

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SEDIMENT LOADS IN CANALS 18, 23, AND 24 IN SOUTHEASTERN FLORIDA

By

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IN SOUTHEASTERN FLORIDA

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ABSTRACT

Suspended-sediment concentrations and suspended-sediment discharges were determined in selected canals in St. Lucie, Martin, and Palm Beach Counties, in southeastern Florida. Sediment rating curves were developed to relate water discharge to sediment concentration at the three sites sampled. An evaluation of the concentration and sediment loads shows that larger amounts of suspended sediment were being carried into the St. Lucie River estuary than were being carried into the Loxahatchee River estuary.

Peat and muck soils in areas drained for agricultural planting and citrus cultivation are readily carried by runoff waters into the major canals that traverse the region.

INTRODUCTION

The amounts of sediment discharged into tidal estuaries have been the subject of increasing concern to those interested in the changes in the economic, natural, and esthetic conditions of estuarine environments. Although relatively detailed studies have been made in other coastal areas, little or no information has been obtained in south Florida.

The purpose of this report is to present the results of an investigation on suspended sediment loads carried by three canals in southeastern Florida. Sediment, discharge, and stage data were collected during a normally high discharge period, July to November, 1969, from Canals 23 and 24, which discharge into the St. Lucie River estuary, and from Canal 18, which discharges into the Loxahatchee River estuary.

The investigation was made by the U.S. Geological Survey in cooperation with the Central and Southern Florida Flood Control District. The daily discharges for the three canals during the investigation, as well as the instantaneous discharges at the time the sediment samples were collected, were furnished by the Flood Control District.

PURPOSE AND SCOPE

The primary objective of the investigation was to provide data on the particle size and volume of the suspended sediment transported by three major canals that discharge into the estuarine environments of the St. Lucie River and the Loxahatchee River.

A secondary objective was to determine what percentage of the total yearly suspended sediment load could be expected to have been discharged during the period studied. The 20 weeks of the investigation represent 38 percent of the year, during which time more than 60 percent of the total yearly discharge of water was recorded.

The project also provided the opportunity to relate sediment tonnage discharged to unit area drained and to volume of water discharged from that area.

AREA OF INVESTIGATION

The area investigated includes parts of St. Lucie, Martin and Palm Beach Counties along the southeast coast of Florida, as shown in figure 1.

Fig. 1
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The area is drained by four major canals that discharge into the St. Lucie River and the Loxahatchee River, which enter tidal estuaries near Stuart and Jupiter, respectively. Canal 18 drains the south part of the area, and Canals 23 and 24 drain the north part. Figures 2, 3, and 4 show the boundaries of the basins drained by the three canals and the land use in the basins. The investigation did not include St. Lucie Canal, which carries drainage from its basin and inflow from Lake Okeechobee.

Figs. 2,
3, & 4
near here

The average annual rainfall ranges from 65 inches in the south part of the area to about 53 inches in the north part. Rainfall usually occurs in short intense afternoon showers during the summer and as a slow drizzle of longer duration during the rest of the year.

Rainfall records for Stuart show that the average monthly rainfall from December through June is 3.8 inches and from July through November, 6.2 inches.

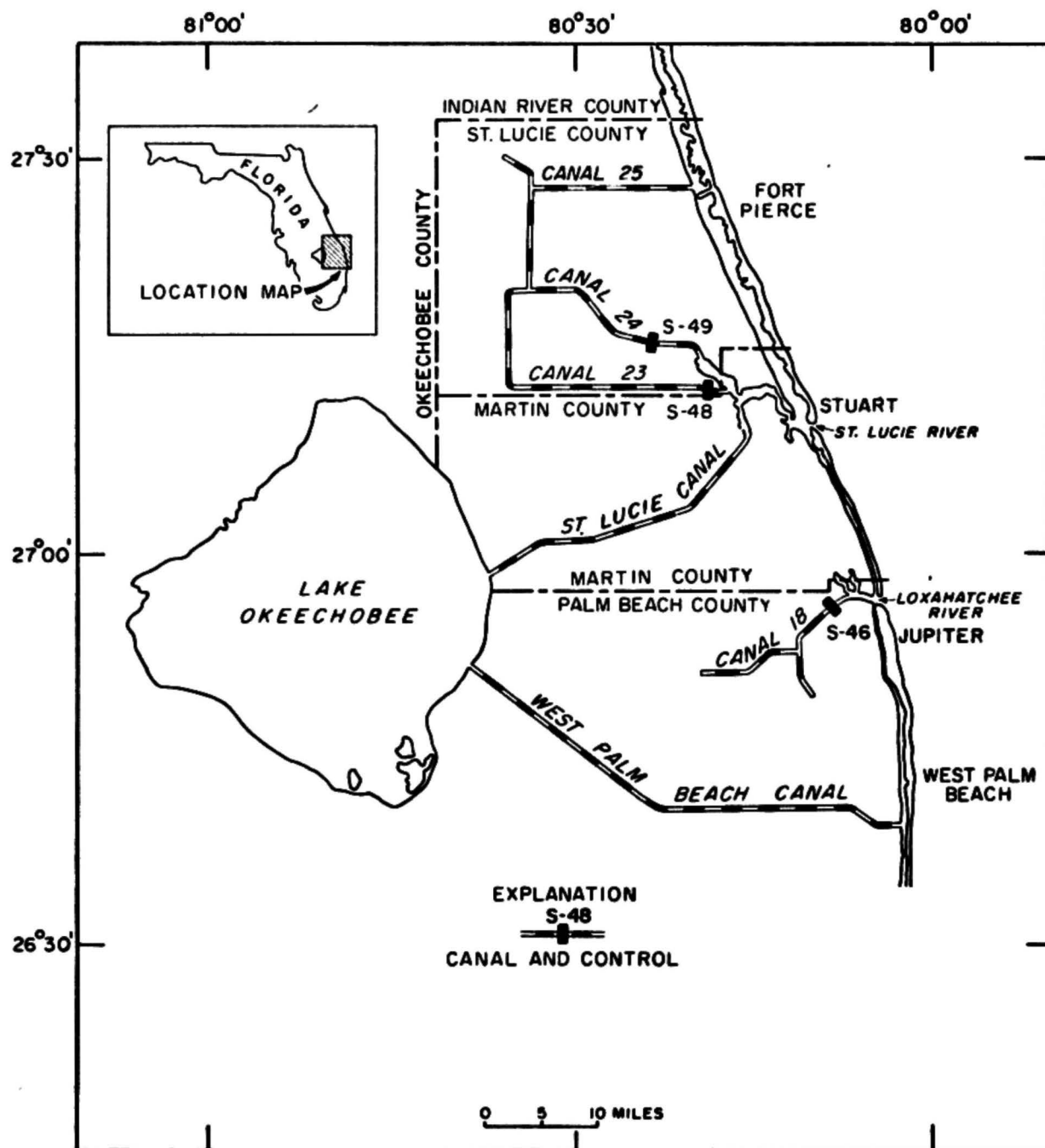


Figure 1.--Map of southeastern Florida showing the area of investigation.

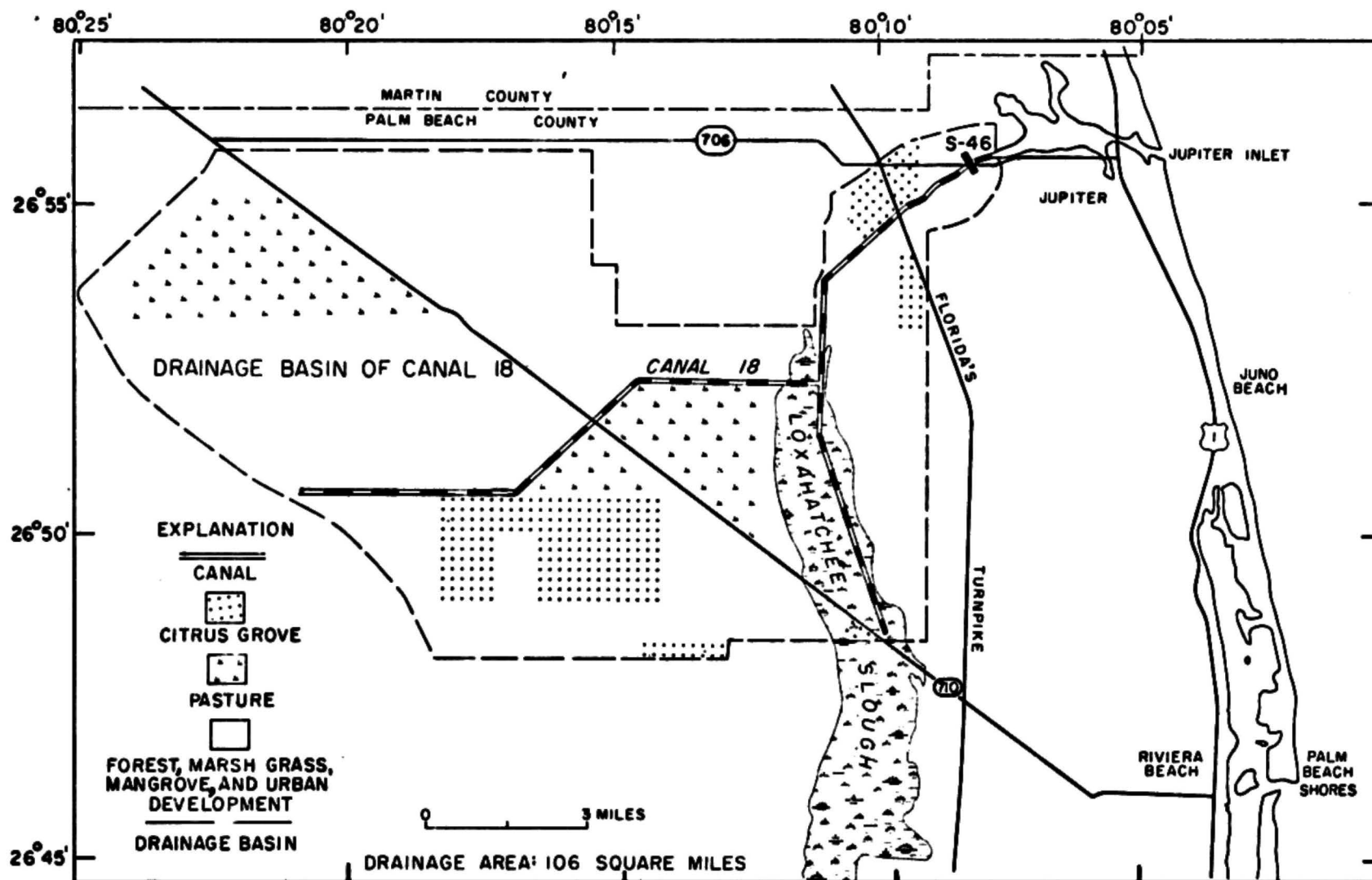


Figure 2.--Map of the drainage basin of Canal 18 showing the land use

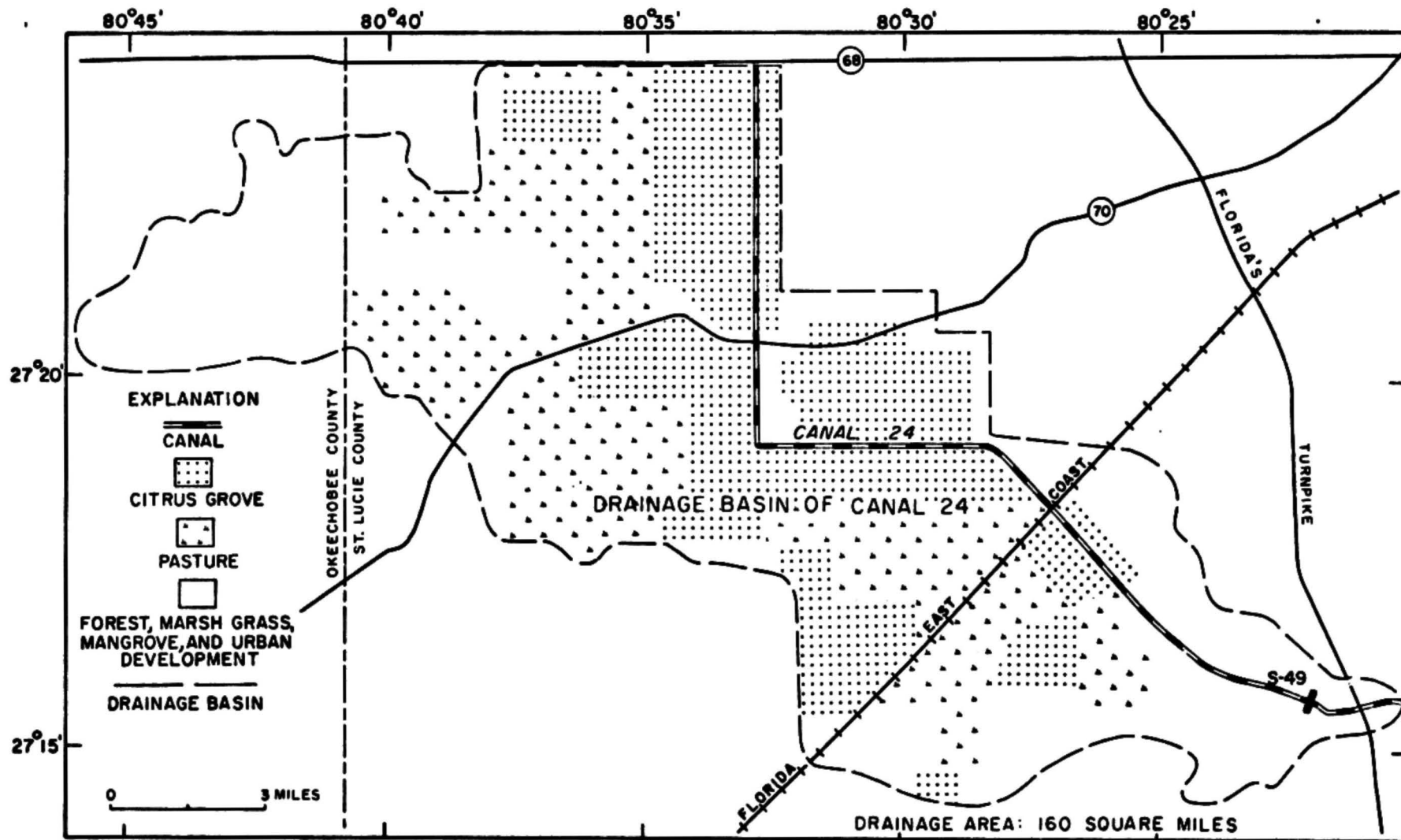


Figure 4.--Map of the drainage basin of Canal 24 showing the land use

The elevation of the land surface ranges from a few feet above mean sea level along the coast to 57 feet at the southwest corner of St. Lucie County. The entire area is of low relief, with the exception of an area of rolling terrain north of Jupiter.

Thirty to 35 percent of the land is presently (1970) used for pasture and 20 to 25 percent for citrus groves and truck farming. About 30 percent of the total area is forest and marsh grass, and the remainder is occupied by urban development and coastal mangroves. (See figs. 2-4).

Natural vegetation consists of cypress trees, pond grass, and sawgrass in the flatwoods and grass in the area of higher elevation. The soils are poorly drained sands or loamy sands that overlie limestone; the soils are covered with the characteristic peat and muck present throughout much of the area. This organic deposit is thickest in the north reaches of the area investigated and near Lake Okeechobee.

The natural drainage pattern has been changed considerably by the construction of hundreds of small flood control and drainage canals. These canals crisscross the area and finally empty into the major drainage canals shown in figure 1. The canals cut into the upper layers of a shallow water-table aquifer consisting mostly of sand and shell beds of the Pamlico Sand that overlie layers of sandy limestone of the Anastasia Formation. These upper layers are of low permeability, when considered as a water-yielding zone, but they are permeable enough to absorb most of the rainfall, thus reducing surface runoff. The canals are generally fed by ground water discharged directly into them and by whatever surface runoff reaches them.

Operation of the canal system is solely for the purpose of flood control and drainage during the wet season and for water management during the dry season. The canal system has made possible the development of extensive agricultural areas.

Increasing water requirements have brought about a plan to backpump water from the canals into Lake Okeechobee during high water levels for later release to agricultural lands during dry periods.

SAMPLING SITES AND PROCEDURES

Depth-integrated samples of canal water were obtained weekly at each of three stations on random days from the first week in July 1969 to the second week in November 1969. Canal 18 was sampled at the center and the downstream side of the bridge on State Road 706 approximately 300 feet upstream from Control Structure 46. (see fig. 2.) The sampler was lowered and raised at a constant rate with a crane-mounted sounding reel. Canal 23 was sampled near the middle of the canal at the protective cable about 500 feet upstream from Control Structure 48 (see fig. 3). The sampler was lowered and raised from a boat using a sounding reel. Canal 24 also was sampled from a boat at the protective cable approximately 600 feet upstream from Control Structure 49 (see fig. 4).

Samples were collected with a depth-integrating U.S.D.H. 59 suspended sediment sampler with a quarter-inch diameter nozzle. This nozzle allowed an intake velocity to the sampler that was approximately equal to the velocity in the canal, and, as a pint bottle was used, the horizontal length of sample filament was almost 50 feet.

Early in the investigation, samples were collected at one-third, one-half, and two-thirds of the width of each canal, but the analyses of these samples showed that the sediment concentration was the same for each sampled point of the cross section at all three sites. Therefore, for the remainder of the investigation, samples were collected at the center of the canals only.

Samples were analyzed by the U.S. Geological Survey laboratory in Ocala, Florida. The gravimetric method was used for the determination of sediment concentration, and the bottom withdrawal tube method together with sieve analyses were used for the particle-size determinations. Detailed explanations of the laboratory techniques used in water quality, sediment concentration, and particle-size determinations may be found in the references listed at the end of this report.

RESULTS OF INVESTIGATION

Graphs of weekly measurements of gage height, discharge, and sediment concentration for Canal 18 are shown in figure 5. Except from August 24 to September 4 and September 17 to 24, there is a direct relationship between discharge and sediment concentration for Canal 18. This relationship, however, is variable, as indicated by different sediment concentrations for the same discharge at different times. No relationship between gage height and sediment concentration is apparent from figure 5, probably because gate operations at Structure 46 prevented any direct relationship between gage height and discharge.

Fig. 5
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Structure 48 on Canal 23 is a fixed crest dam with no gates. Water levels were above the crest of Structure 48 during July 1 to November 15, 1969.

The graphs for Canal 23 (fig. 6) show in general a direct relationship between sediment concentration, gage height, and discharge. The sediment concentration deviates slightly from the general relationship during July 29 to August 4, August 30 to September 4, and September 29 to October 7.

Fig. 6
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here

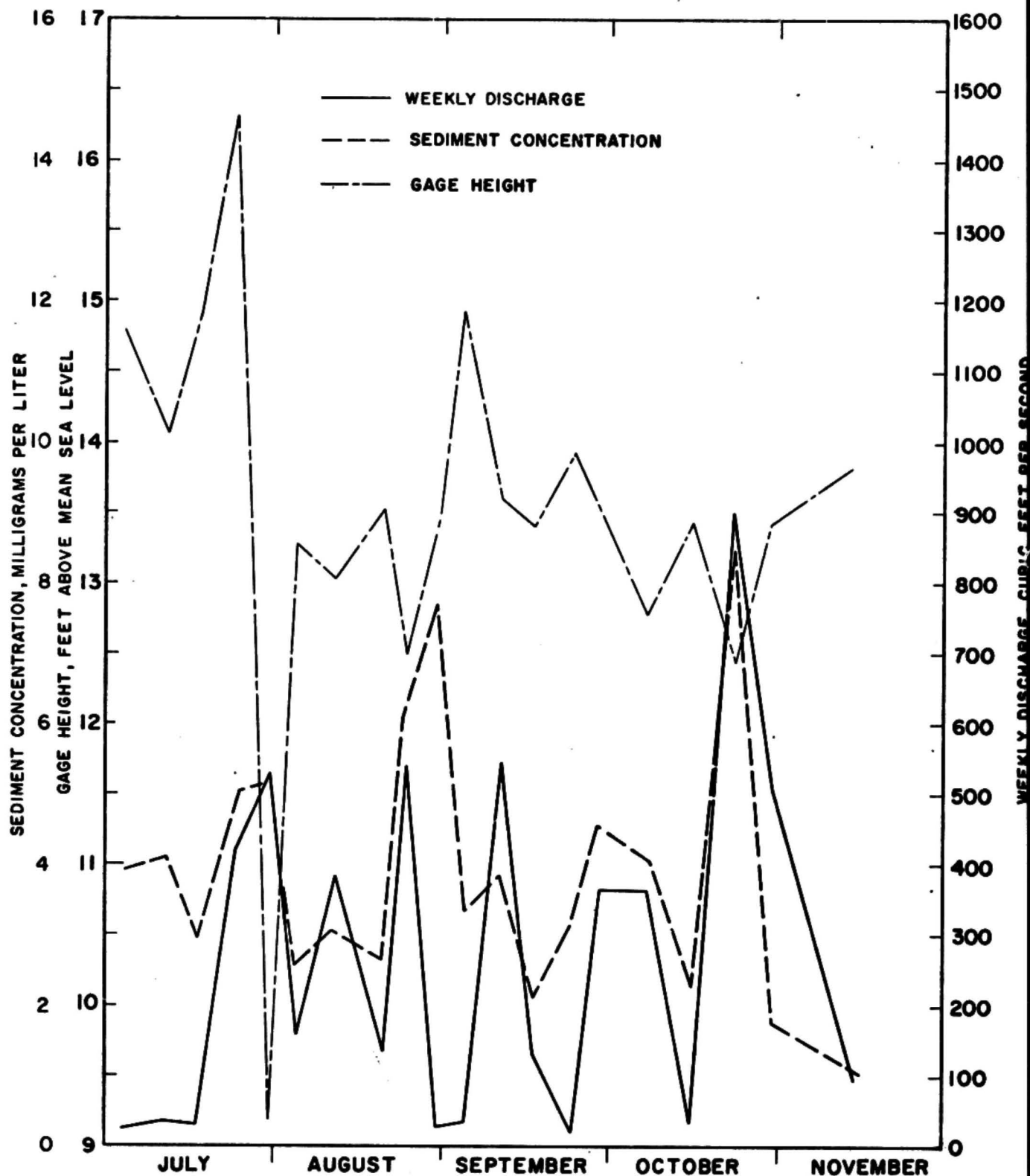


Figure 5.--Graphs of weekly discharge, gage height, and sediment concentration for Canal 18 near Structure 46.

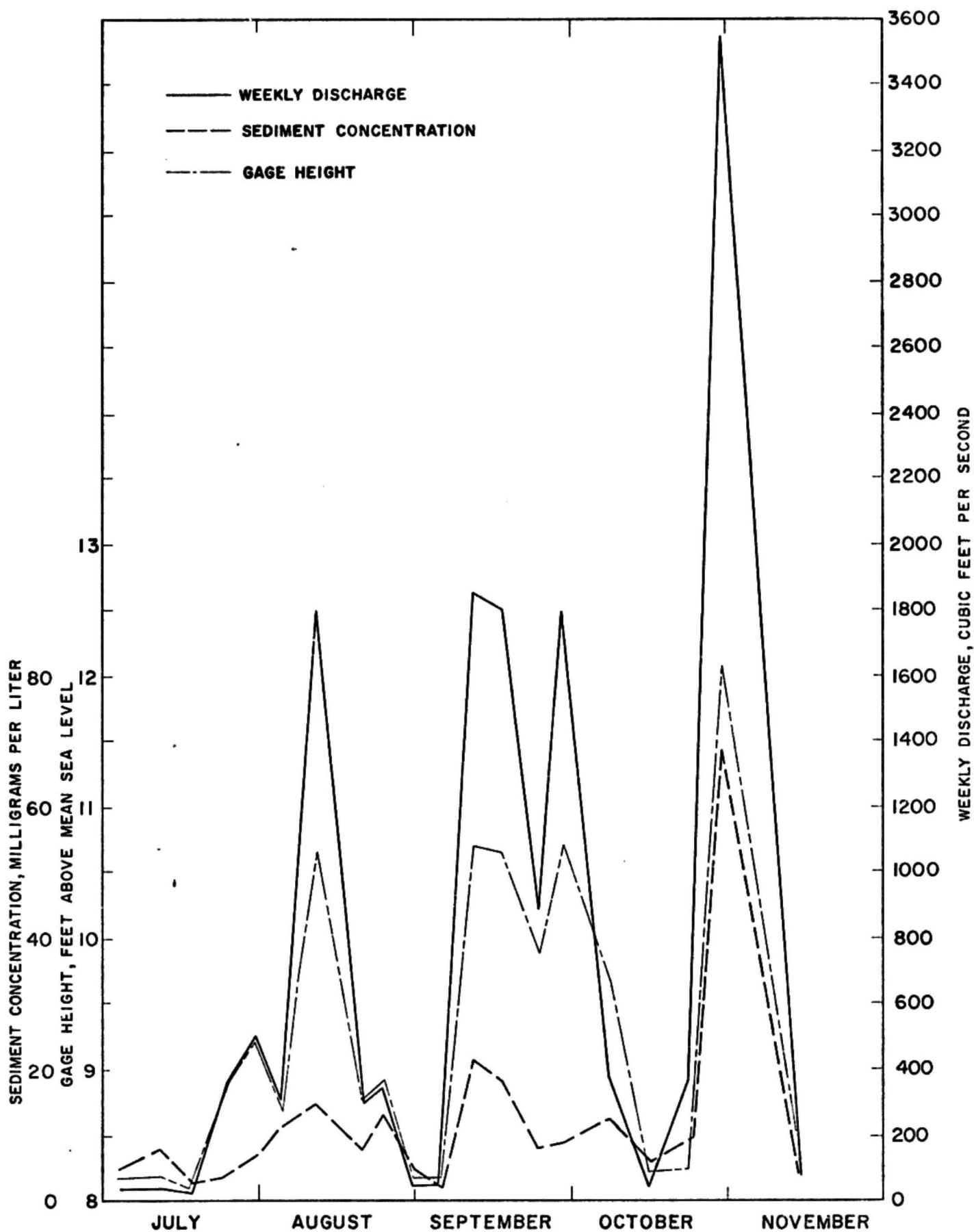


Figure 6.--Graphs of weekly discharge, gage height, and sediment concentration for Canal 23 near Structure 48.

The graphs for Canal 24 are shown in figure 7. At Canal 24 a direct relationship exists between discharge and sediment concentration, except for July 3-11 and July 17-24. The operations of the gate at Structure 49 also prevent a direct relationship between gage height and discharge.

Fig. 7
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here

Curves of sediment concentration versus discharge were developed for all three canals. (See figs. 8-10.) These curves show the maximum, minimum, and median sediment concentration that may be expected for a given discharge. Particle-size analyses were run on two samples collected at each site. One sample was collected during low flow and the other during high flow.

Figs. 8,
9 & 10
near here

The results of the particle-size analysis for a sample from Canal 18 are shown in figures 11 and 12, from Canal 23 in figures 13 and 14, and from Canal 24 in figures 15 and 16.

Figs. 11
& 12
near here

Figs. 13
& 14
near here

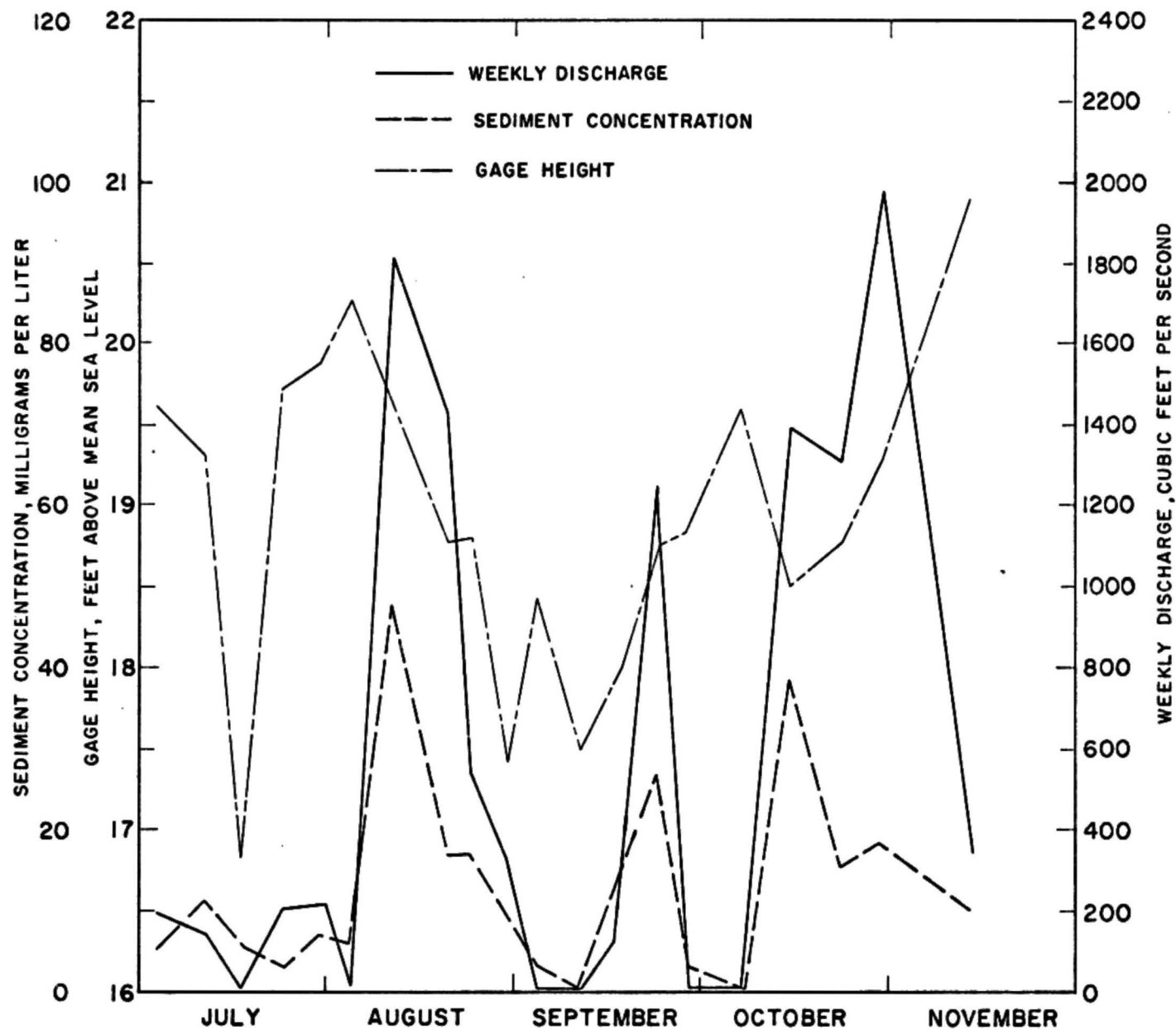


Figure 7.--Graphs of weekly discharge, gage height, and sediment concentration for Canal 24 near Structure 49.

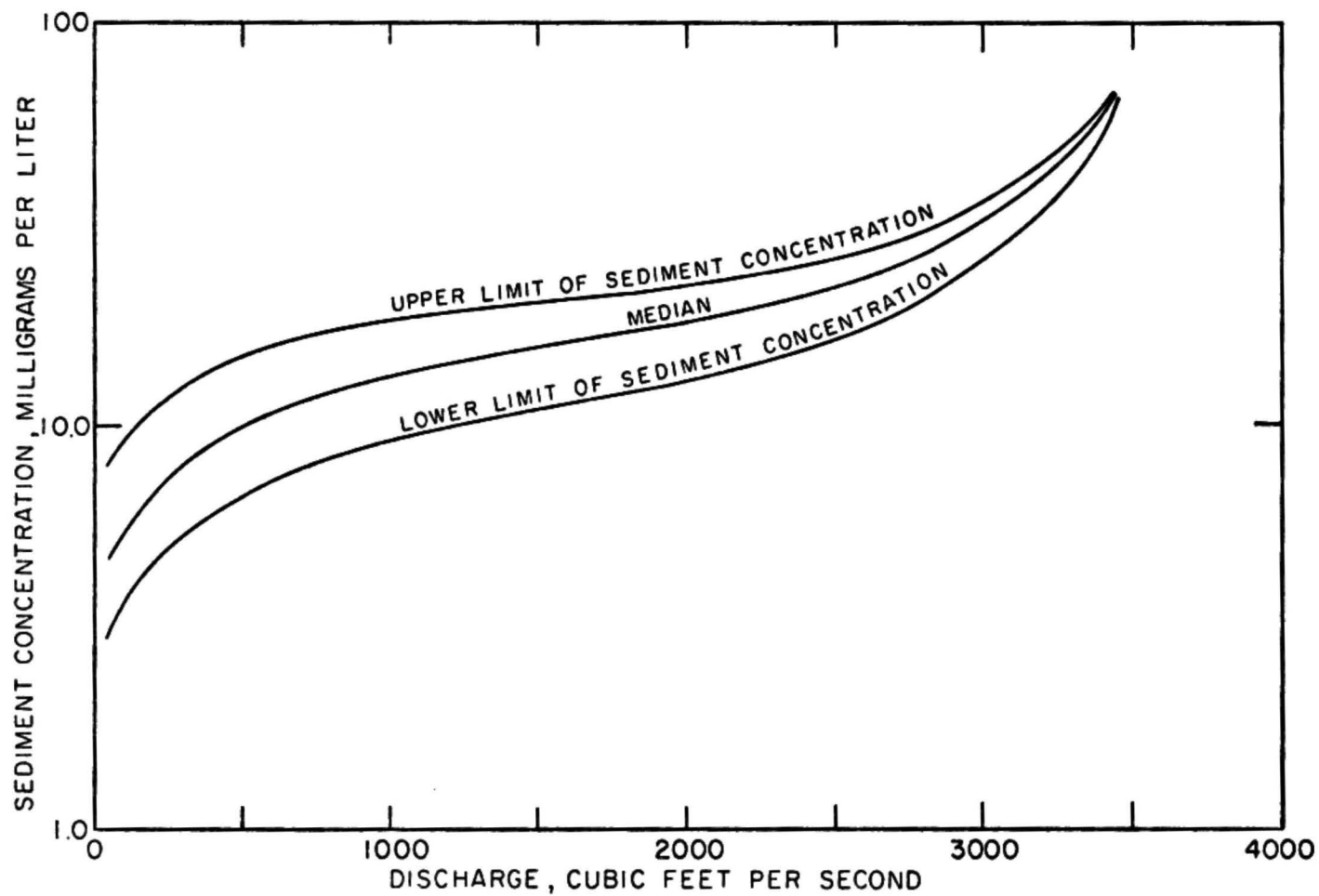


Figure 9.--Suspended sediment transport curve for Canal 23 near
Structure 49.

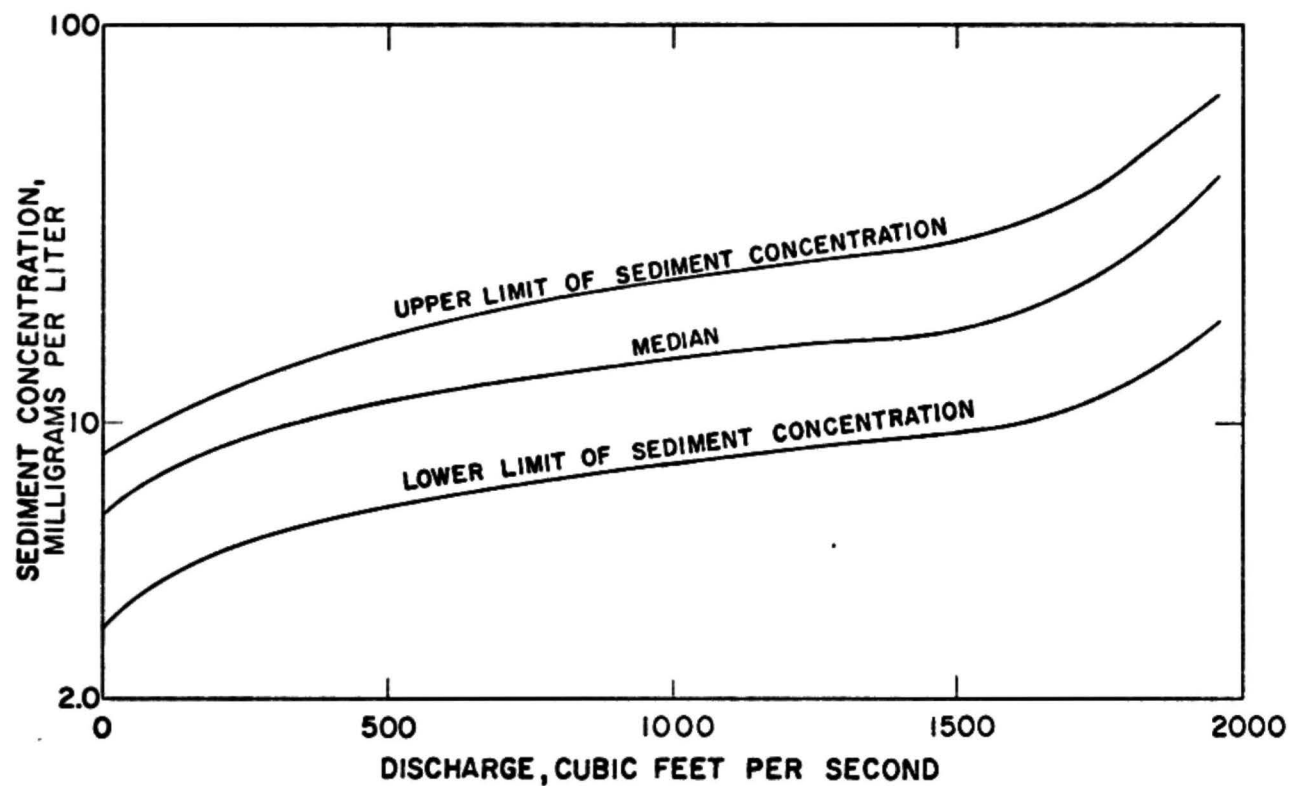


Figure 10.--Suspended sediment transport curve for Canal 24 near
Structure 49.

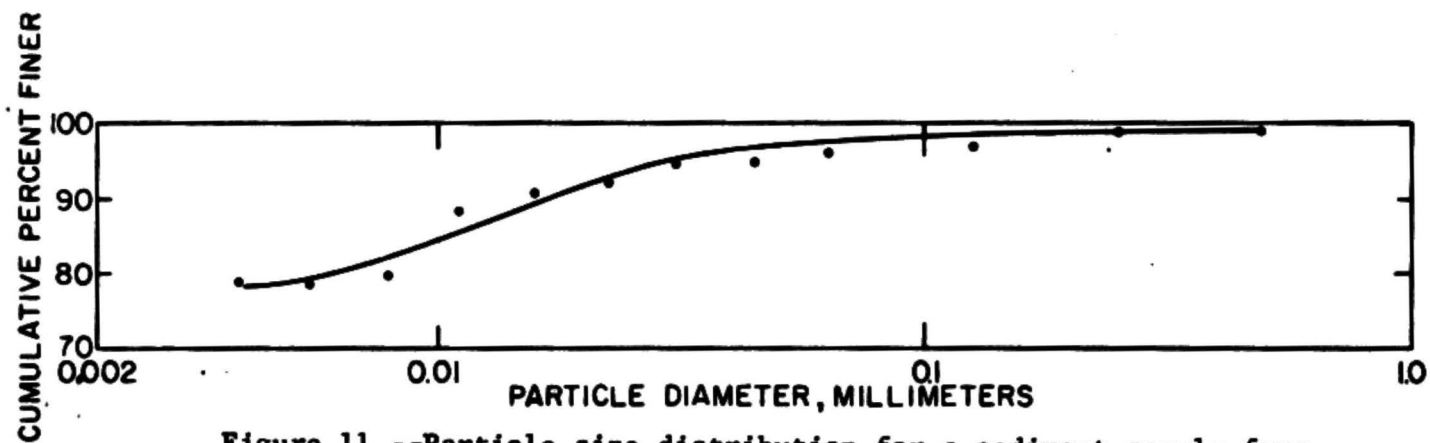


Figure 11.--Particle size distribution for a sediment sample from Canal 18 near Structure 46 during a low flow period.

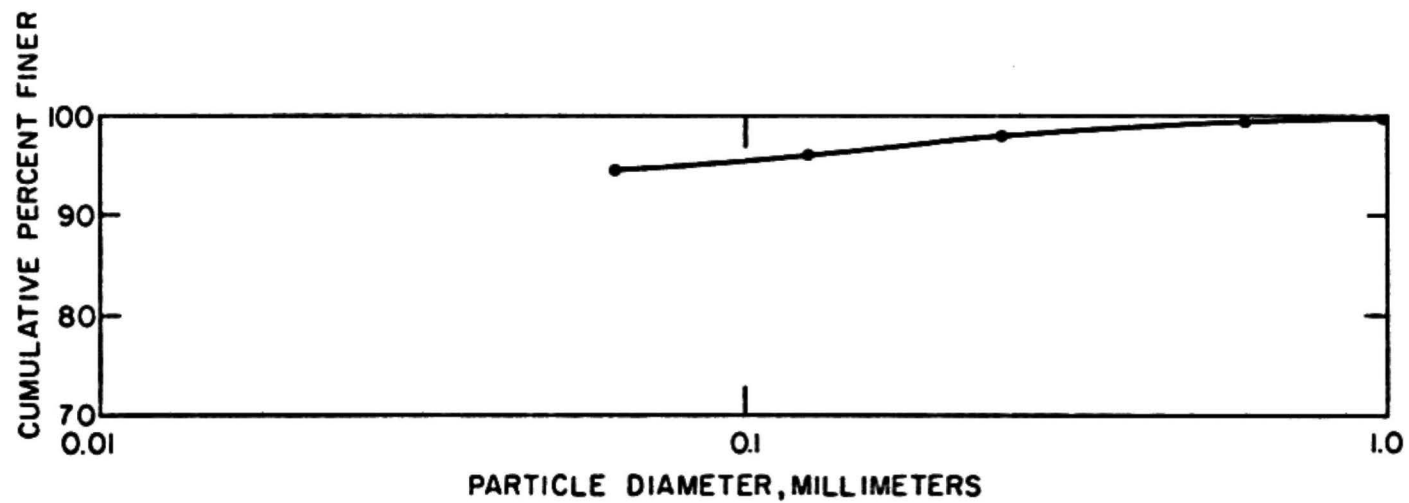


Figure 12.--Particle size distribution for a sediment sample from Canal 18 near Structure 46 during a high flow period.

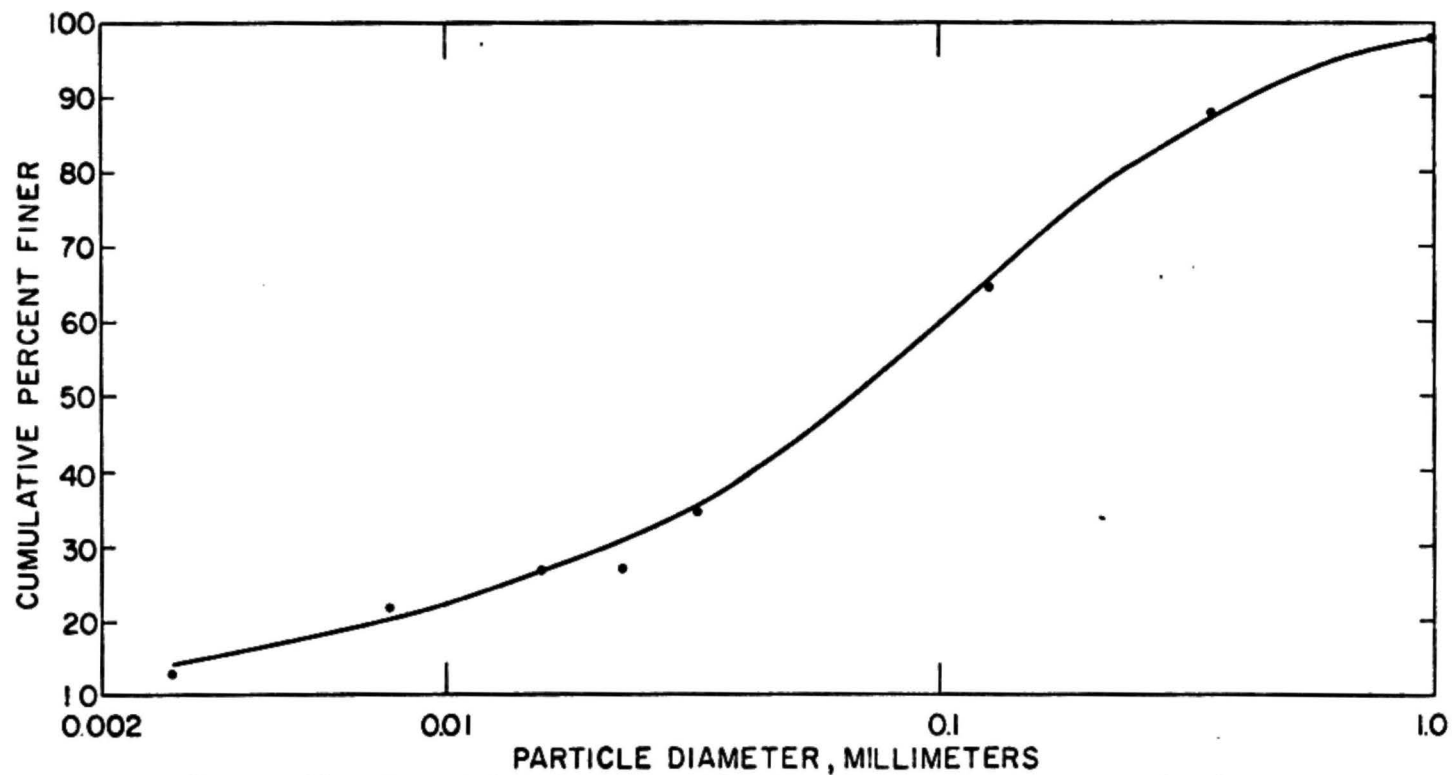


Figure 13.--Particle size distribution for a sediment sample from Canal 23 near Structure 48 during a low flow period.

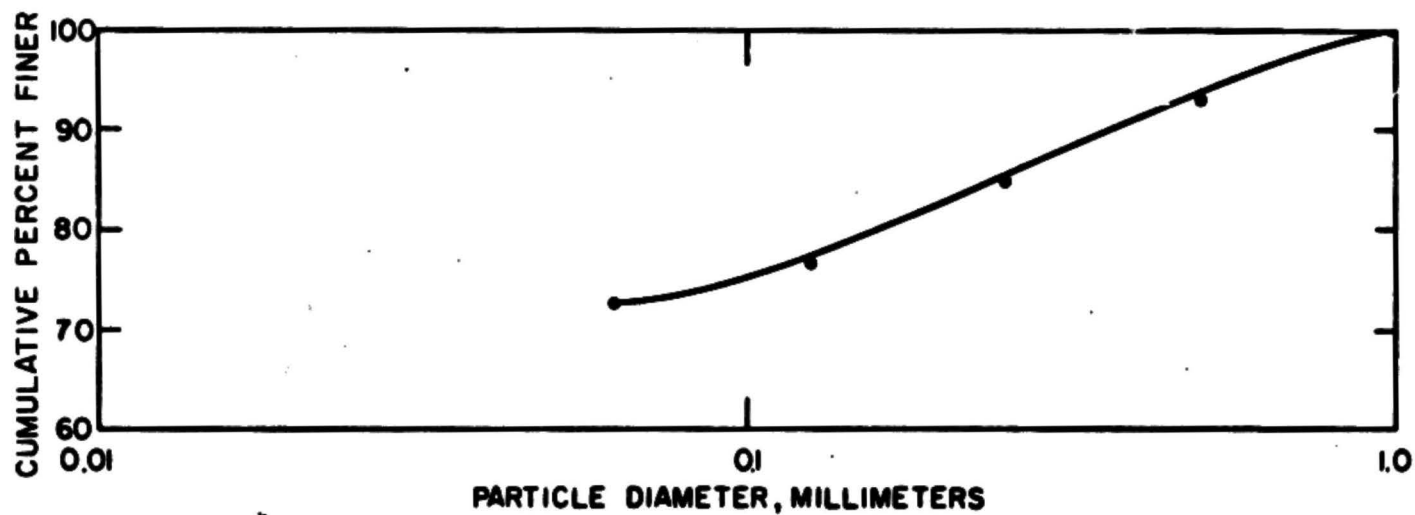


Figure 14.--Particle size distribution for a sediment sample from Canal 23 near Structure 48 during a high flow period.

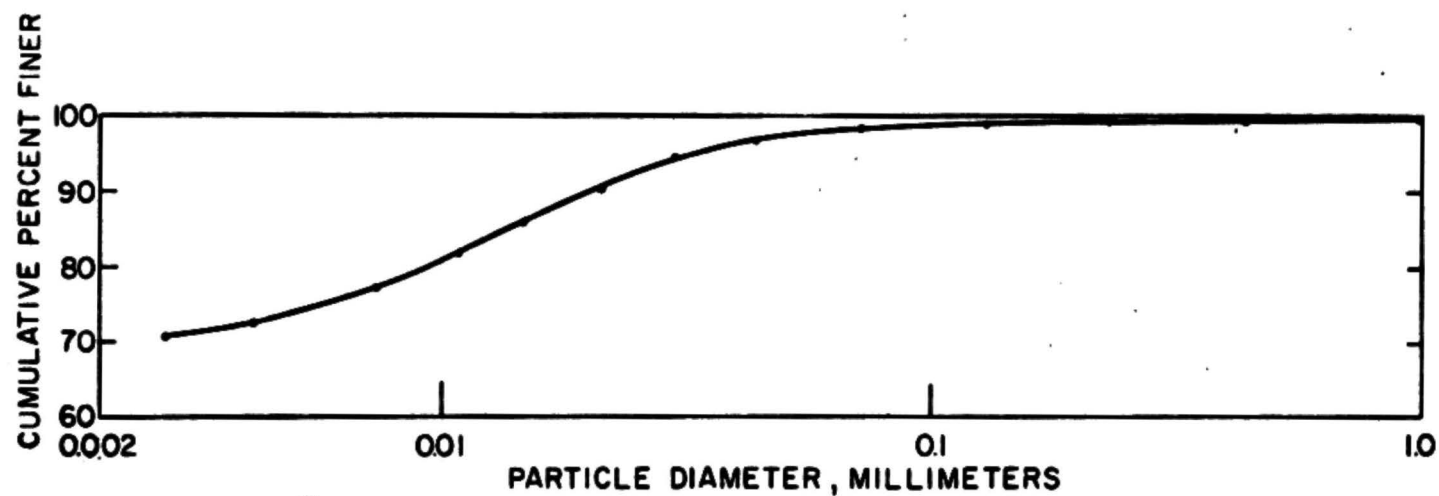


Figure 15.--Particle size distribution for a sediment sample from Canal 24 near Structure 49 during a low flow period.

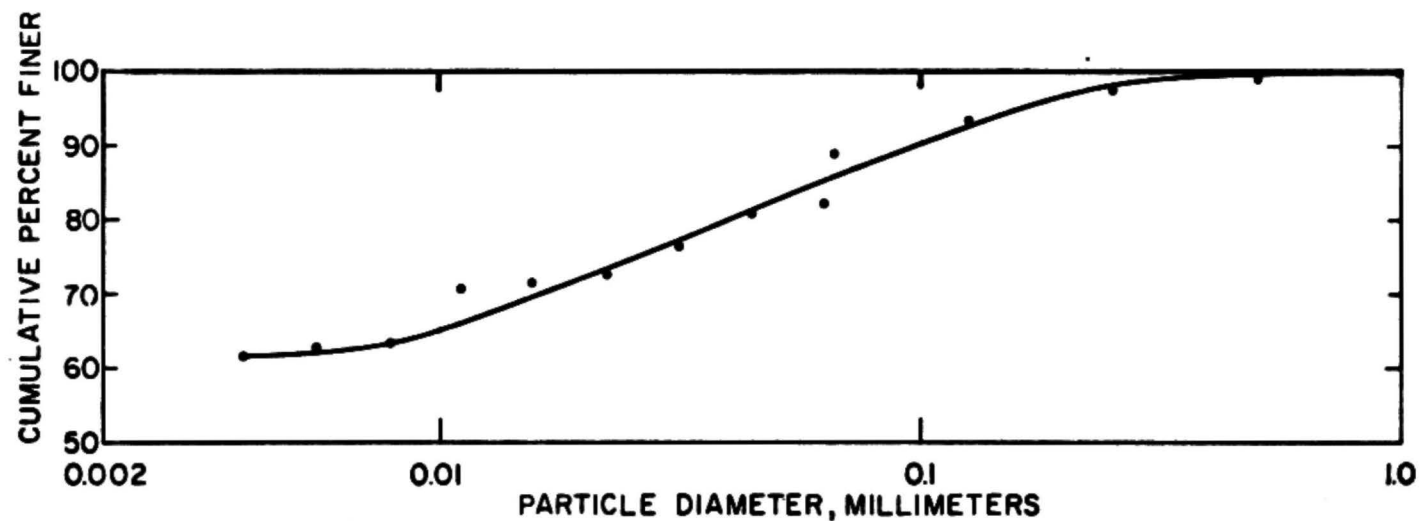


Figure 16;--Particle size distribution for a sediment sample from Canal 24 near Structure 49 during a high flow period.

The Subcommittee on Sedimentation Terminology of the American Geophysical Union (Lane and others, 1947, p. 337) classifies sediment by particle size as follows:

Clay Size: Smaller than 0.004 mm
Silt Size: Between 0.004 and 0.062 mm
Sand Size: Between 0.062 and 2.0 mm

The table below lists the particle-size distributions of the suspended sediment collected from the three canals.

The similarity in size distribution of suspended particles at low and high discharges and, consequently, at different velocities, indicates a uniform vertical distribution of sediments in the canals. This is because the whole suite of sediment sizes must be in suspension even at low velocities for that similarity to exist when the velocities are high.

<u>Sampling Site</u>	<u>Date</u>	<u>Instantaneous Sediment Concentration (milligrams per liter)</u>	<u>Discharge (cubic feet per second)</u>	<u>Particle Size (percent finer than)</u>					
				<u>1mm</u>	<u>0.5mm</u>	<u>0.25mm</u>	<u>0.125mm</u>	<u>0.0625mm</u>	<u>0.004 mm</u>
Canal 18 near S-46	July 11, 1969	0.2	Leakage	100	100	99	97	96	79
Canal 18 near S-46	Oct. 15, 1969	4	170	100	100	98	96	95	86
Canal 23 near S-48	July 11, 1969	6	40	100	93	85	77	73	66
Canal 23 near S-48	*Oct. 15, 1969	8	170	95	91	75	64	48	16
Canal 24 near S-49	July 11, 1969	11	140	100	100	99	99	98	72
Canal 24 near S-49	Oct. 15, 1969	38	1,380	100	99	98	94	82	61

* Data incomplete; sediment would not settle.

Except for the particle-size data listed for the sample collected October 15, 1969, from Canal 23 at S-48, the table shows that the sediment concentration and discharge have little to do with particle-size (mostly clay-size) of the sediment. The particle-size data for this sample are anomalous because the sediment would not settle during analysis; the weight of the segment withdrawn from the bottom of the sedimentation tube was deficient by the amount remaining in suspension.

A study of the chemical analyses of these samples shows that there is no apparent relationship between sediment concentration and most chemical constituents.

Low iron concentrations and high color units, suggest the presence of organic compounds in the water. This is further indicated by the appearance of the samples at the time of collection and during analysis in the laboratory. Of the three sets of samples, only the set taken from Canal 23 showed an increase in nitrate with increase in suspended sediment. Two of the three sets of samples showed an increase in sulfate with increases in sediment concentration. Nitrate and sulfate are end products of decomposition of organic plant protein. No tests were made of the sediment to determine its nature, but the fragmentary evidence strongly suggests its organic composition.

Table 1 shows the results of chemical analyses of water samples taken from Canals 18, 23 and 24 at the sites of the control structures.

Table 1
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Tables 2, 3, and 4 show the daily mean discharge, sediment concentration, and tons per day of sediment for Canals 18, 23, and 24 respectively.

Tables 2,
3 & 4
near here

The monthly and annual water discharge for Canals 18, 23 and 24 for 1963-69 are shown in table 5. The discharge during July 1 to November 15 represents, on the average, about 70 percent of the total yearly discharge of Canal 18. During the 1969 calendar year the same period represented nearly 70 percent of the total. Similarly, for Canal 23, the discharge for July 1 to November 15 represents, on the average, approximately 60 percent of the yearly discharge, and for 1969 the discharge for the same period represented about 60 percent of the total flow for the calendar year. In Canal 24 the approximate percentages are 50 percent of the discharge on the average and 60 percent of the total flow for the 1969 calendar year.

Table 5
near
here

Table 1.--Chemical analyses of water from Canals 18, 23, and 24.

Station	Date of collection	Discharge (cfs)	Silica (SiO ₂) (mg/l)	Iron (Fe) (mg/l)	Manganese (Mn) (mg/l)	Calcium (Ca) (mg/l)	Magnesium (Mg) (mg/l)	Strontium (Sr) (mg/l)	Sodium (Na) (mg/l)	Potassium (K) (mg/l)	Bicarbonate (HCO ₃) (mg/l)	Carbonate (CO ₃) (mg/l)	Sulfate (SO ₄) (mg/l)	Chloride (Cl) (mg/l)	Fluoride (F) (mg/l)	Nitrate (NO ₃) (mg/l)	Phosphate (PO ₄) (mg/l)	Residue at 180 C (mg/l)	Dissolved solids		Hardness as CaCO ₃		Specific conductance (micro-mhos at 25 C)	pH	Color	Temperature (C)	Alkalinity			Sediment Concentration
																			Calculated	Residue	Calcium	Non-carbonate					Ca	Mg	Ca+Mg	
C-18 at S-46	7-11-69	39	6.0	-	-	46	1.1	-	16	0.8	128	-	13	26	0.3	0.6	-	198	173	128	23	316	9.0	40	32	178	63	105	4	
C-18 at S-46	10-15-69	37	4	70	-	29	3.4	-	12	0.9	88	⊙	4.8	19	0.2	0.6	-	154	117	86	16	225	7.2	40	27	88	43	72	2	
C-23 at S-46	7-11-69	40	8.4	-	-	52	7.3	-	33	2.6	136	-	42	53	0.3	2.1	-	317	268	160	46	470	8.7	120	32	136	67	112	8	
C-23 at S-46	10-15-69	50	7.0	280	-	46	5.7	-	24	1.4	116	⊙	30	43	0.3	0.6	-	267	217	139	44	418	7.4	80	27	116	57	95	6	
C-26 at S-49	7-11-69	143	7.6	-	-	46	11	-	56	2.6	108	-	43	106	3.0	1.3	-	416	329	165	77	630	7.3	80	19.7	166	53	89	11	
C-26 at S-49	10-15-69	1,380	1.0	250	-	40	6.0	-	28	1.6	92	⊙	31	96	0.5	1.3	-	267	211	125	49	402	7.5	120	27	92	45	75	38	

Table 2.-- Daily mean discharge, sediment concentration, and tons per day of sediment for Canal 18.

Day	JULY			AUGUST			SEPTEMBER			OCTOBER			NOVEMBER		
	Discharge (cfs)	Sediment concentration (mg/l)	Sediment discharge (tons per day)	Discharge (cfs)	Sediment concentration (mg/l)	Sediment discharge (tons per day)	Discharge (cfs)	Sediment concentration (mg/l)	Sediment discharge (tons per day)	Discharge (cfs)	Sediment concentration (mg/l)	Sediment discharge (tons per day)	Discharge (cfs)	Sediment concentration (mg/l)	Sediment discharge (tons per day)
1	64	4	0.72	141	3	1.1	124	4	1.4	170	3	1.2	271	3	2.3
2	64	4	.72	152	3	1.1	142	4	1.6	267	4	2.0	300	3	2.6
3	67	4	.76	0	0	0	150	4	1.6	193	3	1.7	227	3	1.6
4	63	4	.71	212	3	1.7	131	4	1.4	262	4	2.2	315	3	2.6
5	63	4	.71	214	3	1.7	20	3	0.15	104	3	0.73	245	3	2.3
6	59	4	.67	186	3	1.4	106	4	1.6	233	4	2.2	300	3	2.4
7	59	4	.67	541	3	7.7	142	3	1.2	214	3	1.4	271	3	1.9
8	0	0	0	220	4	1.5	134	3	.93	259	4	2.4	341	3	3.5
9	59	4	.67	114	4	0.52	130	4	.77	194	3	1.7	242	3	2.1
10	0	0	0	111	4	.42	131	4	.67	214	3	1.4	300	3	2.1
11	0	0	0	240	4	1.5	130	4	.53	167	3	1.4	314	3	2.2
12	0	0	0	72	3	.21	140	4	.6	220	4	2.1	329	3	2.3
13	0	0	0	10	1	.01	135	4	.62	123	3	.93	334	3	2.4
14	0	0	0	240	3	1.7	100	4	.53	170	3	1.5	425	3	3.4
15	0	0	0	155	4	.66	252	3	1.7	171	3	1.5	345	3	3.1
16	0	0	0	140	4	.74	134	4	.76	140	3	1.2			
17	14	3	.14	142	4	.72	244	4	2.4	136	3	.76			
18	0	0	0	142	4	.76	154	4	1.6	41	2	.26			
19	0	0	0	140	4	.74	241	3	1.2	106	3	1.1			
20	59	3	.67	130	3	.91	124	3	1.0	202	3	1.7			
21	0	0	0	0	0	0	234	4	2.5	271	4	2.6			
22	0	0	0	100	3	.21	124	3	1.1	220	3	1.2			
23	0	0	0	100	3	.21	210	4	2.4	220	3	1.2			
24	400	3	3.5	44	3	.93	154	4	1.7	150	3	1.0			
25	0	0	0	43	3	.57	154	4	1.6	123	2	.76			
26	0	0	0	142	4	1.5	267	4	3.2	241	3	2.6			
27	0	0	0	134	4	1.4	170	4	1.6	220	3	1.2			
28	0	0	0	134	4	1.4	236	3	2.6	145	3	1.5			
29	841	4	2.1	61	3	.56	103	3	.61	144	3	1.2			
30	254	4	1.4	67	3	.62	234	4	2.4	144	3	1.2			
31	234	4	2.3	142	4	1.6				154	4	1.2			
TOTAL	2240		47	2527		36	2002		42	2750		49	2744		37

Underlined values show that an actual sample was collected that day.

Table 4.-- Daily mean discharge, sediment concentration, and tons per day of sediment for Canal 24.

Day	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER	
	Discharge (cfs)	Sediment concentration (mg/l)	Discharge (cfs)	Sediment concentration (mg/l)	Discharge (cfs)	Sediment concentration (mg/l)	Discharge (cfs)	Sediment concentration (mg/l)	Discharge (cfs)	Sediment concentration (mg/l)
1	135	4	604	14	341	8	404	1	144	31
2	133	4	614	11	350	1	439	4	144	01
3	130	5	1,093	15	374	7	851	11	17	02
4	134	11	770	11	350	1	707	10	14	02
5	136	22	604	15	374	7	851	11	17	02
6	307	10	604	14	605	9	554	10	19	04
7	174	4	750	13	454	11	554	10	19	04
8	187	10	774	13	554	10	554	10	19	04
9	181	10	1,455	17	67	07	67	15	20	05
10	144	11	605	9	649	14	544	8	10	09
11	105	10	477	10	1,170	13	545	9	10	29
12	73	10	474	10	803	13	437	8	10	29
13	73	10	705	13	844	14	46	8	10	29
14	59	9	1,379	13	1,374	19	149	0	10	30
15	43	8	1,474	15	1,094	10	442	0	10	30
16	47	1	1,454	15	1,049	10	404	0	10	30
17	0	0	1,450	15	654	14	470	0	10	30
18	0	0	1,445	15	654	14	470	0	10	30
19	40	0	1,101	13	270	14	350	11	19	30
20	40	0	1,101	13	270	14	350	11	19	30
21	145	5	455	14	454	14	540	10	14	30
22	401	5	401	14	555	14	611	11	14	30
23	404	5	1,004	14	555	14	611	11	14	30
24	170	1.1	455	13	472	15	544	10	14	30
25	107	2	454	13	472	15	544	10	14	30
26	135	4	1,014	19	464	13	464	10	14	30
27	420	5	1,114	17	451	13	454	10	14	30
28	743	11	1,074	14	130	13	454	10	14	30
29	474	19	404	13	454	13	454	10	14	30
30	474	19	404	13	454	13	454	10	14	30
31	1,074	15	404	13	454	13	454	10	14	30

Underlined values show that an actual sample was collected that day.

Table 5.--Monthly and annual discharge, in acre-feet for Canal 18 at
Structure 46, Canal 23 at Structure 48, and Canal 24 at
Structure 49.

CANAL 18 NEAR STRUCTURE 46

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL	JULY 1 to NOV. 15
1963	0	303	0	0	0	950	684	2,400	9,980	18,920	2,760	1,880	37,880	34,030
1964	13,920	4,410	789	50	1,490	7,370	3,180	9,560	13,300	24,600	17,880	5,650	102,200	61,140
1965	1,080	2,900	1,500	77	0	2,660	2,730	6,190	5,800	14,640	11,650	1,680	50,690	39,670
1966	11,420	8,620	4,550	1,110	5,150	23,950	24,240	11,550	9,390	11,220	2,950	1,730	115,880	58,110
1967	305	784	206	0	0	3,500	11,700	10,850	8,750	28,610	6,640	916	72,060	65,110
1968	0	175	0	0	578	14,900	13,900	10,140	8,570	13,360	4,150	0	65,770	49,200
1969	290	0	2,030	0	3,810	4,930	5,530	8,580	9,640	11,400	14,210	3,950	64,370	44,570
AVG.	3,860	2,460	1,300	1,300	1,580	8,320	8,850	8,470	9,350	17,480	8,610	2,260	74,690	50,260

CANAL 23 NEAR STRUCTURE 48

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL	JULY 1 to NOV. 15
1963	-	-	-	-	-	-	-	770	3,710	7,540	2,650	5,570	-	-
1964	-	-	2,720	1,880	2,320	1,700	11,590	27,080	29,040	16,780	6,910	2,340	-	90,890
1965	600	7,980	4,740	1,730	270	1,370	7,270	8,090	11,380	23,160	11,740	1,280	79,610	58,890
1966	31,700	20,100	7,580	2,750	4,140	27,140	45,710	29,850	18,770	45,470	5,990	2,590	241,790	143,050
1967	1,800	2,870	2,560	8,920	480	5,470	17,680	11,530	3,030	15,730	1,790	540	72,400	49,260
1968	420	390	330	330	5,630	58,400	59,200	12,370	4,230	6,060	7,500	1,740	156,600	86,870
1969	2,000	1,870	14,650	2,660	15,330	23,210	12,950	43,500	25,380	53,220	29,410	22,970	247,150	153,890
AVG.	7,300	6,640	5,430	3,050	4,700	19,550	25,730	19,130	13,650	23,990	9,430	5,290	159,510	97,480

CANAL 24 NEAR STRUCTURE 49

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL	JULY 1 to NOV. 15
1963	0	0	0	0	1,590	60	3,310	0	15,910	10,310	11,410	16,400	58,990	33,500
1964	16,020	18,980	4,380	5,530	13,660	8,390	16,360	36,840	28,850	15,490	16,470	16,690	197,660	105,190
1965	16,160	13,170	12,580	3,690	150	8,740	18,150	12,900	19,410	22,560	16,280	16,560	160,620	82,110
1966	25,860	19,430	12,460	8,950	16,390	27,670	30,420	24,030	15,690	35,890	12,020	11,580	240,390	111,490
1967	0	1,170	0	0	0	9,690	20,170	12,090	12,290	11,580	790	0	67,780	56,920
1968	0	0	0	0	12,050	84,120	32,510	7,110	7,760	12,470	3,550	0	159,570	62,620
1969	3,400	0	18,760	760	18,380	21,240	13,040	52,690	32,450	45,560	47,070	34,660	288,010	173,670
AVG.	8,780	7,540	6,880	2,700	8,890	22,840	19,140	20,810	18,910	21,980	15,370	13,700	167,570	89,470

Table 5 also shows that during February and April 1969 there was no flow in Canal 18 and, therefore, no sediment discharge. In January the sediment load must have been small, as the discharge was very low that month. March, May, June, and December were the only months (other than the months during which samples were collected) during which any significant amount of sediment could have been discharged; however, figure 8 shows that the sediment concentration will generally be below 3 mg/l at discharges below 220 cfs. Examination of the daily discharges for the period not sampled shows that 3 days in late November and 2 days in early May were the only days in which a discharge of 220 cfs was reached. It seems that at no other time could the sediment discharge have exceeded 1 ton per day, and, therefore, the conclusion can be made that the annual suspended sediment discharged by Canal 18 in 1969 could not have been more than 350 tons, of which 211 was discharged during July 1 to November 15.

Analysis of the daily discharge data, comparison of these data with other discharge data for which sediment concentrations are known, and the sediment-transport curves of figure 9 were used in a similar manner to obtain an estimate of annual suspended sediment discharge for Canal 23. On that basis, it was estimated that the load carried by Canal 23 during 1969 did not exceed 4,500 tons, of which 3,310 tons was discharged during July 1 to November 15.

A similar examination of data for Canal 24 discloses that the total suspended sediment load discharged by it during 1969 was about 9,000 tons, of which 6,810 was discharged during July to November 15.

The relationships between sediment yield and drainage area, annual discharge, and length of canal are shown in table 6 for all three canals.

Table 6
near
here

Table 6.--Relationships of sediment yield with drainage area, annual discharge, and length of canal for Canals 18, 23, and 24.

Canal	Length (miles)	Drainage Area (sq. miles)	Annual Discharge (acre-feet)	Annual Sediment yield (tons)	Tons per sq.mile	Tons per thousand acre-feet
18	17	106	74,690	350	3.3	4.7
23	24	162	159,510	4,500	27.8	28.2
24	20	160	167,570	9,000	56.2	53.7

CONCLUSIONS

In contrast to Canal 18, Canals 23 and 24 carry relatively large quantities of suspended sediment into the St. Lucie River estuary at Stuart during high discharge. Maximum sediment-discharge rates of 730 and 2,550 tons per day and average rates of 23 and 42 tons per day during July 1 to November 15 were computed for Canal 23 and Canal 24, respectively, while Canal 18 carried little sediment, a maximum of 21 tons per day and an average of 1.5 tons per day during the same period.

Chemical analyses show that the water from Canals 23 and 24 are of similar chemical quality, but that of Canal 18 has considerably lower concentrations of most constituents.

The preponderance of citrus groves in the area drained by Canals 23 and 24 may partly explain the differences in sediment discharge rates and in water quality.

Most of the sediment in the canals originates in the cultivated areas; some of it comes from the decomposition of the vegetal matter in the canals. The sediment consists predominantly of particles that remain in suspension at low velocities.

Clearing of virgin land and preparation of the land for farming or pasture results in an increase per unit area of the amount of sediment in runoff water. This is indicated by comparing the data for Canal 18, which drain a relatively virgin area, with data for Canals 23 and 24, which drain an area that is extensively developed for agricultural use and pasture.

Increasing agricultural activity in the area will probably increase the amount of suspended sediment discharged into the canals and estuaries in future years.

GLOSSARY

- Flatwoods: A vegetal environment characterized by clusters of cypress trees towering above the pond grasses and marshes and separated by sawgrass.
- Muck: A soil of extremely soft consistency. The term is applied herein to soils that are predominantly an organic silt.
- Peat: An extremely compressible, but loose soil that is very dark in color and which contains much fibrous organic material. When dry, it floats and can be easily transported with surface runoff.
- Sediment: Solid material that originates mostly from soils and is transported by, suspended in, or deposited by water; it includes chemical and biochemical precipitates and decomposed organic matter, such as humus.

Sediment discharge: The rate at which dry weight of sediment passes a section of a stream, or is the quantity of sediment, as measured by dry weight or by volume, that is discharged in a given time.

Suspended sediment: The sediment that at any given time is maintained in suspension by the upward components of turbulent currents or that exists in suspension as a colloid.

Tons per day: The quantity of materials in solution or suspension that passes a stream section during a 24-hour period.

Transit velocity: The velocity at which the sampler is lowered and raised. The velocity should be uniform and slow enough to allow the air in the sampler to be compressed by the inflowing water proportionally to the hydrostatic head.

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