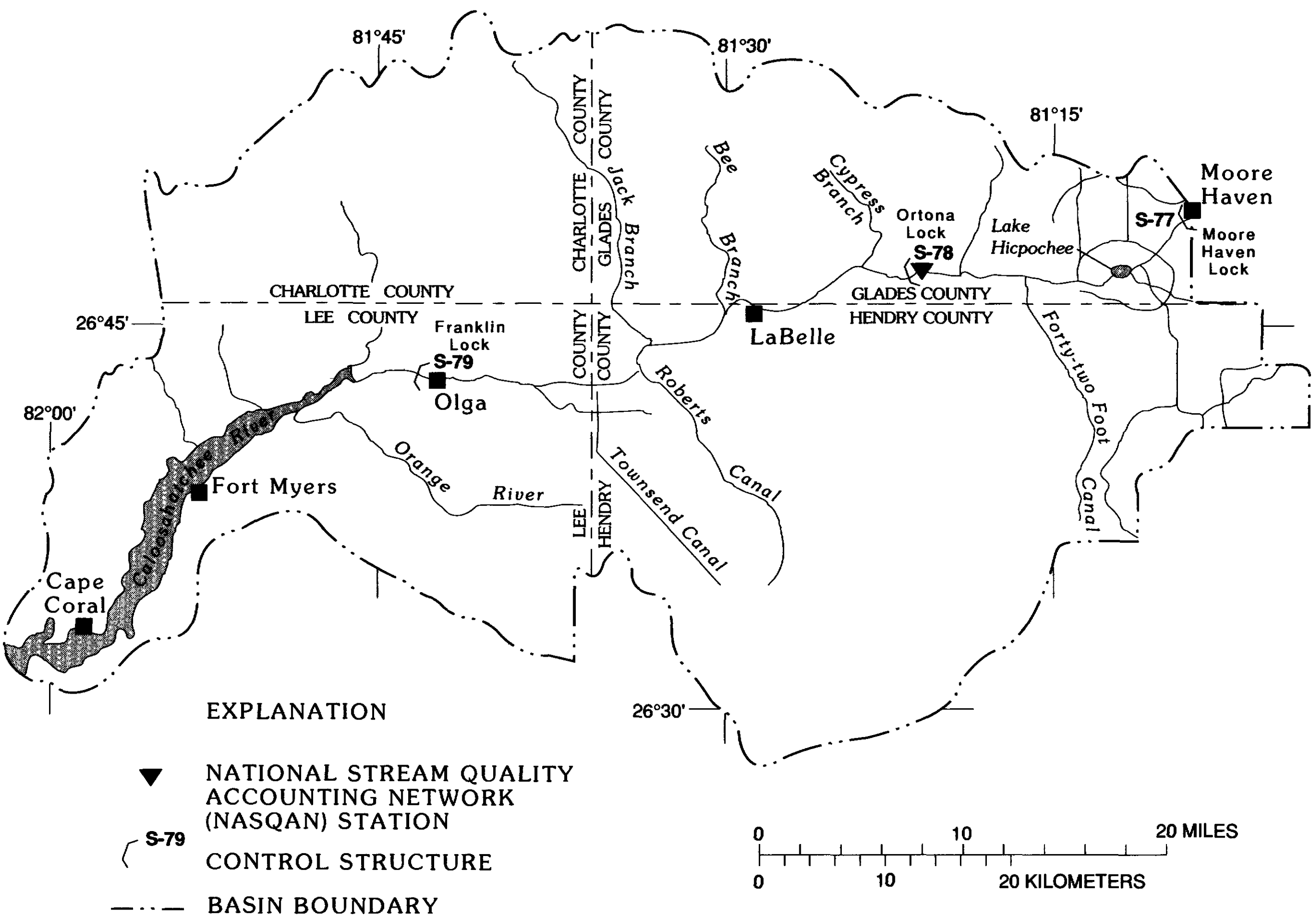

Figure 6. Caloosahatchee River basin.

Much of the Peace River basin in Polk County has been strip mined for phosphate. This type of mining impacts on river flow in two ways. First, strip mining alters the natural drainage patterns in the basin. Rainwater that ran off under natural conditions may be internally drained to settling ponds as a result of mining. Second, processing phosphate ore requires large amounts of water, most of which is pumped from the Floridan aquifer system. Part of this process water is eventually discharged to the Peace River and its tributaries as effluent. Further discussion of the discharge from phosphate processing plants is included in the sections "Streamflow Characteristics" and "Water-Quality Characteristics."

At normal stages, the channel of the Peace River upstream from Arcadia is well defined. Downstream from Arcadia, the river's flood plain widens, and the channel becomes braided. In some places, the marsh and the swampy area bordering the river spans more than 1 mi. During periods of low flow, the river is affected by tide as far as 5 mi upstream from Fort Ogden.

Like the Myakka, several areas near the mouth of the Peace River have been channelized for development of waterfront homesites. Seawalls and bulkheads are commonplace.

For purposes of this report, the Caloosahatchee River basin (fig. 6) is a hydrologic cataloging unit that has an area of 1,378 mi^2. The basin extends from Moore Haven Lock to the mouth of the river in San Carlos Bay. (Upstream from Moore Haven, outside the study area, a channel connects the river to Lake Okeechobee. Because of this connection with Lake Okeechobee, the Caloosahatchee River basin could, theoretically, be extended to include the entire drainage area of the lake, which would be an additional 5,650 mi^2.) The flatness of the terrain and an extensive network of drainage canals make definition of drainage divides very tenuous. Land-surface elevations reach a maximum of about 75 ft above sea level near the divide between the Peace and the Caloosahatchee River basins. Land surface slopes gradually from about 25 ft above sea level at Moore Haven to sea level at the mouth, which is a distance of about 70 mi.

The Caloosahatchee River was originally a shallow, meandering stream that had its headwaters near Lake Hicpochee. In its natural state, the river could go dry during the dry season, and the saltwater front could move as far upstream as Ortona Lock, structure S–78 (Fan and Burgess, 1983). Dredging and straightening of the channel began in the 1880's at the upper end of the river. In the 1930's, the U.S. Army Corps of Engineers continued to straighten, widen, and deepen the channel. Moore Haven Lock, structure S–77, and Ortona Lock, structure S–78, were completed by the Corps of Engineers in 1937. In the 1960's, the Corps of Engineers did extensive dredging and installed Franklin Lock, structure S–79, near Olga.

Tributaries south of the Caloosahatchee River have been extensively modified. Many of the tributary flows are regulated by pumping stations, gated spillways, or culverts that have adjustable controls. Relatively large volumes of water may flow toward the river during the wet season, but the direction of flow is frequently reversed by irrigation pumps during the dry season. The base flows of some tributaries may be significantly lowered by pumping from shallow irrigation wells and stream intakes; flows of other tributaries may be slightly augmented by irrigation return flow.

As is the case for the Myakka and the Peace Rivers, large areas near the mouth of the Caloosahatchee River have been channelized for development of waterfront homesites. One planned development, the city of Cape Coral, is platted for more than 140,000 homesites, many of which are on more than 400 mi of dredged canals.

The coastal area and barrier islands (figs. 1, 2) adjacent to Charlotte Harbor total 355 mi^2. In the coastal area surrounding the harbor, several natural streams have been widened and deepened to increase their capacity for drainage. Also, many mangrove areas are crisscrossed by mosquito-control ditches. On Sanibel Island, several real estate lakes have been dug, the natural drainage system has been channelized and expanded, and some water-level control structures have been constructed. A few areas along the harbor shoreline and on the barrier islands have been dredged and filled for waterfront homesites.

LAND USE

The Charlotte Harbor estuarine system is affected by land use and land management throughout the inflow area. Development and population growth result in changes in land use that may produce changes in the quality or the quantity of water flowing into the estuary.

Land-use information has been compiled by several agencies in several formats. Unfortunately, the categorization and the classification of types of land use are rarely consistent from one source to the next. The lack of uniformity makes it virtually impossible to compare land-use data from different sources.

Data in tables 3 and 4 were digitized from land-use and land-cover maps that were generated from 1972–73 aerial photography as part of a national mapping effort (U.S. Geological Survey, 1979a–c). Anderson and others (1976) proposed the classification system used for these data. Table 3 shows land-use data broken down by river basin. Table 4 shows data by county for all 10 counties that are either partially or completely within the inflow area.

Based on the 1972–73 data, the majority of the inflow area is used for agriculture and range (table 3). Agricultural land and rangeland totaled about 70 percent of the land area in the Peace and the Myakka River basins and 65 percent in the Caloosahatchee River basin. Urban land area ranged from about 1 percent of the Myakka basin to about 7 percent of the coastal inflow area. Wetlands totaled 11 to 14 percent of the river basin area and more than 30 percent of the coastal inflow area.

The data in table 4 are for entire counties, even where only part of the county is in the study area; for example, Manatee and Sarasota Counties show relatively large areas of urban land use, but the urban areas occur along the gulf coast, not within the Myakka River basin. The county breakdown provides a basis for comparison with other sources of land-use data, such as county planning departments.

Based on the 1972–73 data, agricultural land and rangeland are the predominant types of land use in every county. About 35 percent of the land in Lee County and more than 80 percent of the land in De Soto and Hardee Counties is used for agriculture and range (table 4). The section of wetlands in every county is substantial. In Polk County, phosphate strip mining is a significant type of land use. Areas of urban development cover less than 10 percent of the total land in Charlotte and Lee Counties; these occur primarily along the shoreline of the harbor and have a great potential for expansion. Urban areas in De Soto, Hardee, Glades, and Hendry Counties cover less than 2 percent of the land and are composed of small interior towns that have a limited probability of growth. As noted above, the urban growth areas in Manatee and Sarasota Counties are outside the study area. In Polk County, urban development centers around the lakes in the headwaters of the Peace River, which provide desirable locations and potential for expansion.

Land-use data for 1984 (tables 5, 6) were prepared at the University of Florida by using Florida Department of Revenue statistics compiled by county tax assessors. The 1984 data are structured for an entirely different purpose than the 1972–73 data, and, consequently, the data for the two periods cannot generally be compared; for example, a house on a 5-acre parcel of land in a rural area would fall into rangeland or agricultural land in the 1972–73 classification. For tax purposes, the parcel is considered to be residential and would be classified as such in the 1984 data. In looking at both sets of data, it is essential to adopt the perspective of the classifying agency.

Table 3. Land use and land cover by river basin, 1972–73
[In acres]

Land use or land cover	Caloosahatchee	Coastal	Myakka	Peace
Total	**895,013**	**[1]390,831**	**364,776**	**1,452,683**
Urban or built-up land	**33,902**	**15,449**	**4,033**	**71,197**
Residential	24,641	12,899	3,153	49,491
Commercial and services	3,845	455	158	7,670
Industrial	731	59	0	6,751
Transportation, communication, and utilities	840	801	40	3,005
Industrial and commercial complexes	59	0	0	0
Mixed	623	118	0	1,601
Other	3,163	1,117	682	2,679
Agricultural land	**251,820**	**16,358**	**94,424**	**657,824**
Cropland and pasture	217,097	11,960	91,053	443,465
Orchards, groves, and so forth	34,575	4,398	3,262	214,092
Confined feeding operations	20	0	0	89
Other	128	0	109	178
Rangeland	**328,392**	**60,451**	**167,359**	**354,822**
Herbaceous	235,254	41,533	166,153	337,377
Shrub and brush	1,018	385	1,206	939
Mixed	92,120	18,533	0	16,506
Forest land	**80,843**	**25,699**	**21,824**	**74,073**
Deciduous	0	0	0	0
Evergreen	79,963	25,699	21,824	73,638
Mixed	880	0	0	435
Water	**21,191**	**164,147**	**7,334**	**51,191**
Streams and canals	4,240	405	484	1,947
Lakes	820	949	2,807	32,688
Reservoirs	336	89	20	11,011
Bays and estuaries	15,795	[1]162,704	4,023	5,545
Wetland	**128,109**	**69,931**	**40,970**	**182,768**
Forested	37,926	60,106	26,776	139,248
Nonforested	90,183	9,825	14,194	43,520
Barren land	**50,756**	**38,796**	**28,832**	**60,808**
Dry salt flats	0	0	0	0
Beaches	198	2,471	227	0
Sandy areas	0	1,621	188	564
Bare, exposed rock	0	0	0	0
Strip mines, quarries, pits	1,127	119	128	48,571
Transitional areas	49,431	34,585	28,289	11,673
Mixed	0	0	0	0

[1] Includes water-surface area of Charlotte Harbor. Percentage estimates in text are based on land area only.

Although the Florida Department of Revenue requires that all counties provide certain minimum data, the data have not been uniformly verified. Populous urban counties generally have had a head start in automating, updating, and verifying their tax-assessment data. Reporting units vary from county to county; some report parcel size in acres, some in square feet, some in front footage and depth. In view of these constraints, the acreage data in tables 5 and 6 should be used with caution. Acreage values for Manatee County are not currently available. The tax-assessed estimate of total residential acreage in Polk County seems low when compared to urban residential area estimated from the 1972–73 USGS maps.

According to the 1984 data, agricultural land is predominant in the inflow area, except for the coastal basin surrounding Charlotte Harbor (table 5). Land taxed for agricultural purposes ranges from about 18 percent of the coastal basin to about 70 percent of the Peace and the Caloosahatchee River basins. Land taxed for residential use is the predominant form of land use in the coastal basin

Table 4. Land use and land cover by county, 1972–73
[In acres]

Land use or land cover	Charlotte	De Soto	Glades	Hardee
Total	**521,345**	**406,666**	**632,985**	**408,56**
Urban or built-up land	**19,620**	**7,237**	**2,551**	**3,24**
Residential	15,993	3,479	1,690	2,96
Commercial and services	1,305	1,918	208	9
Industrial	0	40	59	4
Transportation, communications, and utilities	830	702	40	12
Industrial and commercial complexes	0	0	0	[illegible]
Mixed	187	979	40	[illegible]
Other	1,305	119	514	1
Agricultural land	**63,448**	**216,414**	**155,518**	**239,70**
Cropland and pasture	54,127	160,707	152,849	166,96
Orchards, groves, and so forth	9,311	55,707	2,629	72,65
Confined feeding operations	0	0	0	0
Other	10	0	40	7
Rangeland	**219,459**	**127,477**	**227,584**	**87,57**
Herbaceous	167,043	127,477	212,372	87,57
Shrub and brush	494	0	0	0
Mixed	51,922	0	15,212	0
Forest land	**20,540**	**4,557**	**31,244**	**12,16**
Deciduous	0	0	0	0
Evergreen	20,233	4,557	30,513	12,16
Mixed	307	0	731	0
Water	**71,958**	**2,174**	**61,895**	**44**
Streams and canals	2,600	0	1,097	0
Lakes	653	2,046	60,719	43
Reservoirs	623	128	79	1
Bays and estuaries	68,082	0	0	0
Wetland	**84,767**	**47,770**	**152,780**	**65,33**
Forested	40,683	32,005	37,985	63,01
Nonforested	44,084	15,765	114,795	2,32
Barren land	**41,553**	**1,037**	**1,413**	**9**
Dry salt flats	0	0	0	0
Beaches	1,344	0	0	0
Sandy areas	1,621	227	178	9
Bare, exposed rock	0	0	0	0
Strip mines, quarries, pits	119	59	247	0
Transitional areas	38,469	751	988	0
Mixed	0	0	0	0

(fig. 2) and represents about 42 percent of the land area. The mining land in the Peace River basin includes actively mined and reclaimed phosphate lands.

It is not possible to evaluate trends by comparing the 1972–73 data with the 1984 data. Both sets of data are presented because they can serve as a base against which future comparisons can be made. They both document, from different perspectives, the existing land use and land cover in the inflow area. They also point out the need for a more standardized and systematic process for the collection and the categorization of land-use data.

WATER USE

Water use mirrors changes in land use; for example, increases in urban areas result in increased municipal demand, and increases in cropland produce greater demands for irrigation water. From 1970 to 1980, the population of Florida increased by almost 3 million. During the same period, total freshwater use in Florida increased by 1,541 Mgal/d (Leach, 1983).

Water-use data for Florida are collected as part of the National Water Use Data System of the USGS. Leach

Hendry	Highlands	Lee	Manatee	Polk	Sarasota
765,698	**708,541**	**664,911**	**509,146**	**1,283,138**	**389,299**
4,812	**17,012**	**44,687**	**28,397**	**106,788**	**46,950**
2,886	9,321	33,735	21,508	69,278	37,214
395	3,944	3,786	2,847	10,774	4,013
297	356	850	563	15,518	455
563	2,076	1,235	1,067	6,208	860
59	0	20	158	0	0
128	0	969	0	642	0
484	1,315	4,092	2,254	4,368	4,408
330,212	**291,396**	**89,274**	**191,705**	**459,349**	**80,378**
301,241	238,921	76,217	168,071	271,321	78,401
28,941	52,455	12,978	23,070	187,444	1,977
0	0	20	188	376	0
30	20	59	376	208	0
183,125	**222,701**	**145,466**	**188,897**	**210,306**	**161,370**
129,760	222,701	81,634	187,464	209,258	160,757
0	0	1,601	1,433	1,048	613
53,365	0	62,231	0	0	0
100,097	**22,526**	**41,711**	**20,955**	**104,951**	**32,213**
0	0	0	0	0	0
96,845	22,526	41,711	20,925	104,793	32,045
3,252	0	0	30	158	168
18,137	**46,693**	**141,701**	**29,436**	**92,477**	**18,947**
425	1,433	3,569	7,492	316	563
17,633	44,993	771	2,076	74,350	2,145
79	267	741	1,651	17,811	59
0	0	136,620	18,217	0	16,180
117,869	**87,377**	**121,872**	**47,108**	**218,045**	**29,099**
55,717	72,145	99,889	36,087	174,782	18,859
62,152	15,232	21,983	11,021	43,263	10,240
11,446	**20,836**	**80,200**	**2,648**	**91,222**	**20,342**
0	0	0	0	0	0
0	0	2,481	662	0	1,255
0	208	0	148	346	188
0	0	0	0	0	0
208	10	1,127	316	76,504	445
11,238	20,618	76,592	1,522	14,372	18,454
0	0	0	0	0	0

(1983) presented 1980 water-use data for Florida and discussed the differences between water withdrawn and consumptive use, as well as summaries of previous investigations. In addition to USGS reports, the South Florida and the Southwest Florida Water Management Districts collect and update some water-use data (Southwest Florida Water Management District, 1984; Stieglitz, 1985).

As shown in table 7 and figure 7, except for the Peace River basin, irrigation is the predominant type of water use throughout the Charlotte Harbor inflow area (Leach, 1983). Irrigation constitutes from 62 to 86 percent of the total water use in the Caloosahatchee, the Myakka, and the coastal inflow areas. In the Peace River basin, irrigation totals 39 percent of total water use, and industry, particularly phosphate mining and chemical manufacturing, totals 47 percent. Except for the coastal inflow area, which uses 37 percent of its water for municipal supply, public supply totals only 5 to 12 percent of water use. Throughout the inflow area, ground water is the primary source of supply.

In table 8, water use in 1975 is compared to water use in 1980 by county. The data are taken from Leach (1978, 1983). As table 8 shows, irrigation water use has varied substantially. Between 1975 and 1980, five of the counties had a decrease in the total number of acres irrigated, and

Table 5. Tax-assessed land use by river basin, 1984

[In acres. Data for Myakka River basin cannot be compiled because data for Manatee County were unavailable]

Tax-assessed land use	Caloosahatchee	Coastal	Peace
Total	**628,561**	**129,882**	**1,843,648**
Residential	**85,346**	**54,135**	**68,103**
Commercial	**12,347**	**13,400**	**54,445**
Industrial	**9,382**	**236**	**75,718**
Institutional	**29,023**	**1,069**	**28,155**
Government	**10,655**	**22,221**	**122,381**
Mining	**0**	**20**	**143,431**
Other	**23,853**	**15,501**	**107,025**
Agricultural	**457,955**	**23,300**	**1,244,390**
Cropland	35,264	4,625	128,010
Timber	28,250	494	4,201
Grazing	345,794	16,385	801,874
Citrus	45,673	1,673	211,451
Miscellaneous	888	123	97,591
Dairies	2,086	---	1,263

five of the counties had an increase. Climate, as well as acreage, has an impact on the amount of irrigation water use. Because rainfall during 1980 was more than that during 1975 in some parts of the study area (fig. 3), the need for irrigation decreased in 1980; also, increased fuel costs and reductions in the amount of pasture irrigation contributed to the decrease in irrigation (Duerr and Sohm, 1983). Between 1975 and 1980, decreases in industrial water use were substantial in most of the counties, probably as a result of economic constraints and conservation measures. Rural water use increased in Glades, Highlands, Lee, and Polk Counties and decreased in the other counties. Public water supply remained virtually unchanged in the rural counties—Hardee, De Soto, Glades, and Hendry. Increases in public supply in Manatee and Sarasota Counties resulted from expanding urban areas along the gulf coast, which is outside the study area. Public-supply water use in Lee and Sarasota Counties almost doubled between 1975 and 1980.

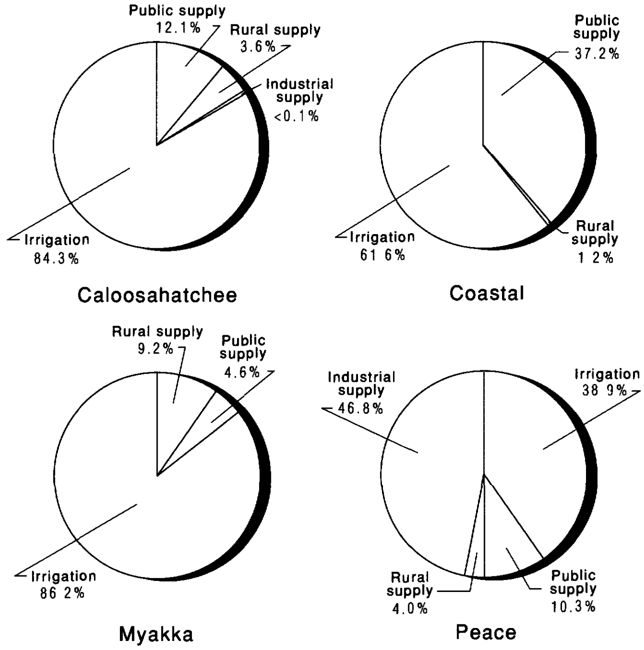

Figure 7. Water use by river basin, 1980.

Table 9 shows the amount of water used per acre for urban, agricultural, and industrial land uses. The table is based on 1972–73 land-use data (table 4) and 1975 water-use data (table 8). Urban land use in table 9 is urban minus industrial land from table 4. Industrial land use in table 9 is the sum of industrial plus strip-mined land from table 4. Agricultural water use in table 9 is the sum of rural and irrigation water use from table 8.

Table 6. Tax-assessed land use by county, 1984

[In acres. Data for Manatee County are unavailable]

Tax-assessed land use	Charlotte	De Soto	Glades
Total	**421,220**	**423,457**	**491,87**
Residential	**57,364**	**12,572**	**14,73**
Commercial	**12,931**	**20,930**	**7,47**
Industrial	**1,434**	**10,569**	**12**
Institutional	**6,152**	**432**	**20**
Government	**84,902**	**4,347**	**37,24**
Mining	**57**	**0**	[illegible]
Other	**8,131**	**16,716**	**21,37**
Agricultural	**250,249**	**357,891**	**410,72**
Cropland	6,467	57,856	28,46
Timber	0	88	59,08
Grazing	228,804	254,047	311,00
Citrus	14,734	44,845	8,92
Miscellaneous	244	1,055	18
Dairies	0	0	3,06

Table 7. Water use by river basin, 1980
[In million gallons per day]

Water use	Caloosahatchee	Coastal	Myakka	Peace
Total	**215.82**	**10.13**	**28.55**	**310.29**
Public supply	**26.01**	**3.77**	**1.30**	**31.90**
Ground water	12.99	3.06	.00	27.68
Surface water	13.02	.71	1.30	4.22
Rural supply	**7.80**	**.12**	**2.64**	**12.49**
Ground water	6.78	.12	2.46	12.34
Surface water	1.02	.00	.18	.15
Domestic	6.07	.09	.76	8.75
Livestock	1.73	.03	1.88	3.74
Industrial supply	**.09**	**.00**	**.00**	**145.30**
Ground water	.09	.00	.00	145.30
Surface water	.00	.00	.00	.00
Limerock mining	.00	.00	.00	.30
Chemical products	.00	.00	.00	36.64
Phosphate mining	.00	.00	.00	95.41
Citrus processing	.09	.00	.00	9.81
Food processing	.00	.00	.00	2.28
Other	.00	.00	.00	.86
Irrigation	**181.92**	**6.24**	**24.61**	**120.60**
Ground water	84.07	5.62	24.06	116.08
Surface water	97.85	.62	.55	4.52

Within the Charlotte Harbor inflow area, industrial and mining water uses per acre are almost four times as great as urban and agricultural water uses combined (table 9). For the counties encompassing the inflow area, urban water use averaged about 340 (gal/d)/acres, agricultural water use averaged about 440 (gal/d)/acre, and industrial water use averaged more than 2,900 (gal/d)/acre. Industrial and mining land-use values for Glades and Hardee Counties are probably inaccurate. The tax-assessment records (table 6) show only 125 acres of industrial land in Glades County but 35,035 acres in Hardee County. The two counties were excluded from the average computation because of the questionable accuracy of the data.

Within an urban area, water use varies greatly, depending on individual land uses. Alexander and others (1984) defined water use per acre by type of urban land use

Hardee	Hendry	Highlands	Lee	Polk	Sarasota
404,689	**727,518**	**482,040**	**475,493**	**1,495,114**	**335,754**
12,130	**25,839**	**23,605**	**174,138**	**29,839**	**48,809**
951	**1,162**	**1,435**	**25,336**	**55,797**	**26,798**
35,035	**627**	**583**	**14,532**	**45,334**	**6,990**
277	**956**	**1,814**	**31,567**	**26,423**	**6,935**
4,428	**56,515**	**7,287**	**40,938**	**66,072**	**29,242**
0	**0**	**0**	**0**	**221,065**	**40**
5,722	**12,282**	**23,241**	**48,687**	**337,141**	**20,579**
346,146	**630,137**	**424,075**	**140,295**	**713,443**	**196,361**
64,443	84,552	6,043	18,342	1,487	2,166
0	0	2,538	1,183	464	3
204,964	493,278	370,859	107,684	419,840	192,413
73,113	50,049	40,896	11,418	194,564	1,607
10	95	973	1,276	96,828	91
616	2,163	2,766	392	260	81

Table 8. Water use by county, 1975 and 1980

[In million gallons per day]

Water use	Charlotte		De Soto	
	1975	1980	1975	1980
Total	**40.00**	**31.16**	**69.19**	**37.73**
Public supply	**4.08**	**4.93**	**0.76**	**0.71**
Ground water	.18	.00	.76	.71
Surface water	3.90	4.93	.00	.00
Rural supply	**1.51**	**1.24**	**4.05**	**2.15**
Ground water	1.51	1.24	4.05	2.15
Surface water	.00	.00	.00	.00
Domestic	1.17	.89	1.12	1.20
Livestock	.34	.35	2.93	.95
Industrial supply	**.10**	**.00**	**.59**	**.53**
Ground water	.10	.00	.59	.53
Surface water	.00	.00	.00	.00
Limerock mining	.00	.00	.00	.00
Chemical products	.00	.00	.00	.00
Phosphate mining	.00	.00	.00	.00
Citrus processing	.00	.00	.23	.28
Food processing	.10	.00	.11	.00
Other	.00	.00	.25	.25
Irrigation	**34.31**	**24.99**	**63.79**	**34.34**
(Acres)	(11,300)	(13,589)	(42,660)	(43,085)
Ground water	34.31	22.49	61.79	33.31
Surface water	.00	2.50	2.00	1.03

Water use	Glades		Hardee	
	1975	1980	1975	1980
Total	**54.07**	**125.70**	**97.11**	**43.55**
Public supply	**0.20**	**0.21**	**1.20**	**1.27**
Ground water	.20	.21	1.20	1.27
Surface water	.00	.00	.00	.00
Rural supply	**1.10**	**1.28**	**3.95**	**2.58**
Ground water	.70	.77	3.95	2.58
Surface water	.40	.51	.00	.00
Domestic	.40	.72	1.16	1.19
Livestock	.70	.56	2.79	1.39
Industrial supply	**.00**	**.00**	**1.45**	**.79**
Ground water	.00	.00	1.45	.79
Surface water	.00	.00	.00	.00
Limerock mining	.00	.00	.00	.00
Chemical products	.00	.00	.00	.00
Phosphate mining	.00	.00	.00	.66
Citrus processing	.00	.00	.00	.12
Food processing	.00	.00	1.45	.00
Other	.00	.00	.00	.01
Irrigation	**52.77**	**124.21**	**90.51**	**38.91**
(Acres)	(45,400)	(92,300)	(51,516)	(32,665)
Ground water	11.16	17.41	90.51	38.91
Surface water	41.61	106.80	.00	.00

Table 8. Water use by county, 1975 and 1980—Continued

Water use	Hendry 1975	Hendry 1980	Highlands 1975	Highlands 1980
Total	**297.24**	**248.26**	**152.40**	**99.77**
Public supply	**2.05**	**2.00**	**4.26**	**4.95**
Ground water	.25	.38	4.26	4.95
Surface water	1.80	1.62	.00	.00
Rural supply	**5.30**	**2.50**	**3.04**	**6.30**
Ground water	4.40	1.67	1.94	4.84
Surface water	.90	.83	1.10	1.46
Domestic	.70	.84	1.84	3.37
Livestock	4.60	1.66	1.20	2.93
Industrial supply	**.82**	**.23**	**.70**	**.95**
Ground water	.22	.23	.70	.95
Surface water	.60	.00	.00	.00
Limerock mining	.00	.00	.00	.00
Chemical products	.00	.00	.00	.00
Phosphate mining	.00	.00	.00	.00
Citrus processing	.22	.09	.70	.71
Food processing	.60	.00	.00	.00
Other	.00	.14	.00	.24
Irrigation	**289.07**	**243.53**	**144.40**	**87.57**
(Acres)	(155,000)	(189,100)	(139,650)	(98,200)
Ground water	76.89	109.59	86.80	75.85
Surface water	212.18	133.94	57.60	11.72

Water use	Lee 1975	Lee 1980	Manatee 1975	Manatee 1980
Total	**91.61**	**86.66**	**51.11**	**92.03**
Public supply	**16.02**	**29.84**	**18.91**	**20.86**
Ground water	9.97	16.82	.00	.00
Surface water	6.85	13.02	18.91	20.86
Rural supply	**2.33**	**6.31**	**6.23**	**5.38**
Ground water	2.30	6.22	6.05	5.08
Surface water	.03	.09	.18	.30
Domestic	2.00	6.14	4.40	2.41
Livestock	.33	.17	1.83	2.97
Industrial supply	**8.40**	**4.09**	**1.99**	**.19**
Ground water	.40	4.09	1.99	.19
Surface water	8.00	.00	.00	.00
Limerock mining	8.00	4.09	.00	.00
Chemical products	.00	.00	.00	.00
Phosphate mining	.00	.00	.00	.00
Citrus processing	.00	.00	.00	.00
Food processing	.00	.00	1.34	.00
Other	.40	.00	.65	.19
Irrigation	**64.06**	**46.42**	**23.98**	**65.60**
(Acres)	(42,200)	(20,300)	(26,348)	(33,314)
Ground water	48.53	39.33	22.78	64.94
Surface water	15.53	7.09	1.20	.66

Table 8. Water use by county, 1975 and 1980—Continued
[In million gallons per day]

Water use	Polk		Sarasota	
	1975	1980	1975	1980
Total	**414.75**	**314.95**	**41.32**	**42.09**
Public supply	**31.23**	**35.54**	**10.31**	**19.54**
Ground water	31.23	35.54	9.33	11.07
Surface water	.00	.00	.98	8.47
Rural supply	**11.94**	**16.00**	**8.03**	**1.64**
Ground water	11.81	16.00	7.69	1.59
Surface water	.13	.00	.34	.05
Domestic	9.30	13.84	7.33	1.08
Livestock	2.64	2.16	.70	.56
Industrial supply	**272.23**	**208.71**	**2.99**	**.10**
Ground water	270.38	208.71	2.99	.10
Surface water	1.85	.00	.00	.00
Limerock mining	.00	.30	.00	.00
Chemical products	.05	62.79	.00	.00
Phosphate mining	241.70	129.28	.00	.00
Citrus processing	17.25	12.22	.02	.00
Food processing	6.74	2.28	.13	.00
Other	6.49	1.84	2.84	.10
Irrigation	**99.35**	**54.70**	**19.99**	**20.81**
(Acres)	(101,765)	(93,915)	(14,475)	(9,722)
Ground water	94.38	51.01	17.99	20.39
Surface water	4.97	3.69	2.00	.42

(table 10) for an area of west-central Florida adjoining the Peace River basin. The values they presented can be reasonably transferred as characteristic of the Charlotte Harbor inflow area. The data are based on land-use categories as defined by the Florida Department of Revenue and on actual county utility records; values do not include water used from private irrigation systems. Condominiums produce the most intense water use per acre. Water use varies from less than 200 to more than 25,000 (gal/d)/acre depending on land use.

Agricultural water use is primarily for irrigation. Irrigation varies greatly by crop, season, and type of irrigation system. Duerr and Trommer (1982) provided estimates of water use for various types of crops. The data in table 11 are taken from that report. Nurseries are the greatest water users, in some cases applying almost 9,000 (gal/d)/acre. Peanuts require the least amount of water; about 225 (gal/d)/acre was the reported average.

STREAMFLOW CHARACTERISTICS

Flow characteristics of the rivers in the inflow area have been discussed in several earlier publications. Flippo and Joyner (1968) described low streamflow in the Myakka River basin. Peace River water-supply evaluations by several agencies and consultants were summarized by the Southwest Florida Water Management District (1981). Low-flow frequency analyses for streams in the Myakka and Peace River basins were presented in Hammett (1985). Fan and Burgess (1983) described surface-water availability in the Caloosahatchee basin. Flood-stage profiles of the Myakka and the Peace Rivers were presented in Hammett and others (1978) and in Murphy and others (1978), respectively. Flood profiles of the Caloosahatchee River were included in design memoranda prepared by the U.S. Army Corps of Engineers (1957, 1960, 1961a, b, 1962a, b, 1964). Flood-frequency analyses for stations in the three river basins were provided by Bridges (1982). Flooding in the estuarine reaches of the rivers was evaluated in flood-insurance studies and rate maps by the Federal Emergency Management Agency (1977, 1979, 1981, 1983a–c, 1984).

Data Network

Since the USGS began its data network within the Charlotte Harbor inflow area in 1931, it has operated 32 continuous-record streamflow stations (table 12). About two-thirds of those stations are currently (1986) in operation. Station locations are shown in figure 8. In addition to continuous-record stations, discharge measurements have been made at many partial-record and miscellaneous sites. Numerous continuous-record lake-stage stations are located in the headwaters of the Peace River. Continuous-record

Table 9. Water use by type of land use, 1975

County	Urban		
	Land use[1] (acres)	Water use (Mgal/d)	Water use per acre [(gal/d)/acre]
Charlotte	19,620	4.08	207.95
De Soto	7,197	.76	105.60
Glades	2,492	.20	80.26
Hardee	3,202	1.20	374.77
Hendry	4,515	2.05	454.04
Highlands	16,656	4.26	255.76
Lee	43,837	16.82	383.69
Manatee	27,834	18.91	679.38
Polk	91,270	31.23	342.17
Sarasota	46,495	10.31	221.74
Total	263,118	89.82	341.37

County	Agricultural		
	Land use (acres)	Water use[2] (Mgal/d)	Water use per acre [(gal/d)/acre]
Charlotte	63,448	35.82	564.56
De Soto	216,414	67.84	313.47
Glades	155,513	53.87	346.39
Hardee	239,702	94.46	394.07
Hendry	330,212	294.37	891.46
Highlands	291,396	147.44	505.98
Lee	89,274	66.39	743.67
Manatee	191,705	30.21	157.59
Polk	459,349	111.29	242.28
Sarasota	80,378	28.02	348.60
Total	2,117,396	929.71	439.08

County	Industrial		
	Land use[3] (acres)	Water use (Mgal/d)	Water use per acre [(gal/d)/acre]
Charlotte	119	0.10	840.34
De Soto	99	.59	5,959.60
Glades	[4]306	.00	.00
Hardee	[4]40	1.45	36,250.00
Hendry	505	.82	1,623.76
Highlands	366	.70	1,912.57
Lee	1,977	8.40	4,248.86
Manatee	879	1.99	2,263.94
Polk	92,022	272.23	2,958.31
Sarasota	900	2.99	3,322.22
Total	96,867	287.82	2,971.29

[1] Total urban minus industrial land use from table 4.
[2] Sum of rural and irrigation water use from table 8.
[3] Industrial plus strip-mined land use from table 4.
[4] Not used in computation of average.

Table 10. Water use by type of urban land use

[In gallons per day per acre. Modified from Alexander and others, 1984]

Urban land use	Water use per acre
Single-family residential	462.4
Mobile homes	2,275.3
Multifamily residential	2,602.7
Condominiums	27,568.0
One-story stores	160.7
Supermarkets	1,064.7
Regional shopping malls	933.0
One-story, nonprofessional offices	152.7
Multistory, nonprofessional offices	1,528.6
Professional service buildings	832.7
Restaurants, cafeterias	1,533.7
Service stations	967.6
Enclosed theaters, auditoriums	2,831.0
Nightclubs, bars, cocktail lounges	1,477.4
Bowling alleys, skating rinks, enclosed arenas	439.1
Hotels, motels	647.7
Churches	445.1
Private schools	240.2
Public schools	337.4
Public hospitals	618.5

streamflow and lake-stage data are published annually in the series "Water Resources Data for Florida"; miscellaneous and partial-record station data are available from the files of the USGS.

Diversions and Augmentations

Streamflow is diverted or augmented at several points in the inflow area. Although the Myakka River is not currently used as a source of public water supply, Sarasota County is evaluating plans for developing the Ringling–MacArthur Reserve, including the possibility of direct withdrawals from the Myakka River. The General Development Utilities waterplant at North Port supplies about 1 Mgal/d from the system of canals that connect to the Big Slough Canal north of Charlotte Harbor. The only facility permitted by the Department of Environmental Regulation to discharge effluent into the Myakka River or its tributaries is Myakka Utilities, which has a design outfall capacity of 0.4 Mgal/d.

The General Development Utilities waterplant on the Peace River near Fort Ogden diverts about 4 to 5 Mgal/d. Depending on river flow, withdrawals from the river can vary from 0 to 22 Mgal/d. During high flow, water is pumped to an off-river storage area so that withdrawals do not have to be made during low flow. During December 1984 and January–February 1985, General Development Utilities received special permission from the Southwest Florida Water Management District to temporarily withdraw water from the Peace River even though the discharge

Table 11. Irrigation water use by type of crop, 1980

[In gallons per day per acre. From Duerr and Trommer, 1982]

Crop	Yearly average water applied
Citrus	595
Cucumbers	298
Golf course and sod	3,199
Nursery	8,927
Pasture	446
Peanuts	223
Strawberries	3,720
Spring tomatoes	3,720
Fall tomatoes	2,976
Tropical fish	2,976
Watermelons	1,488

of the river was below the minimum allowable flow specified in their consumptive-use permit.

The city of Punta Gorda maintains a water-supply reservoir on Shell Creek. From about 3 to 6 ft^3/s (2–4 Mgal/d) is diverted from the creek for water supply.

About 25 facilities have permits from the Department of Environmental Regulation to discharge domestic effluent to the Peace River and its tributaries. The combined design capacity for all domestic discharges is about 20 Mgal/d. Actual daily effluent discharge may be substantially less than design capacity, depending on the season of the year. Several domestic effluent outfalls go into lakes in the headwaters region. Consequently, the effluent may augment streamflow only during periods of high water when the lakes overflow.

The Department of Environmental Regulation has given about 60 facilities permits to discharge industrial effluent to the Peace River. More than one-half of the facilities are associated with the phosphate and chemical industry in Polk County. About one-quarter of the industrial facilities are food and citrus processing plants, and the remaining one-quarter include limerock mining and other assorted industries.

The volume of industrial effluent and the timing of discharges are very unpredictable. Citrus and food processing vary with the season and the size of the harvest. Effluent from phosphate processing varies radically from day to day. One plant may discharge 15 Mgal/d one day and then nothing for the rest of the month. Plants may cease operations completely for months at a time. Discharges of 10 to 15 Mgal/d at a single plant are quite common, according to monthly operating reports prepared by phosphate companies for the Florida Department of Environmental Regulation and the U.S Environmental Protection Agency. Even though these large discharges do not occur every day, the magnitude of the discharge and the number of plants represent a potentially significant augmentation of river flow.

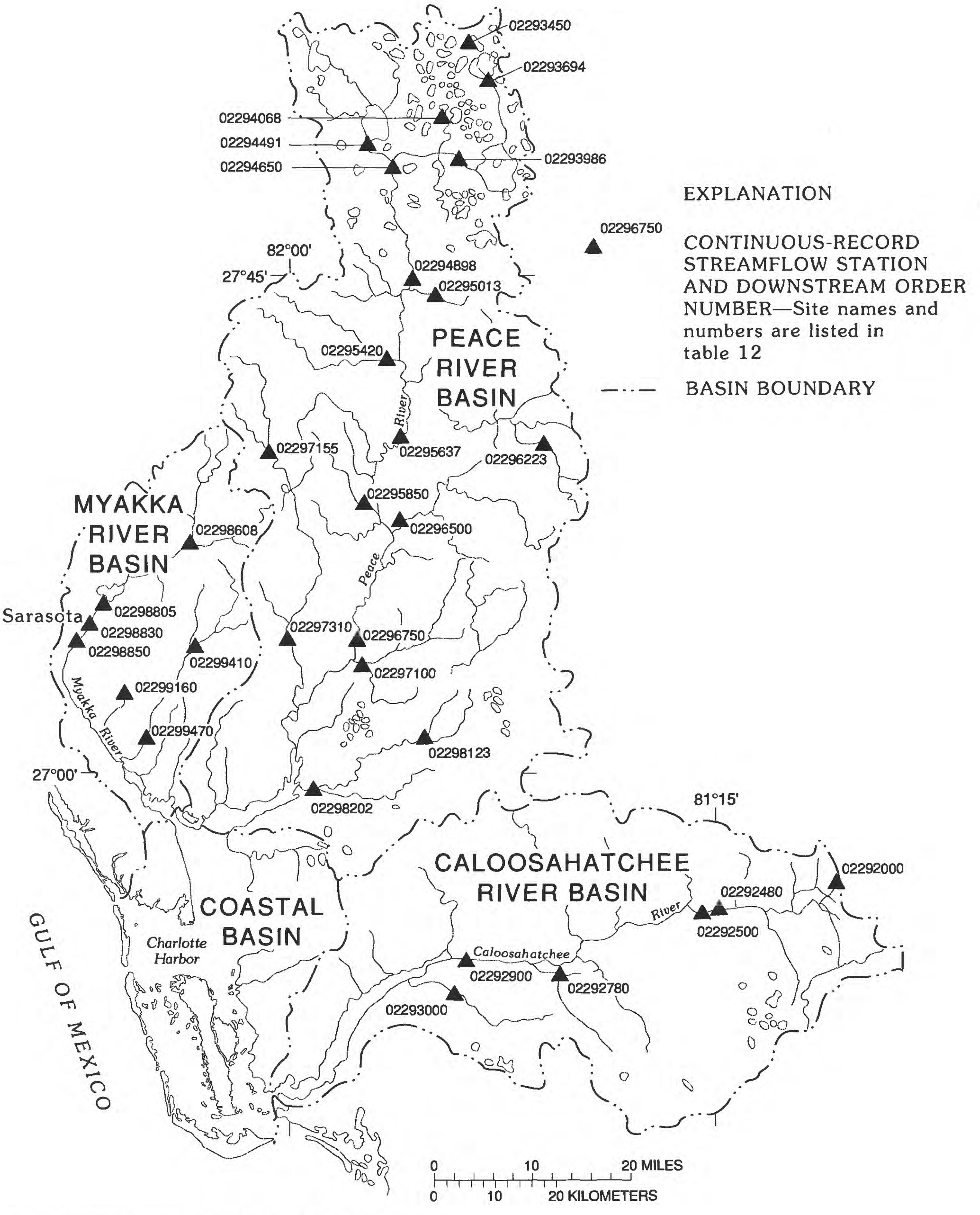

Figure 8. Continuous-record streamflow stations.

Table 12. Continuous-record streamflow stations

Station	Drainage area (mi^2)	Period of record	Average discharge (ft^3/s)	Average runoff (in/yr)	Maximum discharge (ft^3/s)	Minimum discharge (ft^3/s)
02292000 Caloosahatchee Canal at Moore Haven.	Ind[1]	10/38–present	948	Ind[1]	8,290	[2]–4,410
02292480 Caloosahatchee Canal at Ortona Lock.	..do..	7/71–present	887	..do..	9,720	.0
02292500 Caloosahatchee Canal near Citrus Center.	..do..	5/34–9/36	397	..do..	2,240	20
02292780 Townsend Canal near Alva.	..do..	10/75–present	5.81	..do..	1,200	[2]–497
02292900 Caloosahatchee River at structure S–79 near Olga.	..do..	4/66–present	1,616	..do..	21,400	.0
02293000 Orange River near Fort Myers.	83.4	12/35–9/46	41.1	6.69	5,300	.0
02293450 Gum Lake Marsh Outlet at Lake Alfred.	4.2	10/60–9/62	1.94	6.27	29	.0
02293694 Peace Creek Drainage Canal near Dundee.	50	10/46–9/59	32.5	8.83	231	.0
02293986 Peace Creek Drainage Canal near Alturas.	160	10/46–9/71	96.7	8.21	1,740	.10
02294068 Lake Lulu Outlet at Eloise.	23	2/46–9/71	10.7	6.32	218	.0
02294491 Saddle Creek at structure P–11 near Bartow.	135	11/63–present	59.4	5.98	516	.0
02294650 Peace River at Bartow.	390	10/39–present	249	8.67	4,140	1.1
02294898 Peace River at Fort Meade.	465	6/74–present	187	5.46	1,360	1.2
02295013 Bowlegs Creek near Fort Meade.	47.2	2/64–9/68	28.9	8.31	644	.02
02295420 Payne Creek near Bowling Green.	121	10/63–9/68, 10/79–present	105	11.78	3,170	.84
02295637 Peace River at Zolfo Springs.	826	9/33–present	668	10.98	26,300	22
02295850 Oak Creek near Ona.	15	7/81–present	22.4	20.28	482	.04
02296223 Little Charley Bowlegs Creek near Sebring.	41.9	1/52–9/83	35.7	11.57	874	0.0
02296500 Charlie Creek near Gardner.	330	4/50–present	281	11.56	8,160	.13
02296750 Peace River at Arcadia.	1,367	4/31–present	1,141	11.33	36,200	11
02297100 Joshua Creek at Nocatee.	132	4/50–present	106	10.90	8,670	.0
02297155 Horse Creek near Myakka Head.	41	10/77–present	30.6	10.14	1,380	.0
02297310 Horse Creek near Arcadia.	218	4/50–present	195	12.15	11,700	.0
02298123 Prairie Creek near Fort Ogden.	233	10/63–9/68, 10/77–present	204	11.89	5,400	.0
02298202 Shell Creek near Punta Gorda.	373	1/65–present	348	12.67	6,110	.0
02298608 Myakka River at Myakka City.	125	2/63–9/66, 10/77–present	127	13.80	3,770	.0

Table 12. Continuous-record streamflow stations—Continued

Station	Drainage area (mi^2)	Period of record	Average discharge (ft^3/s)	Average runoff (in/yr)	Maximum discharge (ft^3/s)	Minimum discharge (ft^3/s)
02298805 Myakka River below Upper Myakka Lake near Sarasota.	220	1/46–6/51	264	16.30	5,880	0.0
02298830 Myakka River near Sarasota.	229	8/36–present	251	14.88	8,670	.0
02298850 Myakka River below Lower Myakka Lake near Sarasota.	240	1/46–6/51	288	16.30	6,640	.0
02299160 Deer Prairie Slough near North Port Charlotte.	33.2	4/81–present	36.2	14.81	394	.0
02299410 Big Slough Canal near Myakka City.	36.5	10/80–present	42.4	15.78	2,480	.0
02299470 Big Slough near Murdock.	87.5	2/63–9/72	86.6	13.44	2,560	.0

[1] Indeterminate.
[2] Reverse flow.

Lee County and the city of Fort Myers withdraw water from the Caloosahatchee River upstream from Franklin Lock, structure S–79, near Olga. Lee County supplies about 2 Mgal/d from its Olga plant. The city of Fort Myers routes water from the Caloosahatchee River through a system of canals to recharge its well field and then pumps from the well field. The Fort Myers waterplant supplies about 5 Mgal/d.

Ten facilities are permitted to discharge domestic effluent into the Caloosahatchee River and its tributaries. Of the 10, 9 are downstream from Franklin Lock, structure S–79, near Olga. The combined design capacity for domestic discharge is about 25 Mgal/d. The four facilities discharging industrial effluent to the Caloosahatchee River have a combined outfall design capacity of about 10 Mgal/d.

Further discussion of facilities discharging domestic and industrial effluent is included in the section "Water-Quality Characteristics." A list of facilities and a map showing outfall locations are also in that section.

Seasonal and Spatial Variations

As table 12 shows, the range in discharge is substantial in all three rivers. Maximum discharges normally occur in September and October, which are near the end of the summer rainy season. Maximum discharges of record are invariably associated with hurricanes or tropical storms. Streamflow is normally lowest in April and May; at times, about two-thirds of the stations have no flow. Locks and pumping cause reverse flow at two stations in the Caloosahatchee River basin.

Total freshwater discharge from the Myakka River to Charlotte Harbor can be estimated by combining recorded streamflows with estimates of runoff from ungaged areas of the basin. The continuous-record gaging station on the Myakka River near Sarasota represents drainage from 229 mi^2, which is less than one-half of the river basin. Runoff for all stations in the Myakka River basin ranges from 13.44 to 16.30 in/yr. Assuming approximately 14 in/yr runoff for the 373-mi^2 area downstream from the gage on the Myakka River near Sarasota, total discharge of the Myakka River to Charlotte Harbor would average about 630 ft^3/s.

The sum of discharges for the Peace River at Arcadia, Joshua Creek at Nocatee, Horse Creek near Arcadia, and Shell Creek near Punta Gorda represents runoff from about 2,090 mi^2 of the Peace River basin. Runoff at these sites ranges from 10.90 to 12.67 in/yr. Assuming a runoff of about 11.50 in/yr from the remainder of the 2,350-mi^2 drainage area, total discharge of the Peace River to Charlotte Harbor would average about 2,010 ft^3/s.

Gate openings on the Caloosahatchee River are regulated by the U.S. Army Corps of Engineers. La Rose and McPherson (1983) provided a discussion of discharge and storage along the river between Moore Haven Lock, structure S–77, and Franklin Lock, structure S–79, near Olga. There is a substantial seasonal and yearly variation in the relation between discharge at the structures. On the average, however, about one-half of the annual discharge at structure S–79 is discharged from structure S–77, and about one-half is derived from the intervening drainage area. La Rose and McPherson (1983) estimated that about 850 mi^2 of the 1,378-mi^2 cataloging unit of the Caloosahatchee River basin drains into the river upstream from structure S–79. By assuming that about one-half (800 ft^3/s) of the average discharge at structure S–79 is from 850 mi^2, a runoff estimate of about 13 in/yr can be calculated. The only streamflow station downstream from structure S–79, Orange River near Fort Myers, shows an average runoff of 6.69 in/yr. The area downstream from structure S–79 probably has an average runoff rate somewhere between 7 and 13 in/yr, which would produce an average discharge of between 270 and 500 ft^3/s. The total average discharge from the Caloosahatchee River to Charlotte Harbor would be between about 1,900 and 2,100 ft^3/s.

Runoff from the coastal area and rainfall directly on the surface area of the harbor also contribute to the total freshwater inflow to Charlotte Harbor. By estimating that runoff from the coastal area and islands that drain directly into the harbor averages between 7 and 16 in/yr, about 200 to 400 ft^3/s of freshwater would enter the harbor from the coastal area. Average annual rainfall of 52 in. directly onto the 270-mi^2 water-surface area of the harbor accounts for another 1,030 ft^3/s of freshwater inflow. Total inflow from the three rivers, the coastal area, and rainfall amounts to between 5,700 and 6,100 ft^3/s, which is more than 3,500 Mgal/d.

Thus, on the average, the Peace and the Caloosahatchee Rivers contribute about the same volume of flow to Charlotte Harbor. During some years, however, gate operation on the Caloosahatchee River can result in substantial differences in discharge. In 1970 and 1984, total annual discharge of the Caloosahatchee River at Franklin Lock, structure S–79, near Olga was more than twice the combined discharge of the Peace River and Horse, Joshua, and Shell Creeks. Rainfall directly onto the water surface of the harbor provides about one-half as much freshwater inflow as does discharge from either the Peace or the Caloosahatchee Rivers. Rainfall provides more freshwater input than does the Myakka River. Drainage from the coastal area and barrier islands contributes about 5 percent of the freshwater entering Charlotte Harbor.

Duration and Frequency Analyses

Duration analyses for the stations farthest downstream in the Charlotte Harbor inflow area are shown in table 13. Analyses were based on daily discharges for the period of record through water year 1984. The values in table 13 represent the discharges that are equaled or exceeded 10, 50, 90, and 95 percent of the time; the discharge equaled or exceeded 50 percent of the time is the median discharge.

Table 14 shows low-flow frequency distributions for the stations farthest downstream in the inflow area. Distributions covering 1-day and 3-, 7-, 14-, 30-, 60-, 90-, 120-, and 183-consecutive-day periods for recurrence intervals of 2, 5, 10, and 20 years are presented. Hammett (1985) provided a discussion of low-flow terminology and techniques. The distributions are based on station period of record through 1984. The annual series used in calculation is based on the water year beginning on October 1 and ending on September 30. A log-Pearson Type III distribution was used to define low-flow frequency. Distributions

Table 13. Duration analyses for selected streamflow stations

[In cubic feet per second]

Station	Mean discharge that is equaled or exceeded for the given percentage of days			
	10	50	90	95
02292900 Caloosahatchee River at structure S–79 near Olga.	5,880	362	9.6	7.3
02293000 Orange River near Fort Myers.	116	3.6	.02	.01
02296750 Peace River at Arcadia.	2,860	494	129	98.6
02297100 Joshua Creek at Nocatee.	281	19.7	2.9	1.5
02297310 Horse Creek near Arcadia.	549	48.2	2.8	.98
02298202 Shell Creek near Punta Gorda.	945	142	15.1	2.2
02298830 Myakka River near Sarasota.	729	69.3	.11	.01
02299470 Big Slough near Murdock.	242	15.7	1.2	.60

were adjusted for zero flows by using the technique outlined by the U.S. Water Resources Council (1981).

Many streamflow stations in the inflow area cease to flow during the spring dry season. Of the stations farthest downstream, only the Peace River at Arcadia continues to flow during periods of low flow. On the average, the Myakka River near Sarasota may be expected to have no flow for 90 consecutive days once every 10 years. The Caloosahatchee River at Franklin Lock, structure S–79, near Olga occasionally has had no flow. Because of the operation of structure S–79, neither the low-flow nor the flood-frequency distributions should be used to predict expected future discharges of the Caloosahatchee River.

Table 15 shows flood-flow frequency distributions for the stations farthest downstream in the inflow area. Station estimates are taken from a log-Pearson Type III frequency distribution of annual peaks at the station. Regional estimates are computed from regression equations presented by Bridges (1982). A regional estimate was not computed for the Caloosahatchee River at Franklin Lock, structure S–79, near Olga because it is regulated. Station estimates are weighted with regional estimates to compute the best estimate of discharge for each recurrence interval. The weighting procedure is described by the U.S. Water Resources Council (1981).

The Peace River at Arcadia and the Caloosahatchee River at Franklin Lock, structure S–79, near Olga have similar flood-discharge characteristics. Additional discharges from Joshua, Horse, and Shell Creeks, which are downstream from the Peace River at Arcadia, make total

Table 14. Low-flow frequency distributions for selected streamflow stations

[In cubic feet per second]

Station	Period of consecutive days	Lowest average flow, for given recurrence intervals, in years			
		2	5	10	20
02292900					
Caloosahatchee River at structure S–79 near Olga.	1	5.8	2.2	0.9	0
	3	7.4	3.9	2.1	0
	7	9.9	6.2	3.5	0
	14	9.9	6.2	4.5	4.0
	30	18	6.6	4.5	4.0
	60	46	14	7.6	4.9
	90	100	26	13	7.6
	120	150	41	21	12
	183	220	61	36	21
02293000					
Orange River near Fort Myers.	1	0	0	0	0
	3	0	0	0	0
	7	0	0	0	0
	14	0	0	0	0
	30	0	0	0	0
	60	.1	0	0	0
	90	.3	0	0	0
	120	.7	0	0	0
	183	2.0	.6	.3	.2
02296750					
Peace River at Arcadia.	1	99	58	43	33
	3	100	61	46	35
	7	110	67	52	42
	14	120	76	61	51
	30	140	88	71	60
	60	170	110	84	70
	90	220	130	100	81
	120	280	150	110	88
	183	390	200	140	110
02297100					
Joshua Creek at Nocatee.	1	1.3	.5	.2	0
	3	1.4	.6	.3	0
	7	1.9	.6	.3	0
	14	2.2	.8	.4	.2
	30	2.8	1.3	.9	.6
	60	4.8	2.2	1.5	1.0
	90	7.9	3.4	2.1	1.5
	120	12	4.7	2.9	1.9
	183	20	7.6	4.5	2.8

Table 14. Low-flow frequency distributions for selected streamflow stations—Continued

Station	Period of consecutive days	Lowest average flow, for given recurrence intervals, in years			
		2	5	10	20
02297310					
Horse Creek near Arcadia.	1	1.1	0.2	0	0
	3	1.2	.2	0	0
	7	1.3	.2	.1	0
	14	1.5	.4	.2	.1
	30	2.3	.6	.3	.2
	60	5.1	1.4	.7	.4
	90	11	2.9	1.4	.7
	120	19	5.3	2.6	1.4
	183	40	11	5.5	2.8
02298202					
Shell Creek near Punta Gorda.	1	0	0	0	0
	3	0	0	0	0
	7	1.5	0	0	0
	14	6.1	0	0	0
	30	11	0	0	0
	60	23	3.6	1.1	.4
	90	40	13	6.6	3.7
	120	60	26	17	12
	183	88	42	30	23
02298830					
Myakka River near Sarasota.	1	0	0	0	0
	3	0	0	0	0
	7	0	0	0	0
	14	0	0	0	0
	30	.3	0	0	0
	60	3.0	0	0	0
	90	7.7	.2	0	0
	120	15	1.5	.2	0
	183	37	8.0	3.1	1.3
02299470					
Big Slough near Murdock.	1	.4	.1	0	0
	3	.5	.1	0	0
	7	.6	.2	0	0
	14	.7	.2	.1	0
	30	1.2	.3	.1	0
	60	1.8	.5	.2	.1
	90	2.8	1.2	.9	.7
	120	5.7	2.1	1.3	.9
	183	10	3.5	2.0	1.2

inflow from the Peace River more than double that at structure S–79 on the Caloosahatchee River for some recurrence intervals. Unlike the Peace River at Arcadia, the period of record for the Caloosahatchee River at structure S–79 does not include peaks from the 1935, 1947, and 1960 hurricanes (table 1). The frequency distribution computed from the shorter period of record for the Caloosahatchee River may not be representative of true flood characteristics at the site. Flood discharges from the Myakka River basin are about one-fourth of the flood discharges from the Peace River basin.

Trend Analyses

All continuous-record streamflow stations that have 25 or more years of record were analyzed for long-term

Table 15. Flood-flow frequency distributions for selected streamflow stations

[Estimates for each station are presented as follows: top line, log-Pearson Type III analysis of station record; middle line, computed estimate from regional regression equations; bottom line, weighted or best estimate. In cubic feet per second]

Station	Years of record	Discharge for given recurrence intervals, in years					
		2	5	10	25	50	100
02292900							
Caloosahatchee River at structure S–79 near Olga.	18	8,230	13,170	16,790	21,710	25,590	29,660
02293000							
Orange River near Fort Myers.	11	825	1,690	2,510	3,900	5,230	6,870
		755	1,430	1,980	2,800	3,480	4,240
		805	1,600	2,310	3,430	4,460	5,610
02296750							
Peace River at Arcadia.	53	6,950	11,450	15,260	21,150	26,420	32,530
		4,740	8,300	11,100	15,300	18,800	22,700
		6,770	11,140	14,770	20,370	25,390	31,030
02297100							
Joshua Creek at Nocatee.	34	1,710	3,110	4,320	6,190	7,870	9,810
		2,180	3,910	5,290	7,280	8,930	10,700
		1,750	3,200	4,450	6,360	8,040	9,970
02297310							
Horse Creek near Arcadia.	34	1,940	3,460	4,740	6,680	8,370	10,300
		2,890	5,130	6,910	9,480	11,600	13,900
		2,020	3,640	5,020	7,090	8,850	10,910
02298202							
Shell Creek near Punta Gorda.	19	2,670	4,210	5,290	6,700	7,780	8,870
		3,430	6,050	8,130	11,200	13,700	16,400
		2,790	4,540	5,860	7,690	9,060	10,640
02298830							
Myakka River near Sarasota.	47	2,100	3,400	4,480	6,100	7,510	9,120
		1,970	3,580	4,860	6,750	8,320	10,000
		2,090	3,420	4,520	6,180	7,610	9,240
02299470							
Big Slough near Murdock.	9	870	1,510	2,020	2,760	3,390	4,090
		835	1,570	2,180	3,070	3,810	4,630
		860	1,530	2,080	2,890	3,570	4,340

trends. Calendar-year mean discharges were used in the analyses. Smith and others (1982) discussed the relative merits of classical parametric regression analysis and nonparametric tests for trend. The nonparametric Kendall Tau test was selected for use in this evaluation of trends.

The Kendall Tau procedure examines all possible pairs of chronologically ranked data. If the chronologically later measurement of each pair has a higher value than the earlier measurement, then the pair is concordant. Conversely, if the chronologically later measurement has a lower value than the earlier measurement, then the pair is discordant. If the number of concordant and discordant pairs are not statistically different, then no trend is discerned. If the number of concordant pairs is statistically greater than the number of discordant pairs, then an upward trend exists. If the opposite situation occurs, then the trend is downward. Smith and others (1982) defined a Kendall Slope Estimator that describes the magnitude of a trend determined from a Kendall Tau test as the median of the differences (expressed as slopes) of the ordered pairs of data values that are compared in the Kendall Tau test. In the case of annual mean streamflow, the magnitude of the slope is expressed in cubic feet per second per year.

Table 16 shows the results of the trend analyses for continuous-record streamflow stations. The trend is shown as an average change in discharge per year and as a percentage of long-term average discharge (table 12). The statistical significance level for each analysis is listed in the last column—a 0.01 means that the trend was significant at the 1-percent level.

Statistical hypotheses are normally formulated by using significance levels of 10 percent or less. By using those criteria, the decrease in streamflow at the Peace River stations at Bartow, Zolfo Springs, and Arcadia is statistically significant. The trend is not significant at the other stations in the Peace River basin, the Caloosahatchee Canal at Moore Haven, or the Myakka River near Sarasota. Five-year moving averages (Spiegel, 1961, p. 285–286) of annual mean discharge for the Peace River at Arcadia are plotted in figure 9. The long-term decline is very apparent. High discharges around 1947 and 1959–60 resulted from hurricanes (table 1), but the overall trend is downward.

Table 16. Long-term trend analyses for selected streamflow stations

Station	Period of record	Kendall Tau	Significance level	Trend slope: Cubic feet per second per year	Trend slope: Percentage
02292000 Caloosahatchee Canal at Moore Haven.	10/38–present	−0.096	0.35	−8.00	−0.8
02293986 Peace Creek Drainage Canal near Alturas.	10/46–9/71	−.232	.12	−2.92	−3.0
02294650 Peace River at Bartow.	10/39–present	−.252	.01	−3.73	−1.5
02295637 Peace River at Zolfo Springs.	9/33–present	−.242	.01	−6.17	−.9
02296223 Little Charley Bowlegs Creek near Sebring.	1/52–9/83	−.200	.13	−.80	−2.2
02296500 Charlie Creek near Gardner.	4/50–present	−.168	.17	−3.73	−1.3
02296750 Peace River at Arcadia.	4/31–present	−.156	.10	−7.57	−.7
02297100 Joshua Creek at Nocatee.	4/50–present	−.132	.28	−1.44	−1.4
02297310 Horse Creek near Arcadia.	4/50–present	−.191	.11	−3.11	−1.6
02298830 Myakka River near Sarasota.	8/36–present	−.060	.55	−.75	−.3

Deficient rainfall (fig. 3) between 1961 and 1978 does not appear to be the sole cause of the decline in discharges in the Peace River. If rainfall were the controlling factor, then all streamflow stations in the area would show similar trends, which is not the case. In figure 10, accumulated annual mean discharge for the Myakka River near Sarasota is plotted against accumulated annual precipitation for the National Weather Service station at Bartow. Throughout the period of record, the relation between cumulative discharge and cumulative precipitation remains relatively constant. In figure 11, accumulated annual mean discharge for the Peace River at Zolfo Springs is plotted against accumulated annual precipitation at Bartow. For about the first 30 years of record, the relation between discharge and precipitation follows a straight line. After 1965, however, a change in the relation shows up as an alteration in the slope of the line.

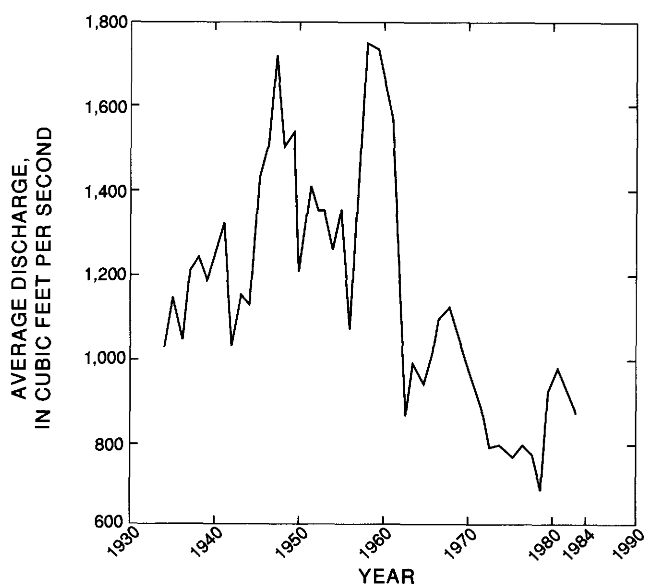

Figure 9. Decreasing trend in 5-year moving averages of annual mean discharge for the Peace River at Arcadia.

Over the period of record of streamflow stations in the Peace River basin, the use of ground water has increased tremendously. Virtually all water used for agriculture and industry is pumped from the Floridan aquifer system. Kaufman (1967) estimated that the phosphate industry in Polk and Hillsborough Counties pumped about 8,000 Mgal/yr in 1934. In 1975, the phosphate industry in Polk County alone pumped about 88,000 Mgal/yr (table 8). Kaufman (1967) estimated citrus irrigation water use in the Peace and the Alafia River basins at about 20,000 Mgal/yr in 1956. In 1980, irrigation ground-water use in only the Peace River basin was about 42,000 Mgal/yr (table 7), about 80 percent of which was for citrus (Leach, 1983).

The progressive decline of the potentiometric surface of the Floridan aquifer system as a result of ground-water pumpage is well documented (Peek, 1951; Kaufman, 1967; Robertson, 1973; Mills and Laughlin, 1976; Wilson, 1977;

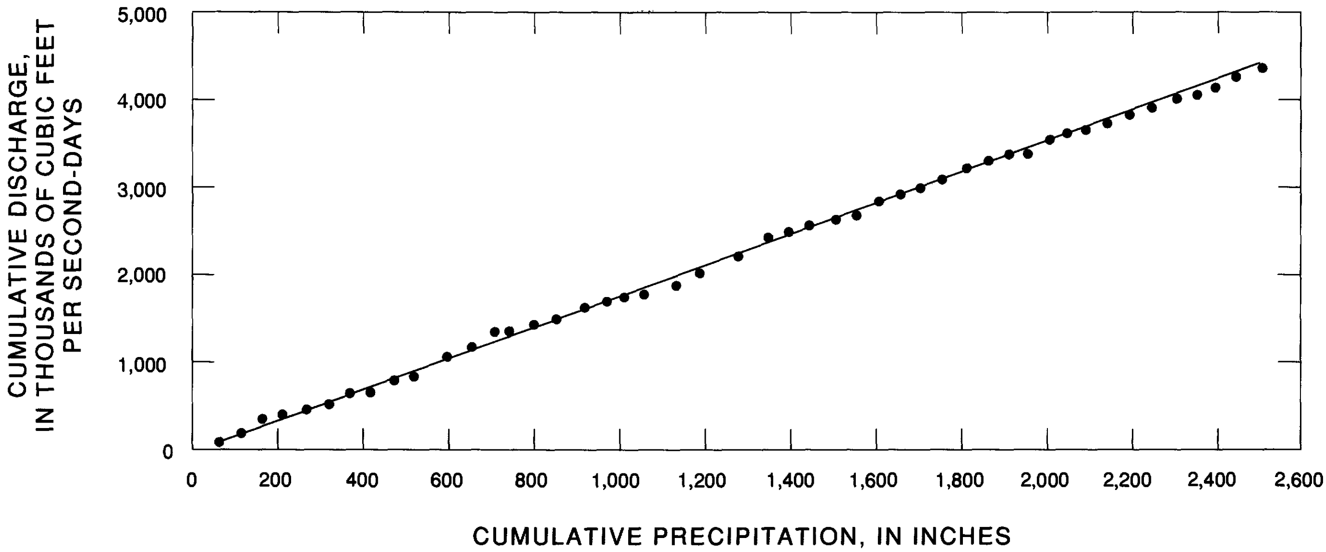

Figure 10. Accumulated annual mean discharge for the Myakka River near Sarasota as a function of accumulated annual precipitation for the National Weather Service station at Bartow, 1937–84.

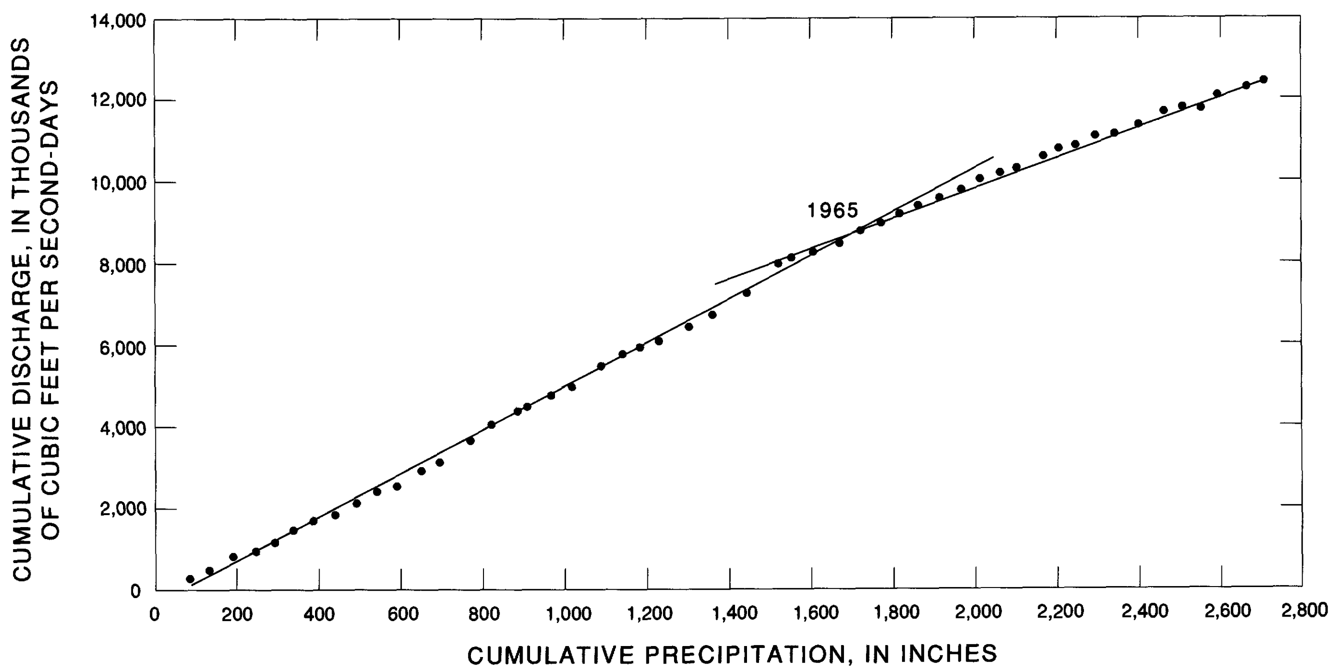

Figure 11. Accumulated annual mean discharge for the Peace River at Zolfo Springs as a function of accumulated annual precipitation for the National Weather Service station at Bartow, 1934–84.

Yobbi, 1983). The decline over the past 50 years is shown in figure 12, which was generalized from a 1934 potentiometric-surface map presented by Kaufman (1967, p. 16) and the May 1984 potentiometric-surface map by Barr and Schiner (1984).

It is probable that the long-term decline in discharge in the Peace River is related to the decline of artesian water levels in the underlying Floridan aquifer system. Decreasing trends in streamflow are more significant (table 16) in the northern and the eastern parts of the basin where the greatest decline in the potentiometric surface has occurred. The cessation of flow in Kissengen Spring as a result of pumpage from the Floridan aquifer system was discussed under "Hydrogeology" in the section "Description of Study Area." The decline in the potentiometric surface also can affect streamflow indirectly by increasing the potential for

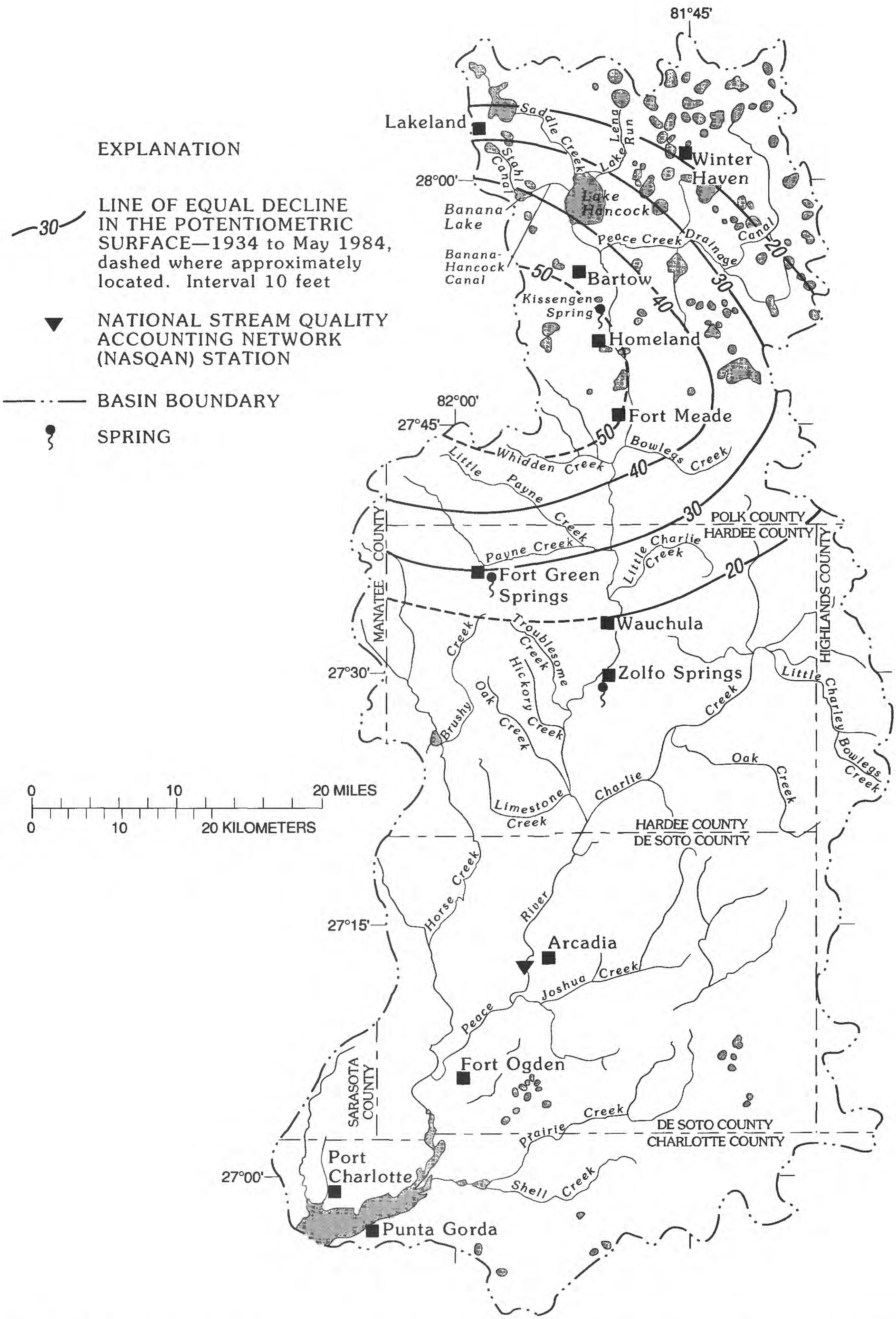

Figure 12. Generalized decline in the potentiometric surface of the Floridan aquifer system, 1934 to May 1984.

downward leakage from the intermediate and the surficial aquifers. Increased leakage reduces the amount of water that is available to contribute to streamflow.

WATER-QUALITY CHARACTERISTICS

Water quality within the Charlotte Harbor inflow area has been discussed in several earlier publications. Dragovich and others (1968) discussed water quality in the Myakka, the Peace, and the Caloosahatchee Rivers. McNulty and others (1972) provided an environmental inventory of all estuaries along the gulf coast of Florida. Estevez (1981) included a discussion of water quality in his review of the Charlotte Harbor ecosystem. Flippo and Joyner (1968) discussed data on ionic composition and physical parameters in their report on the Myakka River. German and Schiffer (1988) prepared an appraisal and description of water quality in the Peace River basin. Environmental Quality Laboratory, Inc. (1979, 1981, 1982), provided hydrobiological monitoring reports for the Peace River downstream from Arcadia. La Rose and McPherson (1983) and Miller and others (1982) presented water-quality assessments of the Caloosahatchee River basin. The coastal area surrounding Charlotte Harbor has been inventoried in a series of shellfish-growing-area surveys by Heil and others (1983, 1984). Water-quality conditions on Sanibel Island and their relation to the harbor were discussed in Clark (1976) and McPherson and O'Donnell (1979).

The potential impacts of the phosphate and the citrus industries on water quality were discussed in several publications. Lackey (1970) described citrus-processing wastes and some of the processes used to mitigate the undesirable qualities of the waste. Additional discussion of citrus-processing waste effluent was presented in Braddock and Crandall (1978), Crandall (1980), and Crandall and Kesterson (1980). Effluent from a citrus-processing plant contributed significantly to the degradation of Lake Apopka in central Florida between 1955 and 1963 (Sheffield and Kuhrt, 1970). Rutledge (1987) discussed the effects of the citrus and the phosphate industries on water quality in the underlying aquifers. Miller and Sutcliffe (1982, 1984) described water quality at phosphate-chemical-processing sites. Miller and Morris (1981) presented a historical summary of phosphate slime spills in the Peace River and discussed the water-quality implications. Martin and Kim (1977) sampled water quality in the Peace River following a slime spill and evaluated long-term impacts.

Sources of Nutrient and Pollutant Loads

Figure 13 shows facilities that have Florida Department of Environmental Regulation permits to discharge industrial and domestic wastewater to surface-water bodies within the Charlotte Harbor inflow area; those facilities that have stormwater-runoff permits are not included. Table 17 provides a listing of the facilities shown in figure 13.

Discharge permits include an estimate of "design flow" (table 17). The actual volume of discharge varies and may be less than or, in some instances, greater than design flow; for example, the design flow for the city of Arcadia's wastewater treatment plant (site 81, table 17 and fig. 13) is 1 Mgal/d. Actual discharges for 1984 and the first 6 months of 1985, as recorded on monthly operating reports, are shown in table 18. The average for the 18 months listed is 0.918 Mgal/d, but discharge varies considerably from month to month.

Design flows for industrial discharges are not included in table 17. In the phosphate industry, design flow is generally the capacity of a spillway or outfall pipe. Discharges by the phosphate industry are highly unpredictable and were discussed in the section "Streamflow Characteristics"; an example of the variability of discharge is included in table 18 for Agrico (site 67, table 17 and fig. 13), which has an outfall on Little Payne Creek. In the citrus-processing industry, discharges are seasonal and variable; Adams Packing Association (site 23, table 17 and fig. 13) is included as an example in table 18.

In Polk County, 70 wastewater outfalls are permitted, which is more than in all the remaining inflow areas combined. About one-half of the outfalls discharge to lakes in the headwaters area of the Peace River basin. As noted above, interconnections between some of the lakes and the Peace River tributaries occur only under high-water conditions. The lake outfalls are divided equally between domestic and industrial effluent; phosphate mining and citrus processing are the major industrial sources. In southern Polk County, outfalls to the Peace river and its tributaries are almost exclusively from the phosphate industry.

Within the Charlotte Harbor inflow area, 42 domestic wastewater outfalls are permitted. Outside of Polk County, most domestic effluent is from package treatment plants for small housing or mobile home developments. The city of Punta Gorda stopped discharging wastewater effluent to the Peace River estuary in September 1984 when they began using spray irrigation for effluent disposal. The city of Fort Myers has a large municipal outfall to the Caloosahatchee River.

According to Lackey (1970), citrus processing produces a strongly buffered, high-carbon waste that may contain inorganic debris from washing, may have a residue of pesticides, and contains toxic peel oils. The degradation of the waste produces objectionable odors and a high biochemical oxygen demand. Research is going on to improve the treatment and disposal process. The water quality of several lakes in the headwaters of the Peace River has been affected by citrus-processing effluent.

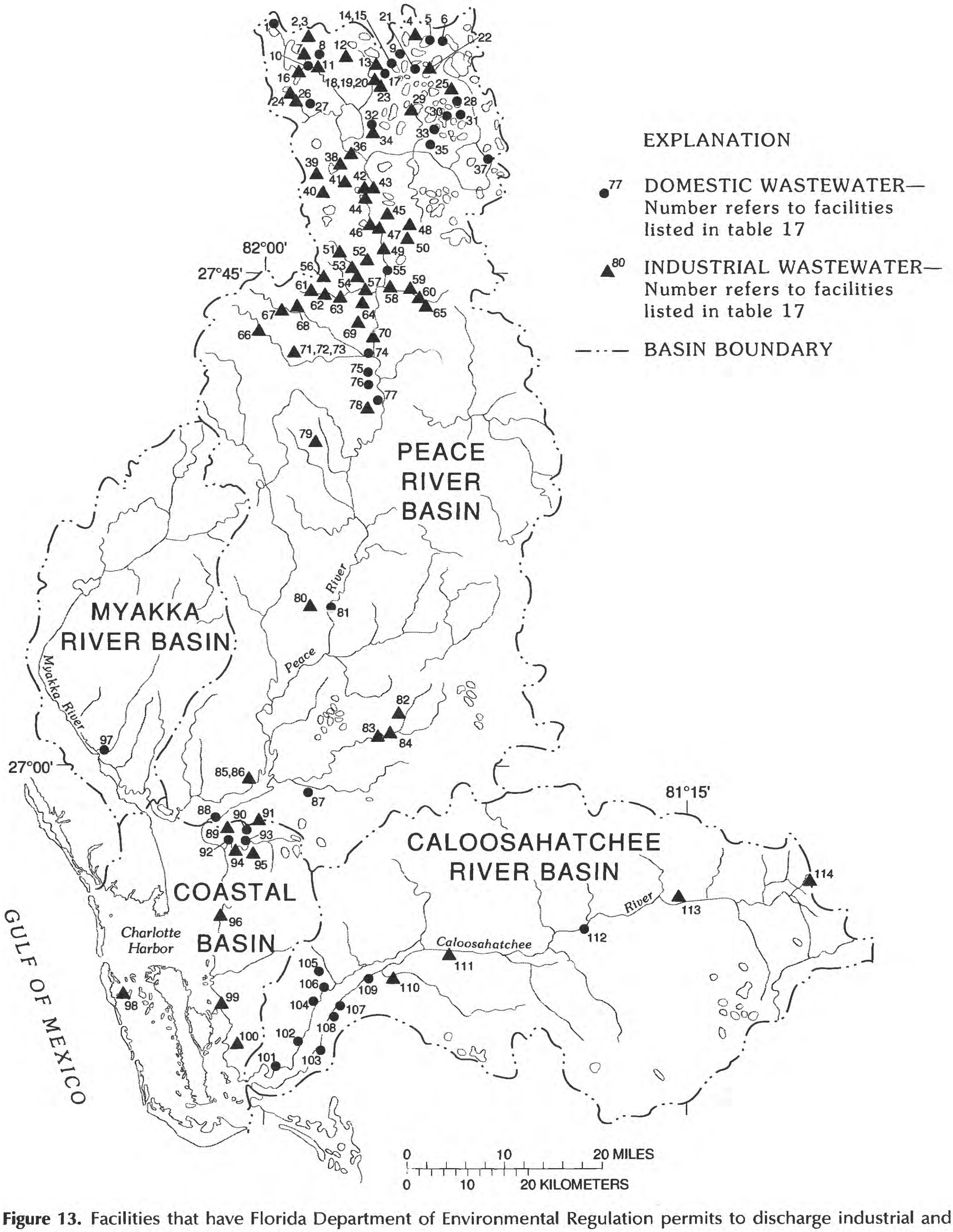

Figure 13. Facilities that have Florida Department of Environmental Regulation permits to discharge industrial and domestic wastewater to surface-water bodies.

Table 17. Facilities that have Florida Department of Environmental Regulation permits to discharge effluent to surface-water bodies

[In million gallons per day. See fig. 13 for locations of site numbers. D, domestic effluent; I, industrial effluent]

Site No.	Facility		Type	County	Receiving body of water
	Name	Design flow			
1	Padgett Elementary School	0.010	D	Polk	Lake Gibson/Lake Parker/Saddle Creek/Lake Hancock/Saddle Creek/Peace River.
2	Agrico		I	..do..	Saddle Creek/Lake Hancock/Saddle Creek/Peace River.
3	..do..		I	..do..	Do.
4	Florida Distillers Company		I	..do..	Lake Haines/Lake Rochelle/Lake Conine/Lake Smart/Lake Fannie/Lake Hamilton/Peace Creek Drainage Canal/Peace River.
5	City of Lake Alfred	.30	D	..do..	Do.
6	Palm Shores Mobile Village	.015	D	..do..	Do.
7	City of Lakeland		I	..do..	Lake Parker/Saddle Creek/Lake Hancock/Saddle Creek/Peace River.
8	Wilson Acres Subdivision	.060	D	..do..	Saddle Creek/Lake Hancock/Saddle Creek/Peace River.
9	Leisure Mobile Home Park	.010	D	..do..	Lake Marianna/Lake Jessie/Lake Idylwild/Lake Cannon/Lake Howard/Lake May/Lake Shipp/Lake Lulu/Wahneta Farm Drainage Ditch/Peace Creek Drainage Canal/Peace River.
10	Combee Elementary School	.010	D	..do..	Saddle Creek/Lake Hancock/Saddle Creek/Peace River.
11	Combee Coin Laundry		I	..do..	Do.
12	Agrico		I	..do..	Do.
13	Jacquins		I	..do..	Lake Lena Run/Lake Hancock/Saddle Creek/Peace River.
14	Flamingo Shores Mobile Home Park	.014	D	..do..	Lake Jessie/Lake Idylwild/Lake Cannon/Lake Howard/Lake May/Lake Shipp/Lake Lulu/Wahneta Farm Drainage Ditch/Peace Creek Drainage Canal/Peace River.
15	Heritage Estates	.016	D	..do..	Do.
16	City of Lakeland		I	..do..	Lake Parker/Saddle Creek/Lake Hancock/Saddle Creek/Peace River.
17	City of Auburndale	1.4	D	..do..	Lake Lena Run/Lake Hancock/Saddle Creek/Peace River.
18	Coca-Cola Sprayfield		I	..do..	Do.
19	Coca-Cola Discharge		I	..do..	Do.
20	..do..		I	..do..	Do.
21	City of Winter Haven	1.7	D	..do..	Lake Conine/Lake Smart/Lake Fannie/Lake Hamilton/Peace Creek Drainage Canal/Peace River.
22	General Foods		I	..do..	Do.
23	Adams Packing Association		I	..do..	Lake Lena Run/Lake Hancock/Saddle Creek/Peace River.
24	Juice Bowl Products		I	..do..	Banana Lake/Lake Hancock/Saddle Creek/Peace River.
25	Indian River Transport		I	..do..	Peace Creek Drainage Canal/Peace River.
26	City of Lakeland	10.0	D	..do..	Stahl Canal/Banana Lake/Lake Hancock/Saddle Creek/Peace River.
27	Valencia Estates	.015	D	..do..	Do.
28	Garden Grove Pines	.114	D	..do..	Peace Creek Drainage Canal/Peace River.
29	Bordo Citrus Ponds		I	..do..	Wahneta Farm Drainage Ditch/Peace Creek Drainage Canal/Peace River.
30	Cypress Gardens Mobile Home Park	.012	D	..do..	Lake Dexter/Lake Ned/Peace Creek Drainage Canal/Peace River.
31	Grove Shore Mobile Colony	.0117	D	..do..	Lake Daisy/Lake Ned/Peace Creek Drainage Canal/Peace River.
32	City of Bartow Airport	.200	D	..do..	Gaskin Branch/Peace Creek Drainage Canal/Peace River.

Table 17. Facilities that have Florida Department of Environmental Regulation permits to discharge effluent to surface-water bodies—Continued

Site No.	Facility Name	Facility Design flow	Type	County	Receiving body of water
33	Orange Manor Mobile Home Park........	0.050	D	Polk........	Lake Eloise/Lake Lulu/Wahneta Farm Drainage Ditch/Peace Creek Drainage Canal/Peace River.
34	Culligan Water Conditioning............		I	..do..	Gaskin Branch/Peace Creek Drainage Canal/Peace River.
35	City of Winter Haven	5.0	D	..do..	Peace Creek Drainage Canal/Peace River.
36	USS Agri-Chem		I	..do..	Bear Branch/Peace River.
37	City of Lake Wales	1.0	D	..do..	Lake Effie/Peace Creek Drainage Canal/Peace River.
38	W.R. Grace and Co.		I	..do..	Bear Branch/Peace River.
39	..do..		I	..do..	Cedar Branch/Sixmile Creek/Peace River.
40	Ben Hill Griffin.........................		I	..do..	Bear Branch/Peace River.
41	W.R. Grace and Co.		I	..do..	Cedar Branch/Sixmile Creek/Peace River.
42	Kaplan Industries		I	..do..	Barber Branch/Peace River.
43	Orange-Co of Florida....................		I	..do..	Sixmile Creek/Peace River.
44	International Minerals and Chemicals		I	..do..	Do.
45	..do..		I	..do..	Peace River.
46	Estech General Chemicals		I	..do..	McCullough Creek/Whidden Creek/Peace River.
47	Mobil Chemical Co......................		I	..do..	Camp Branch/Peace River.
48	..do..		I	..do..	Rocky Branch/Peace River.
49	..do..		I	..do..	Peace River.
50	..do..		I	..do..	Rocky Branch/Peace River.
51	USS Agri-Chem		I	..do..	McCullough Creek/Whidden Creek/Peace River.
52	Florida Orange..........................		I	..do..	Do.
53	Mobil Chemical Co......................		I	..do..	Do.
54	Estech General Chemicals		I	..do..	Do.
55	City of Fort Meade.....................	1.0	D	..do..	Peace River.
56	USS Agri-Chem		I	..do..	Mill Branch/Whidden Creek/Peace River.
57	Estech General Chemicals		I	..do..	McCullough Creek/Whidden Creek/Peace River.
58	..do..		I	..do..	Bowlegs Creek/Peace River.
59	..do..		I	..do..	Do.
60	..do..		I	..do..	Do.
61	USS Agri-Chem		I	..do..	Whidden Creek/Peace River.
62	Gardinier Inc...........................		I	..do..	Do.
63	..do..		I	..do..	Do.
64	Estech General Chemicals		I	..do..	McCullough Creek/Whidden Creek/Peace River.
65	..do..		I	..do..	Bowlegs Creek/Peace River.
66	Agrico		I	..do..	Payne Creek/Peace River.
67	..do..		I	..do..	Little Payne Creek/Payne Creek/Peace River.
68	W.R. Grace and Co.		I	..do..	Do.
69	Gardinier, Inc..........................		I	..do..	Bryant's Branch/Peace River.
70	Mobil Chemical Co......................		I	..do..	Peace River.
71	C F Mining Corp........................		I	Hardee	Hickey Branch/Payne Creek/Peace River.
72	..do..		I	..do..	Do.
73	..do..		I	..do..	Do.
74	City of Bowling Green	.320	D	..do..	Peace River.
75	Pine Cone Mobile Home Park............	.005	D	..do..	Hog Branch/Peace River.
76	Crystal Lake Mobile Home and RV Village.	.043	D	..do..	Peace River.
77	City of Wauchula	1.0	D	..do..	Do.
78	American Orange Corp.		I	..do..	Do.
79	Farmland Industries		I	..do..	Hickory Creek/Peace River.
80	Myakka Processors......................		I	De Soto	Peace River.
81	City of Arcadia	1.0	D	..do..	Do.
82	John Oldham and Son, Inc..............		I	..do..	Prairie Creek/Shell Creek/ Peace River.
83	Rudy Lightsey Shell Pit		I	..do..	Do.

Table 17. Facilities that have Florida Department of Environmental Regulation permits to discharge effluent to surface-water bodies—Continued

[In million gallons per day. See fig. 13 for locations of site numbers. D, domestic effluent; I, industrial effluent]

Site No.	Facility		Type	County	Receiving body of water
	Name	Design flow			
84	Peace River Development, Inc.		I	..do..	Do.
85	Charlotte Harbor Water Association		I	Charlotte	San Marino Canal/Peace River.
86	..do..		I	..do..	Do.
87	Shell Creek Park		D	..do..	Shell Creek/Peace River.
88	City of Punta Gorda		D	..do..	Charlotte Harbor.
89	Florida Mining and Materials		I	..do..	North Fork Alligator Creek/Charlotte Harbor.
90	Charlotte County Public Safety		D	..do..	Do.
91	Gulf Shore Seafood, Inc.		I	..do..	Charlotte Harbor.
92	Windmill Village of Punta Gorda		D	..do..	Drainage Ditch/Charlotte Harbor.
93	Punta Gorda Isles		D	..do..	Canal/Charlotte Harbor.
94	Eagle Point Mobile Home Park		D	..do..	Alligator Creek/Charlotte Harbor.
95	Alligator Utilities, Inc.		I	..do..	Do.
96	Burnt Store Utilities		I	..do..	South Fork Alligator Creek/Charlotte Harbor.
97	Myakka Utilities		D	Sarasota	Tidal Canal/Myakka River/Charlotte Harbor.
98	Useppa Inn and Dock Co.		I	Lee	Pine Island Sound.
99	Greater Pine Island Water Association		I	..do..	Matlacha Pass.
100	City of Cape Coral RO		I	..do..	Cecelia Canal/Matlacha Pass.
101	Fiesta Village	5.0	D	..do..	Idd Canal/Caloosahatchee River.
102	City of Cape Coral	4.0	D	..do..	Caloosahatchee River.
103	City of Fort Myers	6.0	D	..do..	Do.
104	Waterway Estates	1.08	D	..do..	Do.
105	J. Colin English Elementary School	.0096	D	..do..	Yellow Creek/Caloosahatchee River.
106	Price Cutter	.0025	D	..do..	Caloosahatchee River.
107	City of Fort Myers	11.0	D	..do..	Do.
108	Bayshore Elementary School	.009	D	..do..	Daughtry Creek/Caloosahatchee River.
109	Orange River Elementary School	.0096	D	..do..	Billy's Creek/Orange River/Caloosahatchee River.
110	Florida Power and Light		I	..do..	Orange River/Caloosahatchee River.
111	Lee County Utilities		I	..do..	Caloosahatchee River.
112	City of LaBelle	.150	D	Hendry	Do.
113	E.R. Jahna Industries		I	Glades	Do.
114	City of Moore Haven		I	..do..	Do.

Citrus production involves the use of numerous chemicals, including fertilizers, insecticides, herbicides, and fungicides. Benomyl, bromocil, diuron, dicofol, chlorobenzilate, ethylenedibromide, and aldicarb have been used or are currently in use. The trace elements copper, manganese, and zinc also are applied to citrus (Rutledge, 1987). Runoff from citrus groves has the potential to transport any of these substances to the stream system.

Phosphate industry ore-processing plants use a mixture of organic chemicals, including kerosene and fuel oil, to facilitate separation of phosphate ore from unwanted sands and clays. Runoff from sand tailings may represent diffuse sources of organic-chemical contamination (Rutledge, 1987). The chemical processing of phosphate ore into phosphoric acid produces a highly acidic process water. Organic chemicals, including phenols, also are used in processing. The gypsum stacks, cooling ponds, and recirculation ditches of the chemical-processing plants are a potential source of contamination of the surficial aquifer (Miller and Sutcliffe, 1984). Runoff from phosphate mines may increase turbidity and exclude light in receiving bodies of water (Miller and Morris, 1981). The structural failure of retaining dikes has resulted in the discharge of clayey wastes, known as slime, to the Peace River. The effects of these slime spills have been seen as long as 2 years after the event (Martin and Kim, 1977).

Other potential sources of nutrient and pollutant loads have been noted. Ground-water inflow to the rivers and harbor is an apparent source of radium-226 (Miller and Sutcliffe, 1985). Background levels of radium-226 in the rivers and harbor reported by Stoker (1986) are an order of magnitude higher than those found in other parts of the United States (Elsinger and Moore, 1980). Runoff from pasture and cropland carries nutrients and, in some cases, pesticides to the river system. Septic-tank drain fields are another source of nutrients and a potential source of bacterial contamination. Runoff from urban areas may carry heavy metals, nutrients, bacteria, viruses, and pesticides (Lopez and Giovannelli, 1984). Marinas contribute oil and gas, as well as wastewater, to the rivers and the estuarine

Table 18. Variations in discharge for three facilities permitted to discharge effluent to surface-water bodies in the Peace River basin

[In million gallons per day]

	City of Arcadia[1] daily discharge		Agrico[2] daily discharge		Adams Packing Association[3] daily discharge	
	Average	Maximum	Average	Maximum	Average	Maximum
1984:						
January	1.172	1.227	22.75	24	2.03	2.67
February	1.004	1.103	17.50	19	1.97	2.77
March	1.301	1.406	18.40	22	.40	1.19
April	1.445	1.629	17.5	19	.55	1.53
May	1.132	1.326	12	21	.70	1.00
June	.910	1.098	17.75	26	---	---
July	.984	1.242	34.00	72.00	---	---
August	1.170	1.374	29.00	45.00	---	---
September	1.186	1.406	---	---	---	---
October	.862	.991	---	---	---	---
November	.784	.962	3.5	5.0	---	---
December	.798	.893	2.25	3.00	.73	1.19
1985:						
January	.654	.725	4.3	9.0	.77	2.05
February	.673	.745	1.23	2.0	.92	1.87
March	.695	.714	1.35	2.0	.82	2.06
April	.653	.709	8.5	15.0	.65	1.41
May	.598	.623	.3	.6	---	---
June	.503	.554	4.4	9.0	---	---

[1] Site 81 (fig. 13).
[2] Site 67 (fig. 13).
[3] Site 23 (fig. 13).

system. Rainfall and dustfall bring pollutants and nutrients from the air to the river system and estuary.

Data Network

The USGS maintains a NASQAN (National Stream Quality Accounting Network) station in each of the Myakka, the Peace, and the Caloosahatchee River basins (figs. 4–6). Temperature, specific conductance, major inorganic constituents, sediment, organic and minor inorganic constituents, bacterial content, and other biological parameters are measured periodically at NASQAN stations to provide information on their range, diversity, and variability.

The USGS also has collected water-quality data at many sites in addition to the NASQAN stations. Temperature, specific conductance, and pH are measured periodically at continuous-record streamflow stations. Figure 14 shows the location of water-quality data-collection sites for a special regional sampling during November and December 1982. Three additional samplings were made at the stations in the Peace River basin in August 1982, February 1983, and May 1983. Table 19 provides a list of the sampling sites.

Seasonal and Spatial Variations

Figures 15 through 25 show the spatial variation of selected water-quality parameters in the Charlotte Harbor inflow area. Most of the figures represent a synoptic view of conditions during the regional sampling of November–December 1982. Some seasonal variation can be seen in figures 16, 17, 19, 20, 23, and 24, which show dissolved oxygen, total nitrogen, and total phosphorus during the other areal samplings of the Peace River basin.

The Florida Department of Environmental Regulation (1983) set water-quality standards for various classes of surface waters. Those standards, which are cited in the following discussion, are taken from Chapter 17–3 of the "Florida Administrative Code." The classes of surface waters are defined as follows:

Class I–A Potable Water Supplies;
Class II Shellfish Propagation and Harvesting;
Class III Recreation, Propagation, and Management of Fish and Wildlife;
Class IV Agricultural Water Supplies; and
Class V–A Navigation, Utility, and Industrial Use.

Color (fig. 15) is considerably higher in the Myakka River basin than in the Peace and the Caloosahatchee River basins. High color in the Myakka River basin reflects the swampy terrain of the drainage basin and a relatively

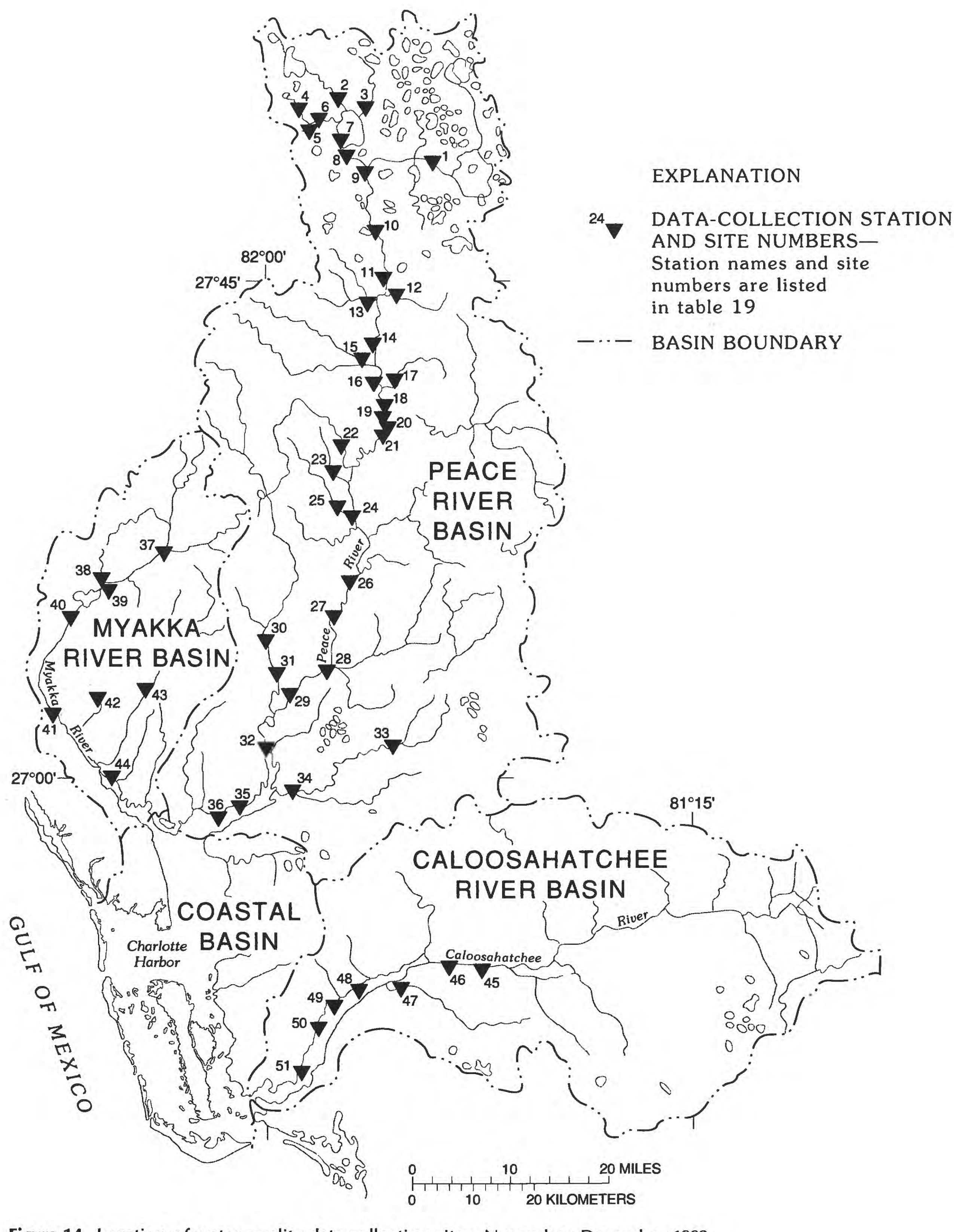

Figure 14. Location of water-quality data-collection sites, November–December 1982.

Table 19. Sites where water-quality data were collected, November–December 1982

[See fig. 14 for locations of site numbers. Eight digit numbers are USGS downstream order numbers; 15-digit number represents latitude-longitude]

Site No.	Station No.	Station name
1	02293986	Peace Creek Drainage Canal near Alturas.
2	02294290	Saddle Creek at State Road 540 near Eaton Park.
3	02294330	Lake Lena Run near Auburndale.
4	02294390	Stahl Canal near Lakeland.
5	02294402	Banana Lake near Highland City.
6	02294409	Banana-Hancock Canal near Highland City.
7	02294462	Lake Hancock near Highland City.
8	02294491	Saddle Creek at structure P–11 near Bartow.
9	02294650	Peace River at Bartow.
10	02294781	Peace River near Homeland.
11	02294898	Peace River at Fort Meade.
12	02295067	Bowlegs Creek at Pisgah Road near Fort Meade.
13	02295163	Whidden Creek near Fort Meade.
14	02295194	Peace River at Bowling Green.
15	02295420	Payne Creek near Bowling Green.
16	02295440	Peace River at State Road 664A near Wauchula.
17	02295557	Little Charlie Creek near Wauchula.
18	02295607	Peace River at Wauchula.
19	02295614	Peace River near Wauchula.
20	02295637	Peace River at Zolfo Springs.
21	02295642	Peace River at State Road 64 at Zolfo Springs.
22	02295735	Troublesome Creek near Zolfo Springs.
23	02295760	Hickory Creek near Zolfo Springs.
24	02295800	Peace River near Limestone.
25	02295870	Oak Creek near Zolfo Springs.
26	02296600	Peace River at Brownville.
27	02296750	Peace River at Arcadia.
28	02297100	Joshua Creek at Nocatee.
29	270700081573200	Peace River near Hull.
30	02297310	Horse Creek near Arcadia.
31	270930081575800	Horse Creek at State Road 761 near Fort Ogden.
32	270243081593400	Peace River below Thornton Branch near Fort Ogden.
33	02298123	Prairie Creek near Fort Ogden.
34	02298202	Shell Creek near Punta Gorda.
35	265727082013100	Peace River estuary between U.S. Highway 41 and Coon Key.
36	265615082042000	Peace River estuary near Punta Gorda sewage outfall.
37	02298608	Myakka River at Myakka City.
38	271804082151500	Myakka River above Upper Myakka Lake at State Road 780.
39	271725082144400	Clay Gulley at State Road 780 near Old Myakka.
40	02298830	Myakka River near Sarasota.
41	02298930	Myakka River near Venice.
42	02299188	Deer Prairie Slough near Warm Mineral Springs.
43	270557082123400	Big Slough at Interstate Highway 75 at North Port.
44	270009082152900	Myakka River estuary near Bird Key.
45	02292900	Caloosahatchee River at structure S–79 near Olga.
46	264257081454100	Caloosahatchee River at State Road 31 bridge near Fort Myers.
47	264115081473200	Orange River at State Road 80 near Fort Myers.
48	264106081494900	Caloosahatchee River at marker 26 near Fort Myers.
49	263902081520300	Caloosahatchee River at marker 42 near Fort Myers.
50	263745081533600	Caloosahatchee River at marker 56 near Fort Myers.
51	263329081555500	Caloosahatchee River at marker 70 near Fort Myers.

smaller inflow from ground water. The Peace River has a substantial base flow from ground water, as does the Caloosahatchee. Also, in the Peace River, effluent from the phosphate industry is composed primarily of pumped ground water. No water-quality standard for color has been set by the Florida Department of Environmental Regulation.

The standard for specific conductance varies, depending on the natural background levels of the water body. For surface waters in which specific conductance is less than 500 μS/cm, it cannot be increased more than 100 percent above background levels to a maximum of 500 μS/cm. For surface waters in which specific conductance is more than 500 μS/cm, it cannot be increased more than 50 percent above background levels to a maximum of 5,000 μS/cm for predominantly freshwaters. This criteria is applicable to all classes of surface water.

Specific conductance (fig. 15) is generally lower in the nontidal reach of the Myakka River than in the Peace River. Specific conductance shows the influence of saltwater in the estuarine reaches of all three rivers. The Caloosahatchee River is brackish all the way to Franklin Lock, structure S–79, near Olga. Seepage and boat lockages sometimes result in brackish water upstream from structure S–79.

Standards for minimum concentrations of dissolved oxygen are set as follows, in milligrams per liter:

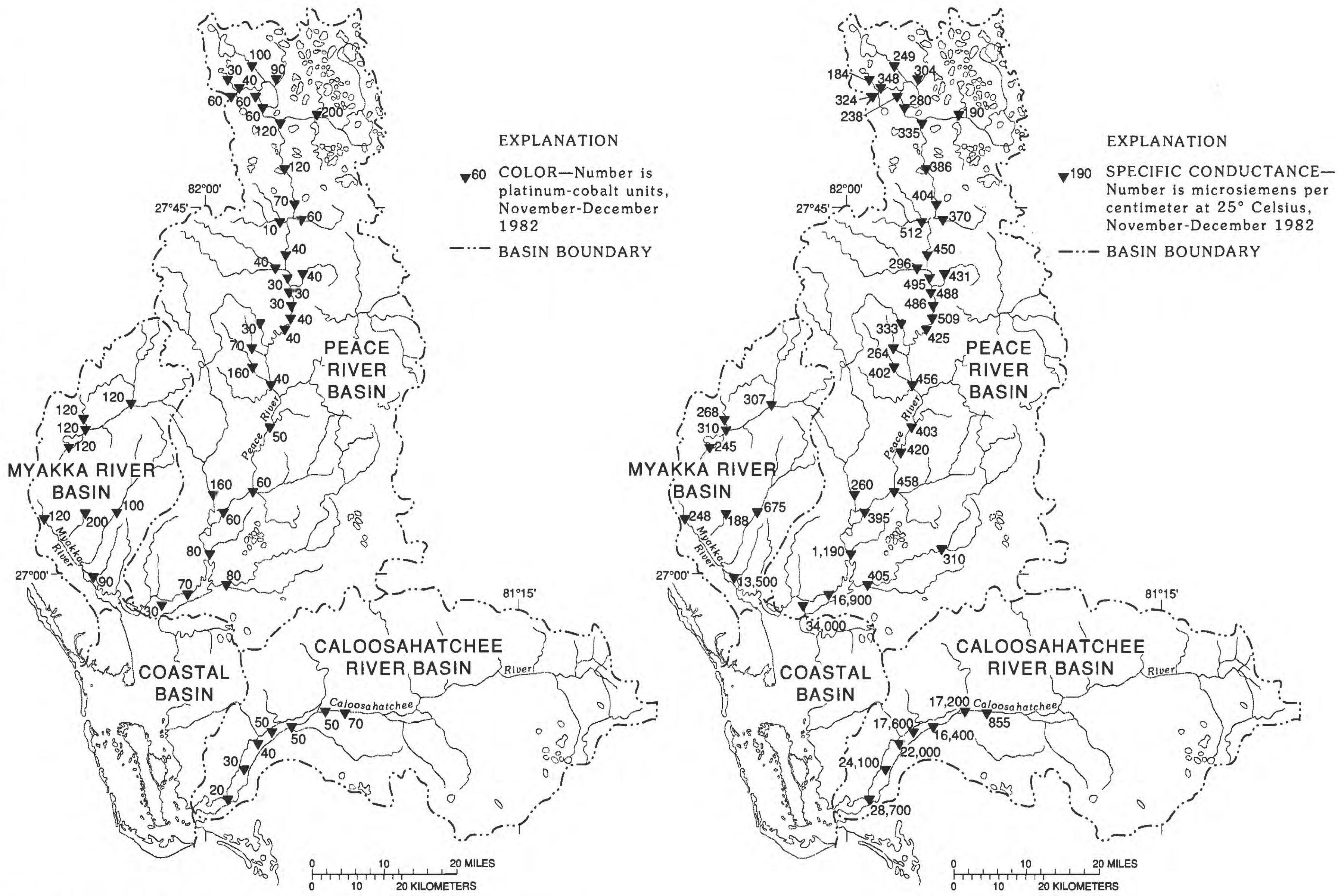

Figure 15. Color and specific conductance, November–December 1982.

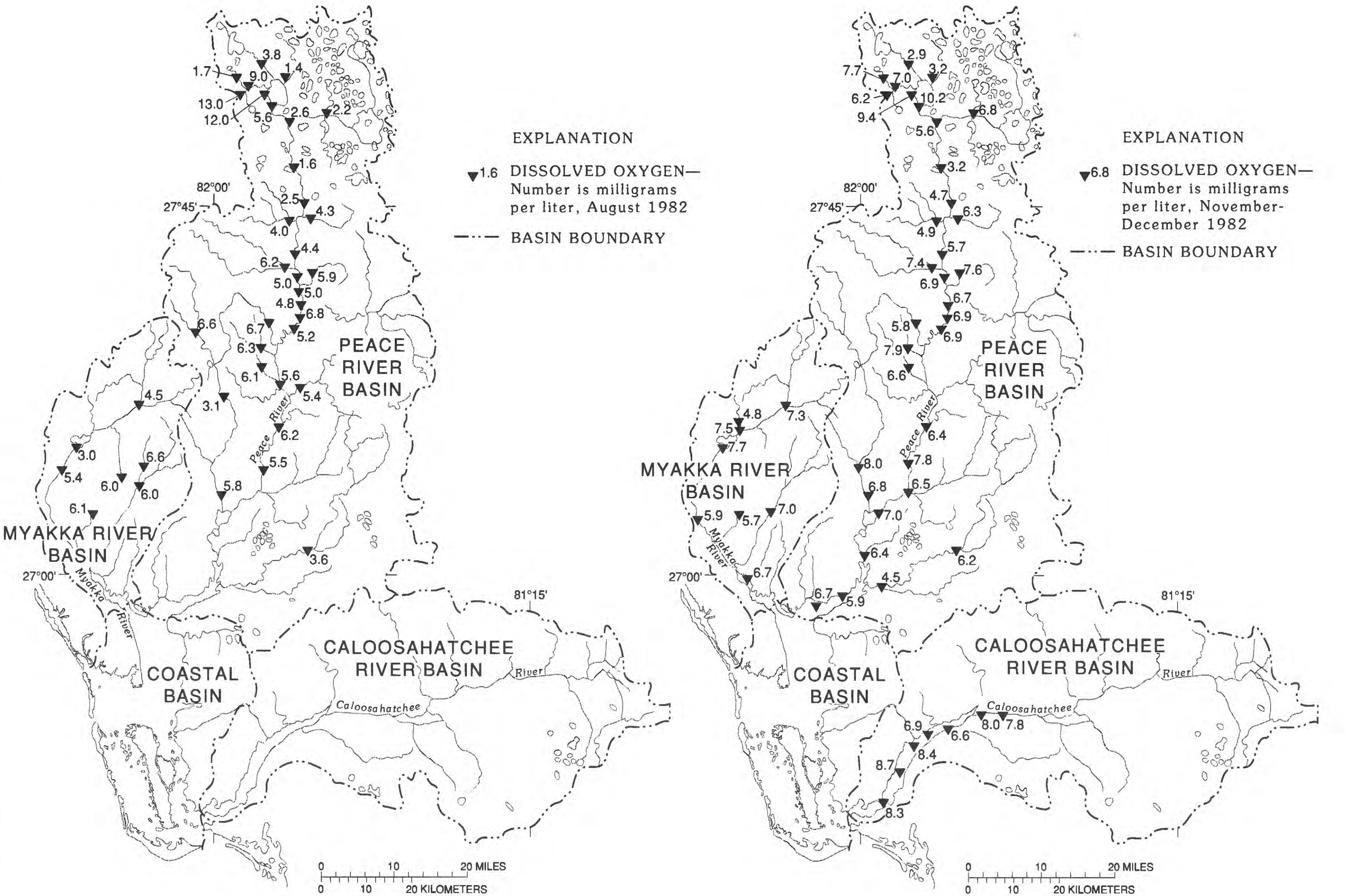

Figure 16. Concentrations of dissolved oxygen, August and November–December 1982.

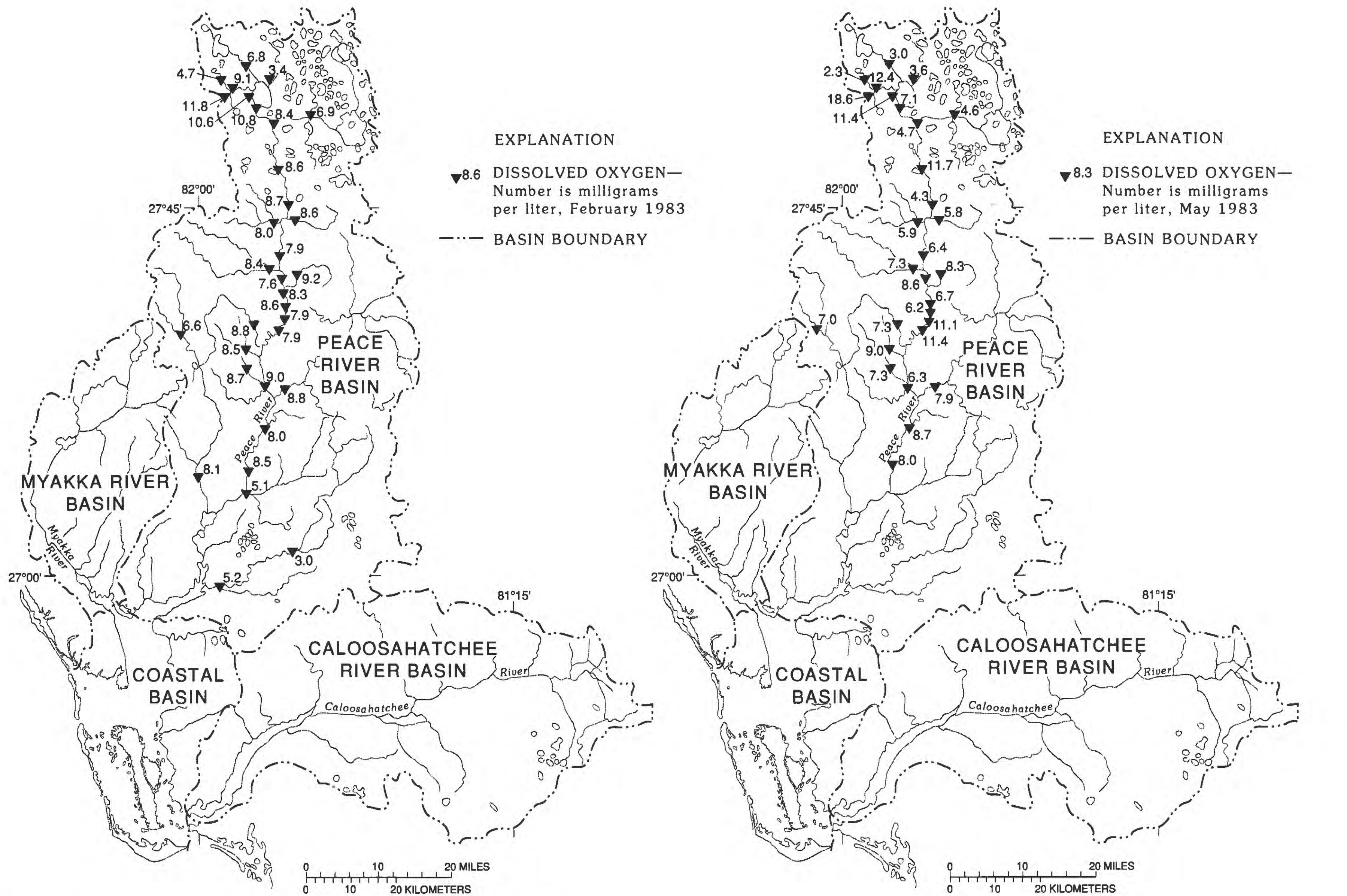

Figure 17. Concentrations of dissolved oxygen, February and May 1983.

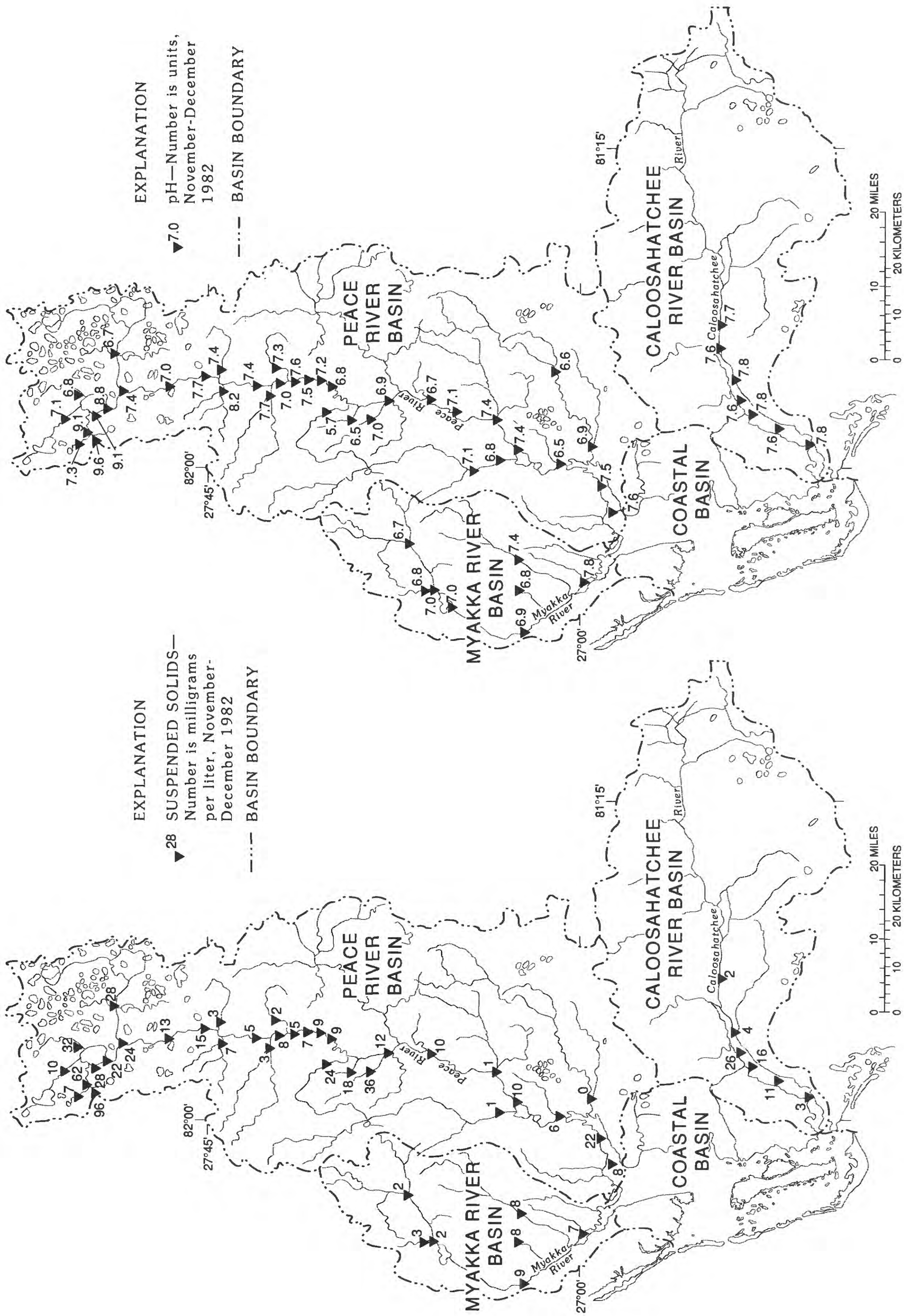

Figure 18. Total suspended solids and pH, November–December 1982.

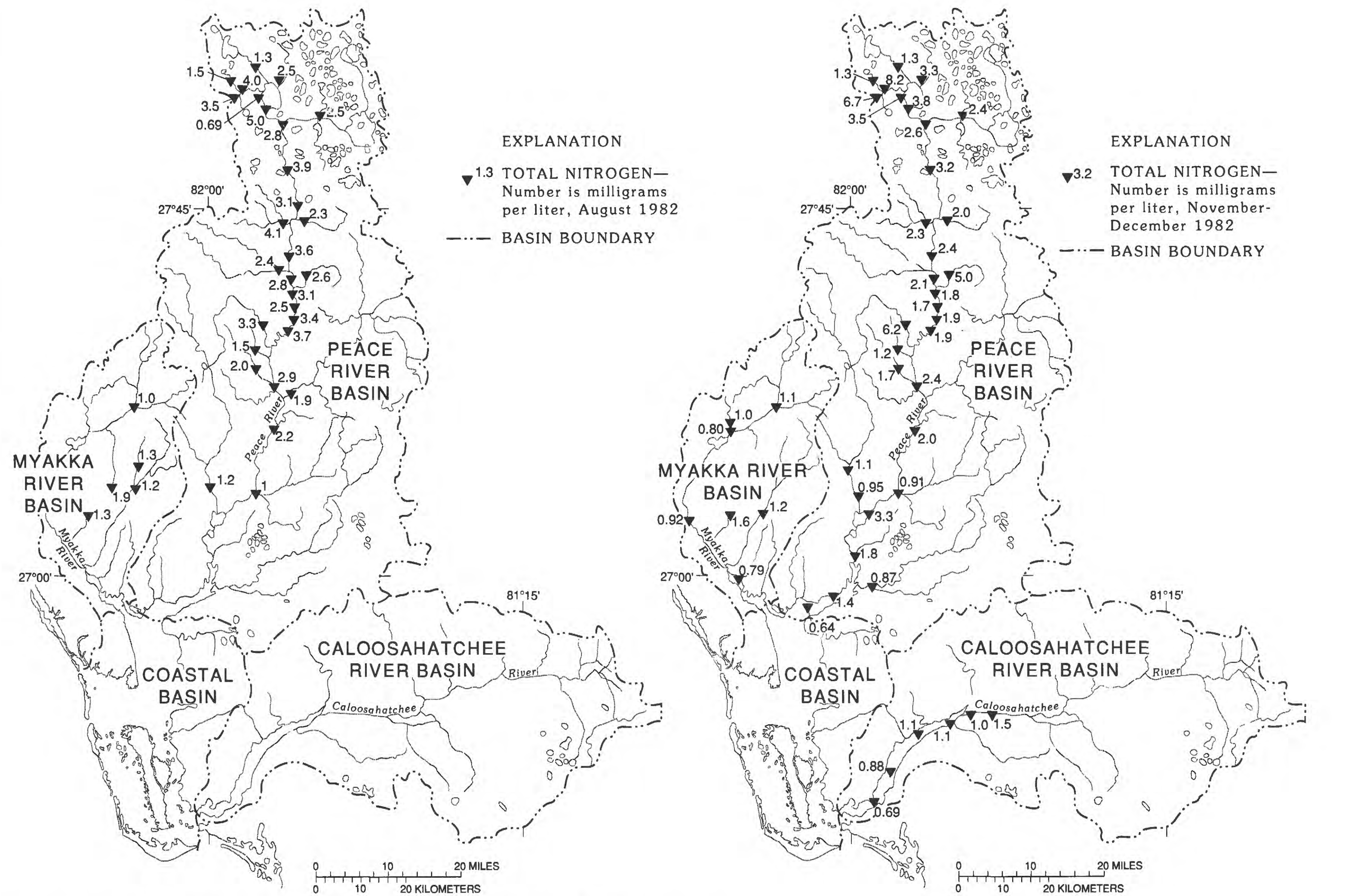

Figure 19. Concentrations of total nitrogen, August and November–December 1982.

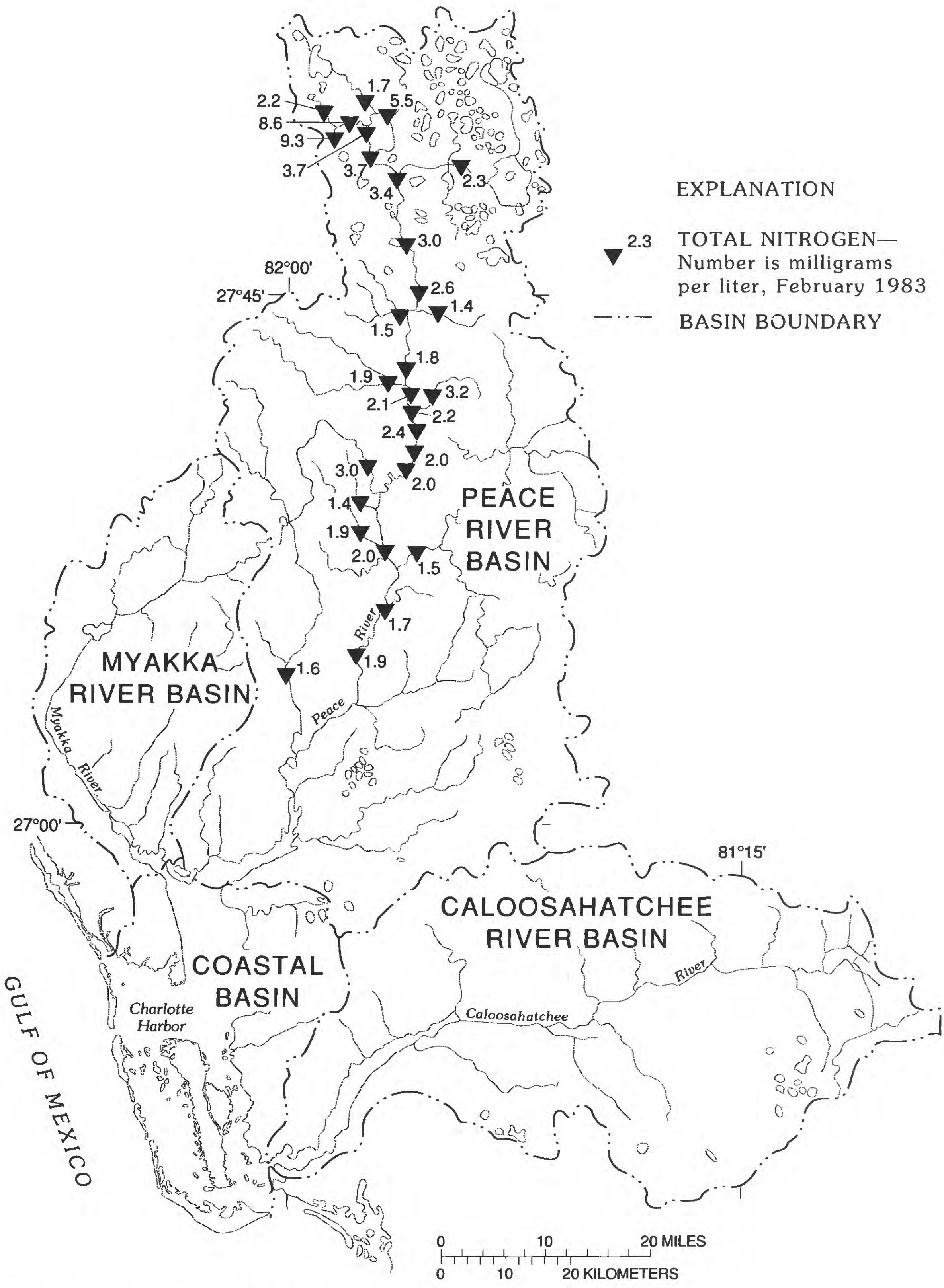

Figure 20. Concentrations of total nitrogen, February 1983.

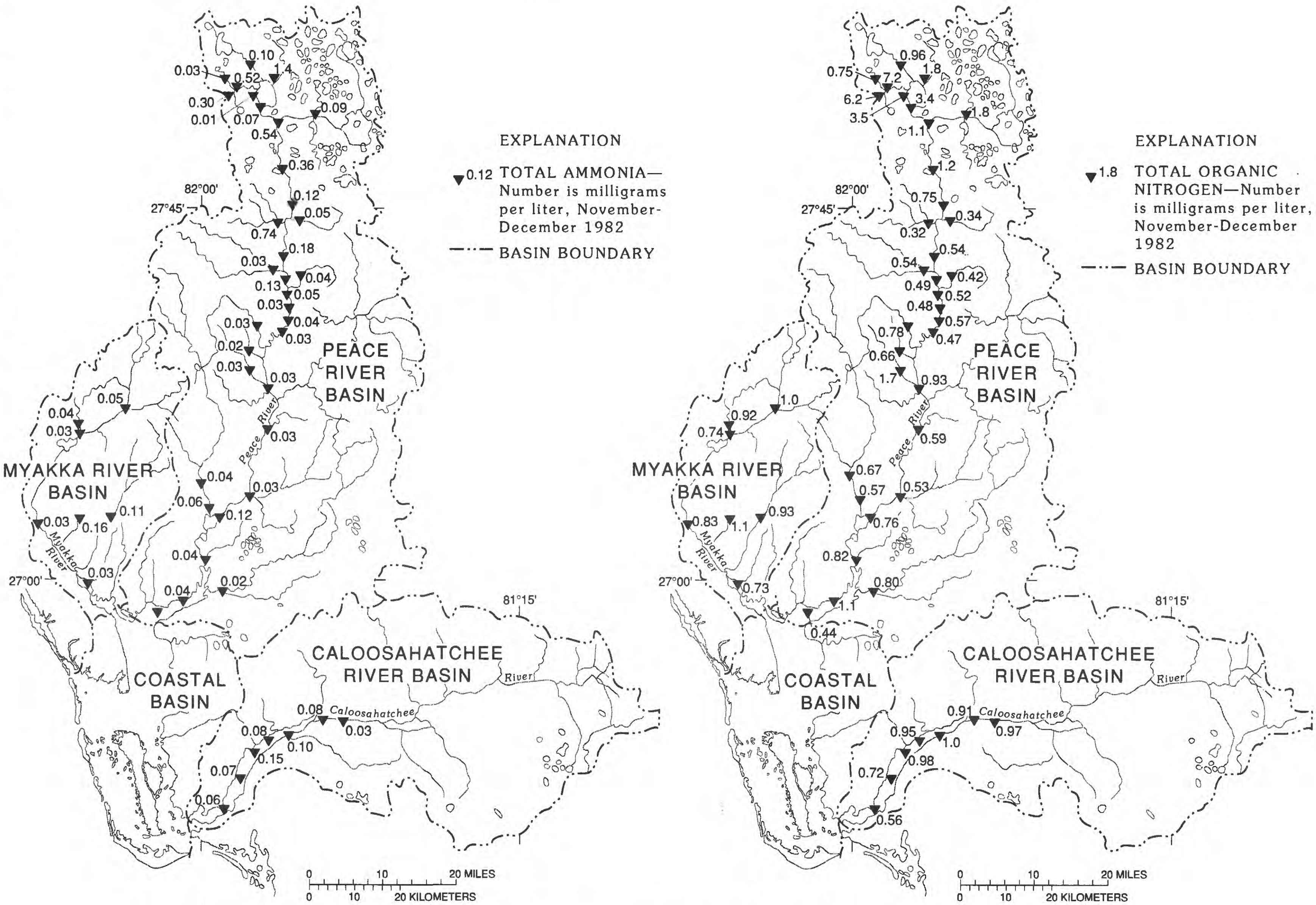

Figure 21. Concentrations of total ammonia and total organic nitrogen, November–December 1982.

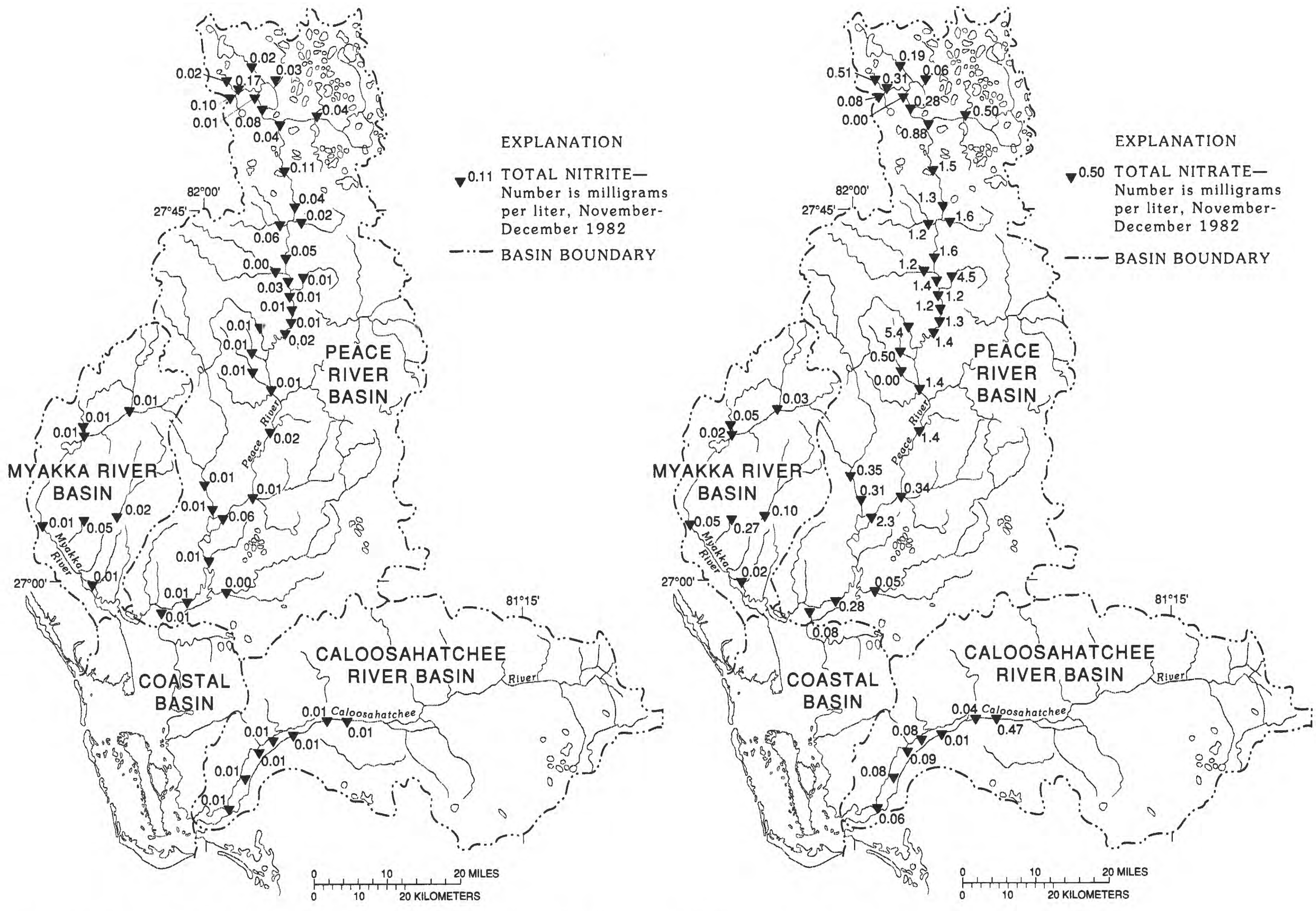

Figure 22. Concentrations of total nitrite and total nitrate, November–December 1982.

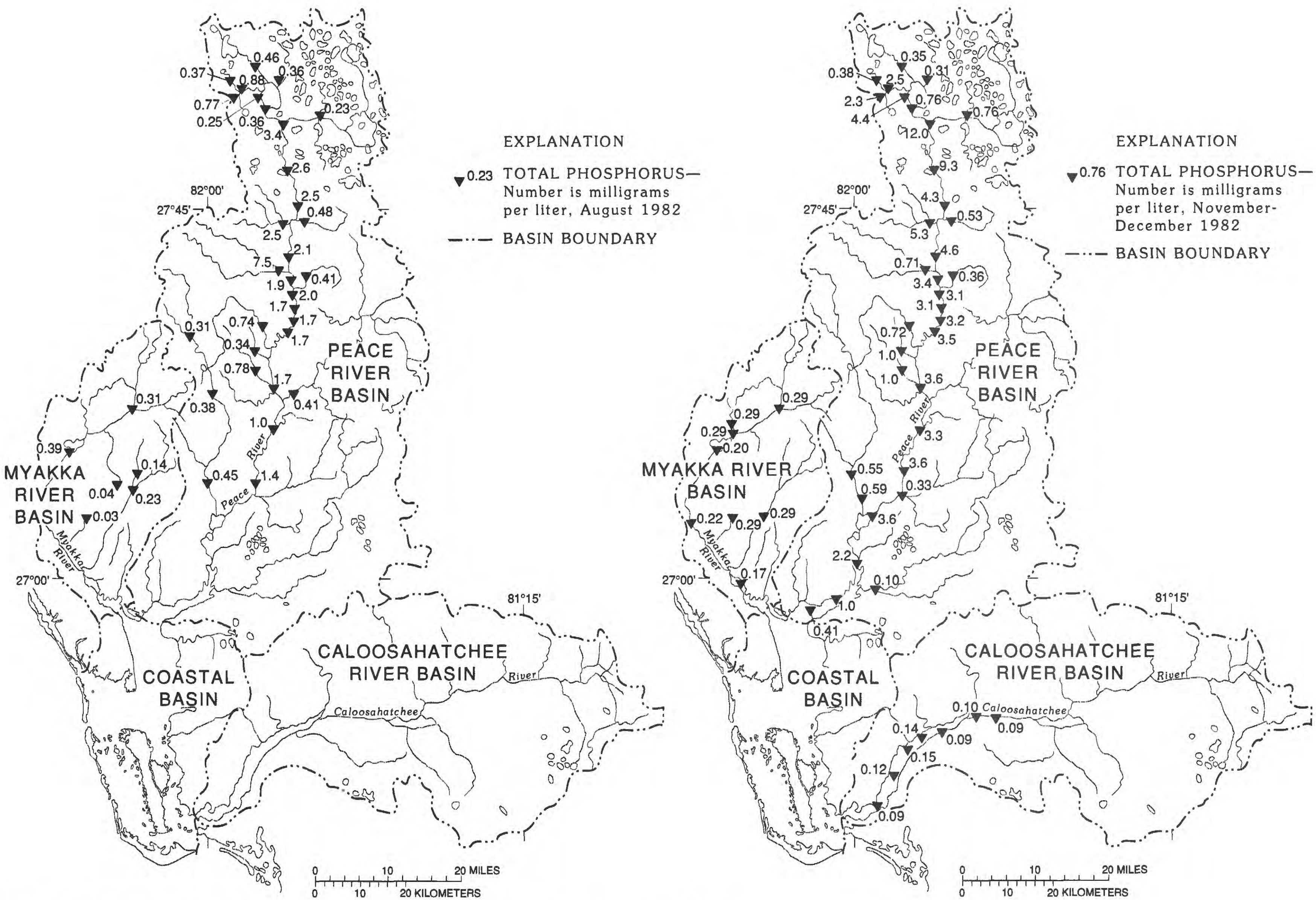

Figure 23. Concentrations of total phosphorus, August and November–December 1982.

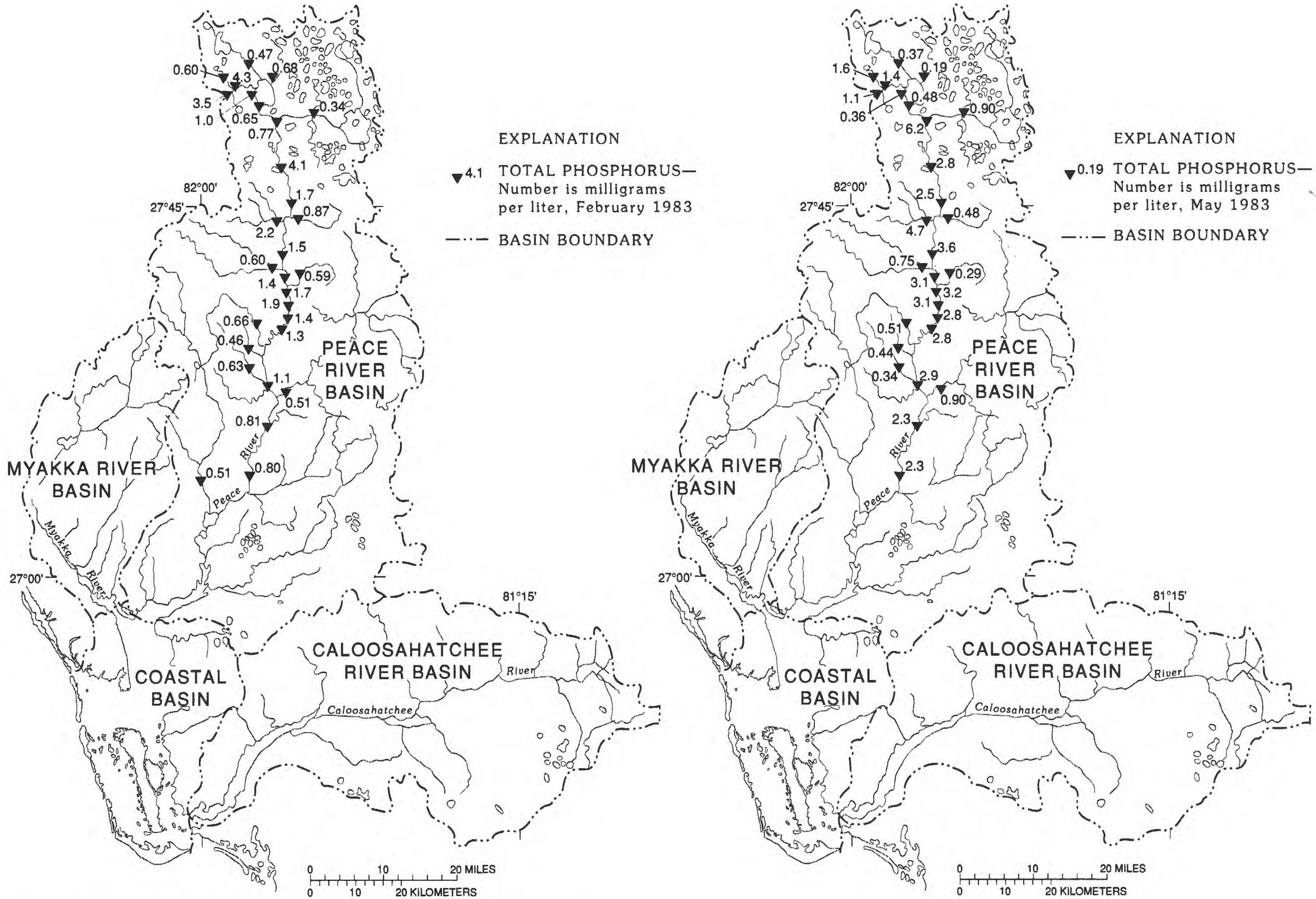

Figure 24. Concentrations of total phosphorus, February and May 1983.

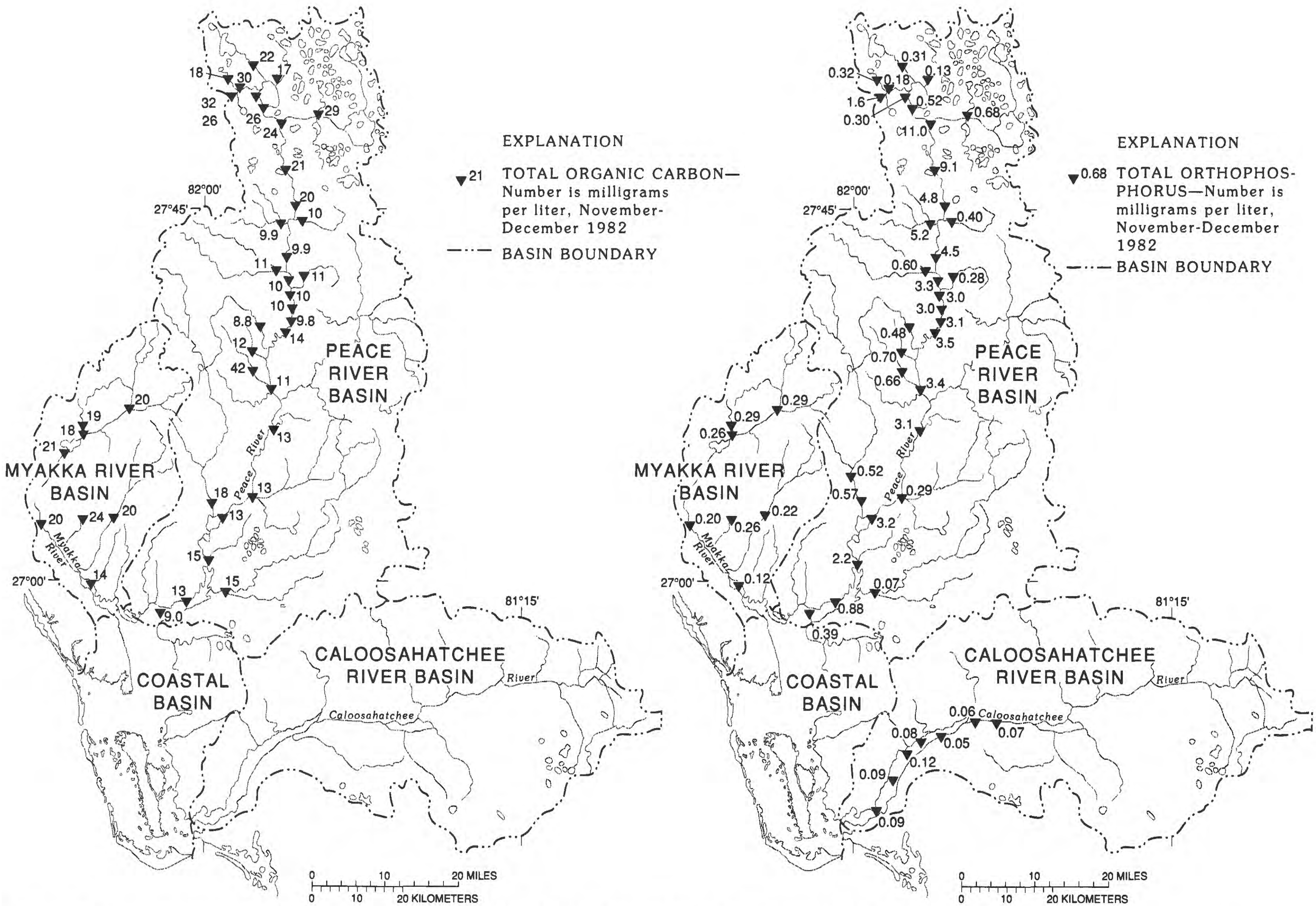

Figure 25. Concentrations of total organic carbon and total orthophosphorus, November–December 1982.

Class of surface water		Dissolved oxygen
I–A	Potable Water Supplies	5.0
II	Shellfish Propagation and Harvesting	4.0
III	Recreation, Propagation, and Management of Fish and Wildlife.	4.0
IV	Agricultural Water Supplies	3.0
V–A	Navigation, Utility, and Industrial Use	2.0

Dissolved oxygen concentrations in the Peace River basin (figs. 16, 17) for August 1982 are the lowest of the four periods sampled. High concentrations, greater than 10 mg/L, of dissolved oxygen for all four samplings are probably the result of algae blooms. The August 1982 concentrations of 1.7, 1.4, and 1.6 mg/L for the Stahl Canal, Lake Lena Run, and the Peace River near Homeland, respectively, were below State standards for all classes of surface waters. The concentrations at the sites farthest upstream—Stahl Canal, Banana Lake, Banana-Hancock Canal, Lake Lena Run, and Lake Hancock—reflect the large volume of domestic and food-processing wastes they receive.

The State standards for pH are as follows:

Class of surface water		Lower limit	Upper limit
I–A	Potable Water Supplies	6.0	8.5
II	Shellfish Propagation and Harvesting.	6.5	8.5
III (fresh)	Recreation, Propagation, and Management of Fish and Wildlife.	6.0	8.5
III (marine)	....do	6.5	8.5
IV	Agricultural Water Supplies	6.0	8.5
V–A	Navigation, Utility, and Industrial Use.	5.0	9.5

The pH (fig. 18) of Banana Lake (pH = 9.6) exceeds allowable standards for all classes of surface waters. The high pH is probably a result of the lake's eutrophication. The Banana-Hancock Canal, Lake Hancock, and Saddle Creek at structure P–11 upstream from Bartow have pH values that exceed allowable standards for all classes except Class V surface waters. Troublesome Creek (pH = 5.7) has a pH of less than that allowed for all classes, except Class V surface waters.

Suspended solids concentrations (fig. 18) in the headwaters of the Peace River show the effect of domestic sewage effluent (fig. 13; table 17). Among the tributaries that enter the Peace River from the west, concentrations of 24, 18, and 36 mg/L for Troublesome, Hickory, and Oak Creeks, respectively, are much higher than concentrations for other agricultural areas. Land use along these three streams is primarily for cattle ranches and orange groves. The State has no standard for suspended solids.

State standards require that concentrations of nutrients cannot be "altered so as to cause an imbalance in natural populations of aquatic flora and fauna" (Florida Department of Environmental Regulation, 1983, p. 12E). Furthermore, the standards allow for nutrients to be limited, as needed, to prevent violations of standards for other constituents.

Distribution of nitrogen species is shown in figures 19 through 22. Figures 19 and 20 show some seasonal variation in the concentration of total nitrogen. Along the main stem of the Peace River, total nitrogen concentrations were highest in August 1982. In Banana Lake and Lake Hancock, concentrations of total nitrogen were highest in February 1983. Organic nitrogen (fig. 21) is the predominant form of nitrogen in those areas receiving domestic wastewater—the Peace River headwaters and the Caloosahatchee River estuary. Cattle ranches are a primary source of organic nitrogen in agricultural areas. High total nitrates (fig. 22), like those sampled at Troublesome and Little Charlie Creeks, probably result from fertilizer runoff from citrus groves or cropland. The concentration and the loading of nitrogen are of special significance to Charlotte Harbor because this element largely limits algal productivity in the harbor (T.H. Fraser, Environmental Quality Laboratory, Inc., oral commun., 1985).

The distribution of phosphorus and orthophosphorus is shown in figures 23 through 25. Total phosphorus concentrations along the main stem of the Peace River were highest in November–December 1982 (figs. 23, 24). Upstream from Saddle Creek at structure P–11, concentrations of total phosphorus were highest in February 1983. Orthophosphorus (fig. 25), which is the predominant form of phosphorus at most sites in the Charlotte Harbor inflow area, reflects the occurrence of phosphate deposits in the river basin (Odum, 1953). The Banana-Hancock Canal (phosphorus = 2.50 mg/L, orthophosphorus = 0.180 mg/L) shows a high percentage of organic phosphorus; this is atypical even for the sites upstream from Bartow that receive domestic wastewater.

Concentrations of total organic carbon (fig. 25) are highest at those sites receiving domestic wastewater effluent. One exception is the site on the western tributary to the Peace River, Oak Creek (42 mg/L), where the high concentration probably results from runoff from cattle ranches.

Table 20 provides a summary of descriptive statistics for selected water-quality constituents at the stations farthest downstream in each of the three river basins. The statistics are computed from the entire period of record at each station. Data shown in figures 15 through 25 do not appear to be anomalous when compared to the data for the longer periods of record at the downstream stations listed in table 20.

Trend Analyses

The Kendall Tau test, which was used in the trend analyses of streamflow, also was used to evaluate trends in water-quality data. Because water-quality data vary

Table 20. Descriptive statistics of selected water-quality constituents at three stations in the Myakka (1963–85), the Peace (1957–85), and the Caloosahatchee (1966–85) River basins

[N, total number of observations. WATSTORE, the USGS's National Water Data Storage and Retrieval System]

Parameter (WATSTORE code)	N	Maximum	Minimum	Mean	Standard deviation
Myakka River near Sarasota					
Temperature (00010)	240	35.0	10.5	24.4	4.1
Turbidity (00076)	56	18.0	.1	2.3	3.0
Color (00080)	172	320	20	138	49
Specific conductance (00095)	367	419	41	148	74
Dissolved oxygen (00300)	186	9.0	0.0	5.2	2.4
pH (00400)	343	8.4	5.3	6.7	.6
Suspended solids (00530)	0	---	---	---	---
Total nitrogen (00600)	46	9.1	.7	1.5	1.2
Total organic nitrogen (00605)	53	8.80	.65	1.43	1.15
Total ammonia (00610)	54	.520	.000	.080	.098
Total nitrite (00615)	53	.050	.000	.012	.008
Total nitrate (00620)	62	.44	.00	.05	.08
Total phosphorus (00665)	77	.99	.03	.34	.18
Total orthophosphorus (70507)	54	.740	.020	.254	.146
Total organic carbon (00680)	37	72	13	23	10
Dissolved chloride (00940)	232	90	5	16	12
Dissolved sulfate (00945)	225	110	.8	21.5	21.5
Dissolved solids (70300)	214	303	42	115	49
Chlorophyll a (70953)	1	20.0	20.0	20.0	---
Peace River at Arcadia					
Temperature (00010)	515	34.0	10.0	24.1	4.2
Turbidity (00076)	61	25.0	.5	4.7	4.3
Color (00080)	378	280	0	88	66
Specific conductance (00095)	722	635	0	286	137
Dissolved oxygen (00300)	317	11.8	3.5	6.4	1.7
pH (00400)	694	71	.7	7.2	3.4
Suspended solids (00530)	2	8.0	6.0	7.0	1.4
Total nitrogen (00600)	83	4.7	.45	1.9	.85
Total organic nitrogen (00605)	112	3.50	.10	.98	.57
Total ammonia (00610)	112	.370	.010	.078	.070
Total nitrite (00615)	101	2.70	.000	.048	.267
Total nitrate (00620)	101	3.9	.00	.87	.71
Total phosphorus (00665)	130	10.0	.14	2.59	1.45
Total orthophosphorus (70507)	102	9.70	.130	2.42	1.34
Total organic carbon (00680)	55	38	.60	15.7	8.5
Dissolved chloride (00940)	466	51	.70	16.2	4.8
Dissolved sulfate (00945)	460	198	1.0	65.9	38.1
Dissolved solids (70300)	357	409	0.0	217	75
Chlorophyll a (70953)	2	12.0	4.0	8.0	5.7
Caloosahatchee River at structure S–79 near Olga					
Temperature (00010)	240	32.5	13.0	25.2	4.5
Turbidity (00076)	31	20.0	1.0	2.9	3.3
Color (00080)	128	500	5	74	54
Specific conductance (00095)	175	5,800	250	769	525
Dissolved oxygen (00300)	207	20.0	.2	6.7	2.5
pH (00400)	156	9.5	6.5	7.8	.4
Suspended solids (00530)	1	2.0	2.0	2.0	---
Total nitrogen (00600)	96	10.0	.32	1.6	1.2
Total organic nitrogen (00605)	111	9.0	.04	1.30	1.12
Total ammonia (00610)	108	.950	.000	.065	.094
Total nitrite (00615)	110	.170	.000	.022	.031
Total nitrate (00620)	110	.67	.00	.19	.16
Total phosphorus (00665)	107	.88	.03	.11	.09
Total orthophosphorus (70507)	108	.320	.010	.086	.047
Total organic carbon (00680)	92	43	.00	19	6
Dissolved chloride (00940)	158	1,640	20	126	165
Dissolved sulfate (00945)	128	284	16	50	28
Dissolved solids (70300)	125	1,300	180	460	194
Chlorophyll a (70953)	1	5.0	5.0	5.0	---

seasonally, additional factors had to be considered in analyzing the data. Considerations and appropriate procedures for evaluating trends in water-quality data were discussed by Smith and others (1982) and Crawford and others (1983).

Hirsch and others (1982) described a Seasonal Kendall test that can be used for evaluating seasonally varying data. In the Seasonal Kendall test, the only discordant or concordant pairs considered are those involving observations occurring in the same month of the year. To estimate the magnitude of any trend, they defined a Seasonal Kendall Slope Estimator, which is the median of all the differences represented by seasonal concordant and discordant pairs.

Concentrations of many water-quality constituents are related to stream discharge. Simple linear regression analysis can be used to adjust water-quality concentrations for discharge. The discharge-adjusted value of a constituent is the actual value minus the regression prediction. When a water-quality concentration and a discharge are related, observed trends in water quality may be the result of variations in stream discharge rather than the result of changes in factors affecting the occurrence and the distribution of the constituent. The validity of using discharge-adjusted concentrations depends on stream discharge data that are stationary (lacks trend). In cases where the trend in stream discharge is known, discharge adjustment should not be made (R.M. Hirsch, USGS, written commun., 1985).

Trends in concentrations of selected water-quality constituents were evaluated at the station farthest downstream in each of the three river basins. Because of the long-term declines in annual mean discharge in the Peace River basin, concentrations in the Peace River at Arcadia were not adjusted for discharge. No trend in annual mean discharge was observed at the Myakka River near Sarasota or at the Caloosahatchee River at Franklin Lock, structure S–79, near Olga; concentrations at these two stations were discharge adjusted when acceptable regression estimates could be made.

Results of the trend analyses are presented in table 21. For those constituents that show significant trends, the relative magnitude of the change can be estimated by comparing the "slope" from table 21 with the "mean" from table 20; for example, the Myakka River near Sarasota shows an increasing trend in dissolved-solids concentration of 4.573 (mg/L)/yr (table 21). The mean dissolved-solids concentration for that site is 115 mg/L (table 20). The dissolved-solids concentration, therefore, has been increasing at a rate of about 4 percent every year [4.573 (mg/L)/yr $\div$ 115 mg/L $\times$ 100 = 3.97 percent].

Of the 51 total trend analyses presented in table 21, 19 are significant at the 5-percent level—17 reflect increases in constituent concentrations and 2 represent decreases. Data from the Myakka River basin show statistically significant increasing trends in specific conductance, chloride, sulfate, and dissolved solids and a decreasing trend in total nitrate. Increasing trends at the Myakka River near Sarasota probably were the result of increased runoff from irrigation during the period of record at the station. Ground water, which has higher concentrations of chloride, sulfate, and dissolved solids than does surface water, is the primary source of irrigation water in the Myakka River basin (table 7). Although the decrease in total nitrate in the Myakka River is statistically significant over the period of record, the magnitude of the decrease [0.005 (mg/L)/yr] is small.

Several water-quality constituents in the Peace and the Caloosahatchee Rivers show trends over the period of record. At the Peace River at Arcadia, the increasing trend in total organic nitrogen may reflect inflow of effluent from wastewater treatment plants. Increases in chloride, sulfate, and dissolved solids probably represent an increased contribution of ground water from irrigation runoff and industrial processing. The increasing trend in specific conductance could result from either wastewater effluent or mineralized ground water. Although the decreasing trend in total phosphorous at the Peace River at Arcadia was reported previously by Smith and others (1982), it is unexpected. Total orthophosphorus also shows a decreasing trend, but it is only significant at the 10-percent level. Total phosphorus is naturally high in the Peace River. Gilliland (1973) suggested that all the ground-water discharge from industrial processing actually dilutes the normally high levels of phosphorus in the river water. The increasing trends in nitrogen and phosphorus in the Caloosahatchee River at Franklin Lock, structure S–79, near Olga reflect effluent from wastewater treatment plants and runoff from agricultural land along the river.

Computation of Loads

A sample loading computation is presented for the Peace River at Arcadia for total nitrogen. Computation of water-quality loads requires a duration analysis of daily discharge at the site and a regression analysis of the water-quality constituent versus discharge. Figure 26 shows the graphical regression analysis used in the loading computation. Loading calculations are presented in table 22. The first two columns of table 22 are the duration analysis of daily discharge. Column 3 is computed from discharge by means of the regression relation. Column 4 is the difference between succeeding pairs of values in column 1. Column 5 is the average of succeeding pairs of values from column 3. Column 6 is the product of columns 4 and 5. The sum of column 6, divided by 100 (to account for the percentage), provides a weighted average load per day. The weighted average load divided by the drainage area provides an average basin yield in tons per day per square mile.

Table 23 provides a summary of average loads and basin yields for selected water-quality constituents. Because all duration and regression analyses are based on the entire

Table 21. Trend analyses of selected water-quality constituents at three stations in the Myakka (1963–85), the Peace (1957–85), and the Caloosahatchee (1966–85) River basins

[N, total number of observations; NS, total number of seasonal observations; slope, Seasonal Kendall Slope Estimator in constituent units per year; trends significant at 5-percent level are underlined. WATSTORE, the USGS's National Water Data Storage and Retrieval System]

Parameter (WATSTORE code)	N	NS	Kendall Tau	Significance level	Slope
Myakka River near Sarasoata					
Temperature (00010)	240	111	−0.144	0.060	−0.125
Turbidity (00076)	56	54	−.225	.084	−.112
Color (00080)	158	76	−.191	.061	[1]−2.158
Specific conductance (00095)	352	148	.648	.000	[1]5.937
Dissolved oxygen (00300)	183	60	.223	.066	[1].191
pH (00400)	329	127	.013	.871	[1].001
Total nitrogen (00600)	46	43	−.119	.492	−.025
Total organic nitrogen (00605)	53	50	.000	1.00	.0000
Total ammonia (00610)	54	51	−.105	.467	−.0000
Total nitrite (00615)	53	50	.065	.651	.0000
Total nitrate (00620)	62	59	−.295	.012	−.005
Total phosphorus (00665)	74	70	.228	.034	[1].012
Total orthophosphorus (70507)	52	47	.012	1.00	[1].001
Total organic carbon (00680)	37	35	−.020	1.00	−.071
Dissolved chloride (00940)	217	130	.376	.000	[1].197
Dissolved sulfate (00945)	211	127	.639	.000	[1]1.783
Dissolved solids (70300)	202	124	.651	.000	[1]4.573
Peace River at Arcadia					
Temperature (00010)	515	198	−0.041	0.438	−0.000
Turbidity (00076)	61	52	−.212	.120	−.333
Color (00080)	378	145	−.058	.374	−.000
Specific conductance (00095)	722	241	.251	.000	4.500
Dissolved oxygen (00300)	317	102	−.090	.273	−.050
pH (00400)	694	226	.093	.057	.006
Total nitrogen (00600)	83	69	.092	.412	.033
Total organic nitrogen (00605)	112	94	.261	.002	.035
Total ammonia (00610)	112	92	−.072	.419	−.001
Total nitrite (00615)	101	83	−.165	.064	−.000
Total nitrate (00620)	101	82	−.126	.191	−.020
Total phosphorus (00665)	130	107	−.209	.008	−.083
Total orthophosphorus (70507)	102	84	−.153	.103	−.090
Total organic carbon (00680)	55	50	.190	.184	.762
Dissolved chloride (00940)	466	217	.453	.000	.297
Dissolved sulfate (00945)	460	215	.217	.000	1.214
Dissolved solids (70300)	357	189	.256	.000	2.889
Caloosahatchee River at structure S–79 near Olga					
Temperature (00010)	240	124	−0.078	0.275	−0.035
Turbidity (00076)	31	28	.435	.059	.500
Color (00080)	128	115	.238	.001	[1]1.549
Specific conductance (00095)	175	129	.019	.804	[1].611
Dissolved oxygen (00300)	207	99	−.150	.074	[1]−.075
pH (00400)	156	127	−.030	.682	[1]−.003
Total nitrogen (00600)	96	83	.321	.000	.060
Total organic nitrogen (00605)	111	98	.367	.000	.044
Total ammonia (00610)	108	94	.042	.639	.000
Total nitrite (00615)	110	96	.029	.739	.000
Total nitrate (00620)	110	96	.193	.022	.012
Total phosphorus (00665)	107	94	.431	.000	.005
Total orthophosphorus (70507)	108	94	.319	.000	.004
Total organic carbon (00680)	92	83	.197	.036	.500
Dissolved chloride (00940)	158	126	.015	.852	[1].114
Dissolved sulfate (00945)	128	116	−.066	.384	[1]−.252
Dissolved solids (70300)	125	113	.080	.300	[1]2.243

[1] Flow adjusted concentrations.

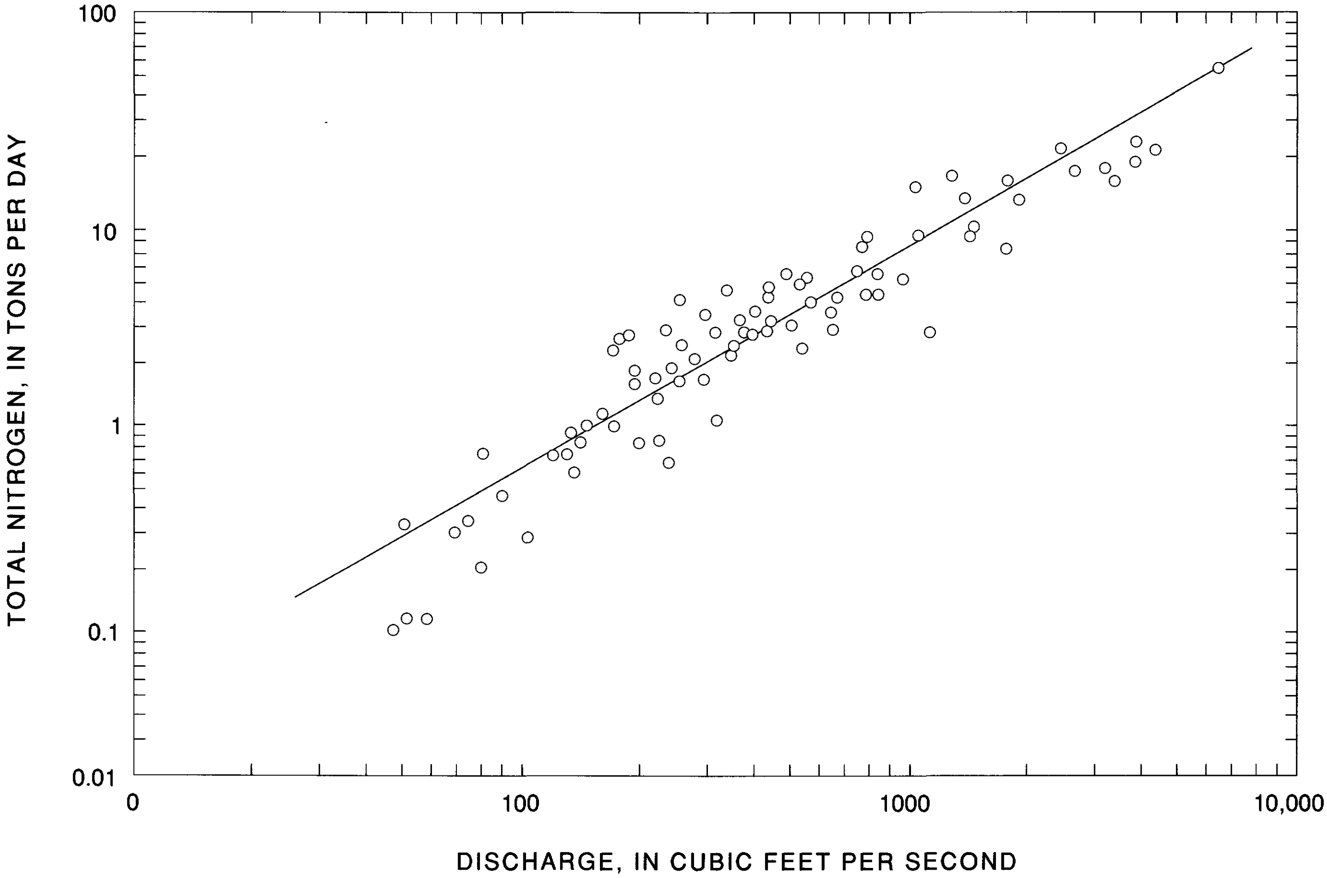

Figure 26. Graphical regression analysis of total nitrogen as a function of discharge used in computation of loads for the Peace River at Arcadia.

period of record at the station, loads and yields represent long-term averages. The period of record for the water-quality data is noted in table 23. The period of record on which the duration analysis is based is shown in table 12. Basin yields for the Caloosahatchee River at structure S–79 were not computed because large inflows from Lake Okeechobee and a poorly defined drainage area render the computation potentially inaccurate and unrepresentative.

The dissolved-solids load measured at the Caloosahatchee River at Franklin Lock, structure S–79, near Olga is greater than the loads for the other two rivers. The structure, however, is affected by saltwater encroachment from seepage and boat locks. The higher average load probably reflects this saltwater encroachment rather than a heavier basin contribution.

The Caloosahatchee River and the main channel of the Peace River carry substantially heavier nutrient loads than does the Myakka River. The Peace and the Caloosahatchee Rivers carry significant loads of nitrogen; organic nitrogen is the predominant species. The phosphorus load of the Peace River overshadows the phosphorus contribution of all the other tributaries and rivers combined. The Myakka River near Sarasota and Horse Creek near Arcadia appear to have similar constituent-loading characteristics.

PROJECTED TRENDS AND FUTURE CONDITIONS

Stresses caused by development within the Charlotte Harbor inflow area can be expected to continue and perhaps even to accelerate. Table 24 provides population projections through 2020 for the 10 counties wholly or partially within the inflow area. The projections are taken from the 1983 edition of the “Florida Statistical Abstract” (Terhune, 1983), which is compiled by the University of Florida’s Bureau of Economic and Business Research. The population figures are based on medium projections that assume annual net migration levels that are similar to the average in the 1970’s. The population of Lee and Charlotte Counties, which border Charlotte Harbor, is expected to increase dramatically. Rural, interior counties, such as Hardee, De Soto, Glades, and Hendry, may not grow as rapidly as the coastal areas.

Table 25 provides percentage estimates of county populations located within the Charlotte Harbor inflow area. The percentage of county land area within the inflow area is presented and is followed by an estimate of the percentage of county population located within the inflow area. Estimates of population percentage were based on

Table 22. Computation of total nitrogen load for the Peace River at Arcadia

Percentage of time	Streamflow equaled or exceeded (ft^3/s)	Total nitrogen discharge (ton/d)	Interval between succeeding percentages of time (percent)	Average total nitrogen discharge for time interval (ton/d)	Total nitrogen discharge multiplied by time interval (ton/d)
0.01	30,000	264.10			
.04	23,000	195.17	0.03	229.64	6.89
.07	19,000	157.03	.03	176.10	5.28
.14	15,000	119.98	.07	138.50	9.70
.30	12,000	93.07	.16	106.52	17.04
.91	9,300	69.63	.61	81.35	49.62
1.60	7,300	52.85	.69	61.24	42.26
2.73	5,800	40.68	1.13	46.77	52.85
4.45	4,600	31.25	1.72	35.96	61.86
6.76	3,700	24.39	2.31	27.82	64.25
9.77	2,900	18.48	3.01	21.43	64.51
13.30	2,300	14.19	3.53	16.34	57.67
17.92	1,800	10.74	4.62	12.47	57.59
23.38	1,400	8.07	5.46	9.40	51.34
29.18	1,100	6.13	5.80	7.10	41.17
33.92	910	4.94	4.74	5.54	26.24
39.95	720	3.78	6.03	4.36	26.30
45.87	570	2.90	5.92	3.34	19.79
52.40	450	2.22	6.53	2.56	16.71
59.03	360	1.72	6.63	1.97	13.05
65.61	290	1.34	6.58	1.53	10.08
73.36	230	1.03	7.75	1.19	9.21
82.02	180	.78	8.66	.91	7.85
88.27	140	.59	6.25	.68	4.27
93.20	110	.45	4.93	.52	2.55
96.36	90	.35	3.16	.40	1.26
98.40	71	.27	2.04	.31	.64
99.49	56	.21	1.09	.24	.26
99.86	45	.16	.37	.18	.07
99.97	35	.12	.11	.14	.02
99.98	28	.09	.01	.11	.00
99.98	22	.07	.00	.08	.00
99.99	18	.06	.01	.06	.00
100.00	14	.04	.01	.05	.00
100.00	0	.00	.00	.02	.00
Total					720.32

Weighted average load per day = 7.20 ton/d average.
Average basin yield = 0.0053 (ton/d)/mi^2 [=1.92 (ton/yr)/mi^2].

land area and census counts of incorporated and unincorporated areas. The percentages in table 25, multiplied by population projections from table 24, were used to produce the population projections for river basins in the inflow area shown in table 26.

According to table 26, the population of the Charlotte Harbor inflow area will increase by almost 200,000 people between 1980 and 1990. By 2020, the population will be more than double that in 1980. Without any increased industrial or agricultural development, an increase in population will produce substantial additional waste loads and demands for water supply.

Table 27 shows the estimated additional water supply needed to meet the demands of a population increase in the Charlotte Harbor inflow area. The estimates in table 27 are based on a projected demand of 125 gal/d per capita for urban domestic water supply. The Hillsborough County Utilities Department, which serves the rapidly growing Tampa Bay area of west-central Florida, uses 125 gal/d per capita in its projections for capital expenditures (J.D. Jeffers, Hillsborough County Utilities Department, written commun., 1985). Additional water-supply requirements, which are shown in table 27, do not include supply for any population outside the inflow area even though it is quite certain that the Myakka River and the adjacent well fields in the basin will be used to provide water for other parts of Sarasota County. Table 27 shows that an estimated additional 76 Mgal/d will be needed to supply the population of the inflow area by 2020.

Table 28 shows the estimated additional wastewater generated as a result of increased population. The disposal of this wastewater is a major environmental concern. Estimates in table 28 are based on an average 100 gal/d per capita as used by the Hillsborough County Utilities Department (J.D. Jeffers, Hillsborough County Utilities Department, written commun., 1985). Estimates of total nitrogen and total phosphorous are based on averages provided in operating reports for six domestic wastewater treatment plants in the inflow area. Average total nitrogen concentration of effluent from more than 75 operating reports was 12.5 mg/L. Average total phosphorous concentration was 2.6 mg/L. By 2020, additional wastewater will increase the nitrogen load in the inflow area by more than 3 ton/d and will increase the phosphorus load by about 0.65 ton/d.

Runoff from urban areas also tends to increase the nutrient loads of receiving bodies of water; for example, Lopez and Giovannelli (1984) reported an average total nitrogen load of about 7 (lb/acre)/yr for nine urban basins in the Tampa Bay area of west-central Florida. The weighted average total nitrogen load for the stations listed in table 23 is about 5.0 (lb/acre)/yr [1.60 (ton/mi^2)/yr].

An estimate of urban acreage was obtained by dividing population estimates by 2.5 people per residence and multiplying by 0.25 acre per residence. Commercial and institutional area estimates of 0.5 acre for every acre of residential land were based on average ratios from Lopez and Giovannelli (1984). The total nitrogen load of the runoff from this additional urban acreage is shown in table 29 and represents the difference between the average of 7 (lb/acre)/yr from Lopez and Giovannelli (1984) and the weighted average total nitrogen loading rate from table 23 [5 (lb/acre)/yr]. By 2020, the additional total nitrogen load, which results solely from additional wastewater effluent and urban stormwater runoff, will be more than three times the current total nitrogen load from the Myakka River (table 23).

Changes in agriculture and industry also may affect the nutrient loads of the rivers and the estuary. The citrus-tree census taken by the Florida Crop and Livestock Reporting Service (1984) indicated that between 1978 and 1984, Glades and Hendry Counties showed substantial increases in the acreage devoted to commercial groves; that Charlotte, De Soto, Highlands, Lee, and Sarasota Counties also showed increases; and that Hardee, Polk, and Manatee Counties showed decreases. Production trends have been projected only to the 1995–96 growing season (Florida Department of Citrus, 1985). A steady increase in production is predicted, partly because of a general trend in the citrus industry to expand southward where freezing weather is less likely to damage trees. Stowasser and Fantel (1985) discussed phosphate mining projections. If replacement mines are brought into production, then capacity may increase until about 1995. By 2000, even with replacement mines, many deposits will be mined out, and production will be substantially less than that of 1984.

Estimates of future loads also can be obtained by extrapolating existing trends. According to table 21, total organic nitrogen at the Peace River at Arcadia is increasing at a rate of 0.035 (mg/L)/yr. At an average discharge of 1,141 ft^3/s, that is equivalent to a loading increase of a little more than 0.1 (ton/d)/yr. Without adjusting for a decreasing trend in streamflow, the load of total organic nitrogen would increase by about 3.8 ton/d over the next 35 years (0.035 mg/L $\times$ 0.0027 $\times$ 1,141 ft^3/s $\times$ 35 years = 3.8 ton/d). Adjusting for the decreasing trend in discharge [7.6 (ft^3/s)/yr; table 16] at the Peace River at Arcadia, the load of total organic nitrogen would increase by about 3.4 ton/d by 2020.

Extrapolation of the trends for the Caloosahatchee River at Franklin Lock, structure S–79, near Olga (table 21) shows that the total nitrogen load would increase by more than 9 ton/d by 2020, and total organic nitrogen would increase by almost 7 ton/d. If a current proposal to divert additional discharge from agricultural areas into the Caloosahatchee River is adopted (Richard Wieckowicz, Florida Department of Environmental Regulation, written commun., 1986), high nutrient runoff from this area could increase nitrogen and phosphorus loads significantly.

The projected increases in nutrient loads to Charlotte Harbor probably will be accompanied by decreases in freshwater inflow. It is not possible to predict whether the decreasing trends in the Peace River basin (table 16) will continue. However, if the trend does continue at the same rate, then, except for brief periods of storm runoff, the Peace River at Zolfo Springs could be dry year-round in about 100 years. The river may decline until it reaches a new equilibrium with the underlying aquifer system, but when that equilibrium will occur is unknown. Based on existing trends, average discharge for the Peace River at Arcadia could be about 875 ft^3/s by 2020. Additional water supply for Sarasota County may reduce the flow of the Myakka River during some months of the year.

SUMMARY

Charlotte Harbor, which has a surface area of about 270 mi^2, is the second largest estuarine system in Florida and is being subjected to the environmental stresses of rapid growth and development. The estuary is affected not only by changes in the surrounding coastal area, but also by changes throughout the inflow area, which is composed of the Myakka River basin (602 mi^2), the Peace River basin (2,350 mi^2), the Caloosahatchee River basin (1,378 mi^2), and the coastal area and islands (355 mi^2) that drain directly into the harbor.

Table 23. Summary of average loads and basin yields for selected water-quality constituents

Station	Dissolved solids		Total nitrogen	
	Tons per day	Tons per day per square mile	Tons per day	Tons per d per squar mile
02292900 Caloosahatchee River at structure S–79 near Olga (1966–84).	1,283.79	---	6.92	---
02296750 Peace River at Arcadia (1957–85).	445.80	0.3261	7.20	0.0053
02297100 Joshua Creek at Nocatee (1965–85).	42.04	.3185	.43	.0033
02297310 Horse Creek near Arcadia (1962–85).	56.86	.2608	.75	.0034
02298202 Shell Creek near Punta Gorda (1966–85).	287.85	.7717	.83	.0022
02298830 Myakka River near Sarasota (1962–85).	13.84	.0604	.93	.0040
02299470 Big Slough near Murdock (1962–72).	8.02	.0911	---	---

Table 24. Population projections through 2020 by county
[In thousands]

County	Census		Population projections[1]					
	1970	1980	1985	1990	1995	2000	2010	2020
Charlotte	27.6	58.5	76.6	94.4	109.1	124.0	141.5	157.4
De Soto	13.1	19.0	21.5	23.9	26.1	28.2	32.2	35.8
Glades	3.7	6.0	6.8	7.5	8.2	8.8	10.0	11.2
Hardee	14.9	19.4	20.8	22.0	23.4	24.6	28.1	31.2
Hendry	11.9	18.6	22.3	25.7	28.7	31.5	36.0	40.0
Highlands	29.5	47.5	57.2	66.2	74.0	81.4	92.9	103.3
Lee	105.2	205.3	257.7	311.0	355.8	400.6	457.4	508.5
Manatee	97.1	148.4	172.7	197.0	217.5	237.1	270.7	300.9
Polk	228.5	321.7	362.4	404.2	442.7	475.7	543.1	603.8
Sarasota	120.4	202.3	238.2	275.9	308.3	342.1	390.6	434.2

[1] Medium projections; assume annual net migration levels similar to the average in the 1970's.

Table 25. Percentage estimates of county populations by river basin

County	Percentage of county land area within inflow area	Percentage of county population by basin				
		Inflow area	Caloosahatchee	Coastal	Myakka	Peace
Charlotte	96	98	11	23	15	49
De Soto	100	100	---	---	1	99
Glades	36	62	62	---	---	---
Hardee	100	100	---	---	1	99
Hendry	31	53	53	---	---	---
Highlands	8	5	---	---	---	5
Lee	55	71	46	25	---	---
Manatee	31	10	---	---	10	---
Polk	46	65	---	---	---	65
Sarasota	60	20	---	---	20	---

Organic nitrogen		Ammonia		Nitrate plus nitrite		Total phosphorus	
Tons per day	Tons per day per square mile	Tons per day	Tons per day per square mile	Tons per day	Tons per day per square mile	Tons per day	Tons per day per square mile
5.98	---	0.27	---	0.96	---	0.60	---
5.51	0.0040	.38	0.0003	1.40	0.0010	4.34	0.0032
.29	.0022	.02	.0002	.14	.0011	.13	.0010
.65	.0030	.02	.0001	.05	.0002	.27	.0012
.63	.0017	.04	.0001	.08	.0002	.19	.0005
.91	.0040	.05	.0002	.03	.0001	.27	.0012
---	---	---	---	---	---	---	---

Table 26. Population projections through 2020 by river basin
[In thousands]

River basin	Census		Population projections					
	1970	1980	1985	1990	1995	2000	2010	2020
Caloosahatchee	60	114	143	172	196	220	251	279
Coastal	33	65	82	99	114	129	147	163
Myakka	38	64	77	90	100	111	127	141
Peace	191	278	318	358	394	426	487	541
Total	322	521	620	719	804	886	1,012	1,124

Table 27. Additional water supply needed to meet demands of increased population through 2020
[In million gallons per day]

River basin	Additional water supply[1]				
	1990	1995	2000	2010	2020
Caloosahatchee	7	10	13	17	21
Coastal	4	6	8	10	12
Myakka	3	4	6	8	10
Peace	10	14	18	26	33
Total	24	34	45	61	76

[1] Represents amount needed above 1980 requirements. Includes domestic supply only. Agricultural and industrial demands may increase requirements further.

The area's climate is subtropical and humid; average temperature is about 72° F, and average annual rainfall is about 52 in. The northern part of the inflow area has been characterized by below-average rainfall since 1960. Stations in the southern part of the study area do not show a deficit during the same period.

Hurricanes and other tropical cyclones produce the most severe weather conditions in the area. In addition to causing severe coastal and riverine flooding, these storms have the potential to alter the physiography of Charlotte Harbor. Along the 30 nmi of coast from Gasparilla Island to Sanibel Island, six to seven hurricanes or tropical storms can be expected to make landfall, and three hurricanes or tropical storms can be expected to exit to the Gulf of Mexico every 100 years. Hurricane Alma, which occurred in 1966, was the last hurricane to pass within 50 mi of the harbor.

Table 28. Additional wastewater, total nitrogen, and total phosphorus loads generated as a result of increased population through 2020

River Basin	1990	1995	2000	2010	2020
	Additional wastewater[1,2]				
Caloosahatchee	6	8	11	14	16
Coastal	3	5	6	8	10
Myakka	3	4	5	6	8
Peace	8	12	15	21	26
Total	20	29	37	49	60
	Additional total nitrogen[1,3]				
Caloosahatchee	0.31	0.42	0.57	0.73	0.83
Coastal	.16	.26	.31	.42	.52
Myakka	.16	.21	.26	.31	.42
Peace	.42	.63	.78	1.10	1.36
Total	1.05	1.52	1.92	2.56	3.13
	Additional total phosphorus[1,3]				
Caloosahatchee	0.065	0.086	0.118	0.151	0.172
Coastal	.032	.054	.065	.086	.108
Myakka	.032	.043	.054	.065	.086
Peace	.086	.129	.161	.226	.280
Total	0.215	0.312	0.398	0.528	0.646

[1] Represents amount above 1980 levels.
[2] In million gallons per day.
[3] In tons per day.

Table 29. Additional total nitrogen loads resulting from urban stormwater runoff through 2020
[In tons per day]

River basin	Additional total nitrogen[1] 1990	1995	2000	2010	2020
Caloosahatchee	0.024	0.034	0.044	0.056	0.068
Coastal	.014	.020	.026	.034	.040
Myakka	.011	.015	.019	.026	.032
Peace	.033	.048	.061	.086	.108
Total	0.082	0.117	0.150	0.202	0.248

[1] Represents amount above 1980 levels.

Throughout the inflow area, a shallow water-table aquifer system is underlain by the artesian Hawthorn aquifer and, under this, by the artesian Floridan aquifer system. Springs in the Peace and the Myakka River basins indicate a probable hydraulic connection between those rivers and the underlying artesian aquifer systems. The Caloosahatchee River appears to be hydraulically connected only with the surficial aquifer system.

Agricultural land and rangeland total about 70 percent of the land area in the Peace, the Myakka, and the Caloosahatchee River basins. In the Peace and the Myakka River basins, less than 10 percent of the total area is urban land. In 1984, about one-half of the land area of the coastal basin was devoted to residential or commercial land uses.

Water use in the inflow area totaled about 565 Mgal/d in 1980. Irrigation accounts for more than 80 percent of the water used in the Myakka and the Caloosahatchee River basins. In the Peace River basin, irrigation and industry account for about 40 and almost 50 percent, respectively, of total water use. Irrigation in the coastal basin accounts for about 60 percent of water use, and public supply accounts for almost 40 percent. Acre for acre, urban and agricultural water uses are about the same and average from 350 to 450 (gal/d)/acre. Industrial water use per acre averages about 3,000 (gal/d)/acre, almost four times as great as urban and agricultural water uses combined.

The flow of the three main tributaries has been affected to varying degrees by man's activities. The

Myakka River has large areas of overflow surface storage and some diking but is virtually unregulated. The flow of the Peace River is unregulated throughout its length; however, many canals and controls are among the lakes in the headwaters area of the Peace River. The flow of the Caloosahatchee River is regulated along its entire length. Channelization is extensive near the mouths of all three rivers.

Total freshwater inflow from the three river basins, the coastal area, and direct rainfall amounts to an average of between 5,700 and 6,100 ft^3/s, which is more than 3,500 Mgal/d. Inflow from the Caloosahatchee River averages between 1,900 and 2,100 ft^3/s. The Peace River contributes an average flow of 2,010 ft^3/s. Inflow from the Myakka River averages 630 ft^3/s, which is only about one-third as much as either of the other two rivers. Rainfall directly onto the harbor contributes the equivalent of 1,030 ft^3/s of freshwater. Drainage from the coastal basin averages from 200 to 400 ft^3/s, which is about 5 percent of the total freshwater entering Charlotte Harbor.

Declining streamflow may result in reduced freshwater inflow to the harbor. A trend analysis of long-term streamflow data shows a statistically significant (90-percent confidence interval) decreasing trend at the Peace River stations at Bartow, Zolfo Springs, and Arcadia. Streamflow data for stations on the Myakka and the Caloosahatchee Rivers do not have significant trends. Since 1933, the annual mean flow of the Peace River at Zolfo Springs has declined at a median rate of 6.2 $(ft^3/s)/yr$. It is not possible to determine whether the trend will continue. If the trend does continue at the same rate, then, except for brief periods of storm runoff, the Peace River at Zolfo Springs could be dry year-round in about 100 years. The decreasing trend in streamflow may be related to a long-term decline in the potentiometric surface of the underlying Floridan aquifer system, which resulted from ground-water withdrawals.

Of the 114 facilities permitted to discharge domestic or industrial effluent to waters that are tributary to Charlotte Harbor, 1 is in the Myakka River basin, 11 are in the coastal basin, 14 are in the Caloosahatchee River basin, and 88 are in the Peace River basin. Of the permitted outfalls, 70 are in Polk County. Effluent discharged to some lakes in Polk County may only reach the Peace River during high-water conditions. Citrus and phosphate ore processing account for most of the industrial effluent.

Several locations in the headwaters of the Peace River show significant effects as a result of receiving wastewater effluent. At some locations, dissolved-oxygen concentrations were lower than 2.0 mg/L, which is the minimum State standard for any class of surface water. At Banana Lake, pH exceeded 9.5, which is the upper limit set by the State for all classes of surface water.

A trend analysis of water-quality data shows significant increases in several constituents at stations in the inflow area. Since 1963, dissolved sulfate concentration has increased at a median rate of about 8 percent per year, and total phosphorus has increased about 7 percent per year at the Myakka River near Sarasota. At the Peace River at Arcadia, total organic nitrogen has increased about 6 percent per year, but total phosphorus has decreased about 6 percent per year since 1957. Over the period of record, total nitrogen has increased about 5 percent per year, and total phosphorus, about 6 percent per year at the Caloosahatchee River at structure S–79.

The rivers that are tributary to Charlotte Harbor transport substantial loads of dissolved solids and nutrients. The Myakka, the Peace, and the Caloosahatchee Rivers transport an average of more than 2,000 ton/d of dissolved solids. More than 17 ton/d of nitrogen is carried by the three rivers, of which about 55 percent is transported by the Peace River; 40 percent, by the Caloosahatchee River; and 5 percent, by the Myakka River. About 85 percent of the phosphorus load (about 6 ton/d) is carried by the Peace River.

Stresses caused by development are expected to continue or increase over the next 35 years. The population in the inflow area is expected to almost double—from about 620,000 to over 1.12 million. By 2020, the increased population alone will need an additional 76 Mgal/d for water supply. Agricultural and industrial demands may further increase water-supply requirements. An additional 60 Mgal/d of domestic wastewater will be generated by the population, which will result in an additional nitrogen load of more than 3 ton/d and an additional phosphorus load of about 0.65 ton/d. The increased population will cause more than 150 mi^2 of land to be converted to urban uses, which will produce another 0.25 ton/d of nitrogen from urban runoff. These increased nutrient loads can be expected to occur concurrently with decreased freshwater inflow, which will cause significant stress to Charlotte Harbor.

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