SUBSURFACE STORAGE OF FRESHWATER IN SOUTH FLORIDA: EVALUATION OF SURFACE-WATER DISCHARGE DATA AT SELECTED SITES

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ABSTRACT

One major requirement for injecting and storing freshwater in aquifers in south Florida is a reliable source of water for injection. During dry periods, drainage canals of the South Florida Water Management District transport controlled releases of freshwater from interior storage areas to recharge the coastal surficial aquifers which yield water for use in the urban areas. During wet periods, freshwater is discharged from the canals to the ocean to minimize flooding in urban and agricultural areas. Water discharged during wet periods may constitute a potential source of freshwater for injection into suitable aquifers.

Discharge data for the 1970-81 water years at 27 canal and river sites were analyzed. Analyses present 30-, 60-, 90-, 120-, and 183-consecutive day low-mean discharges at the 27 sites, to define minimum high-flow period fresh surface-water discharges potentially available for injection during the periods of highest canal flow (usually during wet periods). Curves show the magnitude and frequency of average minimum flows for consecutive-day periods during high-flow periods, assessing the lower limits of amounts of freshwater potentially available for injection during high-flow periods, and how often the discharges recur. Duration curves and tables show the percentage of time that selected discharges during the 1970-80 water years and high-flow periods were equaled or exceeded.

Canal discharge as high as 660 cubic feet per second occurred 70 percent of the time during the high-flow period at one site (Tamiami Canal outlets, Levee 67A to 40-Mile Bend). At 11 other sites, discharges of 110 to 370 cubic feet per second occurred 70 percent of the time during the high-flow periods, while at 9 sites, discharges of 21 to 100 cubic feet per second occurred 70 percent of the time during the high-flow periods. At other sites (those in the Biscayne, Plantation Road, Middle River, C-111, and Cypress Creek Canals), discharges of 0.1 cubic foot per second occurred 70 percent of the time during the high-flow periods.

Criteria for amounts of surplus freshwater considered adequate to support injection systems cannot be established, as they would vary greatly with water needs to be satisfied and with the efficiency of a particular injection system. However, based upon this analysis of discharge at 27 canal and river sites throughout south Florida, it appears that substantial amounts of surface water are potentially available for subsurface injection and storage.

INTRODUCTION

South Florida is an area of rapid urban and suburban expansion that requires increasing quantities of freshwater for municipal and industrial uses. Traditional methods of meeting increased water needs by installing additional wells may no longer be desirable. Well fields, especially near coastal areas, may develop water-quality problems as a result of saltwater intrusion. Also, much of south Florida's freshwater is stored in inland storage areas (Lake Okeechobee and the water-conservation areas). A network of drainage canals of the South Florida Water Management District connected to these storage areas discharge excess water to the ocean to prevent flooding of urban and agricultural areas. During dry periods, controlled releases of stored water are delivered to coastal urban areas to provide recharge to surficial aquifers. However, these storage areas and surficial aquifers may become inadequate to meet the demand for additional freshwater supplies. Creating surface-water impoundments in south Florida is impractical because the land surface has little relief, large land areas are needed, evaporation losses are high, and water-quality degradation from surface runoff is possible. One method of water-supply augmentation under consideration is injection and storage of freshwater in suitable aquifers for subsequent recovery. A major requirement of this method is a reliable supply of freshwater for injection. A potential source of freshwater for injection is surplus surface water discharged from canals to the ocean during high-flow periods (usually during wet periods).

The U.S. Army Corps of Engineers is responsible for assessing the feasibility of subsurface storage and recovery of surplus freshwater as a water-supply alternative for south Floria. The U.S. Geological Survey, in cooperation with the U.S. Army Corps of Engineers, is providing technical support by a study of the multiple and diverse facets of the storage and recovery concept. The study includes: (1) the quantity of surface water from canals and rivers which would constitute a potential source of freshwater for subsurface injection; (2) water needs and water-supply problems in south Florida; (3) location of suitable underground formations; (4) geologic testing and site evaluation; (5) system design and construction; (6) operational problems; and (7) the effect of hydrogeologic, design, and management parameters upon recoverability (Merritt, 1983, p. 3).

Aspects of the study concerned with water needs and water-supply problems, location of suitable injection zones, geologic testing and site evaluation, system design and construction, and operational problems are discussed by Merritt and others (1983). The effects of hydrogeologic, design, and management parameters upon recoverability are discussed by Merritt (1983).

The purpose of this report is to identify, using U.S. Geological Survey discharge data for south Florida, the quantity of fresh surface water discharged from selected canals and rivers that would be potentially available for injection and storage. The area of investigation, referred to as south Florida (fig. 1), includes six of the southernmost counties of the State: Broward, Collier, Dade, Lee, Martin, and Palm Beach Counties.

Discharge data for the 1970-81 water years at 27 canal and river sites throughout south Florida were analyzed to define: (1) the period of time when quantities of fresh surface water are potentially available for injection and storage; (2) the lower limits or minimum amounts of fresh surface-water discharge potentially available during high-flow periods for injection and storage; and (3) how often the minimum high-flow period discharges recur. The analysis includes: (1) a general description of each canal system and location of the canal site where discharge data were analyzed; (2) tabulation of monthly percentage of average annual discharge at the 27 sites for the 1970-81 water years, indicating the period of 4 to 6 consecutive months when the greatest percentage of discharge occurred; (3) maximum, minimum, and mean daily discharges for the period of record analyzed and the period of 4 to 6 consecutive months when the greatest percentage of discharge occurred; (4) number of days when discharge was zero or consisted of estimated leakage through the control structure during the months of greatest discharge; (5) flow-duration curves for the 1970-80 water years and for the months having the greatest discharge during the 1970-81 water years; (6) lowest mean discharges for 30, 60, 90, 120, and 183 consecutive days for the months having the greatest discharge; and (7) frequency curves for 30, 60, 90, 120, and 183 consecutive days during the months having the greatest discharge.

AVAILABILITY OF SURPLUS WATER

Seasonal variation in rainfall significantly affects the availability of surface water. Also affecting the availability of surface water is the uneven geographical distribution of rainfall in south Florida. The following table shows average rainfall (in inches) during 1951-81 and 1970-81 at 10 selected rainfall stations in south Florida (shown in fig. 1):

Station No.	Station	1951-81	1970-81
1	Belle Glade Experimental Station	55.38	52.15
2	Stuart	54.78	51.64
3	West Palm Beach Airport	59.41	57.39
4	Pompano Beach	61.02	54.42
5	Fort Lauderdale	62.07	59.91
6	Miami Airport	57.32	52.44
7	Homestead Experimental Station	63.23	59.73
8	Tamiami Trail at 40-Mile Bend	53.51	47.40
9	Fort Myers Airport	53.58	52.63
10	Naples	52.42	48.61

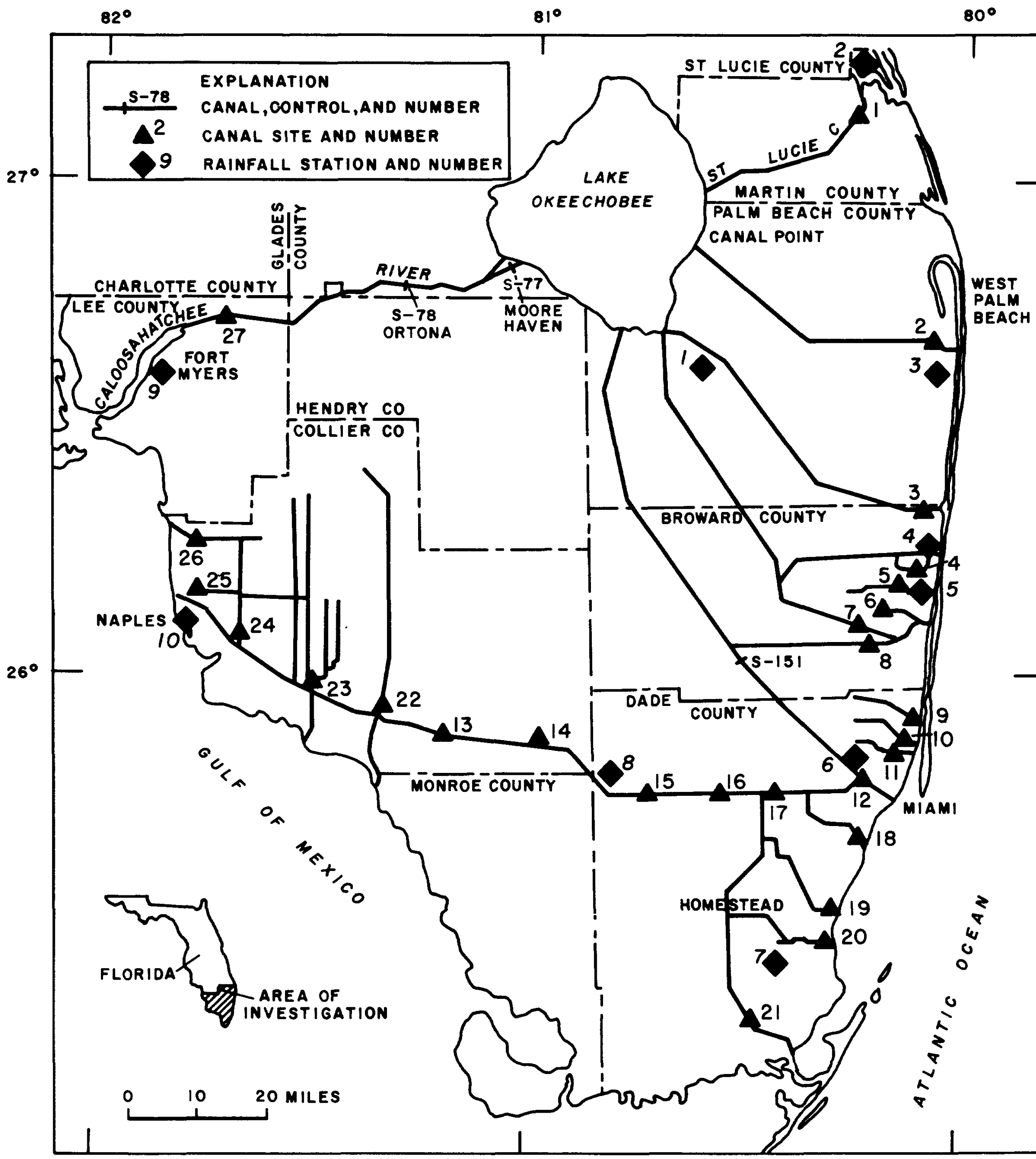

Figure 1.--Location of the area of investigation, rainfall stations, and selected canal sites.

This table shows the geographical variation in rainfall at the selected rainfall stations and also shows that average rainfall at the stations during 1970-81 was less than the average long-term rainfall for 1951-81.

The availability of surface water in south Florida also is influenced by the character of the supplying watershed, recharge to the watershed, and water-management practices within the watershed. These factors influence the volume of water available, the distribution of streamflow in time, and the quality of water.

The amount of surface water discharged through coastal-control structures is significantly affected by operation of the structures, the principal purpose of which is salinity or flood control. During wet periods, water is discharged through the control structures to minimize flooding. During dry periods, water is stored behind the controls to retard saltwater intrusion and to provide lateral recharge by outseepage to well-field areas. Thus, discharge through the controls is chiefly caused by seasonal regulation of water levels at the control structures.

With a few exceptions, discharge data for water years 1970-81 were used in this analysis to eliminate the major influences of regulation and management changes on canal discharge and to insure use of a homogeneous period of record. These years were selected because most modifications to the drainage basins and canal systems, particularly the construction of levees, canals, and controls that could affect flow in the canal systems, were completed and operational by the late 1960's.

PRESENTATION OF DISCHARGE DATA

Discharge records used in this report are stored in the U.S. Geological Survey's WATSTORE daily values files and are published annually in reports by the U.S. Geological Survey entitled "Water resources data for Florida, 1970, 1971, 1972, 1973, and 1974, Part I, surface-water records," (1972, 1973, 1974a, 1974b, 1975), and "Water resources data for Florida, 1975, 1976, 1977, 1978, 1979, and 1980, south Florida surface water" (1976, 1977, 1978, 1979, 1980, 1981). These reports give the location, drainage area, period of record, notations of previously published records, type and history of gages, general remarks, average discharge, extremes of discharge, and comments for each canal site.

Table 1 lists the canals and structures for which discharge data are presented, their site numbers and downstream order numbers, and periods of record used. Figure 1 shows the location of the canal sites. Discussion of discharge data is by individual site and is in the order listed in table 1. Flow-duration and frequency curves and in-text tables of lowest mean consecutive-day discharges are based on periods of 4, 5, or 6 consecutive months when the greatest percentage of discharge occurred (referred to as the high-flow period). Table 2 presents the percentage of average annual discharge at each site by month for the 1970-80 water years or the period of record indicated in table 1.

Table 1.--Canals and structures for which data are presented

Site No.	Downstream order No.	Canal name and structure	Period of record used
1	02277000	St. Lucie Canal at lock near Stuart, S-80	10/69 - 9/80
2	02279000	West Palm Beach Canal at S-155	10/69 - 11/80
3	02281500	Hillsboro Canal at lock near Deerfield Beach.	10/69 - 11/80
4	02282100	Cypress Creek Canal at S-37A	10/69 - 11/80
5	02282700	Middle River Canal at S-36	10/69 - 10/80
6	02283200	Plantation Road Canal at S-33	10/69 - 11/80
7	02285000	North New River Canal at Sewell Lock	10/69 - 11/80
8	02286100	South New River Canal at S-13	10/69 - 11/80
9	02286300	Snake Creek Canal at S-29	10/69 - 11/80
10	02286340	Biscayne Canal at S-28	10/69 - 10/80
11	02286380	Little River Canal at S-27	7/73 - 10/80
12	02288600	Miami Canal at S-26	10/69 - 11/80
13	02288800	Tamiami Canal, Monroe to Carnestown	10/69 - 11/80
14	02288900	Tamiami Canal, 40-Mile Bend to Monroe	10/69 - 11/80
15	02289040	Tamiami Canal, Levee 67A to 40-Mile Bend	10/69 - 12/80
16	02289060	Tamiami Canal, Levee 30 to Levee 67A	10/69 - 2/81
17	02289500	Tamiami Canal near Coral Gables	10/69 - 12/80
18	02290700	Snapper Creek Canal at S-22	10/69 - 11/80
19	02290710	Black Creek Canal at S-21	10/69 - 11/80
20	02290725	Mowry Canal at S-20F	3/70 - 11/80
21	02290769	Canal 111 above S-18C	10/69 - 10/80
22	02291000	Barron River Canal	10/69 - 12/80
23	02291143	Fahka Union Canal	10/69 - 11/80
24	02291270	Henderson Creek Canal	10/69 - 10/80
25	02291300	Golden Gate Canal	10/69 - 10/80
26	02291393	Cocohatchee River Canal	10/69 - 10/80
27	02292900	Caloosahatchee River at S-79	10/69 - 10/80

Table 2.--Monthly percentage of average annual discharge at 27 sites for water years 1970-80

Site No.	Downstream order No.	Canal name and structure	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Mean discharge (ft^3/s)
1	02277000	St. Lucie Canal at lock near Stuart, S-80.	14.8	14.2	1.28	7.83	10.2	12.1	15.6	2.36	3.16	3.04	11.0	4.45	395
2	02279000	West Palm Beach Canal at S-155	12.7	8.69	5.26	5.93	3.40	4.90	3.39	5.98	10.1	11.8	10.5	17.5	426
3	02281500	Hillsboro Canal at lock near Deerfield Beach.	11.3	10.6	5.83	6.59	4.11	6.30	5.42	7.17	9.58	9.65	9.03	14.4	177
4	02282100	Cypress Creek Canal at S-37A	9.94	10.2	6.94	3.90	2.59	5.47	6.69	7.37	10.7	10.3	10.0	16.0	118
5	02282700	Middle River Canal at S-36	8.93	8.29	4.21	3.25	4.04	4.23	4.63	9.76	14.3	12.0	11.6	14.7	65.7
6	02283200	Plantation Road Canal at S-33	7.68	10.3	7.68	5.20	5.43	5.27	7.74	7.35	11.6	8.88	9.81	13.0	21.1
7	02285000	North New River Canal at Sewell Lock.	9.59	12.4	7.05	4.29	4.01	6.92	7.79	5.42	12.0	10.8	9.60	10.1	176
8	02286100	South New River Canal at S-13	8.20	9.63	7.94	6.97	6.90	6.92	5.08	7.70	10.3	9.99	9.47	10.9	142
9	02286300	Snake Creek Canal at S-29	11.3	8.59	5.50	4.95	3.48	3.19	4.28	8.00	12.7	11.1	11.4	15.5	346
10	02286340	Biscayne Canal at S-28	11.9	7.34	2.99	3.16	1.87	1.63	4.55	10.1	16.5	13.3	10.9	15.5	77.5
1/11	02286380	Little River Canal at S-27	9.67	7.57	6.29	5.83	4.83	2.93	4.67	10.0	11.7	10.2	12.4	13.9	138
12	02288600	Miami Canal at S-26	12.0	10.4	7.08	7.34	5.93	4.40	5.72	6.77	9.24	8.65	9.29	13.2	225
13	02288800	Tamiami Canal, Monroe to Carnestown.	15.1	5.23	3.26	1.92	1.65	4.78	1.31	0.69	4.96	14.5	18.7	27.5	334
14	02288900	Tamiami Canal, 40-Mile Bend to Monroe.	6.6	7.24	3.81	2.41	2.15	4.16	2.50	1.48	5.72	13.6	18.0	22.3	210
15	02289040	Tamiami Canal, Levee 67A to 40-Mile Bend.	16.9	15.9	10.5	6.56	7.10	6.42	4.65	2.56	4.71	5.07	6.63	13.0	685
16	02289060	Tamiami Canal, Levee 30 to Levee 67A.	15.3	13.2	8.18	6.62	5.53	3.18	3.16	4.93	5.58	6.66	1.18	15.8	64.1
17	02289500	Tamiami Canal near Coral Gables	10.2	10.1	9.86	8.23	6.47	5.21	4.43	6.74	8.20	8.79	9.69	12.1	131
18	02290700	Snapper Creek Canal at S-22	17.5	10.8	4.21	2.12	2.02	1.14	1.73	5.69	11.2	9.66	14.1	19.8	173
2/19	02290710	Black Creek Canal at S-21	12.3	10.5	5.13	2.99	1.97	1.26	1.65	7.05	11.4	12.0	13.0	20.7	127
3/20	02290725	Mowry Canal at S-20F	13.9	11.0	7.17	4.29	4.06	2.16	2.35	4.58	12.4	11.6	12.0	14.4	204
21	02290769	Canal 111 above S-18C	13.1	5.42	1.33	0.38	1.23	0.06	2.65	6.96	26.8	9.58	10.6	21.8	57.5
22	02291000	Barron River Canal	14.6	9.90	7.20	6.04	5.70	5.21	3.29	2.36	6.23	9.99	13.1	16.5	102
23	02291143	Fahka Union Canal	15.0	5.28	2.87	2.93	2.61	3.49	1.91	1.36	6.83	13.8	18.6	25.3	226
24	02291270	Henderson Creek Canal	10.2	3.77	3.98	3.55	3.49	3.46	1.40	1.50	8.80	16.7	22.3	20.8	24.5
25	02291300	Golden Gate Canal	11.1	5.43	4.30	3.44	3.35	3.94	1.99	3.59	9.87	13.9	17.6	21.6	307
26	02291300	Cocohatchee River Canal	11.8	4.17	2.66	2.37	2.52	3.57	1.71	1.66	4.44	11.7	23.1	30.3	29.3
27	02292900	Caloosahatchee River at S-79	9.41	5.14	4.22	8.25	8.40	9.01	6.58	3.48	7.27	11.6	13.8	12.8	1,405

1/ Based on 7 water-year period (1974-80).
2/ Based on 10 water-year period (1970-77, 1979-80) and October through December 1977.
3/ Based on 10 water-year period (1971-80) and March through September 1970.

Tables that show the number of no-flow or leakage-only days and lowest mean discharge for each consecutive day period were generated by WATSTORE daily values computer programs. Flow-duration curves and tables and the frequency curves were also derived from WATSTORE programs. Frequency curves were graphically fitted using the plotting position formula:

$$\text{Recurrence interval} = (\underline{n} + 1)/\underline{m}$$

where n is the number of years, and m is the order number. The order number is the ranking from the smallest to the largest of an array of values of lowest mean discharge for specified consecutive days during the period of consecutive months having the greatest percentage of annual discharge.

Frequency curves are based upon and represent only those conditions present during the period of record used. These frequency curves are applicable for the existing patterns of climate, regulation, and diversions. Extrapolation of flow characteristics for large recurrence intervals should consider the effects that changes in the canal systems, climate, or management practices could have on discharge.

St. Lucie Canal at Lock near Stuart, Site 1

Water in the St. Lucie Canal flows from the east edge of Lake Okeechobee northeasterly to the South Fork of the St. Lucie River (fig. 2). Flow is regulated by navigation locks and control structures at Lake Okeechobee (S-308) and near the coast at S-80.

The gaging station is at the upstream end of the Stuart lock chamber (S-80), 6.3 miles southwest of Stuart. Mean daily discharge from October 1969 to September 1980 was 395 ft^3/s. The maximum and minimum daily discharges were 11,500 and 4 ft^3/s, respectively. The minimum discharge represents the estimated leakage through the control that occurred for 58 days during 1976, when the locks were closed for repairs. Estimated leakage and lockage discharges, as determined by the U.S. Army Corps of Engineers, vary during the year and range from 12 to 20 ft^3/s. There was no well-defined period of high discharge during water years 1970-80 (table 2). For this reason, frequency analyses are not presented for this site. Only the flow-duration analysis for the 1970-80 water years is presented. The following table lists the number of days in each water year when discharge consisted of only leakage or lockage:

	Water years										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Number of days discharge consisted of leakage or lockage only.	12	149	281	365	342	365	365	343	288	192	175

Flow-duration data are shown in figure 3 and are listed in table 3.

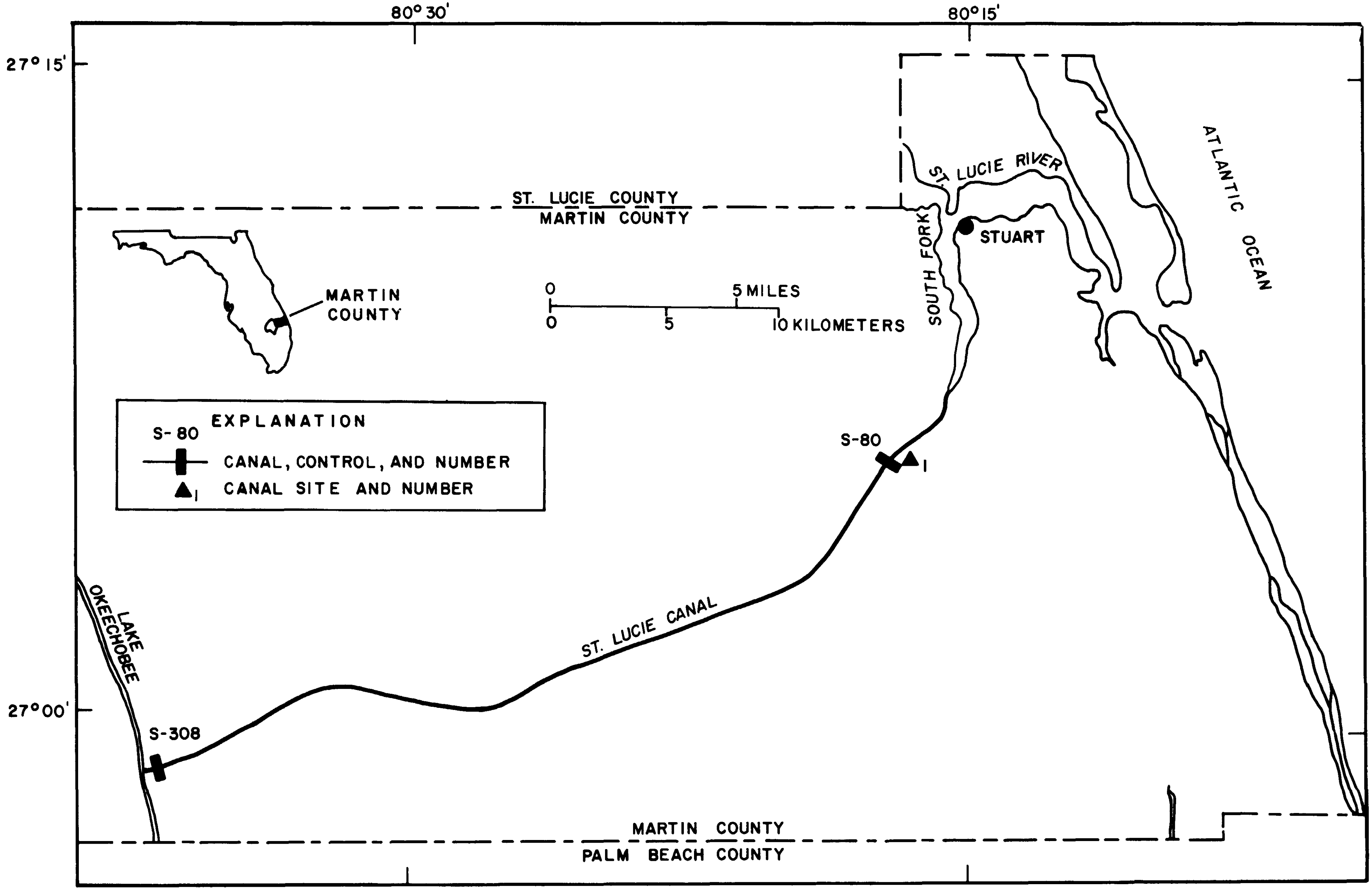

Figure 2.--Location of canal, canal site, and controls in Martin County.

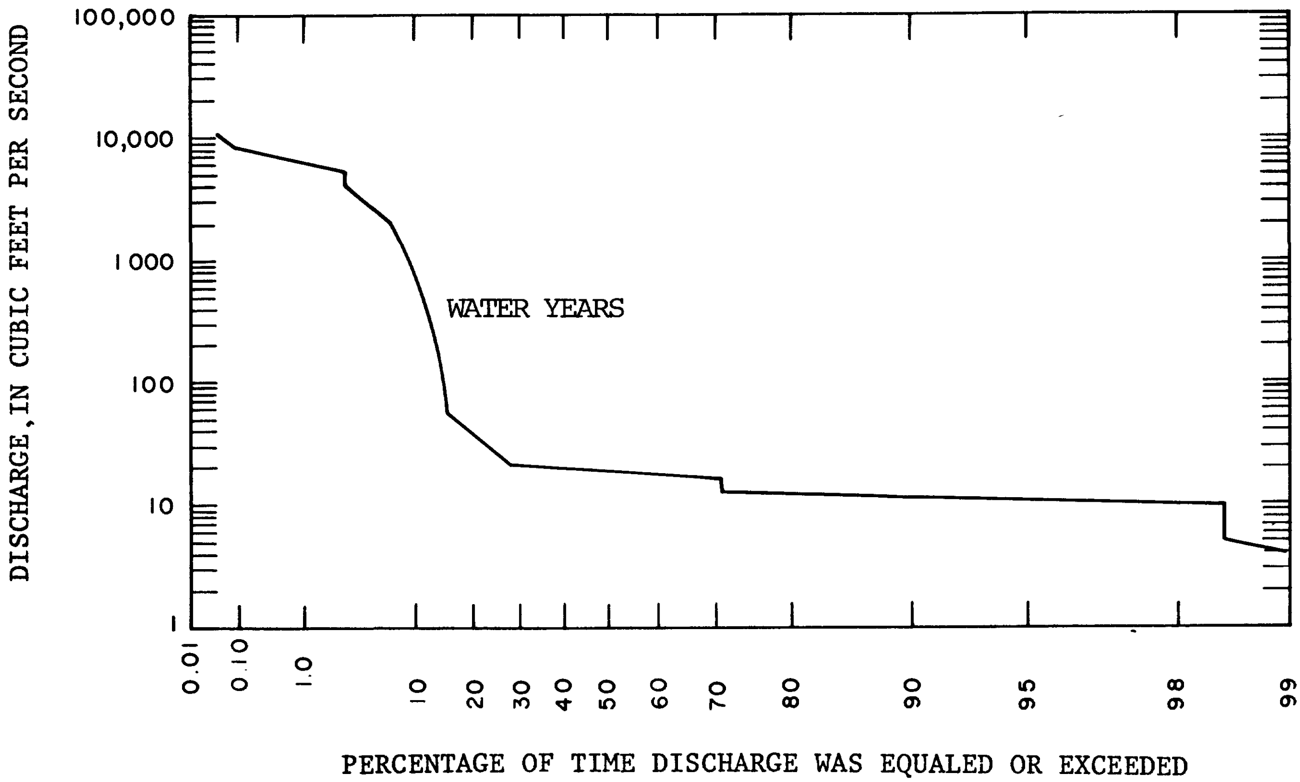

Figure 3.--Flow-duration curve for water years 1970-80, St. Lucie Canal at lock near Stuart, site 1.

Table 3.--Summary of flow-duration data at 27 canal sites for water years 1970-80

[Discharge in cubic feet per second]

Site No.	Downstream order No.	Canal name and structure	Mean discharge	Discharge equaled or exceeded for indicated percentage of time						
				95	90	75	70	50	25	10
1	02277000	St. Lucie Canal at lock near Stuart, S-80.	395	10	11	13	17	19	28	680
2	02279000	West Palm Beach Canal at S-155	426	11	11	58	90	240	640	1,100
3	02281500	Hillsboro Canal at lock near Deerfield Beach.	177	20	21	22	23	66	230	460
4	02282100	Cypress Creek Canal at S-37A	118	.0	.0	.1	.1	12	160	390
5	02282700	Middle River Canal at S-36	65.7	.0	.0	.0	.0	.1	80	240
6	02283200	Plantation Road Canal at S-33	21.1	.0	.0	.1	.1	16	33	51
7	02285000	North New River Canal at Sewell Lock.	176	15	16	17	17	90	210	380
8	02286100	South New River Canal at S-13	142	.0	.1	42	55	110	220	310
9	02286300	Snake Creek Canal at S-29	346	.1	.1	.4	.4	240	570	920
10	02286340	Biscayne Canal at S-28	77.5	.0	.0	.0	.1	.1	120	260
1/11	02286380	Little River Canal at S-27	138	.0	.1	60	78	130	200	260
12	02288600	Miami Canal at S-26	225	.0	2.0	65	95	210	340	490
13	02288800	Tamiami Canal, Monroe to Carnestown.	334	.0	.0	23	34	97	510	1,000
14	02288900	Tamiami Canal, 40-Mile Bend to Monroe.	210	.0	.1	17	27	74	300	680
15	02289040	Tamiami Canal, Levee 67A to 40-Mile Bend.	685	30	41	100	140	380	940	1,900
16	02289060	Tamiami Canal, Levee 30 to Levee 67A.	64.1	.0	.0	14	20	42	81	170
17	02289500	Tamiami Canal near Coral Gables	131	6.5	28	75	83	120	190	250
18	02290700	Snapper Creek Canal at S-22	173	.0	.1	.1	.2	.3	310	530
2/19	02290710	Black Creek Canal at S-21	127	.0	.0	.1	.1	79	190	330
3/20	02290725	Mowry Canal at S-20F	204	.0	.0	.1	.1	160	340	500
21	02290769	Canal 111 above S-18C	57.5	.0	.0	.0	.0	.1	12	48
22	02291000	Barron River Canal	102	5.5	8.9	23	35	97	170	210
23	02291143	Fahka Union Canal	226	.0	.0	23	42	110	330	700
24	02291270	Henderson Creek Canal	24.5	.6	2.1	5.1	6.4	12	32	65
25	02291300	Golden Gate Canal	307	4.6	25	77	97	200	440	760
26	02291393	Cocohatchee River Canal	29.3	.9	1.6	4.3	5.2	10	29	85
27	02292900	Caloosahatchee River at S-79	1,405	8.7	9.3	12	26	300	1,500	5,200

1/ Based on 7 water-year period (1974-80).
2/ Based on 10 water-year period (1970-77, 1979-80) and October through December 1977.
3/ Based on 10 water-year period (1971-80) and March through September 1970.

West Palm Beach Canal at West Palm Beach, Site 2

Water in the West Palm Beach Canal flows from Canal Point on the southeast edge of Lake Okeechobee to just south of West Palm Beach (fig. 4). Discharge and the water-surface elevation in the canal are regulated for irrigation and drainage purposes by operation of hurricane gate structure 5 (HGS-5) at Canal Point, S-5A control structure, and control structure and gate in the lock chamber at West Palm Beach (control structure S-155). The lock chamber is not used for navigation.

The gaging station is on the upstream side of the lock and control structure (S-155), 0.6 mile upstream from the bridge on U.S. Highway 1 at West Palm Beach. Mean daily discharge from October 1969 to September 1980 was 426 ft^3/s. The maximum and minimum daily discharges were 4,280 and 10 ft^3/s, respectively. The 10 ft^3/s value is estimated leakage (U.S. Geological Survey Water Data Report FL-78-2A1). Table 2 shows the greatest percentage of discharge for the 1970-80 water years occurred during June through November. Mean daily discharge for June through November 1970-80 was 573 ft^3/s. The maximum and minimum daily discharges for the high-flow period were 4,280 and 10 ft^3/s, respectively. The following table lists the number of days in each June through November period when discharge consisted of leakage only:

	June - November periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Number of days discharge consisted of leakage only.	0	0	6	4	0	0	35	2	0	0	0

Figure 5 shows flow-duration data for the 11 water years and the 11 June through November periods. Tables 3 and 4 list the flow-duration data for the water years and the June through November periods, respectively.

The following table shows the lowest mean discharge (in cubic feet per second) for selected periods of consecutive days in each June through November period for West Palm Beach Canal at West Palm Beach:

Number of consecutive days	June - November periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
30	205	216	102	235	181	205	70	65	404	181	186
60	404	343	197	495	455	270	240	125	556	187	219
90	501	331	252	674	522	459	548	196	618	208	458
120	559	360	303	695	594	538	693	459	632	581	461
183	681	425	544	713	569	591	599	392	697	633	461

Figure 6 shows frequency curves based on the above data.

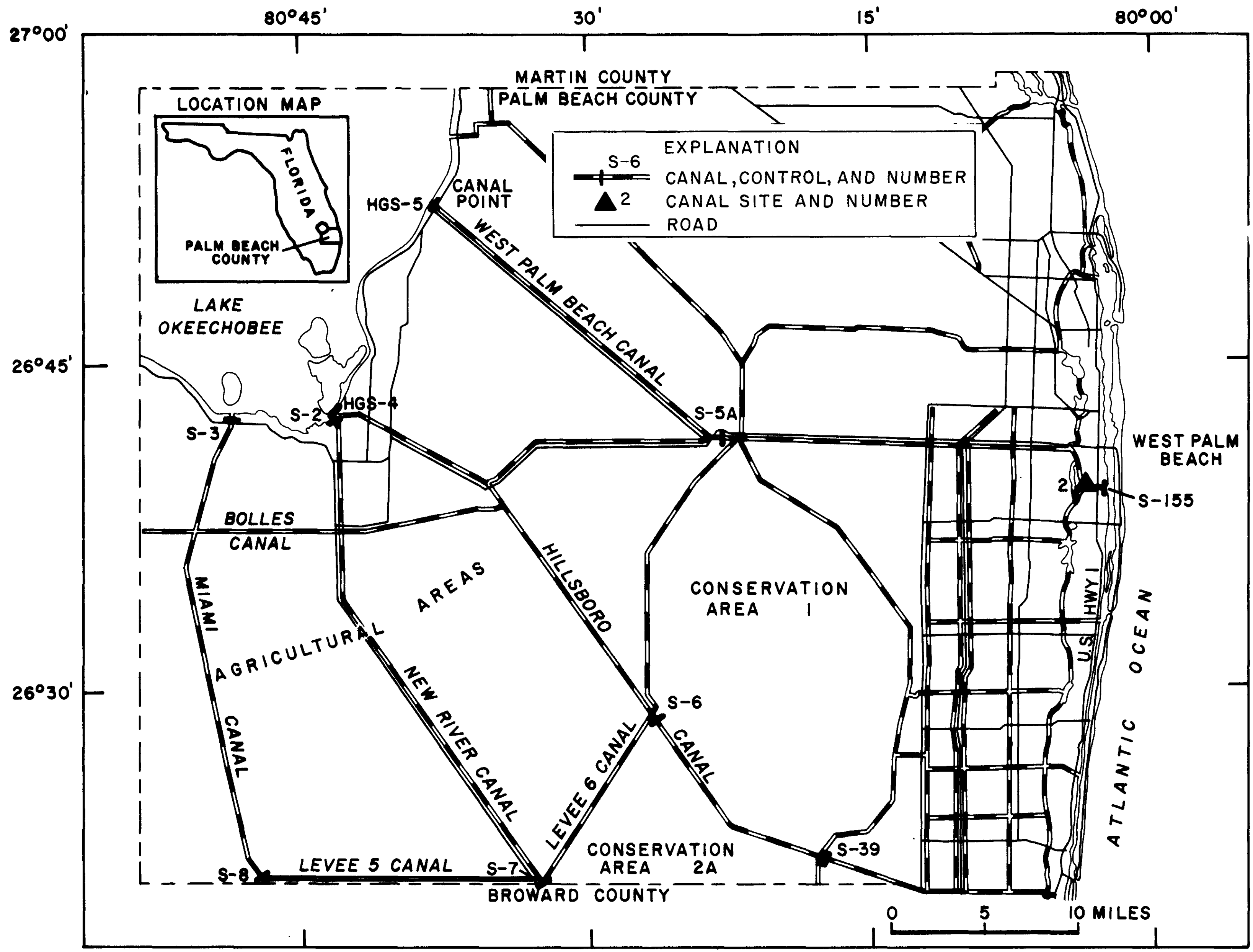

Figure 4.--Location of canals, canal site, controls, and major roads in Palm Beach County.

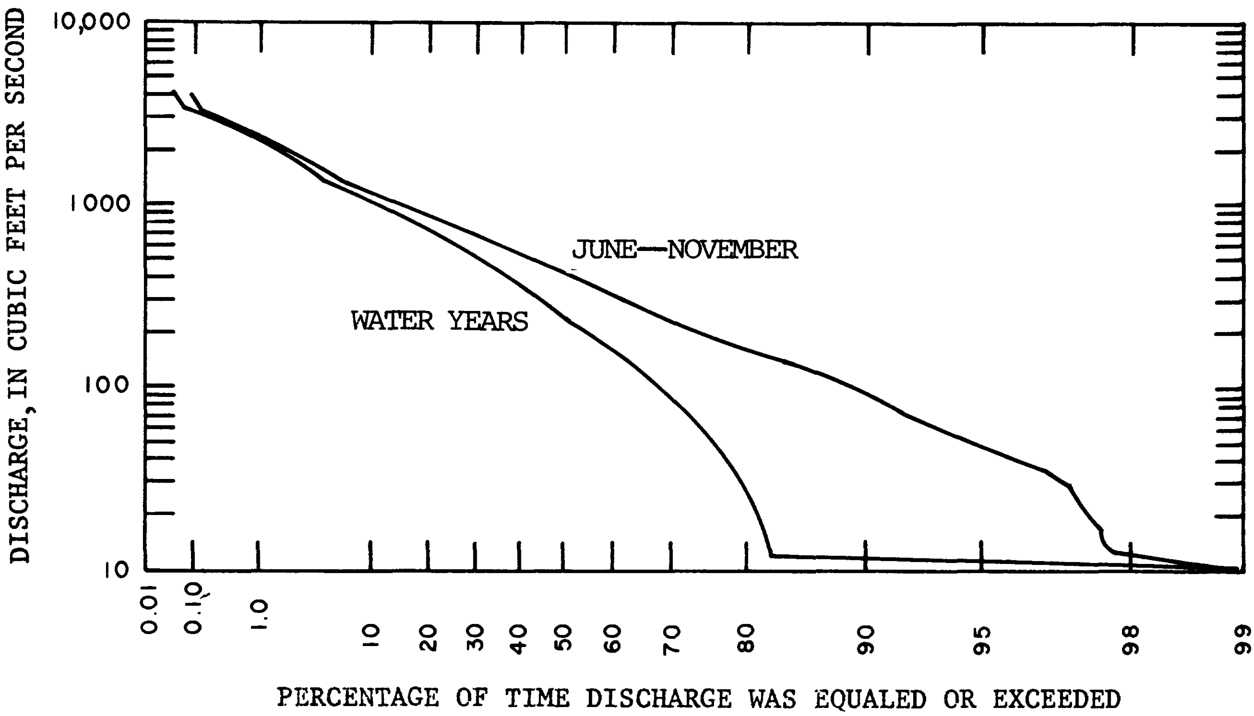

Figure 5.--Flow-duration curves for water years 1970-80 and the June through November periods 1970-80, West Palm Beach Canal at West Palm Beach, site 2.

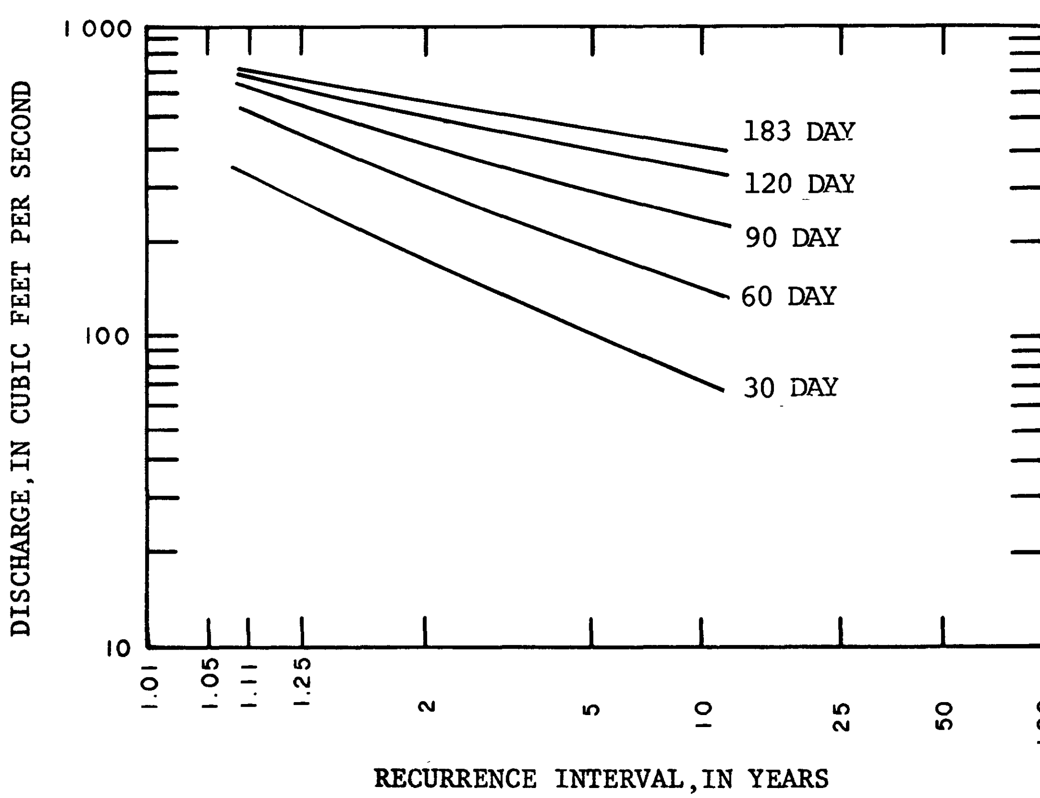

Figure 6.--Frequency curves for the indicated number of consecutive days, June through November 1970-80, West Palm Beach Canal at West Palm Beach, site 2.

Table 4.—Summary of flow-duration data at selected sites for selected periods of consecutive months during 1970-81 water years

[Discharge in cubic feet per second]

Site No.	Downstream order No.	Canal name and structure	Mean discharge	Discharge equaled or exceeded for indicated percentage of time: 95	90	75	70	50	25	10
				June through November, 1970-80						
2	02279000	West Palm Beach Canal at S-155	573	50	98	210	240	430	800	1,200
3	02281500	Hillsboro Canal at lock near Deerfield Beach.	215	21	22	37	53	140	290	480
4	02282100	Cypress Creek Canal at S-37A	148	.0	.0	.1	.1	66	230	410
6	02283200	Plantation Road Canal at S-33	24.8	.0	.0	.1	.1	21	39	54
7	02285000	North New River Canal at Sewell Lock	207	16	19	71	92	160	250	390
8	02286100	South New River Canal at S-13	164	17	34	80	93	150	230	320
9	02286300	Snake Creek Canal at S-29	468	.2	.3	180	220	410	730	1,000
12	02288600	Miami Canal at S-26	264	2.9	35	150	170	260	380	510
18	02290700	Snapper Creek Canal at S-22	281	.1	.1	.3	81	270	440	630
1/19	02290710	Black Creek Canal at S-21	203	.1	.2	85	100	160	260	420
20	02290725	Mowry Canal at S-20F	304	.0	.1	160	180	290	430	580
23	02291143	Fahka Union Canal	403	6.5	43	140	170	300	570	940
				May through October, 1970-80						
5	02282700	Middle River Canal at S-36	94.8	.0	.0	.1	.1	14	160	300
10	02286340	Biscayne Canal at S-28	119	.0	.0	.1	.1	78	190	310
21	02290769	Canal 111 above S-18C	97.7	.0	.0	.0	.1	.1	32	350
				May through October, 1974-80						
11	02286380	Little River Canal at S-27	185	28	62	120	140	180	240	300

1/ Based on June through November 1970-77, 1979-80, and October through November 1978.

Table 4.—Summary of flow-duration data at selected sites for selected periods of consecutive months during 1970-81 water years—Continued

[Discharge in cubic feet per second]

Site No.	Downstream order No.	Canal name and structure	Mean discharge	Discharge equaled or exceeded for indicated percentage of time						
				95	90	75	70	50	25	10
				June through October, 1970-80						
24	02291270	Henderson Creek Canal	46.3	3.8	7.8	18	21	38	64	95
25	02291300	Golden Gate Canal	539	110	160	290	330	470	690	1,000
27	02292900	Caloosahatchee River at S-79	1,730	9.8	13	270	340	780	2,000	5,000
				July through October, 1970-80						
13	02288800	Tamiami Canal, Monroe to Carnestown	739	72	120	300	370	650	1,100	1,500
14	02288900	Tamiami Canal, 40-Mile Bend to Monroe	429	55	76	170	200	340	650	950
26	02291393	Cocohatchee River Canal	67	6.4	9.8	21	24	40	91	160
				July through December, 1970-80						
17	02289500	Tamiami Canal near Coral Gables	156	58	73	98	110	150	210	260
22	02291000	Barron River Canal	139	27	43	85	98	140	190	240
				September through December, 1970-80						
15	02289040	Tamiami Canal, Levee 67A to 40-Mile Bend.	961	420	462	620	660	860	1,100	1,600
				September through February, 1970-80						
16	02289060	Tamiami Canal, Levee 30 to Levee 67A	69.4	7.5	13	28	33	51	84	150

Hillsboro Canal near Deerfield Beach, Site 3

The Hillsboro Canal extends 52 miles south and east from the southeast tip of Lake Okeechobee to the Intracoastal Waterway. At its upper end, it is joined in a common pool at Lake Okeechobee by the North New River Canal. Discharge into and out of Lake Okeechobee is regulated by hurricane gate structure 4 (HGS-4) and pump station 2 (S-2) (fig. 4). Pump station 6 (S-6) downstream from the lake maintains water levels in agricultural areas southeast of the lake. Water removed from the canal by S-6 is transferred into Conservation Area 1. The canal also collects and distributes water between Conservation Areas 1 and 2A. Discharge through the canal is also regulated at control structure 39 (S-39) which releases water into Broward County, 10 miles west of Deerfield Beach (fig. 7). Water then flows eastward to a lock and dam near Deerfield Beach, where discharge to the Intracoastal Waterway is regulated by a control structure and gate in the lock chamber. The lock chamber is not used for navigation.

The gaging station is at the upstream end of the lock chamber, 2 miles west of Deerfield Beach and 4.4 miles east of State Road 7. Mean daily discharge from October 1969 to September 1980 was 177 ft^3/s. The maximum and minimum daily discharges were 3,030 and 20 ft^3/s, respectively. The 20 ft^3/s is estimated leakage through the control (U.S. Geological Survey Water Data Report FL-78-2A1). Table 2 shows the greatest percentage of discharge for the 1970-80 water years occurred during June through November. Mean daily discharge for June through November 1970-80 was 215 ft^3/s. The maximum and minimum daily discharges for the high-flow period were 2,620 and 20 ft^3/s, respectively. The following table lists the number of days in each June through November period when discharge consisted of leakage only:

	June - November periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Number of days discharge consisted of leakage only.	34	87	20	13	15	40	22	36	13	38	28

Figure 8 shows flow-duration data for the 11 water years and the 11 June through November periods. Tables 3 and 4 list the flow-duration data for the water years and June through November periods, respectively.

The following table shows the lowest mean discharge (in cubic feet per second) for selected periods of consecutive days in each June through November period for Hillsboro Canal near Deerfield Beach:

Number of consecutive days	June - November periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
30	25	22	38	119	92	24	79	30	93	30	70
60	154	23	84	188	167	54	86	47	118	54	79
90	194	34	123	307	216	122	158	140	161	60	123
120	177	70	144	375	202	213	195	223	176	137	126
183	252	125	214	353	248	241	190	204	210	182	141

Figure 9 shows frequency curves based on the above data.

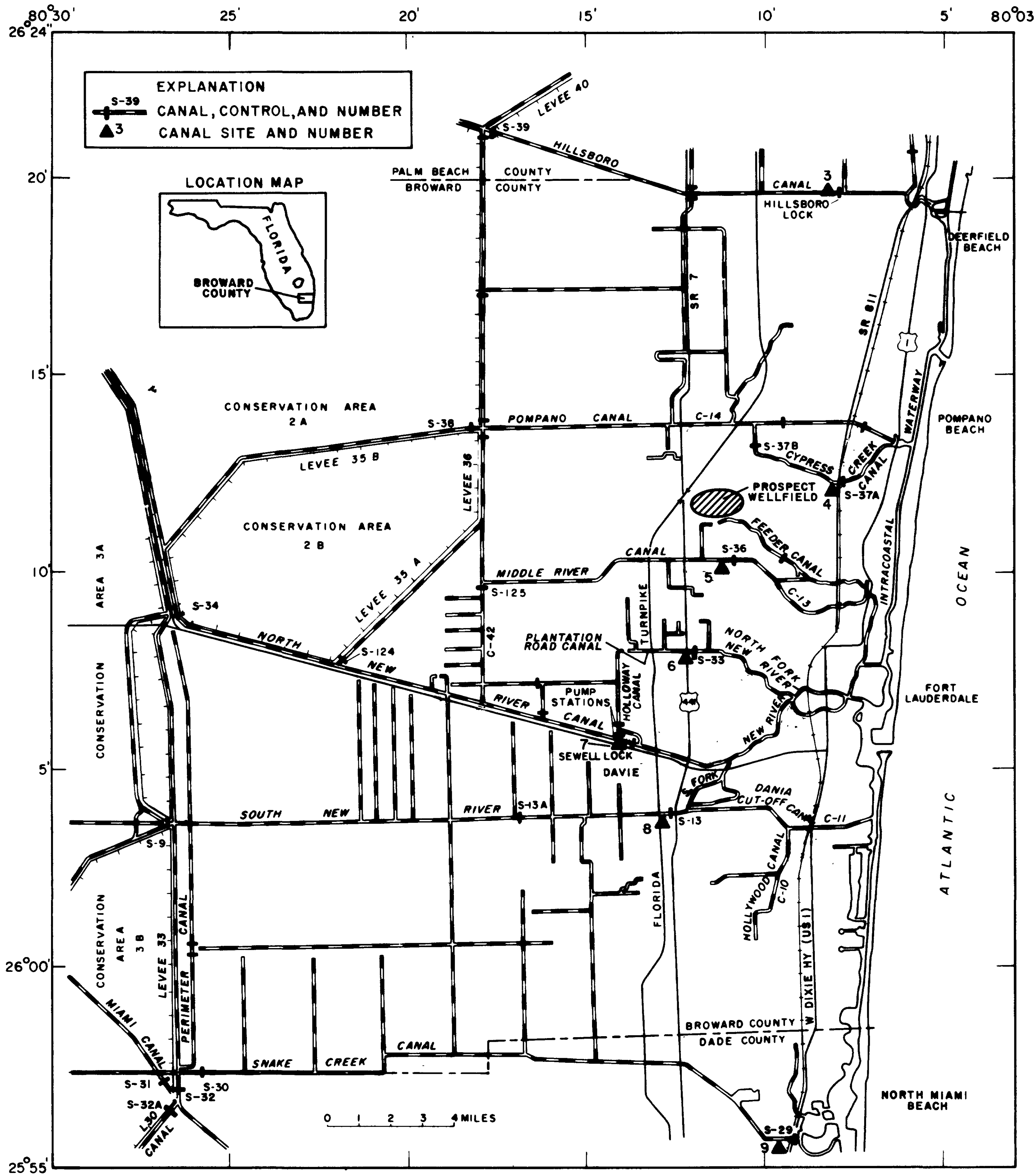

Figure 7.--Location of canals, canal sites, controls, and major roads in Broward County.

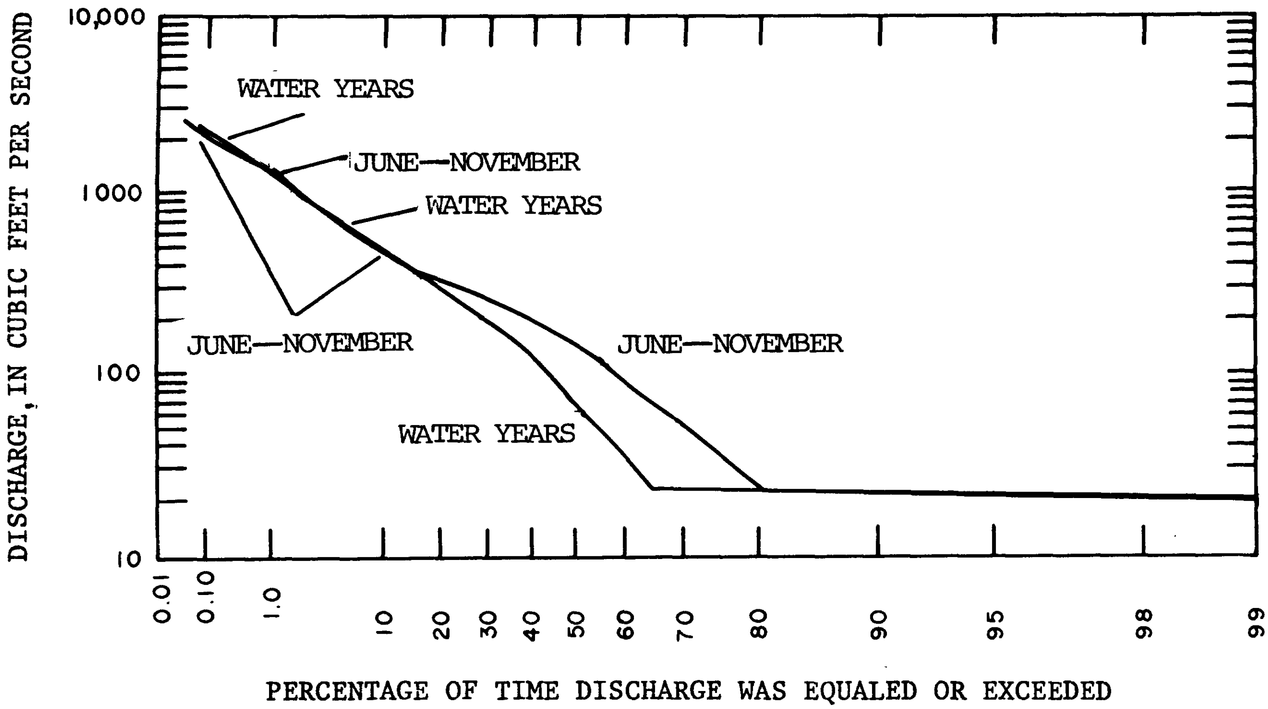

Figure 8.--Flow-duration curves for water years 1970-80 and the June through November periods 1970-80, Hillsboro Canal near Deerfield Beach, site 3.

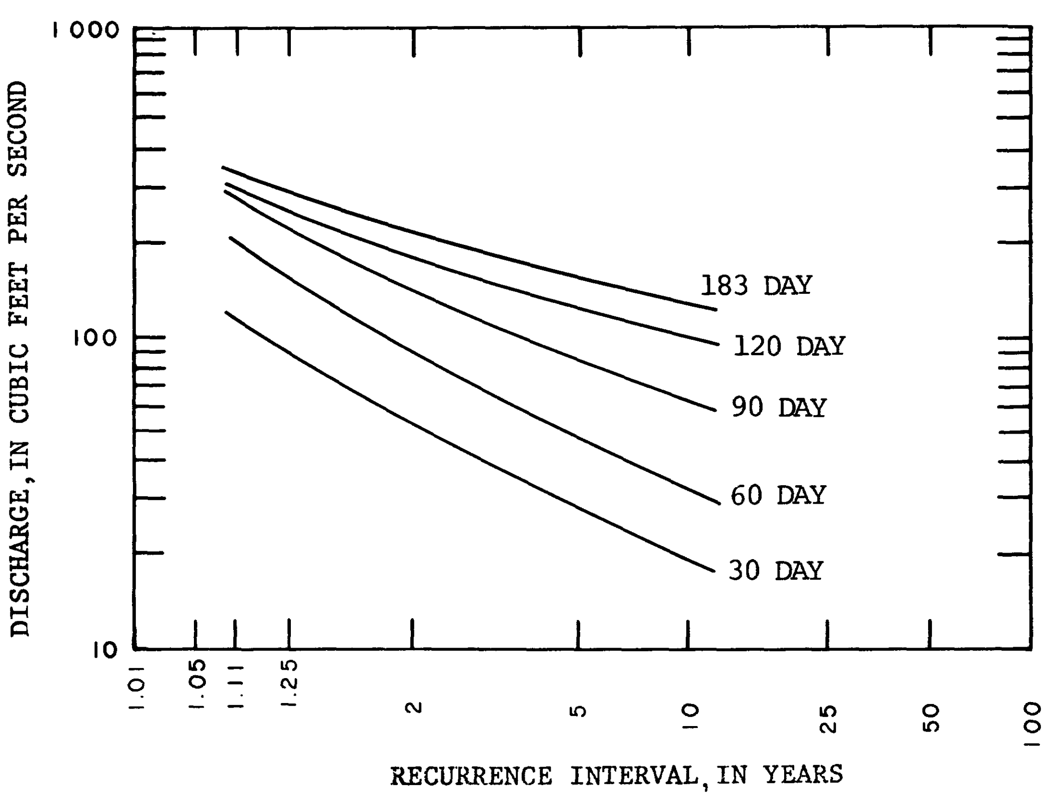

Figure 9.--Frequency curves for the indicated number of consecutive days, June through November 1970-80, Hillsboro Canal at Deerfield Beach, site 3.

Cypress Creek Canal at S-37A near Pompano Beach, Site 4

The Cypress Creek Canal is connected to the Pompano Canal, 3 miles west of Pompano Beach (fig. 7). At this point, flow either continues eastward through the Pompano Canal or is diverted southeastward in the Cypress Creek Canal. Discharge in the Cypress Creek Canal is regulated by operation of the salinity-control structure 37A (S-37A) and control structure 37B (S-37B), 2.8 miles upstream of S-37A. Discharge into the Cypress Creek Canal is also affected by operation of control structure 38 (S-38) on the Pompano Canal at Levee 36 (fig. 7). Flow at S-37A is affected by tides and occasionally reverses.

The gaging station is on the upstream side of the bridge on State Road 811, 300 feet upstream from S-37A and 3 miles southwest of Pompano Beach. Mean daily discharge from October 1969 to September 1980 was 118 ft^3/s. The maximum and minimum daily discharges were 2,950 and 0.0 ft^3/s, respectively. Table 2 shows the greatest percentage of discharge for the 1970-80 water years occurred during June through November. Mean daily discharge for June through November 1970-80 was 148 ft^3/s. The maximum and minimum daily discharges for the high-flow period were 1,910 and 0.0 ft^3/s, respectively. The following table lists the number of no-flow days in each June through November period:

	June - November periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Number of no-flow days.	20	91	1	31	26	73	99	111	53	97	85

Figure 10 shows flow-duration data for the 11 water years and the 11 June through November periods. Tables 3 and 4 list the flow-duration data for the water years and June through November periods, respectively.

The following table shows the lowest mean discharge (in cubic feet per second) for selected periods of consecutive days in each June through November period for Cypress Creek Canal at S-37A near Pompano Beach:

Number of consecutive days	June - November periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
30	6.5	0	113	35	49	0	0	0	114	0	6.7
60	55	0	118	92	95	21	12	18	148	15	70
90	67	5	122	128	109	65	99	102	189	13	115
120	68	36	129	148	104	116	167	153	230	79	153
183	214	57	158	136	130	136	160	151	207	137	142

Figure 11 shows frequency curves based on the above data.

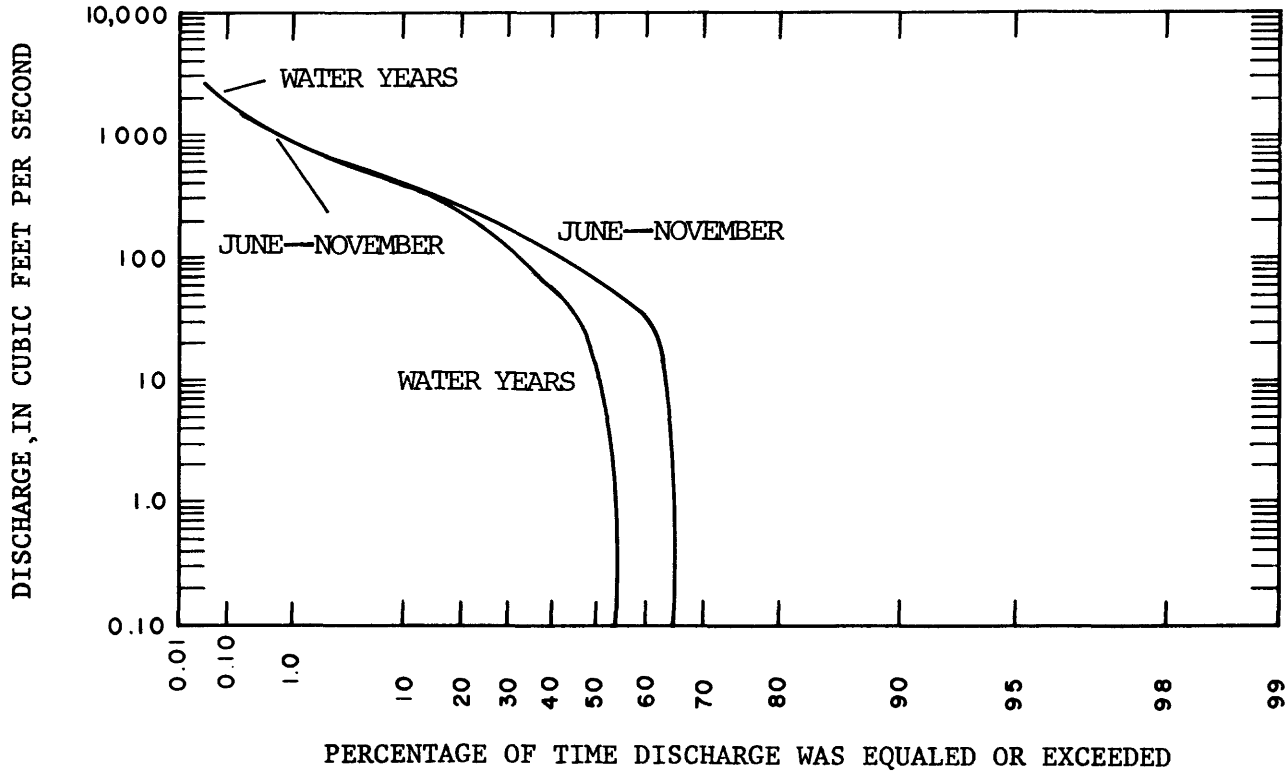

Figure 10.--Flow-duration curves for water years 1970-80 and the June through November periods 1970-80, Cypress Creek Canal at S-37A near Pompano Beach, site 4.

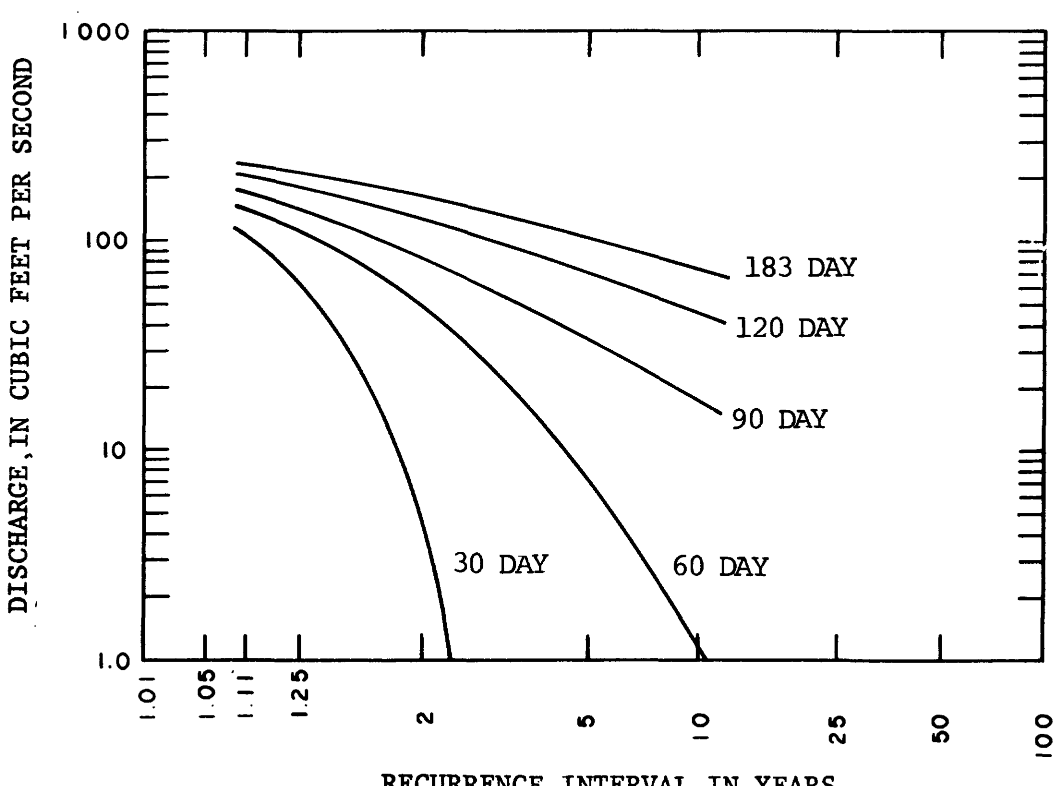

Figure 11.--Frequency curves for the indicated number of consecutive days, June through November 1970-80, Cypress Creek Canal at S-37A near Pompano Beach, site 4.

Middle River Canal at S-36 near Fort Lauderdale, Site 5

The Middle River Canal extends eastward from Canal C-42 near Conservation Area 2B through the northern part of the Fort Lauderdale area to the Intracoastal Waterway (fig. 7). Discharge is regulated by operation of salinity-control structure 36 (S-36) and at times is affected by tides and reversed. A bypass feeder canal is connected to the north side of the Middle River Canal, 1 mile west of S-36. Discharge into the feeder canal from the Middle River Canal recharges the Biscayne aquifer in the area of Fort Lauderdale's Prospect well field.

The gaging station is 120 feet upstream from S-36, 1.5 miles east of the bridge on U.S. Highway 441 and 5 miles west of Fort Lauderdale. Mean daily discharge from October 1969 to September 1980 was 65.7 ft^3/s. The maximum and minimum daily discharges were 1,490 and -24 ft^3/s, respectively. Table 2 shows the greatest percentage of discharge for the 1970-80 water years occurred during May through October. Mean daily discharge for May through October 1970-80 was 94.8 ft^3/s. The maximum and minimum daily discharges for the high-flow period were 1,200 and 0.0 ft^3/s, respectively. The following table lists the number of no-flow days in each May through October period:

	May - October periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Number of no-flow days.	149	174	46	126	146	38	102	51	73	57	41

Figure 12 shows flow-duration data for the 11 water years and the 11 May through October periods. Tables 3 and 4 list the flow-duration data for the water years and the May through October periods, respectively.

The following table shows the lowest mean discharge (in cubic feet per second) for selected periods of consecutive days in each May through October period for Middle River Canal at S-36 near Fort Lauderdale:

Number of consecutive days	May - October periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
30	0	0	14	0	0	3.7	4.7	40	9.5	54	94
60	0	0	26	0	24	37	68	59	51	92	135
90	0	0	38	18	22	87	116	102	94	97	155
120	37	0	50	22	32	114	108	102	123	108	163
183	35	3	64	29	32	150	128	135	150	151	161

Figure 13 shows frequency curves based on the above data.

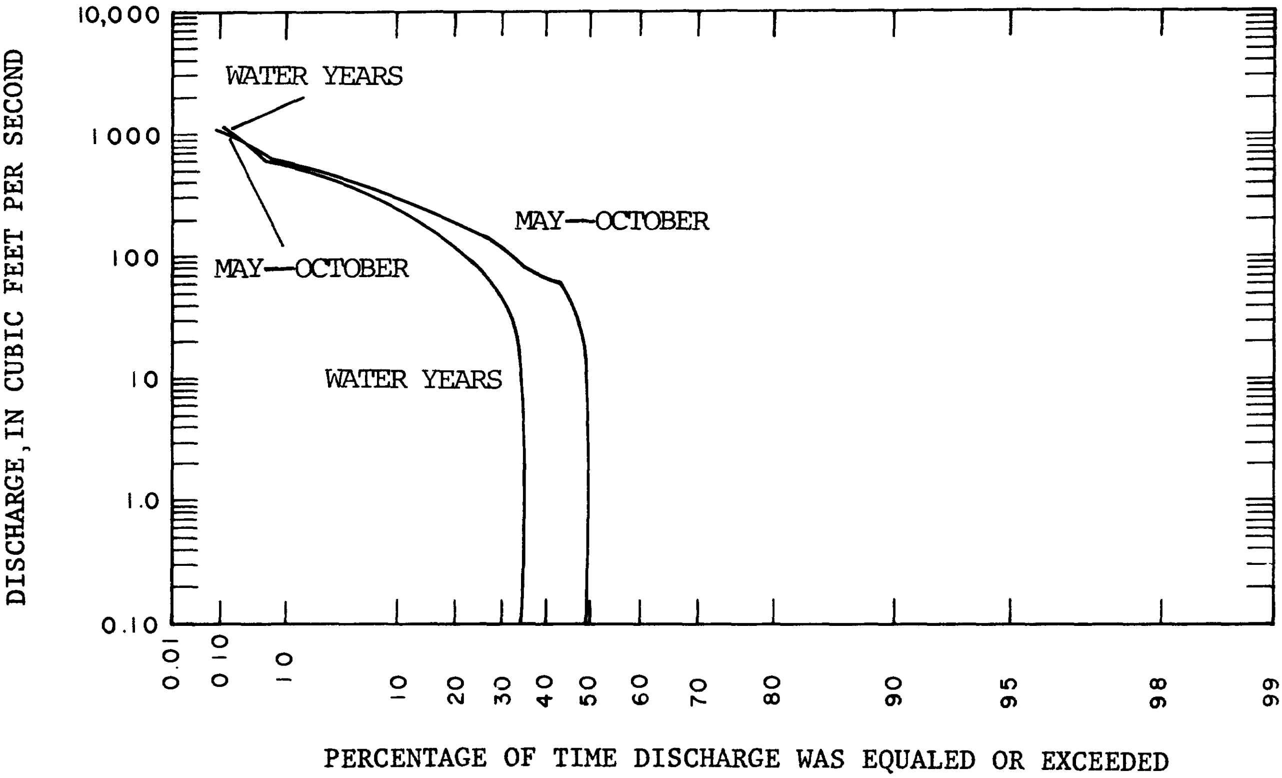

Figure 12.--Flow-duration curves for water years 1970-80 and the May through October periods 1970-80, Middle River Canal at S-36 near Fort Lauderdale, site 5.

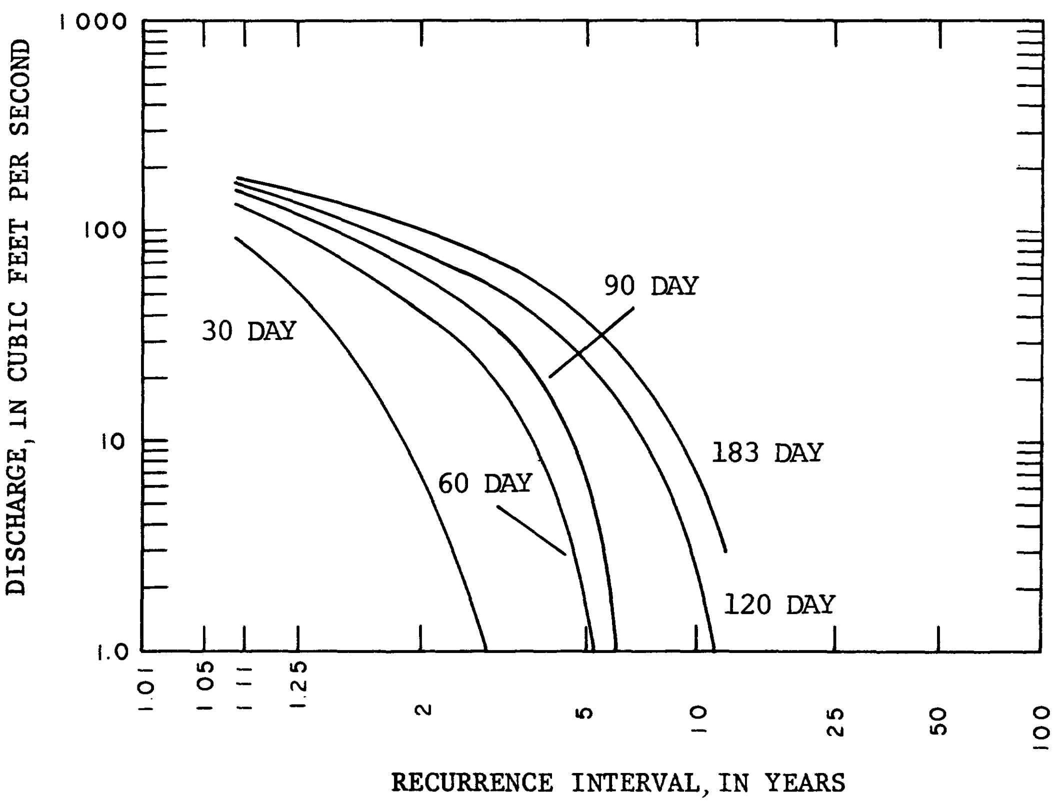

Figure 13.--Frequency curves for the indicated number of consecutive days, May through October 1970-80, Middle River Canal at S-36 near Fort Lauderdale, site 5.

Plantation Road Canal at S-33 near Fort Lauderdale, Site 6

The Plantation Road Canal (fig. 7) is joined to the North Fork of the New River approximately 4 miles downstream of salinity-control structure 33 (S-33). It extends westward to the Holloway Canal which runs north and south about 1 mile west of the Florida Turnpike. Discharge in the Plantation Road Canal is regulated by S-33 and at times is affected by tides and reversed. Seaward flow in Plantation Road Canal at S-33 is generally small because of its relatively small drainage area (Sherwood and others, 1973, p. 24).

The gaging station is 130 feet upstream from S-33, 0.5 mile east of the bridge on U.S. Highway 441 and 4 miles west of Fort Lauderdale. Mean daily discharge from October 1969 to September 1980 was 21.1 ft^3/s. The maximum and minimum daily discharges were 614 and 0.0 ft^3/s, respectively. Table 2 shows the greatest percentage of discharge for the 1970-80 water years occurred during June through November. Mean daily discharge for June through November 1970-80 was 24.8 ft^3/s. The maximum and minimum daily discharges for the high-flow period were 604 and 0.0 ft^3/s. The following table lists the number of no-flow days in each June through November period:

	June - November periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Number of no-flow days.	61	148	29	19	14	70	32	49	24	77	92

Figure 14 shows flow-duration data for the 11 water years and the 11 June through November periods. Tables 3 and 4 list the flow-duration data for the water years and the June through November periods, respectively.

The following table shows the lowest mean discharge (in cubic feet per second) for selected periods of consecutive days in each June through November period for Plantation Road Canal at S-33 near Fort Lauderdale:

Number of consecutive days	June - November periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
30	0	0	2.6	14	18	0	4.3	2.3	11	0.13	0.96
60	0	0	14	26	28	9	19	9.1	16	11	2.6
90	7.9	0.06	27	33	29	16	28	21	19	11	4.1
120	9.4	3.0	29	34	30	20	36	20	21	18	6.6
183	17	6.5	33	35	31	24	37	29	23	25	12

Figure 15 shows frequency curves based on the above data.

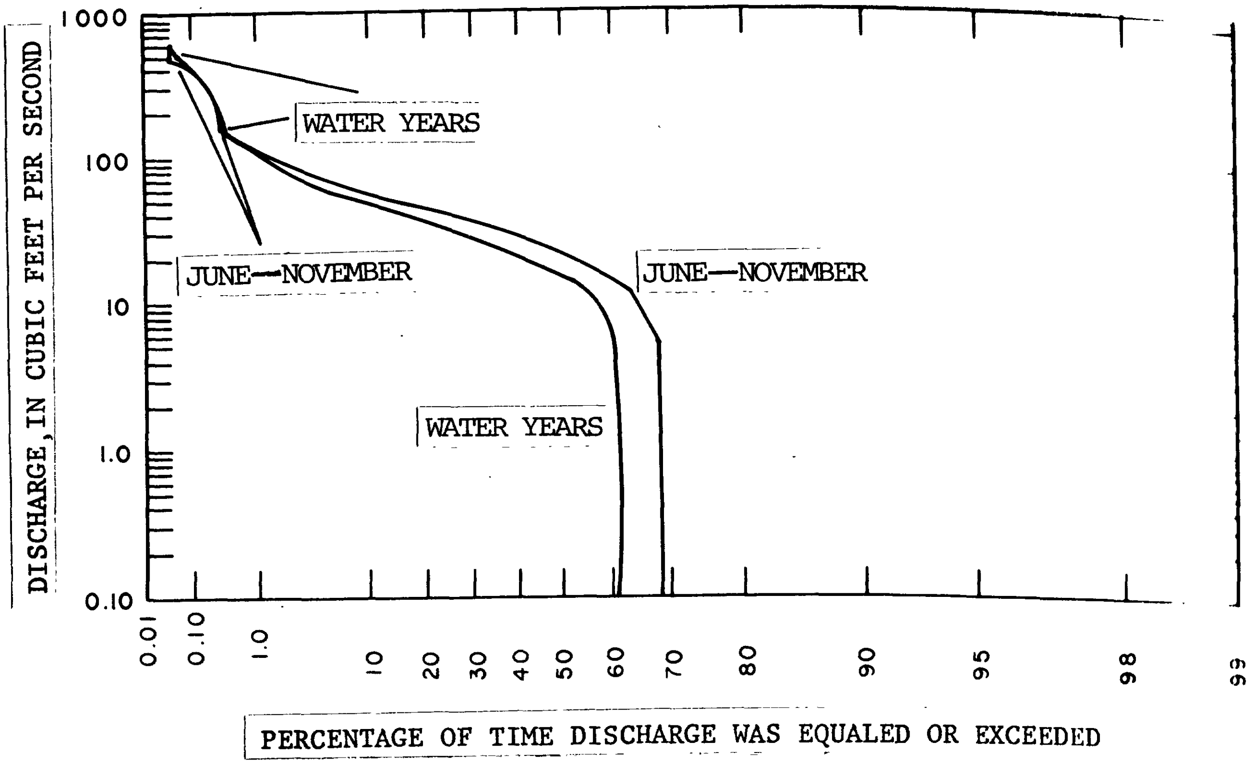

Figure 14.--Flow-duration curves for water years 1970-80 and the June through November periods 1970-80, Plantation Road Canal at S-33 near Fort Lauderdale, site 6.

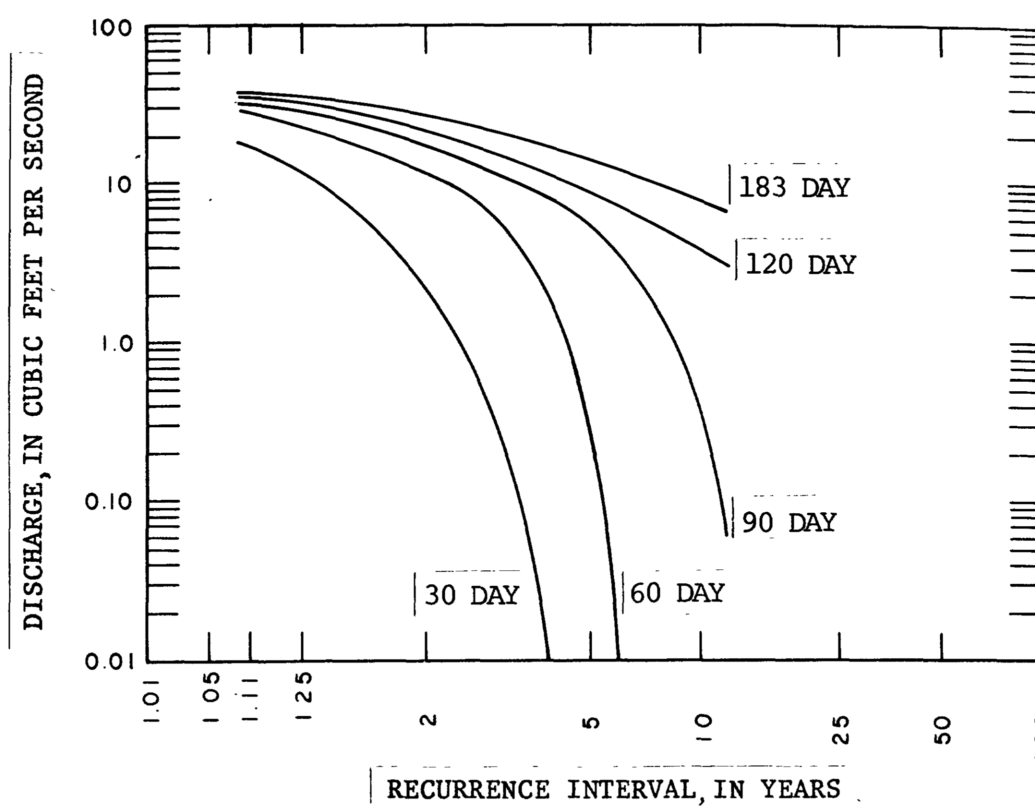

Figure 15.--Frequency curves for the indicated number of consecutive days, June through November 1970-80, Plantation Road Canal at S-33 near Fort Lauderdale, site 6.

North New River Canal near Fort Lauderdale, Site 7

The North New River Canal extends 60 miles from the lower eastern tip of Lake Okeechobee south and east to New River, and thence to the ocean (figs. 4 and 7). Its headwaters near Lake Okeechobee join those of the Hillsboro Canal. Like the Hillsboro Canal, discharge between the lake and the canal is regulated by hurricane gate structure 4 (HGS-4) and pump station 2 (S-2). At the Palm Beach-Broward County line, about 30 miles downstream from Lake Okeechobee, the North New River Canal is joined by Levee 5 and 6 canals (fig. 4). At this point, discharge is regulated by pump station 7 (S-7) and gates at S-7 that remove floodwaters from agricultural areas to the north into Conservation Area 2A. Inside Conservation Area 2A, the North New River Canal is divided by levees into an upper and lower segment. The lower canal segment collects and distributes water between Conservation Areas 2A and 3A. From the southern edge of Conservation Area 2B, flow in the North New River Canal is southeastward to the control at Sewell Lock. In this reach, the discharge is augmented by seepage and inflow from several lateral canals. Flow at times is affected by tides.

The gaging station is 20 feet upstream from the salinity-control structure at Sewell Lock, 6 miles southwest of Fort Lauderdale. Mean daily discharge from October 1969 to September 1980 was 176 ft^3/s. The maximum and minimum daily discharges were 2,160 and 15 ft^3/s, respectively. The 15 ft^3/s value is estimated leakage through the control (U.S. Geological Survey Water Data Report FL-78-2A1, 1979). Table 2 shows the greatest percentage of discharge for the 1970-80 water years occurred during June through November. Mean daily discharge for June through November 1970-80 was 207 ft^3/s. The maximum and minimum daily discharges for the high-flow period were 1,700 and 15 ft^3/s, respectively. The following table lists the number of days in each June through November period when flow consisted of leakage only:

	June - November periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Number of days discharge consisted of leakage only.	4	48	1	20	23	30	13	11	16	1	0

Figure 16 shows the flow-duration data for the 11 water years and the 11 June through November periods. Tables 3 and 4 list the flow-duration data for the water years and the June through November periods, respectively.

The following table shows the lowest mean discharge (in cubic feet per second) for selected periods of consecutive days in each June through November period for North New River Canal near Fort Lauderdale:

Number of consecutive	June - November periods										
days	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
30	95	25	55	35	34	15	32	38	137	68	146
60	197	27	112	61	152	100	54	72	156	119	189
90	217	37	149	93	141	139	102	133	181	118	200
120	227	39	166	134	155	186	150	202	184	145	227
183	540	91	205	134	161	182	149	224	203	166	217

Figure 17 shows frequency curves based on the above data.

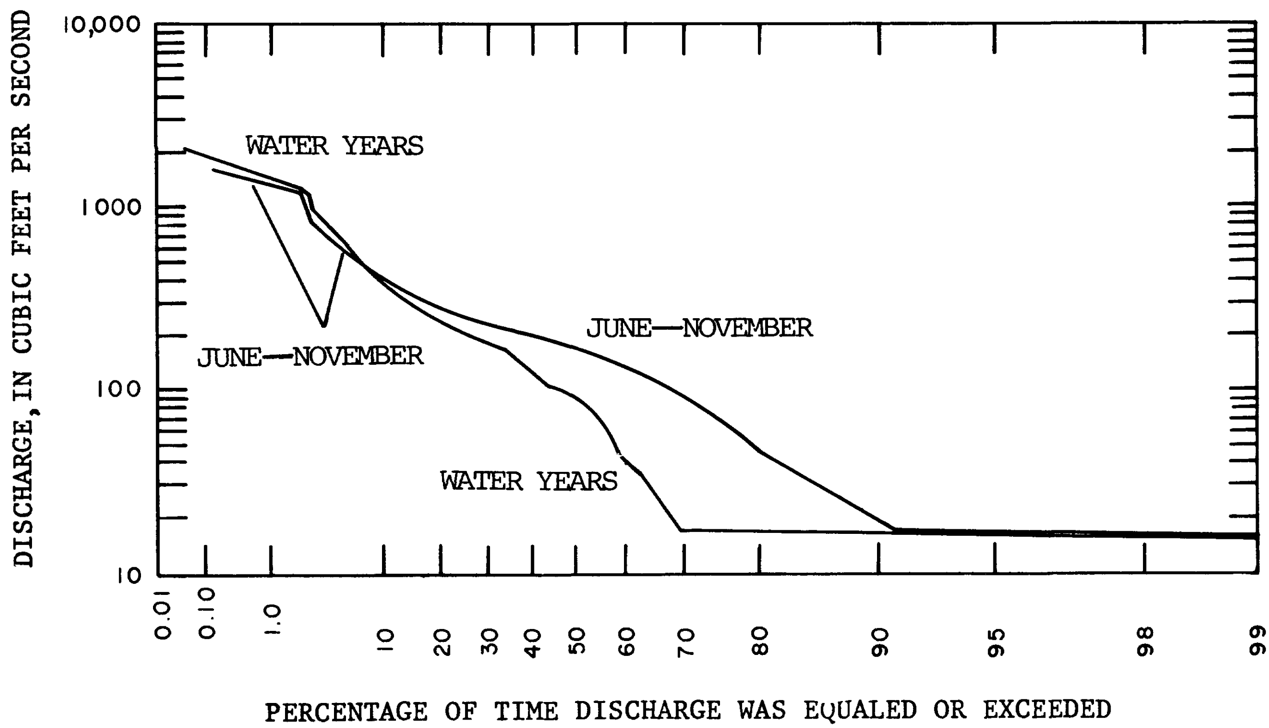

Figure 16.--Flow-duration curves for water years 1970-80 and the June through November periods 1970-80, North New River Canal near Fort Lauderdale, site 7.

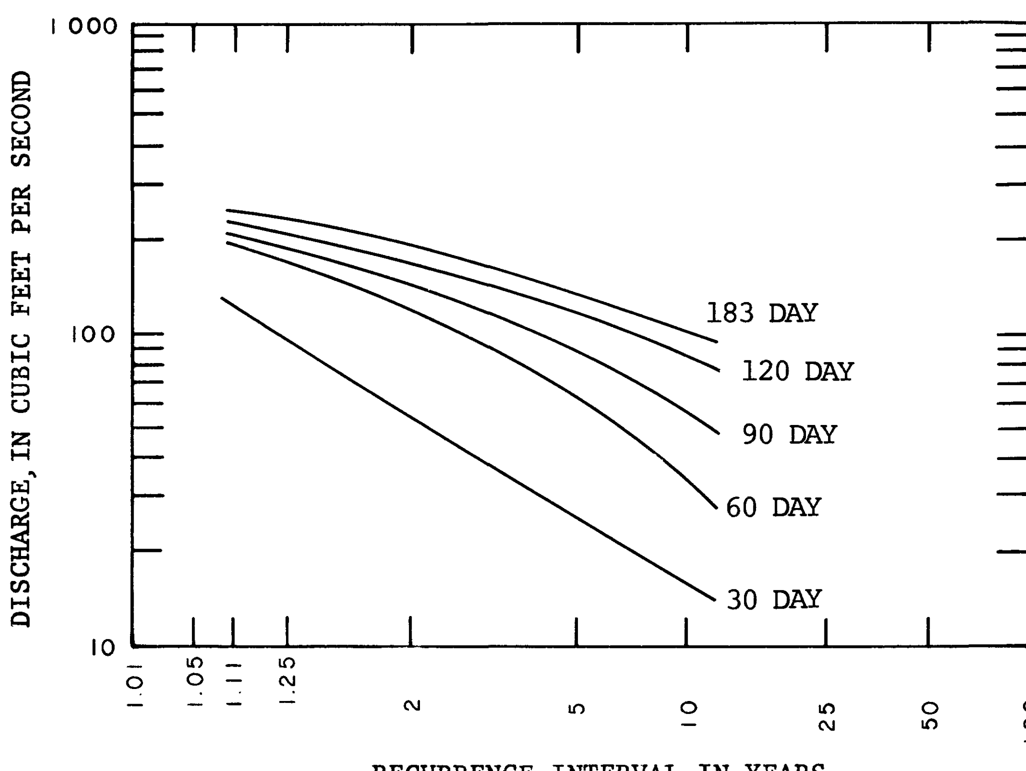

Figure 17.--Frequency curves for the indicated number of consecutive days, June through November 1970-80, North New River Canal near Fort Lauderdale, site 7.

South New River Canal at S-13 near Davie, Site 8

The South New River Canal originates in Conservation Area 3A in western Broward County and flows eastward for 23 miles to the junction with the Dania Cutoff Canal and the South Fork New River (fig. 7). The South Fork New River flows northeastward joining the New River system, whereas the Dania Cutoff Canal continues eastward to the Intracoastal Waterway. Between Conservation Area 3A and the Florida Turnpike, many drainage and irrigation canals enter the South New River Canal from both sides.

The amount and direction of flow in the South New River Canal are regulated by three control structures (fig. 7). Backpumping station 9 (S-9), 15 miles west of U.S. Highway 441, is the only pumping station on the southeast boundary of the conservation areas. Station S-9 removes floodwaters from the canal into Conservation Area 3A for use during dry periods (Sherwood and others, 1973, p. 27). Control structure 13A (S-13A) regulates flow in the central reach of the canal. Pumping station 13 (S-13) and the gate at S-13 assist gravity flow by pumping seaward excess water during flood periods. During dry periods, S-13 is used to regulate discharge from the South New River Canal. Flow is affected by tides and sometimes reversed.

The gaging station is 150 feet upstream from S-13, 300 feet west of U.S. Highway 441, and 1.5 miles east of Davie. Mean daily discharge from October 1969 to September 1980 was 142 ft^3/s. The maximum and minimum daily discharges were 987 and -111 ft^3/s, respectively. The -111 ft^3/s discharge represents reverse flow. Table 2 shows the greatest percentage of discharge for the 1970-80 water years occurred during June through November. Mean daily discharge for June through November 1970-80 was 164 ft^3/s. The maximum and minimum daily discharges for the high-flow period were 871 and -111 ft^3/s, respectively. The fol-following table lists the number of backpumping or no-flow days in each June through November period:

	June - November periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Number of back-pumping, no-flow, or reverse flow days.	0	17	4	16	9	2	3	9	1	0	2

Figure 18 shows flow-duration data for the 11 water years and the 11 June through November periods. Tables 3 and 4 list the flow-duration data for the water years and the June through November periods, respectively.

The following table shows the lowest mean discharge (in cubic feet per second) for selected periods of consecutive days in each June through November period for South New River Canal at S-13 near Davie:

Number of consecutive days	June-November periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
30	151	24	72	67	64	78	83	23	114	145	239
60	173	31	100	87	82	93	158	50	132	160	256
90	183	42	121	108	97	110	185	125	151	174	268
120	189	48	130	116	109	113	197	134	162	180	269
183	229	63	152	121	120	120	211	143	167	198	272

Figure 19 shows frequency curves based on the above data.

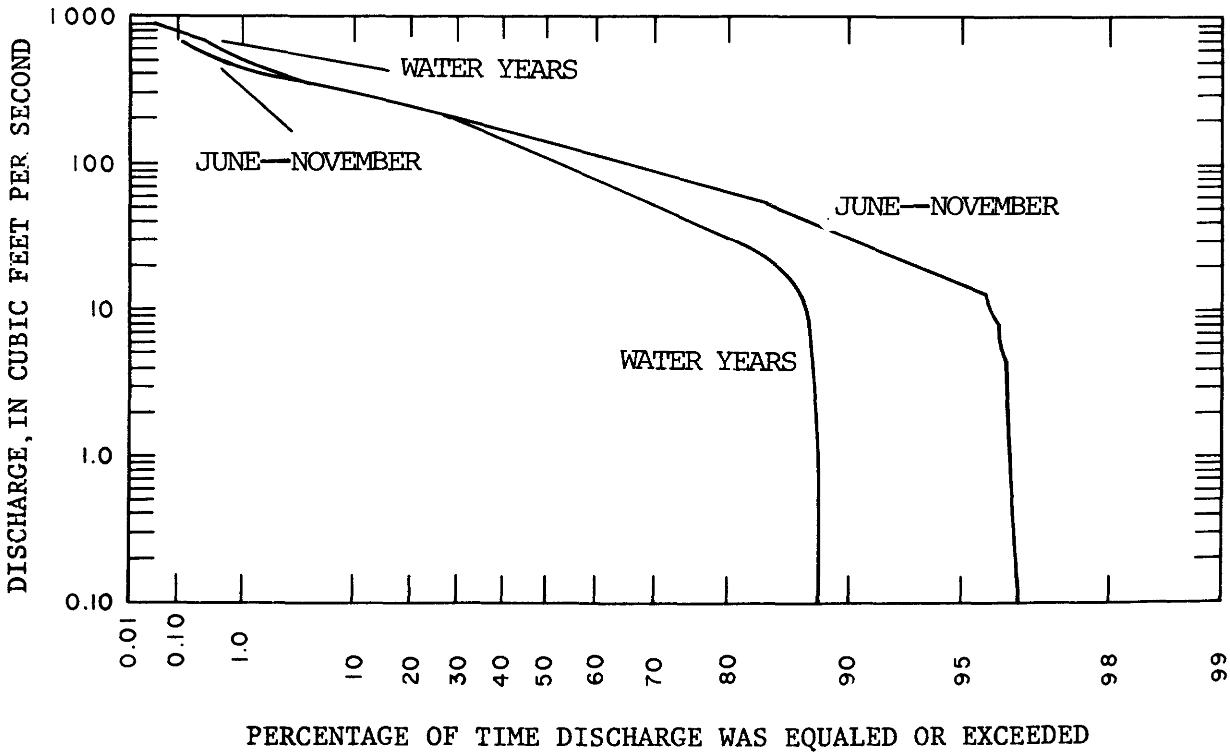

Figure 18.--Flow-duration curves for water years 1970-80 and the June through November periods 1970-80, South New River Canal at S-13 near Davie, site 8.

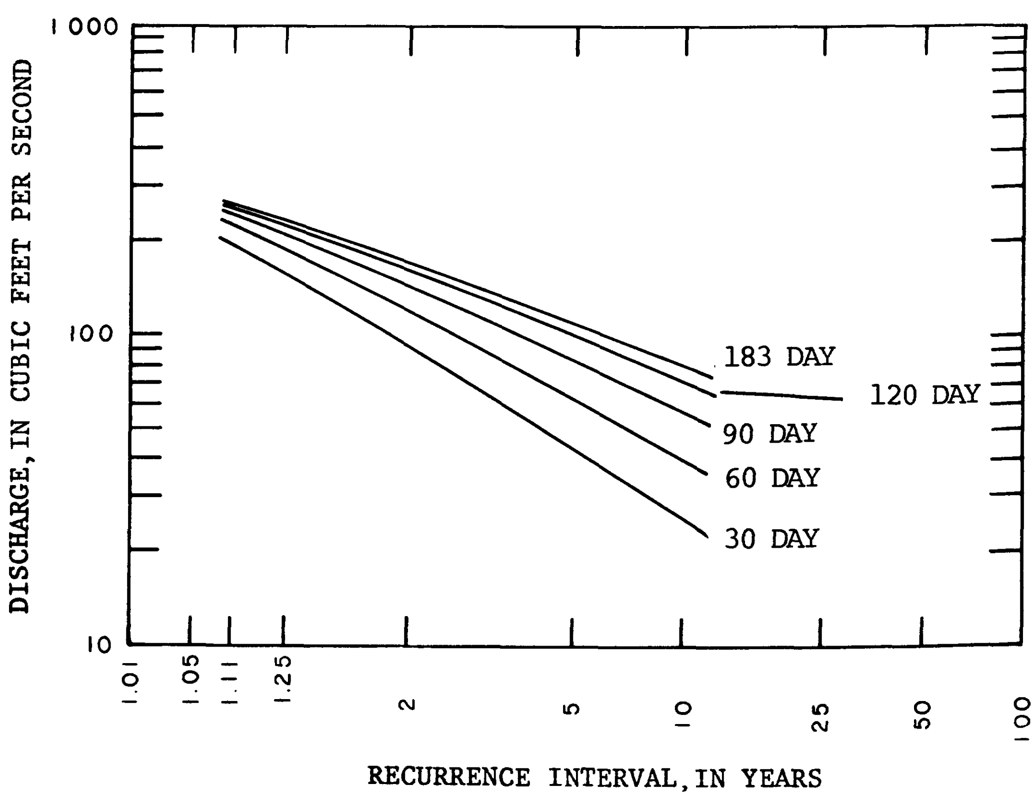

Figure 19.--Frequency curves for the indicated number of consecutive days, June through November 1970-80, South New River Canal at S-13 near Davie, site 8.

Snake Creek Canal at S-29, North Miami Beach, Site 9

The Snake Creek Canal originates in Conservation Area 3B in western Broward County (fig. 7). The canal is the primary drainage canal for the coastal area along the Dade-Broward County boundary and forms the south hydraulic boundary for Broward County (Sherwood and others, 1973, p. 27). Discharge into the canal is chiefly by ground-water inflow, although a considerable amount of surface runoff can occur during rainy periods. Water from the conservation areas to the canal is manipulated by control structure 30 (S-30), 0.75 mile east of Levee 33 (Sherwood and others, 1973, p. 27). Flow is regulated by the operation of the salinity-control structure 29 (S-29) that provides flood protection during wet periods and prevents saltwater intrusion during dry periods. Flow is affected by tides and is sometimes reversed.

The gaging station is on the downstream side of the West Dixie Highway bridge in North Miami Beach, 0.3 mile upstream from S-29 (fig. 20). Mean daily discharge from October 1969 to September 1980 was 346 ft^3/s. The maximum and minimum daily discharges were 2,250 and 0.0 ft^3/s, respectively. Table 2 shows the greatest percentage of discharge for the 1970-80 water years occurred during June through November. Mean daily discharge for June through November 1970-80 was 468 ft^3/s. The maximum and minimum daily discharges for the high-flow period were 1,790 and 0.0 ft^3/s, respectively. The following table lists the number of no-flow days in each June through November period:

	June - November periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Number of no-flow days.	13	10	3	21	27	23	16	54	35	55	49

Figure 21 shows flow-duration data for the 11 water years and the 11 June through November periods. Tables 3 and 4 list the flow-duration data for the water years and the June through November periods, respectively.

The following table shows the lowest mean discharge (in cubic feet per second) for selected periods of consecutive days in each June through November period for Snake Creek Canal at S-29, North Miami Beach:

Number of consecutive days	June - November periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
30	169	209	199	195	49	147	313	67	251	93	194
60	288	282	295	332	257	355	433	212	356	134	239
90	312	328	364	506	315	481	566	521	385	184	301
120	328	346	416	607	351	531	558	476	456	358	310
183	491	357	527	543	329	596	607	560	452	375	321

Figure 22 shows frequency curves based on the above data.

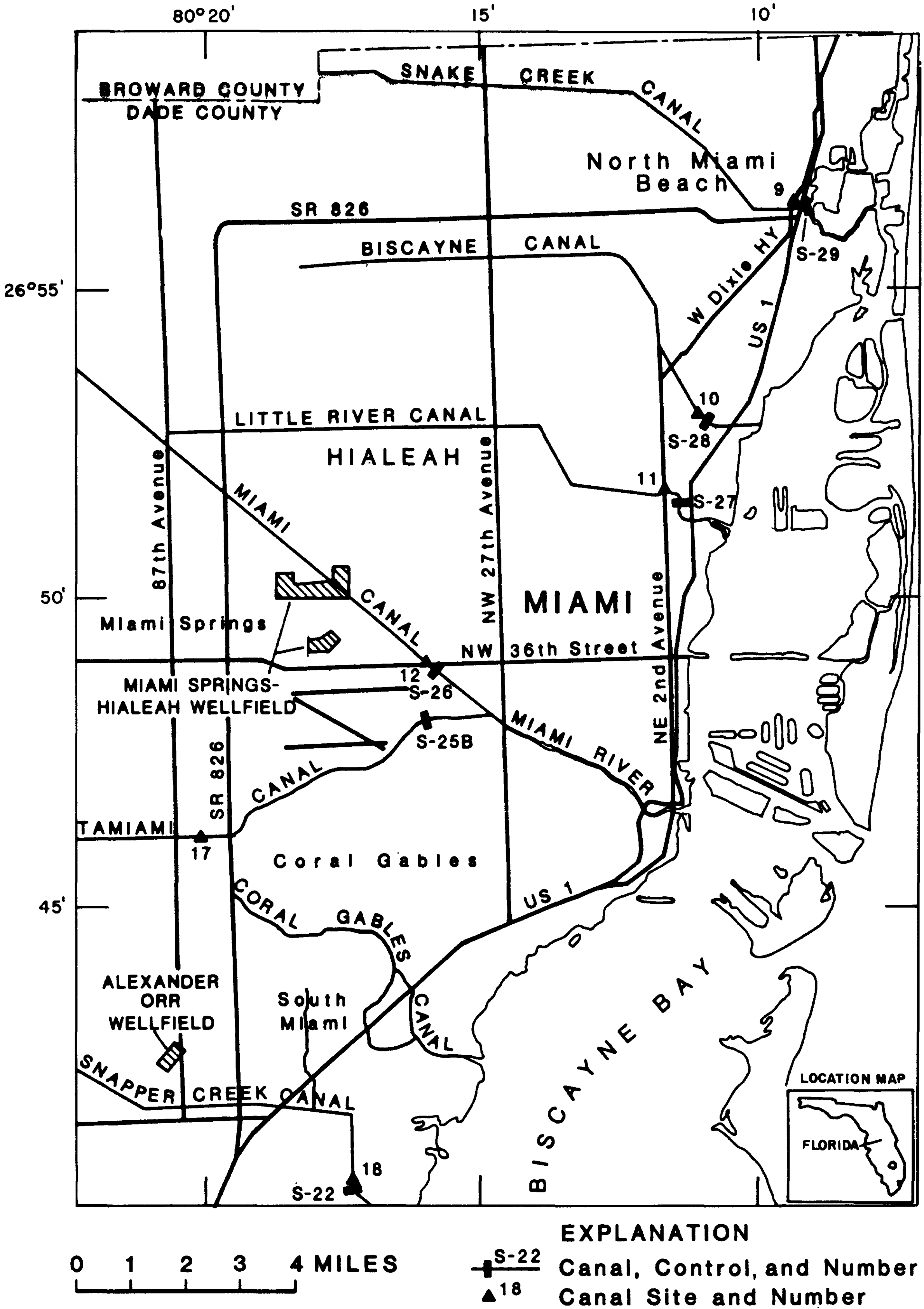

Figure 20.--Location of canals, canal sites, controls, and major roads in northeast Dade County.

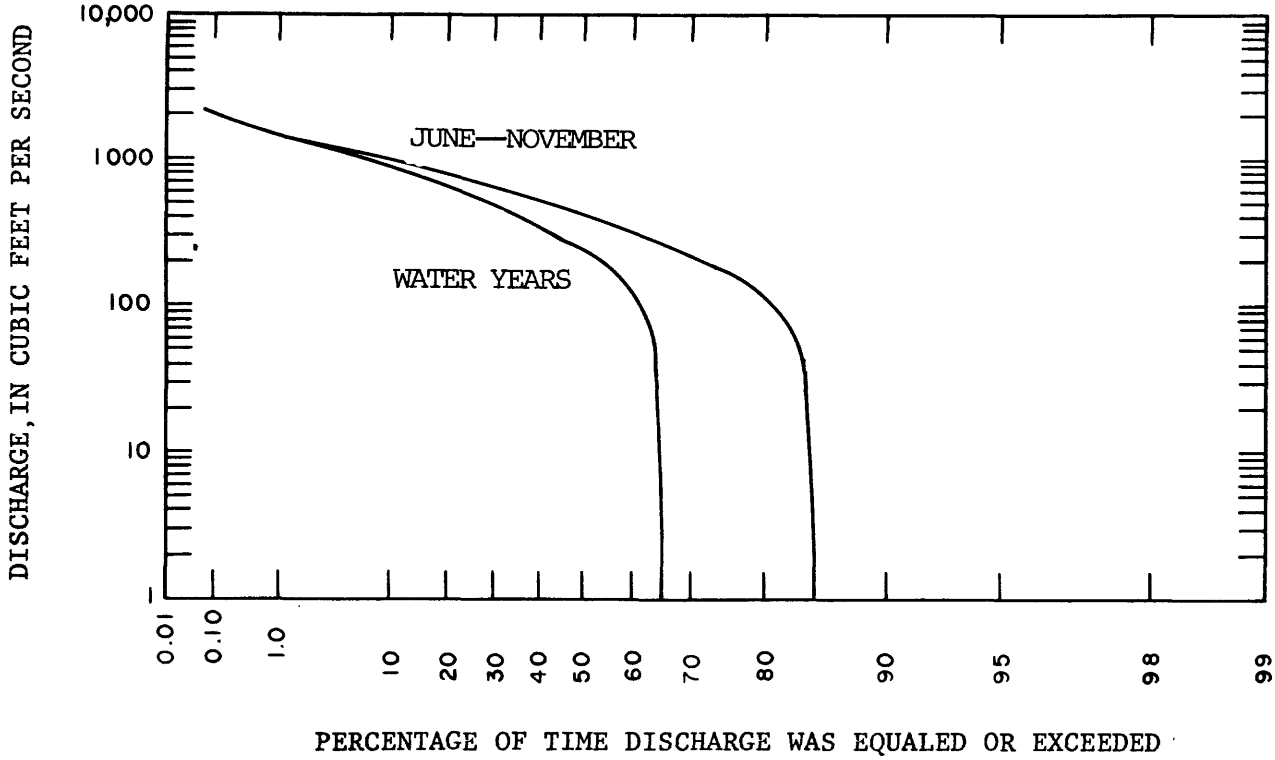

Figure 21.--Flow-duration curves for water years 1970-80 and the June through November periods 1970-80, Snake Creek Canal at S-29, North Miami Beach, site 9.

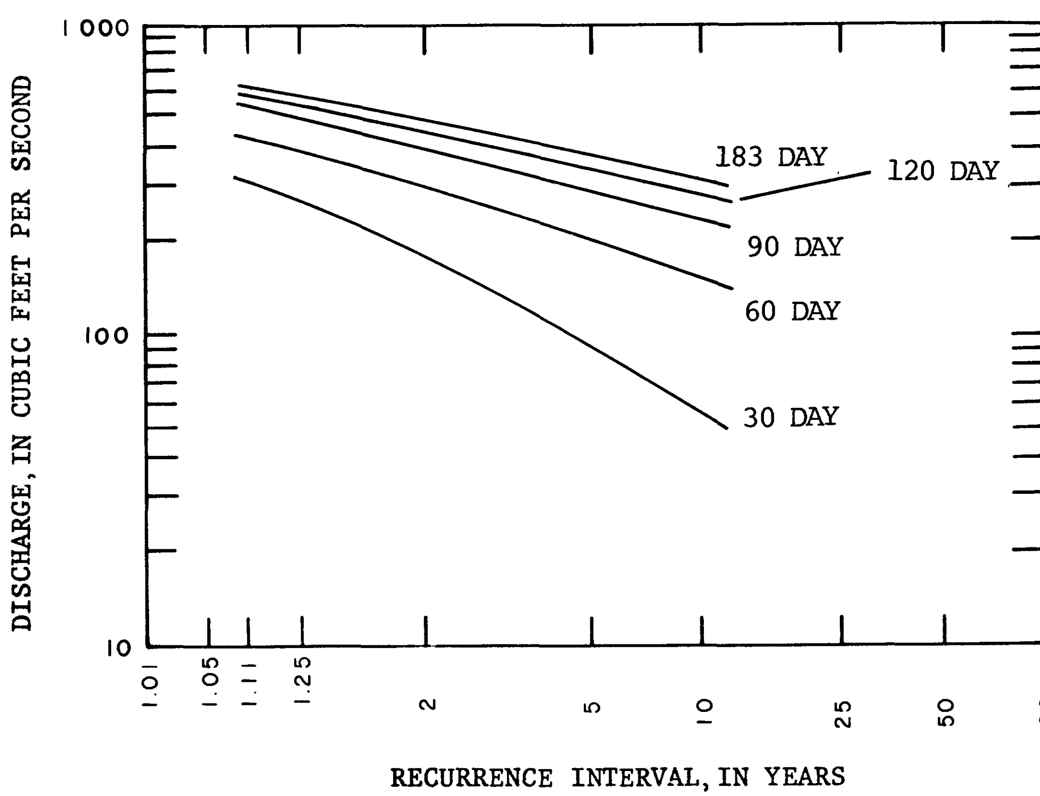

Figure 22.--Frequency curves for the indicated number of consecutive days, June through November 1970-80, Snake Creek Canal at S-29, North Miami Beach, site 9.

Biscayne Canal at S-28 near Miami, Site 10

The Biscayne Canal extends east about 10 miles from State Road 826 and then southeast to upper Biscayne Bay in north Dade County (fig. 20). Discharge is regulated by the operation of salinity-control structure 28 (S-28), 1.2 miles upstream of the canal's mouth. Flow is at times affected by tides and is occasionally reversed.

The gaging station is 100 feet upstream from S-28, 0.7 mile upstream from U.S. Highway 1, and 1.7 miles north of Miami. Mean daily discharge from October 1969 to September 1980 was 77.5 ft^3/s. The maximum and minimum daily discharges were 1,260 and 0.0 ft^3/s, respectively. Table 2 shows the greatest percentage of discharge for the 1970-80 water years occurred during May through October. Mean daily discharge for May through October 1970-80 was 119 ft^3/s. the maximum and minimum daily discharges for the high-flow period were 956 and 0.0 ft^3/s, respectively. The following table lists the number of no-flow days in each May through October period:

	May - October periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Number of no-flow days.	93	98	63	40	57	70	34	75	83	26	69

Figures 23 shows flow-duration data for the 11 water years and the 11 May through October periods. Tables 3 and 4 list the flow-duration data for the water years and the May through October periods, respectively.

The following table shows the lowest mean discharge (in cubic feet per second) for selected periods of consecutive days in each May through October period for Biscayne Canal at S-28 near Miami:

Number of consecutive days	May through October periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
30	5.5	4	42	0	24	20	53	7.1	38	40	12
60	14	37	60	52	64	36	132	58	62	51	24
90	31	56	67	97	96	46	154	124	72	73	61
120	51	47	107	113	113	83	191	114	88	106	81
183	85	84	135	130	123	85	178	157	98	148	77

Figure 24 shows frequency curves based on the above data.

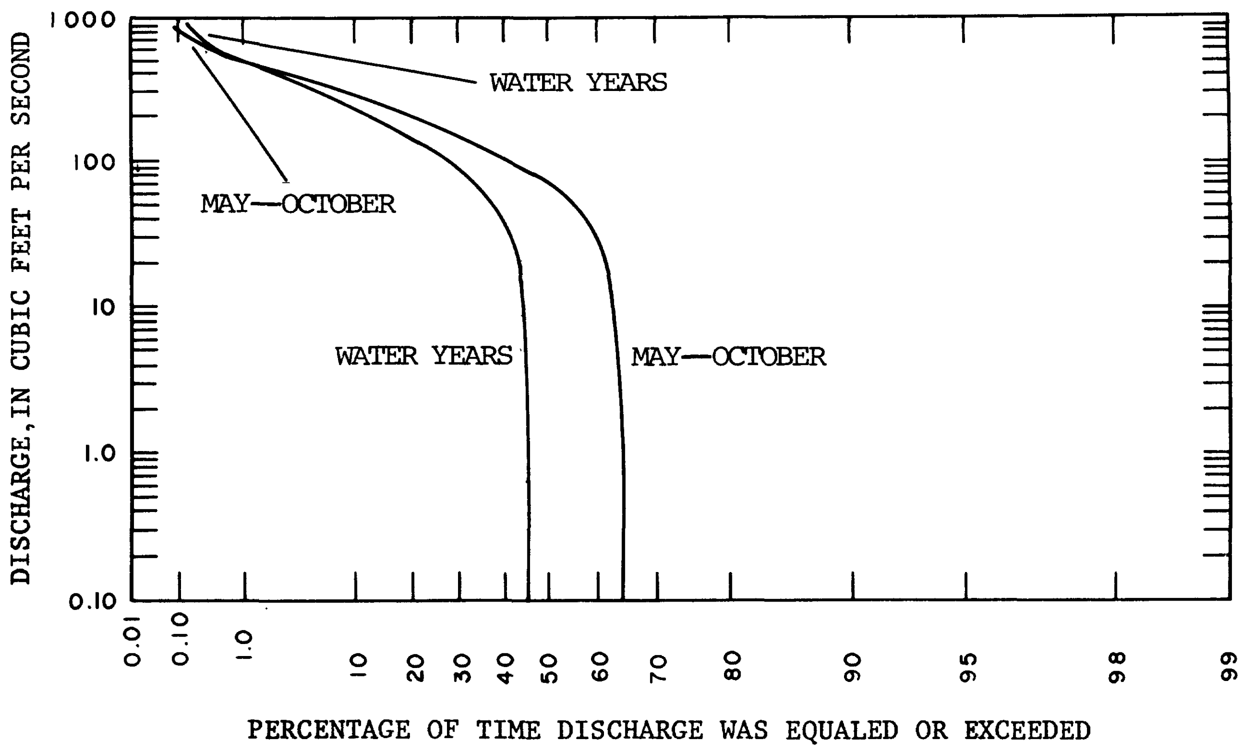

Figure 23.--Flow-duration curves for water years 1970-80 and the May through October periods 1970-80, Biscayne Canal at S-28 near Miami, site 10.

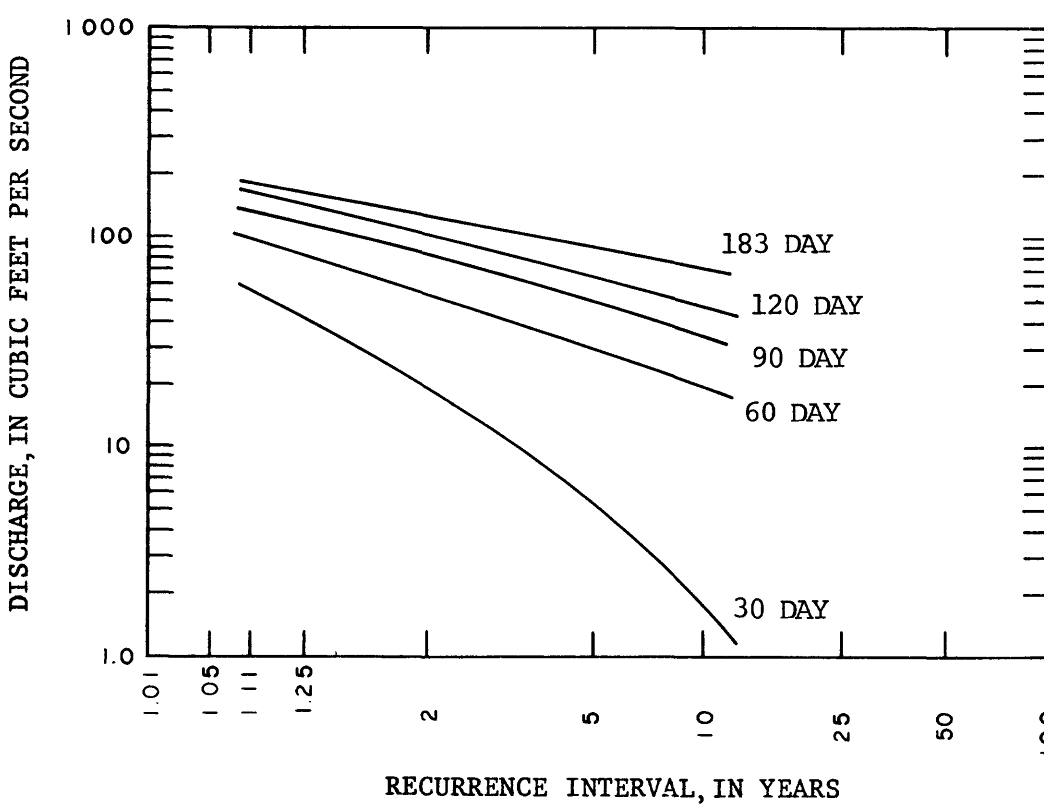

Figure 24.--Frequency curves for the indicated number of consecutive days, May through October 1970-80, Biscayne Canal at S-28 near Miami, site 10.

Little River Canal at S-27, Miami, Site 11

The Little River Canal is approximately 11 miles long and extends from upper Biscayne Bay 4.5 miles northwesterly and then westerly to 87th Avenue, 0.1 mile northeast of the Miami Canal (fig. 20). Discharge in Little River Canal is affected by inflow from numerous lateral canals and is regulated by operation of salinity-control structure 27 (S-27), 1.6 miles upstream of its mouth. Flow is at times affected by tides and is sometimes reversed.

The gaging station is at N.E. 2nd Avenue in Miami, 0.4 mile upstream from S-27. Mean daily discharge from July 1973 to September 1980 was 138 ft^3/s. The maximum and minimum daily discharges were 921 and 0.0 ft^3/s, respectively. Table 2 shows the greatest percentage of discharge for the 1974-80 water years occurred during May through October. Mean daily discharge for May through October 1974-80 was 185 ft^3/s. The maximum and minimum daily discharges for the high-flow period were 892 and 0.0 ft^3/s, respectively. The following table lists the number of no-flow days in each May through October period:

	May - October periods						
	1974	1975	1976	1977	1978	1979	1980
No-flow days	5	9	0	4	4	9	6

Figure 25 shows flow-duration data for the 7 water years and the 7 May through October periods. Tables 3 and 4 list the flow-duration data for the water years and the May through October periods, respectively.

The following table shows the lowest mean discharge (in cubic feet per second) for selected periods of consecutive days in each May through October period for Little River Canal at S-27, Miami:

Number of consecutive days	May - October periods						
	1974	1975	1976	1977	1978	1979	1980
30	124	99	130	82	121	57	100
60	196	129	163	165	147	64	113
90	199	165	170	174	147	73	152
120	207	174	191	171	154	99	160
183	205	176	196	222	155	166	172

Figure 26 shows frequency curves based on the above data.

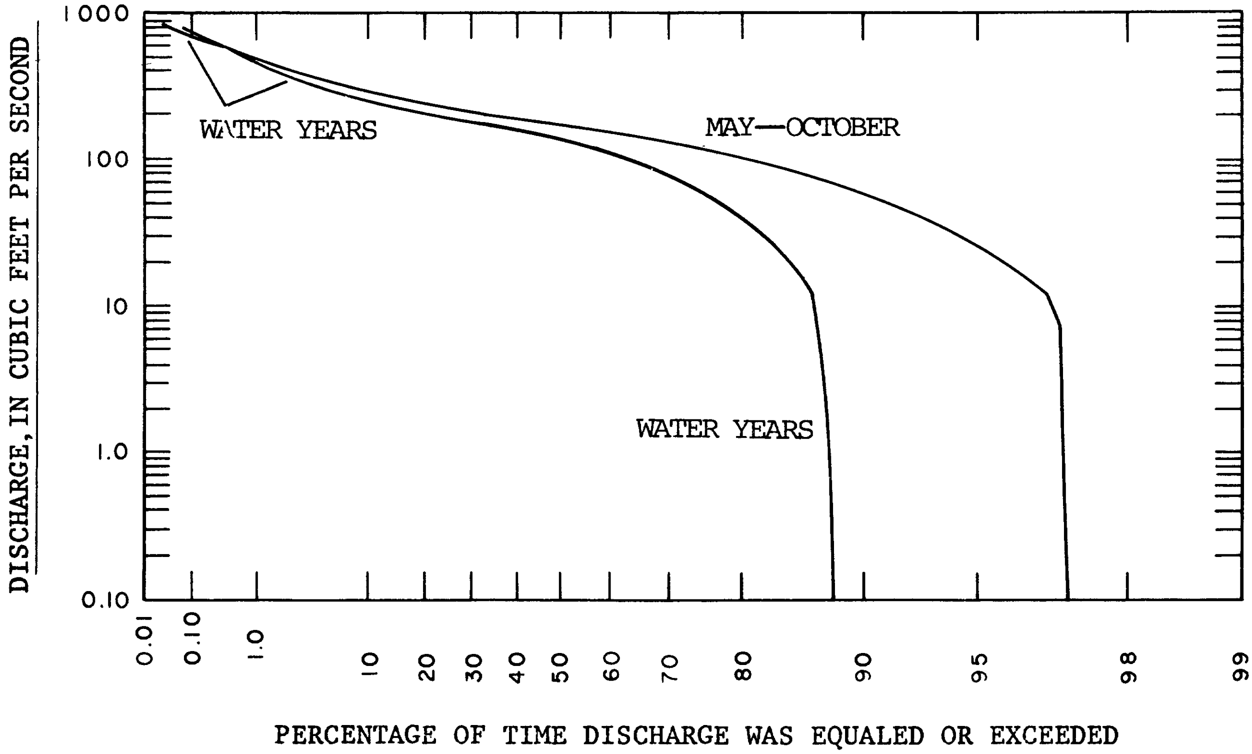

Figure 25.--Flow-duration curves for water years 1974-80 and the May through October periods 1974-80, Little River Canal at S-27, Miami, site 11.

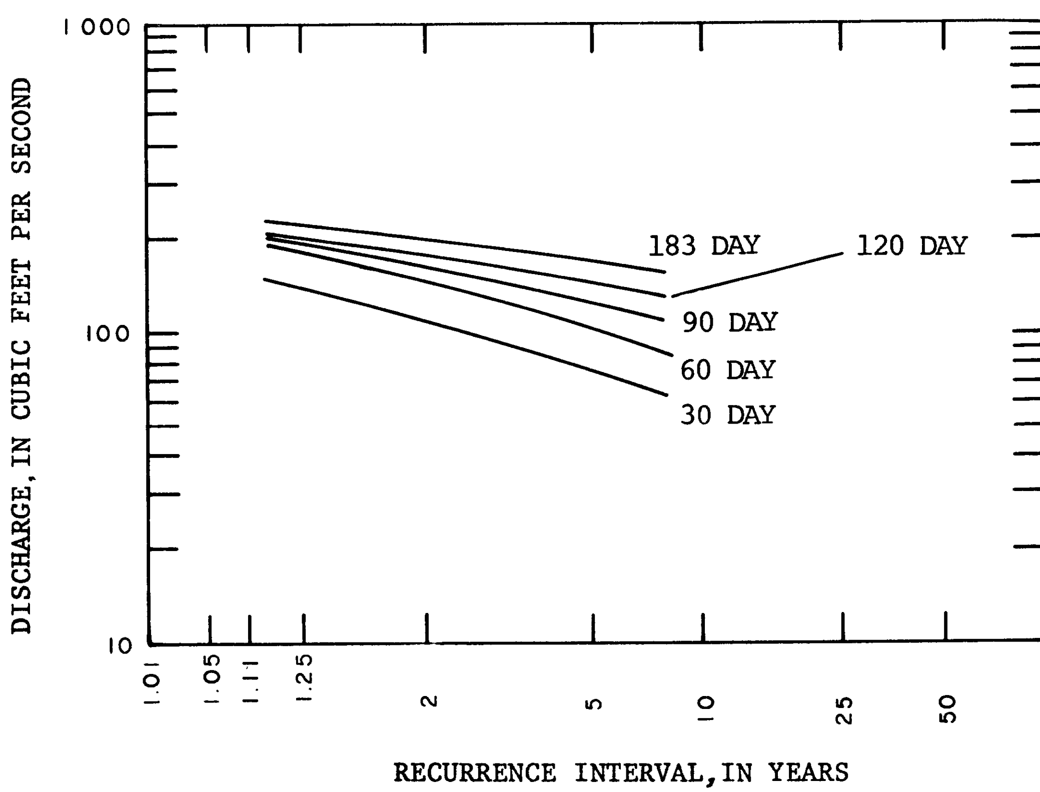

Figure 26.--Frequency curves for the indicated number of consecutive days, May through October 1974-80, Little River Canal at S-27, Miami, site 11.

Miami Canal at N.W. 36th Street, Miami, Site 12

The Miami Canal is a manmade extension of the Miami River. The Miami River originally extended inland from Biscayne Bay to just west of N.W. 27th Avenue (fig. 20). Dredging of the Miami Canal began in 1909 and proceeded northwestward into the Everglades. The lower section of the canal was completed in 1932 and extended from Miami to the South New River Canal. The middle section extended from the South New River Canal to the Bolles Canal and the upper section from Bolles Canal to Lake Okeechobee. However, because of the poor conveyance capacity of the middle section, the upper and lower sections were essentially independent of each other (Parker and others, 1955, p. 406). Because of this, a new canal was constructed during 1967-69, in place of and parallel to the old Miami Canal to more effectively route water from Lake Okeechobee (Meyer, 1972, p. 46).

Excess water in the upper Miami Canal drainage area is pumped by pumping station 3 (S-3) into Lake Okeechobee (fig. 4). In the middle reach of the canal from the Bolles Canal, 40 miles southward to the L-30 Canal, excess water is pumped southward by pumping station 8 (S-8) and gate into Conservation Area 3A. Control structures 151 (S-151) and 31 (S-31) regulate flow from Conservation Areas 3A and 3B to the lower reach of the Miami Canal, and control structures 32 (S-32) and 32A (S-32A) regulate seepage from Conservation Area 3B into the lower reach of the Miami Canal (figs. 1 and 7). The lower reach drains Hialeah and Miami Springs and is an important source of recharge to Miami Springs-Hialeah well fields (fig. 20). Discharge is affected by levee and control structures 31 (S-31), 32 (S-32), and 32A (S-32A) and by salinity-control structure 26. Seepage losses above the gaging station occur through the canal bed into the surficial aquifer in the vicinity of the Miami Springs-Hialeah well field also. Flow at times is affected by tides and is sometimes reversed.

The gaging station is at the downstream end of the N.W. 36th Street bridge fender at Miami, 200 feet upstream from S-26. Mean daily discharge from October 1969 to September 1980 was 225 ft^3/s. The maximum and minimum daily discharges were 1,220 and 0.0 ft^3/s, respectively. Table 2 shows the greatest percentage of discharge for the 1970-80 water years occurred during June through November. Mean daily discharge for June through November 1970-80 was 264 ft^3/s. The maximum and minimum daily discharges for the high-flow period were 1,000 and 0.0 ft^3/s, respectively. The following table lists the number of no-flow days in each June through November period:

	June - November periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Number of no-flow days.	4	0	0	0	5	6	0	0	0	3	76

Figure 27 shows flow-duration data for the 11 water years and the 11 June through November periods. Tables 3 and 4 list the flow-duration data for the water years and the June through November periods, respectively.

The following table shows the lowest mean discharge (in cubic feet per second) for selected periods of consecutive days in each June through November period for Miami Canal at N.W. 36th Street, Miami:

Number of consecutive days	June - November periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
30	297	36	90	77	96	64	167	194	249	176	0.33
60	380	50	176	158	115	116	196	220	272	194	30
90	446	68	228	215	149	131	230	287	305	222	52
120	428	135	260	277	167	165	259	283	341	269	90
183	493	158	304	282	165	199	288	305	361	278	75

Figure 28 shows frequency curves based on the above data.

Tamiami Canal Outlets, Monroe to Carnestown, Site 13

The Monroe to Carnestown section is the westernmost section of the Tamiami Canal outlets (fig. 29). Flow is to the south through 19 outlets. Discharge consists of runoff from the Big Cypress Swamp watershed through the Tamiami Canal outlets from Monroe, 55 miles west of Miami to a point 1 mile east of State Highway 29 at Carnestown. Flow at the westernmost outlets is slightly affected by tides.

Mean daily discharge from October 1969 through September 1980 was 334 ft^3/s. The maximum and minimum daily discharges were 4,980 and 0.0 ft^3/s, respectively. Table 2 shows the greatest percentage of discharge for the 1970-80 water years occurred during July through October. Mean daily discharge for July through October 1970-80 was 739 ft^3/s. The maximum and minimum daily discharges for the high-flow period were 4,980 and 5.2 ft^3/s, respectively. The following table lists the number of no-flow days in each July through October period:

	July - October periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Number of no-flow days.	0	0	0	0	0	0	0	0	0	0	0

Figure 30 shows flow-duration data for the 11 water years and the 11 July through October periods. Tables 3 and 4 list the flow-duration data for the water years and the July through October periods, respectively.

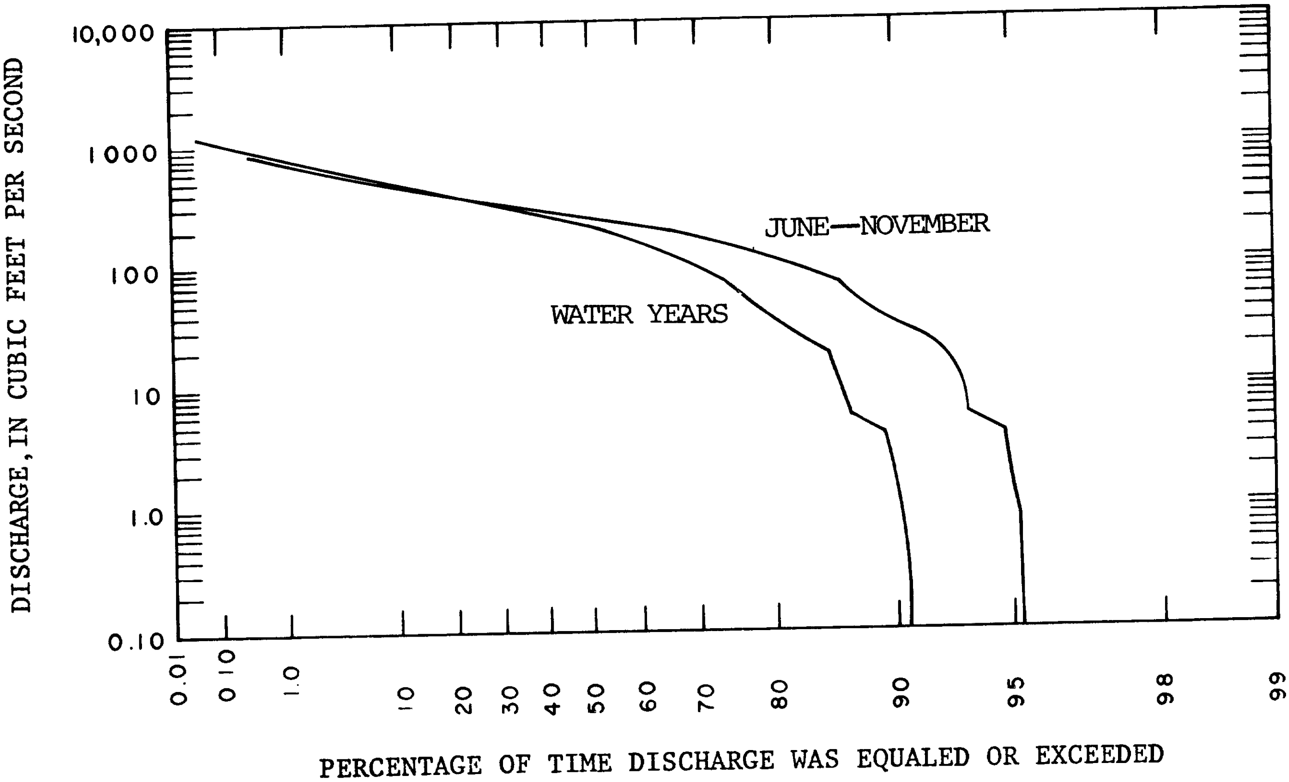

Figure 27.--Flow-duration curves for water years 1970-80 and the June through November periods 1970-80, Miami Canal at N.W. 36th Street, Miami, site 12.

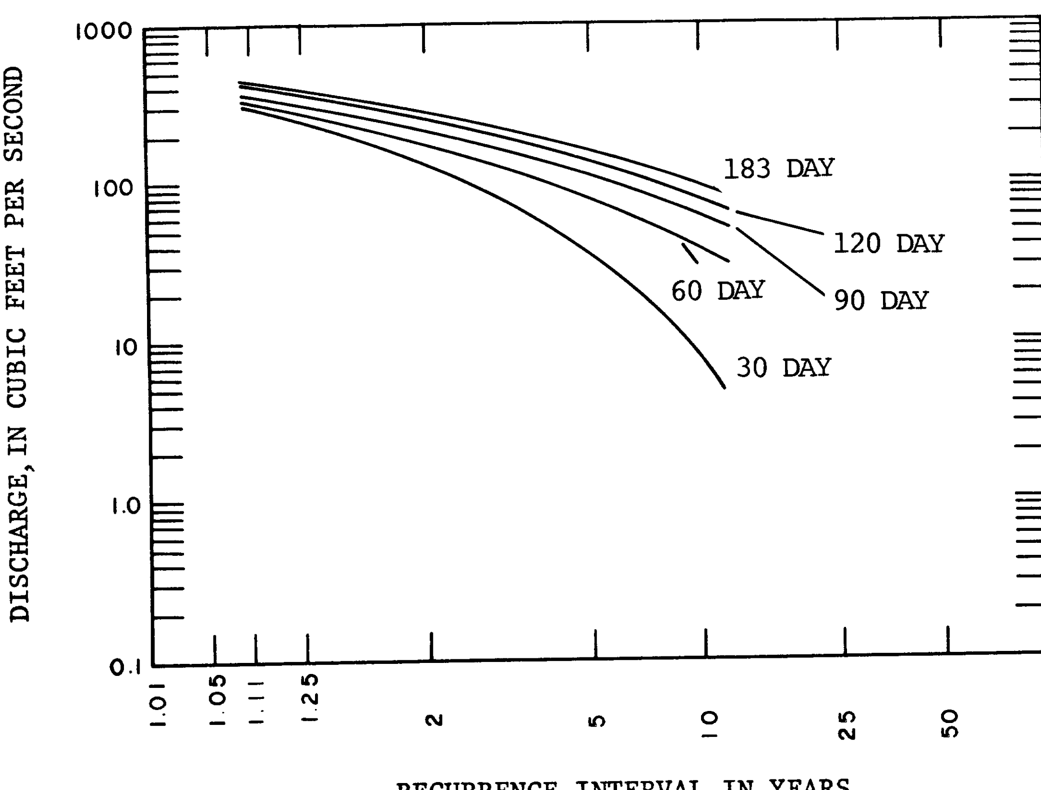

Figure 28.--Frequency curves for the indicated number of consecutive days, June through November 1970-80, Miami Canal at N.W. 36th Street, Miami, site 12.

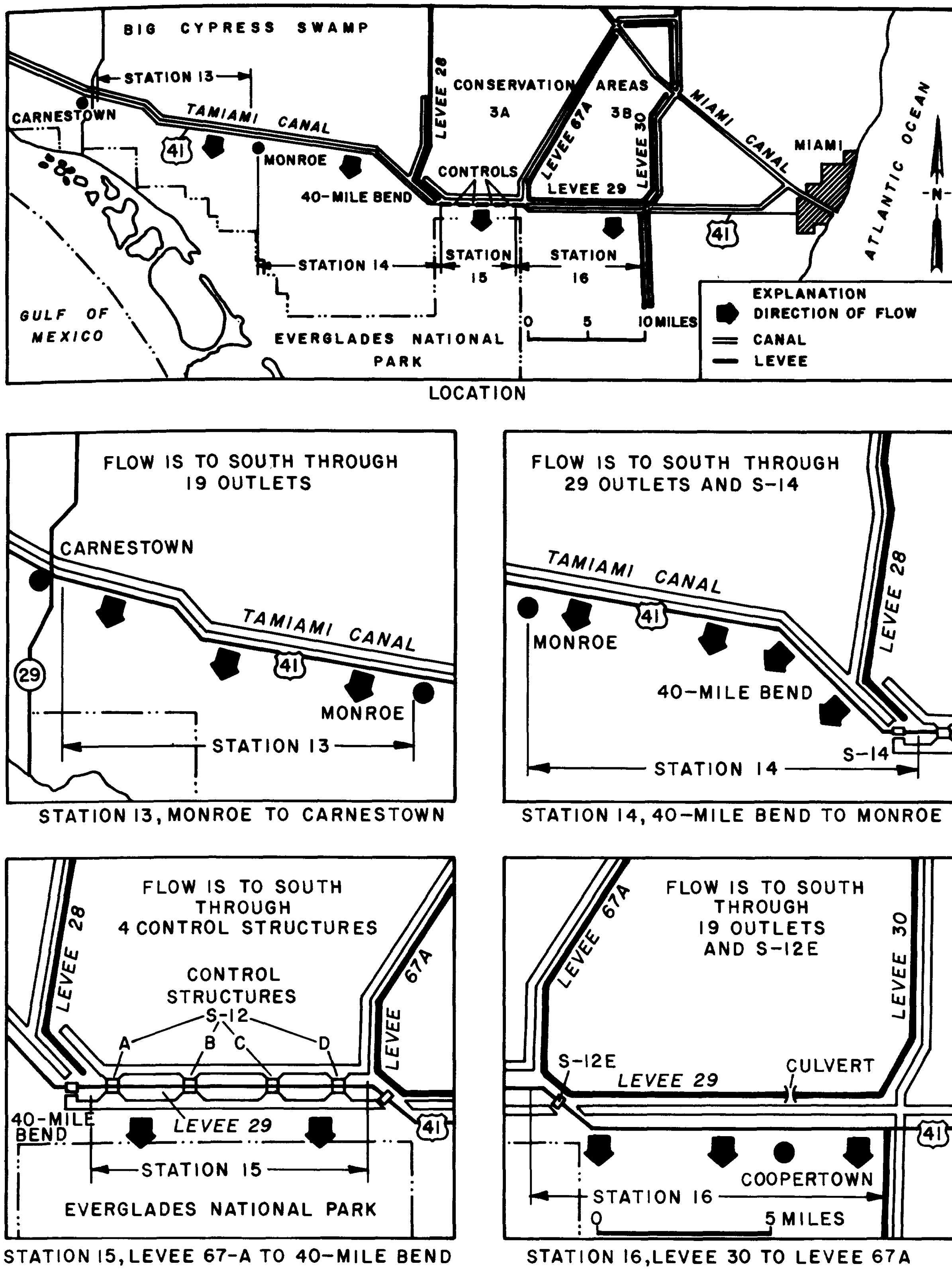

Figure 29.--Location of the Tamiami Canal outlets.

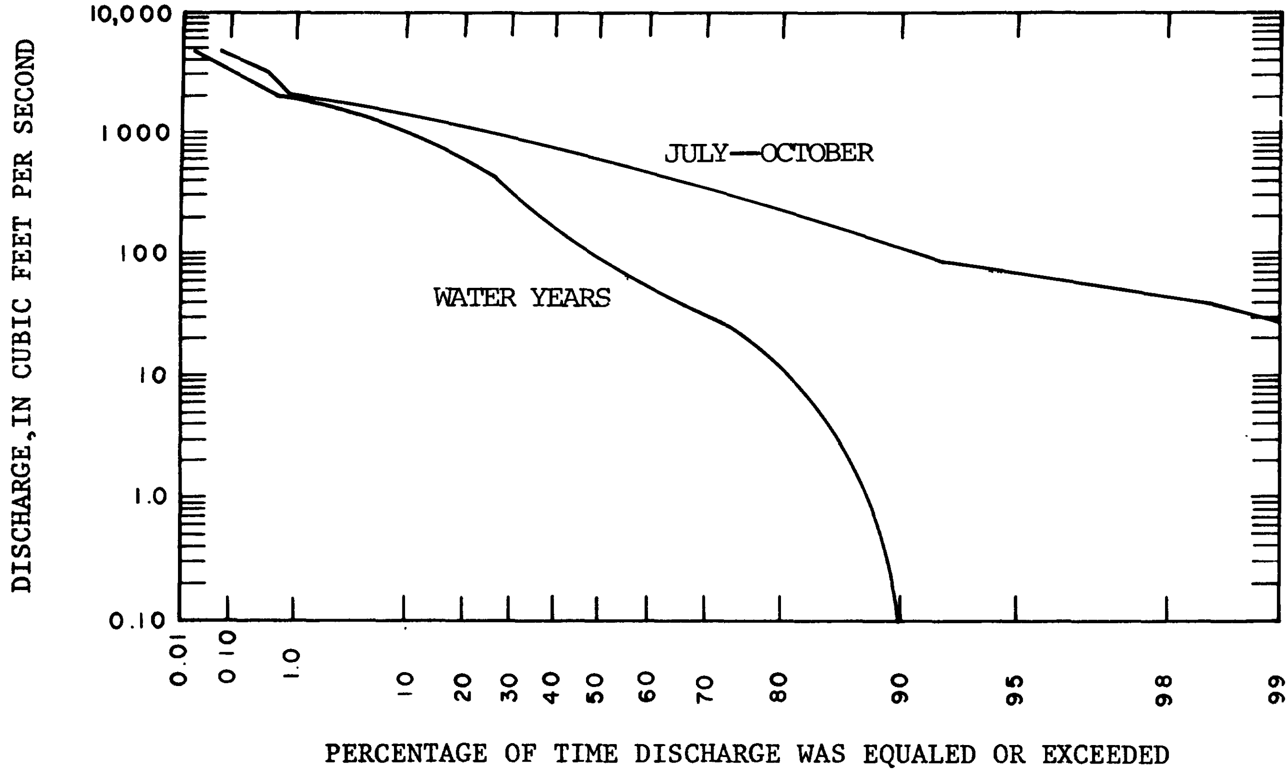

Figure 30.--Flow-duration curves for water years 1970-80 and the July through October periods 1970-80, Tamiami Canal outlets, Monroe to Carnestown, site 13.

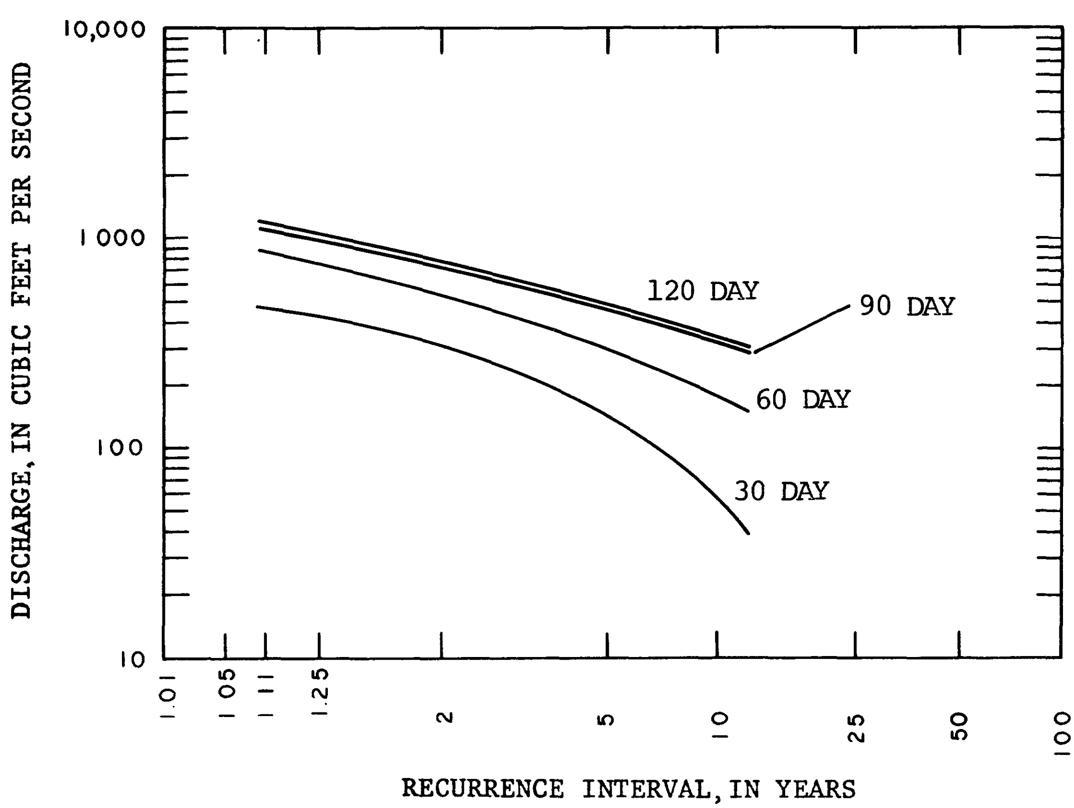

Figure 31.--Frequency curves for the indicated number of consecutive days, July through October 1970-80, Tamiami Canal outlets, Monroe to Carnestown, site 13.

The following table shows the lowest mean discharge (in cubic feet per second) for selected periods of consecutive days in each July through October period for Tamiami Canal outlets, Monroe to Carnestown:

Number of consecutive days	July - October periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
30	428	283	118	476	171	393	324	277	287	247	40
60	660	678	158	825	351	444	630	921	405	416	242
90	738	1,140	367	1,000	551	586	859	824	433	746	475
120	857	1,250	320	929	611	660	886	937	430	815	451

Figure 31 shows frequency curves based on the above data.

Tamiami Canal Outlets, 40-Mile Bend to Monroe, Site 14

Discharge for Tamiami Canal outlets, 40-Mile Bend to Monroe, consists of runoff from the Big Cypress Swamp watershed. Discharge is to the south through 29 bridges (fig. 29).

Mean daily discharge from October 1969 through September 1980 was 210 ft^3/s. The maximum and minimum daily discharges were 1,690 and 0.0 ft^3/s, respectively. Table 2 shows the greatest percentage of discharge for the 1970-80 water years occurred during July through October. Mean daily discharge for July through October 1970-80 was 429 ft^3/s. The maximum and minimum daily discharges for the high-flow period were 1,690 and 4.7 ft^3/s, respectively. The following table lists the number of no-flow days in each July through October period:

	July - October periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Number of no-flow days.	0	0	0	0	0	0	0	0	0	0	0

Figure 32 shows flow-duration data for the 11 water years and the 11 July through October periods. Tables 3 and 4 list the flow-duration data for the water years and the July through October periods, respectively.

The following table shows the lowest mean discharge (in cubic feet per second) for selected periods of consecutive days in each July through October period for Tamiami Canal outlets, 40-Mile Bend to Monroe:

Number of consecutive days	July - October periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
30	143	94	65	262	141	227	243	136	219	62	116
60	232	361	145	453	191	287	383	178	292	176	251
90	342	559	154	589	322	318	518	406	374	261	405
120	472	606	162	591	368	389	505	396	450	390	355

Figure 33 shows frequency curves based on the above data.

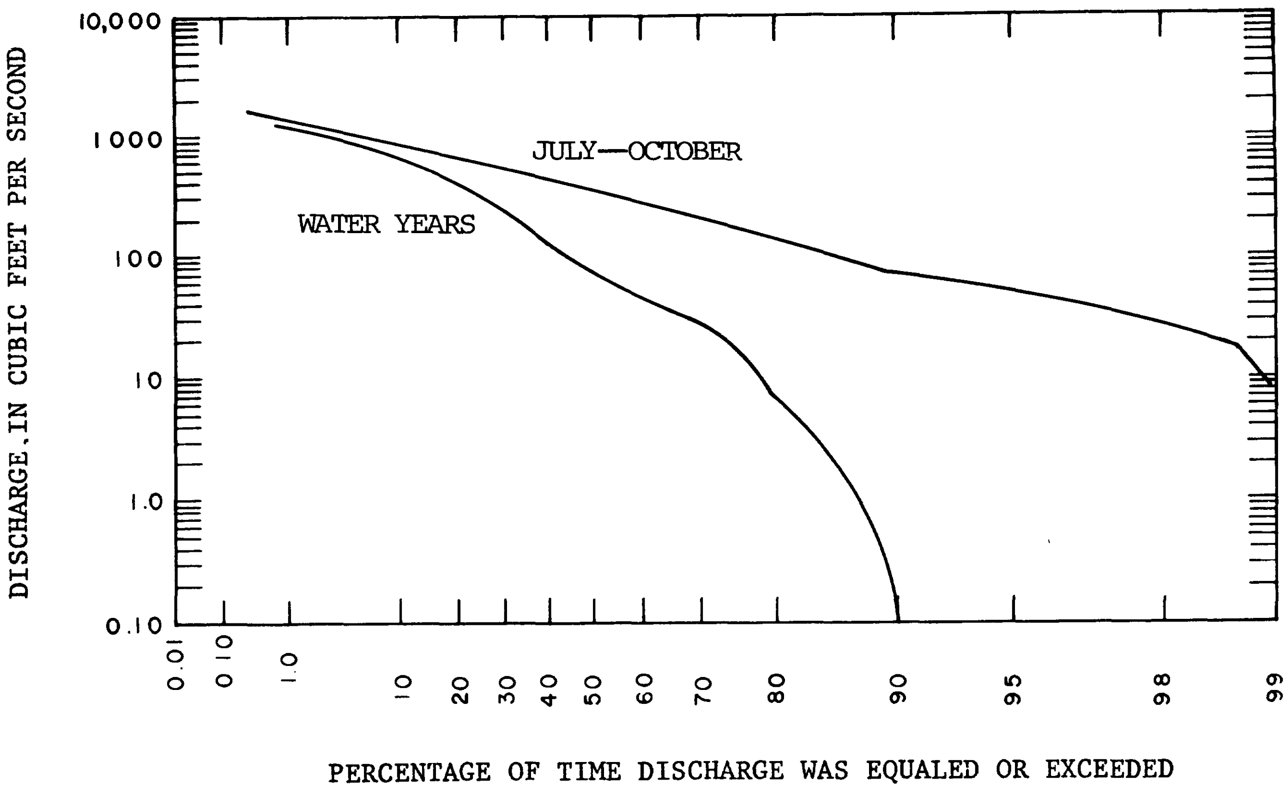

Figure 32.--Flow-duration curves for water years 1970-80 and the July through October periods 1970-80, Tamiami Canal outlets, 40-Mile Bend to Monroe, site 14.

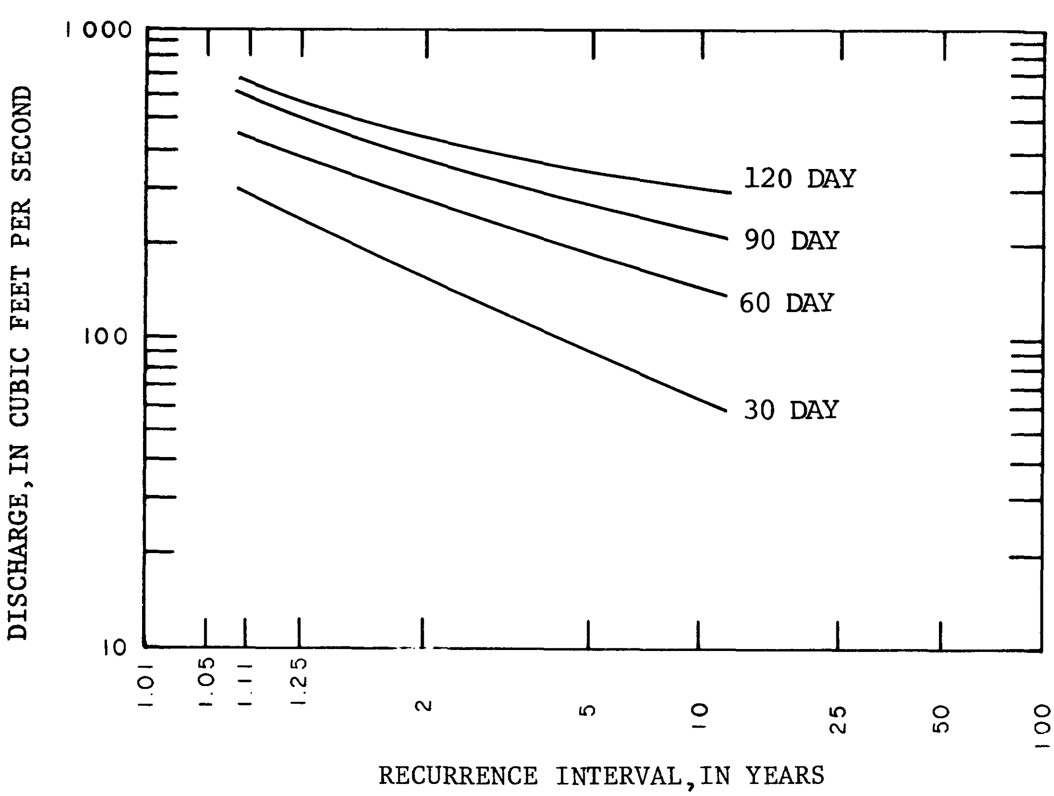

Figure 33.--Frequency curves for the indicated number of consecutive days, July through October 1970-80, Tamiami Canal outlets, 40-Mile Bend to Monroe, site 14.

Tamiami Canal Outlets, Levee 67A to 40-Mile Bend near Miami, Site 15

Discharge for Tamiami Canal outlets, Levee 67A to 40-Mile Bend, consists of discharge through S-12 structures A, B, C, and D from Conservation Area 3A (fig. 29).

Mean daily discharge from October 1969 through September 1980 was 685 ft^3/s. The maximum and minimum daily discharges were 4,700 and 0.0 ft^3/s, respectively. Table 2 shows the greatest percentage of discharge for the 1970-80 water years occurred during September through December. Mean daily discharge for September through December 1970-80 was 961 ft^3/s. The maximum and minimum daily discharges for the high-flow period were 3,860 and 270 ft^3/s, respectively. The following table lists the number of no-flow days in each September through December period:

	September - December periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Number of no-flow days.	0	0	0	0	0	0	0	0	0	0	0

Figure 34 shows flow-duration data for the 11 water years and the 11 September through December periods. Tables 3 and 4 list the flow-duration data for the water years and the September through December periods, respectively.

Table 5 presents discharges to the Everglades National Park through the S-12 structures (A-D) for site 15 and shows the actual, scheduled, and surplus discharge to the park for the indicated water years.

The following table shows the lowest mean discharge (in cubic feet per second) for selected periods of consecutive days in each September through December period for Tamiami Canal outlets, Levee 67A to 40-Mile Bend near Miami:

Number of consecutive days	September - December periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
30	407	519	584	485	713	524	583	528	620	596	564
60	765	678	709	647	893	772	758	740	835	935	742
90	823	777	775	786	1,040	859	873	889	1,130	1,220	826
120	769	736	762	773	1,440	816	1,040	862	1,280	1,140	972

Figure 35 shows frequency curves based on the above data.

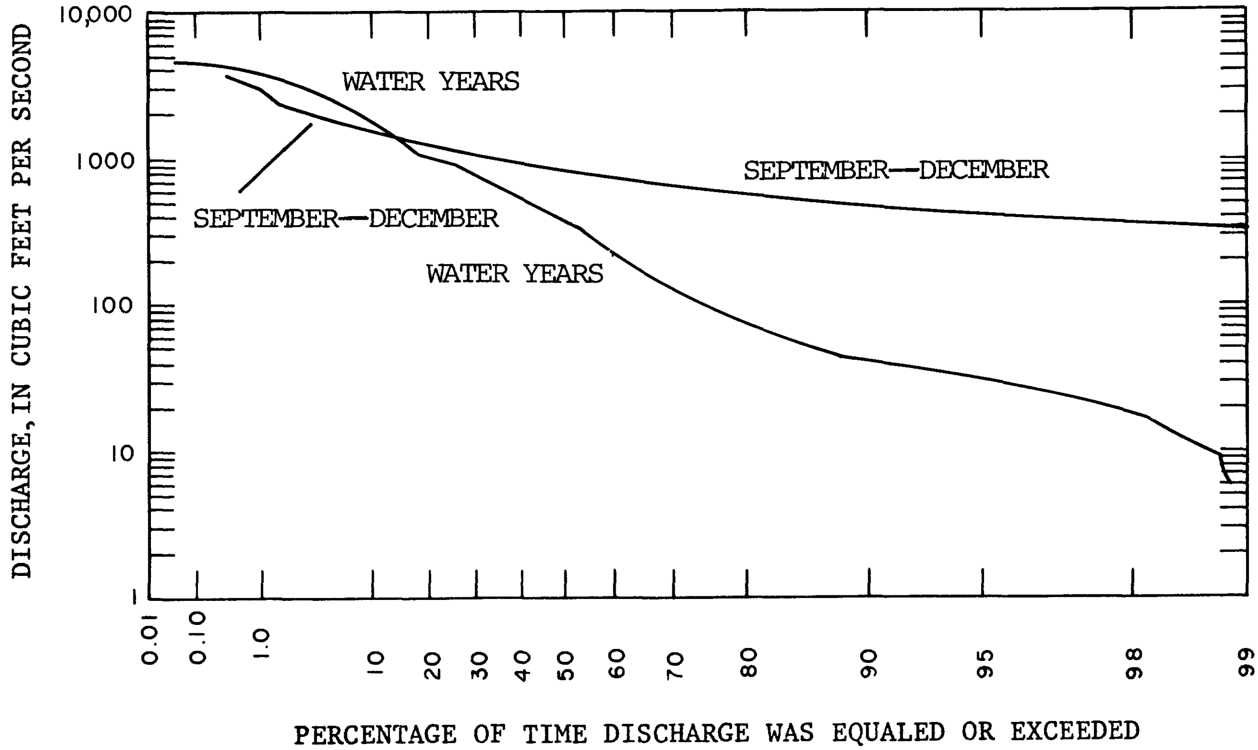

Figure 34.--Flow-duration curves for water years 1970-80 and the September through December periods 1970-80, Tamiami Canal outlets, Levee 67A to 40-Mile Bend near Miami, site 15.

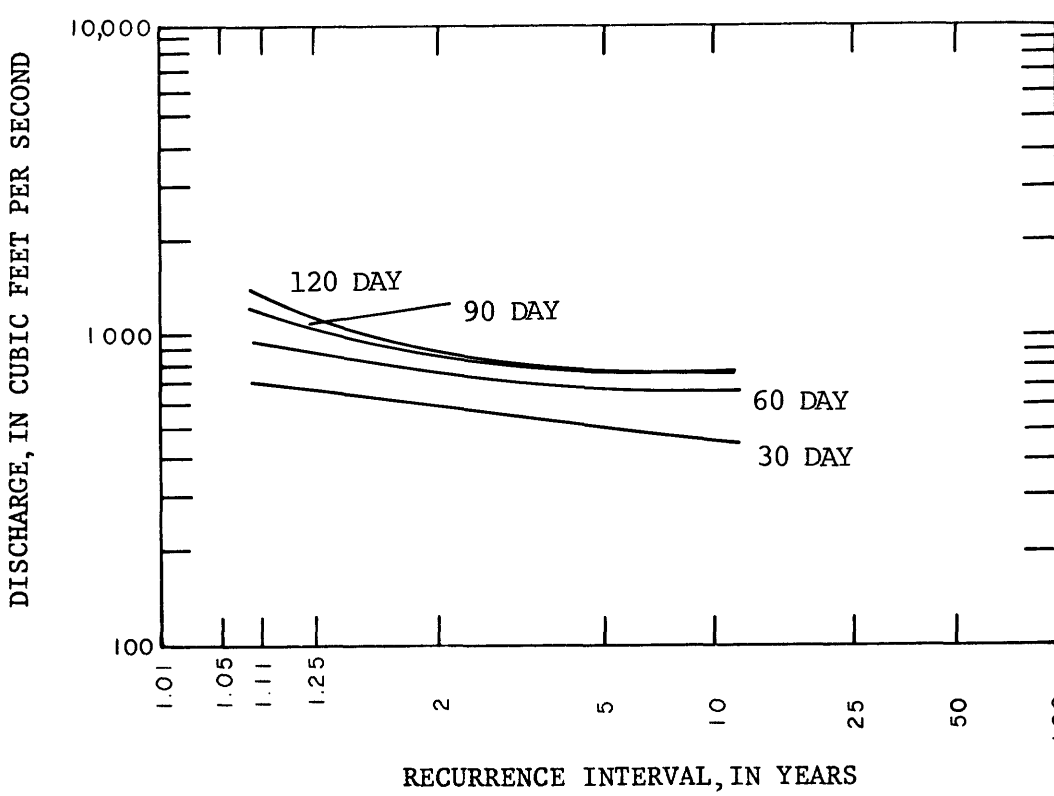

Figure 35.--Frequency curves for the indicated number of consecutive days, September through December 1970-80, Tamiami Canal outlets, Levee 67A to 40-Mile Bend near Miami, site 15.

Table 5.--Discharges to the Everglades National Park through Tamiami Canal outlets, Levee 67A to 40-Mile Bend near Miami, site 15

[Discharge in thousands of acre-feet]

Water year	Value	Discharge (acre-feet x 1000)
1970	Actual	1,753.33
	Scheduled	260.00
	Surplus	1,493.33
1971	Actual	255.86
	Scheduled	250.20
	Surplus	5.66
1972	Actual	316.90
	Scheduled	249.42
	Surplus	67.48
1973	Actual	268.21
	Scheduled	260.00
	Surplus	8.21
1974	Actual	428.34
	Scheduled	260.00
	Surplus	168.34
1975	Actual	304.09
	Scheduled	260.00
	Surplus	44.09
1976	Actual	344.37
	Scheduled	260.00
	Surplus	84.37
1977	Actual	273.21
	Scheduled	260.00
	Surplus	13.21
1978	Actual	516.87
	Scheduled	260.00
	Surplus	256.87
1979	Actual	371.50
	Scheduled	260.00
	Surplus	111.50
1980	Actual	623.20
	Scheduled	260.00
	Surplus	363.20

Tamiami Canal Outlets, Levee 30 to Levee 67A near Miami, Site 16

Discharge for Tamiami Canal outlets, Levee 30 to Levee 67A near Miami, consists of seepage through Levee 29 from Conservation Area 3B and occasional releases through a culvert in Levee 29 at Coopertown. Flow is through 19 outlets and S-12E (fig. 29).

Mean daily discharge from October 1969 through September 1980 was 64.1 ft^3/s. The maximum and minimum daily discharges were 456 and 0.0 ft^3/s, respectively. Table 2 shows the greatest percentage of discharge for the 1970-80 water years occurred during September through February. Mean daily discharge for September through February 1970-81 was 69.4 ft^3/s. The maximum and minimum daily discharges for the high-flow period were 380 and 0.0 ft^3/s, respectively. The following table lists the number of no-flow days in each September through February period:

	September - February periods										
	1970 to 1971	1971 to 1972	1973 to 1973	1973 to 1974	1974 to 1975	1975 to 1976	1976 to 1977	1977 to 1978	1978 to 1979	1979 to 1980	1980 to 1981
Number of no-flow days.	0	0	0	0	18	0	0	0	0	0	7

Figure 36 shows flow-duration data for the 11 water years and the 11 September through February periods. Tables 3 and 4 list the flow-duration data for the water years and the September through February periods, respectively.

The following table shows the lowest mean discharge (in cubic feet per second) for selected periods of consecutive days in each September through February period for Tamiami Canal outlets, Levee 30 to Levee 67A near Miami (no 183 consecutive-day value was computed as there are only 181 days in the months September through February):

	September - February periods										
Number of consecutive days	1970 to 1971	1971 to 1972	1973 to 1973	1973 to 1974	1974 to 1975	1975 to 1976	1976 to 1977	1977 to 1978	1978 to 1979	1979 to 1980	1980 to 1981
30	6.6	16	15	1.8	11	8.9	16	41	55	50	2.6
60	9.4	27	21	7.9	18	13	26	45	61	51	8.5
90	16	30	23	13	25	22	35	49	72	57	18
120	30	34	32	30	32	43	53	51	83	59	26

Figure 37 shows frequency curves based on the above data.

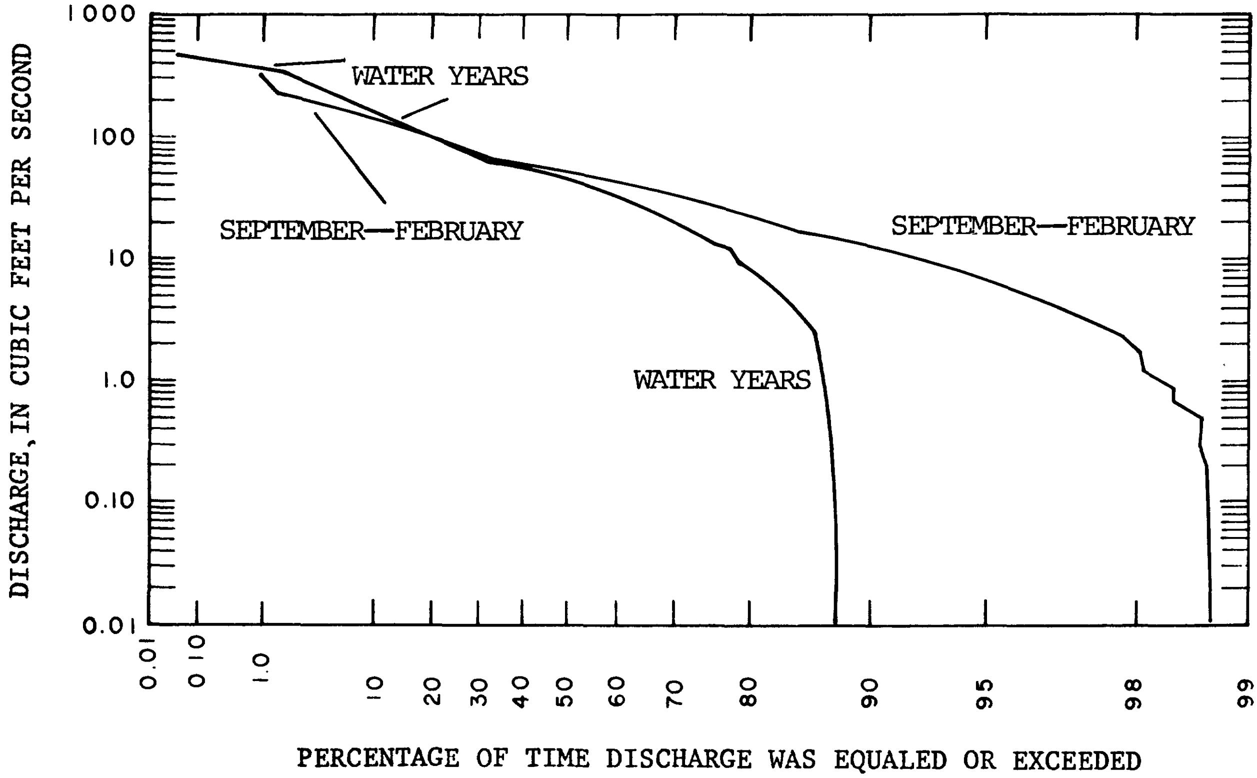

Figure 36.--Flow-duration curves for water years 1970-80 and the September through February periods 1970-81, Tamiami Canal outlets, Levee 30 to Levee 67A near Miami, site 16.

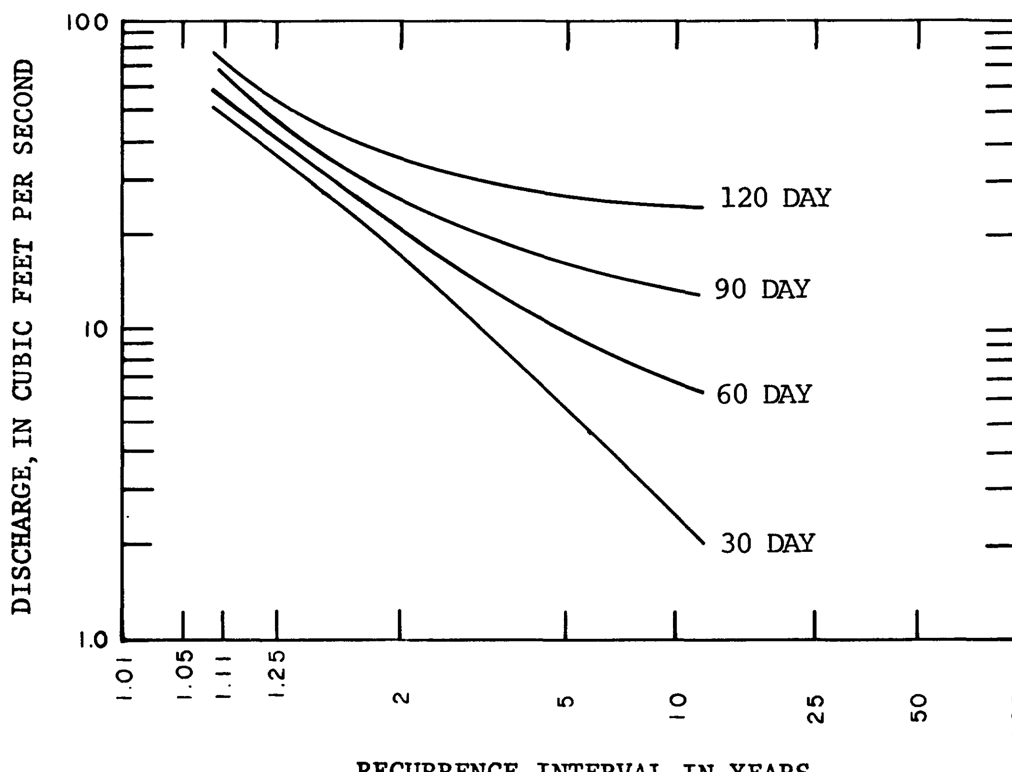

Figure 37.--Frequency curves for the indicated number of consecutive days, September through February 1970-81, Tamiami Canal outlets, Levee 30 to Levee 67A near Miami, site 16.

Tamiami Canal near Coral Gables, Site 17

Discharge for Tamiami Canal near Coral Gables consists of flow in Tamiami Canal eastward from Levee 30 (fig. 38). Discharge in the canal is controlled by control structure 334 (S-334), 10.5 miles upstream from the gaging station (site 17), and is regulated by salinity-control structure 25B (S-25B), 4.7 miles downstream from the gaging station (fig. 20). Flow is diverted to and from Snapper Creek Canal, 3.5 miles upstream from the gaging station, and can be affected by tide.

The gaging station is 0.5 mile upstream from Coral Gables Canal and 3.5 miles west of Coral Gables. Mean daily discharge from October 1969 to September 1980 was 131 ft^3/s. The maximum and minimum daily discharges were 490 and -28 ft^3/s, respectively. Table 2 shows the greatest percentage of discharge for the 1970-80 water years occurred during July through December. Mean daily discharge for July through December 1970-80 was 156 ft^3/s. The maximum and minimum daily discharges for the high-flow period were 384 and 10 ft^3/s, respectively. The following table lists the number of no-flow days in each July through December period:

	July - December periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Number of no-flow days.	0	0	0	0	0	0	0	0	0	0	0

Figure 39 shows flow-duration data for the 11 water years and the 11 July through December periods. Tables 3 and 4 list the flow-duration data for the water years and the July through December periods, respectively.

The following table shows the lowest mean discharge (in cubic feet per second) for selected periods of consecutive days in each July through December period for Tamiami Canal near Coral Gables:

Number of consecutive days	July - December periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
30	148	77	78	109	70	53	25	47	197	186	173
60	151	88	93	111	89	69	71	122	202	200	179
90	172	120	91	121	102	93	88	164	209	204	180
120	185	132	101	139	111	92	95	149	224	217	201
183	183	125	108	145	110	99	110	178	228	219	202

Figure 40 shows frequency curves based on the above data.

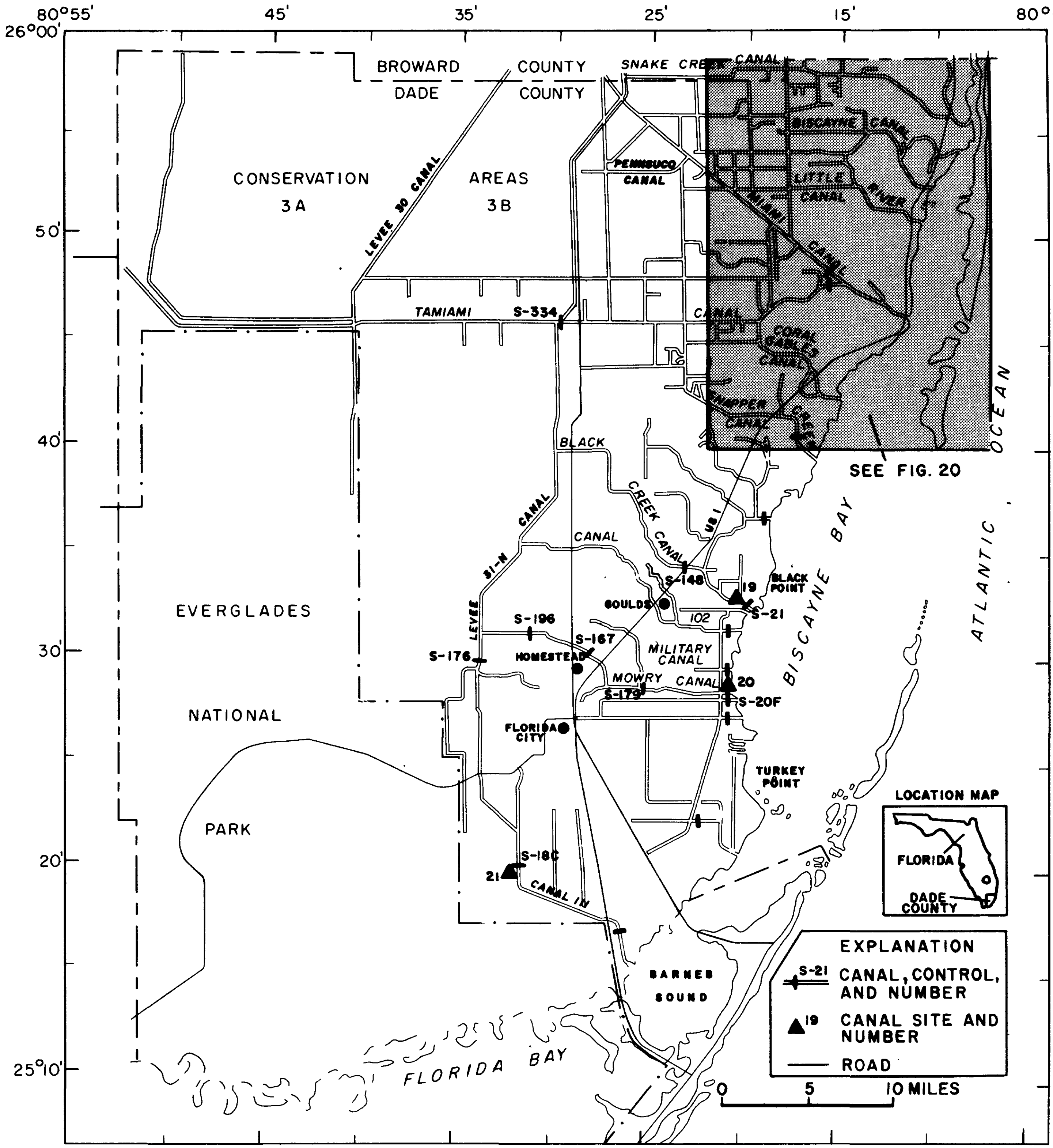

Figure 38.--Location of selected canals, canal sites, controls, and major roads in Dade County.

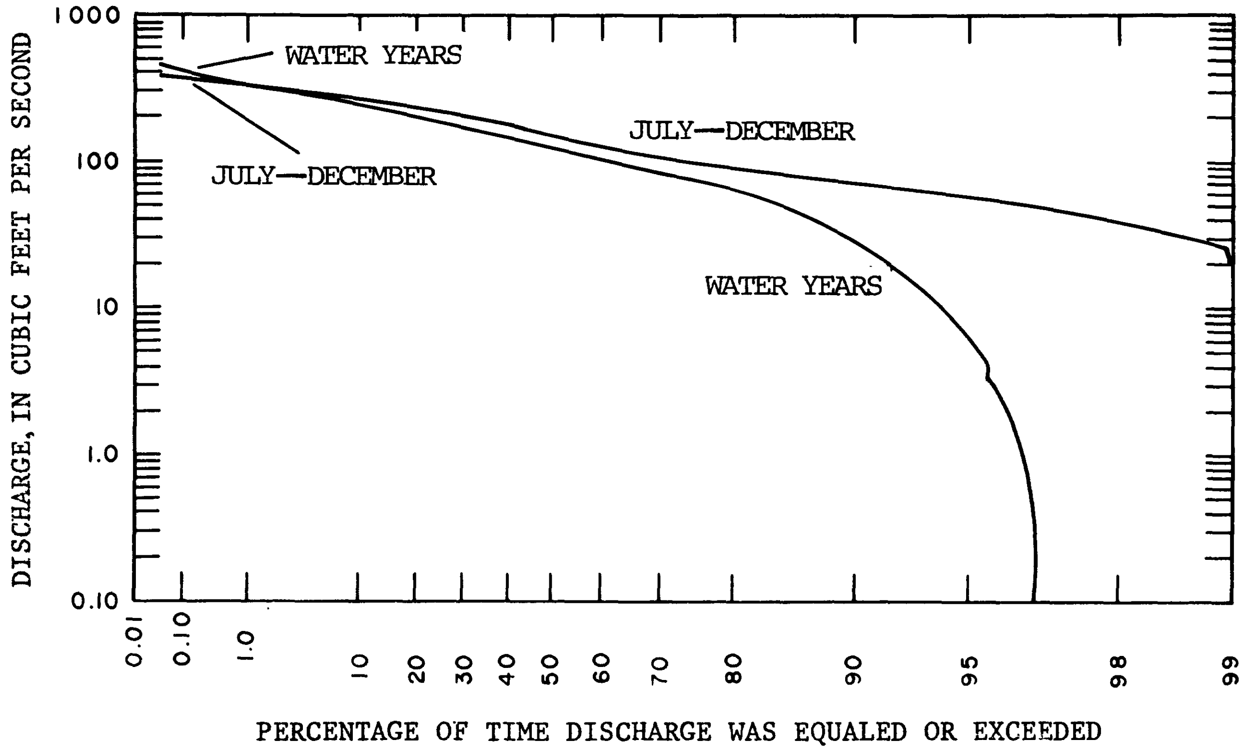

Figure 39.--Flow-duration curves, for water years 1970-80 and the July through December periods 1970-80, Tamiami Canal near Coral Gables, site 17.

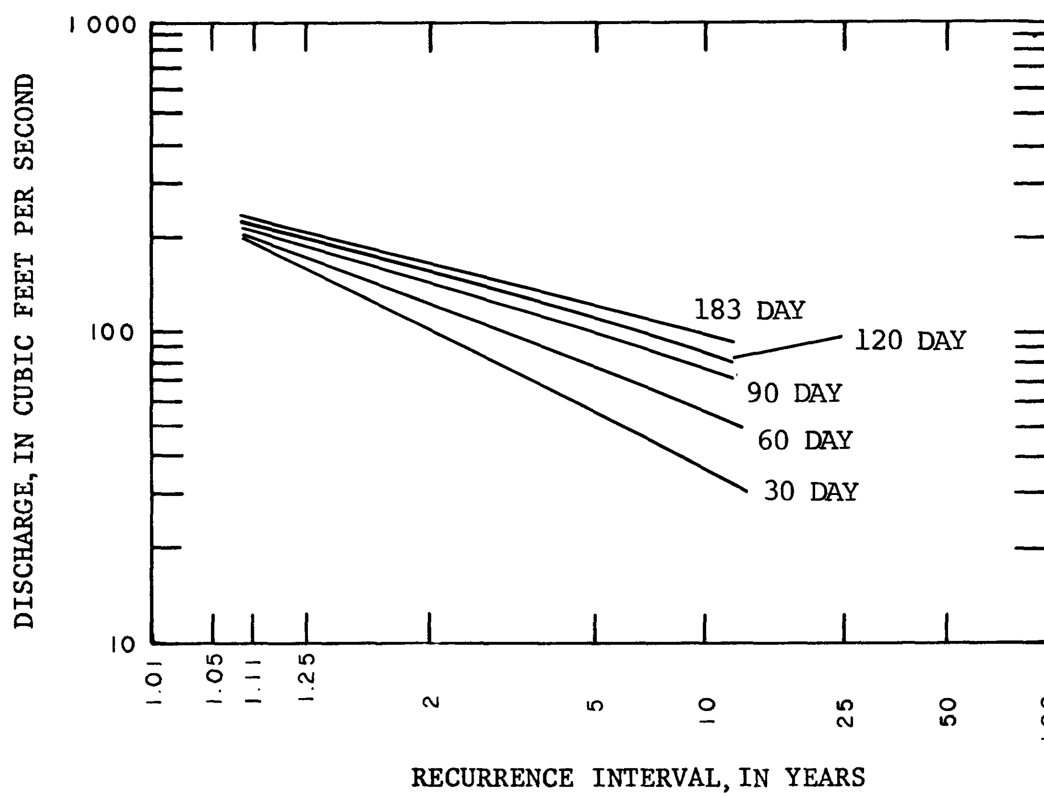

Figure 40.--Frequency curves for the indicated number of consecutive days, July through December 1970-80, Tamiami Canal near Coral Coral Gables, site 17.

Snapper Creek Canal at S-22 near South Miami, Site 18

Snapper Creek Canal is about 19 miles long and extends from just south of the Pennsuco Canal, due south about 9 miles to a junction with the Tamiami Canal, then south and east to Biscayne Bay (fig. 38). From north to south, the canal is joined by numerous canals that, depending on head differentials, contribute to the discharge or divert it into other canals. Flow is generally to the south, but because of the lateral canals and regulation of salinity-control structures on the Tamiami and Snapper Creek Canals, flow occasionally reverses. Discharge is affected by seepage losses through the canal bed into the Miami-Dade Water and Sewer Authority's Alexander Orr Well Field in southwest Miami (fig. 20).

The gaging station is 300 feet upstream from salinity-control structure 22 (S-22), 1.4 miles upstream from the mouth of the canal, and 2.5 miles south of South Miami (fig. 20). Mean daily discharge from October 1969 to September 1980 was 173 ft^3/s. The maximum and minimum daily discharges were 1,280 and 0.0 ft^3/s, respectively. Table 2 shows the greatest percentage of discharge for the 1970-80 water years occurred during June through November. Mean daily discharge for June through November 1970-80 was 281 ft^3/s. The maximum and minimum daily discharges for the high-flow period were 1,280 and 0.0 ft^3/s, respectively. The following table lists the number of no-flow days in each June through November period:

	June - November periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Number of no-flow days.	50	82	12	56	47	24	17	73	32	73	57

Figure 41 shows flow-duration data for the 11 water years and the 11 June through November periods. Tables 3 and 4 list the flow-duration data for the water years and June through November periods, respectively.

The following table shows the lowest mean discharge (in cubic feet per second) for selected periods of consecutive days in each June through November period for Snapper Creek Canal at S-22 near South Miami:

Number of consecutive days	June - November periods										
	1970	1971	1972	1973	1974	1975	1975	1977	1978	1979	1980
30	81	6	224	0	0	83	186	4.5	153	0	51
60	150	20	288	115	82	209	340	99	201	13	121
90	198	28	355	213	146	271	476	215	209	44	203
120	203	120	361	310	157	262	498	300	229	108	251
183	255	157	381	269	181	321	507	287	246	240	249

Figure 42 shows frequency curves based on the above data.

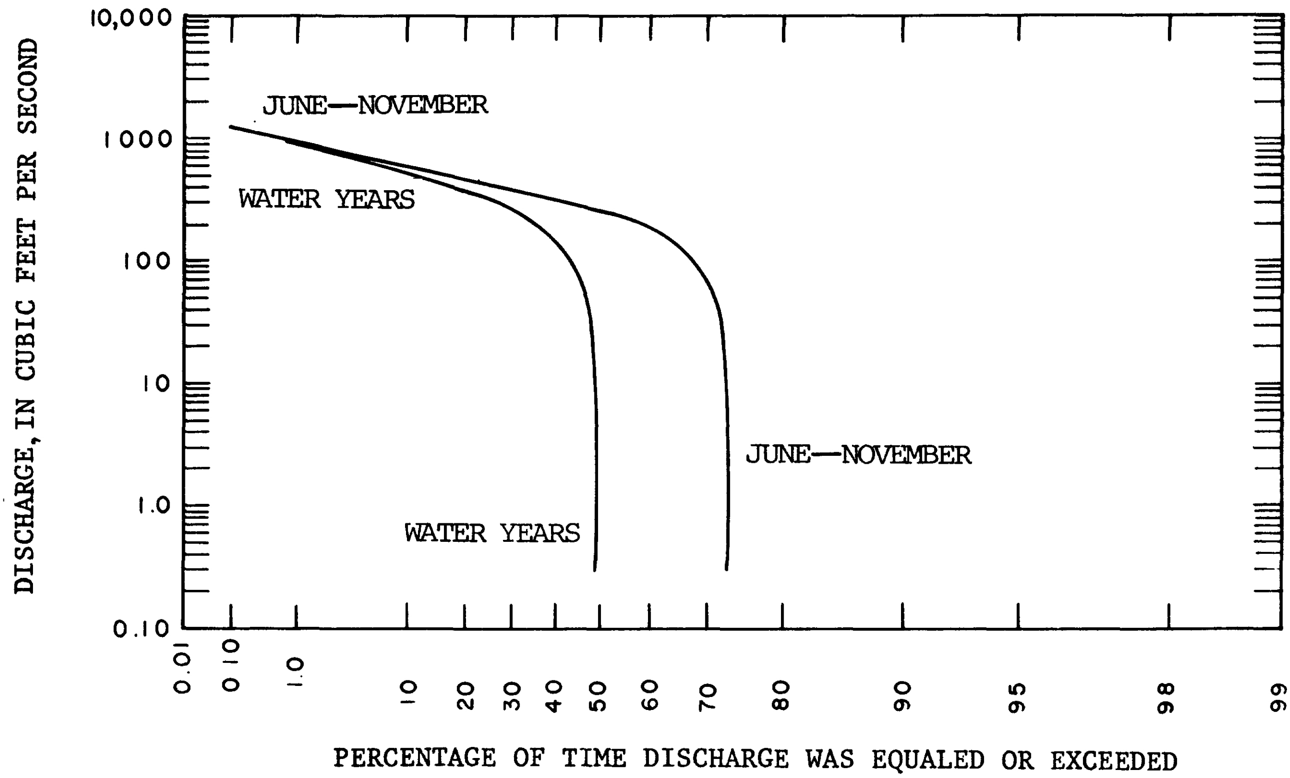

Figure 41.--Flow-duration curves for water years 1970-80 and the June through November periods 1970-80, Snapper Creek Canal at S-22 near south Miami, site 18.

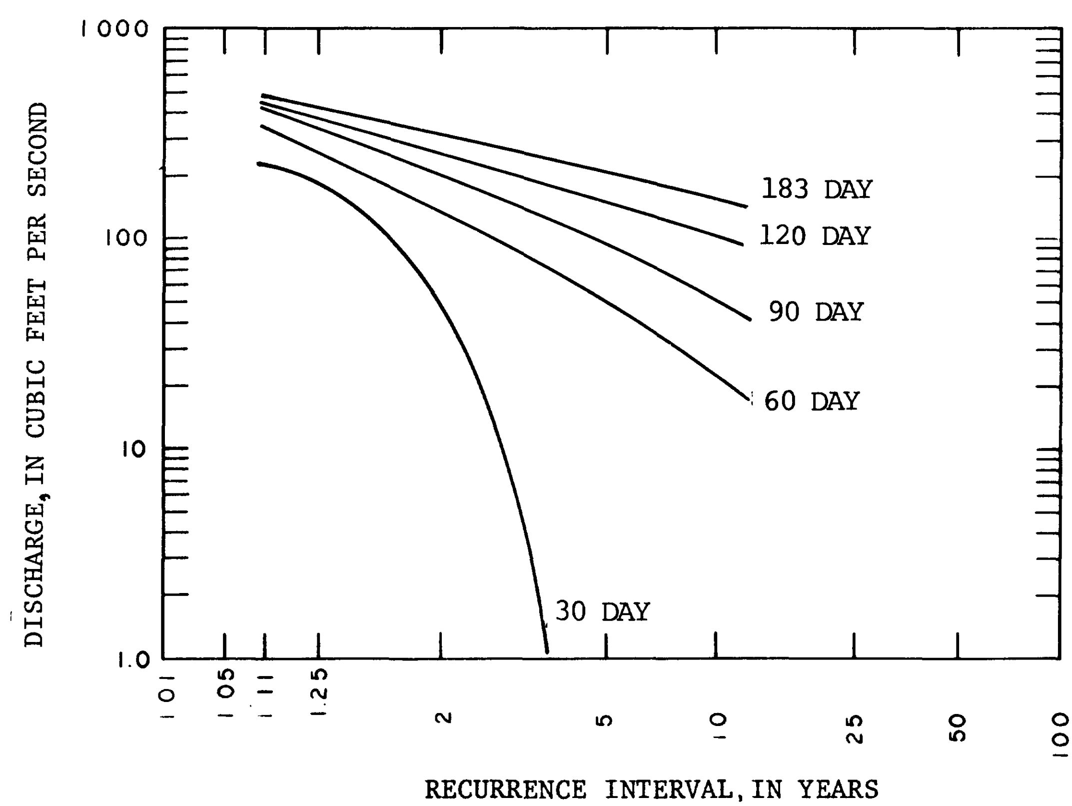

Figure 42.--Frequency curves for the indicated number of consecutive days, June through November 1970-80, Snapper Creek Canal at S-22 near south Miami, site 18.

Black Creek Canal at S-21 near Goulds, Site 19

Black Creek Canal extends from Levee 31-N Canal in central Dade County to Biscayne Bay at Black Point (fig. 38). Flow is regulated by operation of control structure 148 (S-148), by salinity-control structure 21 (S-21), and by pumpage for irrigation. Flow is affected by tide and is occasionally reversed.

The gaging station is in the control house of S-21, 0.5 mile upstream from the mouth and 3.5 miles east of Goulds. Mean daily discharge from October 1969 to September 1980 was 127 ft^3/s, not including the period January through September 1978 when no record was available. The maximum and minimum daily discharges were 2,290 and 0.0 ft^3/s, respectively. Table 2 shows the greatest percentage of discharge for the 1970-80 water years occurred during June through November. Mean daily discharge for June through November 1970-77 and 1979-80 was 203 ft^3/s. The maximum and minimum daily discharges for the high-flow period were 2,290 and 0.0 ft^3/s, respectively. The following table lists the number of no-flow days in each June through November period:

	June - November periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Number of no-flow days.	5	52	11	50	52	22	9	7	--	20	1

Figure 43 shows flow-duration data for the 10 water years, the 10 June through November periods, plus October and November 1978. Tables 3 and 4 list the flow-duration data for the water years and the June through November periods, respectively.

The following table shows the lowest mean discharge (in cubic feet per second) for selected periods of consecutive days in each June through November period for Black Creek Canal at S-21 near Goulds:

Number of consecutive days	June - November periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
30	104	11	136	11	0	62	61	132	--	67	135
60	139	19	160	52	77	122	142	191	--	130	169
90	152	87	188	123	93	128	219	220	--	135	225
120	147	171	186	185	103	129	237	327	--	176	236
183	205	165	223	157	114	153	255	297	--	199	236

Figure 44 shows frequency curves based on the above data.

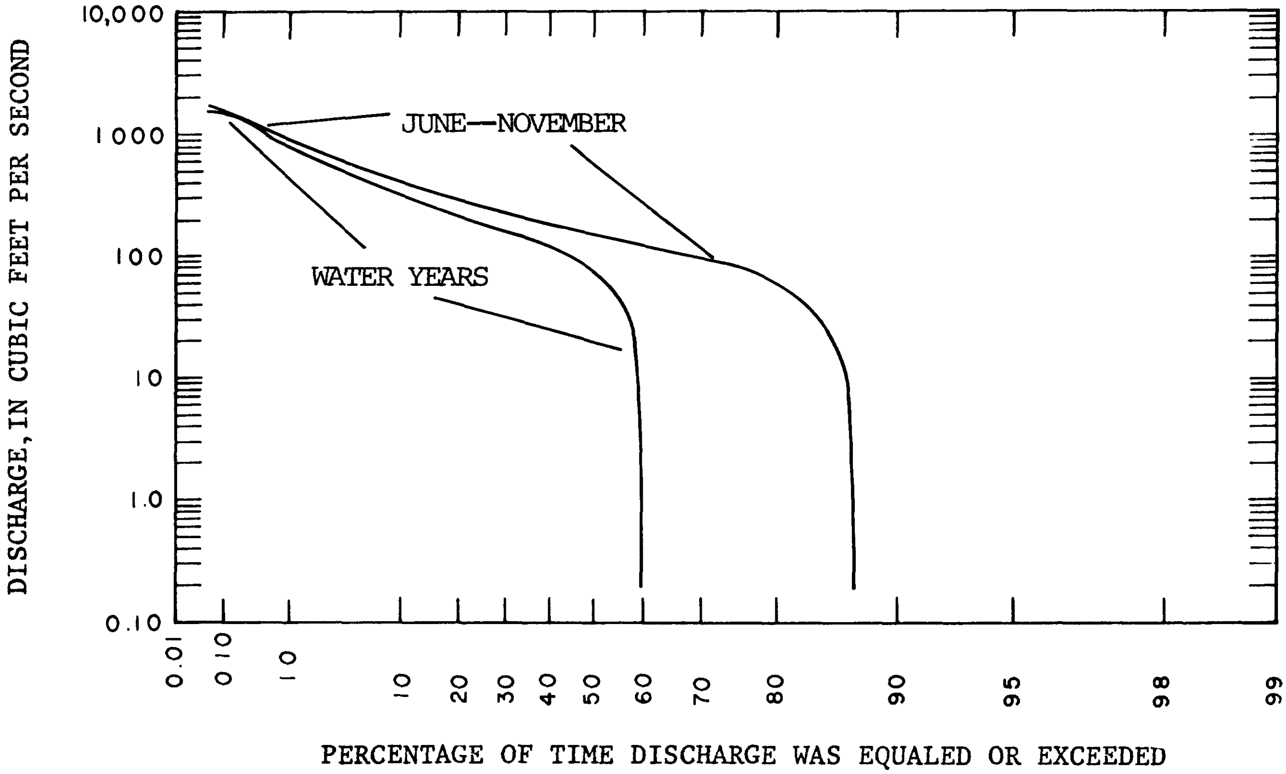

Figure 43.--Flow-duration curves for water years 1970-77, 1979-80, and October through December 1977, and the June through November periods 1970-77, 1979-80, and October and November 1978, Black Creek Canal at S-21 near Goulds, site 19.

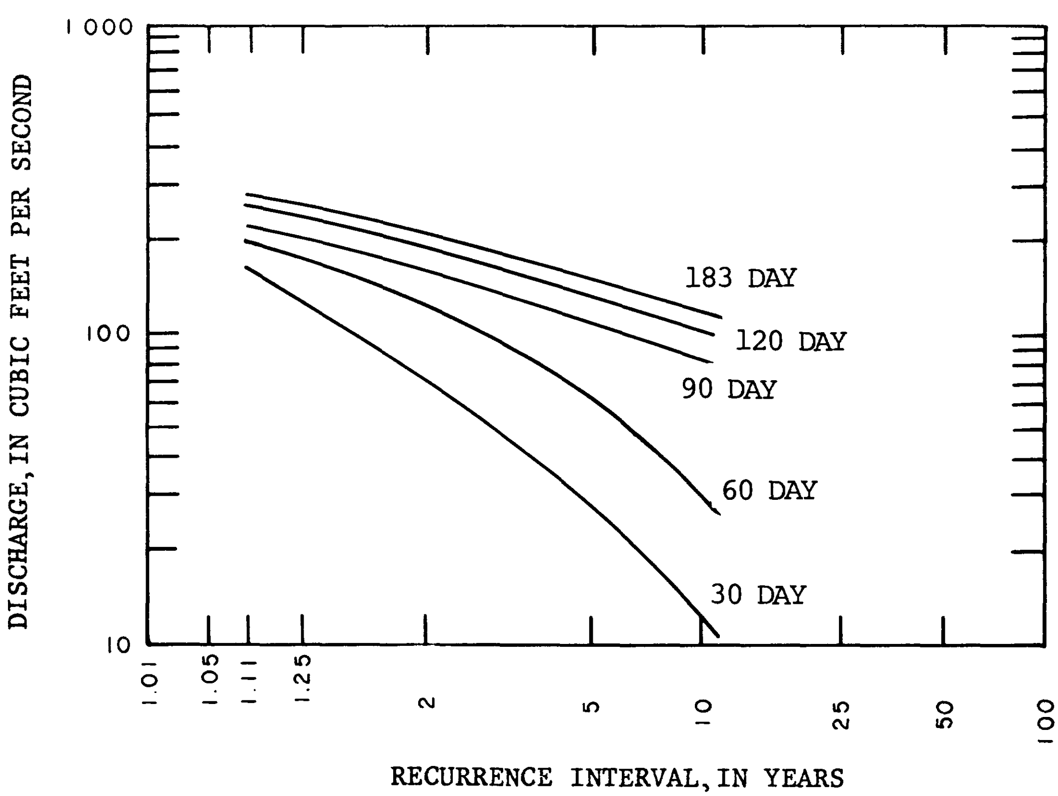

Figure 44.--Frequency curves for the indicated number of consecutive days, June through November 1970-77 and 1979-80, Black Creek Canal at S-21 near Goulds, site 19.

Mowry Canal at S-20F, Site 20

Mowry Canal extends from Levee 31-N Canal in a easterly direction to Biscayne Bay, 2 miles north of Turkey Point (fig. 38). Flow in the Mowry Canal is regulated by operation of control structures 196 (S-196), 167 (S-167), and 179 (S-179), by salinity-control structure 20F (S-20F), and by pumpage for irrigation. Flow is affected by tides and is occasionally reversed.

The gaging station is in the control house for S-20F, 0.5 mile upstream from the mouth of Mowry Canal and 8 miles east of Homestead. Mean daily discharge from March 1970 to September 1980 was 204 ft^3/s. The maximum and minimum daily discharges were 1,870 and 0.0 ft^3/s, respectively. Table 2 shows the greatest percentage of discharge for the period March 1970 through September 1980 occurred during June through November. Mean daily discharge for June through November 1970-80 was 304 ft^3/s. The maximum and minimum daily discharges for the high-flow period were 1,720 and 0.0 ft^3/s, respectively. The following table lists the number of no-flow days in each June through November period:

	June - November periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Number of no-flow days.	33	60	11	23	43	26	5	11	3	37	10

Figure 45 shows flow-duration data for the 10 1/2 water years and the 11 June through November periods. Tables 3 and 4 list the flow-duration data for the water years and the June through November periods, respectively.

The following table shows the lowest mean discharge (in cubic feet per second) for selected periods of consecutive days in each June through November period for Mowry Canal at S-20F:

Number of consecutive days	June - November periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
30	28	27	128	69	0	154	275	124	186	65	221
60	46	41	223	164	117	265	346	193	307	84	237
90	129	71	265	241	163	275	427	274	417	102	270
120	180	130	281	285	165	294	430	288	430	155	301
183	231	173	345	266	180	333	488	323	430	237	340

Figure 46 shows frequency curves based on the above data.

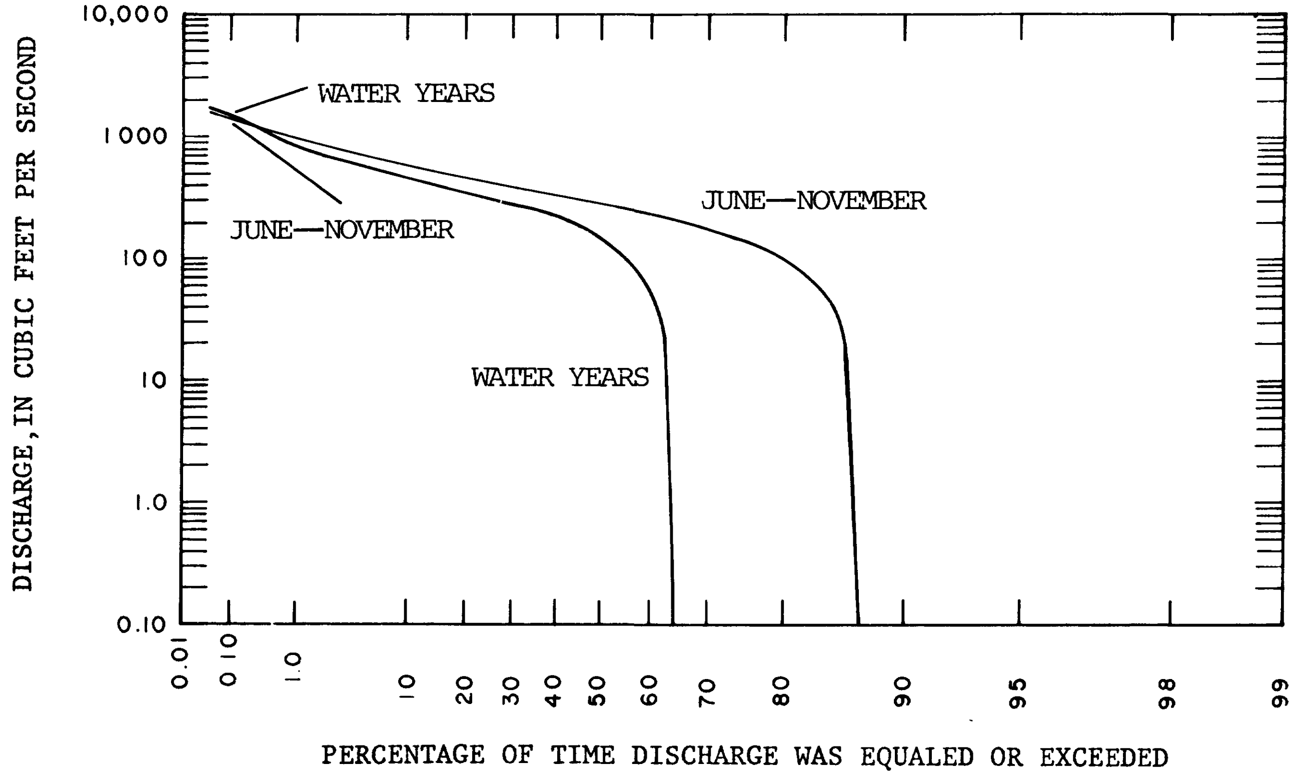

Figure 45.--Flow-duration curves for March 1970 through September 1980 and the June through November periods 1970-80, Mowry Canal at S-20F, site 20.

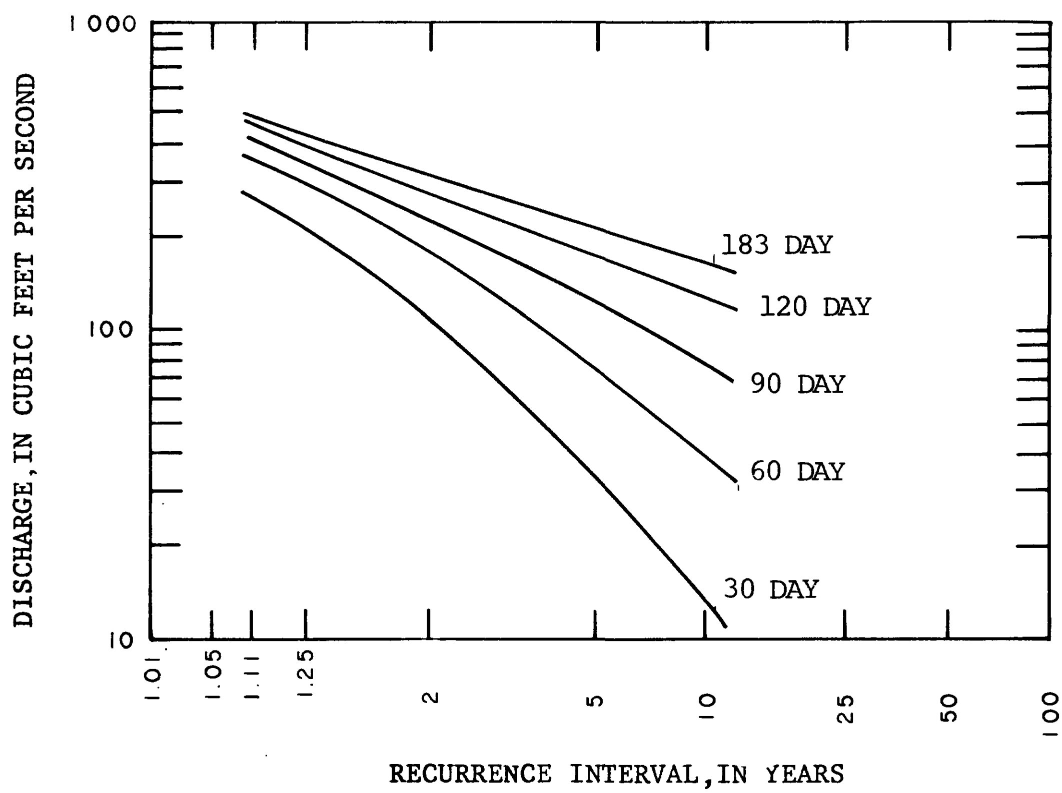

Figure 46.--Frequency curves for the indicated number of consecutive days, June through November 1970-80, Mowry Canal at S-20F, site 20

Canal 111 Above S-18C near Florida City, Site 21

Canal 111 extends from Levee 31-N Canal at control structure 176 (S-176), about 5 miles west of Homestead, south and southeast to Barnes Sound (fig. 38).

The gaging station is in the control house of control structure 18C (S-18C), 8.5 miles south of Florida City (fig. 38). Mean daily discharge from October 1969 to September 1980 was 57.5 ft^3/s. The maximum and minimum daily discharges were 1,570 and 0.0 ft^3/s, respectively. Table 2 shows the percentage of discharge for the 1970-80 water years occurred during May through October. Mean daily discharge for May through October 1970-80 was 97.7 ft^3/s. The maximum and minimum daily discharges for the high-flow period were 1,570 and 0.0 ft^3/s, respectively. The following table lists the number of no-flow days in each May through October period:

	May - October periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Number of no-flow days.	46	89	17	58	184	132	58	33	144	138	128

Figure 47 shows flow-duration data for the 11 water years and the 11 May through October periods. Tables 3 and 4 list the flow-duration data for the water years and the May thorugh October periods, respectively.

The following table shows the lowest mean discharge (in cubic feet per second) for selected periods of consecutive days in each May through October period for Canal 111 above S-18C near Florida City:

Number of consecutive days	May - October periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
30	0	0	10	0	0	0	16	0	0	0	3.4
60	7.8	.25	35	.03	0	6.1	122	0	0	20	103
90	14	1.4	47	10	0	42	159	67	20	14	106
120	31	1.19	81	53	0	65	133	64	15	27	107
183	26	6.6	277	68	0	69	161	124	109	76	147

Figure 48 shows frequency curves based on the above data.

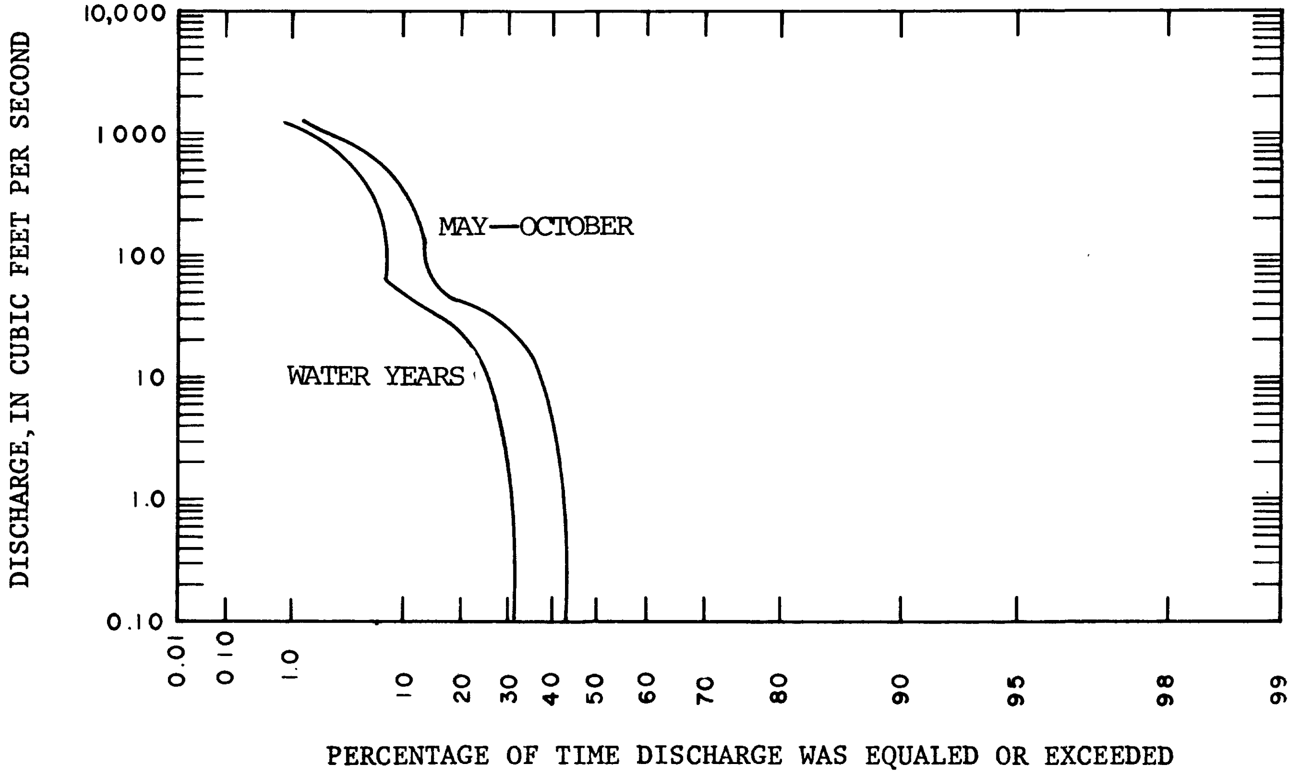

Figure 47.--Flow-duration curves for water years 1970-80 and the May through October periods 1970-80, Canal 111 above S-18C near Florida City, site 21.

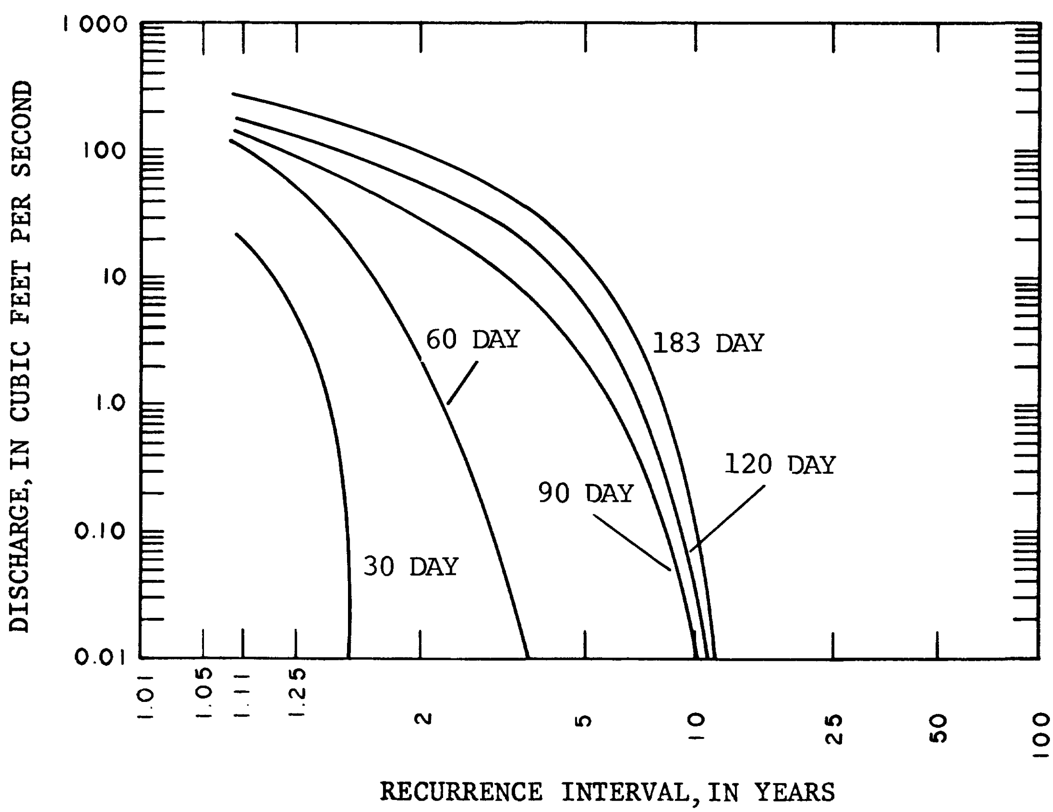

Figure 48.--Frequency curves for the indicated number of consecutive days, May through October 1970-80, Canal 111 above S-18C near Florida City, site 21.

Barron River Canal near Everglades City, Site 22

The Barron River Canal originates in north-central Collier County near Immokalee and flows approximately 35 miles southward to the Gulf of Mexico (fig. 49). Discharge in the Barron River Canal is seasonally regulated by operation of control structures at, above, and below the gaging station.

The gaging station is 40 feet upstream from the control structure, 0.7 mile north of Copeland, and 7.5 miles upstream from the canal's mouth on the Chokoloskee Bay (fig. 49). Mean daily discharge from October 1969 to September 1980 was 102 ft^3/s. The maximum and minimum daily discharges were 283 and 0.0 ft^3/s, respectively. Table 2 shows the greatest percentage of discharge for the 1970-80 water years occurred during July through December. Mean daily discharge for July through December 1970-80 was 139 ft^3/s. The maximum and minimum daily discharges for the high-flow period were 270 and 9.5 ft^3/s, respectively. The following table lists the number of no-flow days in each July through December period:

	July - December periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Number of no-flow days.	0	0	0	0	0	0	0	0	0	0	0

Figure 50 shows flow-duration data for the 11 water years and the 11 July through December periods. Tables 3 and 4 list the flow-duration data for the water years and the July through December periods, respectively.

The following table shows the lowest mean discharge (in cubic feet per second) for selected periods of consecutive days in each July through December period for Barron River Canal near Everglades City:

Number of consecutive days	July - December periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
30	52	26	81	81	23	29	45	24	35	93	45
60	83	74	93	113	35	72	83	53	59	109	55
90	116	119	103	152	66	115	120	89	75	143	66
120	138	146	125	166	100	137	136	119	105	166	87
183	170	151	128	156	129	133	148	131	133	169	82

Figure 51 shows frequency curves based on the above data.

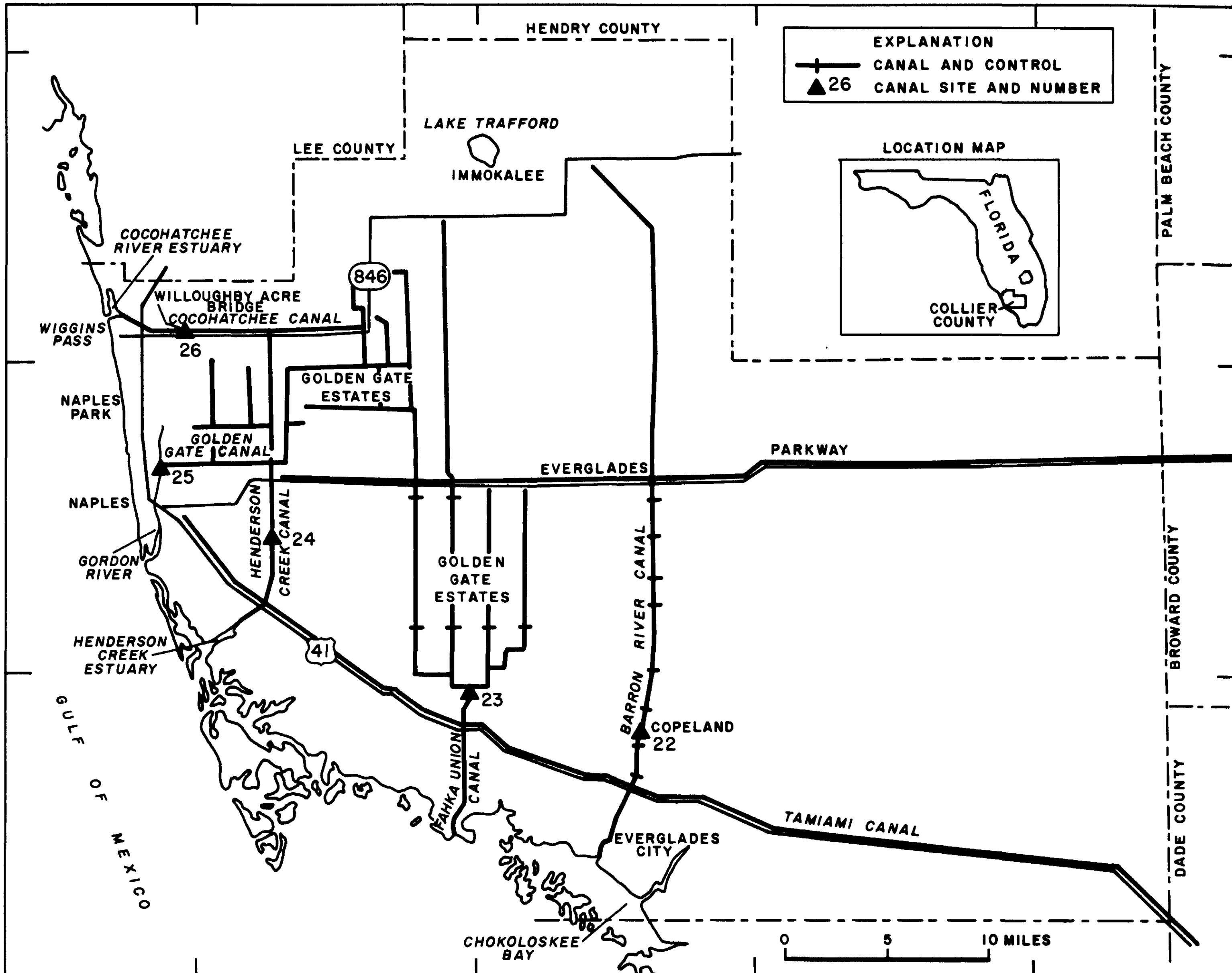

Figure 49.--Location of canals, canal sites, controls, and major roads in Collier County.

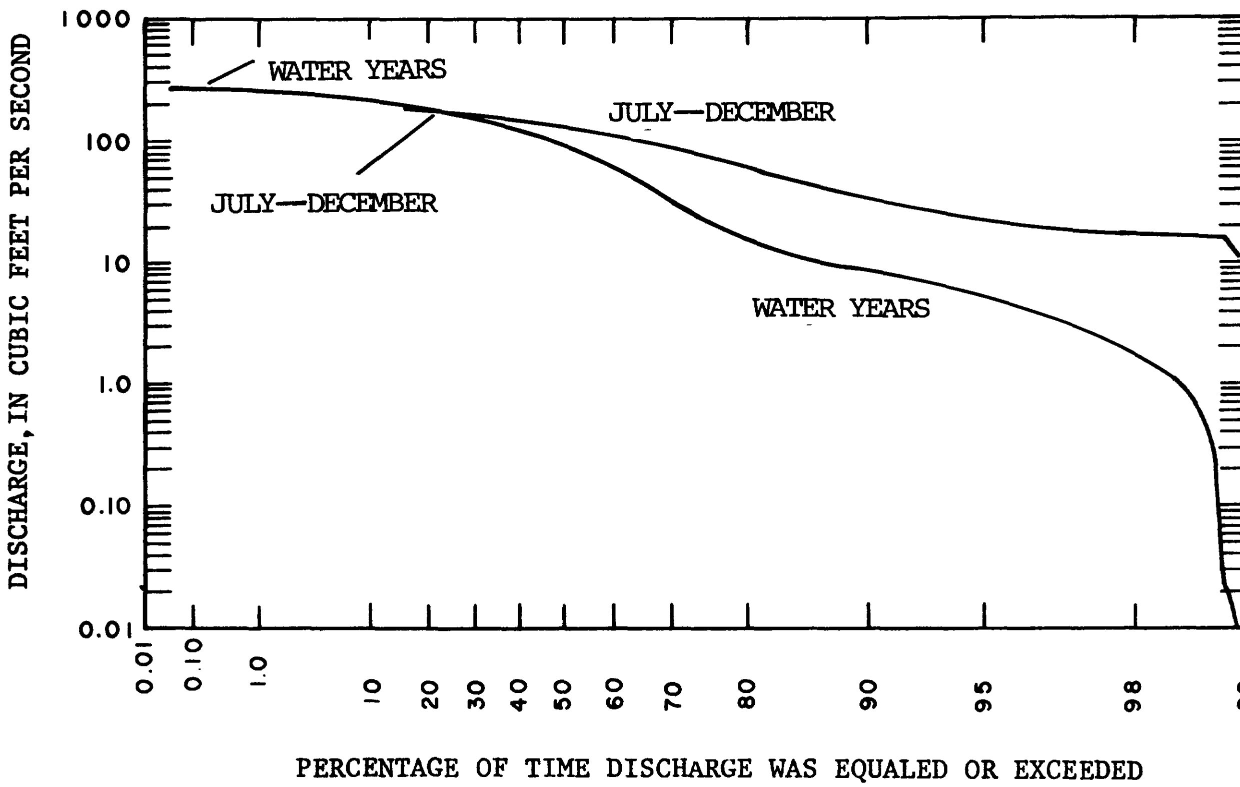

Figure 50.--Flow-duration curves for water years 1970-80 and the July through December periods 1970-80, Barron River Canal near Everglades City, site 22.

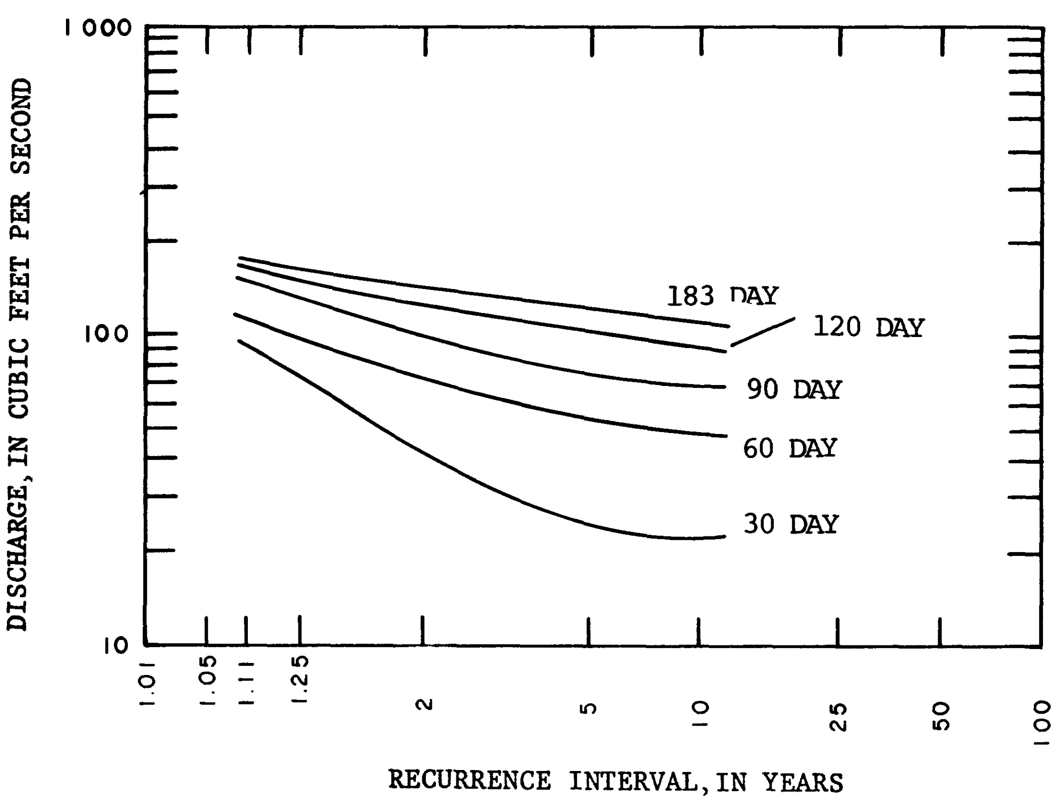

Figure 51.--Frequency curves for the indicated number of consecutive days, July through December 1970-80, Barron River Canal near Everglades City, site 22.

Fahka Union Canal near Copeland, Site 23

The Fahka Union Canal in central Collier County extends northward about 30 miles from the Gulf of Mexico nearly to Lake Trafford (fig. 49). In its northwest reaches, several secondary canals of the Fahka Union Canal system are connected to the Golden Gate Canal system, which helps provide partially controlled drainage of the Golden Gate Estates east of Naples (McCoy, 1962, p. 9). Drainage from the shallow aquifer to the canal is limited by several control structures or weirs. A coastal weir on the main canal just north of U.S. Highway 41 retards saltwater intrusion (Swayze and McPherson, 1977).

The gaging station is 0.5 mile north of U.S. Highway 41 and 9.3 miles west of Copeland. Mean daily discharge from October 1969 to September 1980 was 226 ft^3/s. The maximum and minimum daily discharges were 3,190 and 0.0 ft^3/s, respectively. Table 2 shows the greatest percentage of discharge for the 1970-80 water years occurred during June through November. Mean daily discharge for June through November 1970-80 was 403 ft^3/s. The maximum and minimum daily discharges for the high-flow period were 3,190 and 0.0 ft3/s, respectively. The following table lists the number of no-flow days in each June through November period:

	June - November periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Number of no-flow days.	0	17	0	34	6	22	0	0	0	0	0

Figure 52 shows flow-duration data for the 11 water years and the 11 June through November periods. Tables 3 and 4 list the flow-duration data for the water years and the June through November periods, respectively.

The following table shows the lowest mean discharge (in cubic feet per second) for selected periods of consecutive days in each June through November period for Fahka Union Canal near Copeland:

Number of consecutive days	June - November periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
30	221	115	192	3	47	7.8	43	62	128	62	30
60	310	189	265	232	165	298	109	195	268	66	84
90	411	356	309	427	456	487	157	244	354	93	150
120	468	763	311	591	641	509	172	254	410	191	282
183	476	706	338	484	638	517	217	250	379	174	265

Figure 53 shows frequency curves based on the above data.

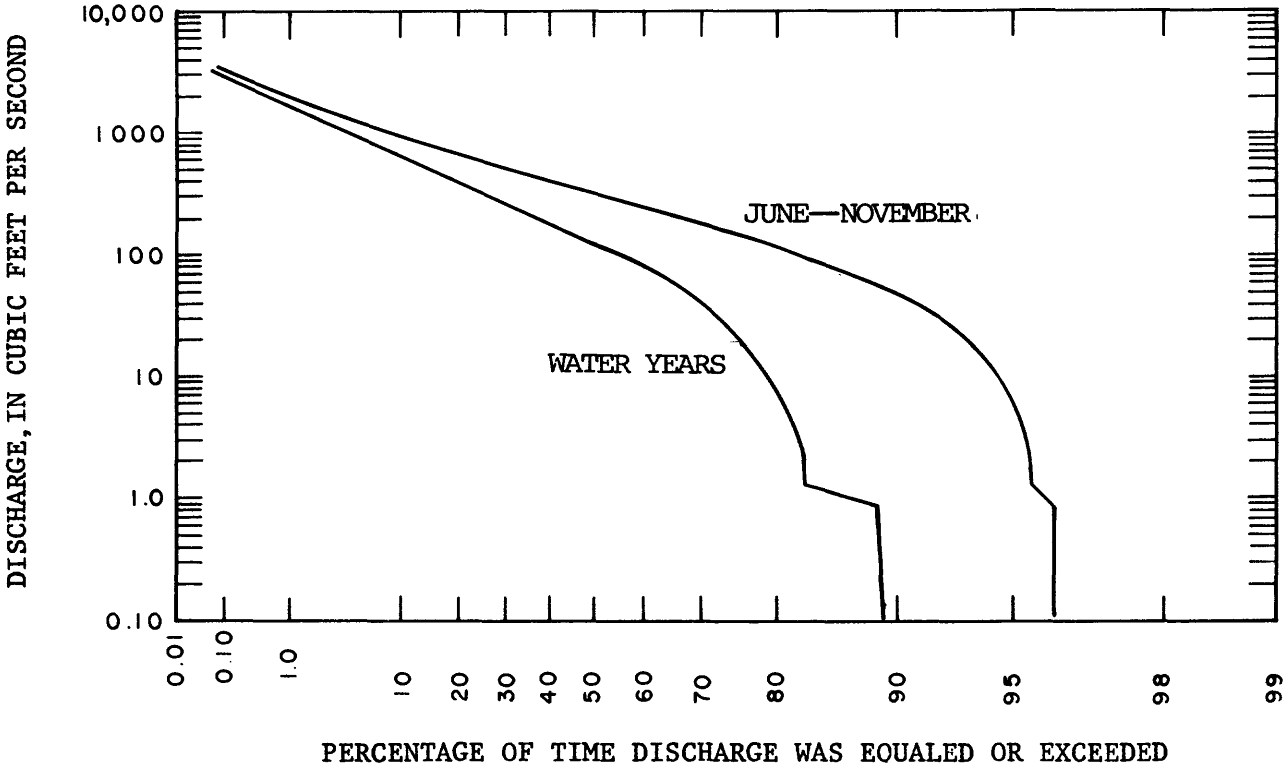

Figure 52.--Flow-duration curves for water years 1970-80 and the June through November periods 1970-80, Fahka Union Canal near Copeland, site 23.

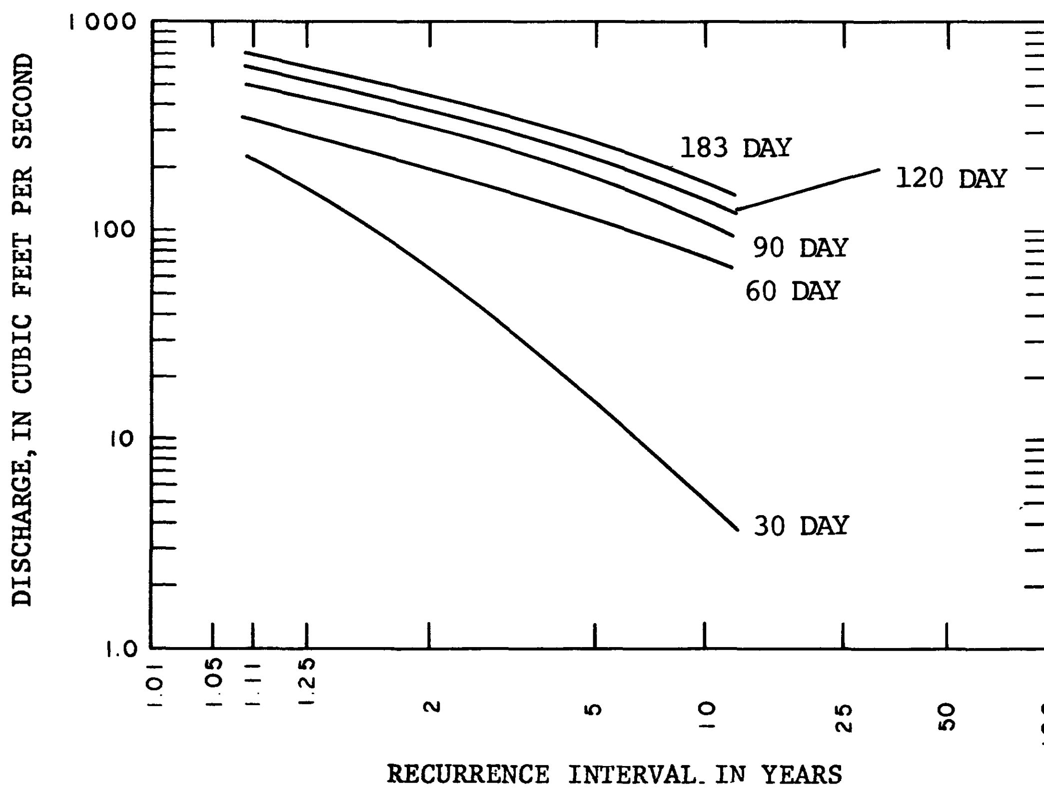

Figure 53.--Frequency curves for the indicated number of consecutive days, June through November 1970-80, Fahka Union Canal near Copeland, site 23.

Henderson Creek Canal near Naples, Site 24

The Henderson Creek Canal in western Collier County flows south 7 miles from the main stem of the Golden Gate Canal into the Henderson Creek estuary (fig. 49). Flow is uncontrolled, except for a structure at the Everglades Parkway. During peak rainy periods, the Henderson Creek Canal may receive some discharge from the Golden Gate Canal (McCoy, 1972, p. 12).

The gaging station is 3.8 miles south of the Everglades Parkway, 5 feet downstream of a private bridge, and about 6 miles southeast of Naples. Mean daily discharge from October 1969 to September 1980 was 24.5 ft^3/s. The maximum and minimum daily discharges were 353 and 0.0 ft^3/s, respectively. Table 2 shows the greatest percentage of discharge for the 1970-80 water years occurred during June through October. Mean daily discharge for June through October 1970-80 was 46.3 ft^3/s. The maximum and minimum daily discharges for the high-flow period were 353 and 0.0 ft^3/s, respectively. The following table lists the number of no-flow days in each June through October period:

	June - October periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Number of no-flow days.	0	0	0	2	10	0	0	2	0	0	0

Figure 54 shows flow-duration data for the 11 water years and the 11 June through October periods. Tables 3 and 4 list the flow-duration data for the water years and the June through October periods, respectively.

The following table shows the lowest mean discharge (in cubic feet per second) for selected periods of consecutive days in each June through October period for Henderson Creek Canal near Naples:

Number of consecutive days	June - October periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
30	37	4.2	26	3.5	16	15	19	18	22	5.2	3.8
60	42	16	29	14	38	46	25	47	42	8.2	10
90	43	29	38	55	47	55	29	74	57	13	17
120	50	38	42	54	48	62	44	89	58	19	25

Figure 55 shows frequency curves based on the above data.

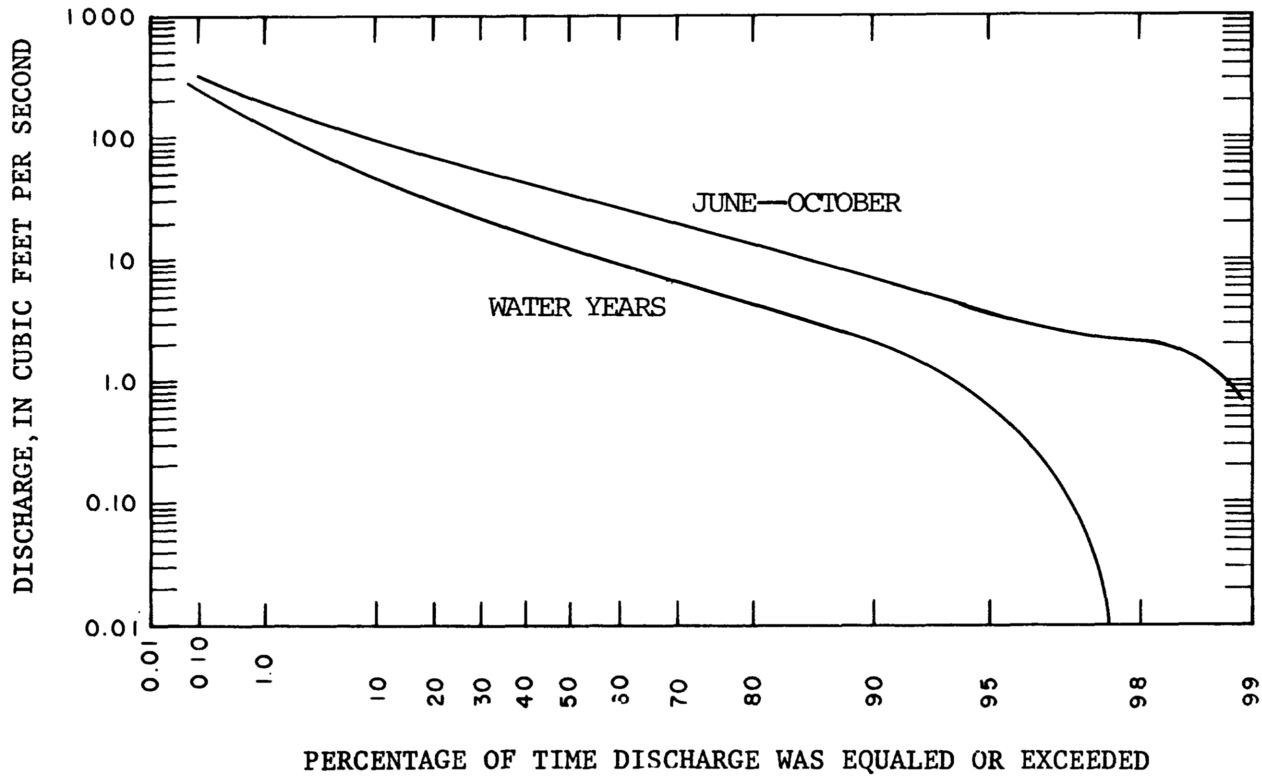

Figure 54.--Flow-duration curves for water years 1970-80 and the June through October periods 1970-80, Henderson Creek Canal near Naples, site 24.

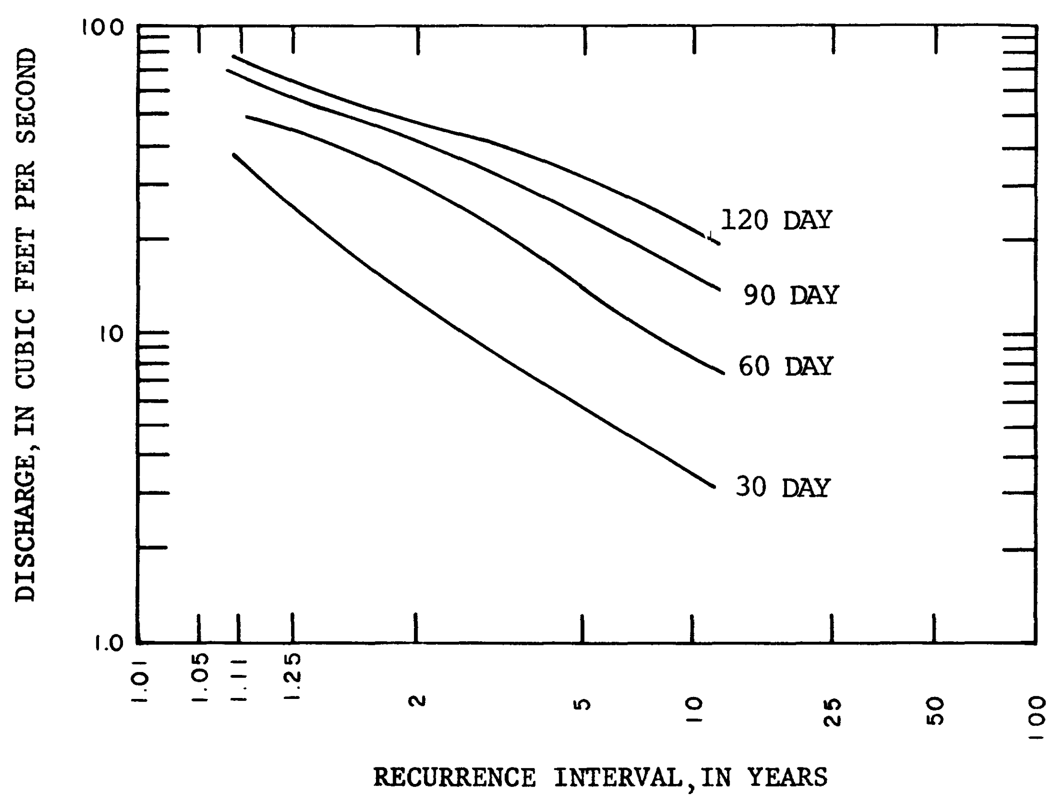

Figure 55.--Frequency curves for the indicated number of consecutive days, June through October 1970-80, Henderson Creek Canal near Naples, site 24.

Golden Gate Canal at Naples, Site 25

The Golden Gate Canal is the primary drainage canal in western Collier County. It extends about 20 miles inland from the Gordon River, draining the western sections of the Golden Gate Estates (fig. 49). The eastern sections are drained by the Fahka Union Canal. These two canal systems drain surface-water runoff, preventing flooding of developed lands (McCoy, 1973, p. 11).

The gaging station is 1.4 miles upstream from the Gordon River and 1.5 miles east of Naples city limits. Mean daily discharge from October 1969 to September 1980 was 307 ft^3/s. The maximum and minimum daily discharges were 3,060 and 0.0 ft^3/s, respectively. Table 2 shows the greatest percentage of discharge for the 1970-80 water years occurred during June through October. Mean daily discharge for June through October 1970-80 was 539 ft^3/s. The maximum and minimum daily discharges for the high-flow period were 3,060 and 5.2 ft^3/s, respectively. The following table lists the number of no-flow days in each June through October period:

	June - October periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Number of no-flow days.	0	0	0	0	0	0	0	0	0	0	0

Figure 56 shows flow-duration data for the 11 water years and the 11 June through October periods. Tables 3 and 4 list the flow-duration data for the water years and the June through October periods, respectively.

The following table shows the lowest mean discharge (in cubic feet per second) for selected periods of consecutive days in each June through October period for Golden Gate Canal at Naples:

Number of consecutive days	June - October periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
30	291	118	366	123	299	90	205	230	159	176	101
60	416	279	474	325	628	228	386	532	296	198	219
90	426	446	531	597	815	297	409	590	428	264	253
120	431	656	616	766	901	347	418	616	432	392	344

Figure 57 shows frequency curves based on the above data.

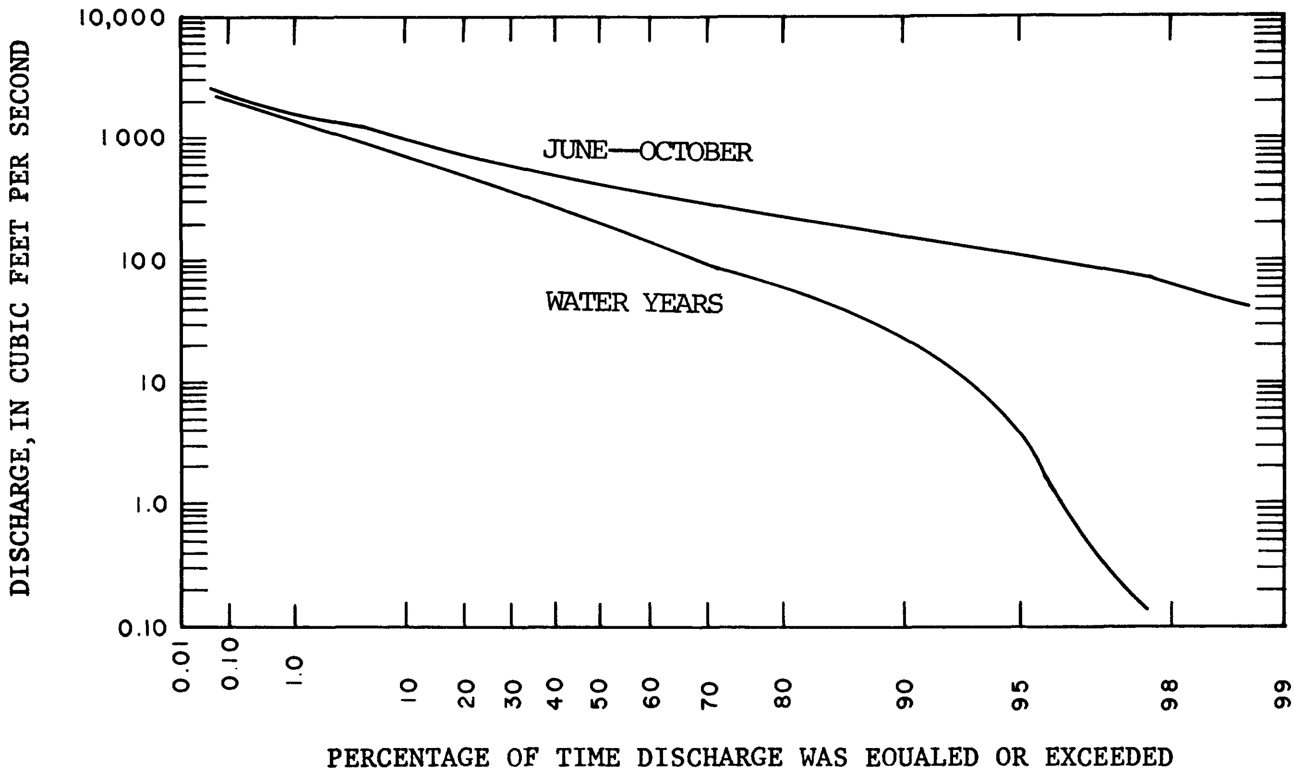

Figure 56.--Flow-duration curves for water years 1970-80 and the June through October periods 1970-80, Golden Gate Canal at Naples, site 25.

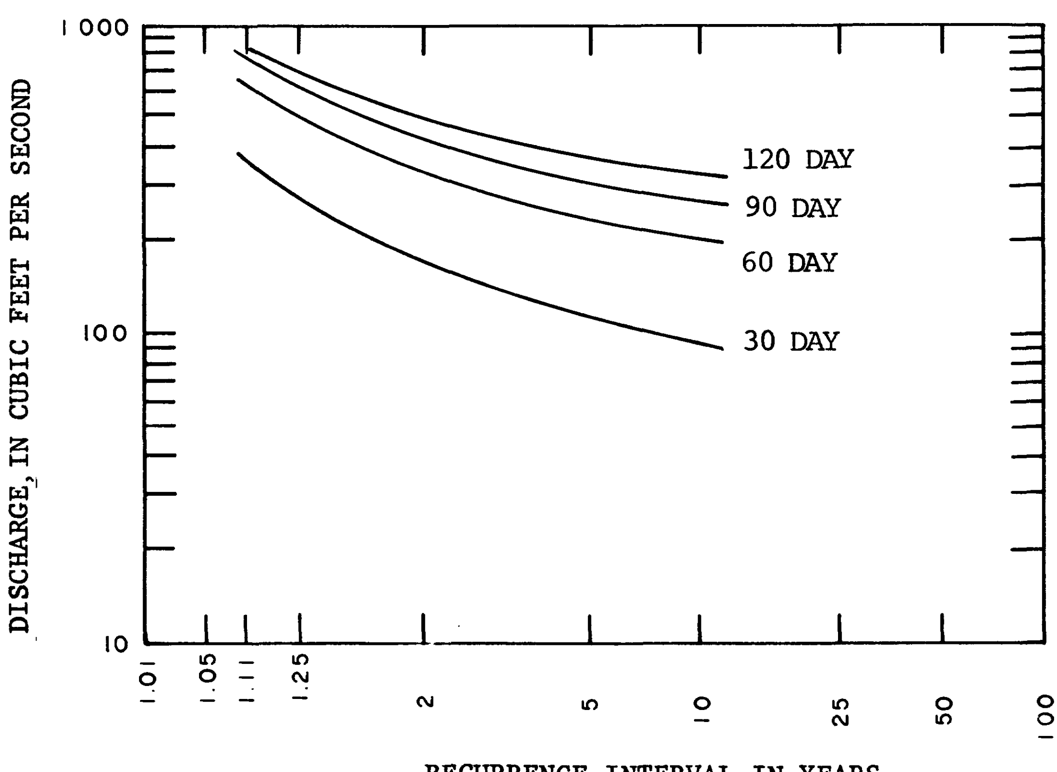

Figure 57.--Frequency curves for the indicated number of consecutive days, June through October 1970-80, Golden Gate Canal at Naples, site 25.

Cocohatchee River Canal at Willoughby Acre Bridge, Site 26

The Cocohatchee River Canal is the northernmost outlet for the Gulf American Corporation (GAC) Canal system. It drains most of the area southwest of Lake Trafford, and during peak wet periods aids drainage of the Golden Gate area. Water from the Cocohatchee River Canal discharges into the Cocohatchee River estuary and ultimately flows into the Gulf of Mexico by way of Wiggins Pass (fig. 49).

The gaging station is on the downstream side of the center of the Willoughby Acre Bridge, 2.3 miles east of the intersection of U.S. Highway 41 and State Highway 846 at Naples Park. Mean daily discharge from October 1969 to September 1980 was 29.3 ft^3/s. The maximum and minimum daily discharges were 454 and 0.0 ft^3/s, respectively. Table 2 shows the greatest percentage of discharge for the 1970-80 water years occurred during July through October. Mean daily discharge for July through October 1970-80 was 67.0 ft^3/s. The maximum and minimum daily discharges for the high-flow period were 454 and 3.0 ft^3/s, respectively. The following table lists the number of no-flow days in each July through October period:

	July - October periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Number of no-flow days.	0	0	0	0	0	0	0	0	0	0	0

Figure 58 shows flow-duration data for the 11 water years and the 11 July through October periods. Tables 3 and 4 list the flow-duration data for the water years and the July through October periods, respectively.

The following table shows the lowest mean discharge (in cubic feet per second) for selected periods of consecutive days in each July through October period for Cocohatchee River Canal at Willoughby Acre Bridge:

Number of consecutive days	July - October periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
30	16	30	27	24	19	14	18	26	9.2	5.0	14
60	28	52	35	125	77	30	26	40	35	7.2	26
90	45	85	49	182	110	39	26	58	73	33	53
120	39	88	47	149	129	38	30	52	70	47	54

Figure 59 shows frequency curves based on the above data.

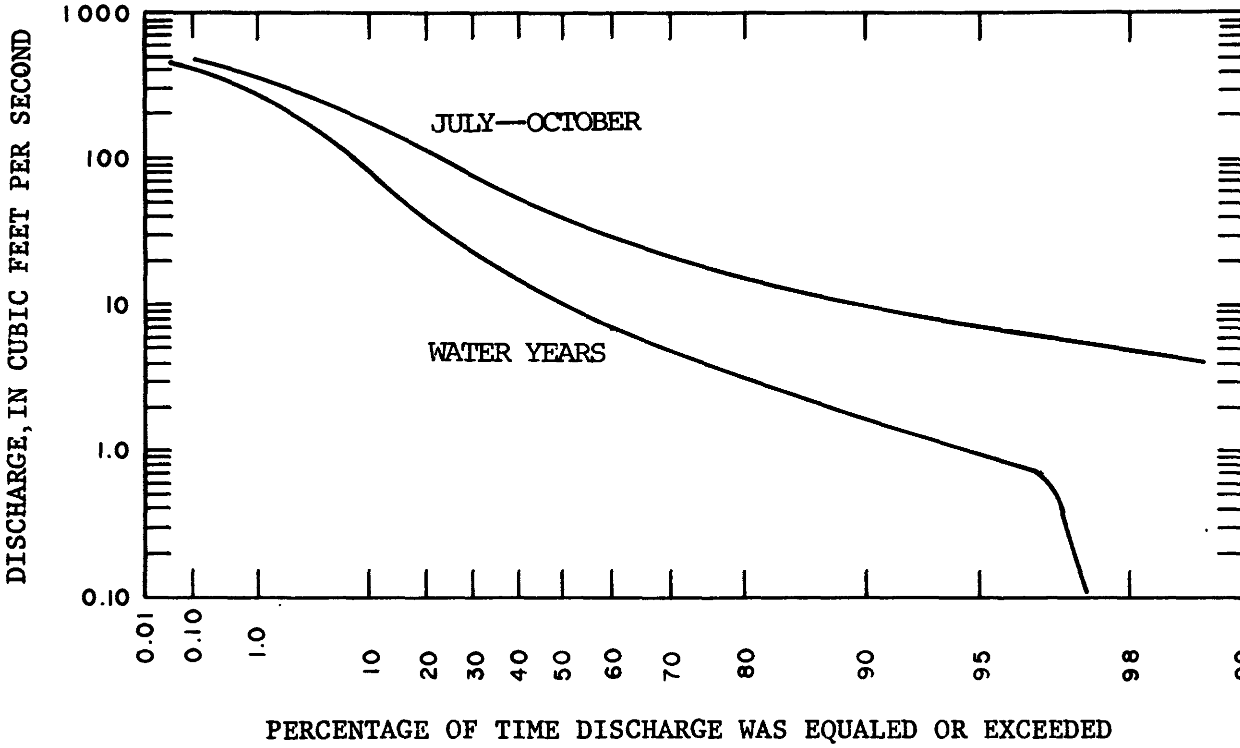

Figure 58.--Flow-duration curves for water years 1970-80 and the July through October periods 1970-80, Cocohatchee River Canal at Willoughby Acre Bridge, site 26.

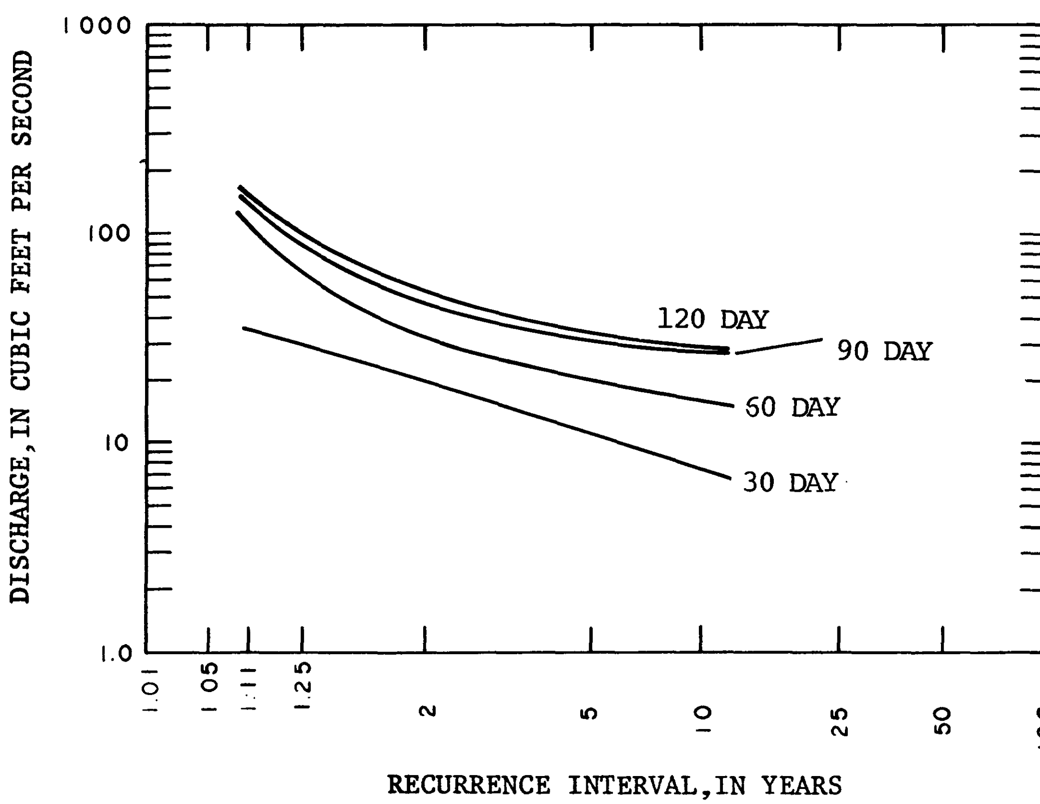

Figure 59.--Frequency curves for the indicated number of consecutive days, July through October 1970-80, Cocohatchee River Canal at Willoughby Acre Bridge, site 26.

Caloosahatchee River at S-79 near Olga, Site 27

The Caloosahatchee River flows from spillway and lock S-77 at Lake Okeechobee near Moore Haven along southern Glades and northwestern Hendry Counties towards the Gulf of Mexico (fig. 1). Flow is regulated by control structures 77 (S-77) and 78 (S-78) at Moore Haven and Ortona, respectively (fig. 1), and by salinity-control structure 79 (S-79) at Olga about 15 miles east of Fort Myers (fig. 60).

The gaging station is in the control house of S-79 at the southeast end of the lock and S-79, 1.2 miles east of Olga. Mean daily discharge from October 1969 to September 1980 was 1,405 ft^3/s. The maximum and minimum daily discharges were 21,400 and 1.5 ft^3/s, respectively. Table 2 shows the greatest percentage of discharge for the 1970-80 water years occurred during June through October. Mean daily discharge for June through October 1970-80 was 1,730 ft^3/s. The maximum and minimum daily discharges for the high-flow period were 15,100 and 2.4 ft^3/s, respectively. The following table lists the number of no-flow days in each June through October period:

	June - October periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Number of no-flow days.	0	0	0	0	0	0	0	0	0	0	0

Figure 61 shows flow-duration data for the 11 water years and the 11 June through October periods. Tables 3 and 4 list the flow-duration data for the water years and the June through October periods, respectively.

The following table shows the lowest mean discharge (in cubic feet per second) for selected periods of consecutive days in each June through October period for Caloosahatchee River at S-79 near Olga:

Number of consecutive days	June - October periods										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
30	439	274	87	548	249	654	139	67	633	157	167
60	540	639	210	1,090	2,630	1,100	610	540	1,190	225	471
90	860	783	225	1,580	5,290	1,070	949	896	2,160	289	717
120	2,050	1,200	236	1,830	5,780	1,270	899	911	2,110	1,170	937

Figure 62 shows frequency curves based on the above data.

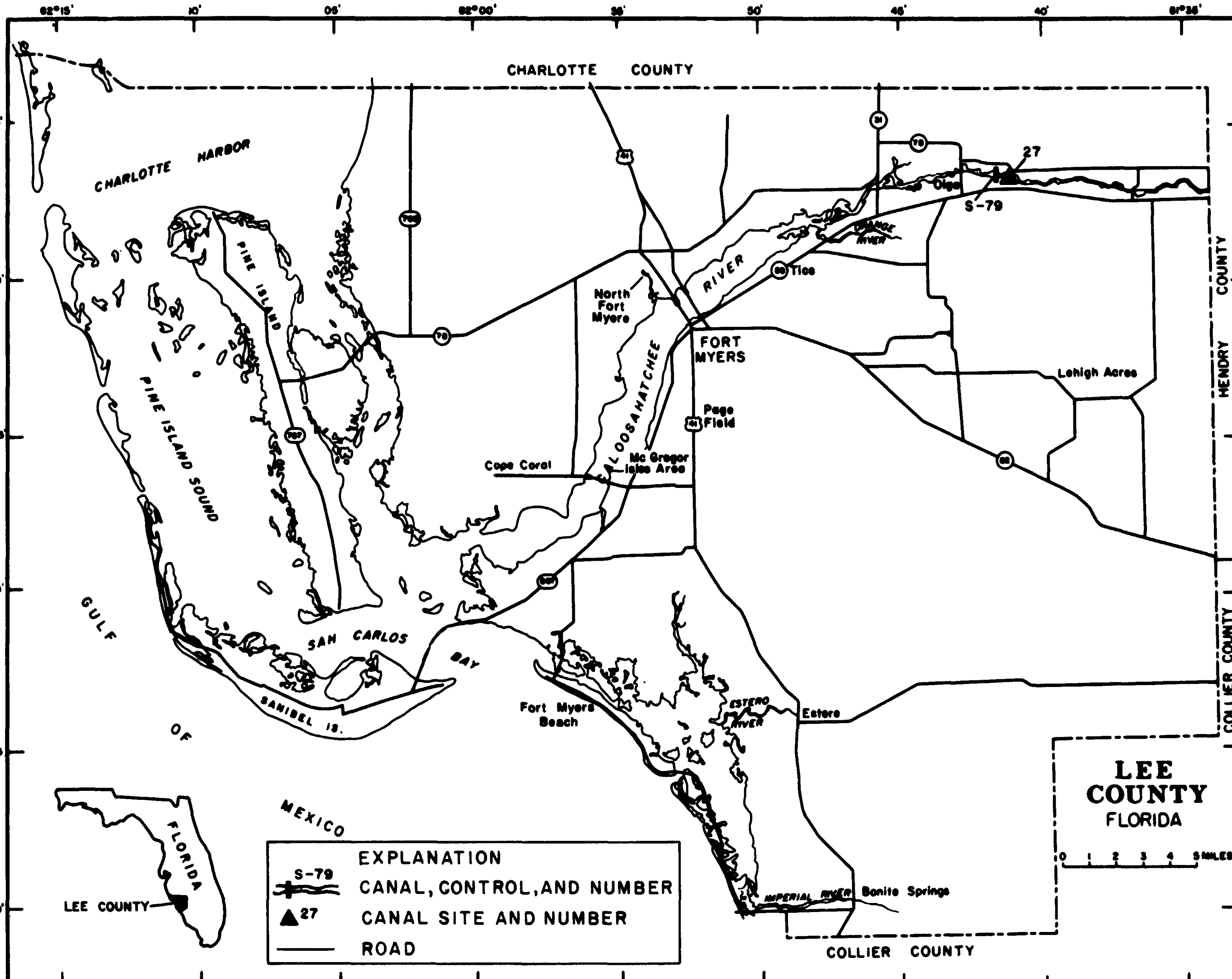

Figure 60.--Location of canal, canal site, control, and major roads in Lee County.

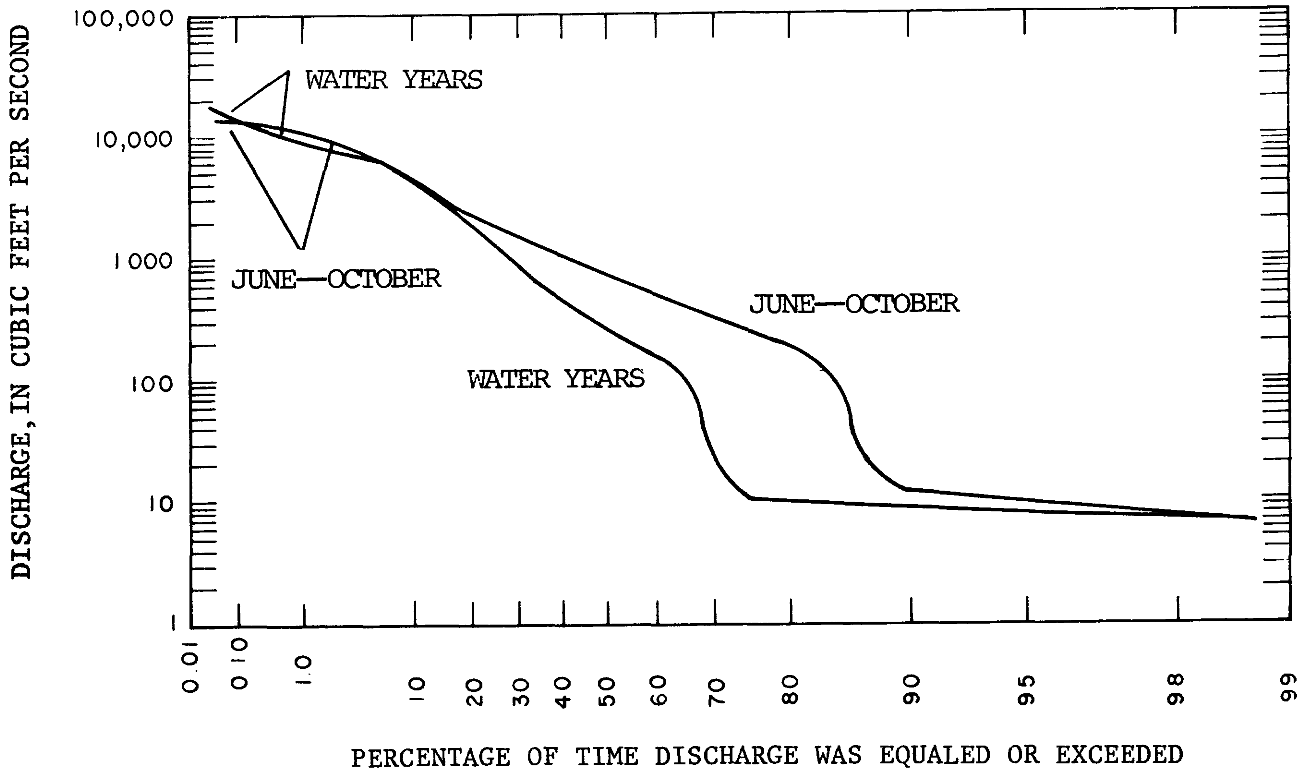

Figure 61.--Flow-duration curves for water years 1970-80 and the June through October periods 1970-80, Caloosahatchee River at S-79 near Olga, site 27.

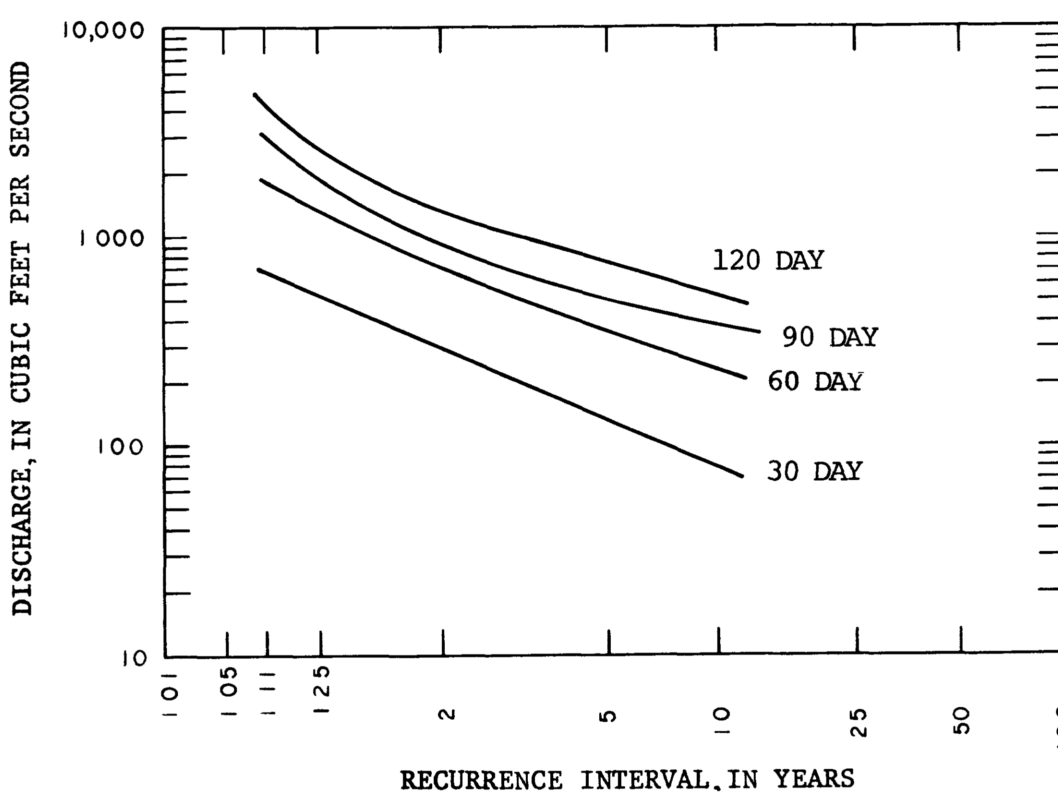

Figure 62.--Frequency curves for the indicated number of consecutive days, June through October 1970-80, Caloosahatchee River at S-79 near Olga, site 27.

SUMMARY AND CONCLUSIONS

As south Florida's population increases, so will the demand for additional sources of freshwater. One method of augmenting existing freshwater supplies may be by injection into suitable aquifers of surplus freshwater when available. A major requirement of this method is a reliable supply of freshwater for injection. A potential source of freshwater for injection is surplus surface water discharged from canals and rivers to the ocean during high-flow periods (usually during wet periods).

Analyses of discharge data for the 1970-81 water years at 27 canal and river sites show that canal discharge as high as 660 cubic feet per second occurred 70 percent of the time during the high-flow period at one site (Tamiami Canal outlets, Levee 67A to 40-Mile Bend). At 11 other sites, discharges of 110 to 370 cubic feet per second occurred 70 percent of the time during the high-flow periods, while at 9 sites, discharges of 21 to 100 cubic feet per second occurred 70 percent of the time during the high-flow periods. At other sites (those in the Biscayne, Plantation Road, Middle River, C-111, and Cypress Creek Canals), discharges of 0.1 cubic foot per second occurred 70 percent of the time during the high-flow periods.

Criteria for amounts of surplus freshwater considered adequate to support injection systems cannot be established, as they would vary greatly with water needs to be satisfied and with the efficiency of a particular injection system. However, based upon this analysis of discharge at 27 canal and river sites throughout south Florida, it appears that substantial amounts of surface water are potentially available for subsurface injection and storage.

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