Hydrogeology and Chemical Quality of Water and Bottom Sediment at Three Stormwater Detention Ponds, Pinellas County, Florida

By Mario Fernandez, Jr., and C.B. Hutchinson

U.S. GEOLOGICAL SURVEY
Water Resources Investigations Report 92-4139

Prepared in cooperation with the
PINELLAS COUNTY, FLORIDA

Tallahassee, Florida
1993

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
ROBERT M. HIRSCH, Acting Director

For additional information
write to:

District Chief
U.S. Geological Survey
Suite 3015
227 N. Bronough Street
Tallahassee, FL 32301

Copies of this report can be
purchased from:

U.S. Geological Survey
Earth Science Information Center
Open-File Reports Section
Box 25286, MS 517
Denver Federal Center
Denver, CO 80225

CONTENTS

FIGURES

TABLES

CONVERSION FACTORS, VERTICAL DATUM, ABBREVIATED WATER-QUALITY UNITS, AND ACRONYMS

Multiply	By	To obtain
inch per year (in/yr)	2.54	centimeter per year
foot (ft)	0.3048	meter
foot per foot (ft/ft)	1.0	meter per meter
foot per day (ft/d)	0.3048	meter per day
foot per year (ft/yr)	0.3048	meter per year
mile (mi)	1.609	kilometer
acre	0.4047	hectare
square mile (mi^2)	2.590	square kilometer
ton	907.2	kilograms

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 the United States and Canada, formerly called Sea Level Datum of 1929.

Abbreviated Water-Quality Units

μg/g	micrograms per gram
μg/L	micrograms per liter
μS/cm	microsiemens per centimeter at 25 degrees Celsius
meq/kg	milliequivalents per kilogram
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
kg/m^2	kilograms per square meter

Acronyms

BDL	below detection limits
FCV	final chronic value
FRV	final residual value
FDER	Florida Department of Environmental Regulation
PAH	polycyclic aromatic hydrocarbons
USEPA	U.S. Environmental Protection Agency

Hydrogeology and Chemical Quality of Water and Bottom Sediment at Three Stormwater Detention Ponds, Pinellas County, Florida

By Mario Fernandez, Jr., and C.B. Hutchinson

Abstract

The hydrogeologic conditions at and near three stormwater detention ponds in Pinellas County, Florida, indicate that there is little potential for chemical contamination of ground water in the surficial aquifer system. The ponds, in the cities of Seminole, Clearwater, and Largo, have been in operation for about 1, 20, and 30 years, respectively. The physical, hydrogeologic, water-quality, and sediment-quality characteristics of each pond and surrounding drainage basin were determined. A network of monitoring wells was installed in each basin to provide for geologic description, physical analyses of soils, aquifer testing, establishing the direction of ground-water movement, and collection of water samples for chemical analyses. Each pond lies within a water-table depression so that ground water seeps laterally toward the ponds from the surficial aquifer system. Ground-water, surface-water, and pond bottom-sediment samples were collected for analyses of inorganic constituents and organic compounds. At the Seminole site, concentrations of the inorganic constituents (except for ammonia-nitrogen and phosphorus) and organic compounds in surface water and ground water were either less than or just above analytical detection limits. One bottom-sediment sample contained a trace of the insecticide dieldrin.

Surface-water quality at the 20-year-old Clearwater pond was similar to that of the 1-year-old pond at Seminole. Bottom sediments in the Clearwater pond, however, contained concentrations of chromium, copper, iron, lead, and zinc that were one order of magnitude greater than concentrations measured in bottom sediment at the Seminole pond. Sixteen organic compounds were detected in the Clearwater pond bottom sediment. Dichlordiphenyl-trichlorethane, dieldrin, and heptachlor were present in sufficient concentrations above the U.S. Environmental Protection Agency's level of concern with respect to bioconcentration in the food chain, but did not exceed the lower level concentration protecting aquatic life from chronic toxicity.

Concentrations of nutrients in ground water at the Largo site were similar to those at the Seminole and Clearwater sites; however, arsenic, chromium, copper, and zinc were substantially greater at the Largo site than those at the Seminole site. Two organic compounds were detected, but concentrations were at or below guidance concentrations. The bottom-sediment sample at the Largo site contained several inorganic constituents and organic compounds at concentrations higher than those in the Seminole pond sediment and were of the same order of magnitude as those in the Clearwater pond sediment. Twenty-three organic compounds were detected in the Largo pond bottom-sediment sample, but none were in sufficient concentrations to cause concern about chronic toxicity on aquatic life. Dieldrin exceeded the value for bioconcentration in the food chain.

INTRODUCTION

Natural and manmade ponds are commonly used in urban and suburban areas to limit the rate of stormwater runoff and to intercept and store some stormwater contaminants before reaching a receiving body of water. There are generally two types of ponds used, detention ponds and retention ponds. Detention ponds detain runoff for a period of time and then discharge the water into receiving surface waters. Retention ponds retain runoff and discharge the water through infiltration into the ground and evaporation. Both types of ponds may receive runoff from the drainage basin from ditches and pipes.

Pinellas County is in a relatively flat coastal area with poorly defined natural drainage. The county is 280 mi^2 in area and has 70 mi of shoreline (fig. 1). Rainfall averages about 52 in/yr, and on average, 10 in/yr of ground-water pumpage is imported from outside Pinellas County. Much of the wastewater plant effluent is sprayed on the land within the county. A large amount of runoff is channeled through a system of retention and detention ponds. The detention period in this system generally is short, and little is known of the effective-ness of ponds to capture and retain stormwater contaminants that may degrade the quality of inland and coastal waters in the county.

The U.S. Geological Survey, in cooperation with Pinellas County, conducted an investigation of the hydrogeology of three sites in and near stormwater detention ponds in the central part of the county, with an emphasis on water quality. The study was conducted between October 1986 and September 1989 and focused on infiltration characteristics of pond bottom sediments and contaminant loads in the water and bottom sediments of each pond.

Purpose and Scope

The purpose of this report is to describe the hydrogeology and water quality at and near three stormwater detention pond sites in Pinellas County. Samples of shallow ground water, pond water, and pond sediment were collected in September 1989 and analyzed for selected nutrients, trace elements, and organic compounds. At the onset of the study, it was assumed that the ponds would be discharging into the ground-water system, and by selecting ponds of different age, there would be striking contrasts in the chemistry and bottom sediments. The scope of the study changed when it became evident from analysis of the samples that valid conclusions about such contrasts could not be drawn using a single-event sampling approach.

Each pond site is described in detail, including physical setting, lithology, cation exchange capacity of underlying clay units, ground-water movement, ground-water quality, pond-water quality, and bottom-sediment quality. Water and sediment quality are compared with criteria established by the Florida Department of Environmental Regulation (FDER) and the U.S. Environmental Protection Agency (USEPA). Conclusions are drawn concerning the ecological effects of pond bottom sediment contamination.

Acknowledgments

The investigation of stormwater detention ponds was coordinated with Gene Jordan, Director of the Pinellas County Department of Public Works. Special appreciation is extended to Paul Dewey and Ferd Richter of the Department of Public Works for their assistance and support in supplying maps and for providing access to the stormwater detention pond areas.

Methods of Study

Three ponds, one each in the cities of Seminole, Clearwater, and Largo, were studied in collaboration with personnel of the Pinellas County Department of Public Works. The physical and hydrogeologic characteristics of each drainage basin were measured, and samples of the ground water, pond water, and pond bottom sediment were collected and analyzed. The physical characteristics determined for the pond sites included drainage basin topography, boundaries, land use, and pond bottom configurations. The average yearly rainfall for Pinellas County was applied to a rainfall-runoff regression model developed by Lopez and Giovannelli (1984, p. 56) to estimate stormwater runoff to the ponds.

Test holes were augered as deep as 38 ft to determine the lithology and thickness of the sands that constitute the surficial aquifer system and to obtain samples of clay from the underlying intermediate confining unit. A plastic casing and well screen were installed in each test hole to obtain a point measurement of the water table in the surficial aquifer system.

The observation well network at each site consists of about 30 wells that were drilled to depths that range from 12 to 38 ft and are within 2,000 ft of the pond. Core samples were collected from selected test holes during drilling and were analyzed for sediment particle size, porosity, hydraulic conductivity, clay mineralogy, and cation exchange capacity. These characteristics were used to define hydrogeologic units. An example of qualitative descriptors for these characteristics is as follows:

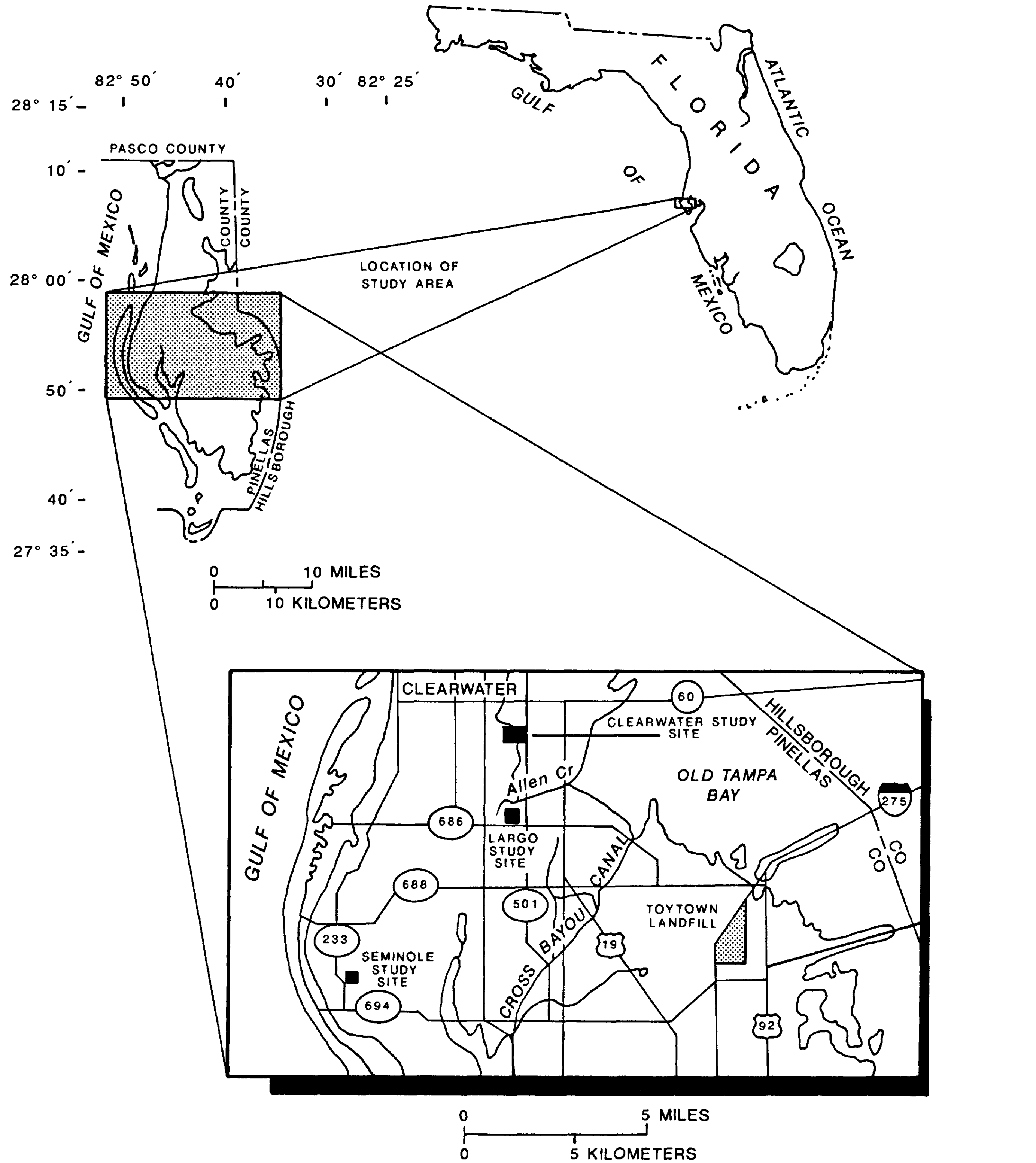


Figure 1. Locations of the three stormwater detention pond study sites.

	Hydrogeologic Unit	
	Surficial aaquifer system	Intermediate confining unit
Particle size	large	small
Porosity	low	high
Hydraulic conductivity	high	low
Cation exchange capacity	low	high

Drilling records were used to determine the thickness of the aquifer incised by the pond, the direction of ground-water movement in the vicinity of the pond, the hydraulic properties of the aquifer, and the contaminant adsorbing capacity of the intermediate confining unit. Water-table maps were used in conjunction with aquifer hydraulic properties to estimate the rate of lateral ground-water flow in the vicinity of each stormwater detention pond. If pond water is leaking to the aquifer, contaminants could be carried downgradient at a velocity calculated by Darcy's law, as follows:

$$V_h = K_h I/n_e, \qquad (1)$$

where,

V_h is horizontal velocity of flow through the surficial aquifer, in feet per day;

K_h is horizontal hydraulic conductivity of the aquifer, in feet per day, estimated from laboratory tests of vertical hydraulic conductivity of core samples;

I is horizontal hydraulic gradient, in feet per foot; and

n_e is effective porosity, dimensionless, estimated from laboratory tests of core samples.

Cation exchange was useful for estimating the adsorption capacity of the intermediate confining unit. The type of clay and its relative abundance controls the cation exchange capacity, which indicates the ability of the hydrogeologic unit to adsorb and hold many positively charged metal ions within the ground-water regime. The formula for estimating the adsorption capacity is:

$$A = C\,M\,D/F, \qquad (2)$$

where,

A is adsorption capacity of the intermediate confining unit, in kilograms per square meter;

C is cation exchange capacity, in milliequivalents per kilogram;

M is approximate thickness of intermediate confining unit, 3 meters;

D is approximate density of the intermediate confining unit, 2,640 kilograms per cubic meter;

F is factor for converting kilograms to milliequivalents (Hem, 1985, p. 56):

F_{NH4} is 55.4 meq/kg, where NH_4 is ammonium;

F_{Ca} is 49.9 meq/kg, where Ca is calcium;

F_K is 25.6 meq/kg, where K is potassium;

F_{Na} is 43.5 meq/kg, where Na is sodium.

Ground water surrounding the ponds, pond water, and pond bottom sediments were analyzed for inorganic constituents and organic compounds during September 1989. Specific conductance and pH were measured at the pond sites and samples were collected for analyses of nutrients and trace elements. Organic compounds analyzed included acid and base-neutral extractables, volatile organic compounds, chlorphenoxy acid herbicides, and organohalogen and organophosphorus insecticides. Bottom sediments were collected in the deepest part of each pond (based on the results of bathymetric surveys) and were analyzed for the same series of constituents as for ground water, with the exclusion of pH, specific conductance, and volatile organic compounds. Results of water analyses are described with regard to Florida ground-water guidance concentrations (Florida Department of Environmental Regulation, 1989). There are no State guidance concentrations for soil or bottom sediments (Dean Jackman, Florida Department of Environmental Regulation, oral commun., 1984); however, the interim USEPA sediment criteria were used to evaluate pond bottom sediments. These criteria are based on an equilibrium partitioning approach and are designed to indicate guideline values for selected organic compounds that may adversely affect benthic biota.

HYDROGEOLOGIC CONDITIONS AT DETENTION PONDS

The relatively young Seminole pond (1 year old) may provide background conditions for comparison of bottom sediments with those of the mature Clearwater (20 years old) and Largo (30 years old) ponds, both of which may show the effects of many years of accumulation of trace elements and manmade organic compounds. The drainage basins for the Seminole and Clearwater ponds are in residential areas, whereas the Largo pond is adjacent to a commercial area. The locations of the three stormwater detention pond study sites are shown in figure 1.

Two geologic units were identified during test drilling. Pleistocene deposits of sand and organic material, about 10 to 40 ft thick, comprise the surficial aquifer system. About 20 ft of clay within the Hawthorn Group of Tertiary age, as defined by Scott (1988), underlies the surficial aquifer system. The clay has a relatively low permeability compared to the sand and comprises an intermediate confining unit between the surficial and underlying Floridan aquifer systems.

Seminole Site

The Seminole pond is in west-central Seminole near 94th Avenue North and 134th Street North (fig. 2). The pond is about 1 mi from the Gulf of Mexico in a gently sloping area and is about 50 ft above sea level. Land-surface altitude of the drainage area near the pond ranges from 55 to 60 ft above sea level (fig. 2). The pond measures 500 ft by 500 ft (5.7 acres) and is designed to detain a 100-year storm. The surface area of the pond is about one-fifteenth of its drainage basin. A bathymetric survey of the pond indicated an average depth of about 5 ft and a maximum depth of 6 ft near the middle and western side.

The drainage basin is about 83 acres in size and is comprised of low-density residential areas north and south of the pond (fig.2). Stormwater runoff drains through pipes entering the northwest and southwest corners of the pond. The soils of the drainage area are of the Immokolee and Myakka series, which are nearly level, poorly drained, sandy soils (U.S. Department of Agriculture, 1972).

Descriptions of core samples from two test holes 1,500 ft apart at the Seminole pond are listed in table 1. The surficial aquifer system is composed of very fine- to very coarse-grained sand that increases in silt content with depth. The porosity of the sand sample is about 35 percent. The sample collected from the test hole at well Sem 2 at the 36.8- to 37.1-ft depth seems to represent the gradation from sand of the surficial aquifer system to clay of the intermediate confining unit. The sample is 48 percent sand, 10 percent silt, and 42 percent clay (smectite is the dominant clay mineral). The hydraulic conductivity value of 0.7 ft/d is characteristic of sandy clay. The cation exchange capacity of 83 meq/kg is similar to the median value of 88 meq/kg for montmorillonite clay reported by Hutchinson and Stewart (1978) for 12 samples from the intermediate confining unit in Pinellas County. The potential adsorption capacity of the intermediate confining unit, based on the cation exchange capacity of the clayey sand sample, is 12 kg/m^2, or 53 tons per acre, of NH_4.

The configuration of the water table at the Seminole pond for September 1987 is shown in figure 3. In wells within 1,500 ft of the detention pond, water levels ranged from 41.0 to 56.1 ft above sea level. Flow lines superimposed on the water-table map indicate a general movement of ground water from east to west. Although some ground water is intercepted by the pond, which has a surface stage about 1 ft below the surrounding water table, this water drains out of the pond to the west. The westward slope of the water table also indicates that water may leak out of the pond into the surficial aquifer system. Water levels in wells within 1,500 ft of the detention pond were lower in May 1988 and ranged from 38.8 to 55.7 ft above sea level. Water levels in 21 wells were measured in both September and May; changes in water levels ranged from a rise of 0.4 ft (well 19) to a decline of 2.7 ft (well 2). The average change during this period was a decline of 0.8 ft. The estimated velocity of ground-water flow toward the pond from the east, calculated using equation 1, is about 0.4 ft/d, or 150 ft/yr, based on a water-table gradient of 0.007 ft/ft, porosity of 0.35, and an estimated hydraulic conductivity for fine to medium sand of 20 ft/d.

Clearwater Site

The Clearwater pond, near Lakeview Avenue and Hercules Avenue in central Clearwater, is about 2 mi west of Old Tampa Bay (fig. 1). The pond, bordered on the north and east by Allen Creek, is in a topographic depression. Land-surface altitude at the pond is about 15 ft above sea level (fig. 4). The drainage basin is about 20 acres in size and much of the soil is imported fill material.

The detention pond is 150 ft wide and 900 ft long. The drainage basin area is about 23 acres, or about 7.5 times the area of the pond. Stormwater runoff from low-density residential areas enters the

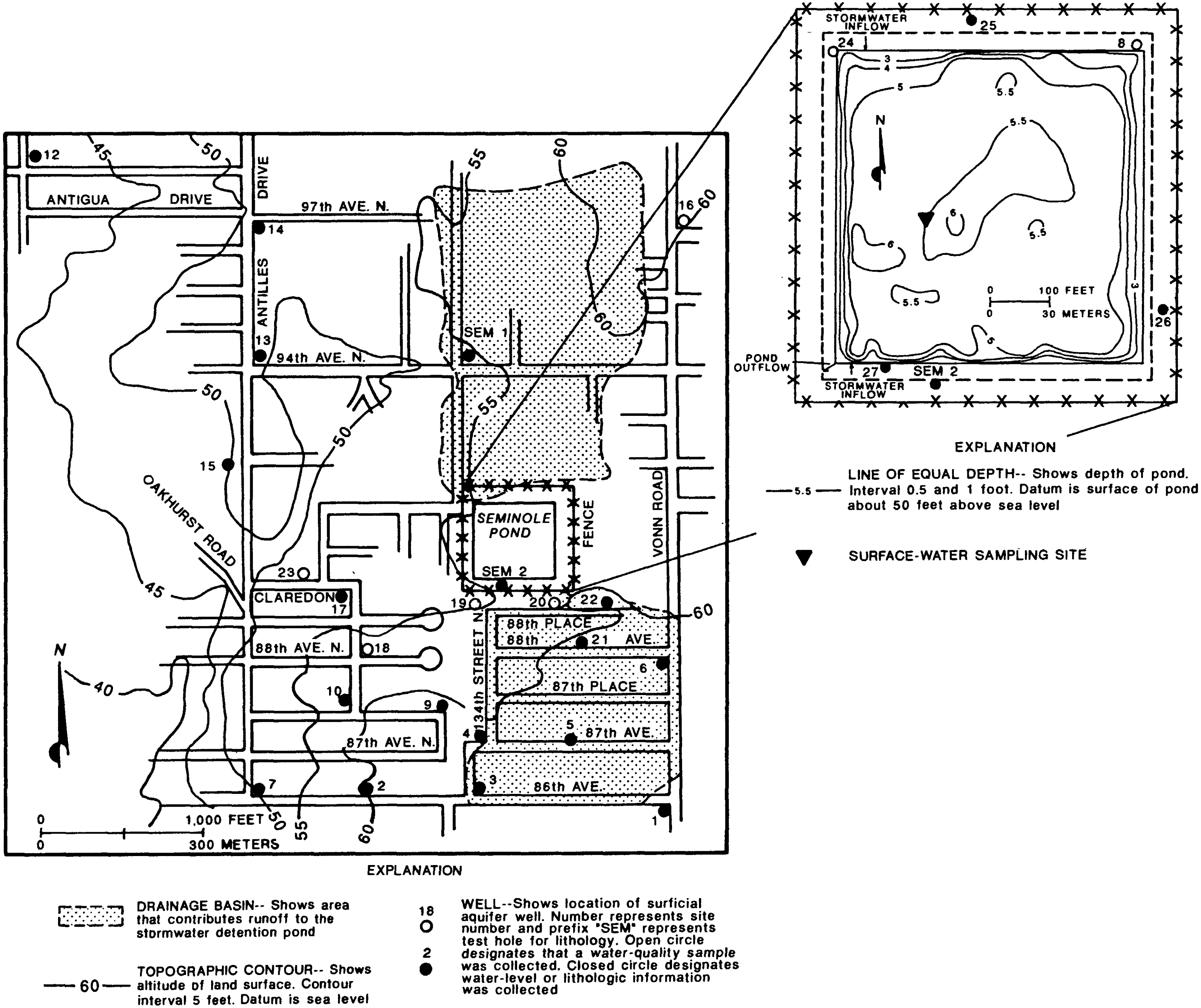


Figure 2. Location of the Seminole stormwater detention pond and hydrologic data-collection network.

Table 1. Lithology and core test results for two test holes at the Seminole stormwater detention pond

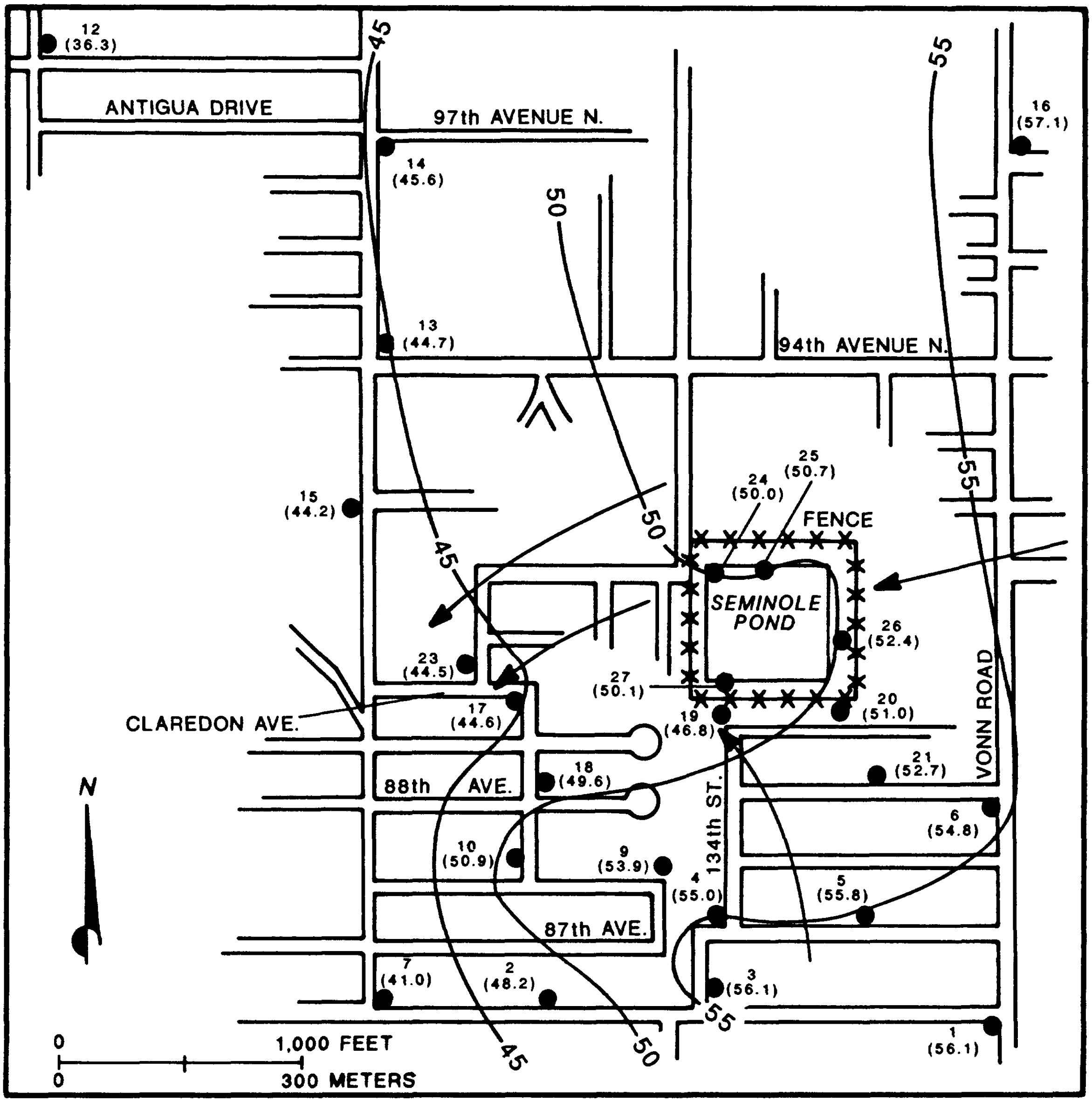
[ft, feet; ft/d, feet per day; meq/kg, milliequivalent per kilogram; , µmicron; ---, no data; >, greater than; <, less than. Locations of wells are shown in fig. 2]

Lithology

Depth below land surface (ft)	Description	Hydrogeologic unit
	Test hole Sem 1	
0-2	Sand, medium to coarse, black to dark brown	Surficial aquifer system
2-14	Sand, silty, fine to medium, black, light to gray brown organics	
14-23	Sand, very fine to fine, brown, with organic silt	
23-27	Sand, coarse, light brown, silty red-brown formation fluid, black organic particulates	
27-29	Sand, increasing silt, dark gray to black	
29-31	Sand, silty to very fine sand, light to dark brown	
31-33	Clay, blue gray, with decreasing black silty sand	Intermediate confining unit
	Test hole Sem 2	
0-6	Sand, very fine to medium, black, organic	Surficial aquifer system
6-12	Sand, very fine to medium, brown, with organic silt, organic particulates	
12-14	Sand, very fine to medium, dark brown, possible hardpan	
14-16	Sand, very fine to medium, dark brown	
16-18	Sand, very fine with scattered coarse grains, brown	
18-30	Sand, very fine with scattered coarse grains, brown to dark brown, with organic silt	
30-32	Sand, very fine, brown, silty, clayey, dark gray-blue	
32-34	Backfill from up above, runny sand	
34-38	Sand, clayey, very coarse, phosphatic	
38	Clay, sandy, gray, very fine sand	Intermediate confining unit

Core test results for test hole Sem 2

Core depth below land surface (ft)	Particle size (percent)			Porosity, total (percent)	Vertical hydraulic conductivity (ft/d)	Cation exchange capacity (meq/kg)	Mineralogy of clay fraction less than 2 µ (percent)			
	Sand	Silt	Clay				>50	25-50	10-25	Trace
2.8-3.1	97.06	2.67	0.27	38.9	16.1	5	---	---	---	---
14.3-14.6	99.89	--	.19	43.2	34.0	14	---	---	---	---
16.4-16.7	99.74	--	.26	35.9	42.5	19	---	---	---	---
24.5-24.8	99.81	--	.20	36.8	8.3	12	---	---	---	---
36.8-37.1	47.89	9.59	42.56	64.9	.7	83	Smectite	Palygorskite	Sepiolite	Francolite Kaolinite



EXPLANATION

—50— WATER-TABLE CONTOUR-- Shows altitude of water table. Contour interval 5 feet. Datum is sea level

◄—— DIRECTION OF GROUND-WATER FLOW

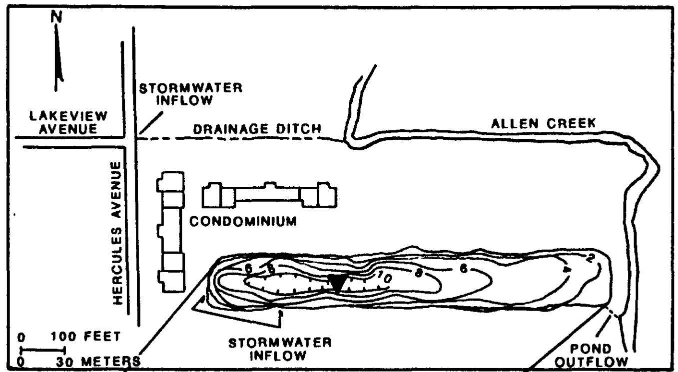
2 (48.2) ● WELL — OBSERVATION POINT-- Shows location of site with water-level measurement. Number is site number. Number in parentheses is altitude of water table, in feet above sea level

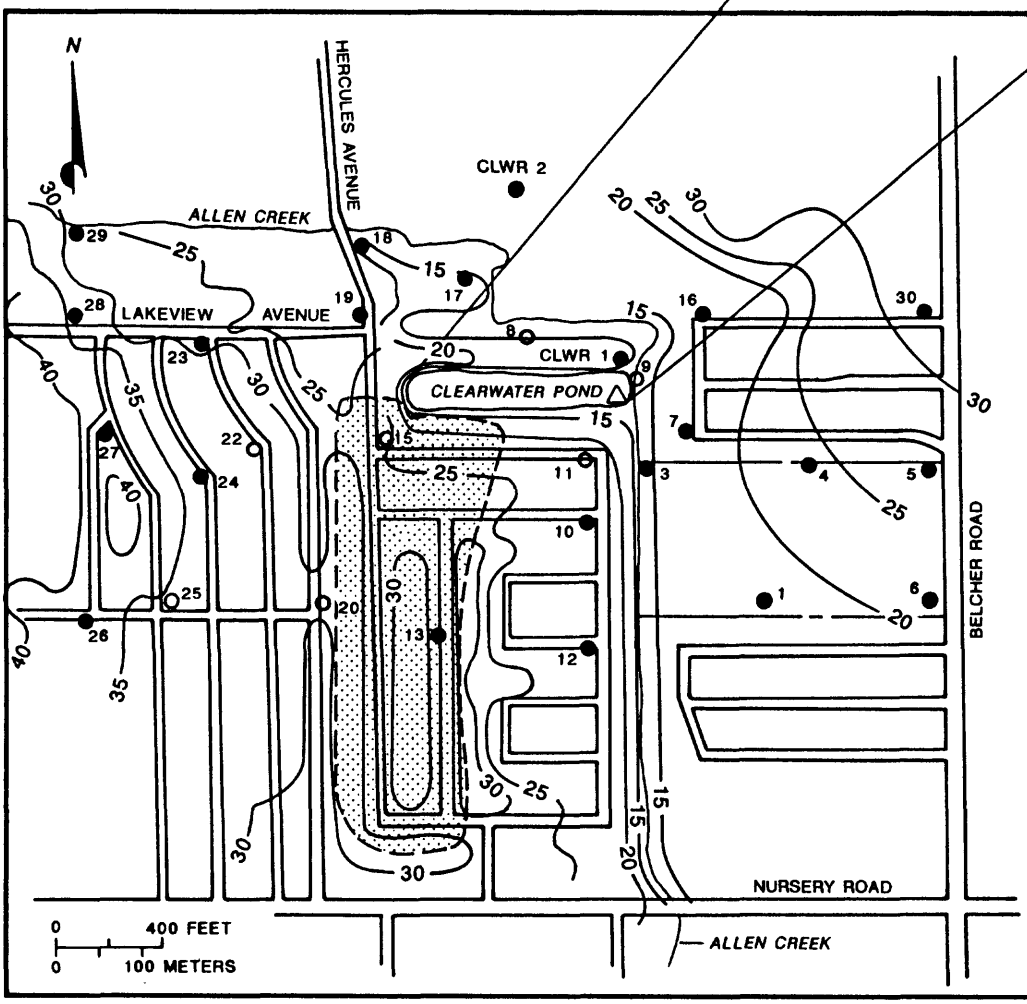
Figure 3. Water table in the surficial aquifer system and generalized direction of ground-water flow at and near the Seminole stromwater detention pond, September 1987.

EXPLANATION

——10—— LINE OF EQUAL DEPTH-- Shows depth of pond. Interval 2 feet. Datum is surface of pond, about 13 feet above sea level

▼ SURFACE-WATER SAMPLING SITE





EXPLANATION

DRAINAGE BASIN-- Shows area that contributes runoff to the stormwater detention pond

—30— TOPOGRAPHIC CONTOUR-- Shows altitude of land surface. Contour interval 5 feet. Datum is sea level

22 O / 12 ● WELL-- Shows location of surficial aquifer well. Number represents site number and prefix "CLRW" represents test hole for lithology. Open circle designates that a water-quality sample was collected. Closed circle designates water-level or lithologic information was collected

△ STAFF GAGE

Figure 4. Location of the Clearwater stormwater detention pond and hydrologic data-collection network.

pond through pipes in the southwest and west shores. The pond was originally a borrow pit used during the construction of nearby condominiums in the early 1970's. The present pond is a continuation of the old excavation and has an outflow to Allen Creek at the southeast corner. A bathymetric survey of the pond indicated an average depth of about 7 ft and a maximum depth of more than 10 ft attained almost entirely in the western half of the pond (fig. 4).

Descriptions of core samples from two test holes 800 ft apart at the Clearwater pond are listed in table 2. The upper 4 to 5 ft of material contains concrete, indicating rubble fill. Underlying this is a 4-ft-thick peat layer, which probably indicates that the filled area was once a swamp. These two upper layers and an underlying 2-ft-thick, very fine to coarse sand layer comprise the surficial aquifer system, which is about 10 ft thick. The porosity of the peat is about 50 percent and the sand about 40 percent. The sample from 14.7 to 14.9 ft is about 80 percent smectite clay. The porosity of the clay is 35.9 percent and is lower than that for the sandy clay core sample below the Seminole and Largo ponds. The vertical hydraulic conductivity value of 3.0 ft/d for the clay sample is uncharacteristically high. The expected value would be one or two orders of magnitude lower than the hydraulic conductivity of sand. An examination of the core sample by laboratory personnel showed fractures where fluid flow was possible. The cation adsorbing potential of the intermediate confining unit, calculated using equation 2, based on a cation exchange capacity of 394 meq/kg, is 56 kg/m^2, or 250 tons per acre of NH_4.

The configuration of the water table at the Clearwater pond in September 1987 is shown in figure 5. Levels ranged from 13.3 to 34.6 ft above sea level. Flow lines superimposed on the water-table map show a general direction of ground-water flow from the west toward the detention pond where the pond stage was 13.3 ft and toward Allen Creek. Ground water also flows toward Allen Creek from the east. Water-table levels were similar in May 1988 and ranged from 12.6 to 33.8 ft above sea level. Water-level changes in 24 wells measured in both September and May ranged from a rise of 1.5 ft (well 3) to a decline of 5.7 ft (well 4). The average change was a net decline of 1.2 ft between September and May. The pond stage was 12.5 ft in May 1988, which represents a 0.9-ft decline since September 1987. The velocity of ground-water flow toward the pond in a 1,000-ft-wide band west of the pond was 0.6 ft/d, or 200 ft/yr, based on a water-table gradient of 0.01 ft/ft, porosity of 0.35, and hydraulic conductivity of 20 ft/d.

Largo Site

The Largo pond is about 2 mi west of Old Tampa Bay (fig. 1) and is about 30 years old. The pond is about 10 ft above sea level, and the land-surface altitude of the surrounding area is about 15 ft above sea level (fig. 6). Most surficial sand in the drainage basin is artificial fill. The drainage basin is about 47 acres in size, and the detention pond is 100 ft wide and 1,000 ft long. The drainage basin area is about 20 times larger than the area of the pond, which is about 2.3 acres. The pond receives runoff from medium-density residential areas of apartments and condominiums on the east and west sides. A heavily traveled commercial area borders the basin on the south along East Bay Drive (fig. 6), but does not contribute runoff to the pond. Stormwater runoff enters the pond through pipes along the east and west banks. It is a wet pond (excavated below the water table) and discharges on the north end through a series of connecting ditches into Allen Creek upstream from U.S. Highway 19 (fig. 1). Results of a bathymetric survey indicate that the average depth of the pond is about 8 ft and that the greatest depth is about 10 ft near the discharge point.

Descriptions of core samples from two test holes 2,300 ft apart at the Largo pond are listed in table 3. At the Largo 1 test hole (fig. 6), augering continued to a depth of 18 ft where a chert bed was encountered. This bed was not present at the Largo 3 test hole where drilling continued to a depth of 26 ft where clay of the intermediate confining unit was encountered. The surficial aquifer system samples generally have a porosity of about 30 percent. The sample from 24.8 to 25.0 ft in well Largo 3 seems to represent the gradation from sand of the surficial aquifer system to clay of the intermediate confining unit. The sample is 45 percent sand, 6 percent silt, and 49 percent clay (kaolinite is the dominant clay mineral). The cation adsorbing potential of the intermediate confining unit, calculated using equation 2, based on a cation exchange capacity of 125 meq/kg, is 18 kg/m^2, or 80 tons per acre of NH_2.

The configuration of the water table at the Largo pond in September 1987 is shown in figure 7. Water levels ranged from 5.1 to 16.9 ft above sea level. Flow pathlines superimposed on the water-

Table 2. Lithology and core test results for two test holes at the Clearwater stormwater detention pond

[ft, feet; ft/d, feet per day; meq/kg, milliequivalent per kilogram; μ, micron; ---, no data; >, greater than; <, less than. Locations of wells are shown in fig. 4]

Lithology

Depth below land surface (ft)	Description	Hydrogeologic unit
	Test hole Clwr 1	
0-4	Sand, fill, peat and concrete fine to medium, cobble-sized concrete	Surficial aquifer system
4-8	Peat, black to dark brown, organic	
8-10	Sand, gray, clean, poorly sorted, very fine to coarse	
10-11	Clay, light brown to blue, some sand	Intermediate confining unit
11-16	Clay, light blue, almost pure plastic	
	Test hole Clwr 2	
0-5	Sand, fill, peat and concrete fine to medium, cobble-sized concrete	Surficial aquifer system
5-7	Peat, black to dark brown, well sorted, fine to medium	
7-9	Peat, sandy to sand with peat, brown, well sorted	
9-11	Sand, brown, very fine to medium	
11-12	Clay, blue, cohesive, some very fine sand	Intermediate confining unit

Core test results for test hole Clwr 1

Core depth below land surface (ft)	Particle size (percent)			Porosity, total (percent)	Vertical hydraulic conductivity (ft/d)	Cation exchange capacity (meq/kg)	Mineralogy of clay fraction less than 2 μ (percent)			
	Sand	Silt	Clay				>50	25-50	10-25	Trace
5.5-5.7	95.74	3.75	0.71	50.5	1.3	[1]143	---	---	---	---
10.8-11.0	96.77	1.18	2.05	39.6	<0.5	75	Smectite	---	---	Illite
14.7-14.9	5.87	12.56	81.57	35.9	[2]3.0	394	Smectite	---	---	Illite Quartz

[1] Small percentage of clays was detected. The sample contained abundant organic colloidal materials that contribute to the high cation exchange capacity.

[2] Flow appeared to be through fractures in the clay. The fractures were not due to sample handling.

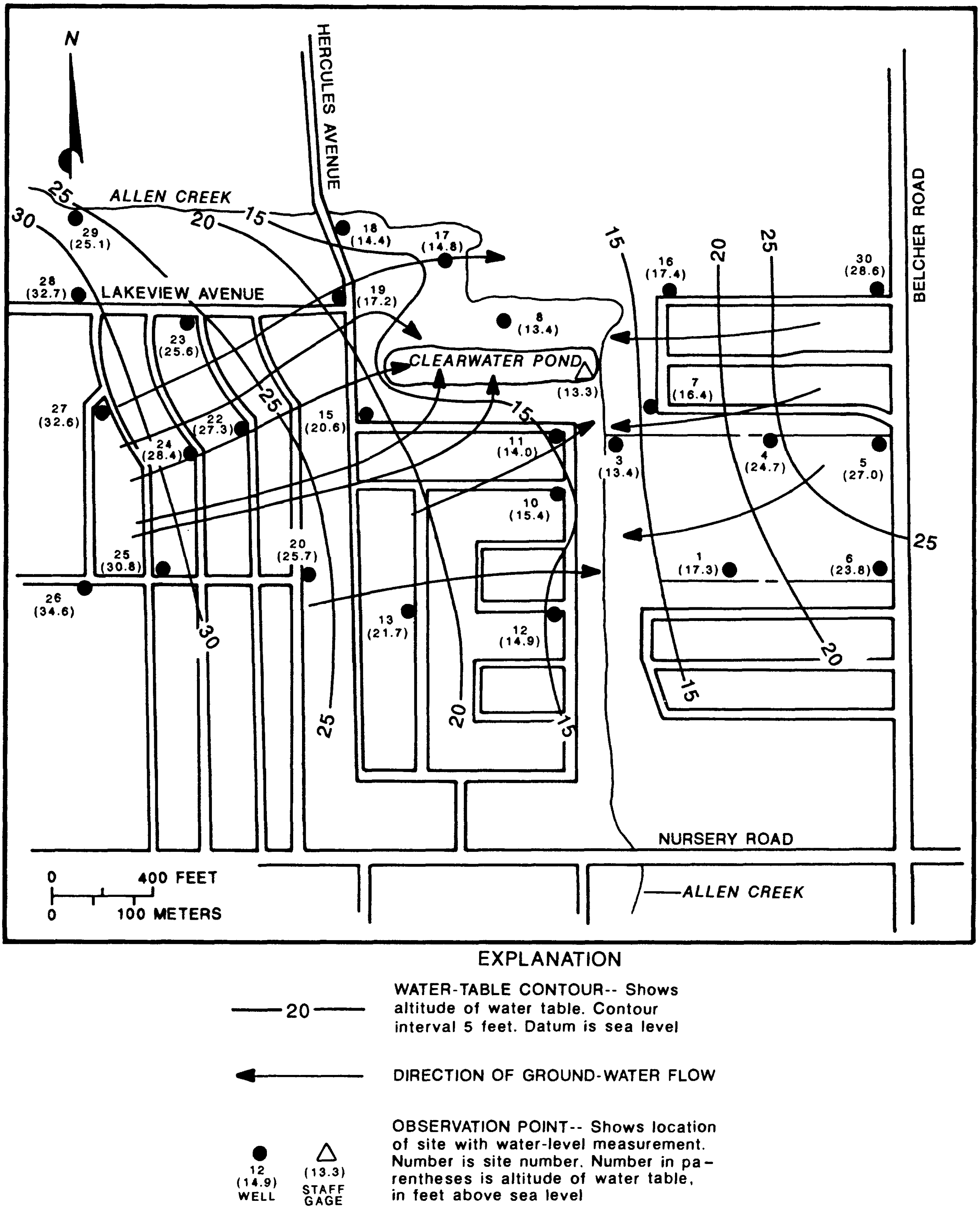


Figure 5. Water table in the surficial aquifer system and generalized direction of ground-water flow at and near the Clearwater stormwater detention pond, September 1987.

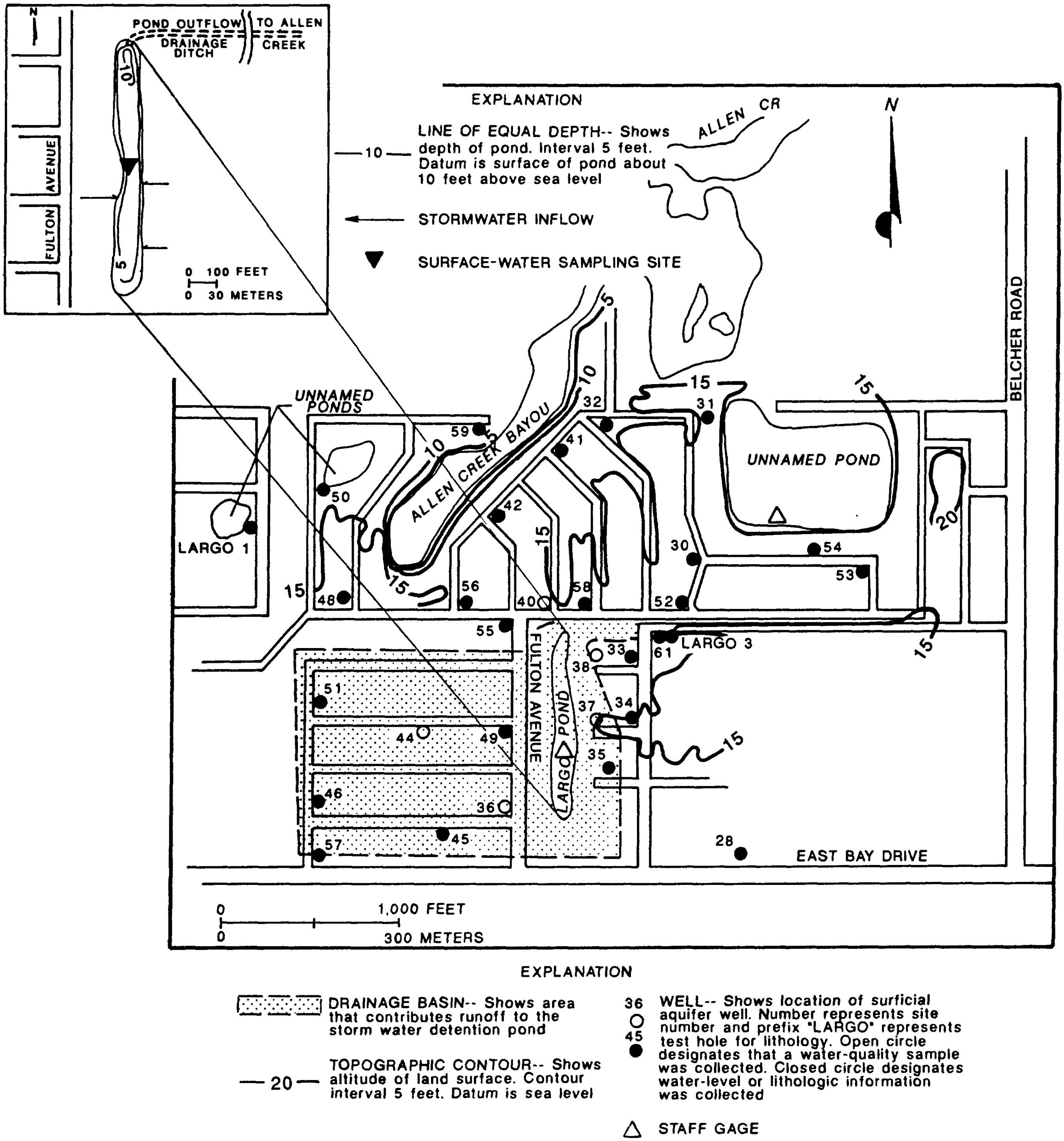


Figure 6. Location of the Largo stormwater detention pond and hydrologic data-collection network.

Table 3. Lithology and core test results for two test holes at the Largo stormwater detention pond

[ft, feet; ft/d, feet per day; meq/kg, milliequivalent per kilogram; µ, micron; ---, no data; >, greater than; <, less than. Locations of wells are shown in fig. 6]

Lithology

Depth below land surface (ft)	Description	Hydrogeologic unit
	Test hole Largo 1	
0-2	Sand, very fine to scattered coarse, black to gray	Surficial aquifer system
2-4	Sand, very fine to coarse, gray, with increasing organics, peat, black to dark brown	
4-6	Peat with sand, very fine to coarse	
6-8	Sand, coarse to fine with increasing clay, fine light gray-brown	
8-14	No recovery, wet, runny	
14-18	Sand, very fine to scattered coarse, light gray-brown with clayey sand, light brown	
18	Chert, cannot penetrate	
	Test hole Largo 3	
0-4	Sand, very fine to fine, dark brown grading to white	Surficial aquifer system
4-6	Sand, silty, very fine to fine	
6-19	Sand, very fine to fine, very light brown to dark brown, root material	
19-23	Sand, very fine to fine, white	
23-24	Sand, clayey, very fine to fine, light brown-gray	
24-26	Clay, sandy, medium gray with decreasing sand to light-brown clay, almost pure plastic	Intermediate confining unit

Core test results for test hole Largo 3

Core depth below land surface (ft)	Particle size (percent)			Porosity, total (percent)	Vertical hydraulic conductivity (ft/d)	Cation exchange capacity (meq/kg)	Mineralogy of clay fraction less than 2 µ (percent)			
	Sand	Silt	Clay				>50	25-50	10-25	Trace
11.9-12.2	94.5	1.4	4.1	32.5	1.9	111	Smectite	---	Kaolinite	Gibbsite, Illite
13.8-14.1	96.5	1.1	2.4	34.8	.6	43	Kaolinite	Smectite	H.I.C.[1]	---
15.2-15.5	89.2	2.1	8.6	25.5	.6	49	Smectite	---	H.I.C.[1]	Illite Kaolinite
15.6-15.8	98.9	.3	.8	34.5	20.7	16	Kaolinite	---	Gibbsite	Smectite
24.8-25.0	44.8	5.8	49.5	61.9	---	125	Illite	Smectite	Kaolinite	Francolite

[1]An aluminum hydroxide interlayered clay (Smectite) that does not fully collapse upon heating.

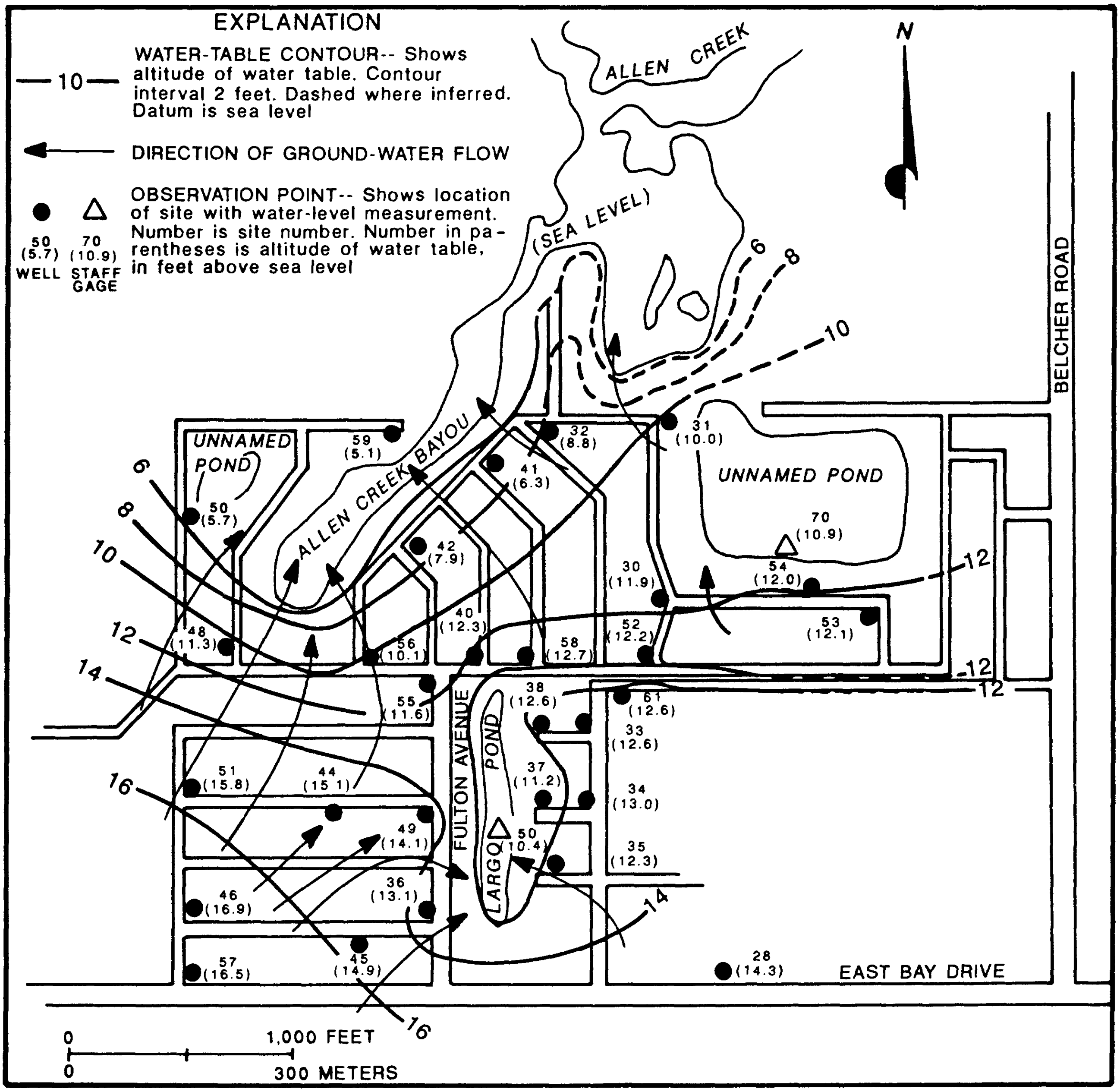


Figure 7. Water table in the surficial aquifer system and generalized direction of ground-water flow at and near the Largo stormwater detention pond, September 1987.

table map show a general movement of ground water from the south toward the detention pond, in which the water level was 10.4 ft above sea level. Surface-water discharge, through a ditch at the north end of the pond, is to Allen Creek. The water-table configuration in May 1988 was lower than in September 1987. Water levels ranged from 4.5 to 15.6 ft above sea level. Water-level changes in 25 wells measured in September 1987 and May 1988 ranged from a rise of 0.5 ft (well 49A) to a decline of 1.9 ft (well 49). The average change was a decline of 0.9 ft between September and May. The pond stage was 9.8 ft above sea level in May 1988, which was 1.1 ft lower than the previous September. The velocity of ground-water flow to the pond from the southwest, calculated using equation 1, was 0.2 ft/d, or 80 ft/yr, based on an average water-table gradient of 0.004 ft/ft, porosity of 0.35, and estimated hydraulic conductivity of 20 ft/d.

QUALITY OF WATER AND BOTTOM SEDIMENTS AT DETENTION PONDS

Water and bottom-sediment samples were collected to evaluate the background quality of water and sediments at the three detention ponds, as well as that of the surrounding ground water. Results of this September 1989 reconnaissance sampling are used to describe the ambient quality of the hydrogeologic system, to make comparisons among ponds, and to make comparisons between ground water and pond water and pond bottom sediments at each site.

Results of the laboratory analyses of water and bottom-sediment samples are presented and discussed in this section. Tables 4 through 6 list the chemical quality of pond water and ground water withdrawn from as many as seven wells at the Seminole, Clearwater, and Largo study sites and presents a comparison of the values with the Florida Department of Environmental Regulation (1989) guidance concentrations. The quality of bottom sediments at each pond is shown in table 7. Concentrations of organic compounds are presented only for those compounds that had concentrations above detection limits; otherwise, the results are summarized according to category and are reported as below detection limits (BDL). The findings are presented according to study site, source of the samples, and the grouping of inorganic constituents and organic compounds. The appendix lists for reference the organic compounds and detection limits of the laboratory analyses for all the water and bottom-sediment analyses performed for this study.

Seminole Site

Water samples from the Seminole pond, wells 8 and 24 next to the pond, and five wells (16, 18, 19, 20, and 23; fig. 2) in the residential area near the pond (fig. 2) were analyzed for nutrients, trace elements, and organic compounds (table 4). There were slight differences between the quality of water from wells next to the pond and the quality of water from wells south and west of the pond. Specific conductance of the seven samples ranged from 140 to 410 µS/cm. Residential area wells 19 and 23 had the slightly higher specific-conductance levels. Organic-nitrogen concentrations in samples from wells next to the pond averaged 9.0 mg/L and ranged from 0.35 to 20 mg/L in water from wells outside the pond area. The high concentrations of organic-nitrogen and ammonia-nitrogen in the sample from well 19 may reflect the effects of residential lawn and garden fertilization. The concentrations of trace elements in ground water next to the pond and in the residential area were low and were below FDER guidance concentrations. One volatile organic compound, xylene, was measured in water samples collected from wells 8 and 24 in concentrations of 7 and 6 µg/L, respectively. These concentrations are below the FDER guidance concentration of 50 µg/L and are near the detection limit of 3 µg/L.

A surface-water sample was collected 100 ft from the west bank of the pond (fig. 2). Except for an organic-nitrogen concentration of 1.2 mg/L, the nutrients and trace elements in the sample were mostly near detection limits. The sample contained no detectable extractable organic compounds, volatile organic compounds, or herbicides. The organophosphorus compound diazinon, however, was detected at a concentration of 0.03 µg/L, but was below the FDER guidance concentration. Malathion also was detected. Concentrations of organic compounds in the pond water generally were lower than those in water from the surficial aquifer, which indicates the water at the time of sampling was surface runoff rather than intercepted ground water.

Table 4. Nutrients, trace elements, and organic compounds in ground water and pond water at the Seminole site, September 1989

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; BDL, below detection limits; ---, no data; <, less than. Locations of sampling sites are shown in fig. 2]

Constituents, compounds, and physical properties	Guidance concentration[1]	Well number 8	16	18	19	20	23	24	Pond water
Specific conductance (µS/cm)	---	293	140	220	410	230	370	285	---
pH (units)	6.5-8.5	5.0	5.3	5.7	5.5	5.9	5.5	3.9	---
Nutrients									
Nitrogen, organic, total (mg/L)	---	[2]11	.70	[2]1	[2]20	[2]4.0	.35	[2]7.0	1.2
Nitrogen, as ammonia, total (mg/L)	---	[2]2.2	.50	[2].02	[2]19	[2].15	.13	[2].28	.01
Nitrogen, as nitrite, total (mg/L)	1	< .01	.02	< .01	[2].04	< .01	< .01	[2].17	< .01
Nitrogen, as nitrate, total (mg/L)	10	< .01	.00	.01	---	< .01	< .01	< .01	< .01
Phosphorus, as P, total (mg/L)	---	[2]30	.15	[2]1.8	[2]13	[2]12	.13	[2]3.3	.05
Trace elements									
Arsenic, total (µg/L)	50	3	<1	<1	2	1	<1	1	<1
Cadmium, total (µg/L)	10	1	1	<1	<1	1	<1	1	1
Chromium, total (µg/L)	50	<1	<1	<1	<1	<1	<1	<1	<1
Copper, total (µg/L)	1,000	4	2	3	5	10	1	20	<5
Lead, total (µg/L)	50	---	<5	5	15	24	<5	---	< .1
Mercury, total (µg/L)	2	[2].3	< .1	.5	[2]2.4	2	< .10	[2]2.2	.1
Selenium, total (µg/L)	10	5	<1	<1	<1	<1	<1	<1	<1
Silver, total (µg/L)	50	<1	<1	<1	<1	<1	1	<1	<1
Zinc, total (µg/L)	5,000	10	10	20	90	10	30	<10	<10
Organic compounds									
Extractables									
Acid and base-neutral	---	---	---	---	---	BDL	BDL	---	BDL
Volatiles									
Xylene (µg/L)	50	7	BDL	BDL	BDL	BDL	BDL	6	BDL
Herbicides									
Chlorophenoxy acids	---	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Insecticides									
Organohalogen	---	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Organophosphorus									
Diazinon (µg/L)	10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	.03
Malathion (µg/L)	---	BDL	BDL	BDL	BDL	BDL	BDL	BDL	.10

[1]Florida ground-water guidance concentrations (Florida Department of Environmental Regulation, 1989).

[2]Based on a non-ideal sample that may have been clouded with particulates.

Table 5. Nutrients, trace elements, and organic compounds in ground water and pond water at the Clearwater site, September 1989

[μS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; μg/L, micrograms per liter; BDL, below detection limits; ---, no data; <, less than. Locations of sampling sites are shown in fig. 4]

Constituents, compounds, and physical properties	Guidance concentration[1]	Well number 8	9	11	15	20	22[2]	25	Pond Water
Specific conductance (μS/cm)	---	260	340	600	610	280	820	550	---
pH (units)	6.5-8.5	5.8	5.6	6.0	6.6	5.5	6.3	6.1	---
Nutrients									
Nitrogen, organic, total (mg/L)	---	1.0	1.6	.80	.92	.63	9.4	3.6	0.07
Nitrogen, as ammonia, total (mg/L)	---	.27	.82	.08	.06	.57	1.6	.76	1.3
Nitrogen, as nitrite, total (mg/L)	1	.02	.04	.02	< .01	< .01	.01	< .01	< .01
Nitrogen, as nitrate, total (mg/L)	10	.01	.03	2.08	< .01	< .01	.01	< .01	< .01
Phosphorus, as P, total (mg/L)	---	7.8	.26	.66	5.8	1.1	17	.8	.27
Trace elements									
Arsenic, total (μg/L)	50	6	<1	1	2	1	<1	2	1
Cadmium, total (μg/L)	10	3	1	<1	1	<1	<1	1	<1
Chromium, total (μg/L)	50	<1	<1	3	<1	6	<1	20	<1
Copper, total (μg/L)	1,000	30	2	3	6	4	3	9	2
Lead, total (μg/L)	50	---	---	---	---	---	---	---	<5
Mercury, total (μg/L)	2	.60	.20	.1	.50	< .1	.10	< .1	< .1
Selenium, total (μg/L)	10	1	<1	<1	<1	<1	<1	<1	<1
Silver, total (μg/L)	50	<1	<1	1	1	<1	<1	<1	<10
Zinc, total (μg/L)	5,000	20	10	50	20	10	10	60	<10
Organic compounds									
Extractables									
Acid and base-neutral									
Acenaphthlene (μg/L)	20	BDL	23	BDL	BDL	BDL	BDL	---	BDL
Fluorene (μg/L)	10	BDL	26	BDL	BDL	BDL	BDL	---	BDL
Volatiles	---	BDL	BDL	BDL	BDL	BDL	BDL	---	BDL
Herbicides									
Chlorophenoxy acids	---	BDL	BDL	BDL	BDL	BDL	BDL	---	BDL
Insecticides									
Organohalogen									
Heptachlor epoxide (μg/L)	.1	BDL	BDL	BDL	.03	BDL	BDL	---	BDL
Organophosphorus									
Diazinon (μg/L)	10	BDL	BDL	.11	BDL	BDL	BDL	---	.12
Malathion (μg/L)	---	BDL	BDL	BDL	BDL	BDL	BDL	---	.15

[1]Florida ground-water guidance concentrations (Florida Department of Environmental Regulation, 1989).

[2]Based on a non-ideal sample that may have been clouded with particulates.

Table 6. Nutrients, trace elements, and organic compounds in ground water and pond water at the Largo site, September 1989

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; BDL, below detection limits; ---, no data; <, less than. Locations of sampling sites are shown in fig. 6]

Constituents, compounds, and physical properties	Guidance concentration[1]	Well number 36	37[2]	38[2]	40	42	44	Pond water
Specific conductance (µS/cm)	---	595	650	295	---	355	---	---
pH (units)	6.5-8.5	7.3	6.8	5.7	---	6.1	5.3	---
Nutrients								
Nitrogen, organic, total (mg/L)	---	.81	62	56	0.42	.82	.15	1.2
Nitrogen, as ammonia, total (mg/L)	---	.09	.37	.44	.68	.98	1.8	.01
Nitrogen, as nitrite, total (mg/L)	1	.01	.01	.11	.01	< .01	.02	< .01
Nitrogen, as nitrate, total (mg/L)	10	.03	.01	.01	< .01	< .01	.01	< .01
Phosphorus, as P, total (mg/L)	---	.62	160	79	.77	2.0	1.8	.05
Trace elements								
Arsenic, total (µg/L)	50	9	10	15	11	2	8	<1
Cadmium, total (µg/L)	10	4	1	<1	1	1	1	1
Chromium, total (µg/L)	50	6	60	<1	2	10	<1	<1
Copper, total (µg/L)	1,000	50	60	110	1	2	1	1
Lead, total (µg/L)	50	---	---	---	---	---	---	<5
Mercury, total (µg/L)	2	< .1	< .10	.60	< .10	< .10	< .10	< .1
Selenium, total (µg/L)	10	5	2	2	<1	<1	<1	<1
Silver, total (µg/L)	50	2	1	<1	1	<1	<1	<1
Zinc, total (µg/L)	5,000	290	240	180	10	<10	<10	<10
Organic compounds								
Extractables								
Acid and base-neutral	---	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Volatiles								
Chloroform (µg/L)	100	BDL	BDL	9.4	BDL	BDL	BDL	BDL
Herbicides								
Chlorophenoxy acids	---	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Insecticides								
Organohalogen								
Chlordane (µg/L)	.1	BDL	BDL	BDL	.1	BDL	BDL	BDL
Organophosphorus								
Diazinon (µg/L)	10	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Malathion ((µg/L)	---	BDL	BDL	BDL	BDL	BDL	BDL	.01

[1]Florida ground-water guidance concentrations (Florida Department of Environmental Regulation, 1989).

[2]Based on a non-ideal sample that may have been clouded with particulates.

Table 7. Nutrients, trace elements, and organic compounds in pond bottom-sediment samples, September 1989

[mg/kg, milligrams per kilogram; µg/g, micrograms per gram; BDL, below detection limits; ---, no data; <, less than]

Constituents and compounds	Seminole pond	Clearwater pond	Largo pond
Nutrients			
Nitrogen, organic plus ammonia, total (mg/kg)	520	9,100	13,000
Nitrogen, as ammonia, total (mg/kg)	15	2.5	50
Phosphorus, as P, total (mg/kg)	130	1,500	2,300
Trace elements			
Arsenic, total (µg/g)	1	2	3
Cadmium, total (µg/g)	.1	3	5
Chromium, total (µg/g)	80	360	420
Cobalt, total (µg/g)	<50	<50	<50
Copper, total (µg/g)	1	30	50
Iron, total (µg/g)	230	7,300	16,000
Lead, total (µg/g)	<10	400	480
Mercury, total (µg/g)	< .1	< .1	< .13
Zinc, total (µg/g)	<10	200	390
Organic compounds			
Extractables			
Acid and base-neutral			
Acenaphthene (µg/g)	BDL	---	50
Anthracene (µg/g)	BDL	20	73
Benzo(b)fluoranthene (µg/g)	BDL	---	1,000
Benzo(k)fluoranthene (µg/g)	BDL	---	1,100
Benzo(a)pyrene (µg/g)	BDL	---	1,100
Chrysene (µg/g)	BDL	170	660
Fluoranthene (µg/g)	BDL	110	320
Fluorene (µg/g)	BDL	23	58
Indeno(1,2,3-c,d)pyrene (µg/g)	BDL	---	700
Phenanthrene (µg/g)	BDL	200	880
Pyrene (µg/g)	BDL	69	200
Benzo(g,h,i)perylene (µg/g)	BDL	---	590
Benzo(a)anthracene (µg/g)	BDL	---	430
Insecticides			
Organohalogen			
Aldrin (µg/g)	BDL	---	4.1
Chlordane (µg/g)	46	35	1,500
DDD (µg/g)	BDL	7	18
DDE (µg/g)	BDL	13	40
DDT (µg/g)	.1	23	17
Dieldrin (µg/g)	2.1	1.8	5.0
Heptachlor (µg/g)	---	.7	---
Heptachlor epoxide (µg/g)	.6	.9	12
Lindane (µg/g)	.2	.2	---
polychlorinated biphenyls (µg/g)	BDL	22	65
Organophosphorus			
Diazinon (µg/g)	.9	1.4	4.4
Ethion (µg/g)	.5	---	2.8

A bottom-sediment sample was collected at the same location as the pond-water sample (fig. 2). The sample was analyzed for selected chemical constituents and organic compounds (table 7). The organic nitrogen concentration in the sediment was about 520 mg/kg, about 35 times greater than the ammonia-nitrogen concentration (15 mg/L). A high organic-nitrogen concentration is typical of sediments that are composed of decaying vegetation. Overall, the trace elements in the sediment, except for chromium (80 μg/g) and iron (230 μg/g), were below or only slightly above detection limits. Concentrations of organic compounds in the sediment samples were near or below laboratory detection limits. All concentrations of the acid and base-neutral extractables were below detection limits (see appendix for specific detection limits). However, detectable concentrations of seven organic insecticide compounds were present in the sample: five organohalogen insecticides, chlordane (46 μg/g), DDT (0.1 μg/g), dieldrin (2.1 μg/g), heptachlor epoxide (0.6 μg/g), and lindane (0.2 μg/g); and two organophosphorus insecticides, diazinon (0.9 μg/g) and ethion (0.5 μg/g).

Clearwater Site

The specific conductance of ground water from seven wells (fig. 4) around the Clearwater pond ranged from 260 to 820 μS/cm (table 5). The specific conductance of water samples from wells 8 and 9 near the pond averaged 300 μS/cm, whereas those samples from the five residential area wells (11, 15, 20, 22, and 25) averaged about 570 μS/cm. The higher mineralization of ground water at the Clearwater site compared to the specific conductance at the Seminole site may be related to the 4-ft-thick peat layer (table 2). Specific conductance also may be influenced by septic tank effluent in the residential area. Nutrient levels generally were the greatest in well 22 in the septic tank area, but FDER guidance concentrations for nitrite and nitrate were not exceeded. Concentrations of trace elements in the ground water around the Clearwater pond were within the range of those at the Seminole site. Four organic compounds were detected in ground-water samples: acenaphthlene at 23 μg/L and fluorene at 26 μg/L in the sample from well 9, which represents ground water beneath Allen Creek (fig. 4); the organohalogen insecticide heptachlor epoxide at 0.03 μg/L in the sample from well 15; and diazinon at 0.11 μg/L in the sample from well 11 (table 5). In well 9, the acenaphthlene and fluorene concentrations were above the guidance concentrations of 20 μg/L and 10 μg/L, respectively.

A surface-water sample was collected in the middle of the pond about 300 ft from the west bank (fig. 4). Except for ammonia-nitrogen at a concentration of 1.3 mg/L, nutrient and trace-element levels were less than or about the same as concentrations reported for the Seminole pond and the local ground water (table 5). No extractables, volatile organic compounds, herbicides, or organohalogen insecticides were detected; however, the organophosphorus compounds diazinon and malathion were detected at concentrations of 0.12 and 0.15 μg/L, respectively. The concentration for diazinon was within the guidance concentration; there are no guidelines for malathion. These insecticides most likely originated from runoff from the residential area around the pond.

A bottom-sediment sample was collected at the same location as the pond-water sample (fig. 4). The sample was analyzed for nutrients, trace elements, and organic compounds (table 7). Concentrations of organic nitrogen (9,100 mg/kg) and phosphorus (1,500 mg/kg) in the pond bottom sediment were an order of magnitude greater than concentrations in the Seminole control pond. The high levels of organic-nitrogen probably reflect the decayed bottom vegetation. Concentrations of chromium (360 μg/g), copper (30 μg/g), iron (7,300 μg/g), lead (400 μg/g), and zinc (200 μg/g) were one order of magnitude greater than concentrations in the Seminole pond. Chromium and copper may originate from the corrosion of metal alloys, whereas lead and zinc originate from gasoline (as a gasoline additive) and automobile tires, respectively (U.S. Environmental Protection Agency, 1982, p. 25).

Six extractable acid and base-neutral compounds, nine organohalogen insecticides, and one organophosphorus insecticide were detected. The six compounds (anthracene, chrysene, fluoranthene, fluorene, phenanthrene, and pyrene) are polycyclic aromatic hydrocarbon (PAH) derivatives of coal tar that originate from asphalt streets and from combustion of gasoline products. The absence of methyl and higher alkylated isomers indicates that these PAH compounds are of pyrolytic origin (Pancirov and Brown, 1977). These and similar PAH compounds were reported in the sediments of a pond at another location in Pinellas County that only received runoff from a parking lot and an asphalt roof (Fernandez, 1985).

Largo Site

Water samples collected from the Largo pond and wells 36, 37, 38, 40, 42, and 44 in the residential area near the pond (fig. 6) were analyzed for nutrients, trace elements, and organic compounds (table 6). Specific conductance of the four samples of ground water that were analyzed ranged from 295 to 650 µS/cm; the average of 470 µS/cm was the highest of the three pond sites. The higher mineralization of ground water at the Largo site probably was caused by the peat layer (table 3). The range in concentration of organic-nitrogen in ground water was 0.15 to 62 mg/L. The cause of the high concentrations of organic-nitrogen in water from wells 37 and 38 is not known. Nitrite and nitrate levels, however, were within ground-water guidance concentrations. Two organic compounds were detected in ground-water samples collected near the pond--a volatile organic compound, chloroform (9.4 µg/L), and an organohalogen insecticide, chlordane (0.1 µg/L). Concentrations of these compounds were at or below the FDER guidance concentrations.

A water sample was collected from the middle of the pond (fig. 6) and analyzed for selected chemical constituents and organic compounds (table 6). One organic compound, the organophosphorus insecticide malathion (0.01 µg/L), was detected in the pond water.

A bottom-sediment sample was collected at the same location as the pond-water sample. The sample was analyzed for nutrients, trace elements, and organic compounds (table 7). The concentrations of nutrients and trace elements in the Largo pond sediments were about the same order of magnitude as those detected in the Clearwater pond sediments and were much greater than concentrations in the Seminole pond. The Largo pond has been in operation for 30 years, or about 10 years longer than the Clearwater pond. Although the Largo pond is near a major roadway and exposed to more vehicular traffic within its drainage basin than the Clearwater basin, the concentrations of chromium, copper, and lead in both ponds were about the same. There were 13 extractable acid and base-neutral (PAH) compounds, 8 organohalogen insecticides, and 2 organophosphorus insecticides detected in the sample of bottom sediment collected in the Largo pond. Six of the same PAH compounds were found in the Clearwater pond sediment, but in somewhat smaller concentrations. The greater levels of PAH in the Largo pond sediment probably reflect abrasion of the nearby, heavily traveled, asphalt-surfaced roadway (fig. 6). The concentration of the insecticide DDT at 17 µg/g was about the same as the 23-µg/g concentration in the Clearwater pond sediment. The dechlorinated DDT metabolites, DDE and DDD, however, were greater than those in the Clearwater pond sediment. The higher concentrations of the DDT metabolites indicate that the DDT concentrations may have been initially greater in the Largo pond than in the Clearwater pond.

Comparison of Water Quality at the Sites

A summary of selected water-quality conditions measured during September 1989 at the three stormwater detention ponds is given in table 8. This summary categorizes quality conditions both among the three pond sites and within matrices (ground water, pond water, and bottom sediment) at individual sites. This overview is very generalized in that it is based on a single sampling at each of the monitoring locations.

The pond water was considered of good quality and no constituents or compounds were detected at levels above those established by the FDER guidance concentrations. Samples of ground water, however, indicated two organic compounds at the Clearwater site and chromium at the Largo site in concentrations above those recommended for Florida ground water. Slight differences in the contaminants identified in the pond water and ground water existed among the sites, particularly in detectable organic compounds.

Analyses of bottom sediment from the three ponds indicated a rather large assemblage of detectable trace elements, pesticides, and industrial organic compounds. The bottom-sediment sample from the 1-year-old Seminole pond contained detectable concentrations of 7 insecticides; the bottom-sediment sample from the 20-year-old Clearwater pond contained 6 acid and base-neutral extractable compounds and 10 insecticides; and the bottom-sediment sample from the 30-year-old Largo pond contained 23 acid and base-neutral extractable and insecticide compounds. Trace elements were common in the bottom sediments of the three ponds, although the trace elements whose concentrations exceeded 100 µg/g were more numerous at the Clearwater and Largo sites than at the younger Seminole site. A general comparison of the chemical composition of the ground and pond water with the bottom sediments of the ponds indicates that trace elements and organic compounds are accumulating in

Table 8. Summary of water quality at the three stormwater detention pond study sites

	Seminole	Clearwater	Largo
Ground water	7 samples	7 samples	6 samples
Range in specific conductance (microsiemens per centimeter)	140-410	260-820	295-650
Range in pH (units)	3.9-5.9	5.5-6.3	5.3-7.3
Constituent or compound exceeding guidance concentrations[1]	pH	pH	pH
Nutrients	None	None	None
Trace elements	None	None	Chromium
Organic compounds	None	Acenapthene Fluorene	None
Pond water	1 sample	1 sample	1 sample
Constituent or compound exceeding guidance concentrations[1]			
Nutrients	None	None	None
Trace elements	None	None	None
Organic compounds	None	None	None
Pond sediment	1 sample	1 sample	1 sample
Indicator of contamination[2]			
Trace elements	Iron	Chromium Iron Lead Zinc	Chromium Iron Lead Zinc
Organic Compounds	Chlordane DDT Dieldrin Heptachlor epoxide Lindane Diazinon Ethion	Anthracene Chrysene Fluoranthene Fluorene Phenanthrene Pyrene Chlordane DDD, DDE, DDT Dieldrin Heptachlor Heptachlor epoxide Lindane PCB Diazinon	Acenapthene Anthracene Benzo (b) fluoranthene Benzo (k) fluoranthene Benzo pyrene Chrysene Fluoranthene Fluorene Ideno pyrene Phenanthrene Pyrene Benzo perylene Benzo anthracene Aldrin, chlordane DDD, DDE, DDT Dieldrin Heptachlor epoxide PCB, diazinon, ethion

[1]Florida ground-water guidance concentrations (Florida Department of Environmental Regulation, 1989).

[2]An arbitrary index that includes a trace element concentration greater than 100 μg/g or an organic compound above the detection limit.

the pond sediments. A single sampling, however, is a very limited experiment and does not allow for any estimate of the chemical variability.

APPRAISAL OF ORGANIC CONTAMINATION OF POND BOTTOM SEDIMENTS

Research has indicated that organic compounds that accumulate in the bottom sediments of stormwater detention ponds may have adverse environmental effects on aquatic organisms. For this study, the procedure used to appraise the potential toxicity of bottom sediments is an interim sediment criteria for selected nonpolar-hydrophobic compounds developed by the U.S. Environmental Protection Agency (1988). The bottom-sediment data for the three ponds were compared with two statistically derived toxicity criteria. The first criterion is the final chronic value (FCV), which is the concentration protecting aquatic life from chronic toxicity. The second criterion is the final residual value (FRV), which is the concentration protecting uses of aquatic life from effects of long-term exposure to contaminated sediments. These uses include consumption of aquatic life by higher-order organisms. For the following summary, it is important to note that these results are based on a very limited sampling of the pond sediments and it is recognized that the chemical variability of bottom sediments within a given area usually is quite significant.

The results of organic analyses of bottom sediments from the three ponds were compared to the interim sediment criteria (table 9). For this comparison, the concentration of an individual organic compound is divided by the concentration of the organic carbon and it is this normalized concentration that is compared with the interim values. The bottom sediments of the three ponds each contained detectable organic compounds for which there are interim criteria, but the normalized concentrations of organic compounds with final chronic value criteria were all less than the FCV. Three of the compounds that were detected, however, had concentrations exceeding the lower value of the FRV. Dieldrin concentrations in bottom sediments exceeded the FRV in the Seminole and Largo ponds, and DDT, dieldrin, and heptachlor exceeded the FRV in the Clearwater pond. It is interesting to note that DDT is still present even though it was banned in 1973. A conclusion of this analysis is that, although the pond sediments are not toxic to aquatic life, there may be a bioconcentration health threat to higher organisms in the food chain.

SUMMARY AND CONCLUSIONS

The effects of stormwater runoff on surface- and ground-water quality were investigated at three stormwater detention ponds in Pinellas County. The study sites were designated as the Seminole, Clearwater, and Largo ponds in accordance with the cities where they are located. The assessment of the ponds was directed toward comparing the physical settings and chemical quality and evaluating the effects of organic compounds on aquatic life.

The Seminole, Clearwater, and Largo ponds are 1, 20, and 30 years old, respectively. The Seminole pond, covering nearly 6 acres, is the largest pond and is within the largest drainage basin, an area of 83 acres. The stage of the Seminole pond is about 50 ft above sea level, and the stage of the other ponds is between 10 and 15 ft above sea level. The range in altitude of the water table within 1,000 ft of each pond was observed to be 0 to 17 ft at Largo, 13 to 31 ft at Clearwater, and 44 to 57 ft at Seminole. The water-table gradient and the hydraulic conductivity and porosity of the surficial aquifer system were used to calculate velocities of ground-water flow toward each pond. Those velocities ranged between 80 and 200 ft/yr.

The chemical qualities of ground water and pond water at the three sites were below most FDER guidance concentrations, although low levels of trace elements and organic compounds were detected. Pond bottom sediments, however, contained detectable levels of trace elements and organic compounds at all three sites. The bottom sediment from the 1-year-old Seminole pond contained undesirable concentrations of 1 trace element and 7 organic compounds; the sediment sample from the 20-year-old Clearwater pond contained detectable concentrations of 4 trace elements and 16 organic compounds; and the sediment sample from the 30-year-old Largo pond contained detectable concentrations of 4 trace elements and 23 organic compounds. These results indicate that contaminants accumulate in the pond sediments, and constituent diversity increases as a function of the age of the pond. Most of the trace elements may have originated from corrosion of alloys, gasoline, and automobile tires. The sources of most organic compounds probably were insecticides applied to nearby

Table 9. Organic compounds in Seminole, Clearwater, and Largo pond bottom sediments and the U.S. Environmental Protection Agency's interim sediment criteria for nonpolar-hydrophobic organic contaminants

[mg/kg, milligrams per kilogram; mg/kg OC, milligrams per kilogram of orbanic carbon; TOC, total organic carbon; kg OC/kg, kilograms of organic carbon per kilogram; ---, no criteria issued]

Compound	Sediment concentration		Sediment quality criteria 95-percent confidence interval[1] (mg/kg OC)			
			FCV[2]		FRV[3]	
	Measured (mg/kg)	Normalized (mg/kg OC)	2.5 percent	97.5 percent	2.5 percent	97.5 percent
		Seminole Pond (TOC = 0.024 kg OC/kg)				
DDT	0.0001	0.004	---	---	0.183	3.80
Dieldrin	.0021	.0875	1.49	273	.010	1.79
Lindane	.0002	.008	.039	.636	---	---
		Clearwater (TOC = 0.020 kg OC/kg)				
DDT	.023	1.1	---	---	.183	3.80
Dieldrin	.0018	.09	1.49	273	.010	1.79
Fluoranthene	.110	5.5	---	---	423	8,375
Heptachlor	.0007	.04	---	---	.015	.84
Lindane	.0002	.01	.039	.636	---	---
PCB	.022	1.1	---	---	3.87	99.9
Phenanthrene	.2	10	32.6	605	---	---
Pyrene	.069	3.4	---	---	265	6,465
		Largo (TOC = 0.174 kg OC/kg)				
Benzo(a)anthracene	.43	2.5	---	---	217	7,999
Benzo(a)pyrene	1.1	6.3	---	---	225	5,018
DDT	.017	.1	---	---	.183	3.80
Dieldrin	.005	.03	1.49	273	.010	1.79
Fluoranthene	.32	1.84	---	---	423	8,375
PCB	.065	.37	---	---	3.87	99.9
Phenanthrene	.88	5.1	32.6	605	---	---
Pyrene	.2	1.1	---	---	265	6,465

[1]95-percent confidence interval: The lower value represents the concentration which, with 97.5-percent certainty, will result in protection from chronic effects on the benthic biota; upper value is concentration above which, with 97.5-percent certainty, will result in hazardous long-term effect; values within the confidence interval represent increasing cause for concern.

[2]Compounds that have criteria as a final chronic value (FCV), which is the concentration protecting aquatic life from chronic toxicity.

[3]Compounds that have a sediment-quality criteria as a final residual value (FRV), which is the concentration protecting uses of aquatic life from effects of long-term exposure to contaminated sediments. These uses include consumption of aquatic life by wildlife.

lawns, coal tar derivatives from asphalt streets, and the combustion of gasoline.

Toxic contaminants tend to accumulate in the bottom sediments of the detention ponds. Bottom-sediment samples from the Seminole, Clearwater, and Largo ponds contained three, eight, and eight, respectively, of the organic compounds for which the USEPA has developed interim sediment criteria. The concentrations of all compounds were below the final chronic value that protects aquatic life from chronic toxicity. Dieldrin was detected in all three pond bottom-sediment samples and DDT and heptachlor were detected in the Clearwater pond bottom-sediment sample. The concentrations of these organic compounds exceeded the final residual value that protects aquatic life from effects of long-term exposure to contaminated sediments. The limited data indicate that pond bottom sediments are not toxic to aquatic life, but they may impair the health of higher-order organisms through bioconcentration.

REFERENCES

Fernandez, Mario, Jr., 1985, Reconnaissance of water quality at a U.S. Department of Energy site, Pinellas County, Florida: U.S. Geological Survey Water-Resources Investigations Report 85-4062, 49 p.

Florida Department of Environmental Regulation, 1989, Florida ground-water guidance concentrations: February 1989.

Hem, J.D., 1985, Study and interpretation of the chemical characteristics of natural water: U.S. Geological Survey Water-Supply Paper 2254, 263 p.

Hutchinson, C.B., and Stewart, J.W., 1978, Geohydrologic evaluation of a landfill in a coastal area, St. Petersburg, Florida: U.S. Geological Survey Water-Resources Investigations 77-78, 40 p.

Lopez, M.A., and Giovannelli, R.F., 1984, Water-quality characteristics of urban runoff and estimates of annual loads in the Tampa Bay area, Florida, 1975-80: U.S. Geological Survey Water-Resources Investigations Report 83-4181, 76 p.

Pancirov, R.J., and Brown, R.A., 1977, Polynuclear aromatic hydrocarbons in marine tissues: Environmental Science and Technology, v. II, no. 10, p. 989.

Rutledge, A.T., 1987, Effects of land use on ground-water quality in central Florida--preliminary results: U.S. Geological Survey Toxic-Waste Ground-Water Contamination Program: U.S. Geological Survey Water-Resources Investigations Report 86-4163, 49 p.

Scott, T.M., 1988, The lithostratigraphy of the Hawthorn Group (Miocene) of Florida: Florida Geological Survey Bulletin no. 59, 148 p.

U.S. Department of Agriculture, 1972, Soil survey of Pinellas County, Florida: Soil Conservation Service, 64 p., 33 pls.

U.S. Environmental Protection Agency, 1982, Preliminary findings of the NURP priority pollutant monitoring program, in Results of the nationwide urban runoff program: v. 11, append. F, p. 25.

----- 1988, Interim sediment criteria values for nonpolar hydrophobic organic contaminants: Washington, D.C., Office of Water Regulations and Standards Criteria and Standards Division.

APPENDIX

Appendix. Detection limits for organic compounds analyzed in water and bottom-sediment samples

[These samples were analyzed using laboratory standard solutions of known chemical composition. Water-detection limits are in micrograms per liter. Sediment detection limits are in micrograms per kilogram. Numbers in parentheses are water-quality standards from the Florida Department of Environmental Regulation, 1989; --, no limits. Modified from Rutledge, 1987]

Type and name of chemical	Detection limit	
	Water	Sediment
Acenaphthene (20)	5.0	10
Acenaphthylene (10)	5.0	10
Anthracene (10)	5.0	10
Benz(a)anthracene (10)	10.0	100
Benzo(a)pyrene (10)	10.0	200
Benzo(g,h,i)perylene (10)	10.0	150
Benzo(k)fluoranthene (10)	10.0	200
Benzo(b)fluoranthene (10)	10.0	200
4-Bromophyenyl phenyl ether (10)	5.0	200
N-Butylbenzyl phthalate (1,400)	5.0	200
bis(2-Chloroethoxy)methane (10)	5.0	200
bis(2-Chloroethyl)ether (10)	5.0	200
bis(2-Chloroisopropyl)ether (10)	5.0	200
4-chloro-3-methyphenol (-)	30.0	600
2-chloronaphtholene (10)	5.0	200
2-chlorophenol (-)	5.0	200
4-chlorophenyl phenyl ether (10)	5.0	200
Chrysene (10)	10.0	150
1,2,5,6-Dibenzo(a,h)anthracene (10)	10.0	400
Di-n-butyl phthalate (700)	5.0	200
1,2-Dichlorobenzene (10)	5.0	200
1,3-Dichlorobenzene (10)	5.0	200
1,4-Dichlorobenzene (75)	5.0	200
2,4-Dichlorophenol (10)	5.0	200
2,4-Dimethylphenol (400)	5.0	200
Diethyl phthalate (5,600)	5.0	200
Dimethyl phthalate (70,000)	5.0	200
4,6-Dinitro-2-methylphenol (50)	30.0	600
2,4-Dinitrophenol (70)	20.0	600
2,6-Dinitrotoluene (10)	5.0	200

Appendix. Detection limits for organic compounds analyzed in water and bottom-sediment samples--Continued

[These samples were analyzed using laboratory standard solutions of known chemical composition. Water-detection limits are in micrograms per liter. Sediment detection limits are in micrograms per kilogram. Numbers in parentheses are water-quality standards from the Florida Department of Environmental Regulation, 1989; --, no limits. Modified from Rutledge, 1987]

Type and name of chemical	Detection limit	
	Water	Sediment
Acid and base-neutral extractables--continued		
Hexachlorobutadiene (10)	5.0	200
Hexachlorocyclopentadiene (10)	5.0	200
Hexachloroethane (10)	5.0	200
Ideno(1,2,3-cd)pyrene (10)	10.0	200
Isophorone (1,050)	5.0	200
Naphthalene (10)	5.0	10
Nitrobenzene (30)	5.0	200
2-Nitrophenol (20)	5.0	200
4-Nitrophenol (10)	30.0	600
N-Nitrosodi-N-propylamine (10)	5.0	200
N-Nitrosodimethylamine (20)	5.0	200
N-Nitrosodiphenylamine (10)	5.0	200
Pentrachlorophenol (30)	30.0	600
Phenanthrene (10)	5.0	10
Phenol (20)	5.0	200
Pyrene (10)	5.0	10
1,2,4-Trichlorobenzene (140)	5.0	200
2,4,6-Trichlorophenol (10)	20.0	600
Volatiles		
Benzene (1)	3.0	--
Bromoform (100)	3.0	--
Carbon tetrachloride (3)	3.0	--
Chlorobenzene (10	3.0	--
Chlorodibromomethane (100)	3.0	--
Chloroethane (6,300)	3.0	--
2-Chloroethylvinyl ether (1)	3.0	--
Chloroform (100)	3.0	--
1,2-trans-Dichlorethylene (4.2)	3.0	--
Dichlorobromomethane (100)	3.0	--

Appendix. Detection limits for organic compounds analyzed in water and bottom-sediment samples--Continued

[These samples were analyzed using laboratory standard solutions of known chemical composition. Water-detection limits are in micrograms per liter. Sediment detection limits are in micrograms per kilogram. Numbers in parentheses are water-quality standards from the Florida Department of Environmental Regulation, 1989; --, no limits. Modified from Rutledge, 1987]

Type and name of chemical	Detection limit	
	Water	Sediment
Volatiles--continued		
Dichlorodifluoromethane (1,400)	3.0	--
1,2-Dichloroethane (3)	3.0	--
1,1-Dichloroethylene (7)	3.0	--
1,2-Dichloropropane (1)	3.0	--
Vinyl chloride (1)	3.0	--
1,3-Dichloropropane (1)	3.0	--
Ethylbenzene (2)	3.0	--
Methyl bromide (20)	3.0	--
Methylene chloride (5)	3.0	--
1,1,2,2-Tetrachloroethane (1)	3.0	--
Tetrachloroethylene (3)	3.0	--
Toluene (24)	3.0	--
1,1,1-Trichloroethane (200)	3.0	--
1,1,2-Trichloroethane (1)	3.0	--
Trichloroethylene (3)	3.0	--
Trichlorofluoromethane (2,400)	3.0	--
Xylene, total (50)	3.0	--
Herbicides		
Chlorophenoxy acids		
2,4-D (100)	.01	0.1
2,4-DP (-)	.01	.1
2,4,5-T (-)	.01	.1
Silvex (10)	.01	.1

Appendix. Detection limits for organic compounds analyzed in water and bottom-sediment samples--Continued

[These samples were analyzed using laboratory standard solutions of known chemical composition. Water-detection limits are in micrograms per liter. Sediment detection limits are in micrograms per kilogram. Numbers in parentheses are water-quality standards from the Florida Department of Environmental Regulation, 1989; --, no limits. Modified from Rutledge, 1987]

Type and name of chemical	Detection limit	
	Water	Sediment
Insecticides		
Organohalogen		
Aldrin (0.05)	0.01	0.1
Ametryne (60)	.1	--
Atrazine (3)	.1	--
Chlordane (0.1)	.1	1
Cyanazine (30)	.1	--
DDD (-)	.01	.1
DDE (-)	.01	.1
DDT (0.1)	.01	.1
Dieldrin (0.05)	.01	.1
EDB (0.02)	.02	--
Endosulfan (0.04)	.01	.1
Endrin (0.2)	.01	.1
Gross polychlorinated naphthalenes (0.5)	.1	1.0
Gross polychlorinated biphenyls (0.5)	.1	1
Heptachlor (0.076)	.01	.1
Heptachlor epoxide	.01	.1
Lindane (4)	.01	.1
Methoxychlor (100)	.01	.1
Mirex (3.5)	.01	.1
Perthane (-)	.1	1.
Toxaphene (5)	1.0	10
Organophosphorus		
Diazinon (10)	.01	0.1
Ethion (14)	.01	.1
Malathion (-)	.01	.1
Methyl parathion (10)	.01	.1
Methyl trithion (-)	.01	.1
Parathion (-)	.01	.1
Trithion (12)	.01	.1

*U.S. GOVERNMENT PRINTING OFFICE: 1993-733-120/80004