UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WATER-QUALITY RECONNAISSANCE OF THE NORTH DADE COUNTY SOLID-WASTE DISPOSAL FACILITY, FLORIDA

By Donald J. McKenzie

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ABBREVIATIONS AND CONVERSION FACTORS

[Factors for converting inch-pound units to International System (SI) of Metric units and abbreviation of units]

Multiply	By	To obtain
inch (in)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
foot per day (ft/d)	0.3048	meter per day (m/d)
square foot (ft^2)	0.0929	square meter (m^2)
foot squared per day (ft^2/d)	0.0929	meter squared per day (m^2/d)
mile (mi)	1.609	kilometer (km)
acre	0.4047	hectare (ha)
gallon (gal)	3.785	liter (L)
gallon (gal)	0.003785	cubic meter (m^3)
million gallons (Mgal)	3,785	cubic meters (m^3)
gallon per minute (gal/min)	0.06309	liter per second (L/s)

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National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "mean sea level." NGVD of 1929 is referred to as sea level in the text of this report.

WATER-QUALITY RECONNAISSANCE OF THE NORTH DADE COUNTY

SOLID-WASTE DISPOSAL FACILITY, FLORIDA

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ABSTRACT

A water-quality sampling reconnaissance of the north Dade County solid-waste disposal facility (landfill) near Carol City, Florida, was conducted during 1977-78. The purpose of the reconnaissance was to determine selected quality characteristics of the surface- and ground-water of the landfill and contiguous area; and to assess, generally, if leachate produced by the decomposition of landfill wastes was adversely impacting the downgradient water quality.

Sampling results indicated that several water-quality characteristics were present in landfill ground water at significantly higher levels than in either the upgradient or downgradient ground water. Moreover, many of these water-quality characteristics were found at slightly higher levels at downgradient site 5 than at upgradient site 1 which suggested that some downgradient movement of landfill leachate had occurred. For example, the average concentrations of chloride and alkalinity in ground water from the deeper monitor wells were 23 and 300 mg/L (milligrams per liter) at background site 1, 194 and 695 mg/L at landfill sites 2 and 4, and 46 and 384 mg/L at downgradient site 5. Selected nutrient and organic characteristics in the deeper monitor wells indicated a similar downgradient increase with average ammonia and total organic carbon concentrations of 1.7 and 19 mg/L (background site 1), 34 and 44 mg/L (landfill sites 2 and 4), and 17 and 25 mg/L (downgradient site 5).

A comparison of the 1977-78 sampling results with the National Primary and Secondary Drinking Water Regulations indicated that iron and color in ground water of the study area frequently exceeded national maximum contaminant levels, and dissolved solids, turbidity, lead, and manganese ocassionally exceeded regulations. Concentrations of iron and levels of color and turbidity of some surface-water samples in the study area also exceeded national maximum contaminant levels.

INTRODUCTION

North Dade County is underlain by the Biscayne aquifer which is a highly transmissive wedge-shaped body of limestone, sandstone, and sand that yields abundant quantities of high-quality ground water for municipal supply and agricultural use. This aquifer extends throughout Dade County northward into Broward and Palm Beach Counties, thus making it a sole source of water for over 3 million southeastern Florida residents. However, because the limestone of this vital aquifer outcrops in many areas, the highly porous and permeable Biscayne aquifer is very susceptible to contamination from a wide variety of sources. The potential for contamination is particularly great in the intensively developed eastern coastal ridge where 90 percent of the population resides.

For several decades, Dade County water-resource planners and managers have been actively engaged in protecting this vital water resource from degradation. Since the 1930's, for example, a primary focus of water agencies has been identifying and impeding saltwater intrusion into the aquifer. As a result of these efforts, many management practices are now utilized that greatly minimize the impact of saltwater contamination of the Biscayne aquifer. More recently, however, water-resource agencies have become increasingly concerned regarding the potential for ground-water degradation throughout the county caused by the ever increasing point sources of contamination. Many of these potential point sources of contamination are the result of various waste-disposal practices. One such source, for example, is the landfill which is a common method for the disposal of solid wastes.

Landfills are a well documented point source of ground-water contamination caused by the biochemical decomposition (decay) of solid-waste and subsequent leachate migration and commingling with local water resources. However, to assess the magnitude of adverse impacts, site specific data are usually necessary. This is because the severity of contamination depends upon the amount and type of refuse, its degree of compaction, the amount of water in contact with it, and the temperature. The principal waste materials that most contribute to leachate quality are biodegradable organic matter, soluble inorganic materials, and soluble metal complexes. Water availability generally determines the rate of decomposition and whether the process is predominantly aerobic or anaerobic. Aerobic decay produces stable end products as carbon dioxide, nitrate, sulfate, water, and relatively inert residue. Anaerobic decay of organic material produces carbon dioxide, methane, ammonia, hydrogen gas, alcohols, and organic acids and other partially oxidized organic species (Salle, 1954, p. 376). Metals, such as iron and manganese, may be concentrated in the leachate in such a reducing environment (Apgar and Langmuir, 1971, p. 77).

This study and report is part of a three-site assessment of water-quality conditions in areas of solid-waste disposal in Dade County; and is primarily intended to furnish county water planners and managers with specific water-quality information regarding the quality of landfill leachate along with generalized observations on the quality impact on contiguous water resources due to leachate encroachment. The results of this study and report are also intended as a general data contribution to the U.S. Geological Survey's activities in the areas of water-quality impacts of surface-waste disposal and ground-water quality. The first assessment was conducted at the Northwest 58th Street disposal facility in Central Dade County (Mattraw and others, 1978), and the third assessment was conducted at the south Dade County solid-waste landfill.

Purpose and Scope

From 1977 to 1978, the U.S. Geological Survey in cooperation with the Dade County Department of Public Works, conducted a water-quality reconnaissance of the north Dade County solid-waste disposal facility (landfill) near Carol City. The general purpose of this reconnaissance was to describe water-quality conditions of the landfill and nearby area; and to assess generally the water-quality impact, or potential impact, of solid-waste leachate migration from the solid-waste disposal facility into contiguous ground- and surface-water resources. The scope of this study primarily included: an electrical-resistivity survey of the study area to determine optimum ground-water monitor sites; the construction of monitor wells of variable depth upgradient within and downgradient from the disposal site; the establishment of stream-sampling sites; and the periodic collection and analysis of ground- and surface-water samples for selected water-quality characteristics.

Specific objectives of the reconnaissance were: (1) determine and describe general water-quality conditions of surface- and ground-water upgradient from, within, and downgradient from the solid-waste disposal site (landfill); (2) generally describe selected water-quality impacts (variations) possibly resulting from the downgradient movement leachate from the landfill; (3) compare selected water-quality characteristics of the landfill area with the National Primary and Secondary Drinking Water Regulations; and (4) based on the 1977-78 reconnaissance, outline a general data-collection program for the monitoring of the landfill area for the purpose of assessing future quality of water impacts caused by leachate migration from the solid-waste disposal site.

Acknowledgments

For assistance in the design of the reconnaissance, the author is indebted to William M. Powell, Director, and Joseph M. Brown of the Dade County Department of Public Works. Much appreciated technical assistance was provided by Sidney Leopold and Anthony Sobrino of the Department. The author expresses special appreciation to Peter Thomas of the Department's Civil Engineering Division for cooperation and technical aid.

DESCRIPTION OF AREA

Including the landfill and adjacent monitor locations, the study area encompassed about 700 acres (fig. 1). Monitoring sites to determine background (upgradient) conditions of ground water (site 1) and surface water (site 7) were located about 1 mile west of the landfill; sites for monitoring the quality of the landfill leachate (sites 2, 3, and 4) and ground- and surface-water commingling (site 8) were located within the active disposal area; and the sites for monitoring the water-quality conditions

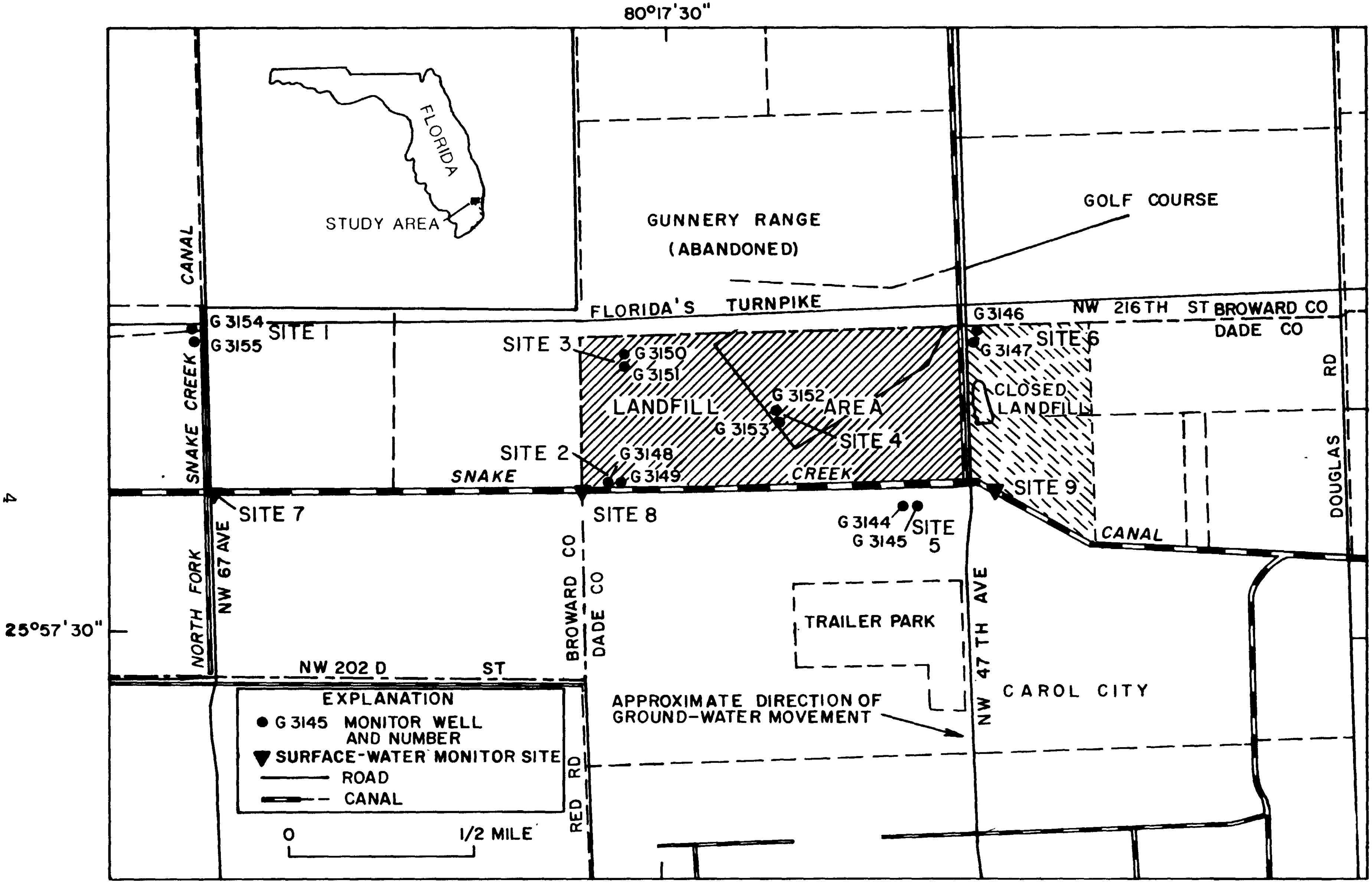

Figure 1.--Location of study area and water-quality monitor sites.

downgradient of ground water (site 6) and surface water (site 9) were located within an abandoned part of the landfill just east of the active disposal area; a second downgradient ground-water site (site 5) was located about 0.1 mile south of the active disposal site.

The north Dade County solid-waste disposal facility occupies about 300 acres. Its northern and western boundaries parallel the Broward County line. Adjacent to the south edge of the landfill is the Snake Creek Canal which is one of the primary canals of the South Florida Water Management District and discharges more water than any other canal in Dade County (Hull, 1978, p. 52). A secondary (unnamed) canal tributary to the Snake Creek Canal parallels the eastern edge of the landfill. A closed section of the landfill that was previously used by the Public Works Department is located on the east side of the secondary tributary.

About 50 percent of the area around the landfill is residential, consisting of trailer parks, apartment houses, and single-family residences; the remainder is undeveloped. Generally, the residential areas are about ¼ mile from the landfill. Present growth trends in the undeveloped areas are for housing or light industry. Carol City, a densely populated area of single-family residences, is approximately 1 mile southeast of the landfill.

The natural land surface at the facility is approximately 5 feet above sea level. The surface material is sandy and ponding does not frequently occur. Moreover, flooding of the disposal site is further minimized because of drainage to the Snake Creek Canal. The climate is humid subtropical with an average annual temperature of about 70°F with an average annual rainfall of about 60 inches. Rainfall is greatest during June through November and least from December through May.

Geology of the Study Area

The Biscayne aquifer is wedge-shaped, ranging in thickness from about 70 to 160 feet along the eastern coast and thinning to about 10 feet along the western edge of Dade County. The base of the aquifer is estimated to be about 100 feet below land surface in the landfill area (Schroeder and others, 1958, fig. 2). The aquifer consists of sand and permeable sandy limestone, and calcareous sandstone. Parker and others (1955, p. 160-167) determined that much of the limestone contains closely spaced cavities formed by solution and indicated further that the Biscayne is one of the most permeable aquifers investigated by the U.S. Geological Survey. In central and north Dade County, however, the sand content in the aquifer increases and thereby reduces the overall permeability. Aquifer tests (Pitt and others, 1975, p. 14) indicated that the average hydraulic conductivity of the Biscayne aquifer ranges from 6.7×10^3 to 9.4×10^3 ft/d. In north Dade County the transmissivity is about 3.7×10^5 ft^2/d (Pitt and others, 1975, p. 14).

Hydrologic Aspects

Because of the highly permeable nature of the aquifer and the good hydraulic connection, water levels in the aquifer and in the canals are closely related. The ground-water level rises in response to rainfall and surface-water inflow, and it declines in response to evapotranspiration, surface-water outflow, and seepage to the ocean. The canals are used for controlled drainage by releases of excess runoff to the ocean during the rainy season and by reduction of runoff to the ocean to maintain high ground-water levels during dry periods. In the study area, drainage is controlled by the Snake Creek Canal.

Ground water moves generally southeast (downgradient) across the landfill area. The average altitude of the water table in the landfill area during 1960-75 was about 2.5 feet above sea level (fig. 2). The contours in figure 2 indicate the generally low ground-water gradient in the north Dade County area.

Landfill History

The north Dade County solid-waste disposal facility has been in operation since about 1952. Waste disposal is presently active in the central part of the site (1978). Detailed operation procedures of waste disposal prior to about 1960 were not documented; however, waste was likely placed directly on the undisturbed land surface without fill-and-cover operations to raise the natural land level. Some dragline excavation probably was done. In recent years, the disposal facility has used the fill-and-cover method. At the end of each day, the accumulated deposits are covered by a layer of soil about 1-foot thick to alleviate offensive odors and animal disease carriers. The thickness of waste materials and layered soil is about 8 feet. The layering has the effect of slowing the rate of infiltration of rainfall and sometimes results in local mounding of the water table.

The quantity of waste deposited in the north Dade County landfill has increased substantially since 1960 (table 1). For example, the total waste deposited in 1974-75 was almost four times greater than that deposited in 1960-61, the first year of available records. The prohibiting of open-pit burning in 1960 has contributed to the greater volume of waste deposited each year since then.

Refuse at the disposal facility consists of trash and garbage from private, municipal, and county sources. The composition and primary sources of the waste are shown in table 2. Sludge from the North Miami Sewage Treatment Plant and Carol City Utilities has been disposed of at the facility, but there are no records to determine the amount or placement area.

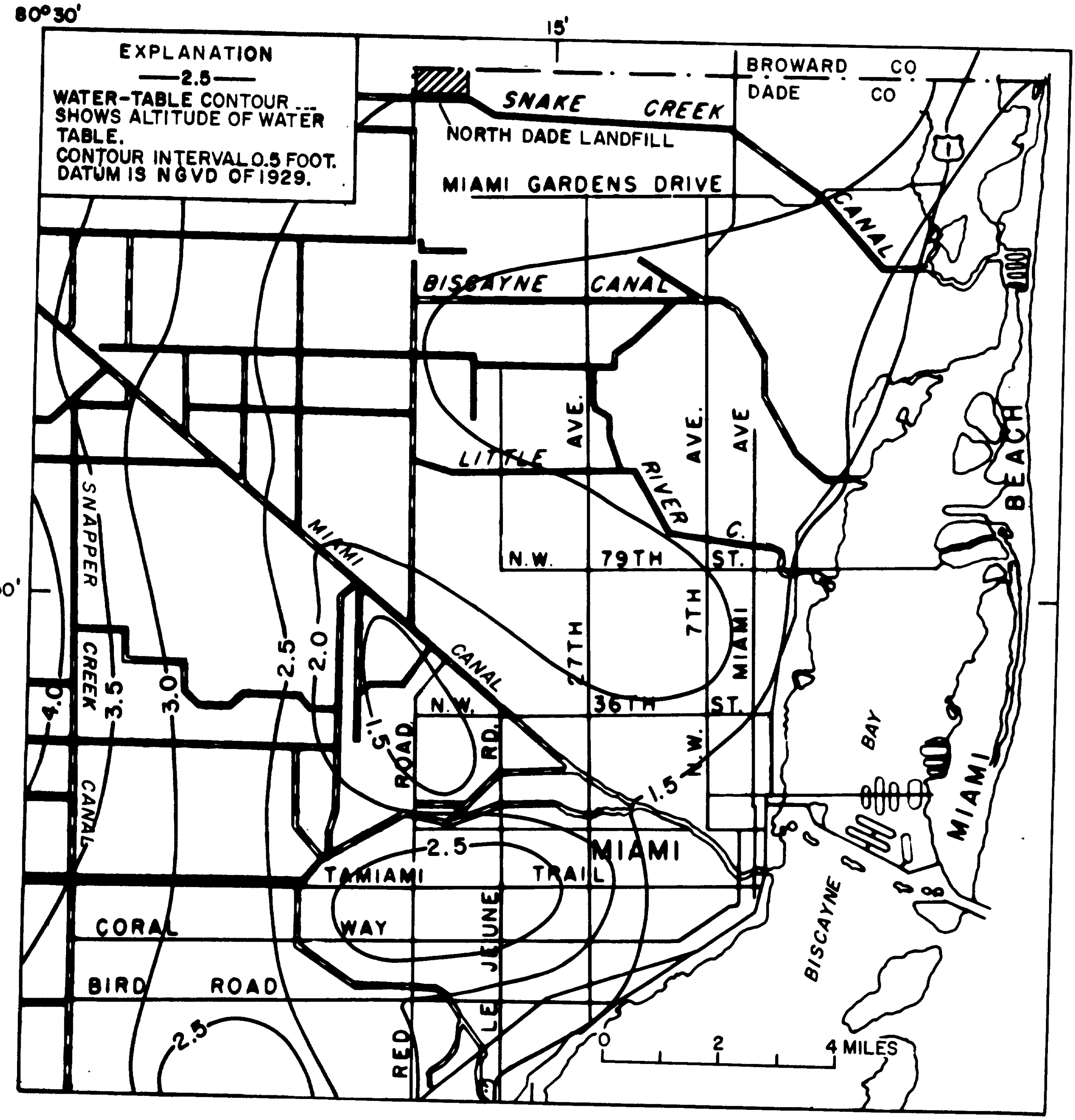

Figure 2.--Average ground-water levels in the general vicinity of the study area in north Dade County, 1960-75 (modified from Hull, 1978, fig. 6).

Table 1.--Waste loads in tons at the north Dade County solid-waste disposal facility, 1960-75

[Dade County Department of Public Works]

Year	Garbage	Trash	Total
1960-61	29,430	9,970	39,400
61-62	39,411	31,145	70,556
62-63	30,883	34,947	65,830
63-64	24,483	[1]56,484	80,967
64-65	26,517	34,156	60,673
65-66	28,001	31,317	59,318
66-67	40,570	37,755	78,325
67-68	52,548	48,146	100,694
68-69	65,842	47,641	113,483
69-70	86,712	54,159	140,871
70-71	97,657	47,314	144,971
71-72	103,515	61,649	165,164
72-73	147,870	95,054	242,924
73-74	137,965	92,937	230,902
74-75	78,821	72,959	151,780
15 years	990,225	755,633	1,745,858

[1] Atypical trash production (load) due to hurricane winds.

Table 2.--Composition of solid wastes at the north Dade County solid-waste disposal facility

[Dade County Department of Public Works]

Category	Composition		Sources
Garbage (65 percent)	Wastes from the preparation, cooking, and serving of food; market refuse, waste from the handling, storage, and sale of produce and meats.		Households, institutions, and commercial concerns such as hotels, stores, restaurants, markets, sewage treatment plants, and septic tanks.
Trash (35 percent)	Bulky wastes	Large auto parts, tires; stoves, refrigerators, other large appliances; furniture, large crates.	Streets, sidewalks, alleys, vacant lots.
	Parkway and street refuse	Street sweeping, dirt; leaves; catch basin dirt; contents of litter receptacles; trees, branches, palm fronds, and stumps.	

METHODS AND PROCEDURES

Electrical-Resistivity Survey

An electrical-resistivity survey of the landfill area was conducted in October 1977 which included a total of 86 resistivity stations in and around the landfill site. The results of the survey were used to select monitor-well sites using the method of approximate resistivity delineation of the leachate plume (U.S. Environmental Protection Agency, 1977b, p. 122).

Use of the resistivity method to define leachate concentration is based on the principle that the electrical conductivity of the ground water is inversely proportional to the resistivity measured in a section of earth containing the ground water. Since the conductivity of landfill leachate is generally much higher than that of natural fresh ground water, a sharp decrease in apparent resistivity will denote the presence of leachate in the measured section.

The results of the survey are shown in figures 3 and 4, reflecting approximately 15-foot and 45-foot depths. Contour lines were extrapolated (dashed) in areas where field data were insufficient to provide a high degree of confidence.

The shallow data in figure 3 and the deep data in figure 4 suggest that the resistivity immediately south and east of the landfill were lower (100-200 ohm/ft) than those immediately to the north and west (200-400 ohm/ft). This resistivity distribution suggests that leachate from the landfill has migrated slightly south and east, the general direction of ground-water movement in this part of the aquifer. The area east of the closed landfill produced significantly higher resistivity values than other areas, indicating absence of leachate. Although some general assumptions were made using these data, they were in fact only used as a means to locate monitoring sites.

Monitor-Site Network

Based on the results of the resistivity survey, monitor wells were established within, south, and east of the landfill where resistivity values were low. The well sites are shown in figure 1. Each site consists of two monitor wells: (1) a shallow well approximately 23 feet deep; and (2) a deep well 47 to 60 feet deep (table 3). The monitor wells penetrate zones of high permeability in the upper part of the Biscayne aquifer.

Wells at site 1 were installed to obtain background data outside and upgradient of the apparent influence of the landfill. The wells at sites 2, 3, and 4 provide information about the nature and concentration of the leachate beneath the landfill. The wells at sites 5 and 6 provide information about leachate movement outside and downgradient from the landfill. Because of the probable connection between the aquifer under the landfill and the canals, surface-water sampling sites 7, 8, and 9 were established on the Snake Creek Canal (fig. 1). Site 7 was selected to represent background quality and sites 8 and 9, contiguous to the landfill, were to monitor the impact of landfill leachate on surface water.

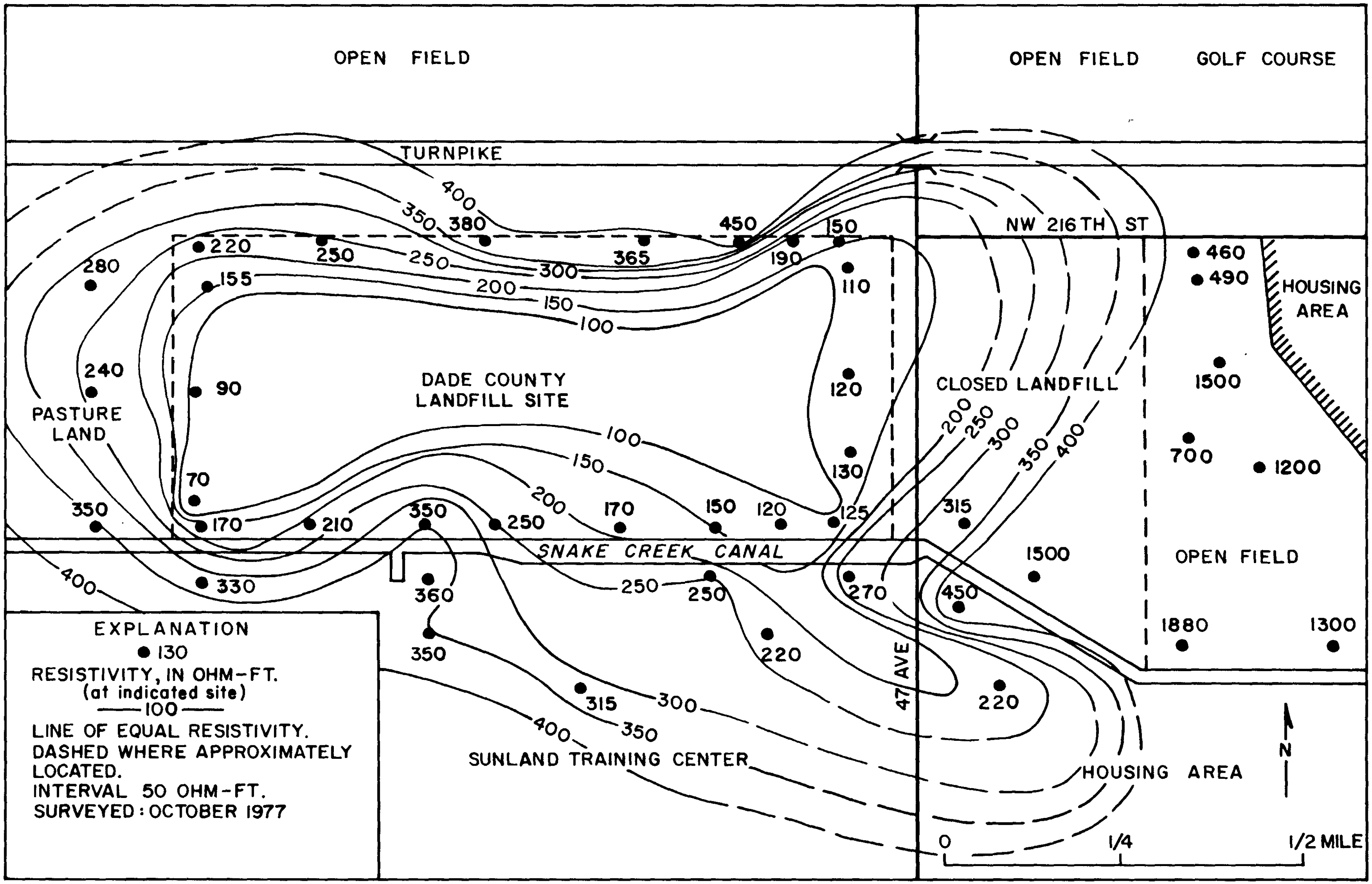

Figure 3.--Electrical-resistivity contours for approximate 15-foot depths (from Benson, 1977).

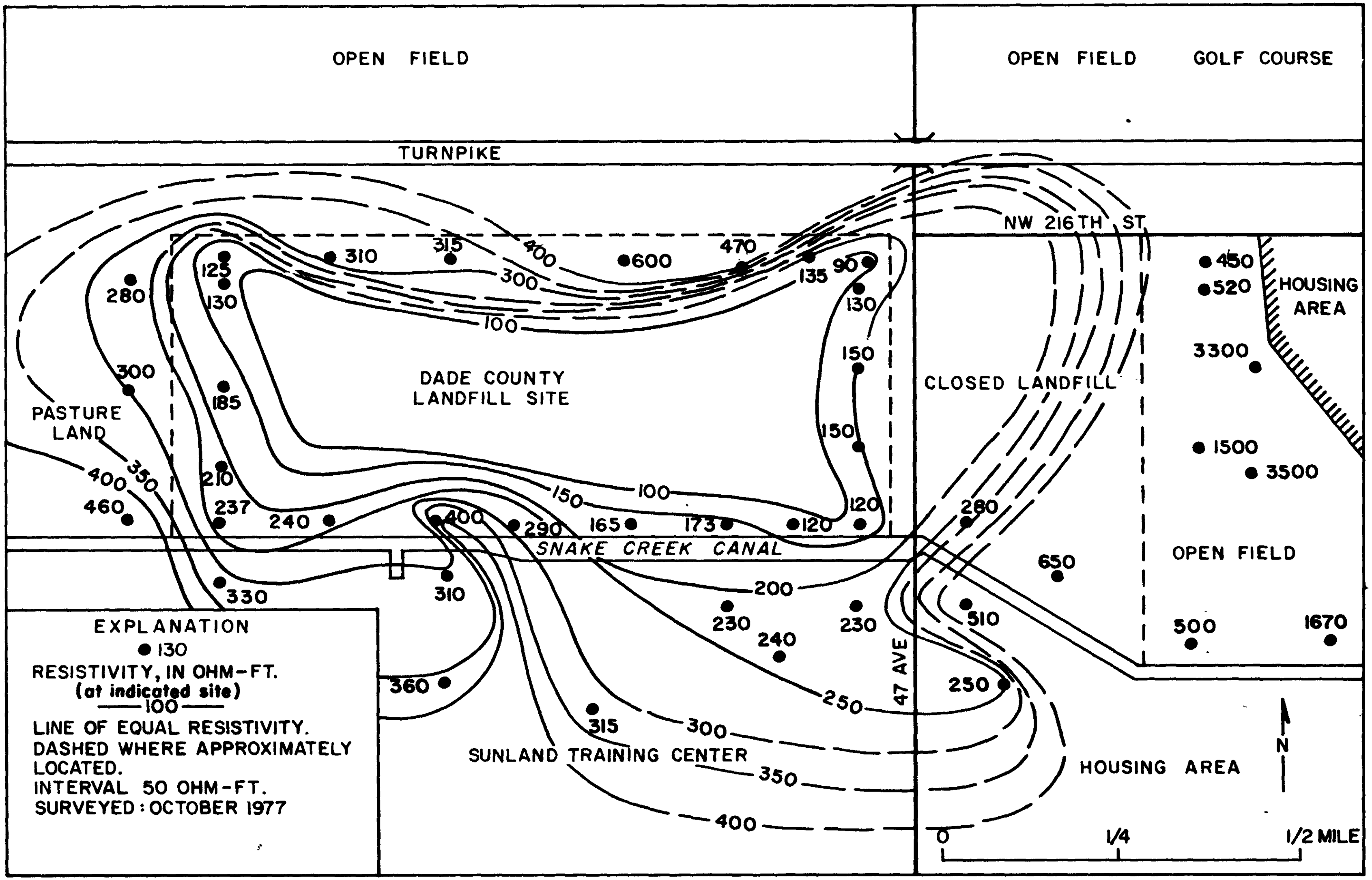

Figure 4.--Electrical-resistivity contours for approximate 45-foot depths (from Benson, 1977)

Table 3.--Ground-water and surface-water monitor sites, identification numbers, and well depths at the north Dade County solid-waste disposal facility

[See figure 2 for location of sites]

Ground-water monitor site No.	Well No.	Identification No.	Below landfill surface depth, in feet
Background wells upgradient from the landfill			
1	3154	255811080184201	23
	3155	255811080184202	47
Wells within the landfill			
2	3148	255752080173601	23
	3149	255752080173602	54.9
3	3150	255810080173601	22.8
	3151	255810080173602	52.8
4	3152	255800080171201	23
	3153	255800080171202	60.3
Wells downgradient from the landfill			
5	3144	255750080164501	22.6
	3145	255750080164502	56.4
6	3146	255813080164201	23
	3147	255813080164202	52

Surface-water monitor site No.	Canal name and location	Identification No.
7	Snake Creek Canal at N.W. 67th Avenue	02286200
8	Snake Creek Canal at N.W. 57th Avenue	255747080174300
9	Snake Creek Canal at N.W. 47th Avenue	255750080164000

Sampling and Analytical Methods

The U.S. Geological Survey National Water-Quality Laboratory-Atlanta in Doraville, Ga., provided the chemical analyses for major ions, trace elements, pesticides, oil and grease, phenols, and detergents. Also, the laboratory made determinations for turbidity, color, specific conductance, dissolved and suspended solids, and pH. The U.S. Geological Survey District Service Unit in Ocala, Fla., provided the chemical analyses for nutrients (nitrogen and phosphorus), organic and inorganic carbon, and chemical oxygen demand (COD). The U.S. Geological Survey office in Miami made determinations for 5-day biochemical oxygen demand (BOD) and for indicator bacteria. Field determinations were made for temperature, alkalinity, specific conductivity, and pH. The analytical techniques used for the determinations are described by Brown and others (1970), Goerlitz and Brown (1972), and Fishman and Brown (1976).

Ground-water samples were obtained by pumping the monitor well long enough to obtain a sample of water representative of the zone at the base of the well. Bottle samplers were used to obtain integrated samples of the surface water.

Retrieval of analytical data is possible from WATSTORE (U.S. Geological Survey) and STORET (U.S. Environmental Protection Agency) using the station identification numbers shown in table 3.

Frequency of Sample Collection

The monitor sites were sampled initially in February 1978 to determine: (1) the presence of any toxic contaminants; and (2) whether any particular constituent should be emphasized or excluded during the next sampling. The sites were then sampled in the dry season (April 1978) when ground-water levels were low and in the wet season (August 1978) when the levels were high (fig. 5).

WATER-QUALITY OF THE STUDY AREA

Quality of Native Ground Water

Samples from the wells at site 1 were used as a general representation of the native or background quality of water upgradient from the landfill. As a very semiquantitative check to establish that the ground water from site 1 was essentially unaltered by commingling with landfill leachate, selected analyses of native water from the Biscayne aquifer in north Dade County (table 4) were compared with analysis of site 1 water (table 5).

The analyses, used as a general representation of native water from the Biscayne aquifer (table 4), are of untreated water from two water-treatment plants and two wells in north Dade County. The untreated sample from each plant which represents a composite of several wells, 60 to 100-feet deep, provided the data for nutrients, metals, and pesticides (Hull, 1975, p. 102-117; Irwin and Healy, 1978, p. 144-146). The analyses of water from the two wells (G-218 and 224) were made by the U.S. Geological Survey (Parker and others, 1955, p. 794) and provided the major ion concentrations shown in table 4. These two wells, located about 6 miles southwest of the north Dade County landfill, were sampled during 1940-41.

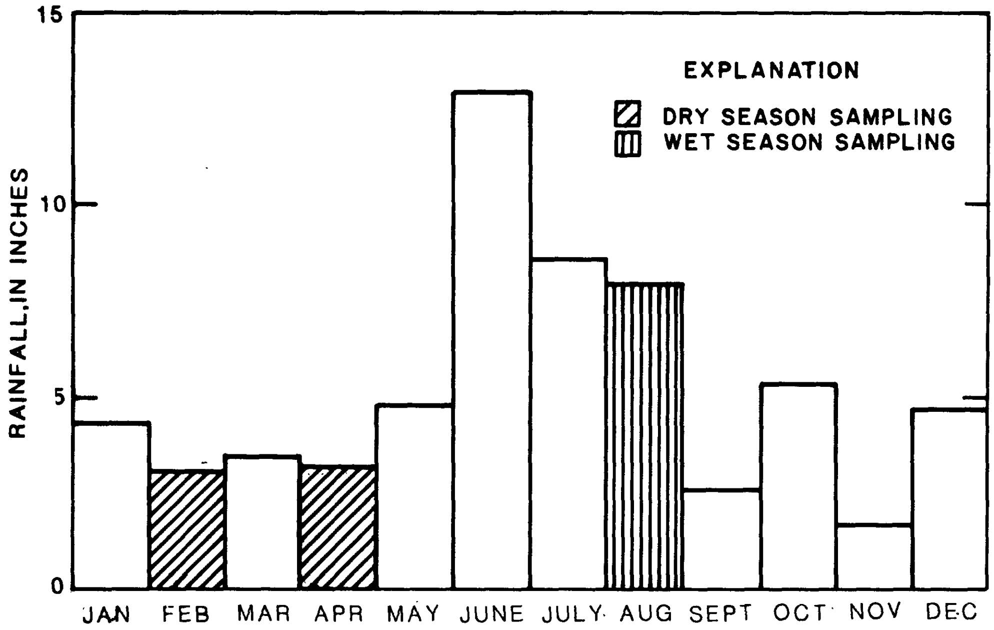

Figure 5.--Rainfall by months in north Dade County for 1978, and months of landfill sample collection.

Table 4.--Summary of general ranges of selected water-quality characteristics of ground water from the Biscayne aquifer in north Dade County

[Concentrations in milligrams per liter (mg/L) or micrograms per liter (ug/L), except as indicated]

Summary of selected analysis of water from wells G-218 (depth, 69 feet) and G-224 (depth, 37 feet), in the general area of the north Dade County solid-waste disposal facility, 1941-42; and two composites of water from supply wells at Hialeah and Preston water-treatment plants, 1976

Major inorganic constituents and related physical characteristics	Number of samples	Concentration in milligrams per liter, except as indicated
Calcium	4	93 - 102
Magnesium	4	6.8 - 9.6
Sodium	4	3.7 - 11
Potassium	6	1.4 - 4.2
Bicarbonate	4	300 - 312
Sulfate	4	2.5 - 28
Chloride	4	18 - 19
Fluoride	6	.2 - .3
Alkalinity, as $CaCO_3$	6	236 - 243
Dissolved solids, residue at 180°C	4	285 - 310
Specific conductance (μmhos/cm at 25°C)	4	527 - 566
pH (units)	6	7.3 - 7.4
Silica	4	6.8 - 11

Analysis of two composite water samples from supply wells at Hialeah and Preston water-treatment plants, 1976

Trace elements	Number of samples	Concentration in micrograms per liter
Arsenic	2	<1 - 4
Barium	2	<100
Cadmium	2	<1
Chromium	2	<10 - 10
Iron	2	180 - 440
Lead	2	5 - 21
Mercury	2	<.5
Selenium	2	<1
Silver	2	<1
Strontium	2	-
Zinc	2	60 - 100

Table 4.--Summary of general ranges of selected water-quality characteristics of ground water from the Biscayne aquifer in north Dade County--Continued

Analysis of two composite water samples from supply wells at Hialeah and Preston water-treatment plants, 1970-74

Nutrients	Number of samples	Concentration in micrograms per liter
Ammonia, total as N------------	17	0.05 - 1.2
Nitrate, total as N------------	17	.00 - .70
Nitrite, total as N------------	17	<.01 - .01
Phosphorus, total as P---------	12	.00 - .02

Results of the analyses of selected ground-water samples of the Biscayne aquifer from outside the immediate study area (table 4) compared with those of ground water from the landfill site 1 (table 5) suggest a similar quality. For example, the ground water in other parts of the county is calcium bicarbonate in type with a range in average dissolved solids of 285 to 310 mg/L (milligrams per liter); the water from site 1 is also calcium bicarbonate with a range in average dissolved solids of 369 to 433 mg/L. Calcium ranged from 98-120 mg/L at site 1 and ranged from 93-102 mg/L in native water (table 4); bicarbonate ranged from 320 to 408 mg/L at site 1 and ranged from 300-312 mg/L in the native water. Further, calcium in the ground water at other sites (table 4) comprised about 82 percent of the total cation composition and calcium in the water from the landfill site 1 (table 5) comprised about 81 percent of the cations. The bicarbonate concentration in the native ground water and site 1 water was respectively about 86 and 85 percent of the total anion composition. The concentrations of iron in the background water at site 1 was somewhat elevated and may have been influenced by the steel well casing.

Quality of Ground Water at the Landfill Site

Table 5 presents a summary of ranges of chemical, (physical, and biological) characteristics of water from monitor wells outside (upgradient and downgradient) and within the disposal facility.

This summary indicates that many characteristics, for example, alkalinity, dissolved solids, chloride, ammonia, and total organic carbon were more concentrated in well water from the landfill (sites 2-4) than in outside wells. However, water from site 5 which is immediately downgradient from the landfill contained high enough levels of some constituents to suggest the possibility of downgradient migration of leachate from the landfill.

The areal distribution of selected water-quality characteristics that appeared to have significant concentration differences among the monitor sites are presented individually in the following sections.

Chloride

Chloride concentrations of the native ground water in the upper part of the Biscayne aquifer in uncontaminated areas range from about 5 to 35 mg/L (Mattraw and others, 1978, p. 25). Well within this reported range, the chloride concentration of water from background (upgradient) monitor wells (site 1) at the north Dade County solid-waste disposal site ranged from 16 mg/L in the shallow well to 23 mg/L in the deep well (table 5). In ground water from the monitor sites within the landfill area (sites 2, 3, and 4), however, the concentrations of chloride were notably higher.

Table 5.--Summary of analytical ranges of selected chemical, physical, and biological characteristics of water samples from ground-water monitor sites 1-6, February-August 1978

[Analyses by U.S. Geological Survey]

Characteristic	Number of samples	Background wells upgradient from landfill 3154-55 (site 1)	Number of samples	Wells within landfill 3148-53 (sites 2, 3, 4)	Number of samples	Wells downgradient from landfill 3144-47 (sites 5, 6)
Major inorganic constituents and related physical characteristics	Concentrations in milligrams per liter, except as indicated					
Calcium	6	98 - 120	18	110 - 220	11	63 - 130
Magnesium	6	6.9 - 8.2	18	.6 - 22	11	.6 - 9.3
Sodium	6	11 - 17	18	9.0 - 150	11	4.7 - 31
Potassium	6	.7 - 1.1	18	.6 - 88	11	.3 - 12
Bicarbonate	7	320 - 408	19	330 - 936	11	170 - 520
Sulfate	6	14 - 30	18	<1.0 - 250	11	3.5 - 25
Chloride	6	16 - 23	18	12 - 230	11	6.3 - 50
Fluoride	6	.2 - --	18	.1 - .2	11	.1 - .3
Alkalinity, as $CaCO_3$	7	260 - 330	19	270 - 768	11	140 - 427
Dissolved solids, residue at 180°C	6	369 - 433	18	388 - 1,250	11	204 - 511
Specific conductance (µmhos/cm at 25°C)	7	557 - 645	18	590 - 2,450	12	320 - 985
pH (units)	7	6.7 - 7.1	18	6.4 - 7.4	12	6.5 - 7.5
Silica	6	8.8 - 10	18	7.7 - 11	11	7.5 - 10
Trace elements	Concentrations in micrograms per liter					
Aluminum	4	10 - 70	12	10 - 130	8	20 - 90
Arsenic	4	<1 - 1	12	1 - 14	8	<1 - 5
Barium	4	<100 - --	12	<100 - 500	8	<100
Cadmium	4	<2 - 3	12	[1]ND - 2	8	[1]ND - <2
Chromium	6	<20 - 20	18	<20 - 50	12	<20
Copper	4	[1]ND - 2	12	[1]ND - 6	8	<2 - 2
Iron	6	1,700 - 3,000	18	520 - 8,500	12	440 - 2,800
Lead	6	7 - 37	17	5 - 53	12	3 - 37
Manganese	6	<10 - 30	18	<10 - 60	12	<10 - 50
Mercury	4	<.5	12	<.5	8	<.5
Selenium	2	<1 - --	6	<1	4	<1
Silver	4	[1]ND - 2	12	[1]ND - <20	8	[1]ND - <2
Strontium	6	880 - 1,000	18	900 - 2,600	11	480 - 1,200
Zinc	3	20 - 40	9	<20 - 30	6	<20 - 30

[1] Not detected.

Table 5.--Summary of analytical ranges of selected chemical, physical, and biological characteristics of water samples from ground-water monitor sites 1-6, February-August 1978--Continued

Characteristic	Number of samples	Background wells upgradient from landfill 3154-55 (site 1)	Number of samples	Wells within landfill 3148-53 (sites 2, 3, 4)	Number of samples	Wells downgradient from landfill 3144-47 (sites 5, 6)
Selected nutrients and related characteristics				Concentrations in milligrams per liter		
Ammonia, total as N----	6	1.6 - 1.9	18	.74 - 53	12	.23 - 21
Nitrite, total as N----	6	<.01 - .01	18	<.01 - .01	12	<.01 - .01
Nitrate, total as N----	6	.00 - .01	18	.00 - .88	12	.00 - .02
Organic nitrogen, total as N----------	6	.88 - 1.1	18	.60 - 10	12	.10 - 4.0
Phosphorus, total as P-	6	<.01 - .01	18	<.01 - .05	12	.01 - .03
Carbon, total organic--	6	4.0 - 26	17	.0 - 70	12	7.0 - 60
Biochemical oxygen demand, 5 day--------	6	0.3 - 1.3	16	.3 - 4.3	12	.0 - 1.6
Chemical oxygen demand (high level)---------	6	38 - 60	18	39 - 190	12	2 - 76
Carbon dioxide (CO_2)---	7	41 - 105	18	23 - 596	11	9.1 - 263
Miscellaneous chemical and physical characteristics				Concentrations in milligrams, except as indicated		
Color (Pt-Co Units)----	6	80 - 130	18	120 - 600	11	20 - 230
Cyanide----------------	2	.00 - .01	5	.00	4	.00
MBAS-------------------	5	.00 - .10	17	.00 - .20	11	.00 - .10
Oil and grease---------	5	0 - 2	18	0 - 2	12	0 - 2
Phenols (ug/L)---------	6	0 - 5	18	0 - 19	11	0 - 8
Turbidity (NTU)--------	4	3 - 8	12	1 - 130	8	2 - 16
Bacteria				Colonies per 100 milliliters		
Coliform, fecal--------	6	<1 - <2	15	<1 - <4	12	<1 - <3
Coliform, total--------	6	<1 - 3	18	<1 - 110	12	<1 - 106
Streptococci, fecal----	6	<2	18	<1 - 14	12	<1 - 2

A graphical presentation summarizing the chloride distribution in the study area is given in figure 6. Site 4, the area of most recent waste deposition, had the highest concentrations of chloride averaging 177 mg/L in the shallow well and 208 mg/L in the deeper well. Site 2 also had elevated chloride concentrations (average of 180 mg/L) in the deeper well, but the chloride averaged only 13 mg/L in the shallow well. The maximum chloride concentration detected was 230 mg/L (April 1978) in water from the deep well at site 4 and the minimum was 6.3 mg/L (February 1978) in water from the shallow at site 6.

Chloride is often used as a leachate tracer. Zanoni (1971, p. 96), for example, reported that the results of most research studies indicated high concentrations of chloride in the leachate directly below solid-waste landfills. Because chloride is commonly generated during the decomposition of solid-waste and thus can be used as a reliable tracer; its areal distribution was also examined in this study to assess the possibility that leachate from the landfill was moving downgradient.

In general, the results of the reconnaissance indicated chloride concentrations were high in the disposal area and slightly increased above background at downgradient site 5. The average concentrations of chloride in water from the shallow monitor wells within the landfill indicated a high variability and ranged from 13 mg/L (site 2), which was below background levels, to 177 mg/L (site 4). Using results from just the deeper wells, the average concentration of chloride increased notably from 23 mg/L (site 1), to 180-208 mg/L (sites 2 and 4) to 46 mg/L (site 5). Overall, the increase in chloride concentration between background site 1 and site 5 suggests downgradient movement of leachate from the landfill area.

Alkalinity

High concentrations of carbon dioxide resulting from organic material decay produce high alkalinity through solubilization and equilibrium of carbonate minerals. As a result, the highest alkalinity in the study area was present in the ground water of the landfill (table 5; fig. 7). The maximum alkalinity was 768 mg/L (February 1978) occurring in water from the deeper well at landfill site 4. The shallow well at site 4 also exhibited high alkalinity having an average concentration of 557 mg/L and range of 500 to 600 mg/L. Both the shallow and deep wells at site 4 showed little variance in concentration between February and August 1978. Landfill site 2 also indicated significant waste decomposition with an alkalinity maximum of 512 mg/L (February 1978) in the shallow well and 700 mg/L in the deep well. Alkalinity at this site remained almost unchanged in both the deep and shallow wells over the wet and dry period. At landfill site 3, the concentration of alkalinity varied little between wet and dry periods ranging from 270 to 302 mg/L. The alkalinity concentrations at downgradient site 6 were lower than at background site 1, but concentrations were slightly higher than background levels at downgradient site 5.

Alkalinity as $CaCO_3$, like chloride, was used as an indicator of leachate production and movement. Similarily, using results from just the deeper wells, the average concentration increased from 300 mg/L at background site 1 to 384 mg/L at downgradient site 5.

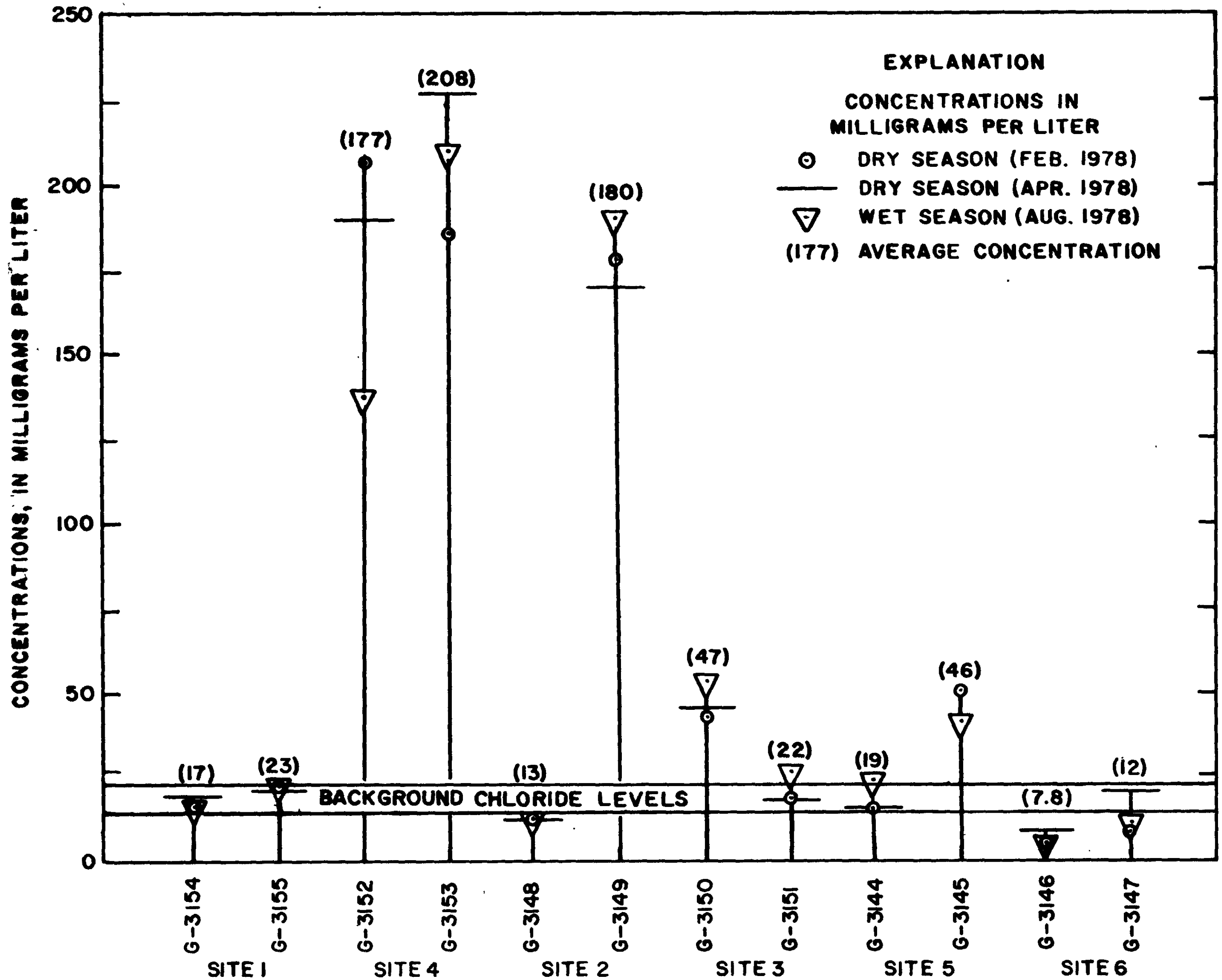

Figure 6.--Concentrations of chloride in ground water from monitor wells at the north Dade County solid-waste disposal facility.

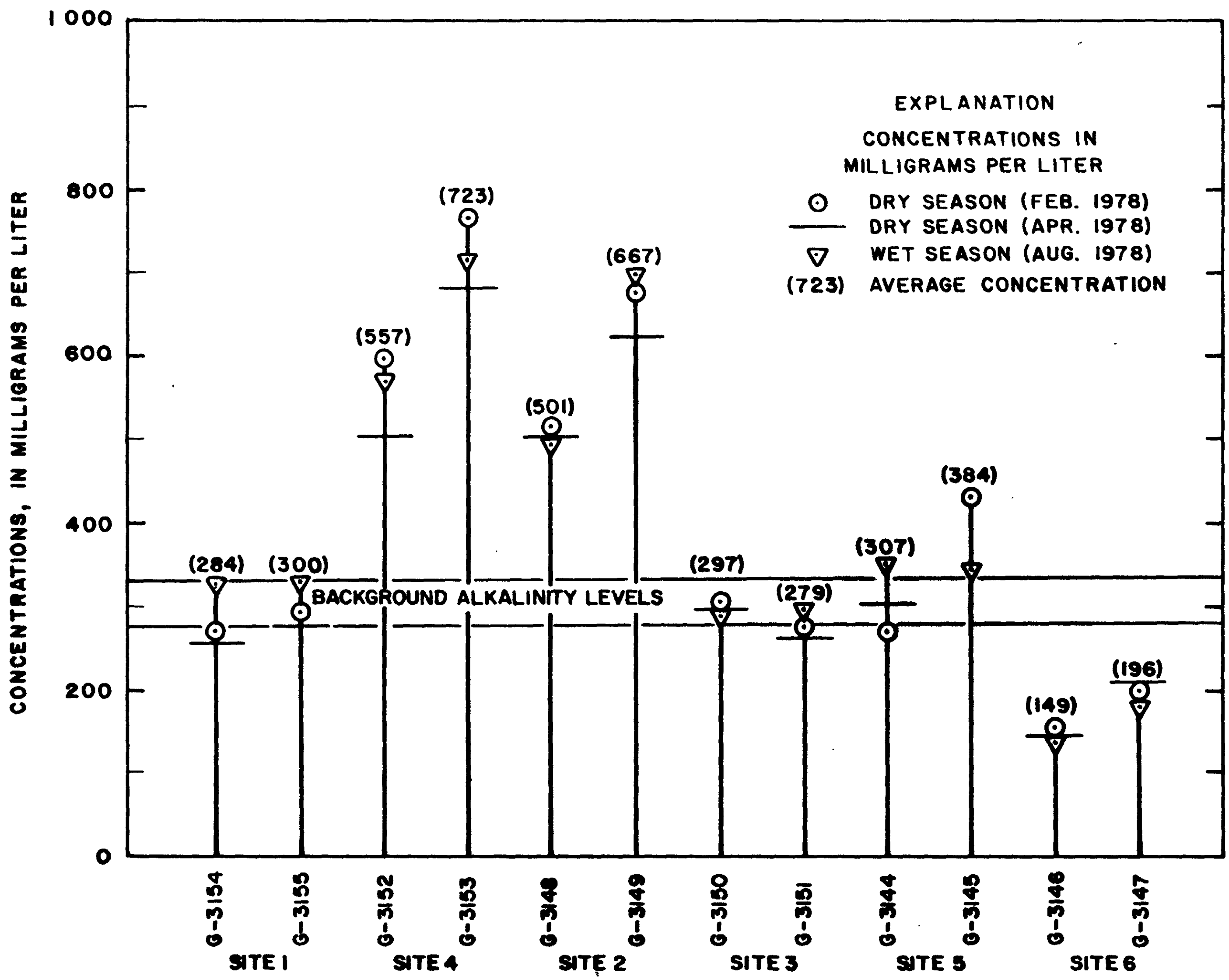

Figure 7.--Concentrations of total alkalinity (as $CaCO_3$) in ground water from monitor wells at the north Dade County solid-waste disposal facility.

Nitrogen and Phosphorus

Results indicated that the organic component of the landfill solid waste was freely decomposed and high levels of ammonia were common. This is because organic matter is decomposed to amino acids and ammonia by numerous species of anaerobic and aerobic bacteria (Salle, 1954, p. 376). Further, the ground water of the landfill is essentially devoid of oxygen (anaerobic); thus, there was then little or no mechanism for oxidizing ammonia to nitrite (NO_2) and nitrate (NO_3) by means of aerobic bacteria. Consequently, ammonia concentrations were high in water from landfill sites 2, 3, and 4 and ranged from 2.4 to 53 mg/L and the nitrate and nitrite concentrations never exceeded 0.88 mg/L (table 5).

The highest ammonia concentrations in the landfill occurred at landfill site 4 (fig. 8). At this site, the concentrations of ammonia in water from the shallow well averaged 22 mg/L and ranged from 17 to 26 mg/L and concentrations in water from the deep well averaged 41 mg/L and ranged from 29 to 53 mg/L. Significant organic decomposition based on high ammonia concentrations was also indicated at landfill site 2 which had a concentration range of 23 to 33 mg/L in water from the deep well. However, water from the shallow well at site 2 varied only slightly ranging from 2.4 to 3.8 mg/L. Landfill site 3 showed only background concentrations of ammonia, but site 3 is probably an area of older waste deposits and complete organic decomposition has occurred. The deep well at site 5, downgradient from the landfill, had an ammonia range of 14-21 mg/L which suggests that leachate migration outside the landfill had occurred. Water from the shallow well at site 5 exhibited low ammonia concentrations ranging from 1.5 to 1.7 mg/L.

A downgradient increase in concentrations of ammonia was most evident using the results from the deeper wells. For example, the average concentration of ammonia is 1.7 mg/L in water from the deep well at background site 1; whereas, the average concentration increased to 41 and 27 mg/L at sites 4 and 2, respectively, and then declines to 17 mg/L in water from the deep well at downgradient site 5.

Concentrations of organic nitrogen in the background water from site 1 ranged from 0.88 to 1.1 mg/L. At landfill site 4, within the area of recent waste, organic nitrogen concentrations were the highest with an average of 4.4 mg/L and a range of 0.6 to 10 mg/L. In water from downgradient monitor site 5, the organic nitrogen in the deep well was 3.4 mg/L in the dry period (February 1978) and 0.1 mg/L in the wet season (August 1978), but was constant at 1.1 mg/L for these same periods in water from the shallow well.

Total phosphorus was present in only trace quantities in the ground water of the landfill site. The maximum concentration of total phosphorus detected during the reconnaissance was 0.05 mg/L (August 1978) at landfill site 2. The concentration of total phosphorus in water from the other landfill wells averaged 0.02 mg/L, the background water (site 1) averaged 0.01 mg/L, and the downgradient ground water (site 5) averaged 0.02 mg/L.

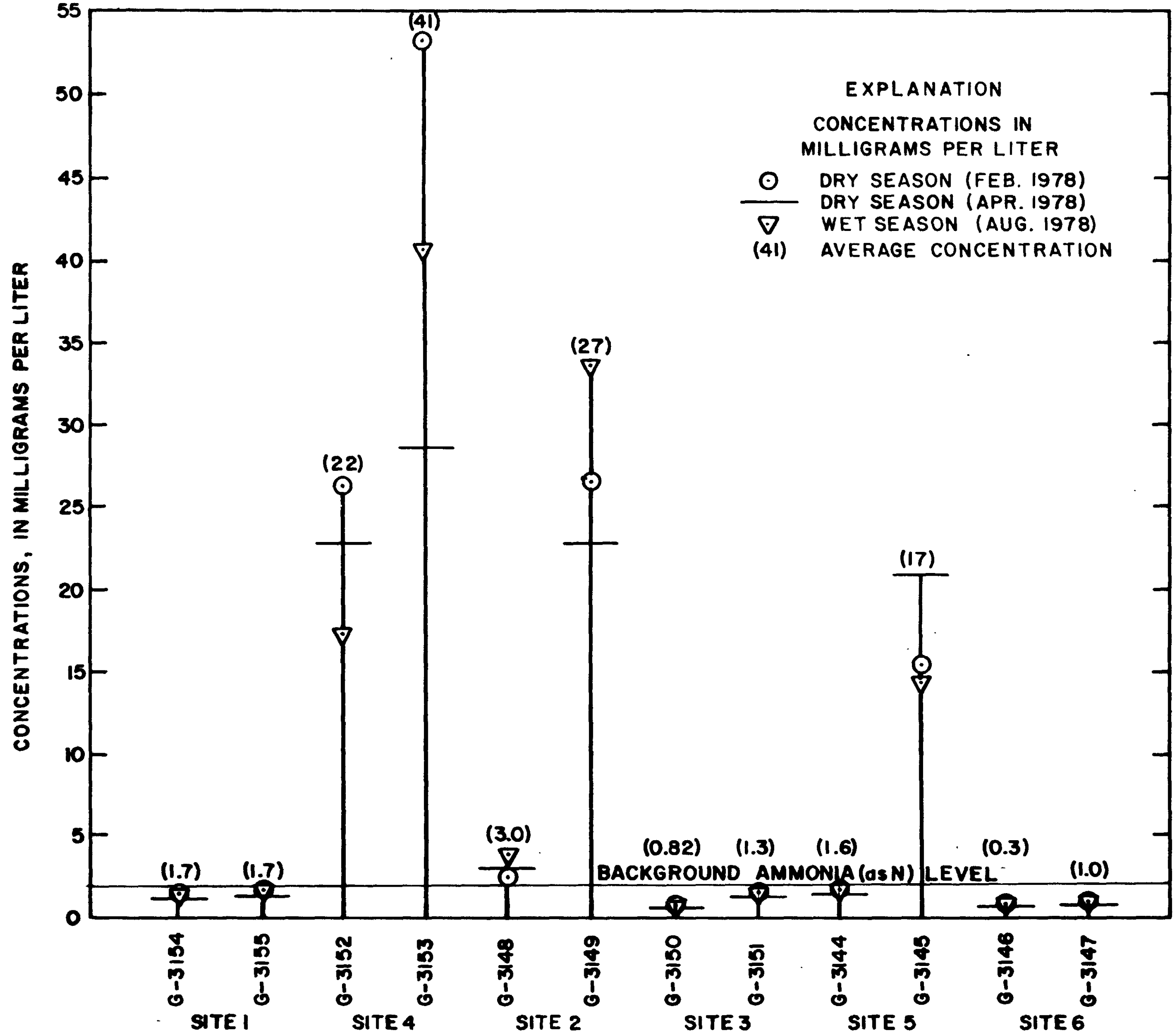

Figure 8.--Concentrations of total ammonia (as N) in ground water from monitor wells at the north Dade County solid-waste disposal facility.

Total Organic Carbon

The concentrations of total organic carbon (TOC) were notably higher in the ground water of the landfill (sites 2, 3, and 4) than in the ground water of background site 1. Also, TOC concentrations appeared slightly higher at downgradient site 5 than at background site 1 (table 5; fig. 9). For example, the average concentrations of TOC at site 1 were 14 mg/L (shallow well) and 19 mg/L (deep well), but at site 5 the average concentrations were 37 mg/L (shallow well) and 25 mg/L (deep well) at site 5. Overall, total organic carbon averaged 16 mg/L at background site 1, 35 mg/L at landfill sites 2-4, and 31 mg/L at downgradient site 5.

Chemical Oxygen Demand

The distribution of the chemical oxygen demand (COD) in water from the monitor wells is shown in figure 10. Chemical oxygen demand (COD) is a general index of the levels of oxidizable materials (usually organic) in a water sample.

The COD concentrations at landfill sites 2, 3, and 4 averaged 110, 52, and 110 mg/L, respectively, with a landfill maximum of 190 mg/L occurring at site 2. The COD concentrations in the ground water at sites 2 and 4 were notably higher in the deeper wells. The background concentration (site 1) averaged 49 mg/L in the shallow well and 50 mg/L in the deep well with individual samples from both wells ranging from 38 to 60 mg/L. At downgradient site 5, the COD concentration averaged 56 mg/L in the shallow well and 71 mg/L in the deep well with individual samples from both wells ranging from 47 to 76 mg/L. The 21 mg/L average increase between the deep wells at site 1 and site 5 may suggest some downgradient movement of oxidizable leachate.

Trace Elements

A summary of trace element data collected at ground-water monitor sites 1-6 is presented in table 5. Results suggest that the concentrations of some trace elements in the ground water from landfill sites 2, 3, and 4 were somewhat higher than those found at the background site 1. For example, ground water of the landfill occasionally contained arsenic, barium, chromium, iron, and strontium in concentrations on the order of twice or greater than those of the background (site 1). Most of the higher concentrations occurred at site 4, the area of recent waste burial. However, the deep well at site 2 also had some elevated concentrations of trace elements. Little difference in trace element concentrations was apparent between the downgradient site 5 and background site 1.

Of the trace elements detected, the high concentrations of iron were perhaps the most notable. For example, at background site 1 the concentrations of iron ranged from 1,700 to 3,000 μg/L (micrograms per liter), at landfill sites 2-4 concentrations ranged from 520 to 8,500 μg/L, and at downgradient site 5 concentrations ranged from 440 to 2,800 μg/L. High iron concentrations, however, are not uncommon in the ground water in this

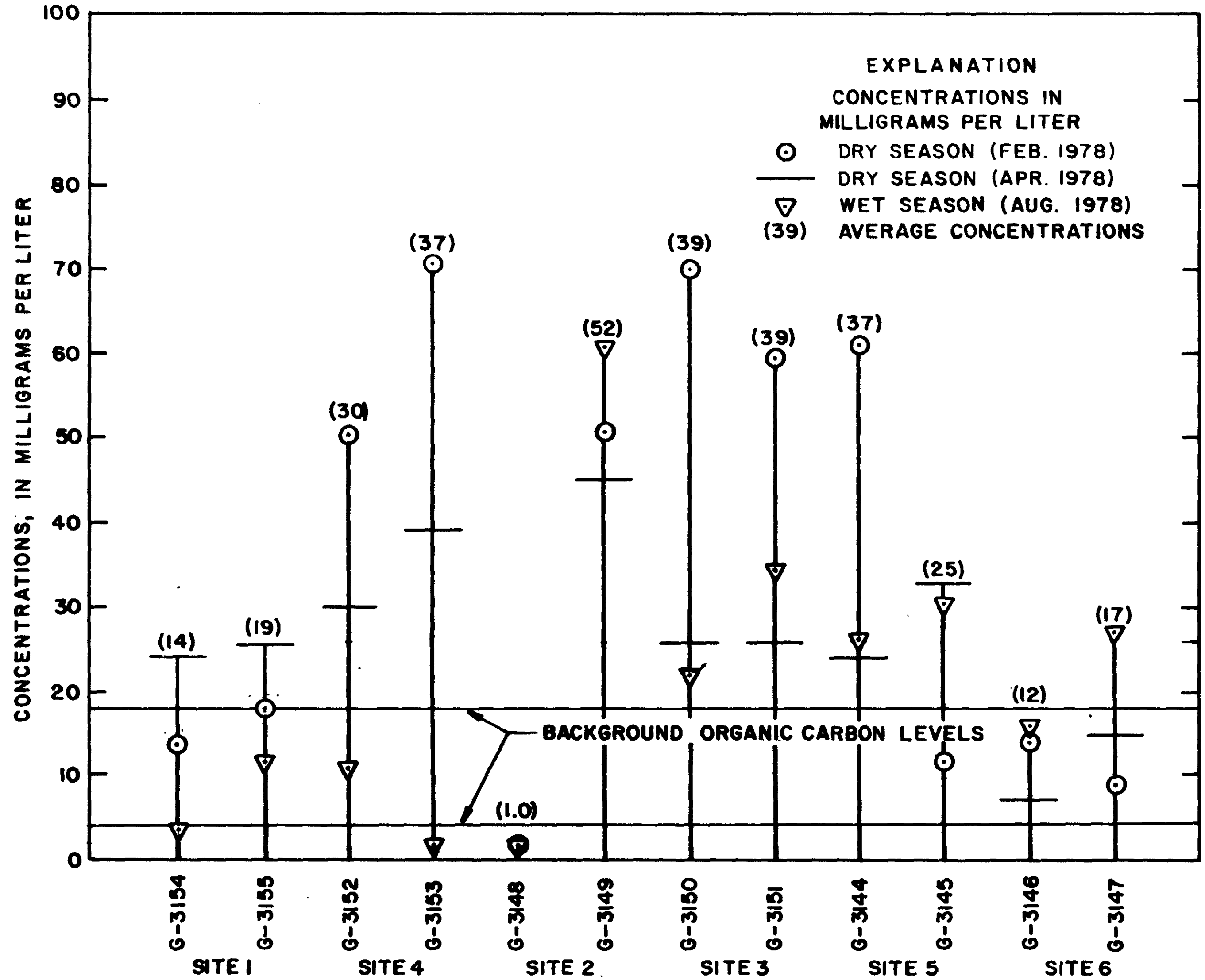

Figure 9.--Concentrations of total organic carbon (TOC) in ground water from monitor wells at the north Dade County solid-waste disposal facility.

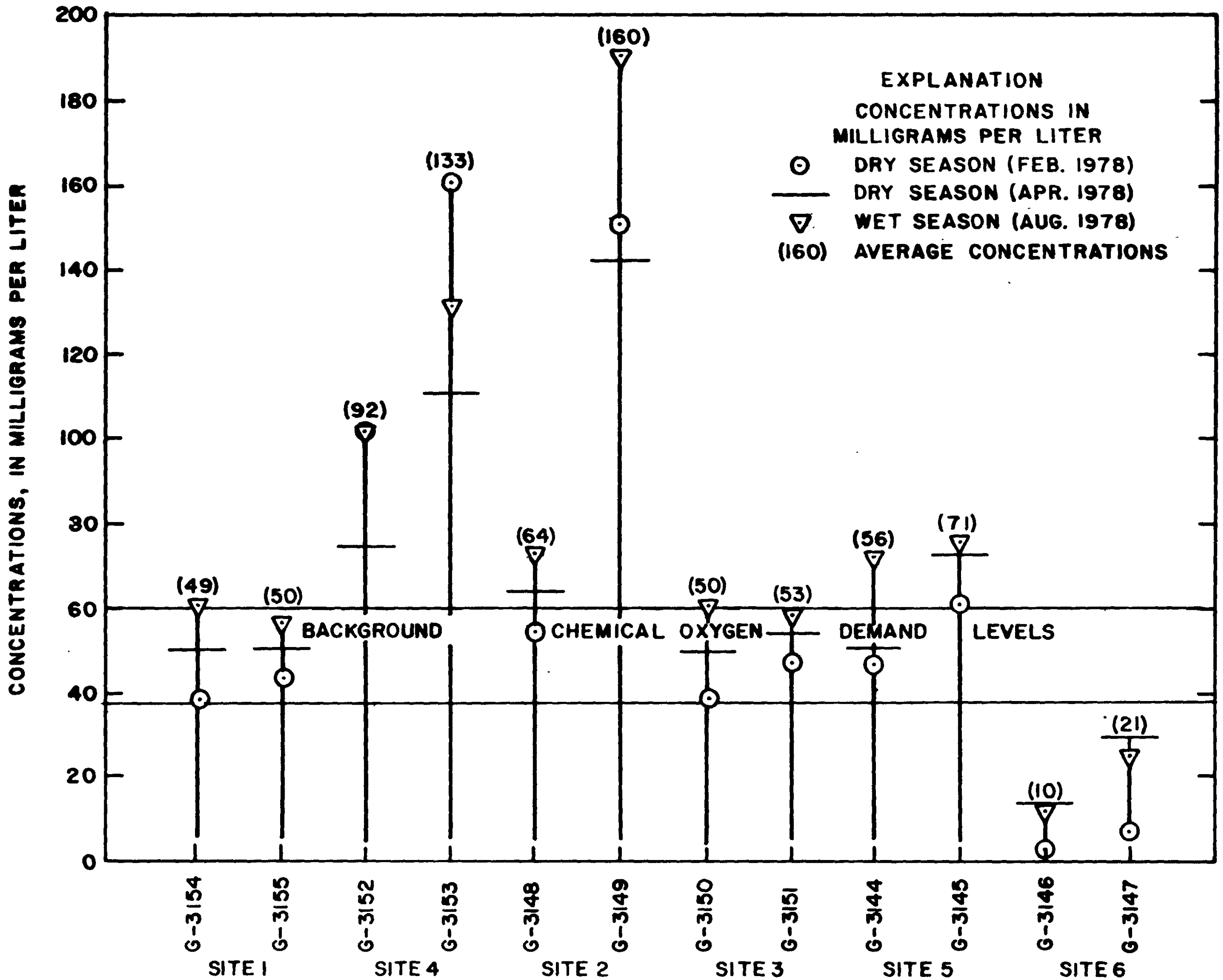

Figure 10.--Concentrations of chemical oxygen demand (COD) in ground water from monitor wells at the north Dade County solid-waste disposal facility.

area of south Florida. For example, ground waters may contain concentrations from less than 1,000 μg/L to 3,000 or 4,000 μg/L (Parker, 1955, p. 731). Some of the iron detected in water samples from the monitor wells may be attributed to the steel well casings; however, because iron is naturally high in water from the Biscayne aquifer, sampling contamination is likely minimal. Therefore, the magnitude of the concentration differences between site 1 and the sites within the landfill indicates that additional iron is likely released and dissolved during the decomposition of solid waste.

Traces of lead ranging from 5 to 53 μg/L were detected in the landfill monitor wells. The average concentration, however, for sites 2, 3, and 4 was only 14 μg/L. The concentrations of lead in ground water from background site 1 ranged from 7 to 37 μg/L and averaged 15 μg/L. The downgradient concentrations ranged from 5 to 30 μg/L (site 5) and 3 to 37 μg/L (site 6), with averages of 15 μg/L (site 5) and 13 μg/L (site 6).

Barium was detected in the ground water from landfill sites 2 and 4 in concentrations ranging from <100 to 500 μg/L. The maximum concentration detected was 500 μg/L occurring in water from the deep well at site 4. Barium concentrations were below detection limits at all other ground-water monitor sites.

Slightly elevated concentrations of arsenic (14 μg/L), manganese (60 μg/L), and chromium (50 μg/L) also occurred in the landfill area of recent deposition.

Selected Pesticides and Industrial Compounds

All monitoring wells at the north Dade County solid-waste disposal facility were sampled in February 1978 and analyzed for the following pesticides and industrial compounds:

Aldrin	Endrin	Naphthalenes
Chlordane	Ethion	Parathion
DDD	Heptachlor	Silvex
DDE	Heptachlor epoxide	Toxaphene
DDT	Lindane	Trithion
Diazinon	Malathion	2,4-D
Dieldrin	Methyl parathion	2,4,5-T
Endosulfan	Methyl trithion	

Results of the February sampling indicated that, except for methyl parathion, all the above organic compounds were below analytical detection (0.00 μg/L). Methyl parathion was detected at a concentration of 0.12 μg/L in water from the deeper well at landfill site 2.

Quality of Surface Water

A summary of water-quality data collected at surface-water monitor sites 7, 8, and 9 is presented in table 6. As site 7 is located about 1 mile upstream (east) from the landfill on the Snake Creek Canal, data from this site were used to establish background surface-water quality. In addition to the 1978 data collected for this study, data on major ions, metals, nutrients, and pesticides have been collected at site 7 from 1960-77. The frequency of sample collection for the 1960-77 data ranged from monthly to three samples per year. Sites 8 and 9 are located to represent the water quality of the canal contiguous and generally down-gradient from the landfill.

Water from background site 7 had a major inorganic composition of calcium bicarbonate with an average dissolved-solids concentration of 371 mg/L. The average concentration of dissolved solids of 371 mg/L at site 7, was slightly lower than the average of 397 mg/L determined for ground-water background (site 1). The composition of both the surface- and ground-water at background sites was primarily calcium bicarbonate; however, the ionic percentage of calcium and bicarbonate was notably lower in the surface water. The average ionic composition of calcium and bicarbonate of water from site 7 was 59 and 69 percent, respectively; whereas, the ionic composition of the background ground water was above 80 percent for both constituents. The presence of higher concentrations of sodium and chloride (relative to calcium and bicarbonate) accounted for the lower ionic-composition percentage of calcium and bicarbonate at surface-water background site 7.

The major ionic composition of the canal water at all three sites is calcium bicarbonate, and results did not indicate an apparent difference between the general chemistry of background site 7 and downgradient sites 8 and 9. That is, the variance in the concentrations of dissolved solids among the sites was generally less than the variance between samples at an individual site. For example, using only data collected during 1978, the average concentrations of dissolved solids at sites 7, 8, and 9 were 410, 380 and 410 mg/L, respectively. The concentration ranges, however, at sites 7, 8, and 9 were 382-443, 354-401 and 396-419 mg/L, respectively. Most of the concentration variance at individual sites was a function of variable runoff (wet and dry periods).

In overview, sites 8 and 9 did not indicate notably higher concentrations of trace elements than those detected at the background surface-water site 7. MBAS (detergent) was detected in suface-water samples, but concentrations were low and occurring at all three sites. Nutrients, namely the nitrogen species, occurred in somewhat higher concentrations in background water (table 6) than at the monitoring sites adjacent to the landfill. However, this difference is attributed to the longer period of data collection (more samples) for site 7. Using only the 1978 data, for example, the average total nitrogen concentrations were 1.1 mg/L (site 7), 1.4 mg/L (site 8), and 1.4 mg/L (site 9). Organic carbon had a maximum concentration of 129 mg/L at site 9; but overall, the total carbon concentration among the three sites varied little, averaging about 20 mg/L.

Table 6.--Summary of analytical ranges of selected chemical, physical, and biological characteristics of water samples from surface-water monitor sites 7 (1960-78), 8 (1978), and 9 (1978)

Characteristic	Number of samples	Background water quality Snake Creek (site 7)	Number of samples	Snake Creek Canal at disposal site (sites 8, 9)
Major inorganic constituents and related physical characteristics		Concentrations in milligrams per liter, except as indicated		
Calcium---------------	39	66 - 94	6	75 - 88
Magnesium-------------	37	.4 - 17	6	8.6 10
Sodium----------------	39	9.6 - 64	6	36 - 55
Potassium-------------	39	.3 - 2.5	6	1.1 - 1.7
Bicarbonate-----------	50	232 - 316	7	270 - 296
Sulfate---------------	39	.3 - 26	6	4.4 - 7.4
Chloride--------------	39	17 - 99	6	58 - 87
Fluoride--------------	39	.2 - .6	6	.2
Alkalinity, as $CaCO_3$--	65	190 - 270	7	220 - 243
Dissolved solids, residue at 180°C----	50	289 - 501	6	354 - 419
Specific conductance (µmhos/cm at 25°C)--	87	424 - 839	6	600 - 690
pH (units)------------	74	7.4 - 8.3	6	7.0 - 7.6
Silica----------------	39	2.5 - 10	6	6.6 - 7.9
Trace elements		Concentrations in micrograms per liter		
Aluminum--------------		0 - 70	4	40 - 70
Arsenic---------------	15	<1 - 20	4	<1 - 1
Barium----------------	3	<100	4	<100
Cadmium---------------	3	<1 - 1	4	[1]ND - 2
Chromium--------------	4	<10 - 10	6	<20 - 20
Copper----------------	6	[1]ND - 20	4	<2 - 2
Iron------------------	22	20 - 700	6	360 - 770
Lead------------------	7	[1]ND - 28	6	5 - 33
Manganese-------------	6	<10 - 20	6	<10 - 20
Mercury---------------	3	<.5	4	<.5
Selenium--------------	3	<1	2	<1
Silver----------------	3	[1]ND - 2	4	[1]ND - 2
Strontium-------------	22	[1]ND - 1,000	6	720 - 790
Zinc------------------	11	10 - 80	6	[1]ND - 20

[1] Not detected.

Table 6.--Summary of analytical ranges of selected chemical, physical, and biological characteristics of water samples from surface-water monitor sites 7 (1960-78), 8 (1978), and 9 (1978)--Continued

Characteristic	Number of samples	Background water quality Snake Creek (site 7)	Number of samples	Snake Creek Canal at disposal site (sites 8, 9)
Selected nutrients and related characteristics		Concentrations in milligrams per liter		
Ammonia, total as N---	23	.08 - .34	6	.13 - .33
Organic nitrogen, total as N----------	35	.52 - 2.1	6	.99 - 1.3
Nitrate, total as N---	73	.0 - .49	6	.00 - .08
Nitrite, total as N---	38	.0 - .45	6	.01 - .02
Phosphorus, total as P----------------	47	.05 - .07	6	<.01 - .02
Carbon, total organic-------------	23	24 - 77	6	5.0 - 129
Biochemical oxygen demand, 5 day at 20°C----------------	32	.2 - 2.3	5	.3 - 1.1
Chemical oxygen demand (high level)--------	3	27 - 60	6	18 - 60
Carbon dioxide (CO_2)--	7	11 - 21	6	11 - 47
Miscellaneous chemical and physical characteristics		Concentrations in milligrams per liter, except as indicated		
Cyanide---------------	1	0.0	2	0.00
MBAS (detergents)-----	7	.03 - 0.1	6	.00 - .10
Oil and grease--------	14	0 - 15	6	0 - 1
Phenols (ug/L)--------	4	0 - .4	6	0 - 5
Color (Pt-Co units)---	4	40 - 70	6	40 - 70
Turbidity (NTU)-------	3	2 - 6	4	3 - 6
Bacteria		Colonies per 100 milliliters		
Coliform, fecal-------	16	10 - 510	6	<2 - 700
Coliform, total-------	20	100 - 12,000	6	5 - 440
Streptococci, fecal---	13	14 - 950	6	<2 - 64

Fecal coliform and streptococci were detected at all sites with no difference indicated among sites. Pesticides and industrial compounds were not detected except for silvex and 2,4-D which were detected at 0.04 μg/L at site 9.

WATER QUALITY OF THE LANDFILL AREA AND NATIONAL DRINKING WATER REGULATIONS

As a general index of water-quality conditions in the study area, maximum levels of selected quality characteristics determined during the 1977-78 reconnaissance were compared with the national maximum contaminant levels (MCL's) established for public drinking water. The maximum contaminant levels used for the comparison are those established by the National Primary and Secondary Drinking Water Regulations (U.S. Environmental Protection Agency, 1975; 1977a). These MCL's are generally the same as those adopted by the State of Florida, Rules of the Department of Environmental Regulation, Chapter 17-22, Water supplies, amended, January 13, 1981.

The general comparison given in table 7 is presented only as a relative index to water-quality conditions. That is, the National Primary and Secondary Drinking Water Regulations specifically pertain to water distributed as a community (public) water supply, and water which is designated for other uses is not necessarily required to meet the MCL's given in table 7.

For general reference, a composite analysis of water from the Biscayne aquifer is also included in table 7; this composite represents numerous historical data collected in north Dade County.

Ground Water

Color and iron were the only characteristics of ground water that occurred at levels exceeding the recommended National Primary or Secondary Drinking Water Regulations both within and outside the landfill area. However, this is not unusual because naturally occurring, highly colored, organic material is commonly present in waters of south Florida and serves to accumulate iron through sorptive processes. Thus, the high levels of color and iron are likely not solely the result of solid-waste decomposition. The maximum levels of color and iron in the ground water of the landfill, however, were considerably higher than the upgradient site 1 which suggests that some color and iron were generated during the decomposition of solid waste.

In addition to iron and color, water from wells within the landfill area (sites 2, 3, and 4) had at least one sample that contained concentrations of chromium, lead, and manganese that equaled or exceeded the national regulations. Some samples from wells in the landfill also contained sulfate, dissolved-solids concentrations, and turbidity levels that equaled or exceeded national MCL's.

In addition to high color and iron, water from downgradient site 5 exceeded the 500 mg/L MCL for dissolved solids in three of the six samples collected, and one sample equaled the 50 μg/L MCL for manganese. At site 1, the MCL for turbidity was exceeded in one sample; the color and iron MCL's were exceeded in all six samples.

Table 7.--Comparison of maximum levels of selected quality characteristics of water from monitor sites 1-9 at the north Dade County solid-waste disposal facility with the maximum contaminant levels established by the National Primary and Secondary Drinking Water Regulations and a reference analysis of untreated-drinking water from the Biscayne aquifer

Characteristic	Maximum contaminant level for Primary Regulation[1]	Recommended maximum contaminant level for Secondary Regulation[2]	Untreated drinking water (Biscayne aquifer north Dade County)	Maximum concentration in ground water at background-monitoring site 1	Maximum concentration in ground water at landfill monitoring sites 2, 3, 4	Maximum concentration in ground water at downgradient monitoring site 5	Maximum concentration in canal sites 8, 9
Concentrations in milligrams per liter, except as indicated							
Chloride	--	250	19	23	230	50	87
Sulfate	--	250	25	30	250	16	7.4
Nitrate nitrogen	10	--	2	.01	.88	.02	.08
Dissolved solids	--	500	--	433	1,250	511	419
Color (Pt-Co units)	--	15	--	130	600	230	70
Turbidity	5	--	--	12	130	5	6
pH units	--	6.5 - 8.5	--	6.7 - 7.1	6.4 - 7.4	6.5 - 7.2	7.0 - 7.6
Detergents	--	.5	--	.10	.20	.10	.10
Concentrations in micrograms per liter							
Arsenic	50	--	2	1	14	2	1
Barium	1,000	--	0	<100	500	<100	<100
Cadmium	10	--	0	3	2	<2	2
Chromium	50	--	10	20	50	<20	20
Copper	--	1,000	--	2	6	2	2
Iron	--	300	--	3,000	8,500	2,800	770
Lead	50	--	7	37	53	30	33
Manganese	--	50	--	30	60	50	20
Mercury	2	--	<.5	<.5	<.5	<.5	<.5
Selenium	10	--	0	<1	<1	<1	<1
Silver	50	--	5	2	<20	<2	2
Zinc	--	5,000	--	40	30	30	20

[1] U.S. Environmental Protection Agency, 1975.
[2] U.S. Environmental Protection Agency, 1977a.

Surface Water

Concentrations of iron and levels of color commonly exceeded the national secondary MCL's at surface-water sites 8 and 9, and the national primary MCL for turbidity was exceeded in one of four samples. Samples of background site 7 also exhibited levels of these characteristics that were about equal or somewhat above the national regulations.

FUTURE WATER-QUALITY MONITORING

A continuation of periodic sampling of ground-water wells would be required to determine more precisely the impact of landfill leachate on local water resources. Based on the results of the study, partial monitoring could be accomplished by seasonal sampling of the deeper wells at landfill sites 2, 3, and 4, and downgradient site 5. However, because monitoring coverage downgradient from the landfill was somewhat limited in scope, the establishment of additional downgradient monitoring wells between the landfill and the residential area would be required to more precisely: (1) verify the existence of a leachate plume; (2) locate the leading edge of the leachate plume, and (3) determine leachate concentration.

The principal objective of future monitoring would be to determine if leachate migration from the landfill is adversely impacting the water resources downgradient. The magnitude of impact, of course, is determined by the designated or beneficial use of the downgradient water. In this part of north Dade County, the water from the Biscayne aquifer is used primarily for drinking water; therefore, the monitoring focus would be directed toward the evaluation of the general suitability of the downgradient water for human consumption. Specifically, the water-quality characteristics of interest would be those mandated under the National Primary and Secondary Drinking Water Regulations. In conjunction with monitoring the nationally regulated characteristics, an additional objective of the monitoring program would be to determine the general inorganic and organic conditions of the local water resources.

Regarding characteristics to be monitored, results of this sampling reconnaissance indicate that dissolved solids or specific conductance and chloride observations would serve as a monitoring index (indicator) for downgradient increases in the inorganic component of leachate migrating downgradient from the disposal site. Total organic carbon and ammonia would serve as a monitoring index (indicator) for downgradient increases in the organic and nutrient component of leachate migration. For the trace elements, iron appears to be a significant byproduct of solid-waste decomposition at this site, and thus, should be considered in future monitoring.

SUMMARY

A water-quality sampling reconnaissance of the north Dade County solid-waste disposal site near Carol City was conducted in cooperation with the Dade County Department of Public Works. The purpose of this 1977-78 reconnaissance was to measure and describe chemical, physical, and biological conditions of the surface and ground water in and contiguous to the landfill; and to assess, in a general way, if leachate generated by solid-waste decomposition in the landfill is adversely impacting the quality of the local water resources. The general scope of the reconnaissance included the collection and analyses of periodic surface- and ground-water samples from nine monitor sites located upgradient from, within, and downgradient from the landfill.

1. Overall, results of the 1977-78 sampling reconnaissance indicated that high levels of many chemical and physical characteristics were present in the ground water of the landfill. These high levels undoubtedly were in part due to solid-waste decomposition and subsequent leachate production. Some of the water-quality characteristics detected at significant levels in the landfill were also detected in downgradient ground water at levels somewhat higher than they were measured upgradient from the landfill.

2. Examination of areal variations in concentrations of selected inorganic and organic characteristics among monitor sites indicated that some downgradient movement of leachate had occurred. For example, the average concentrations of chloride and alkalinity was 23 and 300 mg/L, respectively, at upgradient site 1 compared with 46 and 384 mg/L for downgradient site 5.

3. Concentrations of ammonia nitrogen, and total organic carbon were also quite high in landfill ground water (sites 2-4) and concentrations at downgradient site 5 were higher than those at upgradient site 1. Using just the deep-well results, there was a tenfold increase in the average concentration of ammonia between site 1 (1.7 mg/L) and site 5 (17 mg/L). The areal variation in the average concentration of total organic carbon was also quite notable in the deep wells, ranging from 19 mg/L at upgradient site 1, 52 and 37 mg/L at landfill sites 2 and 4, respectively, and 25 mg/L at downgradient site 5.

4. Concentrations of some trace elements, particularly iron, were elevated in the ground water of the landfill; however, the reconnaissance data did not indicate a notable difference in trace element levels between the background and downgradient sites.

5. For surface-water, no discernible difference in water-quality was indicated between background site 7 and landfill-monitor sites 8 and 9.

6. Maximum levels of selected characteristics of ground water in the study area were compared with the maximum contaminant levels (MCL) established by the National Primary and Secondary Drinking Water Regulations. This comparison showed that levels of iron and color in ground water upgradient, downgradient, and within the landfill exceeded national secondary MCL's. Further, ground water in the landfill also contained concentrations of sulfate, dissolved solids, chromium, lead, and magnesium and levels of turbidity which either approximated or exceeded the national regulations.

7. Surface water at sites 8 and 9 also contained maximum concentrations of iron and levels of color and turbidity that exceeded the national secondary regulations.

8. For future monitoring, additional ground-water sites between the landfill and the nearby residential area would be desirable for a more precise determination of the extent, direction, and water-quality impact of leachate movement.

9. Based on results of this reconnaissance, future monitoring to detect downgradient movement of leachate would, at a minimum, include the following water-quality characteristics: (1) dissolved solids and chloride would serve as a monitoring index for the major inorganic component of leachate; (2) total organic carbon and ammonia would serve as a monitoring index for the general organic and nutrient component of leachate; and (3) iron, which is quite high naturally, but is also being generated within the landfill site and usually exceeds National and State drinking water regulations.

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