GEOLOGICAL SURVEY CIRCULAR 406

FLUVIAL SEDIMENT IN WHITEHEAD WATERSHED AND WHITEHEAD RESERVOIRS NEBRASKA

April 1955 to September 1956

Prepared in cooperation with the
U. S. Department of Agriculture,
Soil Conservation Service and the
U. S. Department of Commerce,
Weather Bureau

UNITED STATES DEPARTMENT OF THE INTERIOR
FRED A. SEATON, *Secretary*

GEOLOGICAL SURVEY
Thomas B. Nolan, *Director*

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CONTENTS

ILLUSTRATIONS

TABLES

FLUVIAL SEDIMENT IN WHITEHEAD WATERSHED AND WHITEHEAD RESERVOIRS, NEBRASKA

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ABSTRACT

This report gives information on the physical characteristics of Whitehead Watershed and on the characteristics of the suspended sediment transported into and discharged from the reservoirs. Selected periods of significant runoff and outflow from April 1955 to September 1956 are discussed.

Particle-size distribution of inflow and outflow samples indicates that all the sand entering reservoir 1 is trapped and that most of the sand entering reservoir 2 is trapped.

Results of chemical analyses of water samples and a comparison of suspended-sediment size analyses in native water and in distilled water with dispersing agent indicate that significant sediment flocculation may occur in the reservoirs.

INTRODUCTION

The study of fluvial sediment in Whitehead Watershed is part of a nationwide investigation of the trap efficiency of detention reservoirs. The Geological Survey is cooperating with the Soil Conservation Service in the work. The sediment investigation in Whitehead Watershed was directed by P. C. Benedict, regional engineer. D. M. Culbertson, area engineer, supervised field operations, compilation of data, and preparation of this report.

Records of water discharge were furnished by D. D. Lewis, district engineer. Records of precipitation were obtained in cooperation with the U. S. Weather Bureau.

PHYSICAL CHARACTERISTICS OF THE WATERSHED

Whitehead Watershed is in the central part of Otoe County, Nebr. (See fig. 1.) The watershed is part of the dissected till plains of eastern Nebraska. The drainage area is approximately 495 acres.

Total relief within the drainage area is about 95 feet. Slopes generally are 4 to 12 percent and range from 100 to 800 feet in length. Figure 1 shows the shape of the watershed and the locations of dams 1 and 2, stabilization structures, two precipitation gages, and sediment sampling points.

Deposits of Pleistocene age mantle the watershed. Peorian loess, of late Pleistocene age, forms a nearly continuous mantle over the eastern half of the area and is on divide areas and upper slopes in the western half of the area. Loess of the Loveland formation, which underlies the Peorian loess stratigraphically in this southeastern Nebraska area, is not exposed to any significant extent. Kansan till, also of Pleistocene age, is generally exposed on moderate to steep slopes in the western part of the watershed. The Kansan till, which is stratigraphically lower than the Peorian loess and the Loveland formation, generally is found topographically lower than these formations. Late Pleistocene to Recent alluvium mantles the small, narrow bottomland areas.

Soil development in the watershed varies mainly with parent material, physiographic position, and slope. Because climate and vegetation in this small drainage basin are homogeneous, they are relatively unimportant determinants of profile differences. Soils developed on loess are predominant in the eastern half of the area and grade into mainly glacial-till soils in the western part of the area. Slope, infiltration rate, soil permeability, and parent material may vary within small areas. Severe erosion has exposed the B horizon in small areas of steeply sloping land.

A soil survey of Otoe County, Nebr., 1/ indicates that 61.6 percent, or about 305 acres, of the watershed is occupied by soils of the Sharpsburg series, which are developed on Peorian loess. Of the 305 acres, about 155 acres is Sharpsburg silty clay loam; 112 acres is Sharpsburg silty clay loam, rolling phase; and 38 acres is Sharpsburg silty clay loam, eroded rolling phase. About 29.3 percent, or 145 acres, of the watershed is occupied by soils of the Carrington series, which are developed on glacial till. Of the 145 acres, about 5 acres is Carrington clay loam; 125 acres is Carrington clay loam, eroded rolling phase; and 15 acres is Carrington loam, eroded rolling phase. Soils of the Burchard-Carrington complex, developed on glacial till, occupy about 2.0 percent of the watershed. The Judson-Wabash complex, developed on colluvial-alluvial material, occupies about 7.1 percent of the watershed.

Figure 2 shows the relation between soils, parent material, physiographic position, and slope in Whitehead Watershed.

Most of the drainage area is under cultivation; corn, sorghum, oats, and wheat are the main crops. Much of the steeply sloping land is in native grass or is seeded to grasses and legumes, and small areas of native grass are along the major channels. Nearly all the minor drainageways have been seeded to grass to prevent gully formation.

1/ U. S. Department of Agriculture, 1950, Soil survey of Otoe County, Nebr.

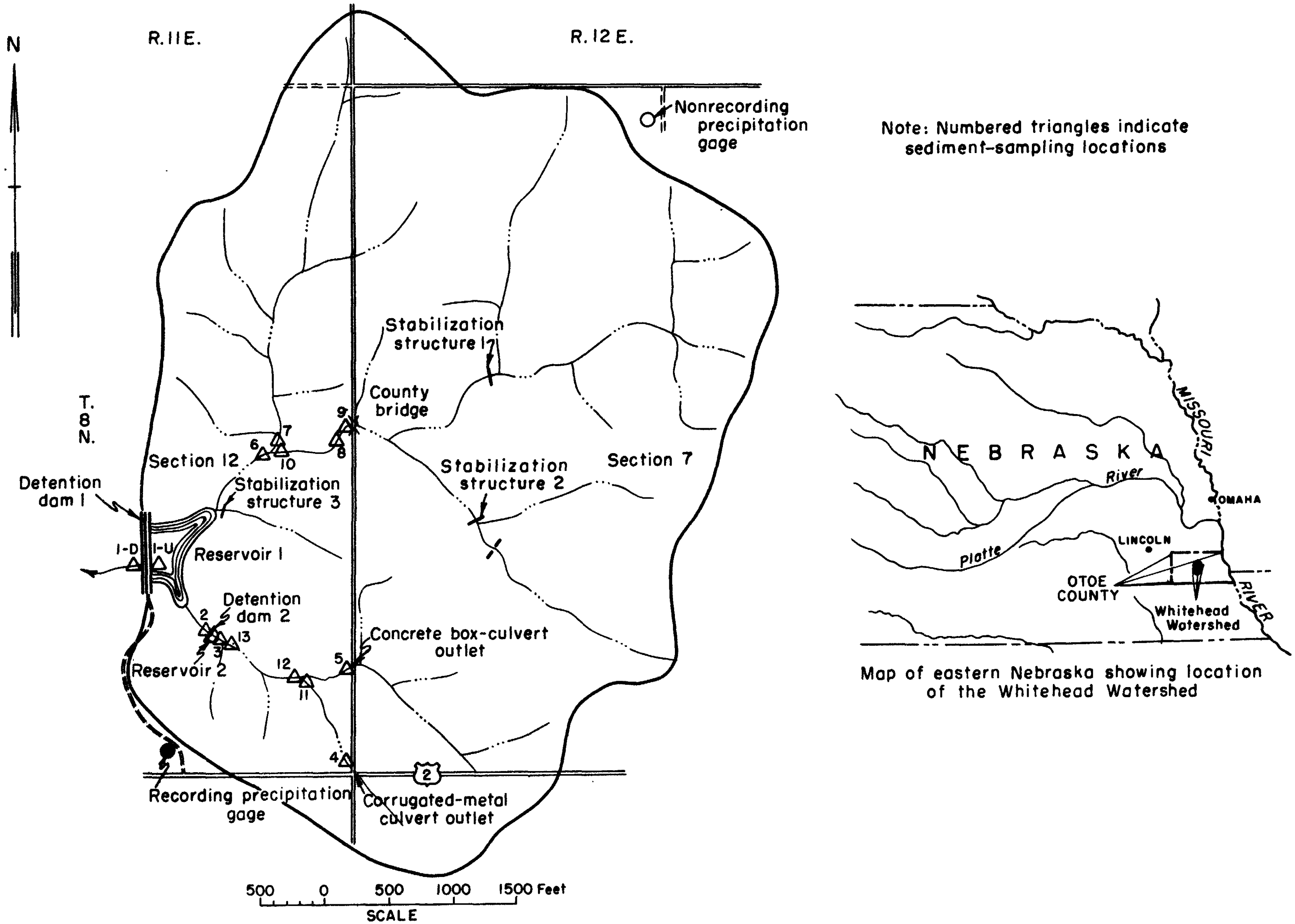

Figure 1.--Map of Whitehead Watershed.

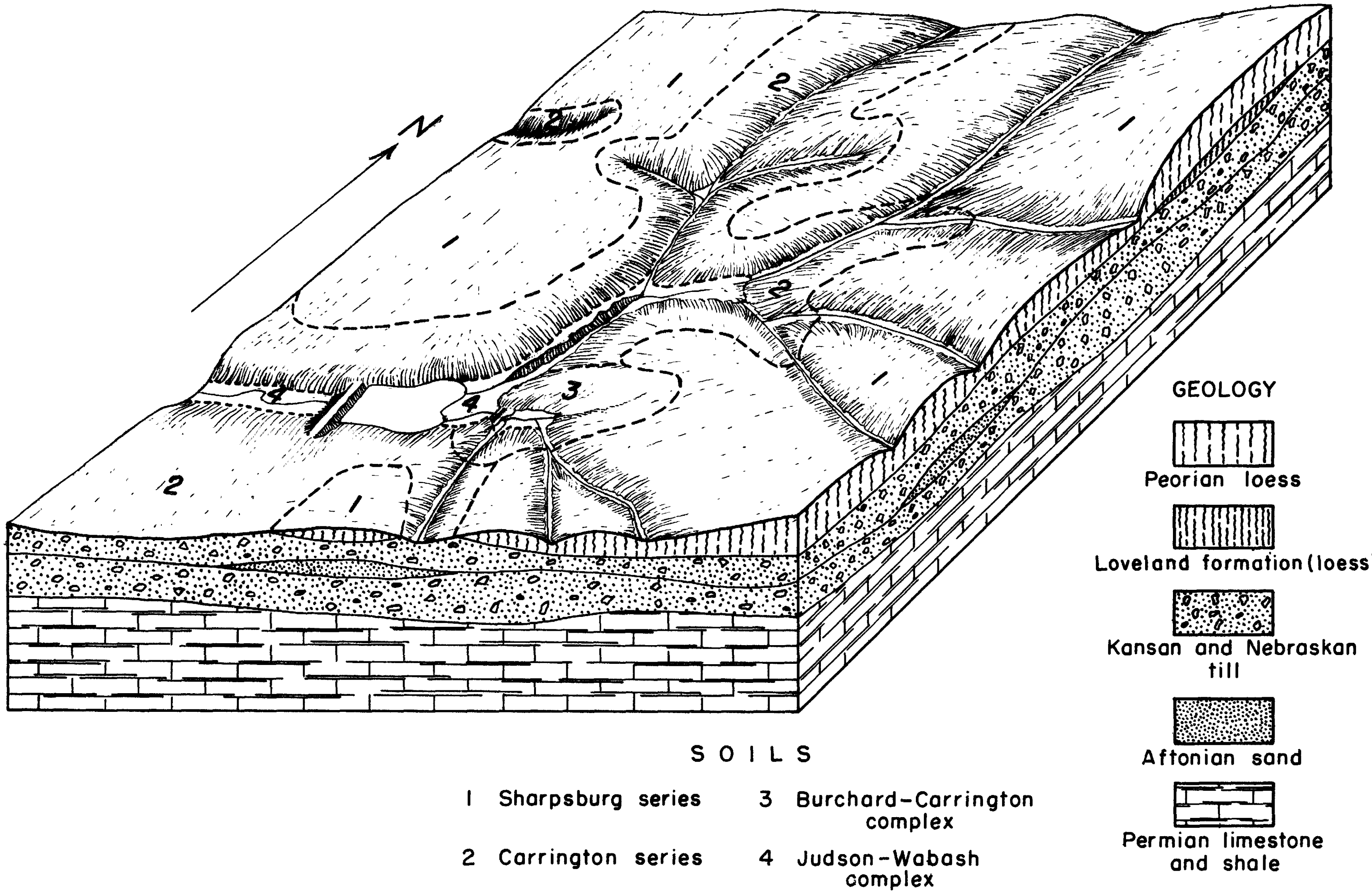

Figure 2. --Generalized view of part of Whitehead Watershed showing the relation of soils to geology and physiographic position. Subsurface geology is inferred. Area shown is about 450 acres.

The major channels of the dendritic drainage system have very steep or vertical banks. The main channel leading into the northeast corner of reservoir 1 is incised 4 to 8 feet below the flood plain. Graded or level terraces that are constructed on nearly all the cultivated land and on some of the pastureland have modified the natural runoff patterns on most of the watershed.

STRUCTURES AND RESERVOIRS

Reservoir 1 (fig. 3) has a capacity of 125.6 acre-feet and a surface area of 16.0 acres at crest of emergency spillway, elevation 1,144 feet, mean sea level; at the top of the drop inlet, elevation 1,134 feet, the capacity is 30.5 acre-feet and the surface area of the reservoir is 5.0 acres. Table 1 gives the area and capacity of 1-foot increments of elevation for this reservoir. Reservoir 2 (fig. 4) has a capacity of 4.25 acre-feet and a surface area of 1.29 acres at crest of emergency spillway, elevation 1,152 feet, mean sea level; at the top of the drop inlet, elevation 1,149.34 feet, the capacity is about 1.94 acre-feet and the surface area of the reservoir is about 0.6 acre. Table 2 gives the area and capacity for this reservoir.

Drainage from approximately 350 acres flows directly into reservoir 1. Channel-stabilization structures 1 and 2 exert a minor control on runoff from the northeast part of the watershed. Drainage from approximately 145 acres flows into reservoir 2; outflow from reservoir 2 flows into reservoir 1. Drainage from a very small area passes through stabilization structure 3 near the northeast corner of reservoir 1.

Table 1.--Area and capacity of reservoir 1 from survey of March 1955

Gage height (ft)	Elevation (ft)	Area (acres)	Capacity (acre-ft)
-11.00	1,122	....	0.5
-10.00	1,123	....	1.0
-9.00	1,124	....	2.0
-8.00	1,125	....	3.3
-7.00	1,126	....	5.0
-6.00	1,127	....	7.0
-5.00	1,128	....	9.0
-4.00	1,129	....	12.0
-3.00	1,130	....	15.0
-2.00	1,131	....	18.0
-1.00	1,132	3.32	22.0
0.00	1,133	4.15	26.0
1.00	1,134	5.00	30.5
2.00	1,135	5.90	35.5
3.00	1,136	6.85	41.5
4.00	1,137	7.89	48.1
5.00	1,138	8.90	55.6
6.00	1,139	9.98	64.0
7.00	1,140	11.00	73.6
8.00	1,141	12.20	84.4
9.00	1,142	13.50	96.7
10.00	1,143	14.64	110.3
11.00	1,144	16.00	125.6

Table 2.--Area and capacity of reservoir 2 from survey of March 1955

Gage height (ft)	Elevation (ft)	Area (acres)	Capacity (acre-ft)
8.20	1,141.2	0	0
9.00	1,142	.03	.02
10.00	1,143	.10	.09
11.00	1,144	.16	.22
12.00	1,145	.22	.41
13.00	1,146	.28	.63
14.00	1,147	.34	.92
15.00	1,148	.40	1.29
16.00	1,149	.50	1.74
17.00	1,150	.75	2.33
18.00	1,151	1.03	3.15
19.00	1,152	1.29	4.25

The deposition of sediment in reservoir 1 is affected by detention dam 2 and, to a lesser degree, by the stabilization structures. Flow regulation through reservoir 2 is similar to that through reservoir 1 except that the time of detention is shorter because of a smaller reservoir capacity and a larger discharge tube. The drop-inlet structure at reservoir 1 has a concrete riser having a rectangular opening 30 by 24 inches, and the discharge tube has a circular opening 18 inches in diameter. The drop-inlet structure at reservoir 2 has a metal riser 48 inches in diameter, and the discharge tube is 36 inches in diameter. Stabilization structures 1 and 2 have earth spillways; stabilization structure 3 has a metal drop-inlet arrangement similar to that of reservoir 2.

METHOD OF OPERATION

During the period April 1, 1955, to September 30, 1956, sediment was sampled at 14 locations in the Whitehead Watershed. (See fig. 1.) Outflow from reservoirs 1 and 2 was sampled at locations 1-D, 1-U, and 2; and flow upstream from the reservoirs was sampled at locations 3 to 13. Locations 10 to 13 were not used before June 30, 1956.

Outflow was sampled from reservoir 2 at the discharge-tube outlet and from reservoir 1 at the discharge-tube outlet and at the trash rack that protects the inlet of the discharge tube. Samples were collected at the outlets with a U. S. DH-48 sampler (figs. 5 and 6) and at the trash rack with automatic suspended-sediment samplers in vertical stacks on the upstream corners of the rack (figs. 7 and 8). At reservoir 1 samples were also collected at the outlet with a continuous suspended-sediment sampler having the sampler intake nozzle in a fixed position inside the discharge tube.

Inflow to the reservoirs was sampled with a U. S. DH-48 sampler at locations 4, 5, 6, 7, 8, 9, 10, 11, 12, and 13 and with automatic suspended-sediment samplers at locations 3, 6, 7, and 8. The automatic samplers were placed in the channels so that the initial samples were collected when the flow reached a depth of about 0.7 foot. Automatic samplers were generally arranged in vertical stacks so that successive samples were obtained as the stage increased. Manual sampling at locations 5 and 9 was done by a

Figure 3.--Detention dam 1, Whitehead Watershed (June 24, 1955, reservoir elevation about 1,140 ft).

Figure 4.--Detention dam 2, Whitehead Watershed (May 5, 1955).

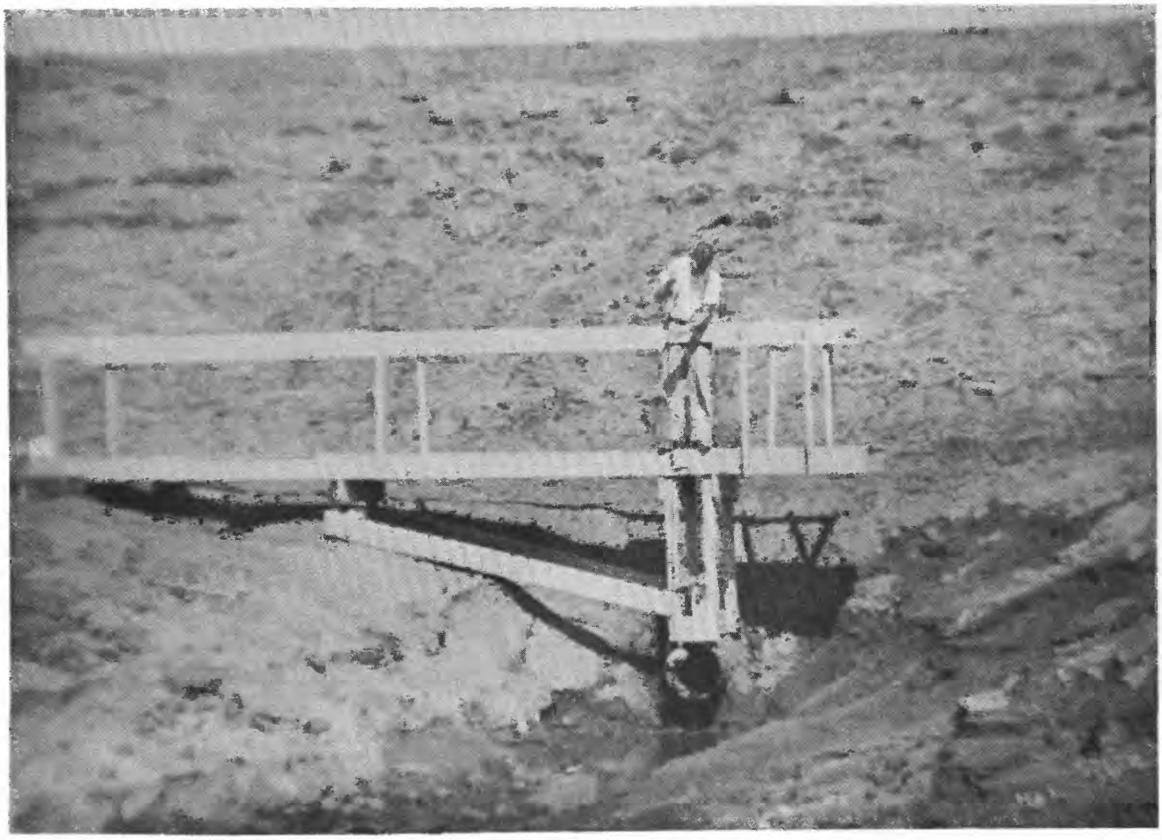

Figure 5.--Discharge-tube outlet, reservoir 1. Note sampler at end of discharge tube.

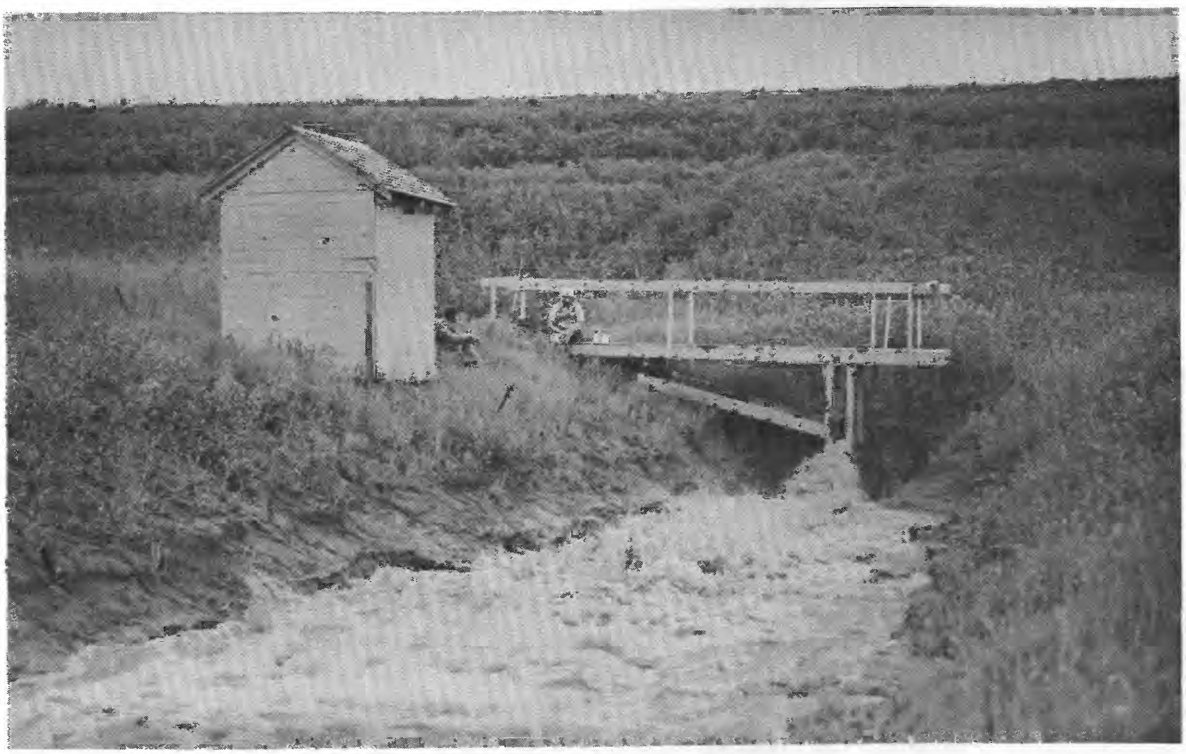

Figure 6.--Outflow from discharge tube, reservoir 1, June 24, 1955. Water discharge about 32 cfs.

Figure 7.--Vertical stack of automatic suspended-sediment samplers at trash rack, reservoir 1.

Figure 8.--Partly submerged vertical stack of automatic suspended-sediment samplers at trash rack, reservoir 1 (June 24, 1955, reservoir elevation about 1,140 ft).

local resident, who was assisted by Geological Survey personnel during periods of major runoff.

Precipitation was measured at a recording gage about a quarter of a mile south of reservoir 1 and at a nonrecording gage about 1 mile northeast of reservoir 1 (fig. 1).

OUTFLOW PERIODS

Seven periods of significant runoff and outflow occurred from April 1, 1955, to September 30, 1956. Table 3 gives the maximum gage height, total water discharge, and total sediment discharge at reservoir 1 for these periods.

Table 3.--Summary of outflow periods at reservoir 1

Date	Maximum gage height (ft)	Water discharge (acre-ft)	Sediment discharge (tons)
1955			
Apr. 23-24.......	2.31	9.32	10
Apr. 27-28.......	1.21	.60	.9
June 24-26.......	7.81	59.7	135
June 28-29.......	2.03	6.74	11
Apr. 1 to Sept. 30.	....	....	156.9
1956			
July 2-4.........	2.07	....	a11
July 31-Aug. 3...	2.03	5.95	1.0
Aug. 18-20.......	4.55	25.8	25
Oct. 1, 1955, to Sept. 30, 1956...	....	....	37.0

a Partly estimated.

The largest outflow period was June 24-26, 1955. In 12 hours, 4.30 inches of rain fell at a maximum intensity of about 2.00 inches per hour. At reservoir 1, peak inflow was 653 cfs, peak outflow was 32.8 cfs, peak concentration of outflow was 3,400 ppm, maximum instantaneous sediment discharge was 275 tons per day, and total sediment discharge was 135 tons. Hydrographs of inflow and outflow, continuous concentration of outflow, accumulated precipitation, and some instantaneous concentrations of inflow are shown on figure 9. Gage-height trace, continuous concentration of outflow, accumulated precipitation, and some instantaneous concentrations of inflow at reservoir 2 for the period of June 23-24, 1955, are shown on figure 10. Samples at location 3 show that the peak concentration of inflow occurred during the initial sharp rise in stage.

On June 28-29, 1955, which was an outflow period of relatively minor significance, 0.85 inch of rain fell in 1.37 hours at a maximum 30-minute intensity of about 1.30 inches per hour. At reservoir 1, peak inflow was 95.0 cfs, peak outflow was 28.4 cfs, peak concentration of outflow was 1,530 ppm, maximum instantaneous sediment discharge was 115 tons per day, and total sediment discharge was 11 tons. Figure 11 shows hydrographs of inflow and outflow, continuous concentration of outflow, accumulated precipitation, and some instantaneous concentrations of inflow.

Very minor outflow occurred July 31-Aug. 3, 1956. On July 31, 1.97 inches of rain fell between 5 and 8 p.m., with 1.41 inches falling between 6 and 7 p.m. At reservoir 1, peak inflow was 131 cfs, peak outflow was 20.4 cfs, peak concentration of outflow was 148 ppm, maximum instantaneous sediment discharge was 7.3 tons per day, and total sediment discharge was 1.0 ton. Figure 12 shows hydrographs of inflow and outflow, continuous concentrations of outflow, and accumulated precipitation.

The second largest outflow period was Aug. 18-20, 1956. Total rainfall was 2.28 inches from 1 to 7 a.m., with 1.90 inches falling between 1 and 3 a.m. At reservoir 1, peak inflow was 241 cfs, peak outflow was 30.6 cfs, peak concentration of outflow was 1,110 ppm, maximum instantaneous sediment discharge was 93 tons per day, and total sediment discharge was 25 tons. Hydrographs of inflow and outflow, continuous concentration of outflow, and accumulated precipitation are shown in figure 13.

Particle-size analyses of suspended-sediment samples are given in tables 4-7. Table 4 lists samples of inflow to reservoir 1, table 5 lists samples of inflow to reservoir 2, table 6 lists samples of outflow from reservoir 2, and table 7 lists samples of outflow from reservoir 1.

Particle-size distribution of inflow and outflow samples is shown graphically in figure 14. The particle-size distribution of these samples shows that the outflow has a higher percentage of clay than the inflow, that most of the sand entering reservoir 2 is trapped, and that all the sand entering reservoir 1 is trapped.

Figure 15 shows the relationship between the percentage of sediment in a specific size class and the suspended-sediment concentration of inflow water to reservoirs 1 and 2. The curves in figure 15 indicate that, in general, the percentage of clay decreases and the percentage of silt increases as the suspended-sediment concentration increases.

A comparison of suspended-sediment size analyses in native water and in distilled water with dispersing agent shows that the water is of such chemical quality as to induce significant flocculation of sediment during certain settling conditions. (See tables 4 to 7.) Results of chemical analyses of water samples collected concurrently with suspended-sediment samples are shown in table 8.

GLOSSARY

Automatic suspended-sediment sampler: a bottle equipped with intake nozzle and exhaust tube, which is mounted in a fixed position and which admits water-sediment mixture when the water rises to the level of the nozzle. A valve prevents entry of water after the bottle is about nine-tenths full.

Flocculation: the formation of larger sediment aggregates caused by coalescence of smaller particles that are subjected to certain physicochemical conditions.

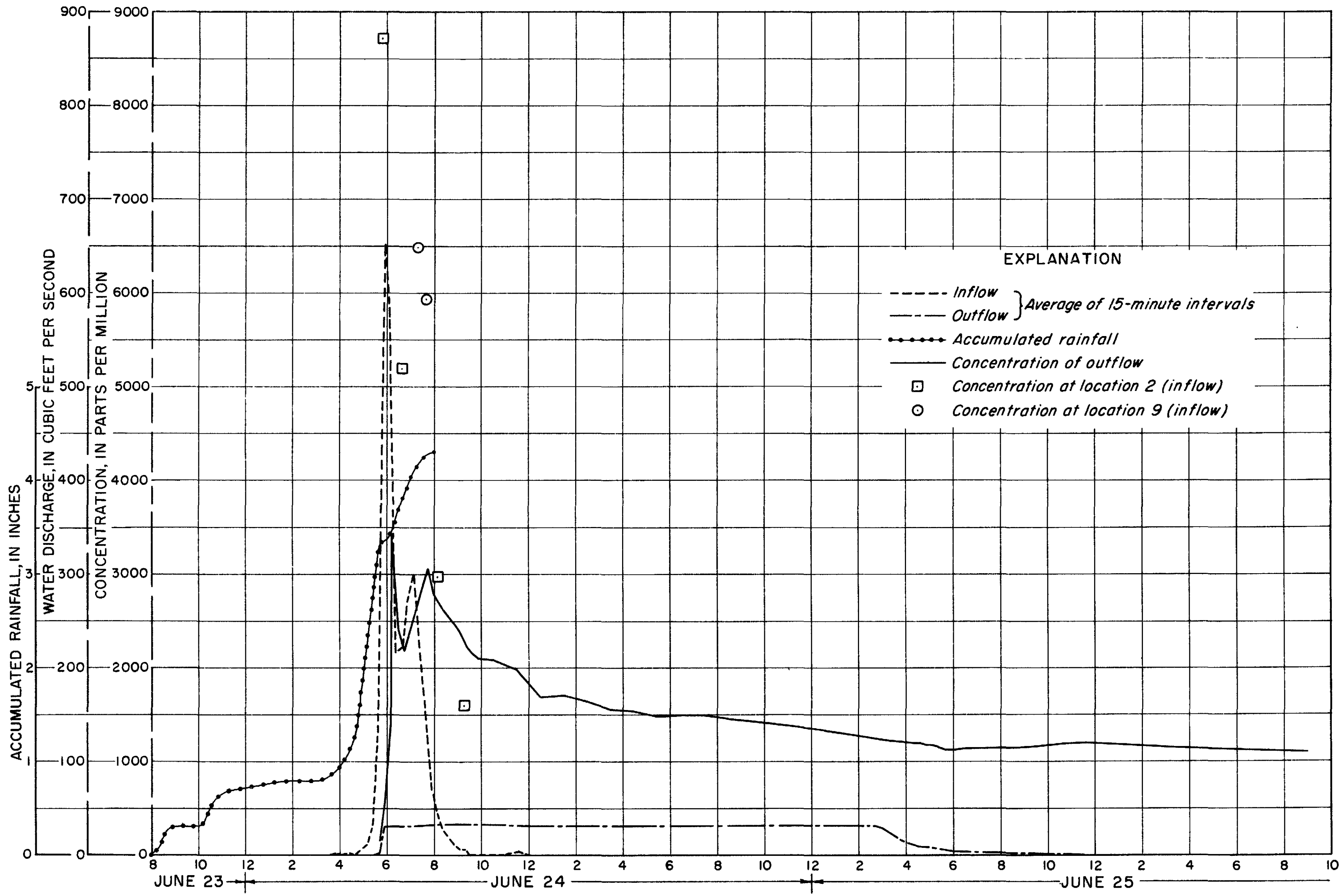

Figure 9.--Water discharge (inflow and outflow), accumulated rainfall, and suspended-sediment concentration, reservoir 1, June 23-25, 1955.

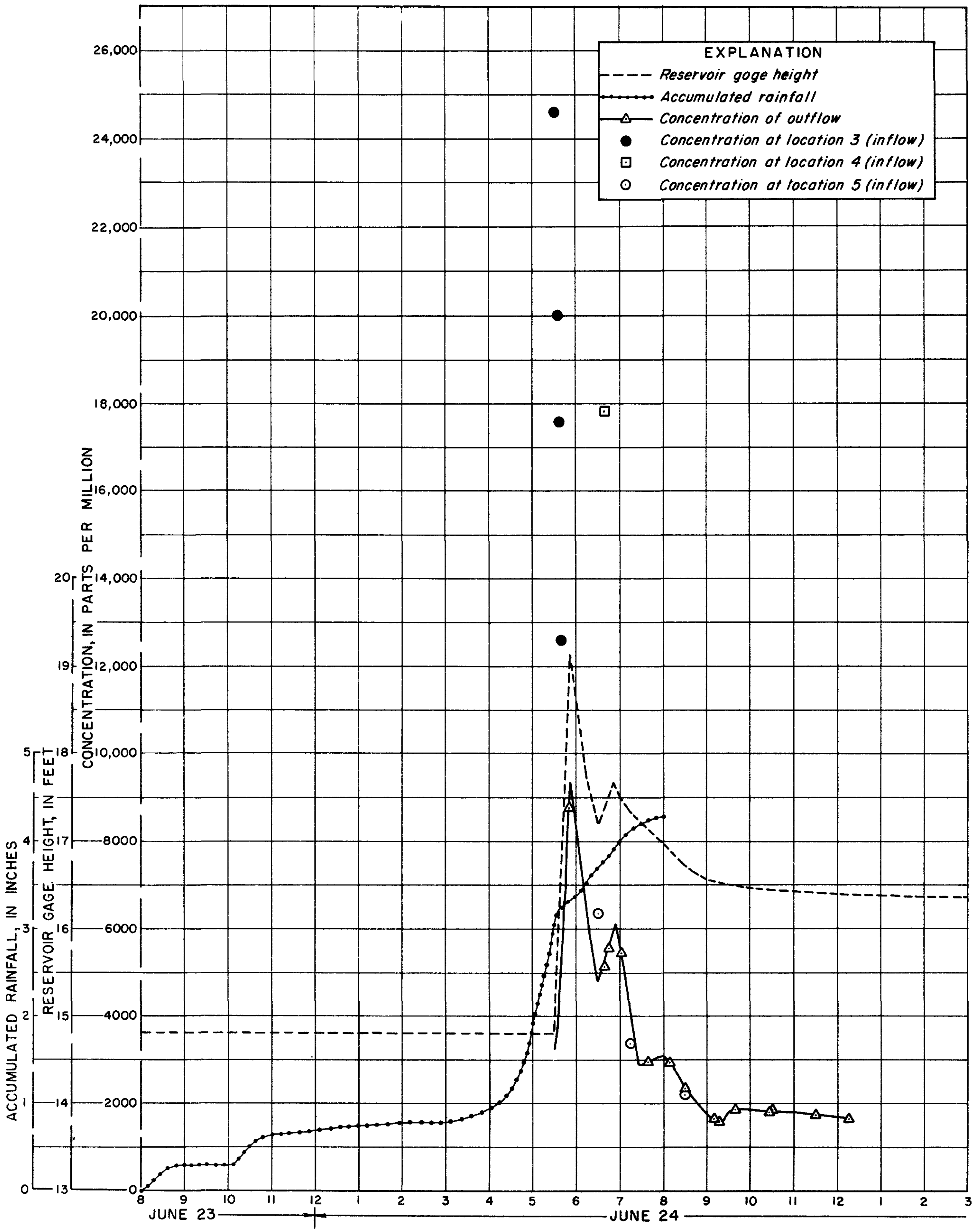

Figure 10.--Reservoir gage height, accumulated rainfall, and suspended-sediment concentration, reservoir 2, June 23-24, 1955.

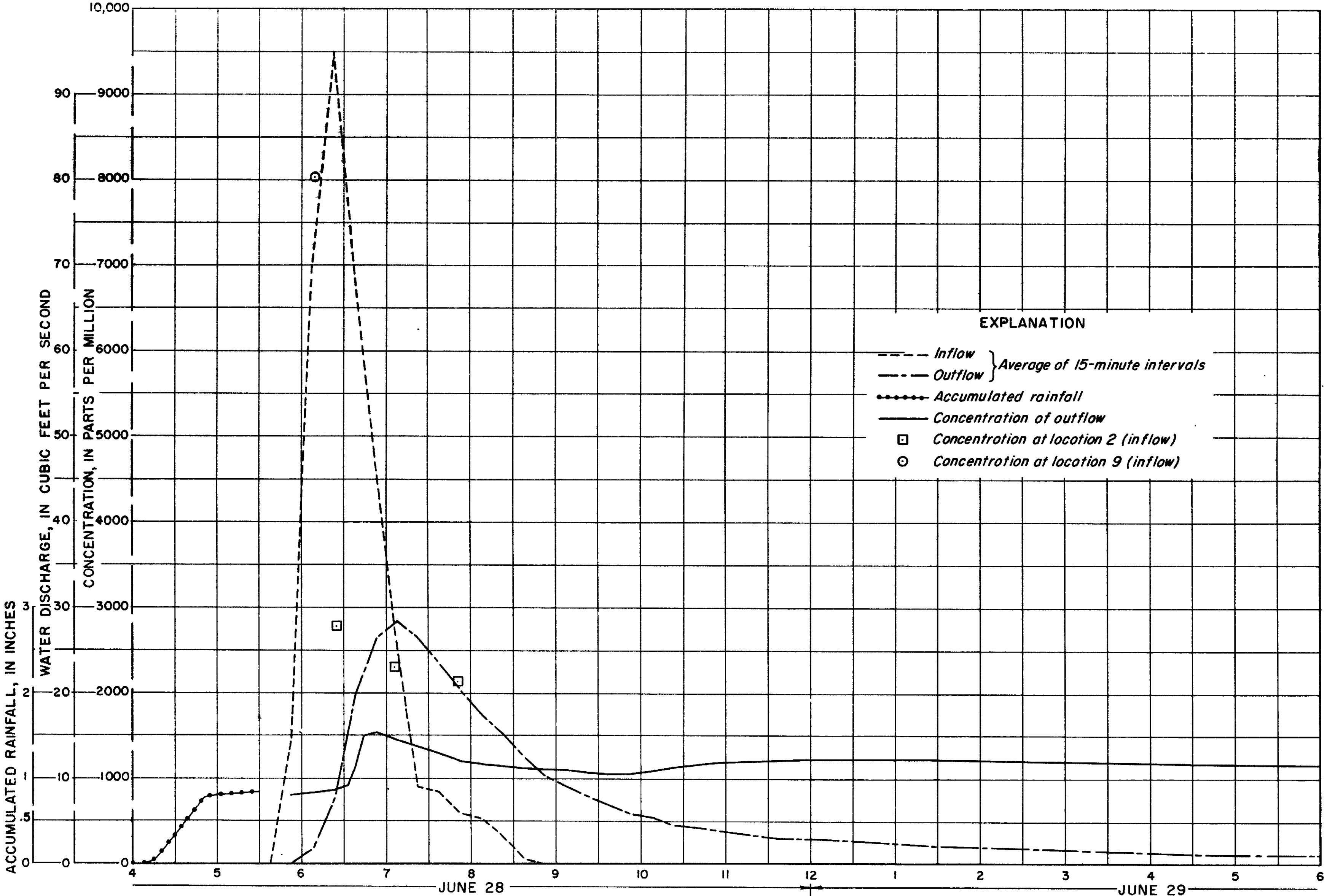

Figure 11.--Water discharge (inflow and outflow), accumulated rainfall, and suspended-sediment concentration, reservoir 1, June 28-29, 1955.

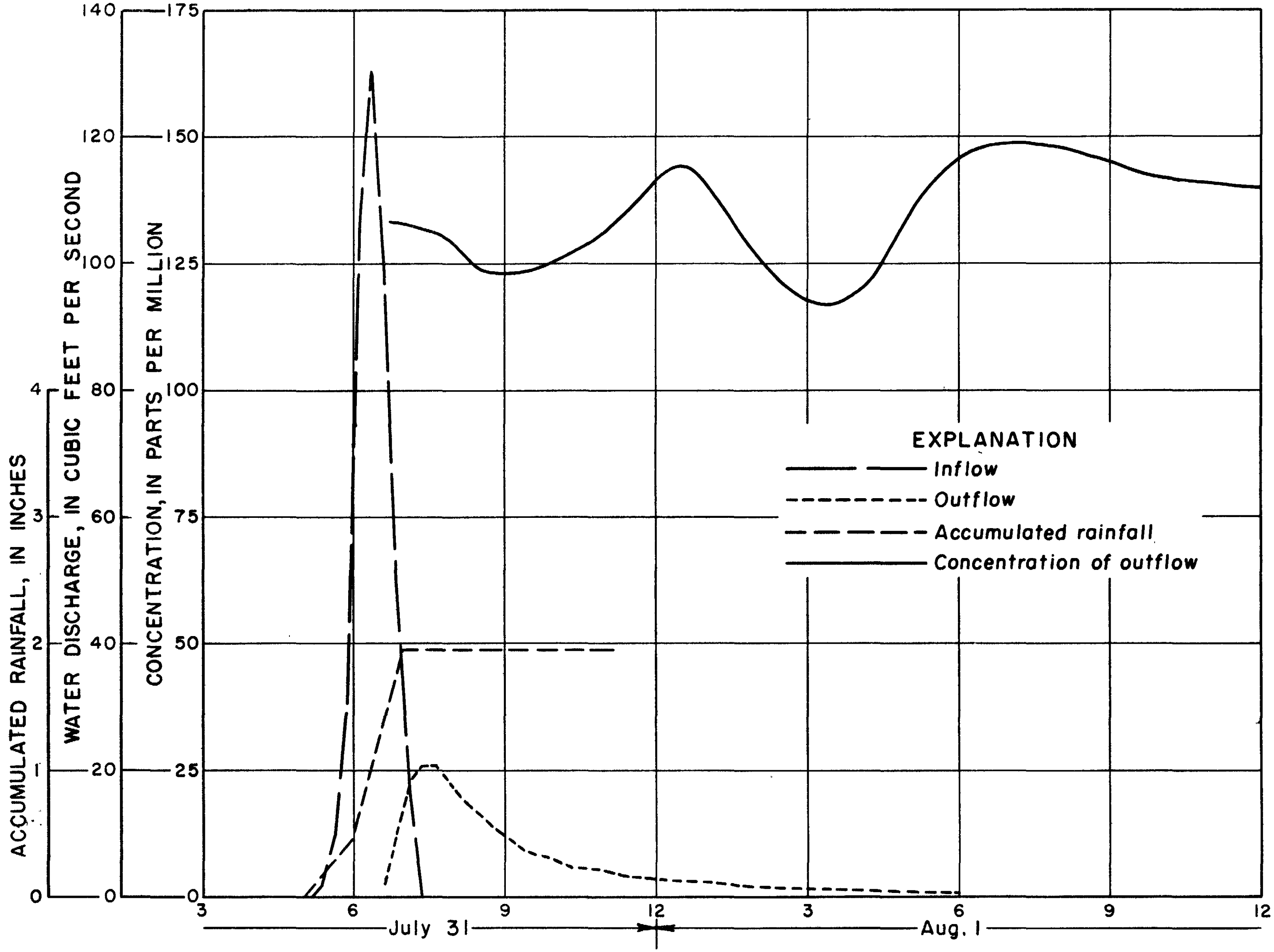

Figure 12.--Water discharge (inflow and outflow), accumulated rainfall, and suspended-sediment concentration, reservoir 1, July 31-Aug. 1, 1956.

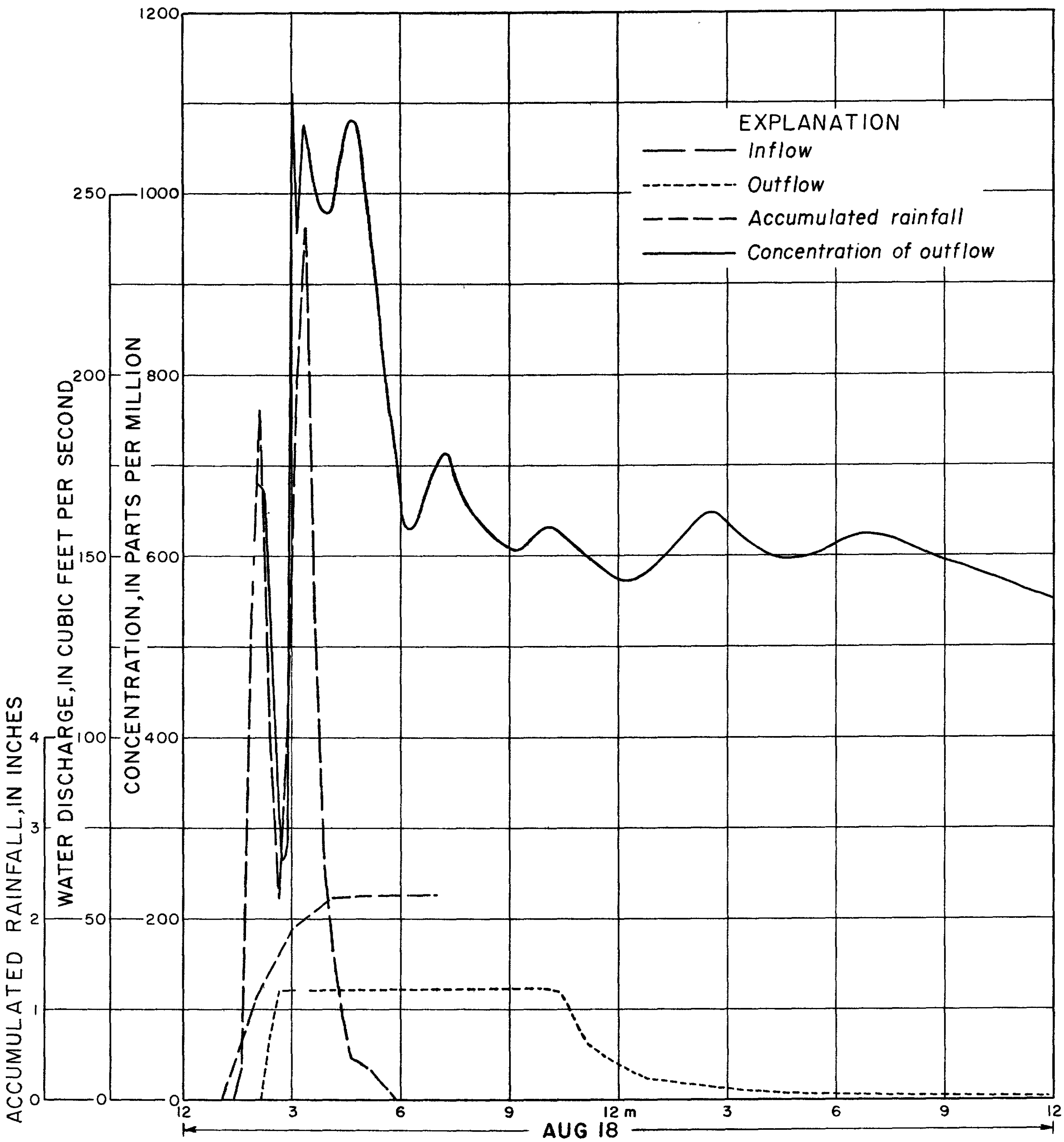

Figure 13.--Water discharge (inflow and outflow), accumulated rainfall, and suspended-sediment concentration, reservoir 1, Aug. 18, 1956.

Table 4.--Particle-size analyses of suspended sediment, inflow to reservoir 1

[Methods of analysis: P, pipette; S, sieve; N, in native water; W, in distilled water; C, chemically dispersed; M, mechanically dispersed; V, visual accumulation tube]

Date	Time	Sampling location a/	Suspended sediment: Concentration (ppm)	Concentration of suspension analyzed (ppm)	Percent finer than indicated size, in millimeters: 0.002	0.004	0.008	0.016	0.031	0.062	0.125	0.250	0.500	1.000	Method of analysis
1955															
June 24 b.	....	7	49,200	14,500	18	23	31	43	65	98	100	......	......	......	VPWCM
Do. b.	....	7	39,600	11,900	22	27	34	44	70	97	99	100	......	......	VPWCM
Do. b.	....	6	28,200	9,080	12	17	28	39	74	97	99	100	......	......	VPWCM
Do. c.	7:20 a.m.	9	6,480	8,360	35	42	50	60	78	93	97	99	100	......	VPWCM
Do. c.	7:20 a.m.	9	6,480	7,080	15	27	41	56	78	93	97	99	100	......	VPN
Do. c.	7:40 a.m.	9	5,920	5,710	38	44	52	62	81	97	99	99	100	......	VPWCM
June 28 b.	....	7	14,200	3,970	42	49	52	66	84	96	99	100	......	......	VPWCM
Do. b.	....	8	16,300	4,390	29	35	44	56	79	95	98	100	......	......	VPWCM
Do. c.	6:10 a.m.	9	8,040	3,260	49	56	62	76	92	99	100	......	......	......	VPWCM
1956															
June 24 b.	d12:30 p.m.	7	34,100	13,400	39	42	48	62	84	97	99	99	100	......	VPWCM
July 2 b.	d1:30 p.m.	6	16,300	12,500	18	26	32	47	79	97	99	99	100	......	VPWCM
Do. b.	d1:00 p.m.	7	100,000	21,500	30	32	38	49	80	94	96	97	99	100	VPWCM
Do. b.	d1:00 p.m.	7	100,000	21,200	20	26	34	48	80	94	96	97	99	100	VPN
Do. b.	d1:05 p.m.	7	58,000	12,100	30	33	37	50	80	97	98	99	100	......	VPN
Do. b.	d1:05 p.m.	7	58,000	12,200	43	47	52	63	83	97	98	99	100	......	VPWCM
Do. b.	d1:20 p.m.	7	14,700	11,100	26	38	48	60	84	99	100	......	......	......	VPWCM
Do. b.	d1:15 p.m.	8	58,400	26,300	19	24	31	43	78	93	97	99	100	......	VPWCM
Do. b.	d1:15 p.m.	8	58,400	20,700	12	17	26	40	75	93	97	99	100	......	VPN
Do. b.	d1:25 p.m.	8	5,580	6,180	43	47	......	63	......	98	100	......	......	......	VPWCM
Do. c.	3:40 p.m.	9	2,260	4,340	72	......	......	91	......	100	......	......	......	......	SPWCM
July 3 c.	9:15 a.m.	9	810	1,990	54	......	......	91	......	100	......	......	......	......	SPWM
Do. c.	9:55 a.m.	7	1,020	2,520	80	83	......	89	......	99	100	......	......	......	VPWCM
Do. c.	10:00 a.m.	10	1,760	3,740	71	77	......	90	......	99	100	......	......	......	VPWCM
Do. c.	10:05 a.m.	6	1,620	3,780	71	74	......	88	......	99	99	100	......	......	VPWCM
Do. c.	10:10 a.m.	8	1,680	3,880	72	77	......	90	......	98	99	99	100	......	VPWCM
Do. c.	10:45 a.m.	6	1,310	3,240	81	86	......	91	......	97	99	99	100	......	VPWCM
July 31 c.	7:00 p.m.	9	6,940	4,220	49	51	59	73	91	100	......	......	......	......	SPWCM
Do. c.	7:00 p.m.	9	6,940	4,060	24	36	53	70	89	98	100	......	......	......	SPN
Do. c.	8:00 p.m.	9	2,130	1,050	85	85	88	94	97	100	......	......	......	......	SPWCM
July 31 b.	d6:40 p.m.	6	100,000	5,040	27	29	30	42	72	97	98	99	100	......	VPWCM
Do. b.	d6:40 p.m.	6	100,000	4,700	9	12	18	39	68	97	98	99	100	......	VPN
Do. b.	d6:25 p.m.	7	35,200	7,460	30	34	41	54	80	99	99	100	......	......	VPWCM
Do. b.	d6:25 p.m.	7	35,200	7,310	5	8	15	26	48	99	99	100	......	......	VPN
Do. b.	d6:35 p.m.	8	37,200	7,200	27	29	35	46	76	96	98	99	100	......	VPWCM
Do. b.	d6:35 p.m.	8	37,200	7,200	8	12	20	35	68	96	98	99	100	......	VPN
Aug. 18 c.	2:40 a.m.	9	4,970	4,280	48	50	57	72	87	99	100	......	......	......	VPWCM
Do. c.	2:40 a.m.	9	4,970	4,210	24	36	52	68	87	99	100	......	......	......	VPN

Do. c........	3:10 a.m.	9	1,220	2,700	79	87	94	99	100	....	....	....	....	....	PWCM
Do. b........	d 2:10 a.m.	7	21,500	6,890	30	34	39	49	79	97	98	99	100	....	VPWCM
Do. b........	d 2:10 a.m.	7	21,500	7,120	12	27	32	48	76	97	98	99	100	....	VPN
Do. b........	d 2:15 a.m.	8	78,600	8,400	28	28	34	46	76	95	98	99	100	....	VPWCM

a Refer to figure 1. b Automatic sampler. c DH-48 sampler. d Obtained from gage-height chart.

Table 5.--Particle-size analyses of suspended sediment, inflow to reservoir 2

[Methods of analysis: P, pipette; S, sieve; N, in native water; W, in distilled water; C, chemically dispersed; M, mechanically dispersed; V, visual accumulation tube]

Date	Time	Sampling location a/	Suspended sediment												
			Concentration (ppm)	Concentration of suspension analyzed (ppm)	Percent finer than indicated size, in millimeters										Method of analysis
					0.002	0.004	0.008	0.016	0.031	0.062	0.125	0.250	0.500	1.000	
1955															
June 24 b......	c 5:30 a.m.	3	24,600	9,680	24	29	40	55	80	99	100	....	....	....	VPWCM
Do. b........	c 5:35 a.m.	3	20,000	7,800	26	33	45	60	90	100	....	....	....	....	VPWCM
Do. b........	c 5:38 a.m.	3	17,600	7,120	24	32	45	65	90	100	....	....	....	....	VPWCM
Do. b........	c 5:40 a.m.	3	12,600	1,610	56	60	67	75	91	100	....	....	....	....	VPWCM
Do. d........	6:30 a.m.	5	6,360	5,870	38	51	61	75	90	98	99	100	....	....	VPWCM
Do. d........	6:30 a.m.	5	6,360	4,960	17	27	44	63	88	98	99	100	....	....	VPN
Do. d........	6:40 a.m.	4	17,800	7,530	25	29	33	38	52	69	81	90	92	95	VPWCM
Do. d........	7:15 a.m.	5	3,380	5,080	44	57	66	76	89	99	100	....	....	....	VPWCM
Do. d........	8:30 a.m.	5	2,210	3,210	56	64	71	76	88	99	100	....	....	....	VPWCM
June 28 b......	c 6:00 p.m.	3	3,730	1,470	60	60	60	76	91	100	....	....	....	....	VPWCM
Do. b........	c 6:03 p.m.	3	10,700	3,820	41	46	55	69	89	100	....	....	....	....	VPWCM
Do. b........	c 6:05 p.m.	3	16,300	5,610	30	38	50	65	87	100	....	....	....	....	VPWCM
Do. d........	6:20 p.m.	5	3,240	2,080	66	75	....	84	94	100	....	....	....	....	VPWCM
1956															
July 2 b......	c 1:20 p.m.	3	913	1,450	84	....	....	95	....	100	....	....	....	....	SPWCM
Do. d.......	4:00 p.m.	5	380	1,810	50	....	....	74	....	94	97	100	....	....	VPWM
July 3 d......	9:10 a.m.	5	906	2,520	58	60	....	70	....	93	96	98	100	....	VPWCM
Do. d.......	9:15 a.m.	11	1,490	3,830	78	81	....	91	....	100	....	....	....	....	VPWCM
Do. d.......	9:20 a.m.	12	1,110	3,130	70	74	....	84	....	99	100	....	....	....	VPWCM
Do. d.......	9:25 a.m.	13	1,180	4,190	69	73	....	85	....	99	100	....	....	....	VPWCM
Do. d.......	10:00 a.m.	5	320	1,660	57	....	....	81	....	97	99	100	....	....	VPWM
July 31 d.....	7:10 p.m.	5	733	1,510	62	66	74	80	95	99	100	....	....	....	SPWCM
Do. d.......	8:15 p.m.	5	210	....	....	....	....	....	....	100	....	....	....	....	S
Aug. 18 d.....	2:45 a.m.	5	5,360	5,300	54	64	73	85	97	100	....	....	....	....	SPWCM
Do. d.......	2:45 a.m.	5	5,360	5,130	27	45	64	81	96	100	....	....	....	....	SPN
Do. d.......	3:15 a.m.	5	5,180	5,830	52	64	73	85	97	100	....	....	....	....	SPWCM
Do. d.......	3:15 a.m.	5	5,180	5,750	25	46	64	81	94	100	....	....	....	....	SPN

a Refer to figure 1. b Automatic sampler. c Obtained from gage-height chart. d DH-48 sampler.

Table 6.--Particle-size analyses of suspended sediment, outflow from reservoir 2

[Methods of analysis: P, pipette; S, sieve; N, in native water; W, in distilled water; C, chemically dispersed; M, mechanically dispersed]

Date	Time	Sampling location a/	Suspended sediment									
			Concentration (ppm)	Concentration of suspension analyzed (ppm)	Percent finer than indicated size, in millimeters							Method of analysis
					0.002	0.004	0.008	0.016	0.031	0.062	0.125	
1955												
June 24	5:50 a.m.	2	8,730	7,240	36	49	62	79	97	100	....	SPWCM
Do	5:50 a.m.	2	8,730	7,310	12	25	38	58	90	99	100	SPN
Do	6:56 a.m.	2	5,260	5,860	45	58	72	85	96	99	100	SPWCM
Do	6:56 a.m.	2	5,260	6,240	20	37	58	79	98	100	....	SPN
Do	9:18 a.m.	2	1,590	1,310	78	87	89	94	95	95	100	SPWCM
Do	9:18 a.m.	2	1,590	1,060	28	50	79	....	....	92	100	SPN
Do	12:15 p.m.	2	1,640	2,180	84	90	95	100	....	....	....	PWCM
June 28	7:06 p.m.	2	2,320	2,090	75	85	88	100	....	....	....	PWCM
Do	7:06 p.m.	2	2,320	1,650	28	49	79	99	100	....	....	PN
Do	7:51 p.m.	2	2,190	2,460	71	86	93	93	....	95	100	SPWCM
1956												
July 3	9:35 a.m.	2	1,100	3,280	68	70	....	73	....	100	....	SPWCM
July 31	7:05 p.m.	2	1,380	1,520	72	75	86	93	97	100	....	SPWCM
Do	7:05 p.m.	2	1,380	1,400	35	61	87	97	98	100	....	SPN
Do	8:10 p.m.	2	658	884	84	86	94	96	99	100	....	SPWCM
Do	10:05 p.m.	2	719	1,240	84	87	89	91	93	100	....	SPWCM
Aug. 18	3:00 a.m.	2	4,840	6,000	58	67	80	92	99	100	....	SPWCM
Do	3:00 a.m.	2	4,840	6,190	23	42	65	86	97	100	....	SPN
Do	4:00 a.m.	2	1,540	1,760	86	93	....	....	97	100	....	SPWCM
Do	6:45 a.m.	2	1,420	1,640	84	....	97	....	97	100	....	SPWCM

a Refer to figure 1.

Table 7.--Particle-size analyses of suspended sediment, outflow from reservoir 1
[Methods of analysis: P, pipette; S, sieve; N, in native water; W, in distilled water; C, chemically dispersed; M, mechanically dispersed]

Date	Time	Sampling location a/	Suspended sediment: Concentration (ppm)	Concentration of suspension analyzed (ppm)	Percent finer than indicated size, in millimeters: 0.002	0.004	0.008	0.016	0.031	0.062	Method of analysis
1955											
June 24	6:10 a.m.	1-D	1,480	1,600	85	87	94	95	98	100	SPWCM
Do	6:10 a.m.	1-D	1,480	1,610	46	78	89	96	97	100	SPN
Do	6:35 a.m.	1-D	2,410	8,480	44	57	72	88	99	100	SPWCM
Do	9:10 a.m.	1-D	1,460	1,700	88	96	96	96	100	....	PWCM
Do	9:10 a.m.	1-D	1,460	1,670	56	80	97	100	....	....	PN
Do	9:15 a.m.	1-D	2,280	3,970	67	81	91	99	99	100	SPWCM
Do	12:10 p.m.	1-D	1,770	2,310	86	86	96	100	....	....	PWCM
Do	12:10 p.m.	1-D	1,770	2,350	48	72	90	99	99	100	SPN
Do	3:10 p.m.	1-D	1,510	3,710	83	96	98	100	....	....	PWCM
June 25	5:05 a.m.	1-D	1,170	2,790	86	98	100	....	....	....	PWCM
June 28	7:15 p.m.	1-D	1,450	2,090	85	90	92	97	99	100	SPWCM
Do	7:30 p.m.	1-D	1,320	1,860	91	92	95	96	98	100	SPWCM
June 29	7:00 a.m.	1-D	1,140	1,490	100	....	....	....	....	....	PWCM
1956											
July 3	9:45 a.m.	1-D	505	1,160	96	....	....	97	....	100	SPWCM
Do	11:30 a.m.	1-D	500	2,540	76	....	....	100	....	....	PWM
Do	1:10 p.m.	1-D	482	1,870	80	....	....	100	....	....	PWM
Do	2:10 p.m.	1-D	452	1,110	77	....	....	97	....	100	SPWM
Aug. 1	2:30 a.m.	1-D	121	724	86	87	88	91	93	100	SPWCM
Aug. 18	3:47 a.m.	1-D	983	1,740	69	74	86	96	97	100	SPWCM
Do	4:30 a.m.	1-D	1,070	1,600	41	43	71	89	89	100	SPN
Do	7:00 a.m.	1-D	699	964	93	94	....	96	97	100	SPWCM
Do	9:00 a.m.	1-D	607	844	79	84	91	100	....	....	PN

a Refer to figure 1.

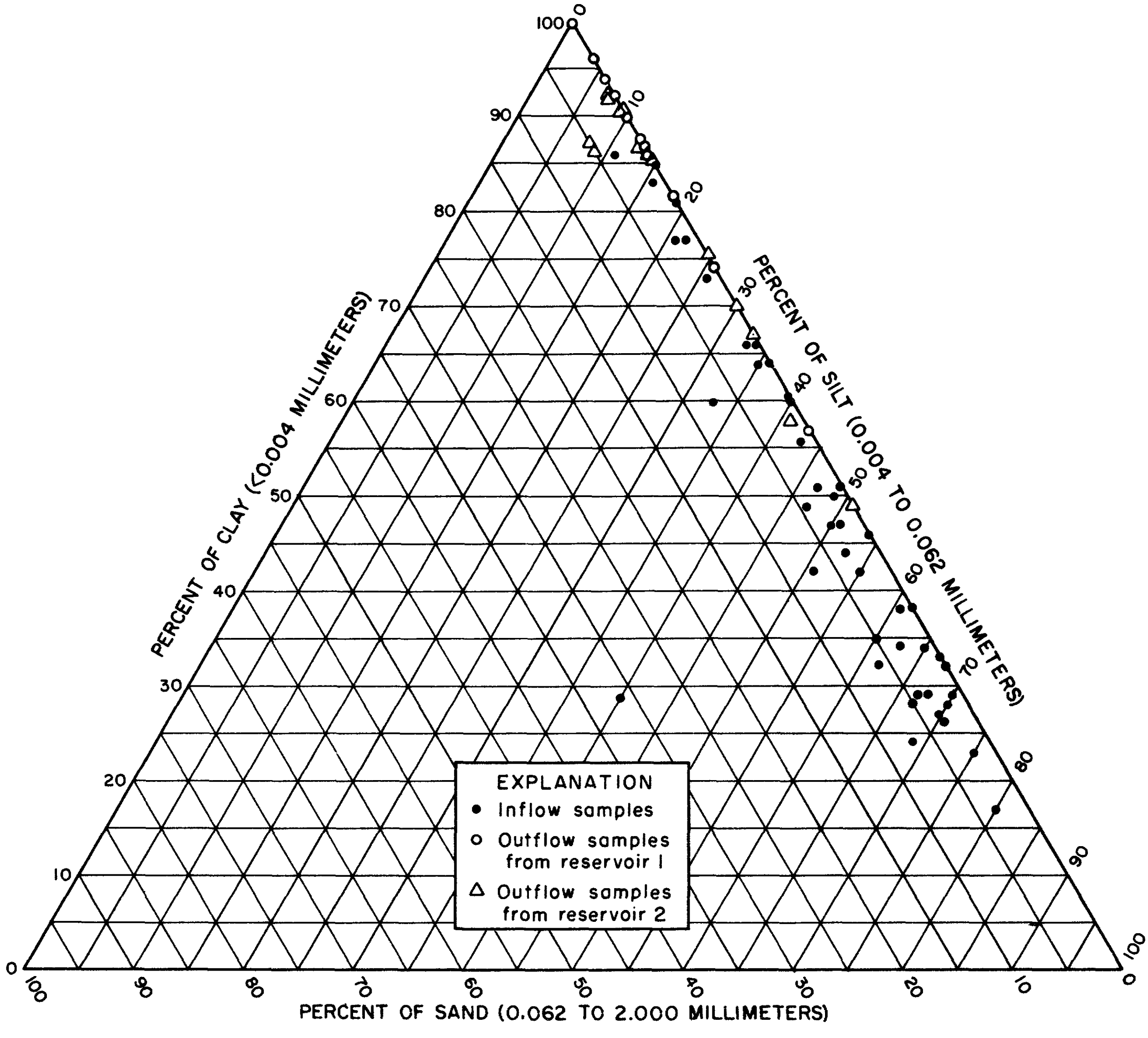

Figure 14.--Percentage of clay, silt, and sand in samples from Whitehead Watershed.

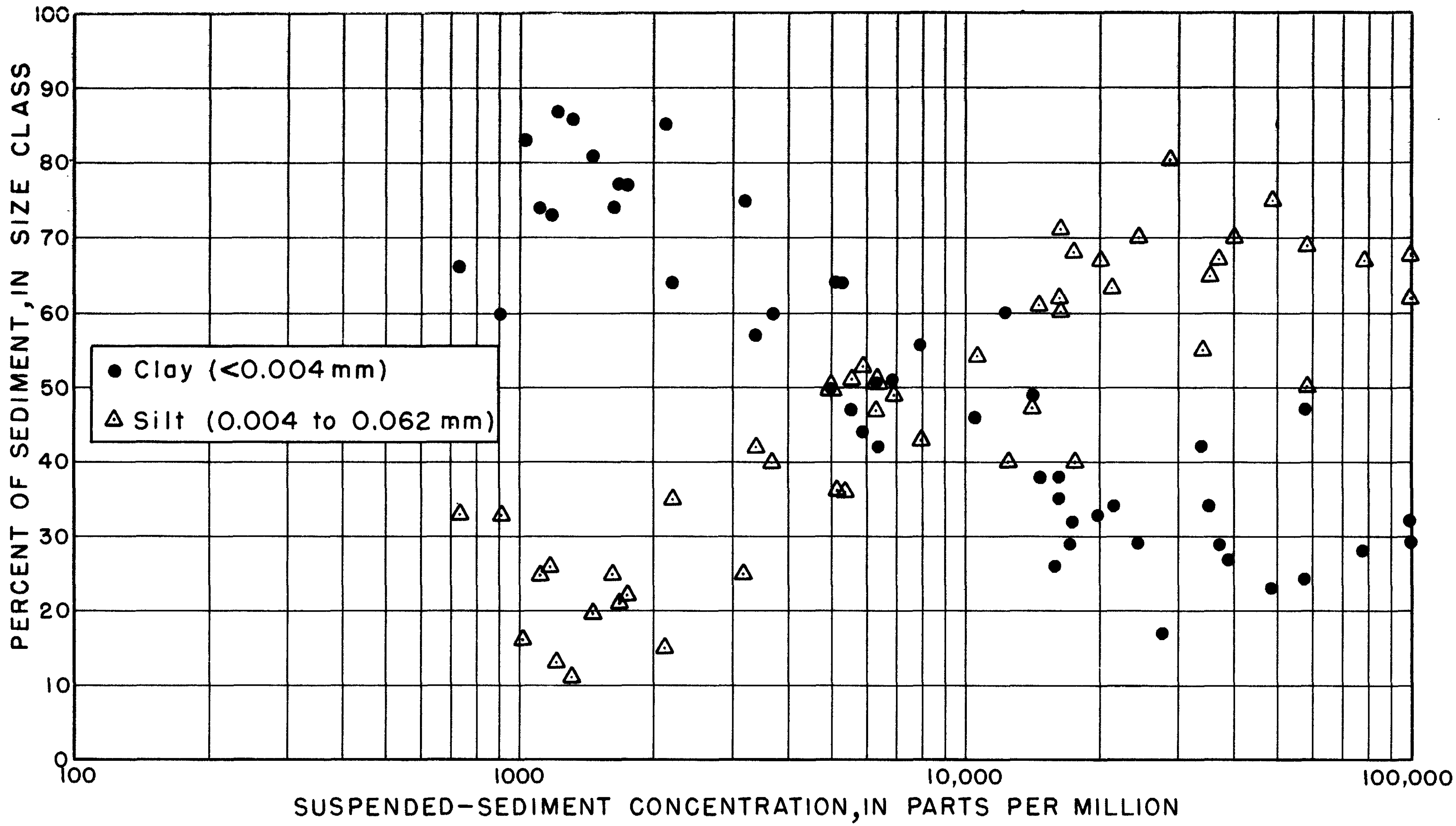

Figure 15.--Relationship of particle size to suspended-sediment concentration of inflow samples.

Table 8.--Chemical analyses, Whitehead Watershed near Syracuse, Nebr.
[Results in parts per million except as indicated]

Date of collection	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Dissolved solids: Residue on evaporation at 180°C	Dissolved solids: Tons per acre-foot	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Sodium-adsorption-ratio	Specific conductance (micromhos at 25°C)	pH
1955													
June 16 a.......	27	6.9	8.8	6.9	114	....	....	96	3	15	0.4	254	7.8
June 24 b.......	8.0	2.2	1.4	3.3	....	54	0.07	29	....	8	.1	72.8	6.7
Do. b.........	9.0	2.8	1.4	3.5	....	60	.08	34	....	7	.1	78.7	6.6
Do. c.........	13	3.0	3.0	3.2	....	81	.11	45	....	12	.2	117	6.6
Do. d.........	8.0	2.2	1.3	2.6	....	53	.07	29	....	8	.1	89.9	6.8
Do. e.........	12	2.4	2.7	3.1	....	63	.08	40	....	12	.2	101	6.7
Do. f.........	23	5.2	6.4	6.1	....	129	.18	79	....	14	.3	200	7.0
1956													
July 2 b.......	8.0	2.9	3.7	9.8	....	123	.17	32	....	15	.3	103	7.8
July 3 b.......	9.5	2.5	4.1	11.0	....	135	.18	34	....	16	.3	112	7.8
Do. d........	7.5	2.3	3.0	4.7	....	79	.11	28	....	16	.2	84.2	7.8
Do. e........	8.5	2.1	2.5	4.4	....	66	.09	30	....	13	.2	93.9	7.6
Do. f........	21	5.3	4.6	4.7	....	103	.14	74	....	11	.2	177	8.3
July 31 b......	12	2.0	4.4	9.1	....	106	.14	38	....	16	.3	127	7.4
Do. d........	11	2.3	4.1	8.5	....	88	.12	37	....	16	.3	113	7.5
Aug. 18 b......	6.5	1.9	3.9	6.1	....	114	.16	24	....	21	.3	87.5	7.3
Do. d........	5.0	1.3	3.0	5.8	....	....	....	18	....	21	.3	57.0	7.0
Do. e........	6.5	2.1	3.4	5.8	....	....	....	25	....	19	.3	71.0	7.2
Do. f........	18	3.9	4.1	2.9	....	124	.17	61	....	12	.2	154	6.0

a Sampling location, 1-U.
b Sampling location, 9.
c Sampling location, 4.
d Sampling location, 5.
e Sampling location, 2.
f Sampling location, 1-D.

Instantaneous sediment discharge: the rate at which dry weight of sediment passes a section of a stream or conduit at a given instant.

Percent sodium: the ratio, expressed in percentage, of sodium to the sum of the positively charged ions (calcium, magnesium, sodium, and potassium)--all ions in equivalents per million.

Sodium-adsorption-ratio: a ratio for soil extracts and irrigation waters used to express the relative activity of sodium ions in exchange reactions with soil.

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$$

The ionic concentrations are expressed in equivalents per million.

Suspended-sediment concentration: the weight of dry sediment per unit weight of water-sediment mixture, expressed as parts per million.

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