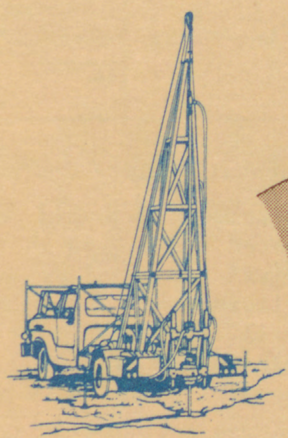
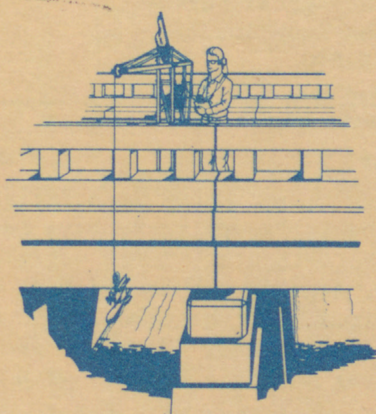
GROUND-WATER QUALITY IN THE DAVIE LANDFILL, BROWARD COUNTY, FLORIDA





U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 76-56

Prepared in cooperation with the
BROWARD COUNTY ENVIRONMENTAL QUALITY CONTROL BOARD

WRI 76-56 GROUND-WATER QUALITY IN THE DAVIE LANDFILL, BROWARD COUNTY, FLORIDA

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16. Abstracts Ground-water adjacent to a disposal pond for septic tank sludge, oil, and grease at the Davie landfill, Broward County, Florida was tested for a wide variety of ground-water contaminants. Three wells adjacent to the disposal pond yielded water rich in nutrients, organic carbon and many other chemical constituents. Total coliform bacteria ranged from less than 100 to 660 colonies per 100 millilitres in samples collected from the shallowest well (depth 20 feet, 6 metres). At well depths of 35 and 45 feet (11 and 14 metres) bacterial counts were less than 20 colonies per 100 millilitres or zero.

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GROUND-WATER QUALITY IN

THE DAVIE LANDFILL, BROWARD COUNTY, FLORIDA

By

Harold C. Mattraw, Jr.

ABSTRACT

Ground water adjacent to a disposal pond for septic tank sludge, oil, and grease at the Davie landfill, Broward County, Florida was tested for a wide variety of ground-water contaminants. Three wells adjacent to the disposal pond yielded water rich in nutrients, organic carbon and many other chemical constituents. Total coliform bacteria ranged from less than 100 to 660 colonies per 100 millilitres in samples collected from the shallowest well (depth 20 feet , 6 m). At well depths of 35 and 45 feet (11 and 14 m), bacterial counts were less than 20 colonies per 100 millilitres or zero.

Concentrations of several constituents in water samples collected from the wells downgradient from the landfill, disposal pond, and an incinerator wash pond were greater than in samples collected from wells that are not in any way affected by the landfill system. A comparison of the sodium and chloride concentrations in water from the downgradient set of wells with the sodium and chloride concentration in water from the incinerator wash pond, adjacent to the disposal pond, indicated that the water from the downgradient set originates in the wash pond. Concentrations of certain constituents in water sampled from a set of wells, upgradient from the sludge pond, were about the same as the concentrations of these constituents in water from unaffected wells in the vicinity of the landfill system. Water from the 25- and 35-foot (11 and 14 m) wells upgradient is chemically free of landfill leachates.

INTRODUCTION

The Davie landfill in southwest Broward County (fig. 1) is the disposal point for all oil and grease sludge collected in the County and for septic tank sludge from the south half of the County. The total sludge load for the landfill is about 5 million pounds (2.3 metric tons) per month. The landfill also receives trash from much of south Broward County and waste from the south Broward incinerator located on the east side of the landfill. The incinerator processes about 125 tons (113 metric tons) of garbage per day. The site is underlain by the Biscayne aquifer which is the source of all municipal and domestic water supplies in the County.

In 1973, because of concern about contamination of water resources, the Broward County Air and Water Pollution Control Board (now Broward County Environmental Quality Control Board) and the U.S. Geological Survey began a cooperative investigation of the effects of leachates from the landfill disposal pond on ground-water quality.

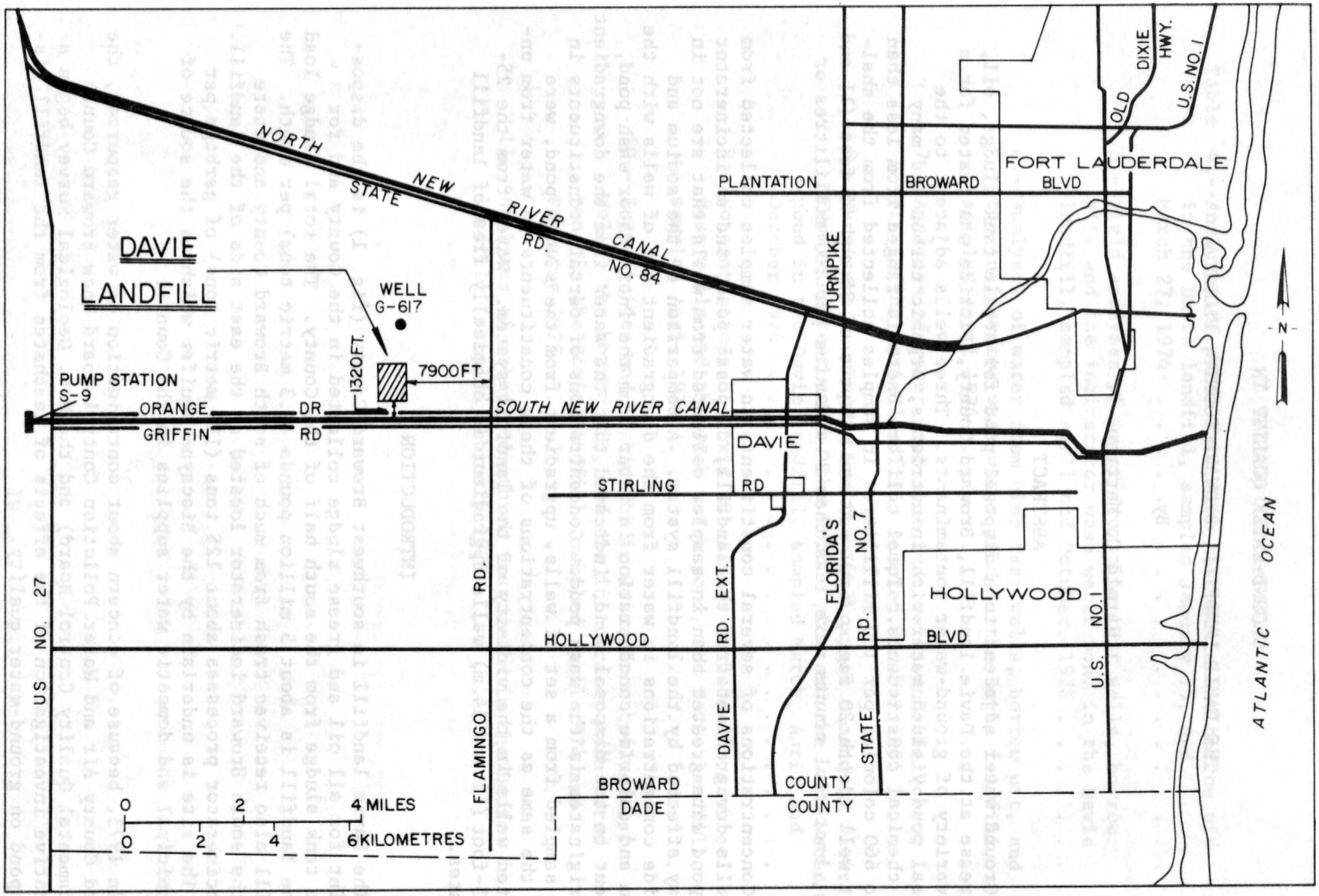

Figure 1.--Location of the Davie landfill, southeast Broward County.

Purpose and Scope

The initial purpose of the investigation was to monitor leachates from the septic tank sludge disposal pond (fig. 2). Nine wells were drilled in 1974 and water samples were collected on five occasions during 1974 and 1975 for chemical, physical and bacteriological analysis. During this period the scope of the investigation was revised to include samplings of the incinerator wash water disposal pond, a borrow pit canal which is the source of the wash water, and three wells in the area of planned landfill expansion.

This report presents the results of test drilling and analyses of water samples from twelve wells and two surface-water sites in the Davie landfill. Included are the nine wells (G-2080-G-2088) designed to monitor septic tank sludge pond leachates, two surface-water sites (borrow pit and incinerator wash water pond) added due to their potential influence on ground-water quality, and three wells (G-2185,6,7) added in November 1974 to monitor ground-water quality around new landfill cells north of the original landfill. Table 1 indicates the month in which water samples were collected from each of the 14 sampling sites.

Acknowledgments

The help of Mr. Victor N. Howard, Pollution Control Officer and his staff in planning and conducting the investigation is greatly appreciated. The Broward County Solid Waste Division under the direction of Messrs. Richard Alameda and Howard Schmidt provided valuable assistance in recovering wells that were buried at the center of the Davie landfill. Mr. Schmidt also aided in providing data on tanker sludge tonnage.

For use of readers who prefer to use metric units, conversion factors for terms used in this report are listed below:

Multiply English unit	By	To obtain metric unit
feet (ft)	0.3048	metres (m)
miles (mi)	1.609	kilometres (km)
inches (in.)	25.4	millimetres (mm)
acres (ac)	.4047	hectare (ha)
square miles (mi^2)	2.590	square kilometres (km^2)
pounds (lb)	.4536	kilograms (kg)
tons	.9071	metric tons
gallons (gal)	3.785	litre (l)

DATA COLLECTION

Study Chronology

Drilling of the nine wells, G-2080 through G-2088, was completed in December 1973. Initial sampling of water from the wells for analysis of specific conductance, temperature, pH, bicarbonate hardness, and bacteria occurred on January 15, 1975. Altitudes of the wells were determined in February. In early March the casings of wells G-2083-5 were sheared off at land surface and covered with incinerator ash by a bulldozer. As soon as the well damage was discovered, the cover materials were removed, the wells

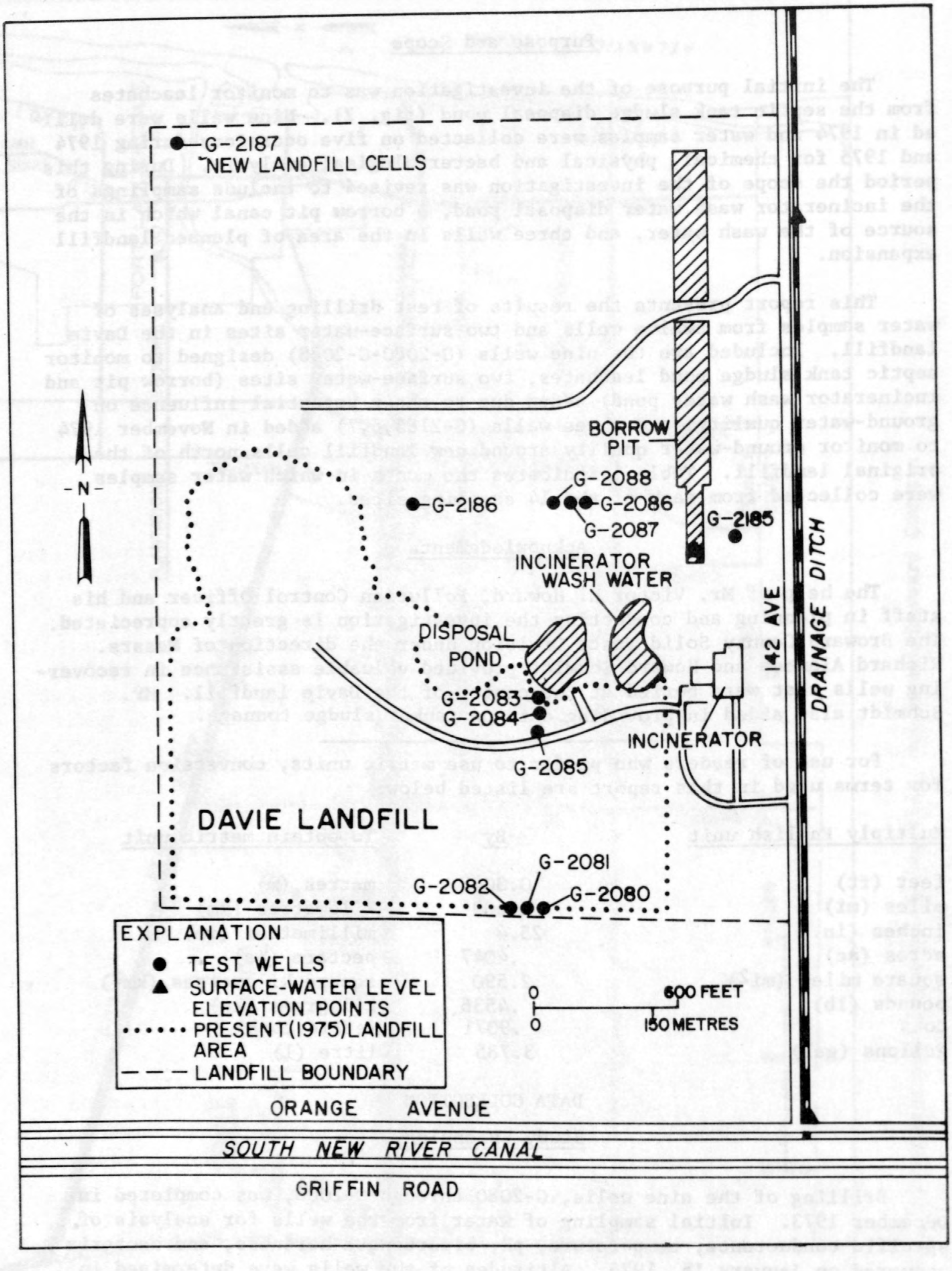

Figure 2.--Sampling-point locations, Davie landfill.

Table 1.--Time of water quality sampling (For location of sampling sites, see fig. 2.)

SAMPLING SITE	1974 JAN	1974 MAR	1974 APR	1974 OCT	1975 FEB
G-2080	X	X	X	X	-
G-2081	X	X	X	X	-
G-2082	X	X	X	X	-
G-2083	X	X	X	X	-
G-2084	X	X	X	X	-
G-2085	X	X	X	X	-
G-2086	X	X	X	X	-
G-2087	X	X	X	X	-
G-2088	X	X	X	X	-
Borrow Pit Canal	-	-	X	X	-
Incinerator wash water	-	-	X	-	-
G-2185	-	-	-	-	X
G-2186	-	-	-	-	X
G-2187	-	-	-	-	X

X Site was sampled.

were recovered, repaired, and the well altitudes reestablished. On March 27, 1974, the wells were resampled to check the degree of disruption due to the well damage. The degree of disruption was slight (Table 2) and, on April 25, 26, 1974, at the end of the dry season, samples were collected.

In September, wells G-2083-5 were again covered with landfill materials, and, in October, at the end of the wet season, the wells were uncovered and sampled.

In November 1974, three wells north of the present landfill area were drilled to the sand below the limestone, a depth of 25 ft (7.6 m) below land surface. During January, the wells were pumped to remove bacterial and oil contamination due to the drilling process. On February 12, 1975, they were pumped and sampled.

Location of Sampling Sites

The South New River Canal (C-11) is a quarter of a mile (.4 km) south of the Davie landfill. Water levels in C-11 are lowered by pump station S-9 (fig. 1) which pumps water into Conservation Area 3. The overall effect on ground water flow is a net southerly component for adjacent areas north of the canal (Bearden, 1975). Wells G-2080-2 are immediately south of the Davie landfill (fig. 2). Wells G-2083-5 are immediately south of the sludge pond and wells G-2086-8 are approximately 300 ft (90 m) north of the northern edge of the sludge pond. The intention of this spatial arrangement was to provide a downgradient well set (G-2080-2) with respect to the sludge pond and a contaminant free well set (G-2086-8) upgradient and north of the sludge pond. The depth, generalized spatial relationship, and the geology of these nine wells are shown in figure 3.

Due to planned expansion of the old landfill site northward, three additional test wells G-2185-7, 25 feet (7.6 m) deep, were installed in November 1974 (fig. 2). Several months after drilling the wells, they were sampled for a broad spectrum of potential landfill and sludge pond leachates.

During the investigation the incinerator wash water pond and the borrow pit canal, which supplies wash water to the incinerator, (fig. 2) were sampled.

Well Construction

Because a 20-foot (6-m) thick limestone layer throughout the immediate area was unusually dense, all 12 wells were drilled with a rotary drilling rig. Two-inch (51 mm) diameter black iron casings were driven into the nine holes drilled in December 1973. One and one half inch (38 mm) galvanized iron casings were inserted into the three wells drilled in November 1974. All wells were completed with 2-foot (.6 m) gauze wrapped well points at either 2 inch (51 mm) or 1½ inch (38 mm) diameter. Screens of the shallow wells were set in a sandy limestone approximately 10 feet (3 m) below the original land surface. Screens of the intermediate depth and the deep wells were set in approximately the middle and near the top of sand zones about 25 and 35 feet (11 and 14 m) respectively below the original land surface. All wells were sealed with concrete at the surface to prevent infiltration of surface water down the casing.

Table 2.--Field analyses of water from nine test wells and borrowpit in the Davie landfill.
(For locations of sampling sites see fig. 2.)

Well number	Well depth (feet)	Specific conductance (umhos/cm at 25°C)	Temper-ature (°C)	pH	Bicarbonate (mg/1)	Biochemical oxygen demand (mg/1)	Bacteria[1] colonies/100 ml		
							TOTAL[2]	FC[3]	FS[4]
Analyses of samples collected January 15, 1974									
G-2080	10	550	24	7.0	396	-	500	<20	<20
G-2081	25	430	24	7.1	256	-	4	<2	<2
G-2082	35	430	23	7.3	264	-	<2	<2	<2
G-2083	20	4,700	33	7.1	1,024	-	<100	<4	8
G-2084	35	2,160	31	7.2	452	-	<10	<4	4
G-2085	45	1,720	30.5	7.1	320	-	20	<4	24
G-2086	10	1,325	23	7.0	192	-	<100	<2	<2
G-2087	25	1,310	26	7.0	220	-	<2	<2	2
G-2088	35	1,325	25.5	7.2	200	-	<2	<2	10
Analyses of samples collected March 27, 1974									
G-2080	10	700	23	7.3	404	2.0	*	<1	33
G-2081	25	440	24.5	7.6	342	.4	<1	<1	<1
G-2082	35	445	24.5	7.2	296	.7	<1	<1	<1
G-2083	20	5,000	34.5	7.1	1,120	7.9	660	348	302
G-2084	35	2,700	32.5	7.0	540	1.2	<1	<1	8
G-2085	45	2,850	31.5	7.1	488	.7	19	1	3
G-2086	10	1,280	23	7.3	300	.5	24	<1	1
G-2087	25	1,420	26	7.0	228	1.8	<1	<1	1
G-2088	35	1,320	25.5	7.4	194	.3	<1	<1	1
Borrow pit	Surface water	960	26.5	7.5	280	.6	180	111	134

* Overgrowths at 5 and 10 ml sample volumes but not coliform bacteria

1 All counts are estimates based on nonideal colony populations
2 Total coliform
3 Fecal coliform
4 Fecal streptoccoci

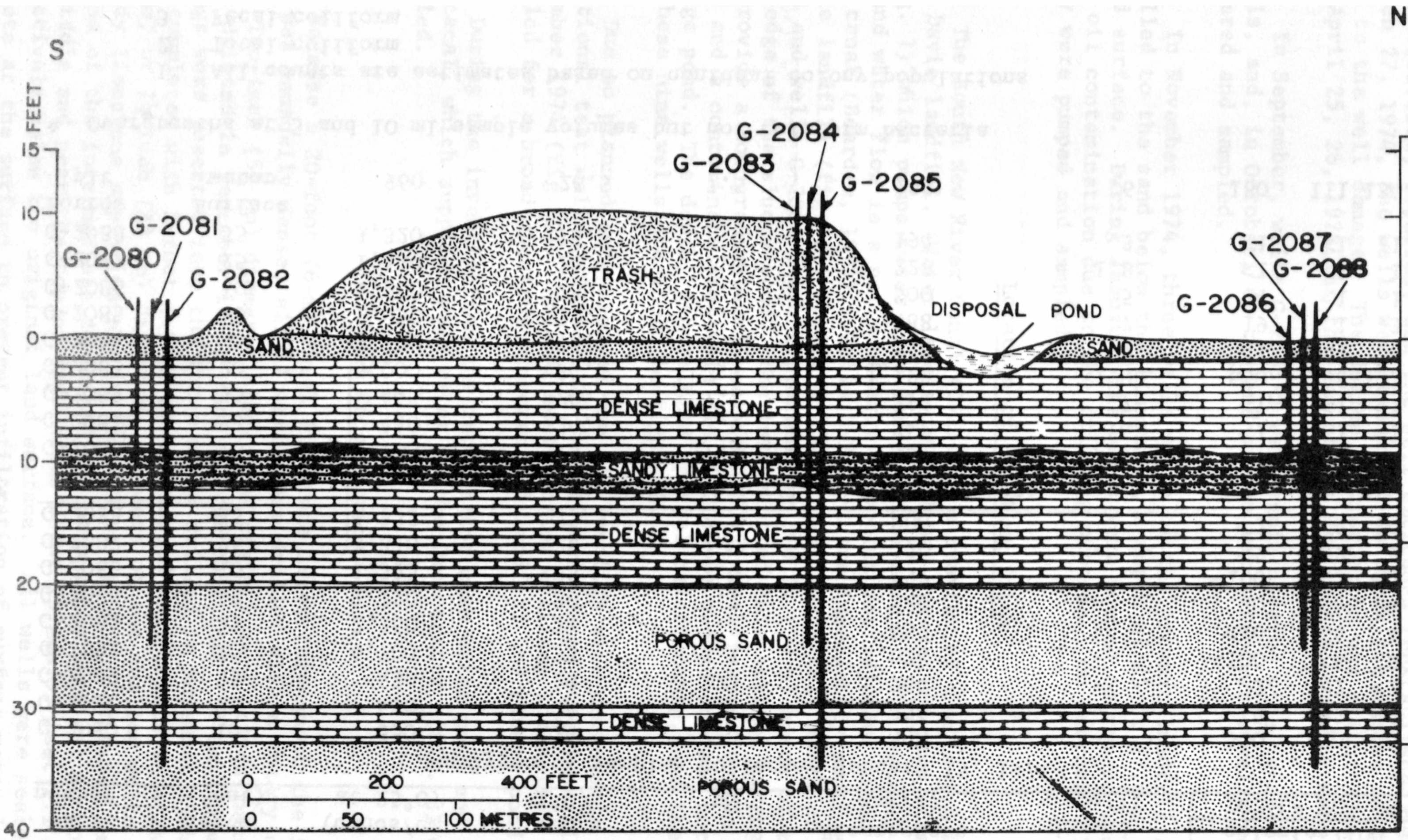

Figure 3.--Sketch showing geology and spatial relationship of nine test wells. Datum is approximately the original land surface.

Sampling Procedures

Water samples are obtained from the wells with a vacuum pump as shown in figure 4. Sterile tygon tubing is lowered down the well into the water. The other end of the tubing is attached to a 5-gal (19-1) glass container. Water flows into the glass jar under the induced vacuum. Twice the volume of water standing in the well casing is removed and discarded before a sample of ground water is kept for analyses. After the sample is obtained, the end of the tygon tubing is crimped and pulled from the well. Bacteria samples are drained into a sterile sample bottle directly from the tygon tubing.

Broward County Ground Water Standards

Chapter Four of Regulation 73-8 (Broward County, 1973) sets water-quality standards for the Broward County Department of Pollution Control (now the Environmental Quality Control Board). Table 3 shows water-quality requirements of that agency for freshwater and specifications for ground water. In Chapter one, general provisions, section 1-2, item 21 defines freshwater:

> (21) FRESH WATERS shall mean all waters of the state which are contained in lakes and ponds, or are in flowing streams above the zone in which tidal actions influence the salinity of the water and where the concentrations of chloride ions is normally less than five hundred (500) mg/1.

As a result, water from well G-2083 is technically saltwater because its chloride concentration is 500 mg/1 (milligrams per litre) or more (table 4). All other water-quality samples had less than 500 mg/1 chloride and are considered freshwater according to Broward County regulations.

DATA ANALYSIS

In the vicinity of the Davie landfill ground water generally flows south (Bearden 1975). Ground water flow in and near the Davie landfill is strongly affected when wash water is being pumped from the borrow pit (fig. 2). Figure 5 depicts the configuration and altitude of the water on April 25, 1974. Lines normal to the contours indicate the direction of ground-water movement in the immediate area. Leachate from the sludge pond, and the incinerator wash-water pond flow northeast toward the borrow pit as well as south.

Specific Conductance

The specific conductance of water is a measure of the fluid's ability to conduct an electrical current. The higher the specific conductance, the greater the number of cations, anions, and other charged species in solution. The specific conductance of water from well G-617 (fig. 1) 1 mile (1.6 km) north of the landfill was 490 umhos per cm at 25 C (Sherwood and others, 1973).

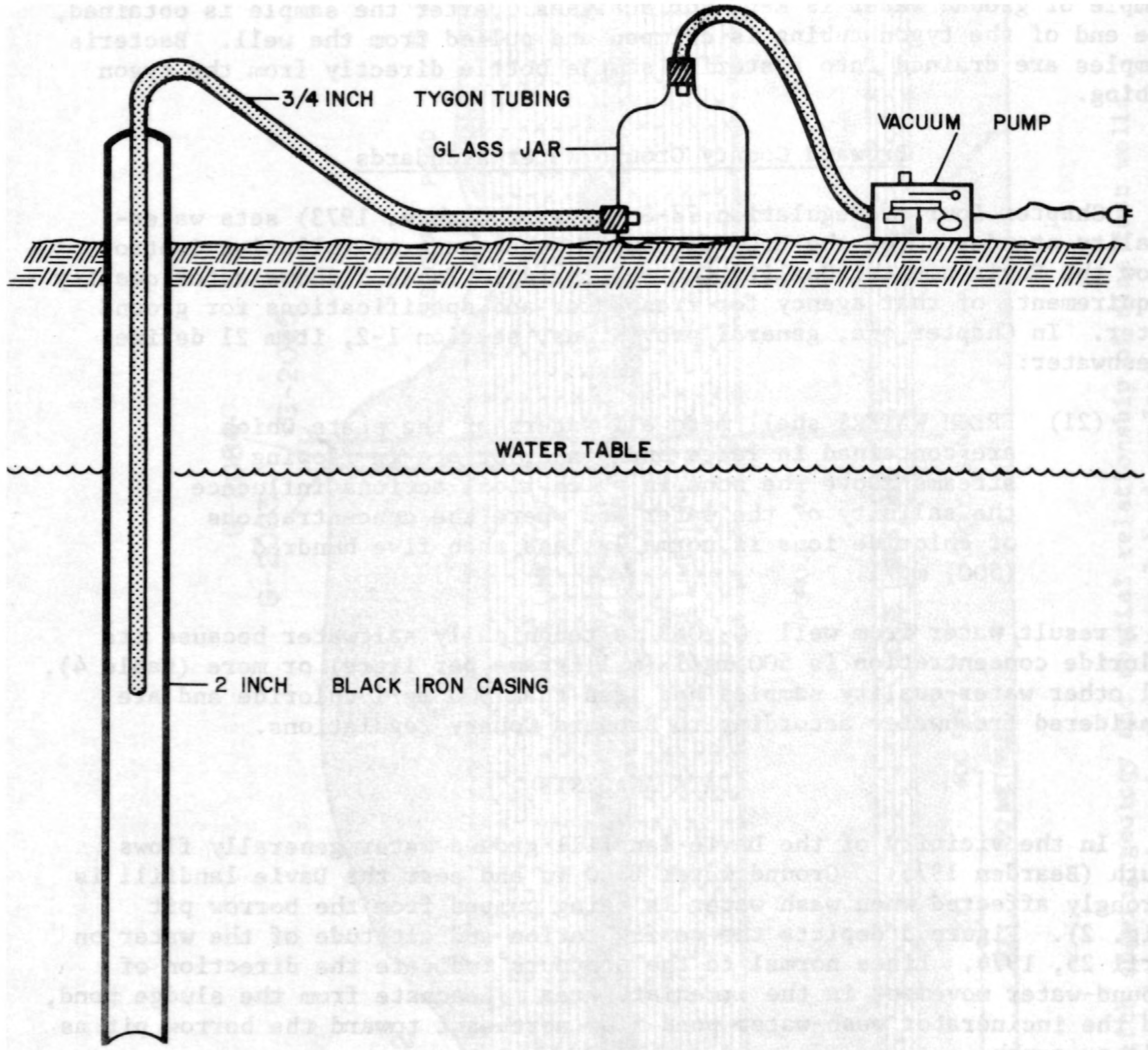

Figure 4.--Sketch showing apparatus for collection of water-quality samples.

Table 3.--Section 4-3 Water Quality Standards for Broward County

(b) STANDARDS FOR FRESH WATER:

ITEM	WATER QUALITY REQUIREMENT
(1) Color	No unnatural discoloration shall be apparent except for that resulting from scientific investigation or environmental monitoring
(2) Odors	None that shall be detectable due to sewage or industrial wastes
(3) Turbidity	Not to exceed 10 Jackson Units
(4) Oil and Grease	Not to exceed 1 mg/1.
(5) Temperature	Not to be above 90°F
(6) Floating Solids	None attributable to sewage, industrial wastes or other wastes
(7) Settleable Solids	None attributable to sewage, industrial wastes or other wastes
(8) Suspended Solids and Sludge	None attributable to sewage, industrial wastes or other wastes
(9) Dissolved Oxygen	Daily average not less than 5 mg/1; single reading never less than 4 mg.
(10) pH	Not less than 6.5 nor greater than 8.5
(11) Nutrients	Total phosphorus as P not to exceed 0.02 mg/1. Total nitrogen (as N from Nitrate, Nitrite, or NH_3 and organic not to exceed 0.1 mg/1.
(12) Coliform	Total Coliform not to exceed 1000 per 100 ml.; Fecal Coliform not to exceed 200 per 100 ml. as a monthly average nor 400 per 100 ml. ten percent of time, nor 800 per 100 ml. in any day.
(13) Radioactivity	Gross Beta not to exceed 1000 pc/1 Radium 226 not to exceed 3 pc/1 Strontium 90 not to exceed 10 pc/1

Table 3.--(Cont'd) Section 4-3 Water Quality Standards for Broward County

Standards for Fresh Water: Continued

ITEM	WATER QUALITY REQUIREMENT
(14) Pathogens (excl. coliform)	Less than 1 per 10 gallons
(15) BOD_5	Not to exceed 5 mg/1
(16) COD	Not to exceed 10 mg/1
(17) Toxic Substances:	
Constituent	Maximum Mean Concentration
(a) Arsenic	Not to exceed 0.05 mg/1
(b) Cadmium	Not to exceed 0.01 mg/1
(c) Total Chromium	Not to exceed 0.05 mg/1
(d) Copper	Not to exceed 0.05 mg/1
(e) Lead	Not to exceed 0.05 mg/1
(f) Mercury	Not to exceed 0.0001 mg/1
(g) Nickel	Not to exceed 0.1 mg/1
(h) Silver	Not to exceed 0.005 mg/1
(i) Zinc	Not to exceed 0.1 mg/1
(j) Cyanide	None detectable
(k) Phenolics	Not to exceed 0.001 mg/1
(l) Chlorinated Hydrocarbons	Not to exceed 0.01 mg/1
(m) Chlorine Residual	Not to exceed 0.01 mg/1
(18) LAS Surfactant	Not to exceed 0.5 mg/1

(c) STANDARDS FOR GROUND WATER:

If the ground water is saltwater as defined herein, the water quality standards for saltwater as appearing in Subsection (a) of this Section shall apply. If the ground water is freshwater as defined herein, the water quality standards for freshwater as appearing in Subsection (b) of this Section shall apply.

Table 4.--Analyses of water from nine test wells and borrow pit in the Davie landfill.
(For location of sampling sites, see fig. 2.)

Well number	Depth (feet)	Chloride (mg/l)	Color (platinum cobalt units)	MBAS Deter-gents (mg/l)	Total iron (ug/l)	Oil and grease (mg/l)	Dissolved solids (mg/l)	Carbon (mg/l)		
								Total	Inorganic	Organic
Analyses of samples collected January 15, 1974										
G-2080	10	20	40	0.00	3,800	3	364	77	69	8
G-2081	25	7.7	30	.20	3,200	0	230	64	56	8
G-2082	35	9.7	20	.30	3,100	1	278	64	58	6
G-2083	20	690	700	1.4	10,000	4	3,450	310	220	90
G-2084	35	390	80	.60	6,500	1	1,350	170	101	69
G-2085	45	340	30	.40	5,700	2	1,230	90	73	17
G-2086	10	290	30	.36	6,000	3	1,020	58	41	17
G-2087	25	270	40	.15	3,800	2	929	64	48	16
G-2088	35	290	40	.36	2,100	2	1,020	51	34	17
Analyses of samples collected March 27, 1974										
G-2080	10	26	80	.00	11,000	2	387	-	-	-
G-2081	25	8.3	100	.00	5,700	2	250	-	-	-
G-2082	35	9.1	70	.00	2,800	2	266	-	-	-
G-2083	20	630	900	1.4	16,000	110	3,240	-	-	-
G-2084	35	440	300	.10	7,400	1	1,550	-	-	-
G-2085	45	460	200	.10	2,900	-	1,560	-	-	-
G-2086	10	260	50	.00	6,500	1	739	-	-	-
G-2087	25	290	60	.00	4,900	0	902	-	-	-
G-2088	35	-	50	.00	2,300	0	848	-	-	-
Borrow pit	-	140		.00	330	0	622	-	-	-

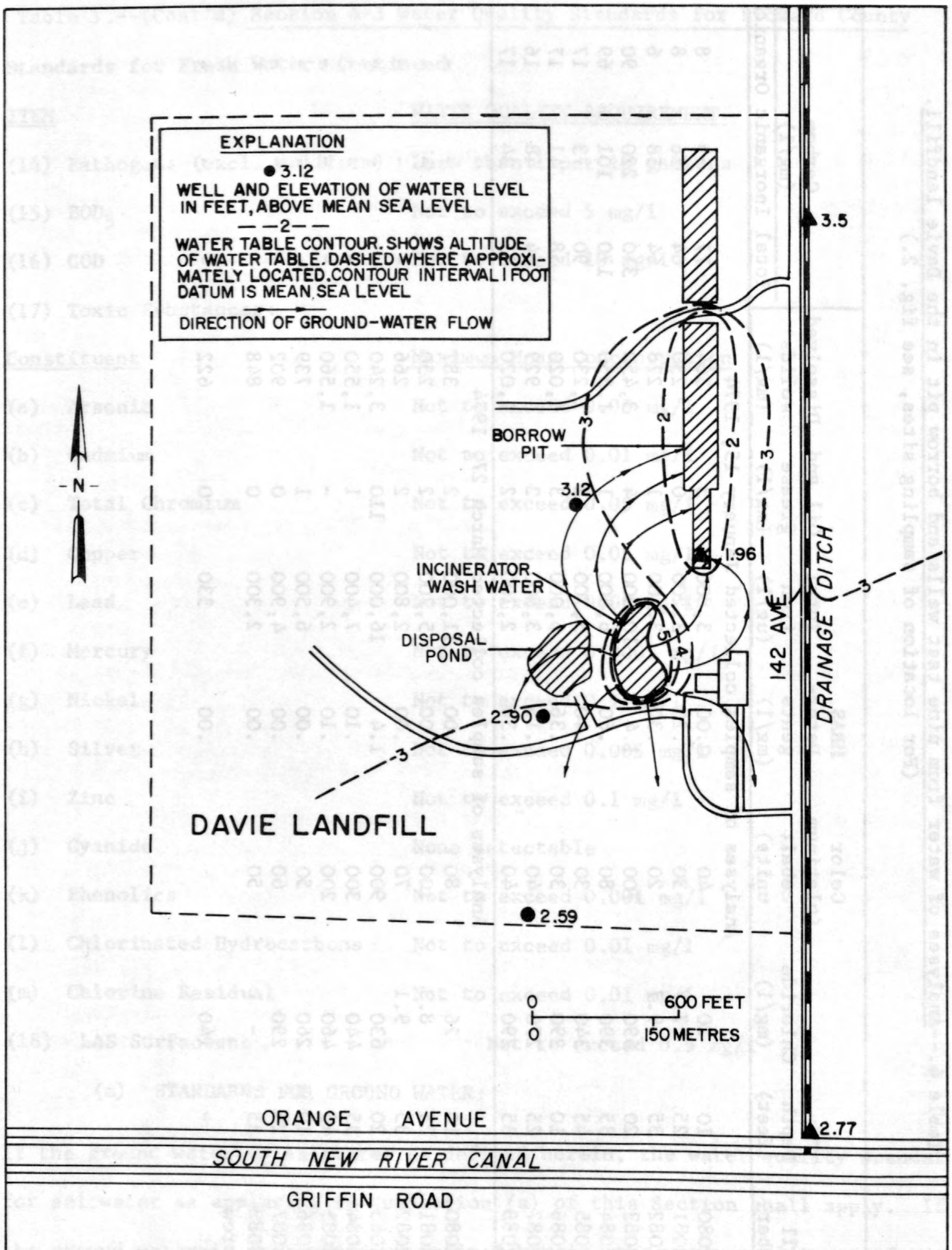

Figure 5.--Water-table altitude for April 25, 1974.

The specific conductance of water from wells G-2081 and G-2082, south of the landfill, were the lowest (420-470 umhos/cm) of all samples collected throughout the investigation (Tables 2 and 5). Water from well G-2080, also south of the landfill, was approximately 50 percent higher than the deeper wells. The increase is understandable in view of the shallow depth and close proximity of the test well to the landfill (less than 50 ft or 15 m).

The specific conductance of water from wells adjacent to the sludge pond is as much as ten fold higher than the water from southern set of test wells. Specific conductance of water from the 20-foot (6 m) well, G-2083, ranged between 4,300 and 5,000 umhos/cm. The highest specific conductance measured in this investigation, 5,300 umhos/cm, was observed in G-2084, during October 1974, after the summer rainy period. This value (5,300 umhos/cm) indicates movement of the landfill and sludge leachates through the 20 feet (6 m) of dense limestone that is found at the six well sites in the area. Specific conductance of water from the well G-2085, increased steadily from 1,720 umhos/cm in January to 3,200 umhos/cm in October 1974.

The specific conductance of water from wells G-2086, G-2087, and G-2088, north of the sludge pond and just west of the borrow pit was greater than that of water from wells G-2080, G-2081, and G-2082, and less than that from wells G-2083, G-2084, and G-2085, just south of the sludge pond (tables 2,5, 6 and 7). The specific conductance of water from wells G-2086, G-2087, and G-2088 was, however, appreciably greater than the background conductance of 500 umhos/cm. The ion enrichment of water from these three wells may have been derived from three discrete sources: the sludge pond, the landfill operation itself, or the incinerator wash water pond.

On the average, and subtracting the background specific conductance of 500 umhos/cm from the conductance of water from wells G-2083 through G-2088, the ion concentration in water from wells G-2083, G-2084, and G-2085, just south of the sludge pit, is more than four times as concentrated as water from wells G-2086, G-2087, and G-2088, west of the borrow pit.

The specific conductance of water in the borrow pit was highly variable. For a sample collected in March 1974 it was 960 umhos/cm, in April, 1,120 umhos/cm, and in October, 600 umhos/cm. As the distance between the borrow pit and the wash water pond is less than 150 feet (45 m) subsurface movement of wash water from the pond toward the borrow pit is encouraged due to the lowering of water levels during pumping at the borrow pit. Ground water throughout the area also recharges the borrow pit during pumping.

Recharge from seasonal summer rainfall dilutes and lowers the specific conductance of the shallow ground water. Thus, during and immediately following the rainy season, the specific conductance of the water in the borrow pit decreases due to the inflow of ground water of lower specific conductance and direct dilution by rainfall. During the dry season, as the specific conductance of the ground water increases, ground-water inflow increases the specific conductance of the water in the borrow pit. This is verified by the specific conductance of the water sampled from G-2086, G-2087 and the borrow pit being much less in October 1974 than in April 1974.

Table 5.--Field analyses of water from nine test wells, borrow pit and incinerator wash water pond in the Davie landfill. (For location of sampling sites, see fig. 2.)

Well number	Depth (feet)	Specific conductance (umhos/cm at 25°C)	Temperature (°C)	pH	Bicarbonate (mg/l)	Biochemical oxygen demand (mg/l)	Bacteria colonies/100 ml Total[1]	FC[2]	TS[3]
				Analyses of samples collected April 1974					
G-2080	10	650	26.0	7.4	324	0.7	220	<1	2
G-2081	25	420	25.0	7.5	256	.3	<1	<1	<1
G-2082	35	430	25.0	7.5	248	.3	<1	<1	<1
G-2083	20	4,300	32.5	7.8	1,180	2.4	340	4	18
G-2084	35	2,700	33.0	7.2	355	.6	<1	<1	<1
G-2085	45	2,500	32.0	7.5	472	.4	3	<1	<1
G-2086	10	1,230	26.0	7.6	168	.2	<1	<1	<1
G-2087	25	1,340	25.0	7.4	184	.1	<1	<1	<1
G-2088	35	1,250	25.0	7.6	168	.2	<1	<1	<1
Borrow pit	--	1,120	26.0	7.4	236	1.0	31,000	40	50
Wash water pond	--	1,220	43.0	8.0	188	6.3	51,000	400	5,900
				Analyses of samples collected October 1974					
G-2080	10	625	24.5	7.2	288	.0	16	<1	<1
G-2081	25	435	24.5	7.5	248	.4	<1	<1	<1
G-2082	35	470	24.5	7.4	238	.2	26	<1	<1
G-2083	20	4,400	31.5	7.3	1,240	3.0	460	3	9
G-2084	35	5,300	29.5	7.6	2,080	3.2	<1	<1	<1
G-2085	45	3,200	29.0	7.5	628	.9	<1	<1	<1
G-2086	10	750	29.0	7.1	224	1.4	1	<1	<1
G-2087	25	800	29.0	7.3	188	1.5	<1	<1	3
G-2088	35	1,280	29.5	7.2	204	1.9	5	<1	<1
Borrow pit	--	600	27.0	7.8	316	1.9	2,200	60	12

1 Total coliform
2 Fecal coliform
3 Fecal streptoccoci

Table 6.--Analyses of water from nine test wells, borrow pit, and the incinerator wash water pond in the Davie landfill, sampled April 1974.
(For location of sampling sites, see fig. 2)

Constituent	Units	WELL NUMBERS G-2080	G-2081	G-2082	G-2083	G-2084	G-2085	G-2086	G-2087	G-2088	Borrow pit	Wash water pond
Depth	ft	10	25	35	20	35	45	10	25	35		
Aluminum, total	ug/l	8,800	220	130	580	340	70	40	170	40	240	1,700
Arsenic, total	ug/l	0	2	0	13	2	0	4	2	10	8	4
Bicarbonate	mg/l	324	256	248	1,180	355	472	168	184	168	236	188
Boron, total	ug/l	140	50	100	3,900	1,100	2,000	230	130	280	330	370
Cadmium, total	ug/l	3	3	3	2	3	3	3	3	3	3	18
Calcium, dissolved	mg/l	120	82	83	130	160	190	180	220	190	170	180
Carbonate	mg/l	0	0	0	0	0	0	0	0	0	0	0
Chloride, dissolved	mg/l	36	8.1	10	610	490	470	270	290	260	230	250
Chromium, hexavalent	ug/l	0	0	0	0	0	0	0	0	0	0	0
Chromium, total	ug/l	15	0	0	8	6	3	0	3	0	3	15
Cobalt, total	ug/l	6	5	5	5	5	5	5	6	6	5	5
Color	platinum cobalt units	100	30	50	1,000	200	200	60	60	30	30	30
Copper, total	ug/l	6	7	7	10	13	6	4	6	4	6	39
Dissolved solids	mg/l	452	265	271	3,510	1,780	1,640	785	867	810	727	995
Fluoride, dissolved	mg/l	.3	.2	.2	.8	.9	.8	.4	.3	.5	1.5	1.3
Hardness, noncarbonate	mg/l	56	15	26	0	180	160	350	430	380	300	330
Hardness, total	mg/l	320	230	230	470	480	550	480	580	510	480	490
Iron, total	ug/l	6,900	3,000	2,700	11,000	8,600	3,200	5,000	3,900	2,900	1,500	720
Lead, total	ug/l	14	8	18	10	11	11	10	7	9	8	530
Lithium, total	ug/l	20	0	0	10	10	10	0	10	10	0	10
Magnesium, dissolved	mg/l	5.0	4.7	5.3	34	18	18	8.0	7.3	9.1	12	8.6
Manganese, total	ug/l	50	25	25	75	75	25	100	25	25	50	75
MBAS detergents	mg/l	.30	.06	.00	.54	.76	.86				.52	0.52
Mercury, total	ug/l	.1	0.1	.0	.0	.8	.1	.1	.0	.0	.1	0.3
Nickel, total	ug/l	19	17	16	15	12	12	11	10	12	17	17
Oil and Grease	mg/l	4	3	4	8		4	6	5	5	7	12
pH	--	7.4	7.5	7.5	7.8	7.2	7.5	7.6	7.4	7.6	7.4	8.0
Potassium, dissolved	mg/l	1.0	0.4	.5	140	63	68	8.6	1.3	13	11	25
Silica, dissolved	mg/l	7.2	9.5	10	13	9.2	13	5.4	7.2	8.0	12	11
Specific conductance, umhos/cm at	25 °C	650	423	431	4,300	2,760	2,500	1,260	1,350	1,260	1,100	1,250
Sodium, dissolved	mg/l	13	6.1	5.9	900	350	320	43	44	42	39	48
Strontium, dissolved	ug/l	960	710	710	1,500	1,700	1,800	1,600	1,900	1,600	1,300	1,400
Sulfate, dissolved	mg/l	30	13	16	880	300	280	83	85	110	74	87
Temperature	°C	26.0	25.0	25.0	32.5	33.0	32.0	25.0	25.0	25.0	26.0	43.0
Zinc, total	ug/l	20	60	40	7,600	51,000	4,300	8,300	100	40	30	1,000

Table 7.--Analyses of water from nine test wells and the borrow pit in the Davie landfill, sampled October 1974.
(For sampling location, see fig. 2.)

Constituent	Units	G-2080	G-2081	G-2082	G-2083	G-2084	G-2085	G-2086	G-2087	G-2088	Borrow pit
		WELL NUMBER									
Depth	ft	10	25	35	20	35	45	10	25	35	-
Aluminum, dissolved	ug/1	0	0	0	0	130	0	0	0	0	0
Bicarbonate	mg/1	288	248	238	1,240	2,080	628	224	188	204	316
Calcium, dissolved	mg/1	110	77	85	100	53	170	170	180	170	130
Carbonate	mg/1	0	0	0	-	-	0	0	0	0	0
Chloride, dissolved	mg/1	26	10	12	460	350	460	220	240	240	100
Dissolved oxygen	mg/1	.0	.0	.0	.0	.0	.0	.0	.0	.0	-
Dissolved solids	mg/1	402	246	250	2,900	3,500	1,900	816	818	918	614
Fluoride, dissolved	mg/1	.1	.1	.1	.7	1.9	.7	.4	.2	1.1	.5
Hardness, noncarbonate	mg/1	55	12	40	0	0	0	280	330	300	98
Hardness, total	mg/1	290	220	240	350	220	500	460	480	460	360
Iron, dissolved	ug/1	280	2,500	2,200	5,800	2,500	4,900	1,800	2,300	1,900	50
Magnesium, dissolved	mg/1	3.7	5.3	5.4	24	20	17	8.9	7.5	8.9	7.5
pH	--	7.2	7.5	7.4	7.3	7.6	7.5	7.1	7.3	7.2	7.8
Phenols	ug/1	1	1	3	240	3	2	140	69	100	0
Potassium, dissolved	mg/1	1.4	.4	.4	110	160	65	12	7.5	14	4.7
Silica, dissolved	mg/1	6.6	9.0	9.5	16	30	11	9.0	7.9	11	9.9
Specific conductance	umhos/cm at 25 C	625	435	470	4,400	5,300	3,200	750	800	1,280	600
Sodium, dissolved	mg/1	11	5.5	5.7	850	1,100	450	40	40	40	27
Strontium, dissolved	mg/1	980	710	710	1,200	610	1,600	1,500	1,800	1,400	1,100
Sulfate, dissolved	mg/1	34	12	16	680	880	390	91	74	74	34
Temperature	degree C	24.5	24.5	24.5	31.5	29.5	30.0	29.0	29.0	29.5	27.0
Zinc, dissolved	ug/1	0	0	80	1,300	2,600	10,000	15,000	80	10	50

Sodium and Chloride

Sodium and chloride are major cations and anions, respectively, which are normally related in water systems. Neither ion has a particularly strong affinity for surface adsorption to the sand or limestone. Sodium and chloride are readily soluble in water and tend to stay in solution in south Florida due to the paucity of ion exchangeable materials. They are not lost or gained when ground-water migrates. As a consequence sodium or chloride can be used to indicate the probable origin of other ground-water constituents.

Figure 6 shows a plot of chloride versus sodium for samples collected from each of the 11 sites in April and October 1974. Water from wells G-2081 and G-2082 is very low in both sodium and chloride (tables 6 and 7) and the analyses cluster near the equivalent weight ratio line. The equivalent weight plot is simply a one for one equivalent weight ratio.

The most obvious important relation depicted in figure 6 is the very tight grouping of sodium and chloride in water from the northern test wells (G-2086 through C-2088), the borrow pit and the incinerator wash water pond. Based on the sodium-chloride ion couple, the incinerator wash water pond appears to be the source of ground-water contamination north of the landfill area. In contrast the water from wells G-2083 through G-2085 adjacent to the sludge pond are enriched in sodium with respect to chloride. The source of contamination in wells G-2083 through G-2085 is probably a combination of landfill and sludge pond leachates.

Nutrients

Three elements, carbon, nitrogen, and phosphorus, are typically grouped together in a category labelled nutrients. This grouping is derived from the universally essential elements necessary for growth.

Carbon exists in two forms; inorganic and organic. The analytical procedure employed determines inorganic carbon and total carbon. Organic carbon is the difference between the two. Tables 4 and 8 list the concentrations of carbon for the January, March, April and October samplings. The concentration of organic carbon in wells G-2081 and G-2082 were lower than other sampling locations throughout the investigation. Concentrations of organic carbon in the shallow southern well (G-2080) were higher than G-2081-2 indicating probable contamination from the landfill.

Both inorganic and organic concentrations of carbon were highest in the center well set (G-2083-5) during all three samplings. The highest carbon concentration, 100 mg/l for organic carbon and 360 mg/l for inorganic carbon, was observed in Well G-2084 during the October sampling. The average concentration of organic carbon in the northern test wells (G-2086 through G-2088) and the borrow pit was slightly higher than the levels observed in the deeper southern wells (G-2081 and G-2082).

Nitrogen is characteristically reported in four forms, organic nitrogen, ammonia, nitrite, and nitrate. The sum of the four species is termed total nitrogen. Under oxidizing conditions bacteria convert the different

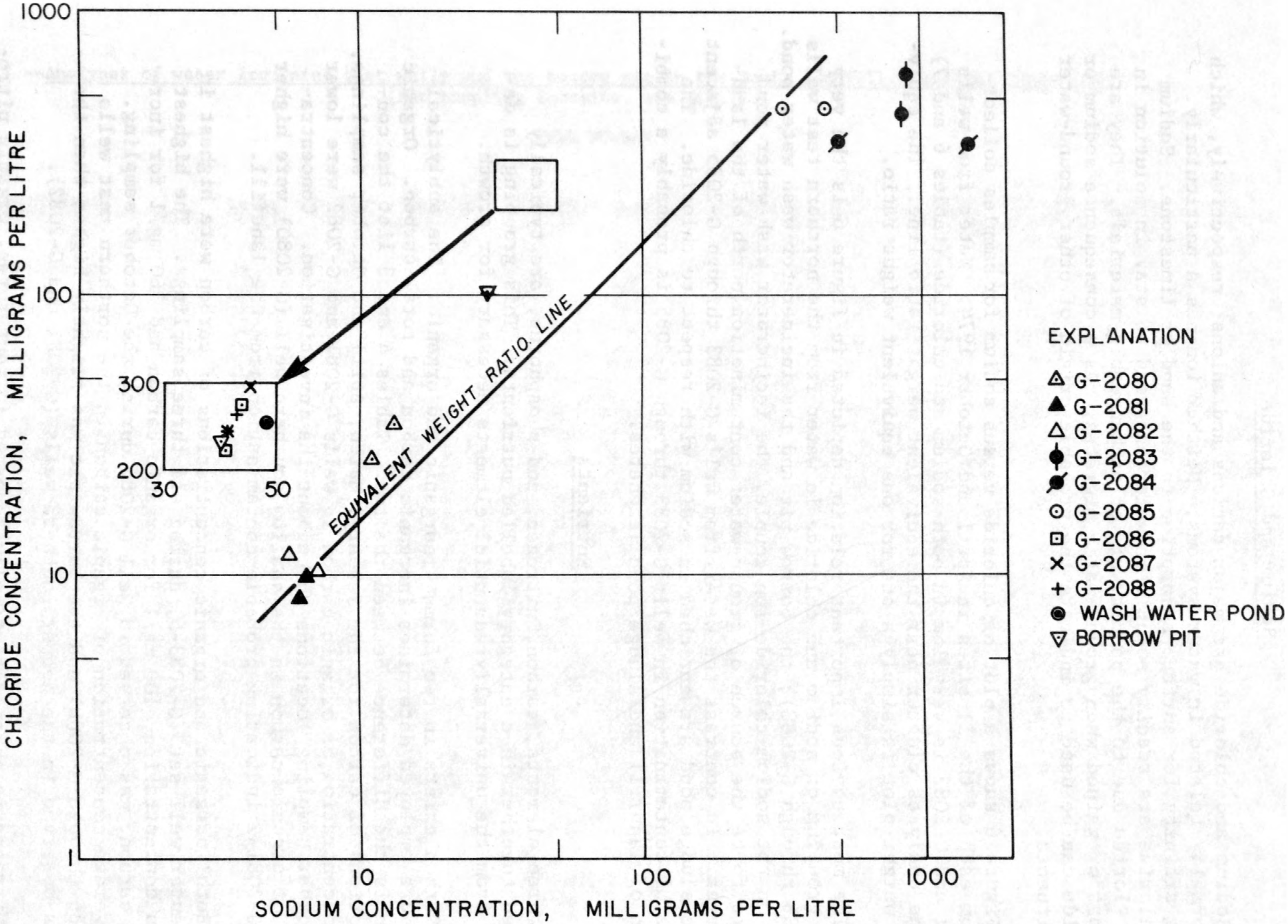

Figure 6.--Chloride versus sodium concentrations.

Table 8.--Nutrients, turbidity and chemical oxygen demand in water from nine test wells, the borrow pit, and the wash water pond in the Davie landfill. (All constituents reported in milligrams per litre except turbidity which is reported in JTU. For location of sampling sites, see fig. 2).

Constituent	G-2080	G-2081	G-2082	G-2083	G-2084	G-2085	G-2086	G-2087	G-2088	Borrow pit	Wash Water pond
				Analyses of samples collected March 1974							
Turbidity	170	110	38	104	44	8	50	51	11	9	-
Total Nitrogen as N	2.7	2.4	.96	23	9.1	8.3	1.7	1.7	2.1	1.8	-
Organic Nitrogen as N	2.1	2.1	.60	11	1.3	.76	1.2	.88	1.9	.91	-
Ammonia as N	.06	.30	.36	11	7.8	7.5	.53	.78	.19	.75	-
Nitrite as N	.00	.01	.00	.01	.00	.00	.00	.00	.00	.01	-
Nitrate as N	.50	.00	.00	.08	.01	.00	.00	.00	.00	.14	-
Total Phosphorus	.05	.15	.05	.43	.10	.02	.01	.15	.01	.01	-
Ortho phosphate	.01	.02	.01	.08	.02	.01	.00	.01	.00	.00	-
Organic Carbon	20	1.0	7.0	78	32	32	9.0	13	10	15	-
Inorganic Carbon	--	58	55	--	108	92	43	45	29	54	-
Total Carbon	--	59	62	--	140	124	52	58	39	69	-
				Analyses of samples collected April 1974							
Turbidity	180	18	17	9	75	10	36	33	16	11	23
Chemical Oxygen Demand	30	17	21	226	102	89	50	42	49	48	60
Total Nitrogen as N	1.8	.70	.92	13	7.9	6.0	1.4	1.4	1.1	2.2	4.2
Organic Nitrogen as N	1.4	.39	.54	3.4	.92	.22	.99	.79	.85	1.0	1.1
Ammonia as N	.14	.31	.38	9.5	7.0	5.8	.43	.63	.27	1.1	2.3
Nitrite as N	.01	.00	.00	.03	.00	.00	.00	.00	.00	.01	.50
Nitrate as N	.21	.00	.00	.04	.02	.01	.00	.00	.00	.05	.31
Total Phosphorus	.05	.02	.02	.10	.28	.02	.01	.04	.01	.02	.52
Ortho Phosphate	.01	.01	.01	.10	.02	.01	.01	.01	.01	.01	.13
Organic Carbon	27	12	14	120	113	90	17	16	18	19	31
Inorganic Carbon	73	52	50	210	160	138	34	39	36	48	34
Total Carbon	100	64	64	330	273	228	51	55	54	67	65
				Analyses of samples collected October 1974							
Turbidity	21	20	17	33	75	15	13	36	6	6	-
Chemical Oxygen Demand	26	18	22	170	280	99	140	55	36	54	-
Total Nitrogen as N	5.8	.75	.81	12	-	8.3	1.5	1.1	1.4	1.8	-
Organic Nitrogen as N	.94	.40	.43	3.9	-	2.1	.99	.78	.92	.97	-
Ammonia as N	.08	.31	.36	8.1	-	6.2	.53	.34	.50	.75	-
Nitrite as N	.05	.02	.01	.04	-	.02	.00	.01	.00	.01	-
Nitrate as N	4.8	.02	.01	.00	-	.00	.00	.00	.00	.07	-
Total Phosphorus	.02	.01	.01	.04	-	.00	.02	.03	.01	.01	-
Ortho Phosphate	.01	.01	.01	.04	-	.00	.01	.02	.00	.00	-
Organic Carbon	19	8.0	10	60	100	50	20	18	14	14	-
Inorganic Carbon	69	56	56	240	360	130	50	41	38	58	-
Total Carbon	88	64	66	300	460	180	70	59	52	72	-

forms into nitrate. The general reaction is:

$$\text{Organic Nitrogen} \longrightarrow \text{Ammonia} \longrightarrow \text{Nitrite} \longrightarrow \text{Nitrate}$$

Under reducing conditions which are characteristic of south Florida ground waters, the reaction is:

$$\text{Organic Nitrogen} \longrightarrow \text{Ammonia} \longleftarrow \text{Nitrite} \longleftarrow \text{Nitrate}$$

Not surprising is the abundance of organic nitrogen and ammonia present in the ground water from well G-2083 adjacent to the sludge pond (fig. 7).

Phosphorus tends to react with calcium carbonate (limestone) to form insoluble mineral species (hydroxyapatite and apatite). Additional phosphorus can be complexed with iron species if the proper conditions exist.

The largest concentration of phosphorus (0.52 mg/l) was in the incinerator wash water pond (table 8). Phosphorus in the ground-water system was highest, 0.43 mg/l (table 8), in the 20 ft (6.3 m) deep well G-2083 adjacent to the sludge pond. At 45 ft (14 m) depth in well G-2085, the concentration of phosphorus had decreased to a background level of 0.02 mg/l (table 8).

Bacteria

Sampling and analysis of ground water for enteric micro-organisms is probably the most vexing task in water-quality programs. The sources of contamination include test-well drilling, sampling, and the actual analysis. The effects of the drilling operation are minimized by pumping the well immediately after drilling and then waiting several months before collecting the first water-quality sample. To avoid contamination during sampling and analysis sterile equipment must be used. Analysis must be carried out immediately under carefully controlled conditions. However, removing the field sample to the laboratory encourages natural dieoff of any contained bacteria. The mobile laboratory employed for bacterial work allows for the earliest possible processing time.

The three most common biological indicators in water samples are total coliform, fecal coliform, and fecal streptococci. Total coliform include a wide spectrum of bacteria from soils, septic tanks, storm water leachate and many other sources. Fecal coliforms are derived solely from warm-blooded animals, especially man, dogs, and cats. Fecal streptococci are derived primarily from other vertebrates and insects and give a total picture of animal activity in a water environment.

Coliform bacteria do not survive in ground water for a very long time (Stone, 1974). Bacteria reported for the January 1974 sampling (table 2) are probably residual from the drilling operation. By March, 660 colonies per 100 ml of total coliform bacteria were found in water from the shallow center well (G-2083) and less than 20 colonies per 100 ml in water from wells G-2084 and G-2085 (table 2). Considering the disruption caused by shearing the casings earlier in March this is remarkable. By April, bacteria in water from well G-2083 was 340 total coliform colonies per 100 ml (table 5). Fecal

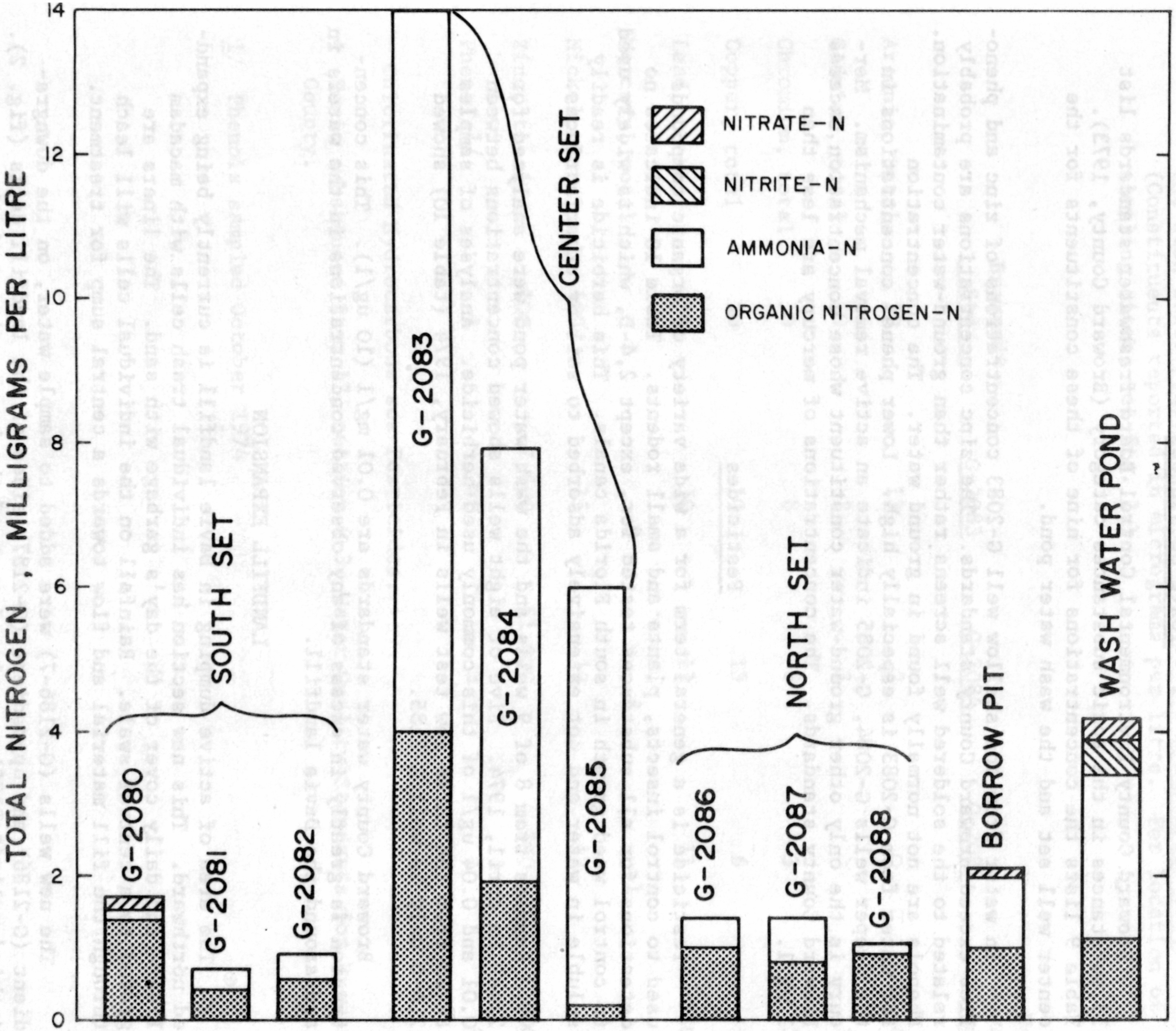

Figure 7.--Total nitrogen concentrations in and around the Davie landfill, April 1974.

coliform and fecal streptococci in well G-2083 decreased from approximately 300 colonies per 100 ml in March to less than 20 colonies per 100 ml in April.

Toxic Substances

Broward County Environmental Control Board freshwater standards list 13 substances in the toxic substances category (Broward County, 1973). Table 9 lists the concentrations for nine of these constituents for the center well set and the wash water pond.

In water from the shallow well G-2083 concentrations of zinc and phenolics exceed Broward County standards. The zinc concentrations are probably related to the soldered well screens rather than ground-water contamination. Phenols are not normally found in ground water. The concentration for water from G-2083 is especially high. Lower phenol concentrations in the deeper wells G-2084, G-2085 indicate an active removal mechanism. Mercury is the only other ground-water constituent whose concentration exceeds Broward County standards. The concentrations of mercury are less than 1 ug/1.

Pesticides

Pesticide is a general term for a wide variety of organic compounds used to control insects, plants and small rodents. Table 10 indicates no detections for all substances tested for, except 2,4-D, which is widely used to control weed growth in south Florida canals. This herbicide is readily soluble in water and not extensively adsorbed to soil or other surfaces.

Samples from 8 of 9 wells and the wash water pond were analyzed for 2,4-D in April, 1974. Five of eight wells showed concentrations between 0.01 and 0.04 ug/1 of this commonly used herbicide. Analyses of samples taken from the three new test wells in February, 1974 (table 10) showed 2,4-D only in well G-2185.

Broward County water standards are 0.01 mg/1 (10 ug/1). This concentration is greatly in excess of any observed concentrations in the waters in and around the Davie landfill.

LANDFILL EXPANSION

The area of active dumping in Davie landfill is currently being expanded northward. This new section has individual trash cells with macadam liners and daily cover of the day's garbage with sand. The liners are graded to a central swale. Rainfall on the individual cells will leach through the fill material and flow towards a central sump for treatment.

The new wells (G-2186-7) were added to sample water, on the downgradient (G-2186) and upgradient (G-2187) sides of the landfill cells (fig. 2). A third well (G-2185) was placed east of the borrow pit to check on potential movement of water from the roadside canal or the borrow pit during periods of no pumping. All wells are finished at 25 ft (7.6 m) below land surface. The actual sample point is at the midpoint of the sand which

Table 9.--Concentrations of toxic substances in water from three test wells and the wash water pond, the Davie landfill, sampled April 1974. (Constituents reported in micrograms per litre. For location of sampling sites, see fig. 2.)

	Broward* Std	G-2083	G-2084	G-2085	Wash water pond
Arsenic, total	50	13	2	0	4
Cadmium, total	10	2	3		18
Chromium, total	50	8	6	3	15
Copper, total	50	10	13	6	39
Lead, total	50	10	11	11	530
Mercury, total	.1	.0	.8	.1	.3
Nickel, total	100	15	12	12	17
Zinc, total	100	7,600	51,000	4,300	1,000
Phenols1/	1	240	3	2	0

Chlorinated Hydrocarbons see Pesticides.

* Toxic substances Item 17, section 4-3, Water Quality Standards for Broward County.

1/ Phenols sampled October 1974

Table 10.--Insecticides and herbicides in water from twelve test wells, the borrowpit, and the incinerator wash water pond in the Davie landfill. (All constituents reported in micrograms per litre. For location of sampling sites, see fig. 2.)

	WELL NUMBER												Borrow pit	Wash water pond
	G-2080	G-2081	G-2082	G-2083	G-2084	G-2085	G-2086	G-2087	G-2088	G-2185	G-2186	G-2187		
Well depth (feet)	10	25	35	20	35	45	10	25	35	25	25	25	-	-
Date sampled	4-74	4-74	4-74	4-74	4-74	4-74	4-74	4-74	4-74	2-75	2-75	2-75	4-74	4-74
Aldrin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chlordane	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
DDD	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
DDE	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
DDT	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.01	.00
Diazinon	.00	.00	.00	.00	-	.00	.00	.00	.00	.00	.00	.00	.00	.00
Dieldrin	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Endrin	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Ethyl parathion	.00	.00	.00	.00	-	.00	.00	.00	.00	.00	.00	.00	.00	.00
Ethyl trithion	.00	.00	.00	.00	-	.00	.00	.00	.00	.00	.00	.00	.00	.00
Ethion	.00	.00	.00	.00	-	.00	.00	.00	.00	.00	.00	.00	.00	.00
Heptachlor epoxide	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Heptachlor	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Lindane	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Malathion	.00	.00	.00	.00	-	.00	.00	.00	.00	.00	.00	.00	.00	.00
Methyl parathion	.00	.00	.00	.00	-	.00	.00	.00	.00	.00	.00	.00	.00	.00
Methyl trithion	.00	.00	.00	.00	-	.00	.00	.00	.00	.00	.00	.00	.00	.00
PCB	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
PCN	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Silvex	.00	.00	.00	-	.00	.00	.00	.00	.00	.00	.00	.00	-	.00
Toxaphene	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
2,4-D	.03	.00	.00	-	.03	.01	.04	.00	.03	.18	.00	.00	-	.00
2,4,5-T	.00	.00	.00	-	.00	.00	.00	.00	.00	.00	.00		-	.00

occurs from 20 ft to 30 ft (6 to 9 m) below land surface. The dense limestone from land surface to 20 feet (6 m) in depth was also found at the three new well locations.

The quality of water from well G-2185 is similar to that in the borrow pit. Water from well G-2186 has specific conductance (table 11) as high as the northern set (G-2086 through G-2088). The higher specific conductance is probably related to landfill leachates from the adjacent present landfill (fig. 2) since the distance from the sludge and wash-down ponds is over 600 ft (183 m) upgradient. The quality of water from well G-2187 (table 11) indicates that the water is unaffected by any of the landfill activities; the chemical analyses are similar to those of water from G-2081 and G-2082, the southern deep wells.

SUMMARY

Three well sets, consisting of three wells each, and two surface water sites were tested for a wide variety of chemical species in the Davie landfill in 1974. Water from all wells in the central well set adjacent to a disposal pond for septic tank sludge showed enrichment of nutrients, organic carbon, and many other constituents. Water from the southern well set was virtually contaminant free. The northern well set was enriched in many constituents. Sodium and chloride concentrations in the incinerator wash water pond were virtually identical to sodium and chloride concentrations in the northern well set. A nearby borrow pit was the source of water for washing the incinerator. The drawdown in the borrow pit created a net flow component towards the borrow pit in much of the landfill area.

Ground water samples from the shallow well (G-2083) adjacent to the sludge pond were high in organic carbon, organic nitrogen, ammonia, and total phosphorus, indicating sludge pond leachates. High ammonia, sodium, and chloride concentrations in the deeper wells (G-2084-5) suggest downward migration of the sludge pond leachates. Bacteria counts in contrast were moderate (100-660 total coliform colonies per 100 ml) in water from the shallow well (G-2083). At a depth of 35 ft, (11 m) G-2084) the bacterial counts were less than 10 colonies per 100 ml or zero. This coincides with bacterial dieoff rates reported by other investigators (Stone, 1974) under similar conditions.

Three additional 25-ft (7.6 m) wells were installed in the area of the planned landfill expansion. The well adjacent to the old landfill (G-2186) showed moderate contamination from the landfill operations; well G-2185 is similar to the water quality in the borrow pit. Well G-2187 north of the new landfill cells was chemically similar to the two deeper wells on the south side of the present landfill.

Table 11.--Analyses of water from three test wells in the Davie landfill, sampled February 1975. (For location of sampling sites, see fig. 2.)

CONSTITUENTS	UNITS	G-2185	G-2186	G-2187
Alkalinity as CaCO3	mg/l	144	342	262
Aluminum, total	ug/l	180	250	500
Arsenic, total	ug/l	17	8	3
Bacteria, total coliform	colonies/100 ml	<2	<1	<2
Bacteria, Fecal coliform	colonies/100 ml	<2	<1	<1
Bacteria, Fecal streptoccoci	colonies/100 ml	<2	<2	<1
Biochemical Oxygen Demand	mg/l	0.2	0.0	1.7
Boron, total	ug/l	270	80	80
Cadmium, total	ug/l	0	0	0
Calcium, dissolved	mg/l	220	130	120
Carbonate	mg/l	0	0	0
Chemical Oxygen Demand	mg/l	42	40	56
Chloride, dissolved	mg/l	320	15	9.5
Chromium, hexavalent	ug/l	0	1	0
Chromium, total	ug/l	10	10	10
Cobalt, total	ug/l	2	0	4
Color	Platinum-Cobalt units	200	80	80
Copper, total	ug/l	0	0	2
Dissolved, Solids at 180 C	mg/l	995	422	383
Dissolved Solids, sum	mg/l	803	404	339
Fluoride, dissolved	mg/l	.4	.4	.4
Hardness, noncarbonate	mg/l	450	17	55
Hardness, total	mg/l	590	360	320
Iron, total	ug/l	3,400	2,200	670
Lead, total	ug/l	2	1	4
Lithium, total	ug/l	0	0	0
Magnesium, dissolved	mg/l	10	7.9	3.9
Manganese, total	ug/l	22	20	30
MBAS, Detergents	mg/l	.1	.1	.1
Mercury, total	mg/l	.0	.0	.5
Nickel, total	ug/l	0	0	3
Oil & Grease	mg/l	.0	.0	52
Organic Carbon	mg/l	14	16	16
pH	pH units	7.3	7.1	7.2
Phenols	mg/l	2	2	0
Potassium, dissolved	mg/l	8.0	.8	.3
Silica, dissolved	mg/l	8.2	11	6.8
Sodium, dissolved	mg/l	52	7.5	3.4
Specific Conductance	umho/cm at 25 C	1,480	730	575
Strontium, dissolved	ug/l	2,700	1,700	1,600
Sulfate, dissolved	mg/l	95	24	35
Temperature	Degree C	24.0	26.0	26.5
Turbidity	JTU	35	25	20
Zinc, total	mg/l	230	640	470
NUTRIENTS				
Total Nitrogen as N	mg/l	1.64	1.55	1.18
Organic Nitrogen as N	mg/l	.77	1.10	1.10
Ammonia as N	mg/l	.85	.43	.06
Nitrite as N	mg/l	.00	.00	.00
Nitrate as N	mg/l	.02	.02	.02
Total Phosphorus as P	mg/l	.00	.01	.03
Orthophosphate as P	mg/l	.00	.00	.02

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