

**STATE OF FLORIDA
STATE BOARD OF CONSERVATION**

DIVISION OF GEOLOGY

Robert O. Vernon, Director

REPORT OF INVESTIGATIONS NO. 51

**CHEMICAL QUALITY OF WATERS OF
BROWARD COUNTY, FLORIDA**

By

Rodney C. Grantham and C. B. Sherwood
U. S. Geological Survey

Prepared by the
UNITED STATES GEOLOGICAL SURVEY
in cooperation with the
FLORIDA BOARD OF CONSERVATION
DIVISION OF GEOLOGY
and
BROWARD COUNTY

Tallahassee, Florida

1968

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June 4, 1968

Honorable Claude R. Kirk, Jr., *Chairman*
Florida State Board of Conservation
Tallahassee, Florida

Dear Governor Kirk:

The Division of Geology of the Florida Board of Conservation is publishing as it's Report of Investigations No. 51, a report on the Chemical Quality of Waters of Broward County, Florida. This report was prepared by Rodney G. Grantham and C. B. Sherwood, of the U. S. Geological Survey, as a part of the cooperative program between the Division of Geology and Broward County.

The data presented in this report indicate that the natural and man associated water problems have mushroomed in Broward County because of the rapid development of the population in this area. Most of the water for municipal and domestic supplies is obtained from the productive Biscayne Aquifer. High iron in the southern part of the county and chlorides in the coast and in the lower part of the aquifer have presented some quality of water problems.

Surface water, as it does nearly everywhere else, varies in chemical quality between rainy years and periods of drought. The use of canal systems in the County for the disposal of wastes causes considerable problems during periods of low rainfall. Pesticides, herbicides, and detergents will probably increase in their occurrence in the waters of the County, and the Water Quality Control Commission should find the data presented in this report of considerable interest.

Sincerely yours,

Robert O. Vernon
Director and State Geologist

Completed manuscript received

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CHEMICAL QUALITY OF WATERS OF BROWARD COUNTY, FLORIDA

By

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U. S. Geological Survey

ABSTRACT

The chemical quality of the abundant surface and ground-water resources of Broward County is generally good. However, natural and man-made problems of water quality are accentuated by the mushrooming need for water and changes in the hydrology of the area caused by rapid urbanization.

Water of good chemical quality for municipal and domestic supplies in Broward County is obtained from the highly productive Biscayne aquifer, which is part of an interconnected ground and surface-water system. The water is calcium bicarbonate in type and ranges from hard to very hard, and from neutral to slightly alkaline. The prime objectionable constituents in the water are iron in the southern part of the county, and chloride near the coast and in the lower part of the Biscayne aquifer in the inland areas.

Large quantities of water are available in the artesian Floridan aquifer at depths below 900 feet, but the water is salty and of limited use. The Floridan aquifer is used for the disposal of sewage effluent at one location.

Surface water in the area is generally good but variable in chemical quality. During the rainy season the mineral content of the water in canals is diluted by surface runoff; however during the dry season the mineral content of the canal water increases because of the increase in the percentage of ground water in the canals and the drainage from swampy inland areas. Large quantities of surface water are used for irrigation in inland areas and for replenishment to coastal parts of the aquifer for municipal supplies and to prevent salt-water intrusion.

The water in parts of Broward County is contaminated by salt-water intrusion and by various wastes such as sewage effluent. The use of the controlled canal system for disposal of waste materials poses a potential problem during periods of little or no flow. Chemical weed killers applied on the land, as well as detergents, have been detected in the ground water indicating movement of waste through the ground. As urbanization and industrial growth continue, problems of waste disposal will become more acute and will require stricter control.

INTRODUCTION

Fresh water is one of south Florida's most valuable natural resources. At present the chief factor limiting the use of water is quality rather than quantity. Broward County has a plentiful supply of water of good chemical quality; however, because of the ever increasing need for water, this resource must be protected by careful management and control. A few chemical quality problems are already present, some natural, some man made. Along the coast salt water occurs in or has entered the aquifer; in many areas iron in the water makes it objectionable; and throughout most of the county the water is hard. Other chemical quality problems involve pollution due to accidental or intentional dumping of wastes and chemicals. With the continued rapid increase in population and the industrial development of the area, the problems of pollution are likely to increase manyfold.

PURPOSE AND SCOPE

The purpose of this report is to make data and observations available on the chemical quality of the surface and ground waters of Broward County for use by water-supply and water-management officials, and to aid in preventing deterioration of water resources by contamination. The chemical constituents of the water are discussed in reference to seasonal changes, areal differences, variation with depth, source of certain dissolved minerals, and chemical properties.

This report was prepared by the U. S. Geological Survey in cooperation with Broward County and as part of the statewide program with the Division of Geology, Florida Board of Conservation. This report constitutes the results of one phase of the investigation of water resources of Broward County under the supervision of H. Klein, Chief, Miami Subdistrict, and C. S. Conover, District Chief, Water Resources Division, U. S. Geological Survey, Tallahassee.

PREVIOUS INVESTIGATIONS

A general report on the chemical quality of surface and ground water of Florida by Collins and Howard (1928) contained a few analyses of water in Broward County. In 1939, an intensive study of the water resources of southeastern Florida was begun. As part of that investigation Parker (1955) presented considerable data on the occurrence, movement and the quality of ground water and surface water in Broward County as well as information on salt-water intrusion. Salt-water intrusion in the Fort Lauderdale area was studied in detail by Vorhis (1948) during his investigation of the geology and ground-water resources of that area.

Schroeder, Klein, and Hoy (1958) conducted a study of the hydrology of the Biscayne aquifer in which they delineated the approximate areas of the salt intrusion in Broward County. A more detailed investigation of salt-water intrusion and some work on water quality in the Oakland Park area was done by Sherwood (1959). The hydrology of Biscayne aquifer in the Pompano Beach area was studied by Tarver (1964). He included information on the chemical quality of the water and salt-water intrusion. Sherwood and Grantham (1965) prepared a leaflet on the mechanics of salt-water intrusion and its effect over a period of years on Broward County.

ACKNOWLEDGMENTS

Appreciation is expressed to Mr. J. Stanley Weedon, Water Control Engineer, Broward County Engineering Department, for his cooperation and courtesy throughout the investigation; to Mr. George T. Lohmeyer, former Director of Sanitary Engineering, Broward County Health Department, for his cooperation and information concerning contamination and sewage disposal; to Messrs. K. A. MacKichan and L. G. Toler, U. S. Geological Survey, for help and guidance in the preparation of this report; to Mr. H. J. McCoy, U. S. Geological Survey, for collecting samples especially during the test-drilling program; and to the residents of Broward County who furnished information about their wells and permitted the collection of water samples.

HYDROLOGIC SETTING

Broward County borders the Atlantic Ocean in southeastern Florida, figure 1. The Atlantic Coastal Ridge occupies most of the county between the coast and the Everglades, a few miles inland, and has an average elevation of 8 to 10 feet above msl (mean sea level). Maximum elevations at isolated points range from 20 to 25 feet above msl. Most of the population is concentrated in the coastal ridge area. In Broward County the ridge is underlain chiefly by permeable sand and limestone. The Everglades, an area of organic soils, lies west of the ridge. The eastern edge of the Everglades is utilized for agriculture, figure 2. The central part is utilized for diked water conservation areas in which water can be stored for release during dry periods. The county is cut by an extensive network of canals of the Central and Southern Florida Flood Control District and several local water-control agencies. These water-control agencies have nearly complete control of water levels and canal flows within the coastal area.

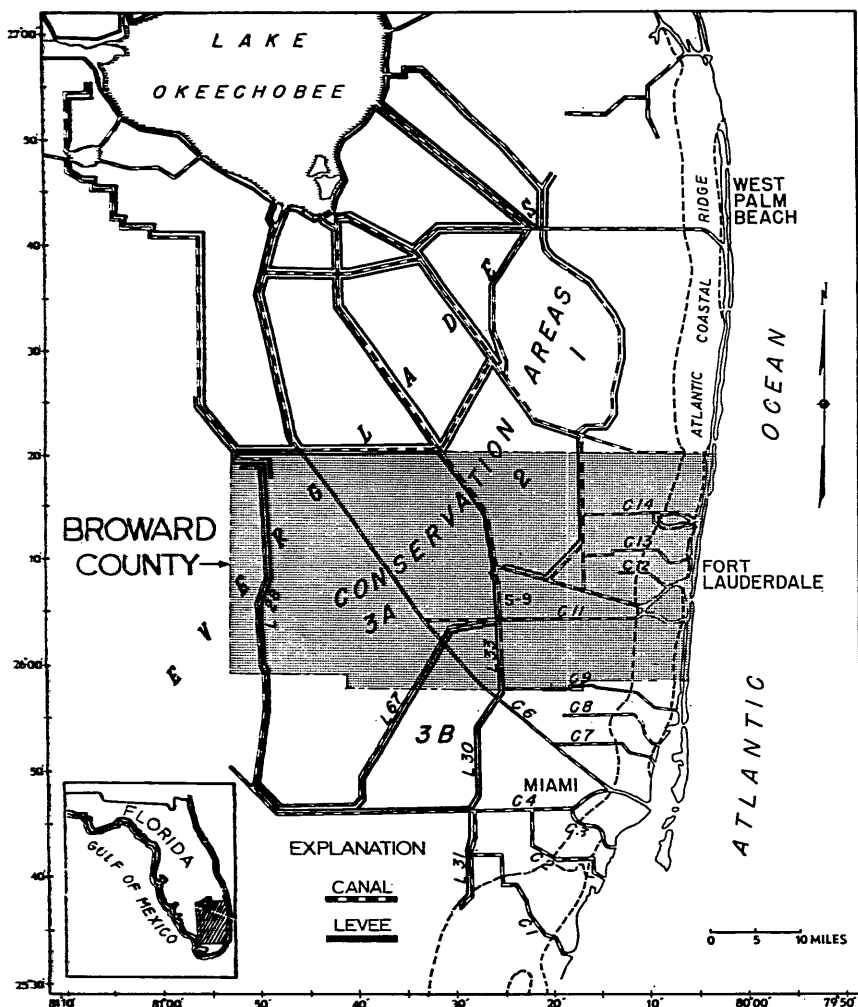


Figure 1. Southeastern Florida showing Broward County, and the water conservation areas of Central and Southern Florida Flood Control District.

The climate in Broward County is semi-tropical. The average temperature is about 75°F. Rainfall averages 60 inches per year with about 75 percent falling from May through October.

The ground and surface waters of southeastern Florida are perhaps better interconnected than in any other area in the United States. The area contains an extensive system of controlled canals and water-conservation areas. The major canals penetrate the highly permeable Biscayne aquifer, and extend eastward from the water conservation areas to the

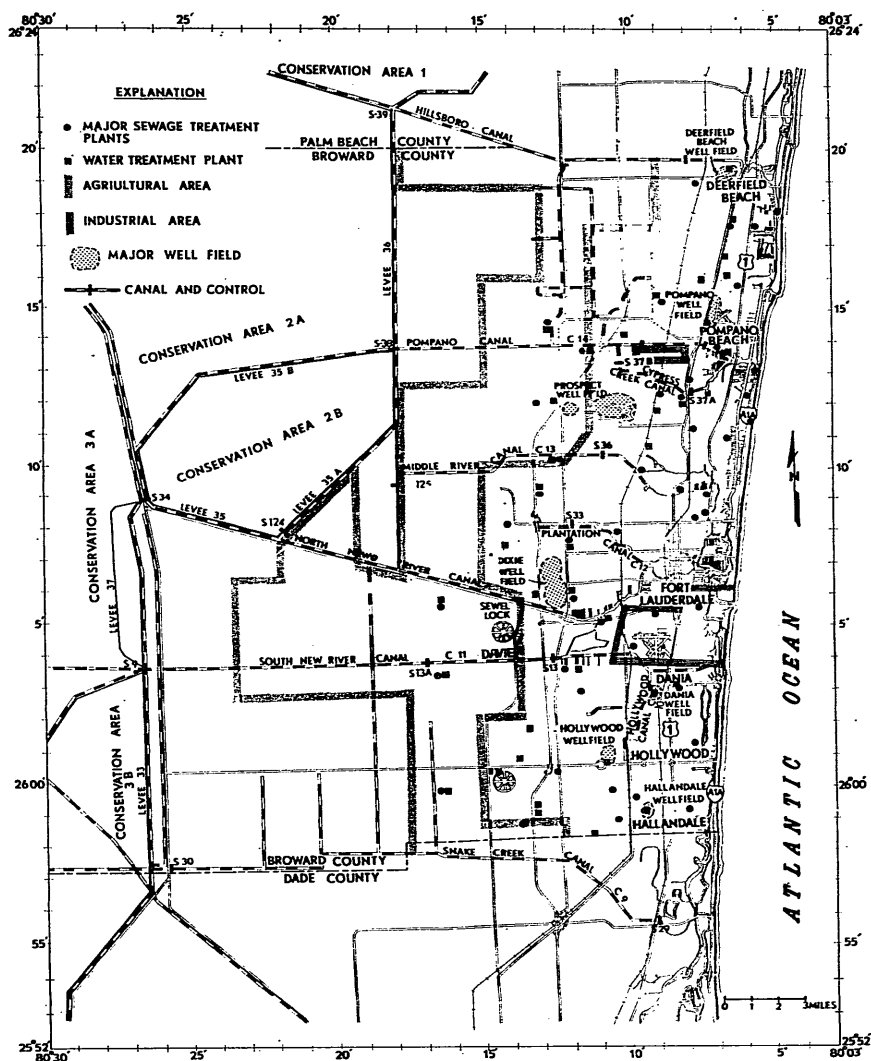


Figure 2. Location of water and sewage treatment plants and generalized agricultural and industrial areas.

ocean. In most cases the flow in the canals is controlled by stage and flow control structures near the coast. During the rainy season the coastal control structures are opened and excess water is discharged to the ocean to prevent inland flooding. This fresh-water flow pushes the salt water in the uncontrolled sections of the canals seaward. During the dry season, the control structures are closed to conserve fresh water and to prevent salt water from migrating upstream beyond the structures.

For a considerable time after the dry season begins water levels along controlled reaches of the canals remain relatively high as a result of ground-water inflow and seepage from the water conservation areas to upstream reaches of the canals. As the dry season progresses and during prolonged drought, water stored in the conservation areas may be released into the canals to maintain adequate fresh-water levels in the canals at the downstream control structures. Because of the higher water levels above a control structure and the good hydraulic continuity water can move from the canals into the aquifer and ground-water levels are thus kept high.

In operation this method of aquifer replenishment can be either beneficial, or detrimental. Beneficially, well fields developed near canals (fig. 2) can withdraw more water than otherwise would be possible, because the infiltration of water from the canals reduces water-level drawdowns caused by pumping. Also, adequate fresh-water levels prevent the intrusion of salt water into the aquifer. Detrimentally, salt water may be trapped upstream of controls during operation unless extreme care is exercised. When this occurs the salty water does not remain stationary but settles and moves upstream because of density currents. During drought periods when controls are closed and canal flows are at a minimum, treated effluents, industrial wastes, and other contaminants which are normally flushed to the sea are retained and tend to be concentrated in the canals.

All municipal water supplies in Broward County are obtained from the Biscayne aquifer. Because of its more stable chemical and bacteriological characteristics ground water from this aquifer is more suitable for municipal use than is canal water. Water treatment ranges from only chlorination to iron removal and softening (zeolite or lime-soda treatment). The productivity of the aquifer and the shallow depths required for large capacity wells are shown by the following pumpage and well data. (See well field locations, fig. 2).

Well Field	Number of wells	Range of depth (feet)	Average Pumpage, 1965 (million gallons per day)
Dixie well field			
(Ft. Lauderdale)	26	100 - 130	11.5
Prospect well field			
(Ft. Lauderdale)	22	100 - 130	16.5
Hollywood well field	14	90 - 120	7.3
Pompano Beach well field	11	100 - 140	8.1
Deerfield Beach well field	9	80 - 120	2.6

COLLECTION OF DATA

Wells and canal sites from which water samples have been collected for chemical analysis are shown in figure 3.

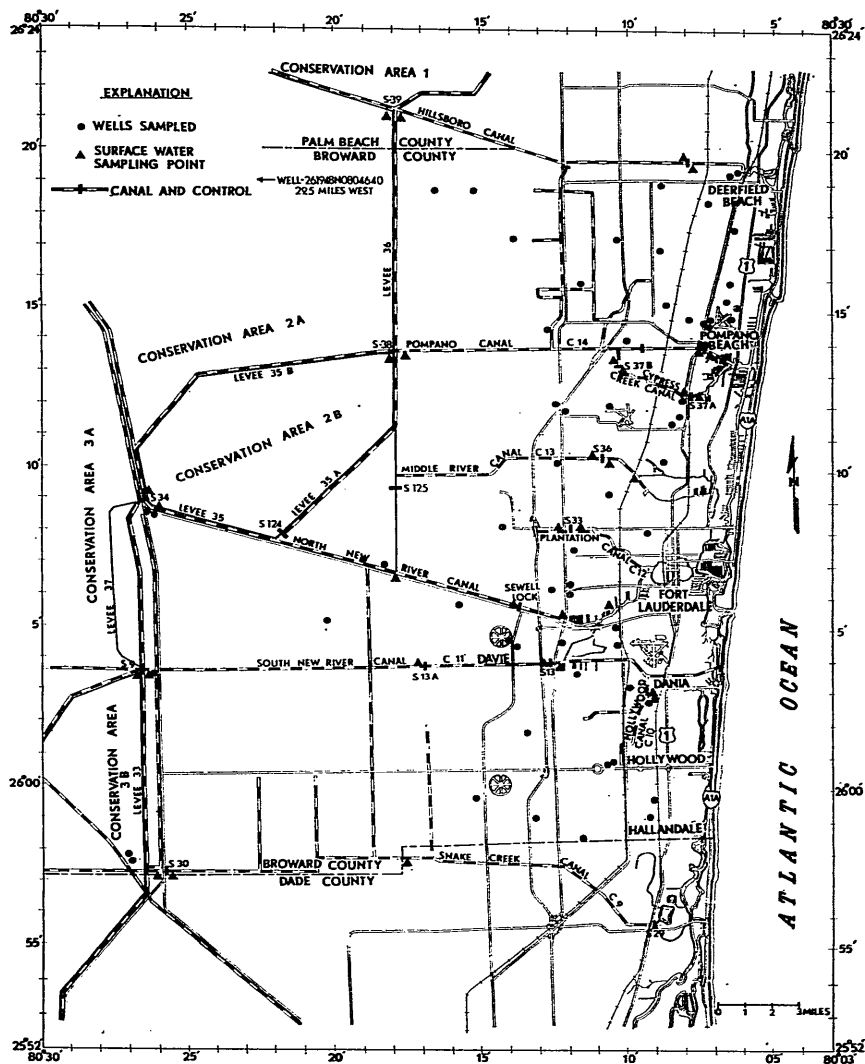


Figure 3. Location of water-sampling stations.

Surface-water samples were collected periodically at high tide immediately upstream of control structures. Samples of ground water were pumped from wells to obtain water representative of the section

during the drilling of 19 test wells. During the construction of test wells, drilling was stopped about every 21 feet (the length of a section of drill stem) and all drilling fluid was pumped out of the drill stem. Water from the aquifer was then pumped out of the drill stem for several minutes and a sample collected. Specific conductance was determined for all samples. Those that had conductance values differing appreciably from previous samples were analyzed for dissolved constituents. All water samples collected during this study were analyzed by the U. S. Geological Survey. Sampling was started in December 1961, however analyses of samples collected during earlier studies are included.

The well-numbering system used in this report is that of the Water Resources Division of the U. S. Geological Survey and is based on a one-second grid of parallels of latitude and meridians of longitude, in that order.

The well number is a composite of two numbers separated by the letter N. The first part consists of six digits; the two digits of the degrees, the two digits of the minutes, and the two digits of the seconds of latitude. The N refers to "north" latitude. The second part consists of seven digits; the three digits of the degrees, the two digits of the minutes, and the two digits of the seconds of longitude. If more than one well lies within a one-second grid, the wells are numbered consecutively and this number is placed at the end of the well number following the decimal. Therefore, the well number defines the latitude and the longitude on the south and east sides of a one-second quadrangle in which the well is located.

Figure 4 is a diagram illustrating the well-numbering system. For example, the designation 275134N0815220.1 indicates that this is the first well inventoried in the one-second grid bounded by latitude $27^{\circ}51'34''$ on the south and longitude $81^{\circ}52'20''$ on the east.

CHEMICAL QUALITY OF WATERS OF BROWARD COUNTY

Chemical analyses of water from wells and canal sites in Broward County are shown in table 1. Standard chemical analyses of water samples as determined by the U. S. Geological Survey are for the cations (positively charged ions), calcium, magnesium, sodium, and potassium; the anions (negatively charged ions) sulfate, chloride, fluoride, nitrate; those contributing to alkalinity (expressed as equivalent amounts of carbonate and bicarbonate), and total iron and silica. Other properties usually determined are pH, hardness, color, specific conductance, and total dissolved solids (as residue and sum of determined constituents). The chemical constituents are commonly reported in ppm (parts per million). One part per million represents 1 milligram of solute in 1 liter

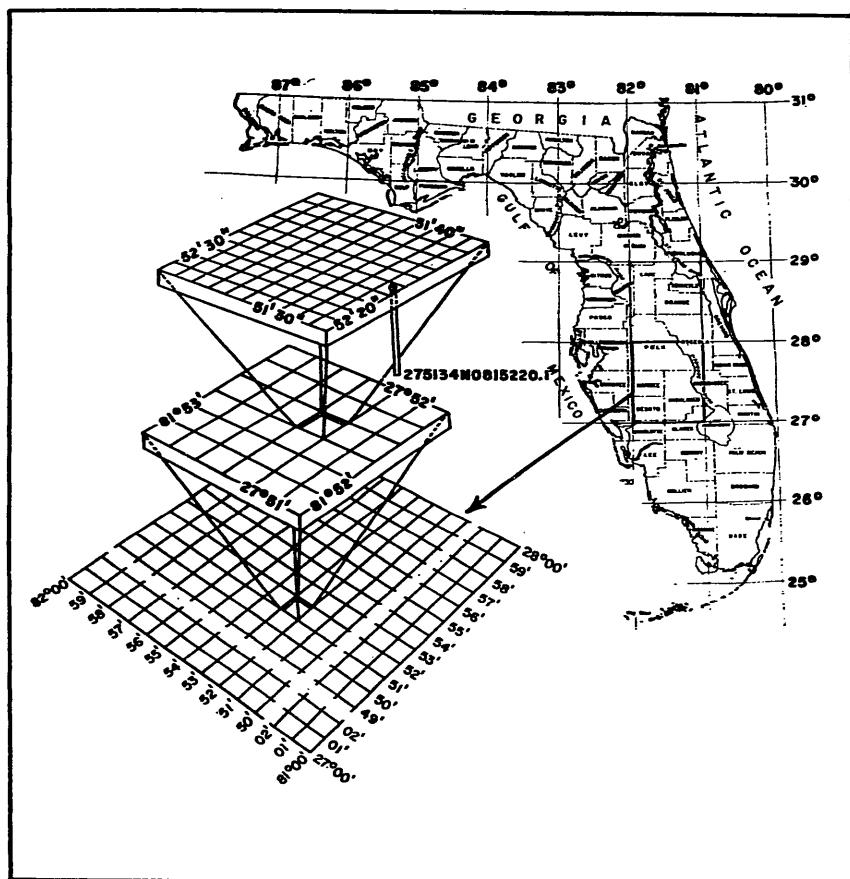


Figure 4. Diagram illustrating the well-numbering system.

of solution, or expressed in English units 8.34 pounds of constituent per million gallons of water.

Dissolved mineral content of water is generally reported in one of two forms: (1) dissolved solids, the weight of residue remaining after evaporation of a known volume of clear water; (2) sum of the individual components, the total of the constituents as determined by chemical analysis. Residue and calculated dissolved solids should be approximately equal, although the residue figure usually is slightly larger. This difference may be caused by organic or inorganic substances not analyzed, or the residue may contain a small amount of water of hydration.

Table 1. CHEMICAL ANALYSES OF WATER FROM WELLS AND CANALS IN BROWARD COUNTY, FLA.

A.—Ground Water

(Chemical analyses, in parts per million, except pH and color)

Well number	Date of collection	Depth of well (ft.)	Specific conductance (micro-mhos at 25°C)	pH	Temperature (°F)	Silica (SiO ₂)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO ₃)	Carbonate (CO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Fluoride (F)	Nitrate (NO ₃)	Iron (Fe)	Dissolved solids		Hardness		Color
																		Residue at 180°C	Calculated	Calcium, magnesium	Non-carbonate	
255829N 0801120	04-06-62	116	553	7.9	77	9.1	98	7.4	15	0.6	310	0	14	22	0.0	0.0	0.56	338	319	275	21	35
255909N 0801317	04-06-62	160	551	7.6	73	8.9	96	7.4	16	0.6	292	0	24	21	0.0	1.1	1.7	346	319	270	30	55
255742N 0802720	09-18-41	32	398	—	83	—	61	10	5.0	—	214	—	1.0	19	—	—	—	—	202	193	—	110
255742N 0802720	09-19-41	56	426	—	77	—	70	8.3	8.2	—	242	—	1.0	19	—	—	—	—	226	209	—	110
255742N 0802720	09-23-41	90	877	—	77	—	50	28	91	—	321	—	25	105	—	—	—	—	457	240	—	20
255742N 0802720	09-24-41	134	1430	—	76	—	48	48	202	—	444	—	26	230	—	—	—	—	763	276	—	20
255742N 0802720	09-25-41	173	1640	—	76	—	42	42	257	—	458	—	33	282	—	—	—	—	875	249	—	20
255742N 0802720	09-26-41	198	2130	—	77	—	33	33	378	—	518	—	39	408	—	—	—	—	1150	218	—	20
255745N 0802722	04-20-64	45	660	7.3	72	5.8	94	8.1	40	0.8	304	0	5.2	66	0.3	0.0	1.3	371	370	268	19	60
255918N 0800917	04-06-62	82	563	7.7	77	5.7	101	2.4	19	2.0	282	0	24	27	0.0	0.5	0.24	324	321	262	31	20
255948N 0800909	04-13-64	80	587	7.8	76	13	66	21	35	1.3	284	0	0.4	56	0.2	0.1	1.5	314	333	252	20	20
255948N 0800909	04-20-64	215	540	8.2	—	8.8	97	5.4	14	0.6	286	0	29	22	0.2	0.2	3.9	338	318	264	30	20
255946N 0801519	04-06-62	121	564	7.7	70	11	102	9.8	13	0.7	314	0	20	20	0.0	1.9	1.6	360	333	295	38	50
260043N 0801042	04-06-62	65	535	7.9	77	6.3	100	2.6	16	0.8	292	0	22	19	0.0	0.1	0.54	320	311	260	20	12
260054N 0801033	04-05-64	20	562	8.0	75	5.3	82	16	18	2.2	298	0	27	28	0.3	0.0	0.68	320	326	272	28	25
260054N 0801033	04-06-64	122	544	8.0	—	8.2	92	0.6	23	0.7	288	0	8.4	47	0.2	0.1	2.0	—	322	232	0	20
260054N 0801033	04-07-64	167	411	7.8	—	11	52	4.5	31	1.6	174	0	4.0	62	0.2	0.7	1.6	—	253	148	6	5
260054N 0801033	04-08-64	200	1020	7.8	—	11	41	70	86	6.3	204	0	10	225	0.3	0.2	0.23	604	550	390	223	10
260149N 0801332	04-06-62	200	335	7.7	78	8.8	59	3.6	7.5	0.6	172	0	13	14	0.1	0.1	0.74	194	192	162	21	35
260251N 0800911	04-06-62	90	603	7.9	78	7.6	110	1.3	22	1.0	300	0	24	36	0.0	0.0	0.65	374	350	280	34	25
260252N 0800914	03-19-64	75	4400	7.9	—	8.3	166	79	700	18	288	0	180	1320	0.5	3.0	—	3080	2620	740	504	20
260252N 0800914	03-20-64	115	1130	8.0	—	6.2	123	32	76	2.5	248	0	40	230	0.3	0.0	0.82	926	653	440	237	20
260312N 0801001	03-16-64	20	1320	7.9	—	13	61	53	180	9.2	300	0	29	285	0.3	0.2	1.2	786	775	370	124	15
260312N 0801001	03-16-64	62	464	8.1	—	6.6	85	7.8	15	1.5	312	0	15	24	0.2	0.0	0.70	—	309	244	0	30
260312N 0801001	03-17-64	200	2750	7.9	—	7.1	119	47	405	6.8	132	0	104	820	0.2	2.4	2.3	1940	1580	490	382	20
260336N 0801157	04-06-62	67	429	7.6	73	8.0	74	6.2	13	1.2	228	0	10	20	0.0	0.9	0.80	262	245	210	23	55
260322N 0801621	04-06-62	170	610	7.7	77	9.9	110	8.6	17	0.7	326	0	27	24	0.0	1.6	2.3	410	360	310	43	55
260338N 0802606	12-06-40	66	538	—	74	—	101	9.1	A12	—	336	—	5.3	25	—	—	—	—	318	289	—	170
260338N 0802606	12-07-40	118	3840	—	77	—	102	67	A618	—	389	—	206	950	—	—	—	—	2130	530	—	35
260338N 0802606	12-07-40	159	4190	—	77	—	83	76	A693	—	358	—	243	1050	—	—	—	—	2320	520	—	25
260338N 0802606	12-09-40	204	4110	—	76	—	74	82	A675	—	371	—	237	1020	—	—	—	—	2270	522	—	25
260438N 0801009	02-20-64	61	496	8.0	—	5.6	111	1.7	3.7	0.7	320	0	14	52	0.3	0.4	1.4	314	301	284	22	50
260438N 0801009	02-24-64	145	471	8.1	—	12	66	5.7	26	0.8	204	0	0	52	0.1	0.1	0.11	—	263	188	21	5
260438N 0801009	03-03-64	197	499	7.9	—	9.4	46	12	98	3.6	172	0	19	75	0.2	0.1	3.2	—	303	164	23	5
260438N 0801009	03-04-64	206	751	7.8	—	—	50	33	74	5.6	250	0	14	116	0.3	0.3	4.4	408	426	260	55	20
260437N 0801217	03-26-64	63	530	7.7	—	6.8	70	15	32	0.8	256	0	4.8	48	0.4	0.6	4.4	344	304	238	28	40

A Calculated Na plus K, reported as Na.

Table 1. CHEMICAL ANALYSES OF WATER FROM WELLS AND CANALS IN BROWARD COUNTY, FLA.—Continued

A.—Ground Water

(Chemical analyses, in parts per million, except pH and color)

Well number	Date of collection	Depth of well (ft.)	Specific conductance (micro-mhos at 25°C)	pH	Temperature (°F)	Silica (SiO ₂)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO ₃)	Carbonate (CO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Fluoride (F)	Nitrate (NO ₃)	Iron (Fe)	Dissolved solids		Hardness		Color	
																		Residue at 180°C	Calculated	Calcium, magnesium	Non-carbonate		
260437N 0801217	03-29-64	187	500	7.9	75	13	85	23	240	10	316	0	10	391	0.2	1.3	0.22	—	930	308	49	10	
260437N 0801217	03-31-64	204	3480	8.0	—	14	78	79	567	24	376	0	54	980	0.4	2.0	4.4	2200	1980	520	212	20	
260427N 0801355	04-06-62	115	438	7.7	78	9.3	78	5.0	13	0.6	240	0	10	18	0.0	0.0	2.2	272	252	215	18	55	
260437N 0801402	06-18-63	126	437	7.7	—	9.6	84	3.8	11	0.0	260	0	6.9	19	0.4	0.0	—	296	263	225	12	45	
260519N 0801017	04-06-62	65	434	7.8	75	9.1	56	12	22	2.3	218	0	0.0	32	0.0	0.2	0.52	240	241	189	10	20	
260542N 0801554	04-02-62	58	559	7.5	76	7.7	86	5.0	28	0.7	244	0	17	45	0.0	3.9	1.6	376	313	235	35	80	
260515N 0802021	09-30-64	28	490	8.1	78	2.2	98	3.8	7.0	2.0	320	0	0.0	10	0.4	4.3	—	—	286	260	0	45	
260604N 0801201	04-06-62	136	443	7.6	73	8.6	83	2.2	9.0	0.5	246	0	8.4	15	0.1	0.3	1.34	254	248	216	14	15	
260609N 0801205	12-03-41	124	436	—	77	—	84	1.7	A9.5	—	252	—	12	13	—	0.0	—	—	245	217	—	5	—
260609N 0801205	12-05-41	147	484	—	77	—	80	22	A11	—	250	—	2.0	18	—	0.2	—	—	257	209	—	5	—
260609N 0801205	12-06-41	171	500	—	76	—	71	2.6	A13	—	226	—	2.1	21	—	0.2	—	—	221	188	—	5	—
260609N 0801205	12-17-41	228	960	—	77	—	82	19	A98	—	332	—	2.7	157	—	0.0	—	—	522	283	—	5	—
260609N 0801205	12-18-41	263	3620	—	77	—	69	57	A572	—	342	—	2.3	970	—	—	—	—	1840	407	—	5	—
260609N 0801205	12-23-41	314	8940	—	76	—	110	139	A1650	—	300	—	333	2720	—	—	—	—	5150	846	—	5	—
260653N 0801849	05-28-64	58	780	8.0	—	15	89	36	44	1.7	376	0	6.4	76	0.4	0.2	0.45	494	454	368	60	50	
260725N 0801155	04-05-62	100	489	7.9	73	9.5	94	2.6	12	0.5	284	0	4.8	18	0.0	0.5	3.0	304	282	245	12	45	
260820N 0801410	04-05-62	155	636	7.8	75	9.7	120	5.0	18	0.6	330	0	24	31	0.0	1.0	3.0	396	372	320	50	25	
260702N 0801907	07-02-63	56	520	8.0	—	7.1	84	5.0	26	0.7	260	0	4.4	43	0.3	0.2	1.3	339	299	230	17	50	
260809N 0800928	02-13-63	23	505	8.0	—	7.0	78	14	19	0.5	234	0	16	44	0.5	0.0	1.0	320	294	254	62	40	
260809N 0800928	02-14-63	113	510	7.9	—	8.1	59	1.2	22	0.5	164	0	24	27	0.2	0.0	0.15	—	223	152	18	30	
260809N 0800928	02-17-63	185	1050	8.0	—	13	69	9.2	132	4.4	192	0	11	240	0.2	0.7	0.41	—	574	210	52	15	
260809N 0800928	02-18-63	208	1330	7.9	—	13	64	57	180	5.4	300	0	12	295	0.4	0.8	0.20	774	776	395	199	30	
260842N 0802629	04-22-64	45	840	7.7	77	20	98	19	66	2.2	388	0	2.8	100	0.5	0.0	1.8	501	—	321	3	70	
260843N 0802629	10-23-41	37	580	—	73	—	94	9.4	A18	—	325	—	6.6	28	—	0.3	—	—	316	273	—	160	—
260843N 0802629	10-25-41	62	594	—	73	—	96	9.4	A18	—	326	—	5.3	31	—	0.3	—	—	321	278	—	120	—
260843N 0802629	10-28-41	133	2180	—	75	—	70	34	A351	—	558	—	43	408	—	—	—	—	1181	314	—	20	—
260843N 0802629	10-30-41	190	2380	—	76	—	56	45	A407	—	572	—	31	443	—	—	—	—	1315	325	—	20	—
260917N 0801045	04-05-62	74	399	7.7	76	11	76	1.3	8.0	0.5	228	0	3.2	14	0.0	0.4	1.8	242	226	195	8	20	
261018N 0800850	01-07-64	23	423	8.1	—	9.2	83	4.1	8.9	0.2	256	0	2.8	16	0.2	0.0	1.9	272	250	224	14	50	
261018N 0800850	01-08-64	56	642	7.4	78	10	83	2.2	58	1.4	282	0	25	63	0.2	0.0	1.4	—	382	216	0	45	—
261018N 0800850	01-09-64	85	459	8.3	78	8.2	75	1.7	17	0.5	204	4	13	32	0.2	0.0	0.22	—	252	194	27	25	
261018N 0800850	01-15-64	167	1120	7.7	—	9.4	94	2.3	116	0.8	126	0	4.8	280	0.2	1.2	1.4	—	571	244	140	8	—
261018N 0800850	01-16-64	186	4850	7.8	—	10	128	125	750	2.0	230	0	24	1580	0.2	1.8	3.1	3230	2730	835	646	20	
261159N 0801038	04-05-62	79	384	7.7	77	7.9	72	3.8	6.4	0.7	220	0	2.8	12	0.0	1.0	0.92	228	215	195	14	15	
261018N 0801217	04-06-62	80	488	8.4	—	7.8	98	1.3	13	0.6	278	6	3.6	19	0.0	1.1	1.1	326	287	250	12	120	
261122N 0800834	04-22-64	84	251	8.1	—	12	44	3.9	6.6	0.6	146	0	0.0	10	0.4	0.1	—	158	150	126	22	20	

A Calculated Na plus K, reported as Na.

Table 1. CHEMICAL ANALYSES OF WATER FROM WELLS AND CANALS IN BROWARD COUNTY, FLA.—Continued

A.—Ground Water

(Chemical analyses, in parts per million, except pH and color)

Well number	Date of collection	Depth of well (ft.)	Specific conductance (micro-mhos at 25°C)	pH	Temperature (°F)	Silica (SiO ₂)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO ₃)	Carbonate (CO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Fluoride (F)	Nitrate (NO ₃)	Iron (Fe)	Dissolved solids		Hardness		Color
																		Residue at 180°C	Calculated	Calcium, magnesium	Non-carbonate	
261122N 0800834	04-28-64	167	329	8.0	—	9.0	77	1.0	9.7	0.6	230	0	5.6	18	0.2	0.1	3.7	—	234	196	8	5
261122N 0800834	05-04-64	204	582	7.8	—	7.3	93	1.0	19	0.8	302	0	31	32	0.5	0.0	—	422	343	274	26	65
261142N 0800822	01-20-64	61	642	8.1	—	9.2	126	1.8	16	0.5	374	0	14	30	0.3	0.0	0.16	356	382	322	16	40
261142N 0800822	01-24-64	180	1790	7.9	76	14	125	7.8	295	6.9	250	0	22	522	0.4	1.9	0.53	—	120	344	139	15
261142N 0800822	01-27-64	186	3520	7.9	—	14	155	23	575	14	278	0	60	1040	0.3	1.8	0.53	2360	2020	480	252	20
261143N 0801211	01-29-64	23	129	7.7	—	7.1	24	1.9	2.1	0.4	66	0	7.2	5.0	0.2	0.0	0.20	98	81	68	14	60
261143N 0801211	01-30-64	197	436	8.2	—	17	26	20	46	4.2	138	0	4.0	70	0.3	0.6	0.07	262	256	148	35	20
261215N 0800808	04-05-62	68	681	7.8	75	5.7	84	7.4	50	3.2	264	0	26	73	0.0	0.0	1.2	408	379	240	24	45
261204N 0801228	04-03-62	104	697	8.0	73	13	124	7.4	23	1.2	390	0	8.0	37	0.0	0.0	2.6	436	406	340	20	35
261358N 0800723	01-03-63	304	493	7.9	77	7.5	82	4.3	16	1.4	266	0	5.2	28	0.3	0.1	3.4	283	276	222	4	5
261358N 0800724	08-27-51	190	261	7.4	—	18	44	2.5	9.8	0.3	136	0	9.0	14	0.4	0.9	—	170	166	120	9	6
261459N 0800639	08-10-60	158	228	8.0	77	3.5	36	1.0	8.3	0.6	113	0	3.6	13	0.2	0.1	0.44	124	122	94	2	5
261445N 0800750	08-10-60	220	116	9.8	78	1.7	8.4	0.2	12	0.6	11	9	2.4	18	0.2	0.1	0.30	58	58	22	0	5
261450N 0800716	04-05-62	105	325	7.8	79	7.0	56	2.1	8.1	0.8	162	0	7.2	13	0.0	0.1	0.58	162	174	148	15	0
261436N 0800719	08-23-61	140	267	7.6	—	12	46	2.5	9.2	0.6	140	0	8.0	14	0.3	0.6	—	168	161	120	5	7
261436N 0800720	09-05-61	203	370	7.6	—	14	70	0.4	11	0.7	222	0	6.5	15	0.4	0.8	—	252	231	189	7	28
261409N 0801000	04-05-62	168	513	7.8	76	14	100	3.8	11	0.8	308	0	2.8	16	0.0	0.2	0.91	320	301	265	12	15
261424N 0801244	04-05-62	117	730	7.7	75	13	132	7.4	21	0.8	420	0	0.0	33	0.0	0.0	0.07	428	416	360	16	5
261408N 0802743	05-19-53	55	1080	7.5	—	16	121	24	89	0.8	500	0	44	105	0.6	2.1	2.1	692	655	416	6	55
261504N 0800602	01-24-61	176	295	8.0	78	9.5	52	2.1	7.7	0.4	162	0	2.8	12	0.3	0.1	0.57	167	167	138	51	5
261547N 0800619	04-05-62	140	315	8.0	80	6.7	56	2.1	8.5	0.6	162	0	6.4	15	0.0	0.1	0.35	152	175	148	15	0
261512N 0800841	04-06-62	150	752	7.8	76	17	126	8.6	30	1.6	412	0	0.0	46	0.0	0.0	0.16	444	432	350	12	7
261527N 0801138	03-12-64	165	740	7.6	74	11	138	5.7	22	1.2	392	0	32	36	0.2	0.1	0.12	494	439	368	47	25
261652N 0800854	04-14-64	145	741	7.6	75	15	138	5.7	23	1.0	388	0	31	36	0.2	0.2	1.38	482	441	368	50	15
261734N 0800621	04-05-62	178	355	7.8	78	6.3	62	3.3	9.9	0.6	192	0	4.0	16	0.0	0.2	0.54	186	197	168	10	0
261704N 0801022	03-12-64	106	650	7.5	77	13	123	1.6	17	1.3	384	0	0.0	25	0.3	0.1	0.42	386	373	326	12	15
261710N 0801350	03-12-64	24	615	7.5	76	4.6	112	12	12	0.7	344	0	31	18	0.1	0.1	0.14	364	360	330	48	10
261822N 0800707	04-14-64	62	485	7.7	77	7.3	98	3.8	8.4	0.4	288	0	4.4	14	0.3	0.0	1.03	336	279	260	24	90
261856N 0800842	03-12-64	100	755	7.7	77	16	135	3.6	29	1.1	364	0	17	63	0.3	0.0	0.82	492	444	352	54	20
261838N 0801513	11-19-63	57	429	7.8	—	3.3	30	29	15	1.0	206	0	15	28	0.1	0.4	0.07	262	223	194	25	20
261838N 0801513	11-25-63	102	1520	7.6	73	14	96	20	210	7.2	310	0	32	340	0.4	0.1	0.07	872	873	320	66	20
261840N 0801633	04-14-64	104	2700	7.7	75	19	175	23	298	8.0	522	0	120	518	0.4	0.6	0.10	1458	1420	530	102	10
261908N 0800622	04-05-62	94	360	7.9	78	6.9	66	0.9	8.7	0.5	194	0	7.2	15	0.0	0.0	0.70	204	201	168	9	25
261914N 0800607	12-06-63	23	232	7.9	79	3.2	50	0.2	2.6	0.2	146	0	4.8	5.0	0.5	0.0	0.48	144	138	126	6	70
261914N 0800607	01-06-64	195	312	8.0	79	9.8	61	1.5	8.5	0.6	176	0	3.6	16	0.3	0.3	0.03	180	189	158	14	20
261948N 0804640	03-13-64	85	2800	7.4	75	7.8	130	42	450	7.4	488	0	64	680	0.5	0.1	0.40	1600	1620	496	96	5

Table 1. CHEMICAL ANALYSES OF WATER FROM WELLS AND CANALS IN BROWARD COUNTY, FLA.—Continued
B.—Surface Water

(Chemical analyses, in parts per million, except pH and color)

Date of collection	Mean discharge (cfs)	Silica (SiO ₂)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Fluoride (F)	Nitrate (NO ₃)	Phosphate (PO ₄)	Dissolved solids		Hardness (as CaCO ₃)		Specific conductance (micro-mhos at 25°C)	pH	Color	
														Residue at 180°C	Calculated	Calcium, magnesium	Non-carbonate				
2-2813. HILLSBORO CANAL AT S-39, NEAR DEERFIELD BEACH																					
Oct. 6, 1960	315	10	0.06	41	9.6	44	4.3	148	27	62	—	0.0	—	—	271	142	20	486	7.7	160	
Dec. 5	449	3.9	.04	25	4.3	23	1.4	90	7.6	32	—	.0	—	—	112	80	6	262	7.6	120	
Jan. 3, 1961	113	1.3	.08	18	4.1	21	2.0	66	7.2	28	—	1.7	—	—	116	62	8	217	7.4	110	
Feb. 1	22	4.4	.05	33	9.1	38	2.0	136	11	52	—	—	—	—	217	120	8	396	7.3	110	
Mar. 1	9	2.6	.04	26	5.4	29	3.5	100	8.8	40	—	.7	—	—	165	87	5	307	6.3	100	
Apr. 3	82	3.5	.04	30	7.1	25	1.8	120	7.2	36	—	.0	—	—	170	104	6	309	7.5	110	
May 1	8	.5	.04	56	12	55	4.4	216	13	69	—	3.8	—	—	320	189	12	600	7.7	50	
June 1	243	17	.07	81	22	74	5.1	290	64	96	—	10	—	—	512	292	55	873	7.5	150	
Aug. 2	10	17	.06	54	17	67	3.7	230	27	90	—	.0	—	—	389	204	16	679	7.8	110	
Sept. 6	118	18	.09	81	30	122	5.6	354	60	153	—	.4	—	—	644	326	36	1095	7.6	200	
Oct. 11	—	17	.02	49	17	98	3.4	210	29	130	—	.3	—	—	453	192	10	783	8.4	100	
Nov. 13	—	7.2	.03	56	22	104	3.5	256	38	135	—	.2	—	—	492	230	20	867	7.9	110	
Dec. 11	—	6.7	.06	74	11	49	4.9	242	25	80	—	.0	—	—	370	230	31	664	7.6	90	
Jan. 8, 1962	—	3.4	.05	69	23	102	4.1	316	29	134	—	2.6	—	—	—	266	8	920	8.2	90	
Feb. 7	—	8.5	.01	72	37	237	7.3	370	67	340	—	1.7	—	—	953	332	28	1750	7.9	80	
Mar. 15	—	9.7	.04	70	22	160	4.7	308	50	205	—	2.1	—	—	676	265	12	1190	7.8	60	
Apr. 7	—	5.2	.05	78	9.1	78	3.5	248	36	113	—	.3	—	—	445	232	29	806	8.0	70	
Apr. 13	—	1.6	.03	60	18	134	4.0	258	52	175	—	.4	—	—	562	224	28	1010	8.1	70	
May 3	—	10	.02	72	17	150	4.4	290	50	190	—	1.4	—	—	638	250	12	1140	7.6	50	
June 15	—	15	.03	84	27	225	5.8	380	64	270	—	1.4	—	—	879	320	9	1540	7.8	90	
Nov. 2	—	17	.11	70	27	128	5.8	318	44	170	—	.3	—	—	619	286	25	1060	7.7	240	
Dec. 4	74	11	.12	58	21	107	4.8	264	28	152	0.8	.2	—	—	610	513	23	14	900	8.0	160
July 17, 1963	—	9.4	.06	96	8.4	76	3.4	308	25	104	.6	.2	—	—	486	475	274	22	806	7.4	80
July 30	—	6.4	.15	29	8.6	49	1.7	118	8.8	58	—	.1	—	—	—	220	108	12	403	7.5	90
Sept. 17	—	10	.03	38	13	64	2.6	156	21	90	—	.0	—	—	—	316	148	20	541	7.4	80
Dec. 10	—	4.8	.03	50	18	90	3.4	222	32	122	—	.2	—	—	—	429	200	18	750	8.0	100
Jan. 14, 1964	—	19	.06	110	40	145	8.0	395	89	194	—	34	—	—	—	834	437	114	1300	7.9	150
Apr. 21	—	6.0	.10	53	18	99	3.2	233	26	132	—	.4	—	—	—	—	205	14	785	8.1	100
May 20	—	6.9	.06	50	13	64	2.2	192	17	99	—	.1	—	—	—	347	178	20	629	7.8	110
June 18	—	11	.12	72	18	67	5.6	210	65	100	—	20	—	—	—	462	250	78	770	7.8	220
July 24	—	16	.15	61	18	87	.0	240	48	124	.7	.9	—	—	562	—	224	28	771	7.7	200
Oct. 28	—	16	—	72	22	117	5.0	284	54	150	.8	5.6	—	—	—	582	270	38	964	7.8	150
Nov. 20	—	13	.04	64	29	106	4.6	300	50	55	.9	.3	—	—	—	601	280	34	910	7.3	140
Jan. 26, 1965	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	890	—	—
Feb. 22	—	2.9	.05	53	17	90	3.7	220	25	24	.6	.3	—	—	—	425	200	20	750	7.1	100
May 21	—	7.0	.00	57	15	76	1.5	218	13	10	.7	2.7	—	—	—	390	202	24	699	7.7	100

Table 1. CHEMICAL ANALYSES OF WATER FROM WELLS AND CANALS IN BROWARD COUNTY, FLA.—Continued

B.—Surface Water
(Chemical analyses, in parts per million, except pH and color)

Date of collection	Mean discharge (cfs)	Silica (SiO ₂)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Fluoride (F)	Nitrate (NO ₃)	Phosphate (PO ₄)	Dissolved solids		Hardness (as CaCO ₃)		Specific conductance (micro-mhos at 25°C)	pH	Color
														Residue 180°C	Calculated	Calcium, magnesium	Non-carbonate			
2-2813.1E. HILLSBORO CANAL AT S-39 BELOW CONTROL, NEAR DEERFIELD BEACH																				
Oct. 7, 1959	1140	3.4	0.03	41	2.8	27	2.2	116	20	34	—	0.0			187	114	19	343	7.9	100
Nov. 10	170	4.0	.05	25	2.3	13	1.9	74	7.2	16	—	.1			106	72	12	188	7.4	80
Dec. 10	28	2.7	.05	30	2.4	17	.7	94	8.0	30	—	.4			137	85	8	268	7.4	60
Jan. 7, 1960	18	3.8	.04	44	3.0	28	.8	128	9.6	43	—	.2			195	122	18	366	7.5	140
Mar. 9	A 10	4.5	.02	85	15	118	3.2	290	45	188	—	.5			602	274	36	1120	7.7	80
Apr. 5	A 10	.8	.03	89	20	165	5.0	366	48	220	—	2.3			730	304	4	1320	8.1	110
June 7	355	9.1	.07	66	7.2	54	5.5	B224	22	82	—	.1			356	194	10	635	8.6	120
July 7	137	9.2	.13	94	3.3	55	1.8	C289	20	80	—	.1			415	248	10	748	8.4	85
July 17, 1963	140	9.7	.06	96	8.4	71	3.2	304	24	98	.6	1.2		478	462	274	25	790	7.6	85
Feb. 22, 1965	—	7.6	.04	90	19	133	5.3	292	42	225	.6	.2			667	304	64	1180	7.6	75
2-2815. HILLSBORO CANAL ABOVE CONTROL, AT DEERFIELD BEACH																				
Apr. 7, 1962	D 40	4.8	0.14	83	10	92	4.3	266	38	120	0.4	0.2		512	—	248	30	877	7.6	75
Aug. 23	D 160	9.3	.05	98	6.2	62	4.1	294	24	95	.6	.0		486	—	270	29	770	7.6	80
Dec. 4	—	11	.12	58	21	107	4.8	264	28	152	.8	.2		610	513	231	14	900	8.0	160
Oct. 8, 1963	D 244	7.5	.05	83	6.1	39	3.9	251	21	60	.4	.1		348	—	232	26	600	7.7	60
Jan. 13, 1964	D 752	8.2	.06	90	7.2	52	5.4	260	36	80	.5	1.3		444	—	254	41	700	7.5	70
Apr. 21	D 72	6.3	.05	94	10	—	—	300	26	102	1.2	.1		476	—	276	30	803	7.6	80
May 20	D 172	7.7	—	98	2.8	64	2.1	276	23	98	.5	.0		470	—	256	30	761	7.6	70
June 18	D 105	8.1	.09	99	2.2	47	3.1	278	22	72	.5	.0		424	—	256	28	670	7.6	75
Sept. 2	D 123	8.5	.11	80	6.0	48	6.1	232	25	76	.4	1.4		—	—	224	58	629	7.2	120
Oct. 28	—	7.1	—	91	4.4	42	3.3	272	10	60	.6	.1		—	352	245	22	622	7.5	70
Feb. 22, 1965	—	7.1	.05	90	10	70	2.6	300	24	102	.5	.2		—	454	266	20	830	7.6	75
Apr. 26	—	5.8	.01	76	.6	54	2.0	197	14	83	.5	.6		—	334	192	30	577	7.5	60
May 21	—	12	.04	76	6.4	45	1.2	236	18	68	.5	.0		—	343	216	22	609	7.1	50

A Leakage of 10 cfs, based on 4 discharge measurements and records of dam operation.

B Includes 12 ppm of carbonate (CO₃).C Includes 18 ppm of carbonate (CO₃).

D Discharge at time of sampling.

Table 1. CHEMICAL ANALYSES OF WATER FROM WELLS AND CANALS IN BROWARD COUNTY, FLA.—Continued

B.—Surface Water

(Chemical analyses, in parts per million, except pH and color)

Date of collection	Mean discharge (cfs)	Silica (SiO ₂)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Fluoride (F)	Nitrate (NO ₃)	Phosphate (PO ₄)	Dissolved solids		Hardness (as CaCO ₃)		Specific conductance (micro-mhos at 25°C)	pH	Color
														Residue at 180°C	Calculated	Calcium, magnesium	Non-carbonate			
2-2815.1E. HILLSBORO CANAL BELOW CONTROL, NEAR DEERFIELD BEACH																				
July 17, 1963	140	9.7	0.06	96	8.4	71	3.2	304	24	98	0.6	1.2		478	462	274	25	790	7.6	85
Oct. 8		6.9	.06	86	4.7	40	3.9	252	21	61	.4	.2		356	—	234	28	600	7.8	80
Jan. 13, 1964		8.2	.06	90	6.7	50	5.3	255	29	82	.5	.8		399	—	232	43	698	7.2	70
Apr. 21		6.2	.04	95	7.5	74	3.2	298	28	100	.6	.0		472	—	268	24	788	7.5	65
May 20		8.0	.03	92	7.4	65	2.3	268	26	102	.5	.0		492	—	260	40	1270	7.8	70
June 18		8.6	—	101	2.9	50	3.3	284	22	72	.5	.0		424	—	264	32	678	7.6	85
Sept. 2		8.6	.01	82	5.0	48	5.5	240	23	74	.4	1.0		—	—	225	32	625	7.4	120
Oct. 28		7.2	—	90	3.8	41	3.2	272	8.8	62	.4	.1		—	351	240	17	610	7.4	60
2-2817. POMPANO CANAL ABOVE CONTROL AT S-38, NEAR POMPANO BEACH																				
July 16, 1963		11	0.06	42	14	91	2.9	191	19	122	0.6	0.0		466	397	161	4	679	8.0	80
Oct. 9		13	.04	32	7.8	55	2.4	124	11	80	.3	.2		276	—	112	10	465	7.5	50
Jan. 15, 1964		11	.04	53	14	58	2.6	196	23	80	.5	.4		384	—	188	28	570	7.4	50
Apr. 22		3.4	.03	31	7.9	50	1.7	134	4.5	61	.4	.1		226	—	110	0	401	7.2	50
May 19		5.8	—	45	4.7	47	1.4	160	3.6	70	.5	.0		300	—	132	1	465	7.4	55
June 17		13	—	50	9.5	100	2.3	176	13	154	.6	.1		468	—	164	20	769	7.8	90
Sept. 1		17	.06	51	16	74	4.0	203	35	108	.6	.0		—	—	193	26	691	7.4	100
Oct. 30		17	.04	38	15	65	3.6	166	19	92	.4	.2		—	332	156	20	572	7.8	60
Mar. 9, 1965		17	.03	51	24	86	3.2	212	18	115	.5	.1		—	419	180	50	694	7.5	80
Apr. 26		15	.04	72	28	134	6.0	324	40	202	1.1	.0		—	658	295	30	1170	7.6	110
May 26		21	.01	70	28	155	6.3	310	36	232	.9	.5		—	703	288	34	1300	7.7	100
June 3		18	.03	61	28	160	5.7	300	30	240	.9	.5		—	692	320	21	1290	7.9	60
2-2817.1E. POMPANO CANAL BELOW CONTROL AT S-38, NEAR POMPANO BEACH																				
Apr. 5, 1962		4.3	—	96	9.8	56	0.7	294	34	94	0.2	0.0		—	440	280	39	765	7.7	50
Apr. 4, 1963		9.3	0.05	70	10	62	1.7	220	6.4	102	.3	.8		456	372	216	36	694	7.7	90
July 16		8.9	.07	71	11	75	2.6	260	17	106	.6	.7		454	421	224	11	746	7.7	100
Oct. 9		7.9	.05	47	6.0	40	2.0	159	7.6	57	.4	.4		248	—	142	12	435	7.6	70
2-2820. POMPANO CANAL ABOVE CONTROL AT POMPANO BEACH																				
Dec. 12, 1961		7.5	0.04	89	5.4	30	0.9	292	15	37	1.3	0.1		—	330	244	4	585	8.0	40
Mar. 12, 1962		13	.51	84	2.6	54	2.6	284	18	58	2.7	.1		—	375	220	0	600	7.4	50
Aug. 23		8.8	.03	84	3.8	29	1.5	252	15	39	.6	.0		—	306	225	18	527	7.7	40
July 17, 1963		8.9	.05	86	7.7	57	2.6	276	20	81	.5	.1		442	400	246	20	712	7.5	70
Oct. 8		8.7	.54	86	1.8	20	2.1	242	18	28	.4	.1		296	—	222	24	470	7.9	45
Jan. 13, 1964		8.2	.03	93	1.9	22	2.2	264	20	28	.6	.1		310	—	240	24	523	7.8	50
Apr. 21		10	.01	94	23	35	1.7	286	28	39	1.5	.0		—	353	244	10	569	7.6	30

Table 1. CHEMICAL ANALYSES OF WATER FROM WELLS AND CANALS IN BROWARD COUNTY, FLA.—Continued

B.—Surface Water

(Chemical analyses, in parts per million, except pH and color)

Date of collection	Mean discharge (cfs)	Silica (SiO ₂)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Fluoride (F)	Nitrate (NO ₃)	Phosphate (PO ₄)	Dissolved solids		Hardness (as CaCO ₃)		Specific conductance (micro-mhos at 25°C)	pH	Color	
														Residue at 180°C	Calculated	Calcium, magnesium	Non-carbonate				
2-2820. POMPANO CANAL ABOVE CONTROL AT POMPANO BEACH—Continued																					
May 20, 1964		11	—	92	2.1	20	1.4	276	13	24	0.9	0.0		338	—	238	12	520	7.9	40	
June 18		9.1	—	96	4.5	18	1.4	278	19	28	.3	.3		322	—	258	30	518	7.7	40	
Sept. 2		7.7	.04	83	3.2	26	2.5	242	18	40	.3	.8		—	301	220	22	500	7.4	50	
Oct. 28		7.4	.03	69	1.0	18	2.2	400	12	26	.4	.0		—	238	176	12	402	7.4	35	
Feb. 22, 1965		11	.02	86	1.3	31	2.2	276	6.4	33	1.9	.0		356	309	220	0	512	7.4	25	
Apr. 26		8.5	.01	74	2.8	26	1.9	220	10	37	1.2	.5		—	270	196	16	457	7.6	20	
May 21		8.6	.05	88	1.6	31	1.3	264	14	36	1.5	.4		—	312	226	10	633	7.9	20	
2-2820.1. POMPANO CANAL BELOW CONTROL, AT POMPANO BEACH																					
Dec. 12, 1961		3.3	0.02	253	755	5890	212	206	1350	10870	0.9	2.7			19800	3740	3570	27500	7.7	30	
Mar. 2, 1962		—	—	—	—	—	—	—	—	12450	—	—			—	—	—	—	—	—	
Aug. 23		5.4	.02	163	326	2710	88	229	650	4880	.7	1.7			8940	1740	1560	13200	7.4	45	
July 17, 1963		8.6	.06	86	7.7	60	2.7	276	22	83	.6	.2		448	407	246	20	702	7.5	65	
Oct. 28, 1964		7.3	.03	112	119	1020	40	222	260	1790	.6	3.0			3460	770	588	5780	7.5	45	
Feb. 22, 1965		3.0	.02	292	774	6570	242	201	1580	11500	1.0	2.8			21100	3910	3740	31100	7.2	25	
2-2821. CYPRESS CREEK CANAL ABOVE S-37A, NEAR POMPANO BEACH																					
Dec. 12, 1961		4.9	0.06	96	9.4	56	2.8	E298	30	90	0.5	0.3		—	437	278	34	766	8.4	55	
Mar. 2, 1962		2.3	.03	107	7.7	40	2.4	296	31	66	.5	.0		—	398	278	36	640	8.0	40	
Apr. 7		16	—	98	9.6	46	2.4	294	34	69	.3	.0		—	420	284	43	802	7.8	30	
Aug. 23		6.6	.05	94	5.0	35	2.8	268	24	52	.4	.0		—	352	255	36	605	7.8	75	
July 17, 1963		6.4	.04	87	7.5	53	2.3	269	22	84	—	.0		464	396	248	28	679	7.6	50	
Apr. 21, 1964		3.7	.03	96	8.4	48	2.9	294	27	76	.5	.0		416	—	274	33	712	7.6	65	
May 20		4.8	.05	137	187	1520	56	252	382	2740	.5	1.0		5620	—	1110	904	8420	7.7	60	
June 18		9.2	—	91	5.1	37	2.1	256	26	54	.4	.0		376	—	248	38	589	7.6	60	
Sept. 2		7.1	.05	80	4.7	39	3.6	232	21	58	.3	.0		—	328	219	29	560	7.2	70	
Oct. 28		7.3	.08	82	4.7	28	2.2	240	19	43	.2	.0		—	300	224	28	520	7.5	80	
Feb. 22, 1965		7.1	.03	98	7.2	50	2.5	302	26	78	.4	.1		—	418	274	26	718	7.8	50	
Apr. 26		5.9	.01	96	7.4	58	3.1	296	25	93	.6	.1		—	435	270	28	753	7.7	45	
May 21		5.8	.03	85	9.0	66	2.7	286	26	95	.5	.1		—	431	249	14	782	7.4	50	
2-2821.1E. CYPRESS CREEK CANAL BELOW S-37A, NEAR POMPANO BEACH																					
Dec. 12, 1961		3.3	0.04	315	934	7440	172	213	1390	13700	1.2	3.1		—	24400	4630	4450	33000	7.4	45	
Mar. 2, 1962		—	—	—	—	—	—	—	—	14200	—	—		—	—	—	—	35000	—	—	
Aug. 23		5.2	.04	167	318	12500	82	237	624	4540	.7	.9		—	18400	1730	1530	12700	7.5	60	
July 17, 1963		4.8	.05	232	523	4440	162	222	1140	7860	.8	8.2			16900	14500	2730	2550	21000	6.9	40
Apr. 21, 1964		.7	.02	320	893	7230	310	189	1780	13200	1.1	.1		26000	—	4470	4320	35800	7.2	45	
May 20		3.3	—	239	594	5050	183	210	1210	8950	.8	.9		17200	—	3040	2870	24500	7.5	40	
June 18		5.1	—	165	284	2370	86	233	596	4370	.7	.6		8700	—	1580	1390	12700	7.5	65	
Sept. 2		6.7	.05	100	71	595	29	229	149	1080	.3	1.3		—	2150	540	352	3300	7.2	70	
Oct. 28		6.9	.09	88	37	278	12	236	80	490	.2	2.0		—	1110	370	176	1980	7.5	80	
Feb. 22, 1965		3.0	.03	1740	17	7270	29	193	1780	13400	1.1	1.8		—	24300	4410	4250	34100	7.4	15	

E Includes 8 ppm of carbonate (CO₃).

Table 1. CHEMICAL ANALYSES OF WATER FROM WELLS AND CANALS IN BROWARD COUNTY, FLA.—Continued
B.—Surface Water
(Chemical analyses, in parts per million, except pH and color)

Date of collection	Mean discharge (cfs)	Silica (SiO ₂)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Fluoride (F)	Nitrate (NO ₃)	Phosphate (PO ₄)	Dissolved solids		Hardness (as CaCO ₃)		Specific conductance (microhm at 25°C)	pH	Color
														Residue at 180°C	Calculated	Calcium, magnesium	Non-carbonate			
2-2827. MIDDLE RIVER CANAL ABOVE S-36, NEAR FORT LAUDERDALE																				
Apr. 7, 1962		17	F 0.41	102	2.3	17	1.8	288	19	26	0.5	0.8		344	—	264	28	549	7.7	60
Aug. 23		11	.03	106	2.6	18	1.4	298	18	27	.3	.8		342	—	275	31	582	7.2	35
July 17, 1963		3.4	.04	85	2.9	25	1.7	244	17	35	.3	.7		336	291	224	24	509	7.5	50
Jan. 15, 1964		6.6	.04	120	2.3	22	1.3	324	32	36	.3	.0		—	381	309	44	632	7.9	40
Mar. 13		9.9	.03	126	4.3	20	.4	360	18	32	.3	.0		—	388	332	37	630	7.5	40
Apr. 21		4.4	.02	123	2.7	21	1.2	342	23	33	.3	.0		392	—	318	38	644	7.6	45
May 19		3.4	—	105	1.5	23	1.3	288	21	36	.2	.0		376	—	268	32	567	7.3	40
June 18		11	—	113	1.9	16	1.0	314	25	22	.3	.0		368	—	290	32	568	7.5	60
Sept. 1		9.1	.11	104	1.1	19	2.9	284	19	33	.2	1.0		—	329	264	32	568	7.3	50
Oct. 28		7.0	—	104	3.0	17	1.9	288	12	26	.4	.3		—	314	272	36	529	7.5	80
Feb. 22, 1965		4.3	.02	124	3.5	26	2.0	352	24	41	.3	.0		448	398	324	36	699	7.7	35
May 21		4.7	.01	80	4.0	25	1.7	276	21	44	.4	.1		—	317	216	0	651	7.2	50
2-2827.0E. MIDDLE RIVER CANAL BELOW S-36, NEAR FORT LAUDERDALE																				
Apr. 7, 1962		—	—	—	—	—	—	—	—	3150	—	—		—	—	—	—	10400	—	45
Aug. 23		8.6	0.04	106	2.6	19	1.4	302	16	30	0.3	0.1		372	—	275	28	599	7.7	55
July 17, 1963		4.9	.04	103	2.0	108	4.8	292	39	181	.4	.1		642	597	308	68	1060	7.5	45
Apr. 21, 1964		5.5	.03	152	147	1240	54	276	310	2260	.5	.1		4520	—	984	758	7150	7.4	50
May 19		5.2	—	121	35	262	9.6	300	80	465	.3	.0		1260	—	445	199	1920	7.3	45
June 18		8.3	—	96	11	20	1.2	308	23	32	.4	.4		386	—	286	34	582	7.6	60
Sept. 1		8.5	.05	102	2.3	19	2.4	283	22	34	.2	2.3		—	332	264	32	550	7.4	50
Oct. 28		7.9	.10	104	2.1	16	2.0	290	22	26	.2	.2		—	309	268	30	540	7.7	90
Feb. 22, 1965	9.8	5.4	.02	158	177	1480	56	264	372	2600	.6	1.8		5530	4980	1120	904	7820	7.5	40
2-2827.5E. MIDDLE RIVER CANAL NEAR FORT LAUDERDALE																				
July 17, 1963		5.7	0.04	124	97	838	31	272	214	1450	0.4	2.0		3260	2900	710	487	5110	7.4	50
Oct. 8		6.7	.09	91	2.7	12	2.1	248	24	20	.2	.1		296	—	238	35	477	7.5	80
2-2830.1E. PLANTATION ROAD CANAL BELOW S-33, NEAR FORT LAUDERDALE																				
Dec. 12, 1961		9.8	0.05	100	4.5	17	2.8	302	13	26	0.3	3.5		—	326	268	20	563	7.6	45
Mar. 1, 1962		—	—	—	—	—	—	—	—	32	—	—		—	—	—	—	700	—	—
Aug. 23		8.0	.04	94	3.8	23	2.0	276	17	32	.4	.0		—	316	250	24	538	7.1	60
Apr. 5, 1963		9.0	.03	91	1.2	24	2.4	268	10	30	.0	9.3		309	—	232	12	529	7.4	60
Oct. 8		7.8	.05	90	2.8	17	1.9	255	18	25	.3	.1		296	—	236	27	500	7.2	70
Apr. 21, 1964		8.8	.03	92	2.1	21	2.9	250	12	32	.2	11		—	305	238	33	540	7.1	45
May 19		6.8	—	95	3.6	18	2.0	250	20	28	.3	13		358	—	252	47	504	7.6	60

F Total Iron (Fe).

Table 1. CHEMICAL ANALYSES OF WATER FROM WELLS AND CANALS IN BROWARD COUNTY, FLA.—Continued
B.—Surface Water

(Chemical analyses, in parts per million, except pH and color)

Date of collection	Mean discharge (cfs)	Silica (SiO ₂)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Fluoride (F)	Nitrate (NO ₃)	Phosphate (PO ₄)	Dissolved solids		Hardness (as CaCO ₃)		Specific conductance (micro-mhos at 25°C)	pH	Color
														Residue at 180°C	Calculated	Calcium, magnesium	Non-carbonate			
2-2830.1E. PLANTATION ROAD CANAL BELOW S-33, NEAR FORT LAUDERDALE-Continued																				
June 18, 1964		7.6	—	99	0.2	16	1.7	264	19	32	0.4	5.2		346	—	248	32	510	7.7	80
Sept. 1		8.1	0.05	91	3.6	1.7	2.0	252	18	28	.2	5.3		—	387	242	36	500	7.3	60
Oct. 28		7.8	.06	99	1.2	13	1.6	266	20	20	.2	7.2		—	301	252	34	508	7.7	60
Feb. 22, 1965		8.6	.04	78	5.2	30	3.5	198	20	50	.4	29		—	323	216	54	552	7.1	50
2-2832. PLANTATION ROAD CANAL ABOVE S-33, NEAR FORT LAUDERDALE																				
Dec. 12, 1961		10	0.08	66	4.7	37	6.3	164	22	84	—	38		—	319	184	50	589	7.0	70
Mar. 1, 1962		11	.04	61	3.9	50	7.3	196	26	70	0.9	9.9		—	337	168	8	557	7.2	50
Aug. 25		7.9	.04	92	5.0	23	2.4	270	17	31	.4	3.6		—	315	250	28	542	7.8	60
Apr. 3, 1963		11	.07	59	10	52	6.2	228	26	60	.5	6.2		—	343	188	1	595	7.0	70
Apr. 5		12	.06	48	5.8	62	8.2	138	25	68	1.2	47		—	345	144	31	582	7.2	90
July 17		8.8	.06	75	8.0	40	2.5	238	16	60	.4	3.5		400	331	220	25	559	7.2	55
Oct. 8		8.1	.42	90	2.8	18	2.1	244	20	26	.3	6.6		320	—	236	36	496	7.5	60
Jan. 15, 1964		10	.12	96	3.0	20	2.6	268	22	30	.3	.0		—	316	252	32	529	7.0	50
Apr. 21		11	.05	62	3.8	40	7.1	152	29	64	.6	1.8		—	294	169	12	576	6.9	100
May 19		7.2	.37	96	.1	19	2.1	244	22	28	.4	14		356	—	240	40	504	7.7	60
June 18		6.7	—	97	1.0	16	1.8	258	20	24	.4	6.8		342	—	246	34	510	7.5	85
Sept. 1		8.7	.05	91	2.7	18	2.2	246	20	27	.3	9.4		—	300	238	36	510	7.3	55
Oct. 28		7.5	.05	98	2.3	13	1.5	272	20	20	.1	.9		—	296	254	31	507	7.4	60
Feb. 22, 1965		8.7	.04	80	3.5	31	3.6	194	20	50	.3	30		—	323	214	55	536	7.2	50
Apr. 26		12	.12	84	6.2	48	6.9	127	25	71	1.0	33		—	295	160	66	600	7.2	60
May 21		10	.02	50	8.5	62	8.0	72	33	87	1.6	62		—	357	160	101	620	7.0	50

Table 1. CHEMICAL ANALYSES OF WATER FROM WELLS AND CANALS IN BROWARD COUNTY, FLA.—Continued
B.—Surface Water
(Chemical analyses, in parts per million, except pH and color)

Date of collection	Mean discharge (cfs)	Silica (SiO ₂)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Fluoride (F)	Nitrate (NO ₃)	Phosphate (PO ₄)	Dissolved solids		Hardness (as CaCO ₃)		Specific conductance (micro-mhos at 25°C)	pH	Color
														Residue at 180°C	Calculated	Calcium, magnesium	Non-carbonate			
2-2846.9E. NORTH NEW RIVER CANAL ABOVE S-34, NEAR FORT LAUDERDALE																				
July 16, 1963		15	0.03	69	15	49	1.9	258	21	78	0.5	1.0		436	377	235	24	603	7.4	60
Apr. 22, 1964	6.6	.03	35	9.8	59	1.4	153	25	74	.4	.1			—	286	128	2	472	7.3	50
May 19	10	—	58	11	50	1.7	220	12	74	.3	.0			308	—	188	8	572	7.5	60
June 17	12	—	69	12	50	1.7	246	11	72	.6	1.4			390	—	220	18	603	7.8	65
Sept. 1	14	.05	72	12	50	2.0	264	4.8	74	.4	.3			—	—	228	12	640	7.3	70
Oct. 30	16	—	62	12	56	2.6	240	4.8	80	.5	.6			—	352	204	8	622	7.5	70
Mar. 9, 1965	12	.03	67	17	64	2.1	272	14	88	.5	.2			—	399	236	13	680	8.0	65
Apr. 26	12	.03	69	24	84	3.8	256	46	132	.8	.0			—	498	270	60	839	7.6	60
May 26	8.5	.00	48	17	60	2.7	182	53	82	.5	.2			—	362	212	41	650	7.6	30
2-2847. NORTH NEW RIVER CANAL BELOW S-34, NEAR FORT LAUDERDALE																				
Apr. 7, 1962		10	0.42	77	15	48	1.8	300	6.0	69	0.2	1.7		402	—	254	8	629	7.8	55
Aug. 23		10	.03	82	15	54	2.0	304	5.6	76	.4	1.6		456	—	266	17	684	7.9	65
July 16, 1963		13	.06	85	18	60	2.1	346	7.2	80	.5	2.8		460	439	288	4	762	7.6	80
Apr. 22, 1964	7.0	.04	48	12	51	1.5	200	7.6	76	.4	.1			312	—	170	6	551	7.4	50
May 19	13	.27	96	15	60	1.7	374	.0	82	.5	.9			—	453	302	0	772	7.6	70
June 17	14	.49	103	14	72	1.8	376	4.8	95	.5	2.9			—	493	314	6	839	7.8	80
Sept. 1	23	.05	93	18	68	2.1	356	7.8	94	.4	.3			—	—	305	14	800	7.2	80
Oct. 30	15	.06	88	19	61	2.0	348	.0	94	.3	1.5			—	452	296	11	783	7.5	75
Mar. 9, 1965	15	.05	102	19	78	2.1	404	5.6	110	.5	2.3			—	534	332	1	900	7.7	90
Apr. 26	13	.04	76	18	80	3.8	266	41	125	.7	.4			—	489	262	44	833	7.6	60
May 26	8.9	.01	62	18	58	2.8	212	53	84	.5	2.0			—	393	228	54	710	7.4	40

Table 1. CHEMICAL ANALYSES OF WATER FROM WELLS AND CANALS IN BROWARD COUNTY, FLA.—Continued
B.—Surface Water

(Chemical analyses, in parts per million, except pH and color)

Date of collection	Mean discharge (cfs)	Silica (SiO ₂)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Fluoride (F)	Nitrate (NO ₃)	Phosphate (PO ₄)	Dissolved solids		Hardness (as CaCO ₃)		Specific conductance (microhm-cm at 25°C)	pH	Color
														Residue at 180°C	Calculated	Calcium, magnesium	Non-carbonate			
2-2848. NORTH NEW RIVER CANAL AT HOLLOWAY LATERAL, NEAR FORT LAUDERDALE																				
Feb. 21, 1961		5.9	0.94	64	6.9	47	2.7	224	9.6	67	—	0.3	—	313	188	4	569	7.7	60	
Apr. 13		4.2	.03	56	8.6	49	2.0	180	6.4	69	—	1.1	—	287	180	32	563	7.7	78	
May 11		11	.45	96	6.9	40	1.4	298	23	64	—	.0	—	390	268	0	581	7.6	60	
June 6		6.4	.02	80	4.0	26	.8	256	11	43	—	.0	—	297	216	6	523	7.5	50	
July 7		9.8	.05	83	11	46	1.2	296	13	62	—	1.1	—	374	252	8	643	8.0	80	
Aug. 9		6.7	.04	59	10	48	1.7	240	4.4	67	—	.2	—	315	188	0	563	7.7	65	
Sept. 11		4.0	.06	64	5.5	20	.6	H196	12	32	—	.3	—	229	182	22	410	7.9	70	
Oct. 12		8.8	.04	100	5.0	22	.8	246	7.2	68	—	1.0	—	334	270	30	580	7.7	80	
Nov. 13		7.7	.04	70	9.6	52	2.8	258	7.6	75	—	1.1	—	353	214	2	627	7.6	55	
Dec. 3		4.1	.03	70	9.1	41	3.1	242	12	65	—	.4	—	324	212	14	583	8.0	60	
Jan. 8, 1962		8.1	.05	67	15	54	2.2	256	22	82	—	1.2	—	378	228	18	660	8.1	55	
Feb. 6		7.3	.05	74	14	58	2.3	272	12	75	—	.6	—	354	242	19	618	8.1	60	
Mar. 6		4.6	.01	62	20	60	2.1	240	18	74	—	.2	—	289	237	40	634	7.9	50	
Apr. 5		5.2	.02	75	9.6	61	2.5	256	18	94	—	1.6	—	396	234	24	720	8.1	60	
May 3		4.7	.02	78	11	56	1.7	280	10	75	—	.0	—	374	240	10	678	7.8	55	
June 11		7.5	.04	71	12	59	2.4	262	18	76	—	.5	—	375	226	12	696	7.5	75	
Aug. 6	D 0.3	6.7	.03	48	9.7	43	1.4	176	14	60	—	.1	—	270	160	16	495	7.6	50	
Oct. 10		4.6	.03	106	3.8	19	.7	294	23	28	0.2	1.4	—	346	332	280	39	538	7.8	65
Nov. 8		8.6	.04	75	11	46	1.9	264	12	68	—	.1	—	—	353	232	16	612	7.8	70
Dec. 6		7.6	.06	78	12	49	1.9	274	12	68	.5	.9	—	412	365	242	18	580	8.1	50
Jan. 10, 1963		7.2	.03	78	13	51	2.1	282	10	72	—	4.3	—	—	373	248	17	520	7.8	70
July 30	G 1.6	7.9	.06	85	12	53	1.4	303	8.2	76	.0	1.0	—	—	394	260	12	673	7.6	60
Oct. 15		8.0	.05	78	8.6	38	1.9	248	19	52	—	1.4	—	—	329	230	0	578	7.6	90
Dec. 10		8.8	.04	80	9.8	44	1.7	266	11	65	—	2.6	—	—	354	240	22	610	7.9	80
Jan. 13, 1964		7.9	.05	88	6.9	33	1.5	268	14	50	.4	1.5	—	—	335	248	28	580	7.6	70
Apr. 22		6.1	.02	65	10	32	1.3	246	5.6	72	—	.2	—	—	—	205	4	581	7.9	50
May 19		11	.05	82	9.6	40	1.8	284	17	66	—	2.6	—	—	369	244	12	619	7.9	60
July 17		9.6	.32	84	11	20	1.6	298	8.0	64	—	.3	—	—	346	254	10	639	7.2	60
2-2850. NORTH NEW RIVER CANAL NEAR FORT LAUDERDALE																				
Oct. 8, 1963	D 744	7.5	0.02	82	6.7	33	1.8	250	19	47	0.4	1.1	—	360	—	232	27	558	7.8	70
Jan. 13, 1964	D 323	9.5	.05	83	6.8	38	1.5	267	8.4	60	.4	.8	—	—	340	235	16	580	7.5	60
Oct. 30	—	8.8	.06	82	7.7	29	1.5	260	16	46	.4	1.8	—	—	321	236	23	552	7.5	80
Feb. 22, 1965	—	7.8	.04	80	9.4	45	1.4	280	8	75	.4	1.5	—	—	362	238	8	638	7.7	65
Apr. 26	—	11	.03	74	22	82	3.8	268	42	130	.8	.0	—	—	498	276	56	878	7.8	70
May 26	—	5.2	.05	50	18	78	4.1	214	40	110	.5	5.0	—	—	416	199	24	1050	7.9	50
2-2851.0E. NORTH NEW RIVER CANAL AT STATE HIGHWAY 7, NEAR FORT LAUDERDALE																				
July 17, 1963		8.2	0.04	80	11	52	2.0	288	10	68	0.4	1.0	—	398	375	246	10	550	7.8	70
Apr. 21, 1964		4.5	.04	101	107	888	32	262	202	1580	.5	9.0	—	3230	2930	690	476	4800	7.3	50
May 19		7.1	.02	86	9.6	44	1.4	270	13	64	.4	.2	—	—	359	254	32	606	7.5	60
June 18		7.1	—	89	6.3	44	1.3	284	10	64	.5	.0	—	394	362	248	16	633	7.7	70
Sept. 1		8.3	.05	82	8.6	39	1.7	269	11	56	.3	1.3	—	—	341	240	20	582	7.4	80

D Discharge at time of sampling.

Table 1. CHEMICAL ANALYSES OF WATER FROM WELLS AND CANALS IN BROWARD COUNTY, FLA.—Continued
B.—Surface Water
(Chemical analyses, in parts per million, except pH and color)

Date of collection	Mean discharge (cfs)	Silica (SiO ₂)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Fluoride (F)	Nitrate (NO ₃)	Phosphate (PO ₄)	Dissolved solids		Hardness (as CaCO ₃)		Specific conductance (micro-mhos at 25°C)	pH	Color
														Residue at 180°C	Calculated	Calcium, magnesium	Non-carbonate			
2-2851.0E. NORTH NEW RIVER CANAL AT STATE HIGHWAY 7, NEAR FORT LAUDERDALE—Continued																				
Oct. 30, 1964		7.2	0.07	86	7.2	29	1.5	264	18	42	.3	1.2		—	322	244	28	553	7.5	80
Feb. 22, 1965		8.4	.03	82	9.6	58	1.9	274	8.0	92	.4	1.3		—	397	244	20	683	7.7	60
Apr. 26		5.6	.02	132	197	1580	60	264	392	2820	.6	3.0		—	5320	1140	924	8740	7.6	70
May 12		3.9	.00	177	314	2640	9.4	199	661	4630	1.4	4.3		—	8540	1730	1570	14100	7.4	50
2-2851.1E. CHULA VISTA DRAINAGE CANAL 1, NEAR FORT LAUDERDALE																				
Oct. 14, 1963		8.2	0.05	86	12	80	6.0	256	34	132	0.4	0.1		548		262	52	860	7.6	70
2-2853.99. SOUTH NEW RIVER CANAL ABOVE S-9, NEAR DAVIE																				
Dec. 13, 1961	—	7.0	0.03	87	8.5	30	1.0	314	6.0	42	0.4	0.9		—	338	252	0	598	7.8	55
Mar. 1, 1962	—	8.6	.30	100	2.5	30	.9	314	12	38	.3	.1		—	347	260	3	770	8.0	50
Aug. 23	—	7.0	.04	84	9.8	41	1.3	280	17	54	.4	.0		—	353	250	20	608	7.6	65
July 16, 1963	—	16	.03	93	29	82	4.2	356	69	118	.7	.0		680	580	352	60	979	8.0	110
Oct. 9	D 97	9.2	.05	94	13	40	1.9	310	24	56	.5	.2		416	—	286	32	640	8.0	50
June 17, 1964	D 105	8.4	.30	98	9.1	44	1.4	324	16	68	.5	1.4		484	—	282	16	700	7.7	80
Sept. 1	D 459	9.3	.07	86	10	33	2.1	280	14	48	.3	.7		—	—	256	26	570	7.5	80
Oct. 30	—	9.0	.05	91	5.1	31	1.7	272	18	44	.3	.1		—	341	248	25	595	7.5	75
Mar. 9, 1965	—	21	.04	52	6.4	70	2.3	216	28	102	.6	.2		—	389	192	0	670	7.5	85
Apr. 26	—	11	.02	68	18	75	2.8	252	35	117	.7	.0		—	452	242	36	783	7.5	60
May 26	—	8.5	.00	72	18	64	2.2	246	40	97	.5	.2		—	423	252	50	759	7.0	50
2-2854. SOUTH NEW RIVER CANAL BELOW S-9, NEAR DAVIE																				
Dec. 13, 1961		9.2	0.07	78	14	42	1.7	312	7.2	57	0.3	1.3		365	252	0	657	8.0	90	
Mar. 1, 1962		8.7	.36	98	2.8	47	1.9	316	1.3	56	.4	1.5		—	374	256	0	670	7.9	70
Aug. 23		8.3	.03	90	12	44	1.7	314	19	60	.5	.7		—	391	274	16	673	8.1	80
July 16, 1963		7.9	.05	90	14	53	1.6	334	14	67	.4	.8		426	414	282	8	713	7.5	100
Oct. 9		9.3	.04	91	13	47	2.0	308	22	68	.4	.7		456	—	282	30	684	7.9	60
Apr. 22, 1964		11	.06	98	12	79	2.2	307	35	108	.6	.2		536	—	292	40	809	8.4	90
May 19		11	.02	99	14	60	1.7	346	22	89	.5	.0		—	467	302	20	788	7.7	65
June 17		8.9	.16	102	7.2	44	1.4	324	15	64	.5	.9		474	—	284	18	697	7.9	80
Sept. 1		9.6	.07	90	6.2	32	2.0	280	14	46	.3	.4		—	380	250	20	583	7.4	80
Oct. 30		10	.08	88	16	47	1.8	318	12	64	.2	1.1		—	401	284	24	696	7.8	80
Mar. 9, 1965		11	.05	89	15	59	1.7	346	7.2	80	.5	1.1		—	435	284	0	750	7.7	80
Apr. 26		13	.04	94	17	60	2.0	338	10	97	.6	.9		—	461	306	29	789	7.6	90
May 26		12	.02	93	15	60	1.5	332	9.2	91	.5	.4		—	447	292	20	820	7.8	65

D Discharge at time of sampling.

Table 1. CHEMICAL ANALYSES OF WATER FROM WELLS AND CANALS IN BROWARD COUNTY, FLA.—Continued

II.—Surface Water

(Chemical analyses, in parts per million, except pH and color)

Date of collection	Mean discharge (cfs)	Silica (SiO ₂)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Fluoride (F)	Nitrate (NO ₃)	Phosphate (PO ₄)	Dissolved solids		Hardness (as CaCO ₃)		Specific conductance (microhm/cm at 25°C)	pH	Color
														Residue at 180°C	Calculated	Calcium, magnesium	Non-carbonate			
2-2860.5 SOUTH NEW RIVER CANAL AT S-13A, NEAR DAVIE																				
Dec. 15, 1959	274	10	0.02	93	6.8	32	0.6	288	11	50	—	0.1	—	346	260	24	612	8.0	55	
Feb. 5, 1960	301	5.7	.02	94	6.2	42	.7	298	8.0	62	—	.6	—	366	260	16	654	8.1	70	
Mar. 21	326	8.2	.01	91	3.2	45	.9	272	6.3	65	—	.5	—	354	240	17	633	8.2	75	
Apr. 13	265	11	.01	78	14	48	1.4	B 302	6.0	70	—	.0	—	377	252	4	670	8.5	80	
June 6	482	6.8	.05	62	6.2	20	5.1	196	18	35	—	.4	—	251	180	20	449	8.1	120	
June 27	340	9.5	.03	89	4.9	30	.6	272	12	45	—	.9	—	326	242	19	579	8.1	80	
July 21	282	8.4	.02	86	6.7	44	1.0	294	7.6	64	—	.4	—	363	242	1	652	7.8	60	
Aug. 22	1 290	10	.03	83	9.0	46	1.0	J 292	9.6	60	—	.0	—	363	244	4	627	8.4	70	
Oct. 14	—	8.4	.04	86	5.2	14	2.1	260	22	20	—	.5	—	286	236	23	496	8.0	80	
Dec. 30	—	8.4	.03	86	10	48	1.0	302	8.4	67	—	.2	—	378	256	8	684	8.0	75	
Jan. 31, 1961	—	10	.02	86	10	44	1.4	306	8.0	64	—	.1	—	375	256	4	669	7.6	80	
Feb. 21	—	7.7	.04	85	10	49	.9	306	6.0	69	—	.6	—	379	253	2	687	8.0	65	
Mar. 17	—	9.1	.03	86	8.1	49	2.5	304	4.8	68	—	.0	—	378	248	0	688	7.7	60	
Apr. 13	—	14	.05	88	8.4	45	2.2	308	9.6	64	—	1.3	—	385	254	2	668	7.9	70	
May 11	—	8.3	.45	83	10	50	1.4	300	7.2	72	0.5	.0	—	381	—	2	682	7.7	70	
June 6	—	8.4	.04	82	9.6	41	1.1	276	18	58	—	.6	—	—	244	18	633	7.9	65	
July 7	—	6.6	.03	65	6.3	50	1.8	236	6.4	72	—	.5	—	325	188	0	574	7.8	55	
Aug. 9	—	7.7	.03	85	14	45	1.1	316	5.6	68	—	.8	—	386	270	10	660	8.2	80	
Sept. 11	—	6.6	.07	85	5.8	47	1.4	304	8.8	64	—	.8	—	371	236	0	639	8.0	70	
Oct. 12	—	6.8	.02	84	12	45	.8	306	22	38	—	1.2	—	361	259	8	665	7.9	80	
Nov. 13	—	8.2	.04	85	10	43	1.2	306	6.0	62	—	1.0	—	367	253	2	651	7.7	65	
Dec. 6	—	7.1	.03	82	11	37	2.2	284	12	56	—	.7	—	348	250	17	616	7.9	55	
Dec. 14	—	7.8	.27	88	8.9	31	1.0	292	12	48	.2	.5	—	342	256	16	660	7.6	75	
Jan. 8, 1962	—	4.8	.04	76	10	46	1.5	280	7.2	67	—	1.0	—	352	230	1	625	8.0	55	
Feb. 6	—	4.3	.03	75	15	54	1.8	284	11	61	—	.2	—	362	248	16	634	8.0	60	
Mar. 1	—	6.0	.05	99	.7	32	1.5	276	10	51	.4	.9	—	338	250	24	540	7.9	70	
Mar. 6	—	3.6	.01	64	15	55	2.1	E 254	9.6	61	—	.1	—	335	221	12	583	8.4	60	
Apr. 5	—	4.7	.02	70	12	50	1.8	270	8.8	66	—	.2	—	347	224	2	621	7.9	60	
May 2	—	7.1	.02	80	7.4	56	1.8	276	11	72	—	.0	—	371	230	4	658	8.2	50	
June 11	—	11	.03	80	9.8	50	1.8	292	8.0	66	—	.1	—	371	240	0	669	7.7	60	
July 10	—	7.8	.03	92	12	38	1.1	296	16	64	—	.0	—	377	279	36	635	7.6	60	
Aug. 6	—	8.3	.04	88	12	36	1.0	304	13	56	—	.0	—	364	269	20	643	7.7	60	
Aug. 23	—	8.0	.03	90	9.8	30	1.1	288	17	42	.4	.8	—	341	265	29	585	7.8	80	
Sept. 12	—	7.9	.01	93	8.3	29	.8	300	14	44	—	.1	—	345	266	20	590	7.8	50	
Oct. 10	—	9.1	.05	94	6.2	54	1.5	312	24	62	—	.7	—	406	260	4	679	7.9	80	
Nov. 8	—	9.2	.37	94	12	47	2.1	320	20	68	—	2.0	—	413	284	22	700	7.7	85	
Dec. 6	—	7.4	.05	93	13	45	1.2	320	19	63	—	.8	—	400	286	24	690	8.2	80	
Jan. 10, 1963	—	35	.06	96	12	45	1.8	320	17	66	—	5.5	—	436	288	26	635	8.0	100	
Mar. 9	—	7.3	.04	88	14	43	1.4	318	12	58	—	.9	—	382	276	16	580	7.9	80	
July 30	—	7.5	F 2.1	89	14	48	1.0	324	12	70	—	1.1	—	403	280	15	689	7.5	80	

B Includes 12 ppm of carbonate (CO₃).

F Total iron (Fe).

I Discharge computed from head-discharge relation and pump rating.

J Includes 6 ppm of carbonate (CO₃).

Table 1. CHEMICAL ANALYSES OF WATER FROM WELLS AND CANALS IN BROWARD COUNTY, FLA.—Continued
B.—Surface Water

(Chemical analyses, in parts per million, except pH and color)

Date of collection	Mean discharge (cfs)	Silica (SiO ₂)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Fluoride (F)	Nitrate (NO ₃)	Phosphate (PO ₄)	Dissolved solids		Hardness (as CaCO ₃)		Specific conductance (micro-mhos at 25°C)	pH	Color
														Residue at 180°C	Calculated	Calcium, magnesium	Non-carbonate			
2-2860.S. SOUTH NEW RIVER CANAL AT S-13A, NEAR DAVIE-Continued																				
Oct. 15, 1963		24	0.06	98	8.6	21	2.4	292	28	32	—	2.6		361	280	40	584	7.7	80	
Oct. 15 L		13	.09	98	5.7	21	1.7	292	19	32	—	.1		386	268	28	560	7.3	85	
Dec. 10		8.3	.11	98	10	46	1.3	328	14	66	—	1.1		407	286	17	680	8.1	80	
Jan. 13, 1964 (1310) K		7.8	.05	97	6.3	33	1.4	301	12	52	0.4	.0		358	268	22	592	7.2	70	
Jan. 13 (1320)		7.6	.04	94	11	37	1.3	312	21	56	.4	.0		382	280	24	631	7.6	50	
Apr. 22		8.9	.02	93	16	56	1.4	342	15	77	—	1.1		—	296	16	738	8.2	80	
May 19		9.7	.10	102	3.8	26	1.2	296	20	36	.5	.0		345	270	28	579	7.3	60	
June 17		8.6	—	98	8.6	24	1.8	298	30	34	—	2.2		354	280	36	583	8.0	90	
2-2861. SOUTH NEW RIVER CANAL ABOVE S-13, NEAR DAVIE																				
Dec. 14, 1961	—	7.0	0.06	104	63	530	20	288	128	942	0.3	1.3		—	1938	518	282	3420	7.8	70
Mar. 1, 1962	—	—	—	—	—	—	—	—	—	7800	—	—		—	—	—	—	—	—	—
Aug. 23	—	8.1	.05	92	8.6	30	1.0	288	16	42	.4	.1		—	340	265	29	587	7.6	45
July 17, 1963	251	8.6	.04	85	19	21	1.0	296	16	54	.4	.0		426	352	291	48	606	7.6	60
Oct. 8	D 67	12	.05	94	5.2	23	1.8	272	21	34	.4	1.9		360	—	256	33	548	7.8	70
Apr. 21, 1964	D 17	5.9	.05	92	3.5	37	1.3	275	13	52	.4	.8		384	—	244	18	613	7.6	80
May 19	D 288	7.7	.08	101	3.9	23	1.2	292	22	34	.4	.0		—	337	268	28	561	7.6	60
June 17	D 151	7.7	—	101	4.4	23	1.2	288	21	35	.4	.8		402	—	270	34	559	7.9	90
Sept. 1	D 176	9.2	.08	91	6.1	21	2.6	268	20	36	.3	.0		—	318	252	32	550	7.0	100
Oct. 30	319	6.9	.10	86	6.2	18	2.0	244	21	31	.3	2.6		—	294	240	40	490	7.5	110
Feb. 22, 1965	12	7.1	.04	98	2.8	25	1.0	296	14	42	.3	1.1		—	337	256	14	571	7.7	90
Apr. 26	—	8.9	.04	95	8.5	54	2.3	290	23	90	.6	.0		—	425	272	34	725	7.5	80
May 21	—	7.5	.48	87	11	43	1.3	276	23	70	.5	.1		—	380	262	36	682	7.5	60
2-2861.1E. SOUTH NEW RIVER CANAL BELOW S-13, NEAR DAVIE																				
Dec. 14, 1961		7.0	0.06	104	63	530	20	288	128	942	0.3	1.3		2230	1940	518	282	3420	7.8	70
Aug. 23, 1962		8.1	.05	92	8.6	30	1.0	288	16	42	.4	.1		—	340	265	29	587	7.6	45
Oct. 10		9.1	.05	94	6.2	54	1.5	312	24	62	—	.7		—	406	260	4	679	7.9	80
Apr. 21, 1964		3.9	.04	119	88	734	29	296	182	1300	.5	.3		2890	—	658	416	4500	7.4	70
May 19		8.3	.03	95	8.0	24	1.2	288	22	36	.4	.7		—	338	270	34	568	7.8	60
June 17		7.8	—	103	2.7	21	1.2	288	22	34	.4	1.7		380	—	268	32	568	7.7	95
Sept. 1		8.0	.13	93	5.8	20	2.4	264	20	34	.3	1.0		—	—	256	40	522	7.3	120
Oct. 30	319	7.6	.03	86	4.3	16	1.9	244	21	29	.3	3.1		—	289	232	32	493	7.5	110
Feb. 22, 1965		8.9	.04	99	4.1	24	1.0	288	15	42	.4	2.2		339	264	28	570	7.0	95	

D Discharge at time of sampling.

Table 1. CHEMICAL ANALYSES OF WATER FROM WELLS AND CANALS IN BROWARD COUNTY, FLA.—Continued

B.—Surface Water

(Chemical analyses, in parts per million, except pH and color)

Date of collection	Mean discharge (cfs)	Silica (SiO ₂)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Fluoride (F)	Nitrate (NO ₃)	Phosphate (PO ₄)	Dissolved solids		Hardness (as CaCO ₃)		Specific conductance (micro-mhos at 25°C)	pH	Color
														Residue at 180°C	Calculated	Calcium, magnesium	Non-carbonate			
2-2861.S. HOLLYWOOD CANAL AT DANIA																				
July 15, 1963		7.3	0.04	164	260	2340	98	259	578	3890	0.6	9.0		8210	7470	1480	1270	12000	7.3	55
Oct. 8		6.1	.06	116	58	470	21	284	132	840	.3	.8		1980	—	530	298	3180	7.7	60
Jan. 13, 1964		7.4	.05	180	299	2470	100	270	612	4480	.6	21		—	8320	1680	1460	14000	7.1	30
Apr. 21		2.4	.00	315	886	7380	295	592	1780	13000	1.2	.1		26000	—	4430	3940	38900	7.2	20
May 27		5.8	—	168	248	2050	78	259	515	3730	.5	.9		7680	—	1440	1230	11200	7.5	60
June 18		7.2	.02	136	48	556	16	232	148	938	.3	.7		2220	—	537	293	3340	7.6	40
Sept. 1		6.2	.04	171	281	2340	86	267	554	4280	.5	1.1		—	7850	1580	1360	13000	7.2	50
Oct. 30		7.0	.03	128	100	781	30	284	212	1400	.2	2.4		—	2800	730	498	4750	7.4	35
Feb. 22, 1965		3.0	.01	316	803	6710	247	213	1620	11900	1.0	2.7		—	21700	4090	3920	31900	7.0	20
Apr. 26		1.0	.00	1900	593	8520	372	178	2220	16600	1.3	17		—	30300	7180	7030	43200	7.4	10
May 21		.8	.00	391	1090	8300	315	180	137	16500	.7	17		—	26800	5460	5310	46000	7.2	10
2-2861.S. SNAKE CREEK CANAL ABOVE S-30, NEAR HIALEAH																				
Dec. 14, 1961		7.6	0.06	78	13	41	2.0	304	6.4	58	—	1.1		—	357	248	0	637	8.1	65
Mar. 1, 1962		9.4	.04	99	5.1	43	1.8	326	4.6	64	0.4	.0		—	388	268	1	670	7.8	50
Aug. 23		8.0	.03	90	16	37	1.9	314	20	51	.4	1.4		—	381	290	33	642	7.8	70
July 16, 1963		7.2	.03	92	3.0	38	1.1	329	8.8	54	.4	.0		430	377	281	12	643	7.7	50
Oct. 9		7.0	.04	62	8.1	23	1.4	205	6.6	32	.7	.1		244	—	188	20	418	7.8	60
Jan. 13, 1964		3.4	.04	79	8.5	34	1.4	268	5.6	48	.3	.1		340	—	232	18	560	7.8	60
Apr. 20		6.5	.03	95	5.6	44	1.3	324	6.7	63	.5	.3		420	—	260	0	670	7.6	60
May 19		4.9	—	86	6.7	34	1.2	288	6.4	46	.4	.2		358	—	242	6	574	7.9	60
June 17		4.0	—	78	3.8	30	1.2	244	.8	40	.4	.6		308	—	210	10	583	7.9	70
Sept. 1		5.0	.05	71	6.3	41	1.0	242	.0	60	.3	.4		—	—	203	4	560	7.4	70
Oct. 31		3.4	.04	64	7.9	36	1.0	232	.0	54	.2	.6		—	291	192	2	510	7.8	45
Mar. 9, 1965		5.1	.03	75	11	48	1.0	280	.4	70	.4	.1		—	349	232	2	628	7.8	50
Apr. 26		7.1	.02	85	17	56	1.2	300	.2	90	.5	.4		—	405	280	34	712	7.9	50
May 26		5.9	.00	81	14	63	.9	314	5.6	88	.5	.8		—	415	258	—	719	7.9	50
2-2861.S.E. SNAKE CREEK CANAL BELOW S-30, NEAR HIALEAH																				
June 3, 1963		4.8	0.03	84	8.6	35	0.8	286	10	48	0.5	0.0		344	333	245	10	565	7.8	55
July 15		5.8	.04	88	7.9	33	1.2	284	16	46	.4	.1		386	338	252	20	565	7.4	70
July 16		7.1	.04	86	12	36	1.1	310	8.2	52	.4	1.5		424	357	262	8	606	7.4	45
Sept. 15		7.6	.02	88	8.4	31	1.8	288	14	43	.4	1.3		374	338	254	18	577	7.6	70
Oct. 9		7.1	.05	70	6.7	25	1.4	232	4.8	34	.4	.5		280	—	202	12	462	7.8	70
Jan. 13, 1964		3.9	.05	79	9.5	33	1.2	264	9.2	48	.3	1.1		332	—	236	20	565	7.5	60
Apr. 20		6.4	.03	92	4.5	42	1.7	266	6.8	60	.5	.2		412	—	249	31	653	8.3	80
May 19		4.9	—	82	9.6	38	1.2	310	6.0	47	.4	.1		382	—	244	0	556	7.8	60
June 17		5.0	.05	77	8.3	32	1.7	258	.8	42	.4	1.4		386	—	226	14	551	7.3	70
Sept. 1		5.7	.05	74	6.7	38	1.0	248	.0	56	.3	.6		—	304	212	9	542	7.5	70
Oct. 30		4.1	.02	66	8.6	35	1.0	236	.0	52	.2	.0		—	283	200	6	510	7.8	45
Mar. 9, 1965		3.7	.03	78	11	48	1.0	280	.0	70	.3	1.5		—	352	240	10	628	7.5	45
Apr. 26		5.9	.06	87	11	54	1.2	299	.8	87	.5	.2		—	395	264	19	699	7.7	60
May 26		5.8	.00	94	6.2	53	.9	296	6.0	88	.5	.2		—	401	260	18	710	7.7	60

Table 1. CHEMICAL ANALYSES OF WATER FROM WELLS AND CANALS IN BROWARD COUNTY, FLA.—Continued
 B.—Surface Water
 (Chemical analyses, in parts per million, except pH and color)

Date of collection	Mean discharge (cfs)	Silica (SiO ₂)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Fluoride (F)	Nitrate (NO ₃)	Phosphate (PO ₄)	Dissolved solids		Hardness (as CaCO ₃)		Specific conductance (micro-mhos at 25°C)	pH	Color	
														Residue at 180°C	Calculated	Calcium, magnesium	Non-carbonate				
2-2862. SNAKE CREEK CANAL AT N. W. 67th AVENUE, NEAR HIALEAH																					
July 16, 1963		6.2	0.03	84	10	33	0.9	291	11	47	0.3	0.1		382	336	251	12	571	7.8	45	
Oct. 9		7.6	.12	90	7.7	31	1.1	288	19	42	.4	.5		390	—	256	20	580	7.5	70	
Jan. 13, 1964		7.7	.13	91	8.0	31	.9	288	18	44	.4	.1		—	345	260	24	579	7.5	50	
Apr. 20		6.1	.04	85	4.9	38	.9	288	7.3	50	.4	.5		360	—	232	0	606	7.6	50	
June 17		6.7	.04	93	7.3	26	.9	292	20	38	.3	1.0		340	—	262	22	562	7.7	70	
Sept. 1		6.6	.05	90	7.7	27	1.0	286	19	39	.4	1.3		—	333	256	22	570	7.6	55	
Oct. 30		6.6	.03	83	12	27	.8	280	19	38	.3	1.2		—	326	256	26	566	7.8	55	
Mar. 9, 1965		5.6	.04	90	7.2	33	.8	288	14	50	.4	.5		—	344	254	18	582	7.6	55	
Apr. 26		6.0	.02	68	17	38	.9	283	64	57	.6	.0		—	333	240	8	588	7.7	50	
May 26		7.9	.03	80	15	45	2.3	292	2.0	76	.5	.3		—	373	260	20	673	7.9	50	

The ability of water to conduct an electric current is directly related to the amount and kind of minerals dissolved in the water. In general, the more minerals dissolved in water, the greater will be the electric conductance. The conductance will also vary slightly depending on the type of minerals present.

Measurement of acidity or alkalinity is recorded as pH. The pH scale is based on the concentration of hydrogen ion in solution and a pH of 7 is considered neutral. Water having pH values below 7 are acidic, and water having pH values above 7 are alkaline. Ground and surface waters in Broward County are slightly alkaline because of the predominance of carbonate and bicarbonate salts in soluble limestones in the shallow subsurface materials.

Hardness in water results when alkaline earth minerals, principally calcium and magnesium, are present in solution and it is commonly expressed as an equivalent amount of calcium carbonate. The U. S. Geological Survey classifies hardness as follows:

0	-	60 ppm	soft
61	-	120 ppm	moderately hard
121	-	180 ppm	hard
over		180 ppm	very hard

In Broward County the water-bearing materials are composed principally of limestone which dissolves in slightly acidic water and produces hard water. Hardness in water is objectionable because it consumes soap in laundry operations and forms incrustation in pipes and boilers. Hardness can be beneficial in water used for irrigation because it helps maintain soil structure and permeability.

Nitrogen is found in water primarily in the form of nitrate; in unpolluted water, nitrate usually does not exceed 10 ppm. Sources of nitrate include decomposition of organic materials and drainage water from soils that are heavily fertilized with nitrate-bearing fertilizer. Leached barnyard refuse can pollute streams and shallow ground water. Where both chloride and nitrate concentrations are above normal for an area the possibility of contamination by human or animal wastes should be investigated.

Color in water may be derived from animal, vegetable, or mineral sources, and is measured by comparing a water sample with standard solutions of platinum and cobalt and reported as units on the platinum-cobalt scale (Hazen, 1892). The maximum color of water used for public supply suggested by the U. S. Public Health Service (1962) is 15 Hazen

units. The objection to color in water for domestic use is primarily aesthetic, although colored water may stain fixtures or laundry. Color in ground waters in Broward County occasionally is high enough to be objectionable and color in surface waters generally is both high and variable.

It is well known today that fluoride can be beneficial to the teeth; however, too much fluoride can cause dental defects such as mottled tooth enamel. People tend to drink more water when the annual temperature is high and, therefore, will take more fluoride into the body. In Broward County, the average annual temperature falls in the established 70.7 and 79.9 degree range, where to be beneficial, the fluoride content of drinking water should range between 0.7 ppm and 1.0 ppm. The average concentration of fluoride should not exceed the maximum of 1.0 ppm.

Water for public use in Broward County should conform to the Florida State Water Standards which are based on the U.S. Public Health Service Drinking Water Standards (1962). According to the standards, the following constituents should not exceed the concentrations shown:

<i>Substance</i>	<i>Concentration (ppm)</i>
Alkyl benzene sulfonate (ABS)	0.5
Arsenic (As)	0.01
Chloride (Cl)	250
Iron (Fe)	0.3
Nitrate (NO ₃)	45.0
Sulfate (SO ₄)	250
Total dissolved solids	500
Fluoride (F)	1.0
Carbon chloroform extract (CCE)	0.2
Phenols	0.001
Zinc (Zn)	5.0
Copper (Cu)	1.0
Manganese (Mn)	0.05

The practical limits of some chemical constituents are based mainly on aesthetic considerations. Within the range of maximum standard concentrations some chemical constituents of water tend to produce a noticeable taste. Most people can detect a salty taste in water when the chloride reaches 200-300 ppm. Water containing a sulfate concentration

of about 250 ppm may have a laxative effect on some people. Iron concentrations of about 0.3 ppm in water will often impart a taste and may discolor laundry or stain porcelain fixtures.

WATER IN THE BISCAYNE AQUIFER

The Biscayne aquifer is the principal source of fresh water for public supply in southeastern Florida. This aquifer is composed chiefly of porous permeable limestone with some sandstone and sand. In Broward County, the aquifer is thickest along the coast where it extends from the land surface to a depth about 150 feet in the south and nearly 400 feet (Tarver, 1964) in the north; it thins to a feather edge near the western boundary of Broward County. The Biscayne aquifer is underlain by clay and marl of low permeability which extend to a depth of about 900 feet.

CHANGES WITH DEPTH AND LOCATION

The chemical quality of water in the Biscayne aquifer differs areally and with depth. Chemical differences with depth in existing wells are difficult, if not impossible, to detect because wells are generally cased to one producing zone. However, multiple-depth information collected during this investigation indicates differences in the chemical quality of the water in the Biscayne aquifer throughout the county. Also, the multiple depth data were used in conjunction with other chemical quality data to prepare maps of the area showing differences in and distribution of the various chemical constituents with depth. Generally the data were from wells which were not contaminated by salt water. The chemical constituents mapped are dissolved solids, hardness as CaCO_3 , and iron. The location of the wells sampled are shown on each map.

The maps in figure 5 show the dissolved solids in water from depths ranging from 0 to greater than 200 feet. The relatively low chemical content of the water in the Fort Lauderdale area indicates the circulation of ground water that results from the combined effect of the drainage by the canal system and the local recharge by rainfall. In the rest of the county the slower movement of the ground water permits more time for the water to dissolve minerals from the materials composing the aquifer. The tendency of the calcareous sands of northern Broward County to hold the water in storage is indicated by the relatively high dissolved solids near the coast in that area. This is supported by the fact that water levels in the northern part of the county are considerably higher than those in the central and southern parts. The higher concentration of dissolved solids in the wells deeper than 200 feet indicates there is much less circulation of water at those depths.

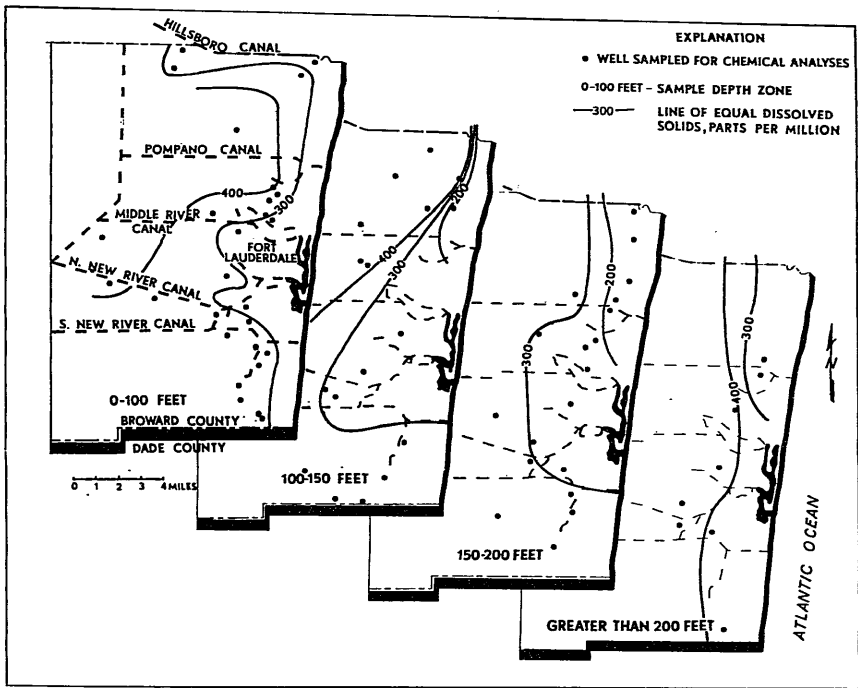


Figure 5. Variation of dissolved solids in ground water of eastern Broward County, 1964.

The maps showing hardness of ground water, figure 6, generally show the same pattern as the dissolved solids maps. A similarity in the illustrations would be expected because calcium and bicarbonate are the major constituents of the natural water of south Florida. The ground water of Broward County ranges from hard to very hard. The hardest water occurs in the northern section and extends nearly to the coast.

The iron content of ground water also varies areally and with depth in the Biscayne aquifer. According to Hem (1959, p. 60), iron usually will occur only in the ferrous state in water whose pH ranges from 7 to 8, the range normally found in Broward County. When water containing ferrous iron and bicarbonate comes in contact with oxygen, the iron is oxidized to the ferric state and precipitates as ferric hydroxide. The bicarbonate in solution is replaced with carbon dioxide which slightly lowers the pH. Aeration as commonly employed to remove iron from water, utilizes this reaction.

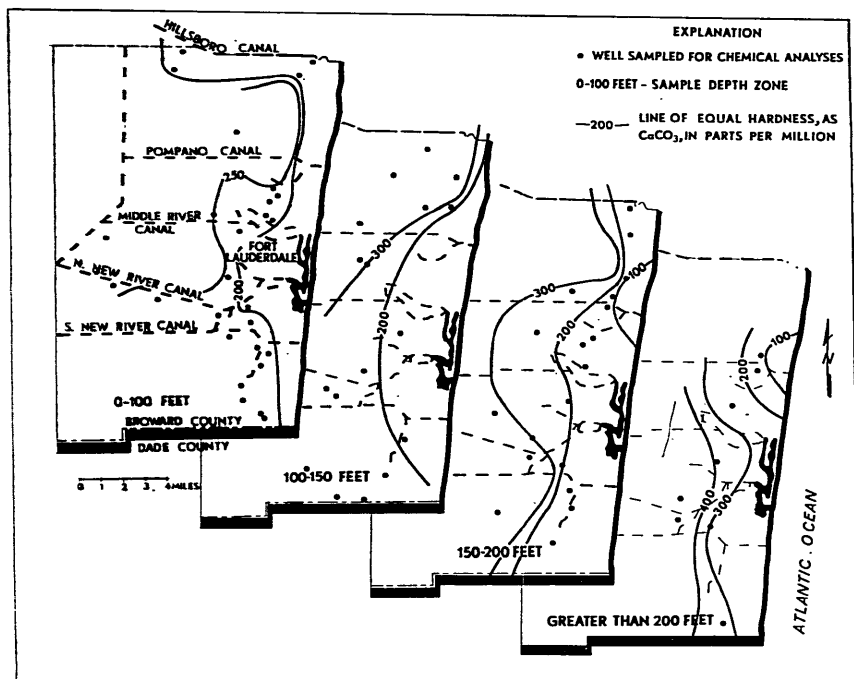


Figure 6. Variation of hardness of ground water of eastern Broward County, 1964.

The maps in figure 7 show that the iron concentration increases to the south and west. The reason for the higher iron content could be the action of certain bacteria on organic material. Sarles and others (1951, p. 235), state that certain bacteria can bring about reactions with organic material which produce ferric hydroxide or ferrous sulfide. Soil micro-organisms also can cause the formation of acids which aid in bringing iron compounds into solution. These reactions occur deep in the sub-surface where there is no free oxygen.

To illustrate differences in chemical quality in an individual well a modified Stiff diagram was used. This method of presentation of data is based on the percentage of the principal cations and anions in terms of equivalents per million (reacting values of ions), and is diagrammed in figure 8. The modified Stiff diagram shows only percentage composition, not the total mineral content of a sample; therefore, the specific conductance was plotted against depth in figure 8 also, in order to show changes in total mineral content of the water with depth in the aquifer.

The analyses of water from Well 260609N0801205 (fig. 8) show the typical changes in the water of the Biscayne aquifer in the coastal area

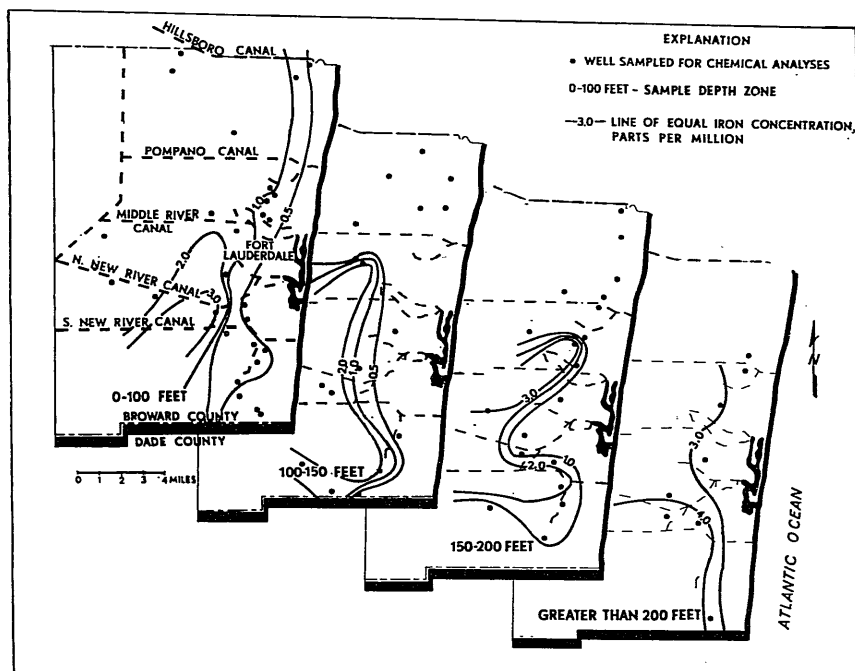


Figure 7. Variation of iron in the ground water of eastern Broward County, 1964.

of Broward County. The shallow water is a calcium bicarbonate type which gradually changes with depth to a sodium chloride type. The diagram representing the 227-foot sample shows the midpoint of the transition from fresh water to saline water. The sample collected at 314 feet shows the typical diagram of sea water, although the specific conductance of sea water would be many times greater.

Analyses of water at different depths from two wells (255742N0802720 and 260843N0802629) in western Broward County showed that the aquifer contains naturally soft water with a high bicarbonate content. Natural softening is caused by a base-exchange reaction in which the calcium in solution is replaced with sodium from an exchange material (clays).

According to Foster (1950, pp. 33-48), base-exchange reaction, accompanied by high bicarbonates, requires that three materials be present: calcium carbonate, carbonaceous material, and a base-exchange material. Calcium carbonate, relatively insoluble in pure water, goes into solution as calcium bicarbonate in the presence of carbon dioxide. Carbonaceous material, such as organic matter, decomposes to produce much of the

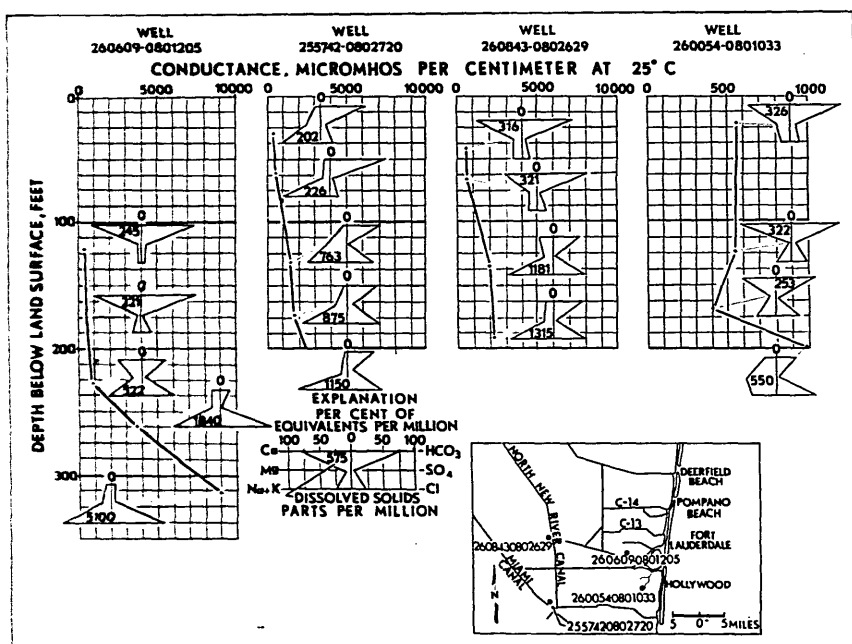


Figure 8. Variation in chemical constituents with depth in water from selected wells.

carbon dioxide in the ground. Carbonaceous material abounds in the organic soil in the Everglades in western Broward County. The base-exchange material, generally clay minerals, is present in the surface marl and as part of the deeper unconsolidated material.

Water from well 255742N0802720 (fig. 8) is naturally soft with high sodium and bicarbonate and low calcium and sulfate. The deeper waters from well 260843N0802629 are the same type but the water at shallow depths is calcium bicarbonate in type. This indicates that the upper section of the aquifer in the area of well 260843N0802629 contains little or no base-exchange material. Water samples from both wells show the presence of salt water in the deeper part of the aquifer, as do all other deep samples collected in this vicinity.

In addition, the dissolved ions in water from several of the wells indicate the presence of dolomitic ($\text{CaMg}(\text{CO}_3)_2$) material in the deeper section. The diagram of the dissolved solids in waters from the 200-foot zone in well 260054N0801033 (fig. 8) shows a high concentration of magnesium (70 ppm). In contrast, very little magnesium (4.5 ppm) occurs at a depth of 168 feet. A similar change was found in six of the wells in which multi-depth samples were collected.

Although chloride is the dominant anion in the 200-foot zone, its concentration is low (250 ppm) and the magnesium/chloride ratio is too high for the magnesium content to be caused by active saltwater intrusion. The EPM ratio of calcium to magnesium in water from the 200-foot zone is 1:3; the EPM ratio in sea water is 1:5, while the EPM ratio in waters from dolomitic rocks is approximately 1:1. It appears, therefore, that the high magnesium content of the deeper waters in these six wells is caused by a combination of solution of a dolomitic source material and the occurrence of salty water at a depth of approximately 200 feet.

The presence of dolomitic limestones at similar depths has been reported in the area around Lake Okeechobee by Mr. Bob Erwin (Oral communication).

The analyses of water from well 261018N0800850, located near the tidal reach of Middle River Canal, are shown in figure 9 by Stiff diagram,

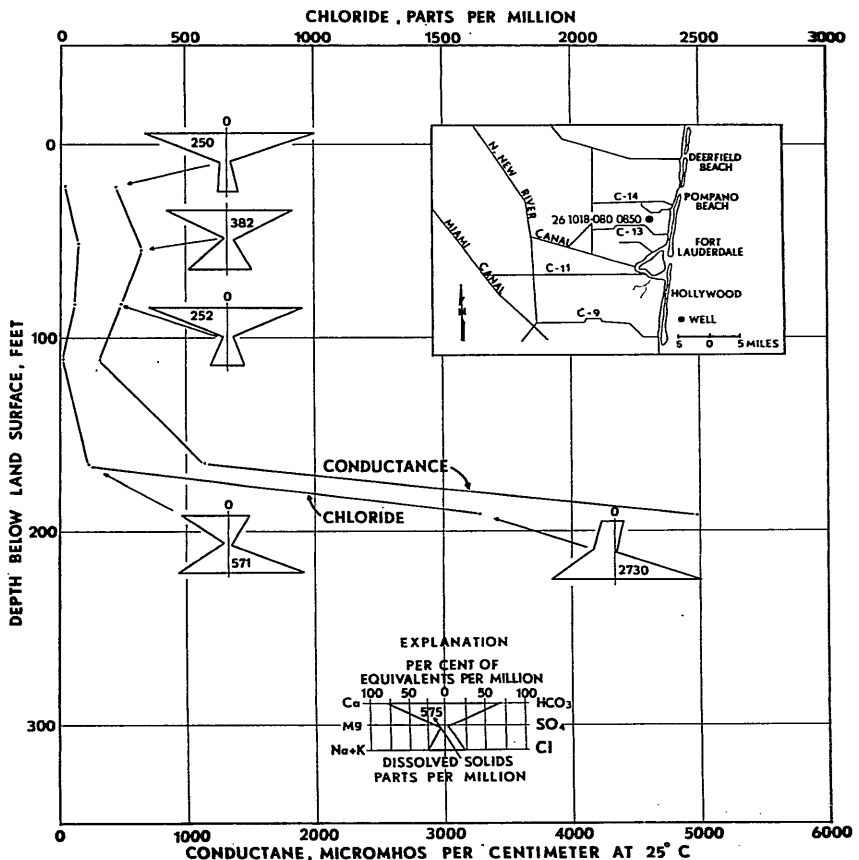


Figure 9. Changes in chemical composition of water from well 261018N0800850 with depth.

chloride content, and specific conductance. The analysis of multiple-depth samples showed that the water from a depth of 23 feet was calcium bicarbonate type; the sample collected at 56 feet had an appreciable increase in sodium chloride concentration and the water from 85 feet was again predominately a calcium bicarbonate type. This indicates that part of the water at the 56-foot depth was salt water infiltrating from the tidal canal, and that material of relatively low permeability exists in the interval between 56 and 85 feet which retards vertical movement of water.

The chloride content increases from 280 to 1580 ppm in the 19 foot interval from 167 to 186 feet. This illustrates the tendency of the heavier salt water to move to the bottom of the aquifer, under the fresh water. It also illustrates the effect of differences in permeability within the aquifer on the extent of sea-water intrusion. The material penetrated during the drilling of the bottom 19 feet of this well ranged in composition from very sandy limestone at the top of this interval, to highly permeable pure limestone in the lower part of this interval. The permeable limestone tends to facilitate salt water intrusion in the Ft. Lauderdale area. The chemical quality conditions in this well are probably typical of many areas near the coast and adjacent to a tidal canal.

CHANGES WITH TIME

Observation well 260515N0802021 was drilled in November 1950, in an undeveloped section of Broward County about 7 miles west of Davie, to provide a record of changes in water levels and water quality caused by drainage in the area and by the storage of water in the conservation areas. The well is 29 feet in depth cased to 28 feet with 6-inch casing. A continuous water-level recorder was installed on the well and hydrologic observations have continued to date. Monitoring of the chemical quality of the water was begun in March 1955, and water samples have been collected periodically and analyzed for mineral content and chemical properties. Even though the well has not been used, changes in chemical quality have occurred during the period of observations. As shown in figure 10, the mineral content of the water decreased from about 400 ppm to less than 300 ppm. The greatest change was in sulfate concentrations which declined steadily from 95 ppm to 0.

According to Hem (1959, p. 101), most sulfides are converted sulfates in the upper oxidized layers of soils, and are leached away. In humid regions, sulfates can be thoroughly leached because the amount of water is large in proportion to the soluble salts. Extended periods of low water levels such as those shown in figure 10 during 1955-57 and increased drainage caused by the improvement of the canal system probably aided

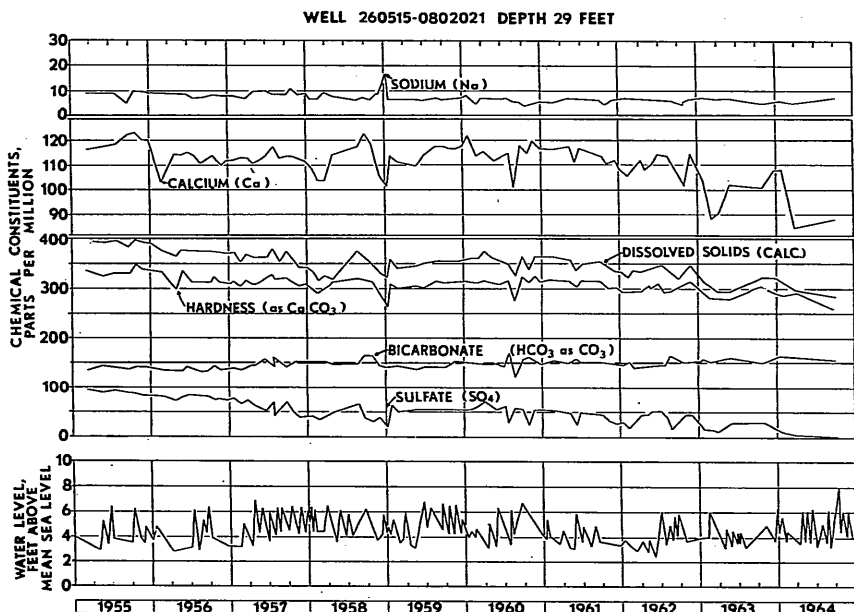


Figure 10. Changes in selected chemical constituents in water from a well seven miles west of Davie, during the period 1955 to 1964.

the flushing of the upper part of the aquifer by recharge from local rainfall. Most of the other constituents in the water decreased slightly during the period of record, a further indication that improved drainage accelerated the movement of ground water which removed the soluble material from the area.

Changes in the ratios of the different chemicals in the water throughout the period of record show that a base-exchange reaction has taken place. Natural softening (see page 31) occurred to a slight degree, but was probably limited by a lack of base-exchange material. During the 10 years of record the calcium decreased from about 120 ppm to 90 ppm, the sodium remained nearly constant, the bicarbonate increased slightly, and the total mineral content decreased. The decrease in hardness with no decrease in bicarbonate also indicates a slight base-exchange reaction.

SEA-WATER INTRUSION

Sea-water intrusion is one of the prime water problems in coastal areas of Broward County. Sea water has moved into the aquifer near the coast and adjacent to uncontrolled reaches of the rivers and canals. Because the majority of salts in sea water are in the form of chlorides,

the chloride content of water is generally used as the index of sea-water encroachment. Figure 11 shows the inland extent of water containing

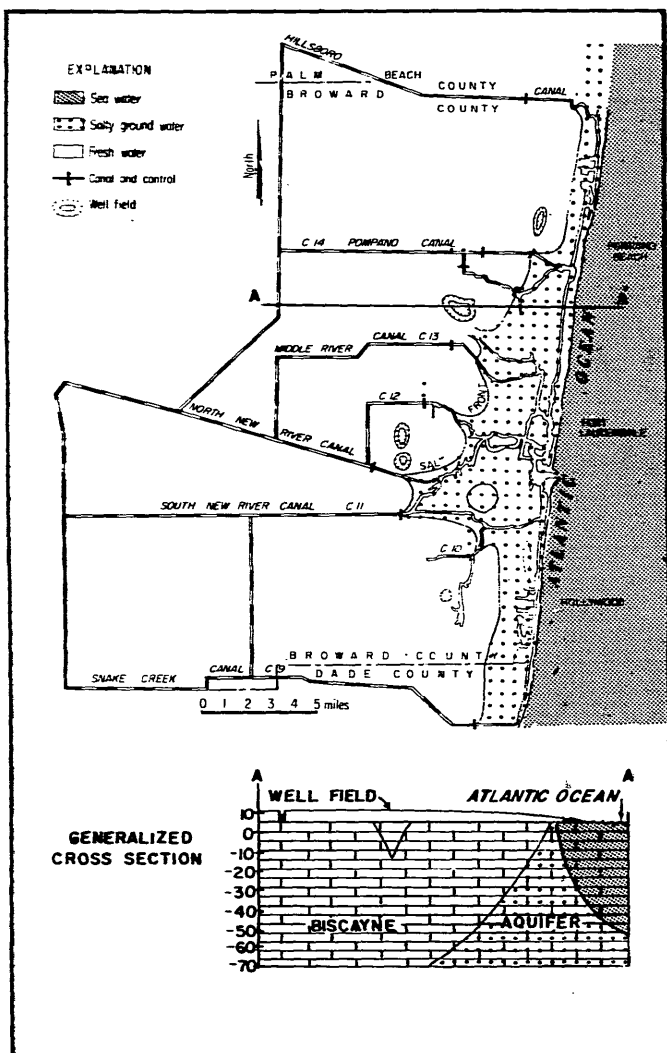


Figure 11. Extent of sea-water intrusion 1964.

1,000 ppm of chloride near the bottom of the Biscayne aquifer in Broward County in 1964. The wedge-shaped, salt-water body in the aquifer is thickest at the coast and thins inland to an edge where it underlies the fresh ground water at depths from 160 to 200 feet below the land surface.

The map sequence in Figure 12 shows successive adjustments of the salt-front pattern, which have occurred since 1941 in response to drainage

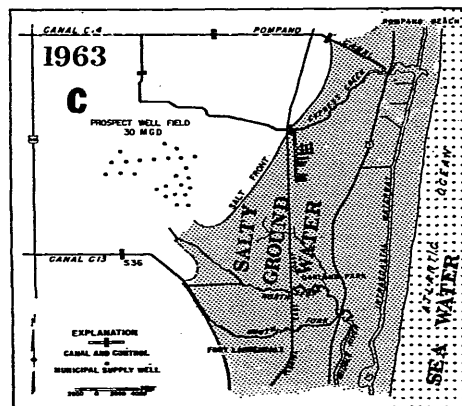
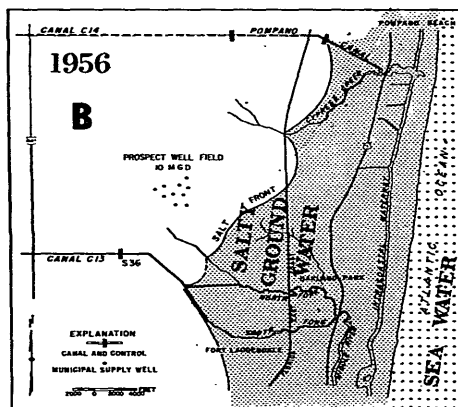
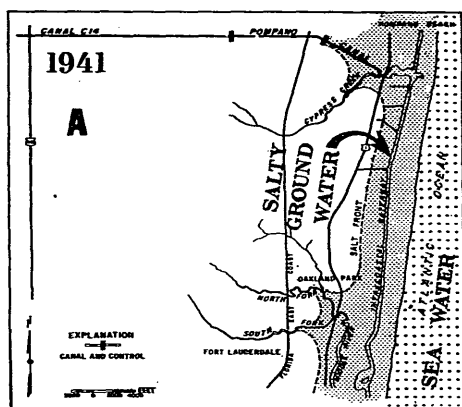


Figure 12. Progressive salt-water intrusion in the Middle River-Prospect Well Field Area, near Fort Lauderdale.

(canal construction), increases in municipal pumping, and salinity-control practices in the Middle River-Prospect well field area near Fort Lauderdale. In the early 1940's, when rapid growth was just beginning, there was very little ground-water pumpage and the existing streams were shallow and relatively ineffective for drainage. This resulted in overall high water levels which prevented salt-water intrusion, except for areas adjacent to the coast and along tidal channels (fig. 12A). During the mid 1950's, as urban areas were expanded, canals were dug to lower water levels to prevent flooding in inland areas. Short, tidal, finger canals were excavated in low-lying coastal areas and the excavated material used to raise land surface elevations, thereby creating water-front property. Ground-water withdrawals were increased to accommodate the growing demand. The combined effect of increased drainage and water use lowered water levels near the coast and caused a gradual inland movement of salt water (fig. 12B).

Salinity-control structures in major canals have done much to retard or even push back intruding salt water. The connection of Cypress Creek into the water-control system has aided the prevention of intrusion in the northern part of Prospect well field even though pumpage has tripled during the period 1956-63; however, the south edge of the well field is threatened with salt-water intrusion (fig. 12C), because the control structure in Canal C-13 is too far upstream to be fully effective.

The increased threat to fresh ground-water supplies resulted in the passage of the salt-intrusion control act by the State Legislature in 1963. This act gives the Broward County Water Resources Department and the Water Resources Advisory Board the power to control man-made changes in the ground and surface water flow system, subject to approval of the Board of County Commissioners.

Brackish water occurs in less permeable materials beneath the Biscayne aquifer along parts of the coastal ridge. This water of inferior quality could be connate water trapped in sediments during deposition or residual sea water remaining in the aquifer as a result of inundation by the sea during Pleistocene time. The brackish water does not appear to be a threat to the shallow fresh water in the aquifer, provided ground-water levels are not excessively lowered. An observation well in the center of the Fort Lauderdale Dixie well field yields water that contains about 700 ppm of chloride from a depth of 211 feet and has shown no appreciable change in chloride during the last 15 years. The well field is pumped at the rate of 10 mgd from an average depth of 150 feet, but the salty water 60 feet below the zone being pumped has shown no indication of upward migration.

Mineralized ground water also occurs under similar conditions in inland areas of Broward County. In an early study of ground water in southeastern Florida, information from several test wells in the Everglades, (Parker 1955, p. 820) showed that the chloride content of the water increased to the west and northwest and with depth in Broward County, figure 13.

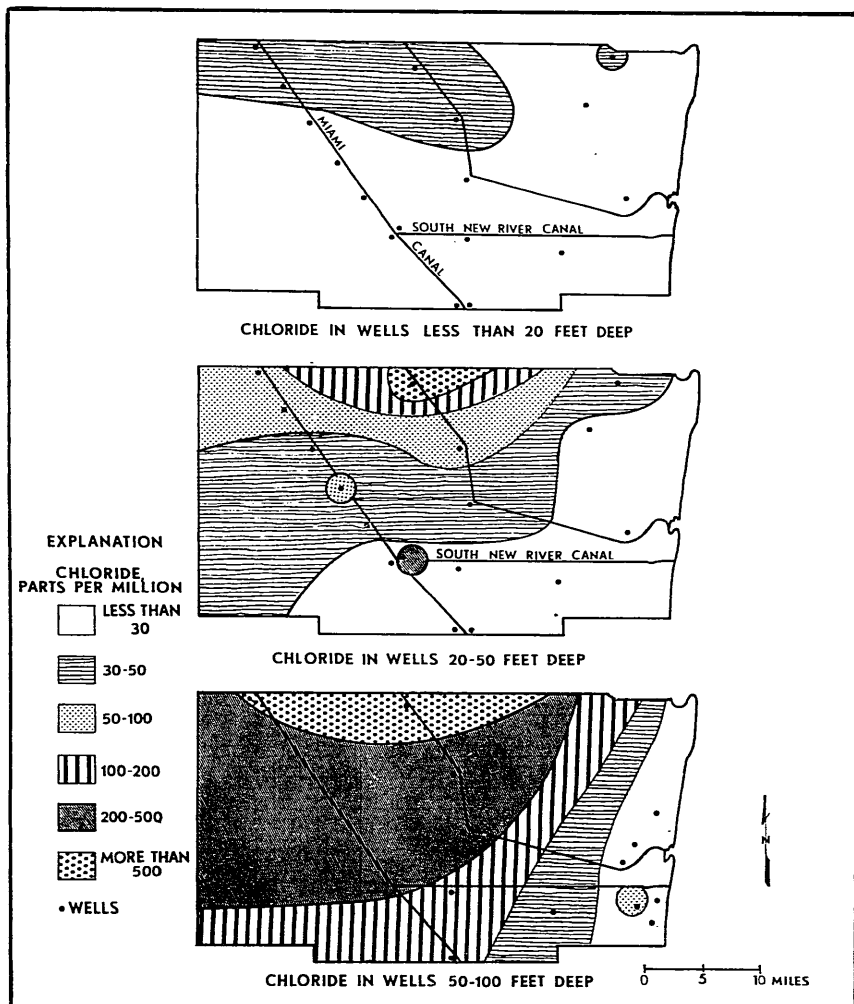


Figure 13. Variation of chloride content with depth in inland areas (after Parker et al).

WATER IN THE FLORIDAN AQUIFER

The Floridan aquifer underlies southeastern Florida at depths greater than 900 feet. It is composed primarily of permeable limestone which dips eastward and southward and is thought to intersect the ocean bottom several miles offshore beyond the Continental Slope. The limestone is overlain by thick impermeable marl and clay. The aquifer is artesian but yields water containing chlorides in excess of 1,500 ppm in Broward County and therefore is too salty for human consumption. In southern Florida the water having high chloride content appears to be chiefly from sea water which has not been flushed from the aquifer. Some of the sea water is connate water and some entered the aquifer during Pleistocene time (Stringfield 1966).

Although the water is too salty for most purposes, the water and the aquifer are used in several ways. In the Pompano Beach area a utility company uses an 18-inch well 1,153 feet deep for disposal of sewage effluent. About 450,000 gpd of treated sewage are pumped into this well. The effluent is discharged into the aquifer against an artesian head of about 30 feet. This same technique is being used or planned for use in other sections of the state to dispose of municipal and industrial wastes to prevent pollution of the streams and shallow fresh ground-water sources.

Because wells in the Floridan aquifer flow freely and the water temperature is constant, it is used for industrial cooling and for air-conditioning units. The water is high in mineral content, contains hydrogen sulfide and therefore is corrosive to most metals. Where fresh water is in short supply, the salty water of the Floridan aquifer has been used for swimming pools, flushing waste systems, and mixing with the fresh water for irrigation of golf courses.

The Floridan aquifer represents a source of very large quantities of water of poor quality. Although it may not be feasible now to utilize this source for many purposes, it has an excellent potential for use in future years when maximum growth is attained and the fresh-water resources in the county approach maximum utilization.

SURFACE WATER

The urban and agricultural sections of Broward County are dissected by a complex system of primary and secondary drainage canals. The larger primary canals convey water seaward, draining the inland areas, and in most instances are controlled near their outlets to the ocean; some control structures however, are several miles inland. The secondary canals are connected to the primary canals and are designed to cope with local

flooding. The control structures on the primary canals have two main functions: the first is to prevent the movement of sea water upstream in the canal, the second is to maintain high fresh-water levels during dry periods to prevent ocean water from seeping into the highly permeable Biscayne aquifer and contaminating the fresh-water supply of the area. Upstream of the controls, the water in the canals is basically fresh and therefore a major natural resource.

The composition of the water in canals in Broward County varies widely with fluctuations in discharge caused by seasonal rainfall. When discharge is high most of the water is surface runoff from inland areas which is highly colored but contains only a small amount of dissolved minerals. When discharge is low most of the water is derived from ground-water inflow and the amount of dissolved minerals increases.

In Broward County, water in the canals is not used directly for domestic supplies. However, during the dry seasons canals supply a major portion of the water which artificially replenishes the various municipal and private well fields. For this reason, the mineral content of the canal water is of importance. During the dry season inflow to the canals is from inland areas where ground-water levels are higher than canal levels, but in coastal areas controls are closed, canal levels are higher than ground-water levels and water generally flows from the canals into the aquifer. Thus the period when canals are the primary supplemental source of replenishment to ground-water supplies occurs when effluent wastes in the canals are most concentrated.

In general, the chemical quality of surface-waters in Broward County is within the limits established by Florida State Water Standards. However, the mineral content of a given surface-water source varies more in a short time period than the content of a given ground-water source, and therefore, surface water is more difficult to treat.

CHEMICAL CONTENT

Surface waters collected during this study are primarily alkaline ranging from pH 6.3 to 8.6. When slightly acid rain water comes in contact with limestones which underlie this area, solution of the limestone causes the ground water to become slightly alkaline. Therefore, during dry periods when most of the water in canals is ground-water inflow, canal water will be alkaline. Canals which are used extensively for disposal of wastes and sewage effluent may periodically become slightly acid. The effluent from sewage treatment plants is a source of nitrate in surface water in this area. Water from Plantation Canal above control structure S-33 had the highest nitrate content found during this study. Eight of the 16 samples (fig. 3) collected showed a nitrate content

ranging from 9.4 to 62 ppm as compared with an average of about 1 ppm for surface waters in the area. The nitrate content of the canal water seems to vary with discharge. The samples that had the highest nitrate content were collected during or immediately after periods of little or no flow whereas samples collected during periods of appreciable flow generally had low nitrate content. In 1965 nearly 1.7 million gallons per day of treated effluent was discharged into the controlled reach of this canal.

Water samples from the Pompano Canal above the control at Pompano Beach contained the highest fluoride in the surface water (2.7 ppm, March 12, 1962). As shown in Figure 14, the fluoride content at this site

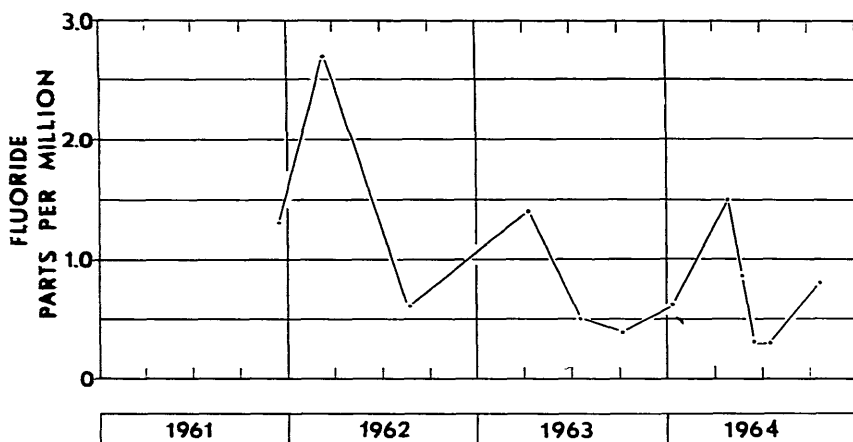


Figure 14. Fluoride content of water from Pompano Canal near Pompano Beach.

fluctuates seasonally. During 1962 it ranged from 2.7 ppm in March to 0.4 ppm in October. The greatest fluoride content apparently occurs during the first heavy rains after the long winter dry season each year. The probable source of the fluoride is the inland agricultural areas drained by the Pompano Canal where fluoride is added to soils by application of fertilizer (U.S. Dept. of Agric. Yearbook, 1957). This soil fluoride could be leached from the ground by irrigation and the runoff from heavy rains.

The Hillsboro Canal which also passes through the same area had a fluoride of 1.2 ppm in April 1964. Fluoride is less likely to be detected in the Hillsboro Canal because of high flows which would cause extensive dilution of any contaminant.

The canal waters of Broward County vary in color from 30 to as high as 240 standard platinum-cobalt units and therefore are in the objection-

able range of the Florida Standards for drinking water. At present this presents little problem because the principal direct use of canal water is for crop irrigation. When canal water infiltrates the aquifer, color is removed as the water moves through the aquifer and is diminished by dilution as the canal water mixes with ground water.

CHANGES WITH TIME

The total mineral content of the water along controlled reaches of canals usually ranges from about 150 to 600 ppm. In the tidal reaches below control structures the water is predominantly sea water although the chloride content varies considerably in response to changes in the rate of discharge of fresh water through the control structures. Daily chloride values derived from continuously recorded conductivity values collected in uncontrolled reaches of North New River Canal, Middle River Canal, and Hollywood Canal during 1964 and 1965 are shown with hydrographs of available canal discharge in Figure 15.

The hydrographs show clearly the effect of discharge on the movement of the salt water in the canals and also, the effects of the lack of control and replenishment to the Hollywood Canal. The highest chloride content in water at these sites occurs during the dry season when discharge is at a minimum. During the wet season when discharge is high the salt water in both primary canals is pushed downstream to coastal reaches of the canals. The chloride content of water in Hollywood Canal is generally high because the canal drains a small urban area and discharge is low.

Major well fields are located near the sampling sites on Middle River and North New River Canals (fig. 2) and ground-water gradients indicate that water flows from the canals toward the well fields during periods of low water levels and heavy pumpage. The graphs of Middle River and North New River Canals show that when a discharge of 50 to 75 cfs occurs through the control structures, the salt front is held downstream from the sampling points. Figure 16 shows the sum of chemical constituents from periodic samples collected at South New River at S-13 and monthly rainfall at the nearby agriculture research station for the period September 1950 through December 1963. At S-13 the mineral content commonly varies inversely with rainfall. The great increase in mineral content in early 1957 is very likely the end result of the extended drought of 1954-56 which had its greatest effect on south Florida near the end of 1956 (Pride, 1962). During a period of low rainfall, mineral content increases as a result of concentration by evaporation and the inflow of more highly mineralized ground water. The extreme decrease in mineral content in late 1957 was caused by dilution due to the above normal rainfall which followed the drought.

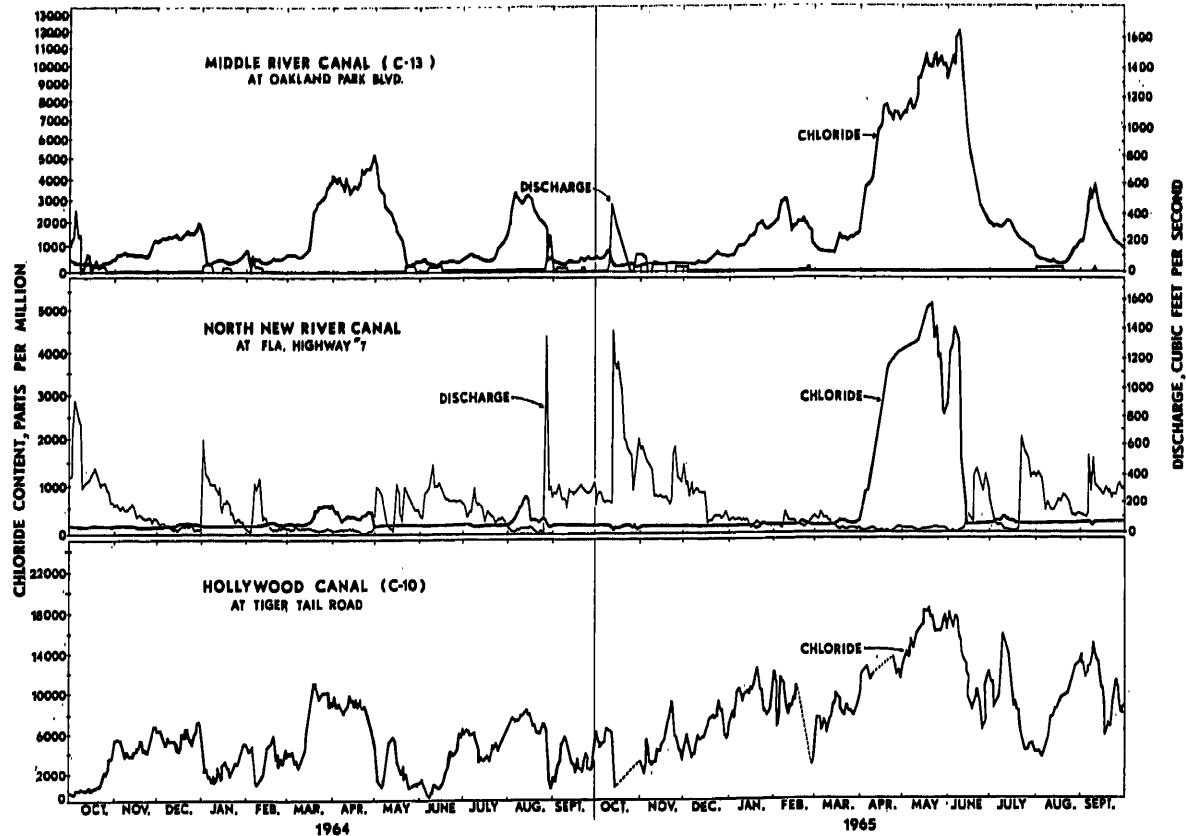


Figure 15. Discharge and chloride content of water from tidal reaches of selected canals.

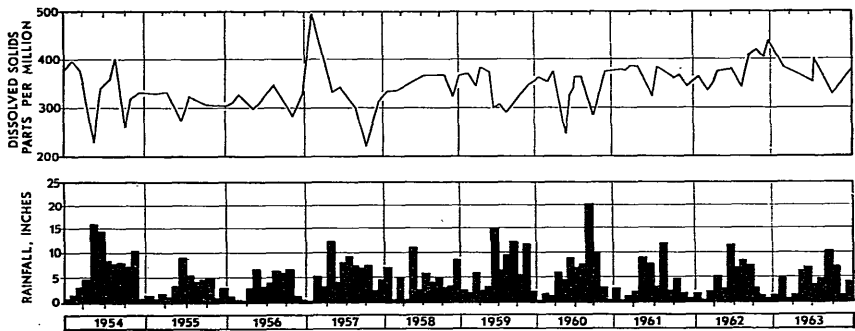


Figure 16. Mineral content of water from South New River near Davie and rainfall, 1954 - 1963.

CONTAMINATION OF WATER RESOURCES

Each public water-supply system in the county is requested to furnish to the Broward County Health Department an annual chemical analysis of the raw water from each producing well and an analysis showing the amount of trace elements present. This practice has resulted in the correction of some potentially dangerous situations.

The analyses of water from several wells in southern Broward County have shown fluctuating increases in ABS (detergents) content in recent years. The wells are in an area served mainly by septic tanks which are thought to be the source of the ABS. The fact that most manufacturers now produce biodegradable detergents may cause a gradual decrease in the ABS content of the water.

In 1962 the trace element analysis of a group of wells showed an increase in arsenic over the previous years. Though not a dangerous concentration, it was enough to warrant checking. The investigation showed a sodium arsenite weed killer had been used in the vicinity which probably leached down to the water table. The arsenic decreased when the use of the weed killer was stopped. As a result of this incident the Broward County Health Department has restricted the use of arsenite weed killers in the vicinity of public supply wells in the county.

Arsenic again became a potential problem in 1965 when an increase was noted in the annual trace element analysis in two well fields. Again the arsenic did not reach a potentially harmful concentration. The arsenic evidently was transported to the well fields through the canal system of the area. The source could be either industrial or agricultural pollutants. Drought conditions limited the dilution and flushing of the arsenic from the canals. Further efforts to trace the source were negated by heavy rains which diluted the mineral content of water in the canals.

Fresh water in streams normally contains several ppm dissolved oxygen. The oxygen is consumed in oxidation of organic material and is replaced by oxygen from the atmosphere. If large quantities of organic matter are in the water, oxygen may be used faster than it is replaced.

Treated waste water, high in organic matter, can cause a problem of oxygen depletion when discharged into the waterways. Large quantities of dissolved oxygen are required to oxidize the organic material. Turbulent flow of water will aid in the oxygen uptake of water; however, the canal system in Broward County generally does not have turbulent flow. When the dissolved oxygen becomes very low, there are often problems of odor, floating sludge, and killing of fish and aquatic life. It is generally established that 5 ppm dissolved oxygen is necessary to support fish life. In extreme cases when the dissolved oxygen is totally depleted, there is no self purification of the water and a septic condition develops.

During the low flow period in December 1966 the U.S. Geological Survey made a study of the diurnal (24 hour) dissolved oxygen content at selected points in the canal system in Broward County. The study showed that the two sites with the lowest dissolved oxygen content, Snake Creek Canal (C-9) and Plantation Canal (C-12), were also the canals which received the greatest amount of treated sewage. Snake Creek Canal receives about 2.5 mgd of treated effluent and had a diurnal range of 0.7 to 1.8 ppm dissolved oxygen. Plantation Canal, which receives about 1.2 mgd of effluent had a range of 1.9 to 3.4 ppm dissolved oxygen. South New River Canal and North New River Canal also had very low diurnal dissolved oxygen content. During this study the dissolved oxygen ranged from 0.3 to 7.6 ppm and the average for all samples collected was 3.5 ppm. The data indicate that at times, the dissolved oxygen concentration of the canal waters is reduced to levels below those necessary to sustain many forms of aquatic life, which is a potential problem if those life forms are to be maintained.

Dissolved oxygen depletion is not the only pollution-caused degradation of canal water in Broward County. Another source of degradation is pollution from chemical contamination. Table 2 lists various minor constituents which were detected by the chemical analyses of the canal waters sampled during the dissolved oxygen study. None of the waters analyzed contained dangerous amounts of these chemicals, but several constituents are present in detectable amounts. Also the presence of ammonia compounds, nitrates, and phosphates indicates probable organic pollution. These analyses again show the same canals as potential problem areas, namely, Plantation, Snake Creek, South New River, North New River and Middle River Canals. The probable reason Middle River Canal

**Table 2. ANALYSES OF MINOR CHEMICAL CONSTITUENTS IN WATER
FROM SELECTED CANALS, DECEMBER 21, 1966.****Chemical analyses, in parts per million**

Site	Lead (Pb)	Zinc (Zn)	Arsenic (As)	Ammonia (NH ₄)	Nitrate (NO ₃)	Nitrite (NO ₂)	Phosphate (PO ₄)
Hillsboro Canal above control at Deerfield Beach	0.00	0.00	0.01	0.03	1.4	0.02	0.33
Pompano Canal above control at Pompano Beach	0.04	0.00	0.00	0.04	0.5	0.01	0.28
Cypress Creek Canal above S-37-A near Pompano Beach	0.01	0.00	0.01	0.06	2.2	0.02	0.69
Middle River Canal, above S-36 near Ft. Lauderdale	0.01	0.00	0.00	3.0	9.1	0.16	1.4
Plantation Canal, above S-33 near Ft. Lauderdale	0.03	0.00	0.00	2.3	1.8	0.50	5.4
North New River Canal above control near Ft. Lauderdale	0.01	0.00	0.02	1.6	0.5	0.01	0.18
South New River Canal above S-13, near Davie	0.02	0.00	0.00	0.13	2.5	0.12	0.29
Snake Creek Canal above S-29, near North Miami Beach	0.03	0.00	0.01	0.05	3.3	0.03	1.0
Snake Creek Canal at 67th Ave., near Hialeah	0.01	0.00	0.00	0.75	0.9	0.00	0.20
W. S. Public Health Recommended Maximum	0.05	5.0	0.05		45		

is in this group, but not in the low dissolved oxygen group, is because the sampling site is just downstream from a large treatment plant and there was not sufficient flow time for the dissolved oxygen to be lowered appreciably.

In conjunction with the current chemical sampling, special samples were taken at selected sites for pesticides analysis (Table 3). These analyses show that Plantation Canal and Snake Creek Canal contain the highest, although not dangerous, concentrations of certain pesticides. The pesticides probably come from the agricultural area in western Broward County.

These studies are only a beginning and need to be followed by more complete studies conducted at various seasons and under different water-flow conditions.

Another source of chemicals in the water is effluent from sewage-treatment plants (fig. 2). In 1965, with only 36 percent of the population served by public sewerage systems, more than 21 mgd of treated effluent were discharged into the waterways of Broward County. Included in the discharge figure was the treated effluent from approximately 900,000 gallons of septic tank sludge material which must be disposed of each month. Records for 1963 showed only about 20 percent of the septic

**Table 3. ANALYSES OF PESTICIDES IN WATER FROM SELECTED CANALS,
DECEMBER 21, 1966.****Analysis by U.S. Geological Survey
(parts per trillion)**

Sampling Site	Lindane	Aldrin	Heptachlor	Heptachlor epoxide	Dieldrin	Endrin	DDD	DDE	o, p' - DDT	p, p' - DDT
Snake Creek Canal above S-29 near North Miami Beach.	10	nd	nd	nd	10	nd	nd	10	nd	nd
Plantation Canal above S-33, near Fort Lauderdale.	10	nd	nd	nd	10	nd	20	10	10	40
Pompano Canal, above control at Pompano Beach.	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Hillsboro Canal above control, near Deerfield Beach.	nd	nd	nd	nd	nd	nd	nd	10	nd	nd

nd—Not detected

tank sludge was being treated in sewage-treatment plants. The Broward County Health Department required complete treatment of sewage and post-chlorination of the effluent before discharging into the receiving water. Sewage-plant effluent is generally higher in nitrates and chloride than the natural water of the area. During drought periods, when the canal control structures are closed, the increased dissolved chemical constituents in canal water caused by sewage can be further concentrated by evaporation of the canal water.

SUMMARY AND CONCLUSIONS

The chemical quality of the water in the interrelated surface and ground-water system of Broward County is generally good. Most of the water used in Broward County is obtained from the Biscayne aquifer which is recharged by local rainfall and by water that infiltrates from the canals. The very permeable limestone of the Biscayne aquifer permits relatively free interchange of water between the aquifer and the canals.

The mineral content of water from the Biscayne aquifer usually meets the water standards set by the State of Florida. The water is hard, and in the southeast part of the county it contains iron in objectionable concentrations. Ground water along the coast is contaminated by salt-water, and parts of the aquifer inland contain salty remnants of ancient sea floodings. The water contained in the major part of the aquifer is a

calcium bicarbonate type but near the bottom of the aquifer it is a sodium chloride type. In one area the deeper water is high in magnesium indicating the presence of dolomite. In southwestern Broward County some natural softening of the water is caused by a base exchange reaction in which the calcium in solution is replaced with sodium from an exchange material, generally clay minerals in the aquifer. Generally, the mineral content of the water increases inland and with depth in the aquifer. The water of lowest dissolved solids is in the Fort Lauderdale area—an intensively drained area where the circulation of water is rapid. Analyses of water collected for ten years from a well at the east edge of the Everglades show a decrease in the dissolved solids and most other chemical constituents; the sulfate concentration declined from 95 ppm to 0.

The Floridan aquifer yields brackish water by artesian flow. Small quantities of this water are used in swimming pools, for cooling, and for mixing with fresh water for irrigation of golf courses. One sewage-treatment plant discharges treated effluent into the Floridan aquifer.

The chemical quality of the surface water of Broward County generally varies seasonally. Mineral content of canal water increases during dry seasons when the contribution to the canals from ground water is greatest, and decreases when the canal water is largely surface runoff. Generally the mineral content does not exceed about 500 ppm. Upstream from the control structures the water is generally a calcium bicarbonate type. The water downstream from the control structures is mainly seawater, with the chloride content varying in response to seasonal runoff and control-structure operations. The interchange between the aquifer and the canal system contributes to the contamination of the waters of Broward County. There has been, and will continue to be, problems of pollution and salt-water intrusion. No serious pollution situations have arisen, but instances of arsenic and detergent contaminations in well fields have occurred. Further studies are needed on the contamination problems. Specific studies are needed on: 1) the relation of treated effluent loads to the discharge in the canals; 2) the effect of the interchange of water between the ground and surface water on fresh water well fields located close to canals; and 3) the use of the Floridan aquifer for the disposal of treated effluent and industrial waste. Continued monitoring of the salt-water intrusion and effects of waste disposal are needed.

To maintain the good quality of the abundant supply of water in Broward County a firm program of planning and management is paramount. If planning and management of the water resource is defaulted,

the rapidly-expanding economy and growing water needs in the area can result in depletion of water resources, contamination of the inland waters by industrial, agricultural, and domestic practices and by intrusion of salt water.

REFERENCES

- Black, A. P.
1951 (and Brown, Eugene) *Chemical character of Florida's waters - 1951*: Florida State Board Cons. Div. Water Survey and Research Paper 6.
- 1953 (and Brown, E., and Pearce, J. M.) *Salt water intrusion in Florida*: Florida State Board Cons. Div. Water Survey and Research Paper 9.
- Brown, Eugene (see Black, A. P., 1951, 1953).
- Collins, W. D.
1932 (and Lamar, W. L., and Lohr, E. W.) *Industrial Utility of Public Water Supplies in the United States*: U. S. Geological Survey Water Supply Paper 658.
- Crooks, J. W. (see Pride, R. W.)
- Foster, Margaret
1950 *The Origin of High Sodium Bicarbonate Waters in the Atlantic and Gulf Coastal Plains*: *Geochimica Et Cosmochimica Acta*, Vol. 1, pp. 33-48.
- Graham, R. G. (see Sherwood, C. B., 1965).
- Hazen, Allen
1892 *A new Color Standard for Natural Waters*: Amer. Chem. Soc. Jour. Vol. 12.
- Hem, John D.
1959 *Study and Interpretation of the Chemical Characteristics of Natural Water*: U. S. Geol. Survey Water Supply Paper 1473.
- Hoy, Nevin D. (see Schroeder, M. C., and Klein, Howard, 1958).
- Klein, Howard (see Schroeder, M. C. and Hoy, Nevin D., 1958).
- Lamar, W. L. (see Collins, W. D., and Lohr, E. W., 1932).
- Langbein, W. B. (see Leopold, L. B., 1960).
- Leopold, L. B.
1960 (and Langbein, W. B.) *A primer on Water*: U. S. Dept. of Interior, Geol. Survey.
- Lohr, E. W. (see Collins, W. D., and Lamar, W. L., 1932).
- Love, S. K. (see Parker, G. G., and Ferguson, G. E., 1955).
- Parker, G. G.
1955 (and Ferguson, G. E., Love, S. K., and others) *Water resources of southeastern Florida, with special reference to the geology and ground water of the Miami area*: U. S. Geol. Survey Water Supply Paper 1255.
- Pearce, J. M. (see Black, A. P., and Brown, Eugene, 1953).

- Pride, R. W.
1962 (and Crooks, J. W.) *The Drought of 1954-56, Its Effect on Florida's Surface-Water Resources*: Fla. Geol. Survey. R. I. 26.
- Rainwater, F. H.
1960 (and Thatcher, L. I.) *Methods for Collection and Analysis of Water Samples*: U. S. Geol. Survey Water Supply Paper 1454.
- Sarles, W. B. et al,
1951 *Microbiology*: Harper & Brothers, p. 235.
- Schroeder, M. C.
1958 (Klein, Howard, and Hoy, Nevin D.) *Biscayne Aquifer of Dade and Broward Counties, Florida*: Fla. Geol. Survey, R. I. 17.
- Sherwood, C. B.
1959 *Ground Water Resources of the Oakland Park Area of Eastern Broward County, Florida*: Fla. Geol. Survey, R. I. 20.
1965 (and Grantham, R. G.) *Water Control vs. Sea-Water Intrusion, Broward County, Florida*: Fla. Geol. Survey Leaflet No. 5.
- Stringfield, V. T.
1966 *Artesian Water in Tertiary Limestone in the Southeastern States*: U. S. Geol. Survey Prof. Paper 517.
- Tarver, George R.
1964 *Hydrology of the Biscayne Aquifer in the Pompano Beach Area, Broward County, Florida*: Fla. Geol. Survey, R. I. 36.
- U. S. Public Health Department
1962 *Public Health Service Publication No. 956*.
- Vorhis, Robert C.
1948 *Geology and Groundwater of the Fort Lauderdale Area, Florida*: Fla. Geol. Survey, R. I. 6.