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LAKE RATHBUN PESTICIDE STUDY

#79-11

By

Jack O. Kennedy
University Hygienic Laboratory
University of Iowa
Iowa City, Iowa 52242

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ABSTRACT

Samples of water, fish and sediment were collected from Lake Rathbun and its major tributaries for pesticide analysis during May, June and July, 1978. Results of the analyses indicated very low pesticide levels occurring in the water, fish and sediment. Dieldrin, Atrazine and Lasso were found most frequently in water; dieldrin, DDE, Heptachlor Epoxide and Chlordane in fish; dieldrin and DDE in the sediment. Highest pesticide levels were observed in the tributaries during high stream discharge and declined as the water flowed through the lake. Herbicide concentrations were more widespread throughout the lake due to their water soluble properties. Although other lakes in Iowa have had problems with high pesticide residues in fish, the pesticide concentrations from fish in Lake Rathbun were well below the Food and Drug Administration Standards and do not create a hazard to the consumer. Four of the organic compounds (Lindane, Endrin, Methoxychlor and Toxaphene) listed in the Safe Drinking Water Act - Primary Standards were below the maximum contaminant level specified for a surface water supply. Pesticides in Lake Rathbun are low and in that respect reflect one of the better water quality lakes in Iowa.

INTRODUCTION

Rathbun Dam, located in south central Iowa and constructed by the Corps of Engineers, impounds the Chariton River forming Lake Rathbun. Rathbun Dam was built to provide storage for flood control, navigation, low flow augmentation and recreation. The lake has also become a source (since early 1976) of water supply for the Rathbun Regional Water Association which has their water intake structure located in the Chariton River downstream (approximately 137M - 450 feet) from the dam. Dam construction was initiated in September, 1965, impoundment of water was begun in November, 1969, with the multipurpose pool level reached in October, 1970. At the normal pool elevation of 275.5 M (904 msl), the reservoir covers 4,450 hectares (11,000 acres) extends 18 kilometers (11.2 miles) upstream from the dam and has about 290 kilometers (180 miles) of shore line. A minimum discharge of $0.3M^3$/sec (11 cfs) is released from the reservoir to maintain low flows in the Chariton River below Lake Rathbun. The two major tributaries to Rathbun are the Chariton River and the South Chariton River (see Figure 1).

Rathbun's 138,550 hectare (535 square mile) watershed is predominantly agricultural and pasture land. A land use inventory (1) has indicated 25% of the 138,550 hectares (342,400 acres) is used for row crops, 27% for other cropland, 24% for pasture, 12% for forest and 12% for other land use. Agena (2) reported that the major nutrient loading to Lake Rathbun is from non-point source runoff which is mostly soil erosion from agricultural land. Not only are nutrients associated with this runoff but also a wide variety of pesticides move with the silt particles ending up in the streams and ultimately the lake.

Water quality data for the Chariton River and Lake Rathbun have been collected on a limited basis by the Iowa Conservation Commission (3), University Hygienic Laboratory (4) and Corps of Engineers (5). Very little of the data collected to date has included analysis for pesticides. Because of known pesticide contamination in Lake Rathbun's watershed through agricultural practices, the Kansas City District of the Army Corps of Engineers deemed it advisable to quantify the existing concentrations and seasonal increases of commonly used pesticides at various levels throughout the project's aquatic ecosystem and to consider their effects on the operation and management of the lake (6). As a result, the University Hygienic Laboratory, University of Iowa, Iowa City, was contracted to collect water, fish and sediment samples from Lake Rathbun, analyze them for pesticide content, interpret the data and report the findings.

SAMPLING METHODOLOGY

A map of the sampling area and a list of sampling stations may be found in Figure 1 and Table 1, respectively.

Sample Collection

Container preparation, collection and sample preservation methods that were utilized during this study are described in Standard Methods for the Examination of Water and Wastewater, 14th edition, (7), and in the Criteria for the National Pollutant Discharge Elimination System (NPDES), Appendix A (8).

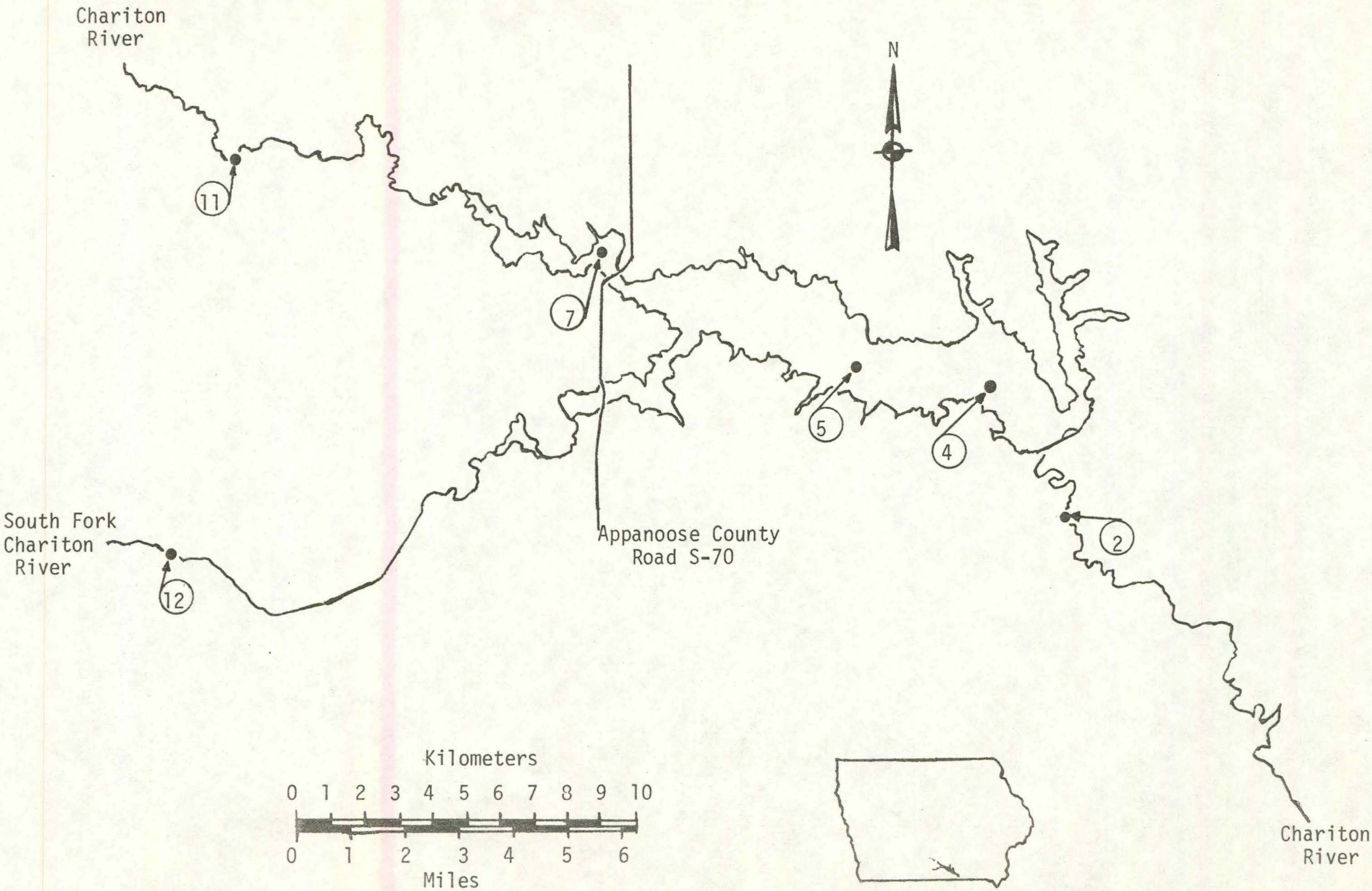


Figure 1. Map of Lake Rathbun Showing Sampling Locations.

TABLE 1

LAKE RATHBUN - CHARITON RIVER
Sampling Locations
May 18 - July 28, 1978

Station	Location
2	NE¼, NW¼, Sec. 1, R18W, T69N, Approximately 3 miles downstream from dam
4	SW¼, SW¼, Sec. 23, R18W, T70N, Over old river channel south of mouth of Honey Creek
5	SW¼, NE¼, Sec. 20, R18W, T70N, Over old river channel south of Iconium
7	NE¼, SW¼, Sec. 9, R19W, T70N, West of the Bridgeview public access area
11	NE¼, SW¼, Sec. 32, R20W, T71N, Lucas County Road Bridge S56
12	NW¼, SW¼, Sec. 5, R20W, T69N, Wayne County Road Bridge S50

Water

Grab samples of water were collected at stations 11 and 12 once a week and once every two weeks at stations 2 and 4 from May 15 to July 28. At station 4 the water sample was depth composited from samples collected by a Kemmerer water sampler at the surface and each subsequent three meters in depth through the water column. Stream samples were collected subsurface using a stainless steel sampling bucket. From each sample collected an aliquot was taken for turbidity and suspended solids analysis. The remaining sample was analyzed for pesticide content.

Sediment

Lake bottom sediment samples for pesticide analysis were collected during the first and last weeks of water sampling. Samples of the uppermost two inches of bottom sediment were composited from six sites located on a transect with two samples collected from each of the following depths: shallow or between three and six meters, mid-depth, and maximum depth. One shallow and one mid-depth sample was obtained from opposite sides of the transect in relation to the maximum depth sample. The three transects were oriented in a north to south direction across the lake and positioned so that stations 4, 5 and 7 were each intersected by one transect. Sediment samples were obtained using a Wildco K.B. brass core sampler and placed in glass containers until extraction.

Fish

In conjunction with the Iowa Conservation Commission , fish specimens were collected by gill nets and shocking from a portion of the lake lying east of Highway S-70 during the first week of water sampling and the week of July 17. When possible, a minimum of five carp 26-35 cm (10-14 inches) in length, five channel catfish 30-40 cm (12-16 inches) in length, five crappie 20-30 cm (8-12 inches) in length and five walleye 36-46 cm (14-18 inches) in length were collected. Filets from each type of fish for each sampling time were composited and analyzed for pesticides.

ANALYTICAL METHODOLOGY

Water, Sediment and Fish

The water and sediment samples were analyzed for the chlorinated insecticides Aldrin, cis Chlordane, trans Chlordane, DDD, DDE, DDT, Dieldrin, Heptachlor and Heptachlor Epoxide; the organophosphates Diazinon, Dyfonate, Malathion and Thimet; and the herbicides Atrazine, Bladex, Lasso, Treflan, Sutan, Sencor and Mocap. Sample preparation and analysis of the water samples was performed as described in NPDES, Appendix A (8). Soil sample preparation and analysis was performed as described in Analysis of Pesticide Residues in Human and Environmental Samples (9). Fish flesh composites were analyzed for Aldrin, cis Chlordane, trans Chlordane, DDD, DDE, DDT, Dieldrin, Heptachlor, Heptachlor Epoxide, Endrin, Lindane and Toxaphene. Fish sample preparation and analytical methods were utilized as described in the Journal of the Association of Organic Analytical Chemists (10). Gas liquid chromatography was used to identify and quantify the pesticides. The pesticide detection levels were 10 nanograms per liter where available analytical technology permitted. When extraneous organic contamination affected the detection level, the detection level conformed to currently recommended analytical procedures. While all the compounds listed above were analyzed for in each respective sample, only the pesticides with detectable levels are included in the results.

RESULTS AND DISCUSSION

Water Levels

Figures 2 and 3 are the hydrographs for stations 11 and 12, approximating the principal inflows to Lake Rathbun during the study period. Table 2 and Figures 2 and 3 demonstrate the variation in flow that can occur over time and within a watershed. Stream discharge in the Chariton River ranged from 5 - 980 cubic feet per second (cfs) while flow in the South Fork Chariton River ranged from 2 - 2689 cfs. During the study the Rathbun pool elevation varied from 910 - 919 feet above msl (6 to 14 feet above normal pool elevation), and outflow ranged from 11 to 1200 cfs (Table 3).

Turbidity and Suspended Solids

Analysis of the turbidity and suspended solids data from four stations (Tables 4 and 5) demonstrated a decline in levels from stations 11 and 12 to stations 4 and 2, an indication that the majority of the particulate matter present in the tributaries was settling out in Lake Rathbun. Turbidity and suspended solids levels at stations 11 and 12, located respectively on the Chariton and South Fork Chariton River, fluctuated widely but directly with stream discharges (Figures 4-7). Station 4 (the lake sample) turbidity and suspended solids were less variable, while station 2, below the dam, had values that were slightly more variable than station 4. The high stream flow observed at stations 11 and 12 on June 27 may have been responsible for the increase in turbidity and suspended solids values at stations 2 and 4 on June 28.

FIGURE 2
Hydrograph for Chariton River - Station 11
May 15 - July 27, 1978

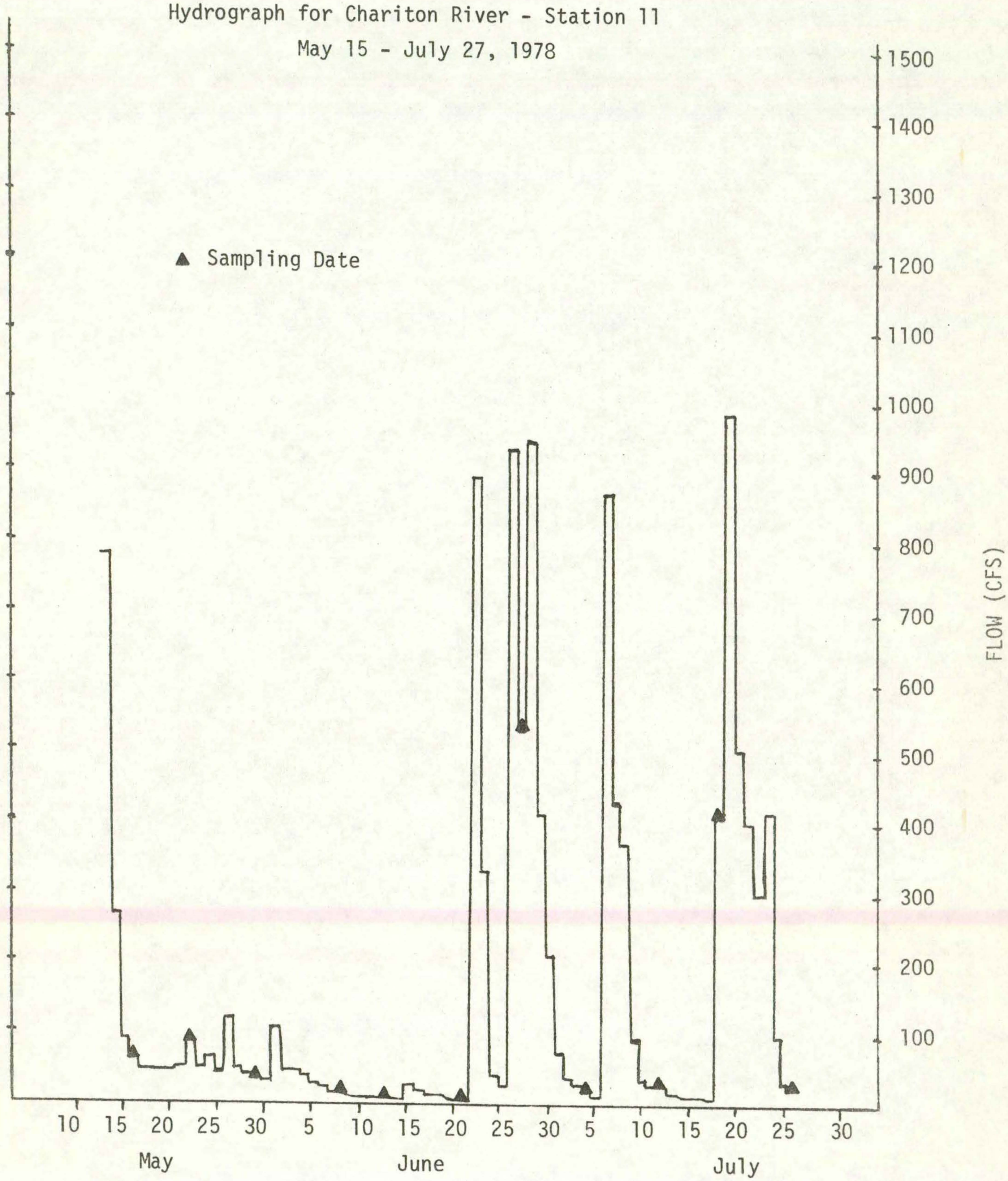


FIGURE 3

Hydrograph for South Chariton River - Station 12

May 15 - July 27, 1978

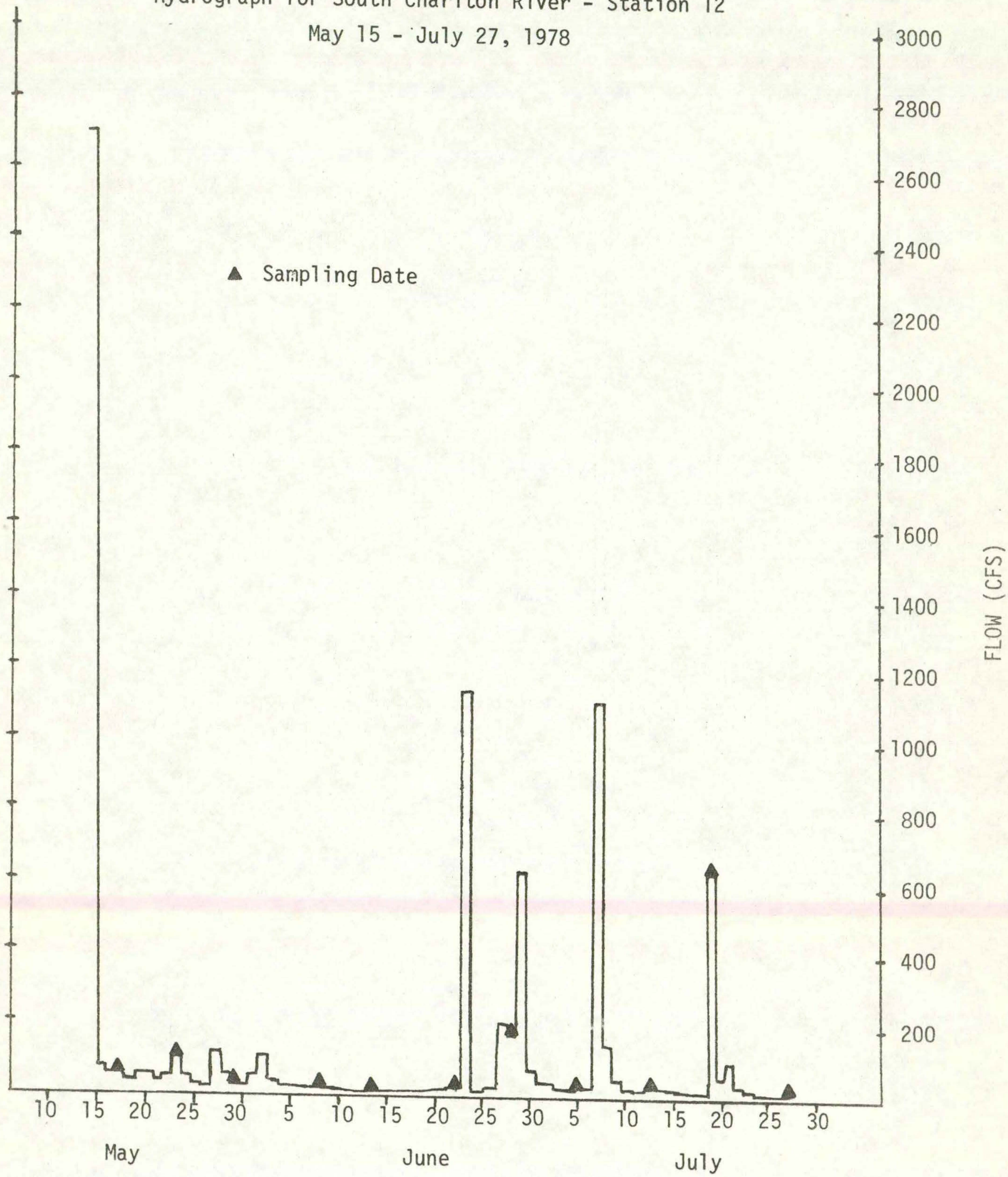


TABLE 2

Chariton River (Station 11) and South Chariton River (Station 12) Discharge
May 15 - July 27, 1978

Date	Station 11	Station 12
May 15	780	2,689
May 16	268	79
May 17	88	63
May 18	62	50
May 19	49	36
May 20	49	57
May 21	51	59
May 22	50	38
May 23	54	44
May 24	88	105
May 25	49	52
May 26	65	33
May 27	41	24
May 28	125	128
May 29	50	47
May 30	40	30
May 31	35	22
June 1	33	46
June 2	109	112
June 3	44	38
June 4	44	22
June 5	40	16
June 6	28	11
June 7	22	11
June 8	17	11
June 9	14	7
June 10	12	7
June 11	11	7
June 12	10	4
June 13	9	4
June 14	7	4
June 15	9	4
June 16	31	7
June 17	20	4
June 18	15	4
June 19	18	4
June 20	16	4
June 21	13	4
June 22	5	2
June 23	888	1,130
June 24	330	7

TABLE 2 (Continued)

Date	Station 11	Station 12
June 25	42	4
June 26	26	16
June 27	930	198
June 28	530	164
June 29	939	620
June 30	410	66
July 1	212	29
July 2	76	29
July 3	36	16
July 4	24	11
July 5	19	7
July 6	14	7
July 7	865	1,092
July 8	430	139
July 9	370	38
July 10	88	22
July 11	36	16
July 12	24	11
July 13	24	16
July 14	19	11
July 15	16	11
July 16	16	7
July 17	14	7
July 18	10	4
July 19	410	616
July 20	980	56
July 21	502	99
July 22	400	35
July 23	300	29
July 24	410	11
July 25	100	7
July 26	36	7
July 27	22	4

TABLE 3

Chariton River (Station 2)
Discharge on Day of Sample Collection

Date Sample Collected	Flow (cfs)
May 18	1200
May 24	1200
May 30	1200
June 8	1200
June 13	1200
June 22	1200
June 28	11
July 5	1200
July 13	1200
July 19	1200
July 27	1200

TABLE 4

Lake Rathbun - Chariton River
Turbidity Values (NTUs)
May 18 - July 27, 1978

Date Collected	Station 2	Station 4	Station 11	Station 12
May 18	27	25	50	26
May 24	NC	NC	40	150
May 30	24	19	11	34
June 8	NC	NC	14	22
June 13	27	24	12	12
June 22	NC	NC	18	18
June 28	70	40	440	210
July 5	NC	NC	72	28
July 13	26	15	140	55
July 19	NC	NC	320	1100
July 27	23	19	80	33

NC - Not Collected

TABLE 5

Lake Rathbun - Chariton River

Suspended Solids Values (mg/l)

May 18 - July 27, 1978

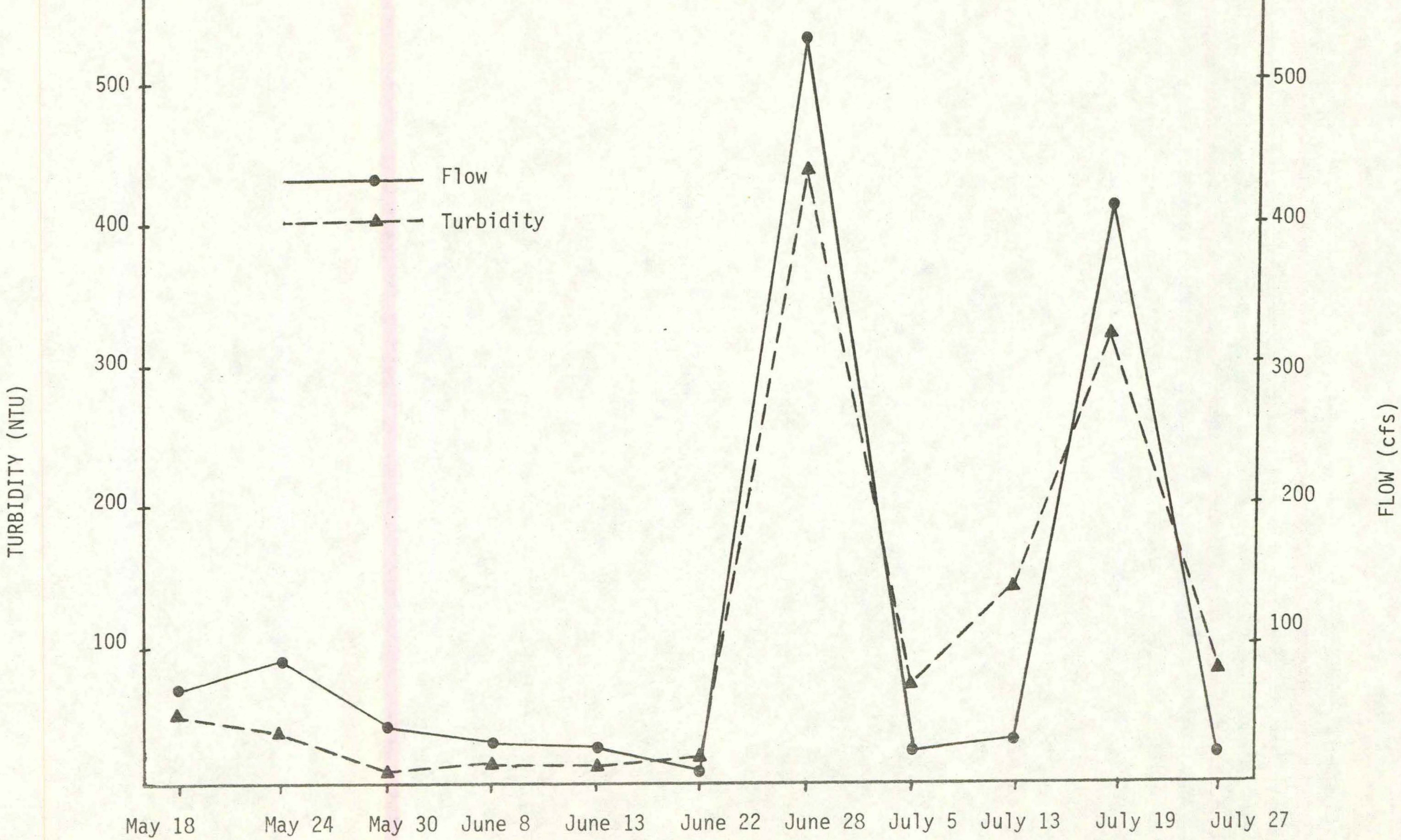
Date Collected	Station 2	Station 4	Station 11	Station 12
May 18	17	7	51	53
May 24	NC	NC	50	330
May 30	18	2	2	54
June 8	NC	NC	36	22
June 13	36	22	28	30
June 22	NC	NC	26	50
June 28	112	50	1000	500
July 5	NC	NC	92	62
July 13	32	10	112	106
July 19	NC	NC	580	2900
July 27	18	56	94	38

NC - Not Collected

FIGURE 4

Station 11 Turbidity and Flow

for Sampling Dates Between May 18 and July 27, 1978



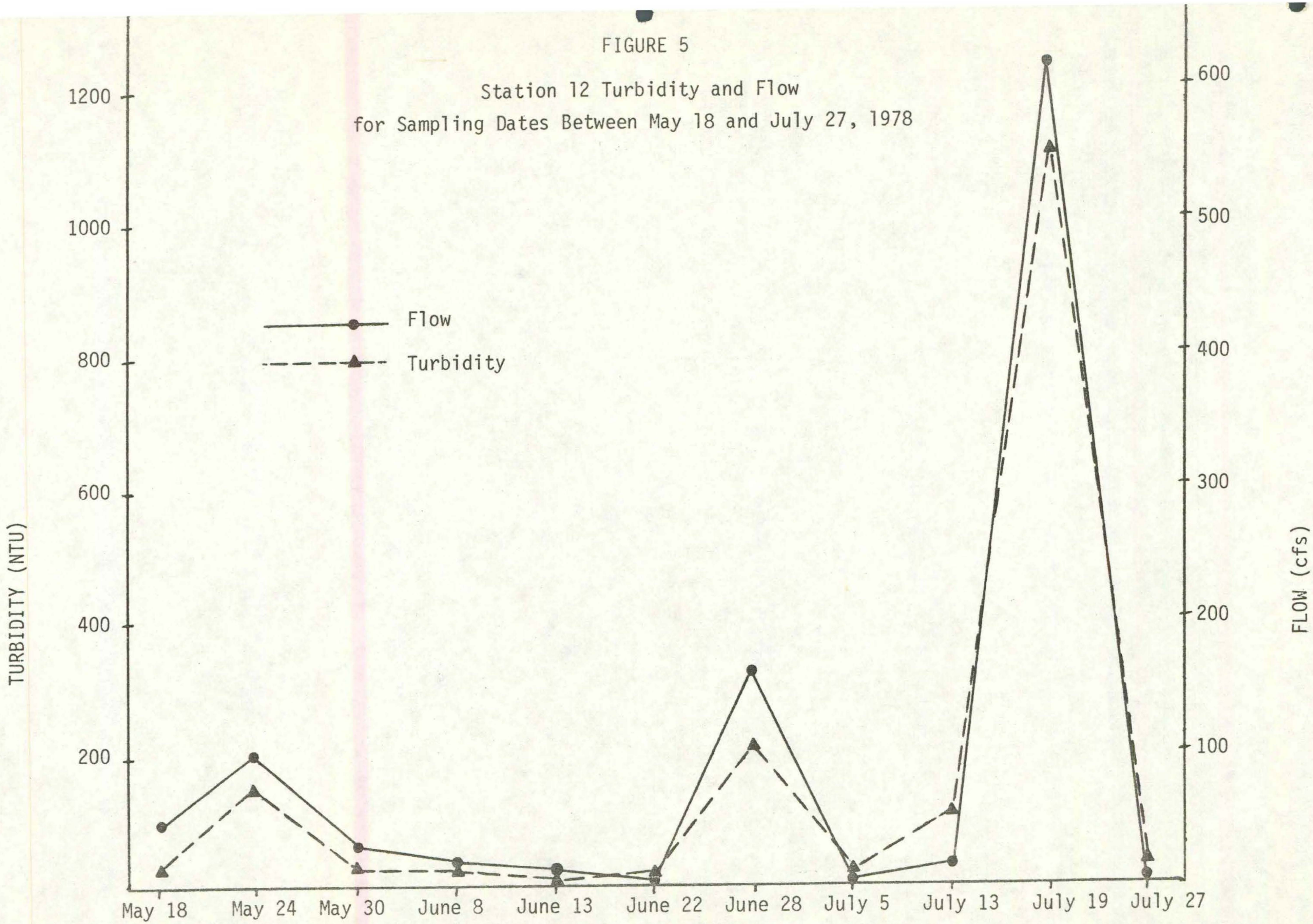


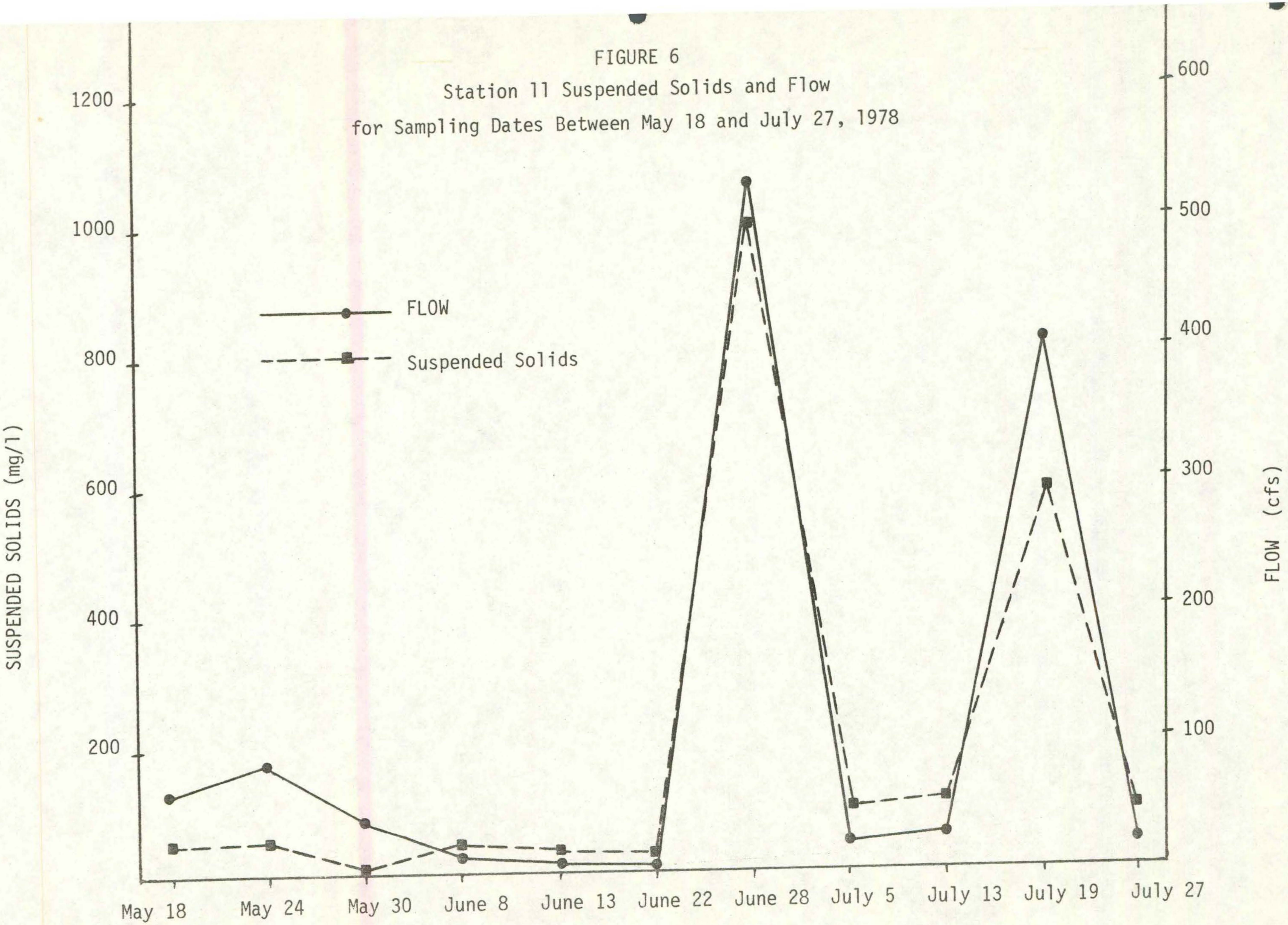
FIGURE 5

Station 12 Turbidity and Flow for Sampling Dates Between May 18 and July 27, 1978

FIGURE 6

Station 11 Suspended Solids and Flow

for Sampling Dates Between May 18 and July 27, 1978



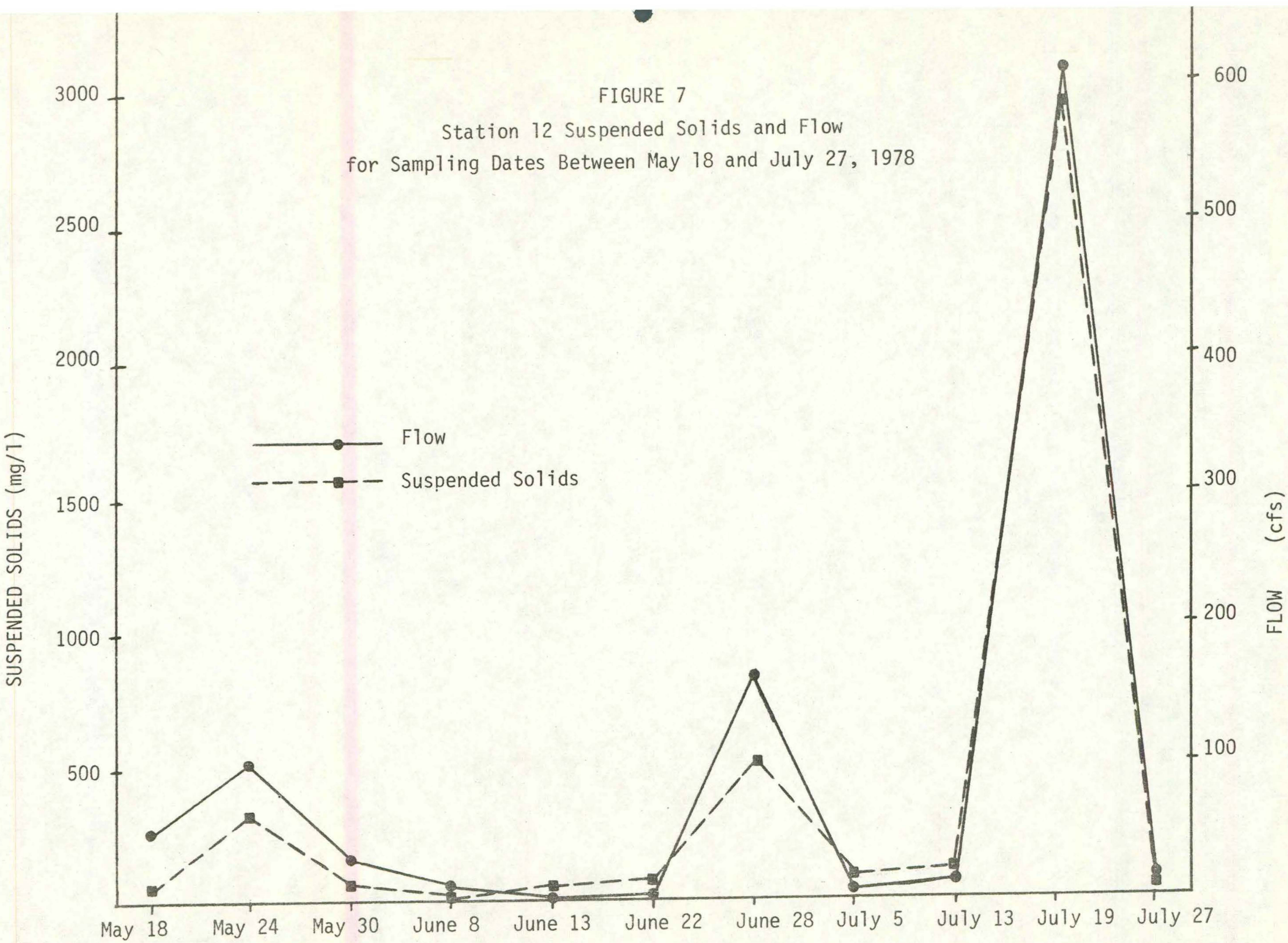


FIGURE 7
Station 12 Suspended Solids and Flow
for Sampling Dates Between May 18 and July 27, 1978

Water Pesticide Data

Water pesticide data for all four stations will be found in Tables 6, 7, 8 and 9. The less than value indicate the typical detection limit for that particular pesticide and has been included in calculating the arithmetic mean. Only pesticides with detectable levels have been included in the tables; the detection limits for pesticides not listed in the tables are: Aldrin - 0.004 ppb; cis and trans chlordane - 0.004 ppb; DDT - 0.010 ppb; DDD - 0.010 ppb; Heptachlor - 0.004 ppb; Heptachlor Epoxide - 0.006 ppb; Diazinon - 0.025 ppb; Malathion - 0.035 ppb and Thimet - 0.030 ppb.

Dieldrin was found in all water samples (100% occurrence) from station 2 (Table 6) averaging 0.006 ppb. DDE was found only in the first sample - 0.006 ppb (17% occurrence). Atrazine (also known as Aatrex) was observed in five of the six samples (83% occurrence) averaging ≤0.66 ppb; Lasso (also known as alachlor) in three of six samples (50% occurrence) averaging ≤0.23 ppb; and Sutan (also known as butylate) in one of six samples (17% occurrence) for an average of ≤1.5 ppb.

Station 4, the lake station, reflected pesticide data (Table 7) very similar to station 2. Dieldrin was found in all samples (100% occurrence) averaging 0.005 ppb; DDE in the first sample only (20% occurrence), averaging ≤0.004 ppb; Atrazine in 67% of the samples with a ≤0.74 ppb average value; Lasso in three of six samples (50% occurrence) averaging ≤0.89 ppb and Sutan was found once (17% occurrence) for an average of ≤1.5 ppb.

TABLE 6

Chariton River - Station 2

Water Pesticide Data
May 15 - July 28, 1978

(All values in μg/l or ppb)

Date	Flow (cfs)	Dieldrin	DDE	Atrazine	Lasso	Sutan
May 18	1200	0.005	0.006	<0.15	<0.025	<0.80
May 30	1200	0.006	<0.004	0.69	<0.025	<0.80
June 13	1200	0.010	<0.004	0.84	<0.025	<0.80
June 28	11	0.005	<0.004	1.1	0.70	<0.80
July 13	1200	0.004	<0.004	0.71	0.34	<0.80
July 28	1200	0.006	<0.004	0.48	0.24	4.7
Mean		0.006	≤0.004	≤0.66	≤0.23	≤1.5

TABLE 7

Lake Rathbun - Station 4

Water Pesticide Data
May 15 - July 28, 1978

(All values in µg/l or ppb)

Date	Dieldrin	DDE	Atrazine	Lasso	Sutan
May 18	0.005	0.005	<0.15	<0.025	<0.80
May 30	*	*	*	*	*
June 13	0.006	<0.004	1.2	<0.025	<0.80
June 28	0.006	<0.004	0.76	0.013[1]	<0.80
July 13	0.006	<0.004	0.96	0.26	<0.80
July 28	0.006	<0.004	0.65	0.12	4.2
Mean	0.005	≤0.004	≤0.74	≤0.089	≤1.5

*Sample container broken in transit

[1]Pesticide values for certain selected samples were obtained below the usual detection limits by non-routine analytical techniques for the purpose of confirming pesticide identification and have been included in the table.

Although dieldrin was found in all samples (100% occurrence) from station 11 (Table 8) with an average of 0.018 ppb, DDE ($\leq$0.004 ppb average) was found only in the first sample collected (17% occurrence). Atrazine and Lasso were found 82% (nine of eleven samples) of the time averaging $\leq$3.9 ppb and $\leq$12 ppb respectively. Four pesticides reported from station 11 were not observed at stations 2 and 4. They were, Bladex, also known as cyanazine, (occurred 55% of the time and averaged $\leq$0.72 ppb); Sencor, also known as metribuzin, (occurred 55% of the time and averaged $\leq$0.35 ppb); Dyfonate, also known as fonofos, (occurred 18% of the time and averaged $\leq$0.028 ppb); Mocap, also known as etroprop, (occurred 18% of the time and averaged $\leq$0.087 ppb); and Sutan, which was found once (9% occurrence) averaging $\leq$0.91 ppb.

Sampling station 12 (Table 9) had pesticide data very similar to station 11. Dieldrin was found in all samples (100% occurrence) averaging 0.015 ppb; DDE was reported twice (18% occurrence) with a $\leq$0.004 ppb average; Atrazine was reported in nine of eleven samples (91% occurrence) averaging $\leq$2.9 ppb; Lasso in nine of ten samples (91% occurrence) averaging $\leq$1.9 ppb; Bladex and Sencor were found in five samples (45% occurrence) with a $\leq$0.24 ppb and $\leq$0.16 ppb average respectively. Dyfonate was found in three samples (27% occurrence) averaging $\leq$0.028 ppb and Mocap in two samples (18% occurrence) averaging $\leq$0.041 ppb. Although Sutan was reported from station 11, none was found at station 12.

TABLE 8

Chariton River - Station 11

Water Pesticide Data
May 15 - July 28, 1978

(All values in μg/l or ppb)

Date	Flow (cfs)	Dieldrin	DDE	Atrazine	Lasso	Bladex	Sencor	Dyfonate	Mocap	Sutan
ay 18	62	0.010	0.006	<0.15	<0.025	<0.060	<0.020	<0.025	<0.015	<0.80
ay 24	88	0.010	<0.04	<0.15	0.10	<0.060	<0.20	<0.025	<0.015	<0.80
ay 30	40	0.014	<0.04	0.25	<0.025	<0.060	<0.020	<0.025	<0.015	<0.80
une 7	17	0.010	<0.04	0.49	9.3	<0.060	<0.020	<0.025	<0.015	<0.80
une 13	9	0.008	<0.04	0.54	2.6	<0.060	<0.020	<0.025	<0.015	<0.80
une 22	5	0.009	<0.04	0.85	1.6	0.99	0.03	<0.025	<0.015	<0.80
une 28	530	0.057	<0.04	10	7.8	1.5	0.51	0.056	0.80	<0.80
uly 5	19	0.026	<0.04	10	5.8	1.8	0.43	<0.025	<0.015	<0.80
uly 13	24	0.021	<0.04	5.3	3.0	1.4	0.28	<0.025	<0.015	<0.80
uly 19	410	0.017	<0.04	13	101	1.9	2.5	<0.025	<0.015	<0.80
uly 28	22	0.013	<0.04	2.2	3.4	0.06	0.05	0.028	0.017	2.0
Mean		0.018	≤0.004	≤3.9	≤12	≤0.72	≤0.35	≤0.028	≤0.087	≤0.91

TABLE 9

South Chariton River - Station 12

Water Pesticide Data
May 15 - July 28, 1978

(All values in µg/l or ppb)

Date	Flow (cfs)	Dieldrin	DDE	Atrazine	Lasso	Bladex	Sencor	Dyfonate	Mocap
May 18	50	0.007	<0.04	<0.15	<0.025	<0.060	<0.020	<0.025	<0.015
May 24	105	0.011	0.005	<0.15	0.21	<0.060	<0.020	0.04	<0.015
May 30	30	0.011	0.006	0.36	0.33	<0.060	<0.020	<0.025	<0.015
June 8	11	0.007	<0.04	0.55	0.68	<0.060	<0.020	<0.025	<0.015
June 13	4	0.006	<0.04	0.66	0.28	<0.060	<0.020	<0.025	<0.015
June 22	2	0.006	<0.04	0.55	0.14	<0.060	<0.020	<0.025	<0.015
June 28	164	0.017	<0.04	14	14	1.2	1.2	0.036	0.31
July 5	7	0.012	<0.04	3.4	2.4	0.14	0.09	0.037	0.010
July 13	16	0.013	<0.04	5.4	0.98	0.35	0.08	<0.025	<0.015
July 19	616	0.063	<0.04	4.7	1.3	0.22	0.23	<0.025	<0.015
July 28	4	0.017	<0.04	1.8	0.24	0.36	0.03	<0.025	<0.015
Mean		0.015	≤0.004	≤2.9	≤1.9	≤0.24	≤0.16	≤0.028	≤0.041

Three major classes of pesticides were found in the water samples during the study: (1) chlorinated hydrocarbon insecticides, (2) organophosphate insecticides and (3) herbicides. The fact that current sampling still detects the presence of dieldrin and DDE (chlorinated hydrocarbons), when their parent compounds have been banned from usage for several years (Aldrin since 1974 and DDT since 1972), illustrates the persistence of these compounds in the environment.

Dieldrin data for all four stations may be found in Table 10. Station 2 and station 4 data reflects a consistent level of dieldrin (0.006 ppb averages) within the lake and in the discharge water. As a point of comparison, the monthly sample collected by the University Hygienic Laboratory for nine years in the Iowa River below Coralville Reservoir averaged 0.012 ppb. Stations 11 and 12 dieldrin values (Table 10) were much more variable with a substantially higher average, 0.018 ppb and 0.015 ppb respectively. The variation in dieldrin content relates directly to stream discharge (Figure 8 and 9). As stream flows rise and fall, so do turbidity and suspended solids, and associated with these soil particles are the persistent chlorinated hydrocarbons. The decline in dieldrin levels as the water passes through the lake is a function of the particulate matter settling out in the upper ends of the lake. In this regard, the lake acts as a sink, allowing the precipitation of chemical compounds associated with the soil particles. A report on the Iowa River (11) has also demonstrated this phenomenon.

TABLE 10

Dieldrin Levels in Chariton River - Lake Rathbun Water Samples
May 15 - July 28, 1978

(All values in µg/l or ppb)

Date	Station 2	Station 4	Station 11	Station 12
May 18	0.005	0.005	0.010	0.007
May 24	NC	NC	0.010	0.011
May 30	0.006	*	0.014	0.011
June 7	NC	NC	0.010	0.007
June 13	0.010	0.006	0.008	0.006
June 22	NC	NC	0.009	0.006
June 28	0.005	0.006	0.057	0.017
July 5	NC	NC	0.026	0.012
July 13	0.004	0.006	0.021	0.013
July 19	NC	NC	0.017	0.063
July 28	0.006	0.006	0.013	0.017
Mean	0.006	0.006	0.018	0.015

*Sample container broken in transit

NC - Not Collected

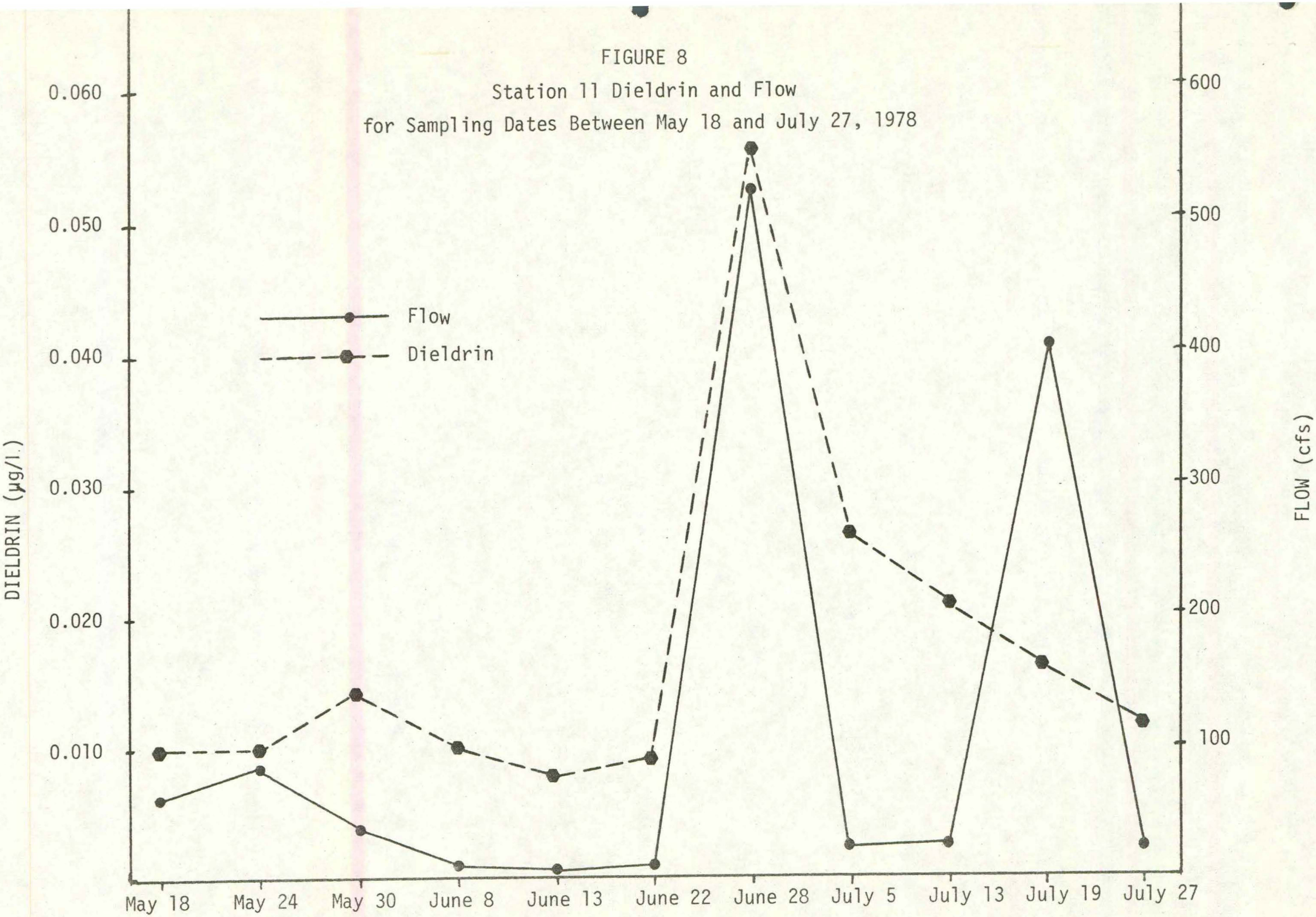


FIGURE 8

Station 11 Dieldrin and Flow

for Sampling Dates Between May 18 and July 27, 1978

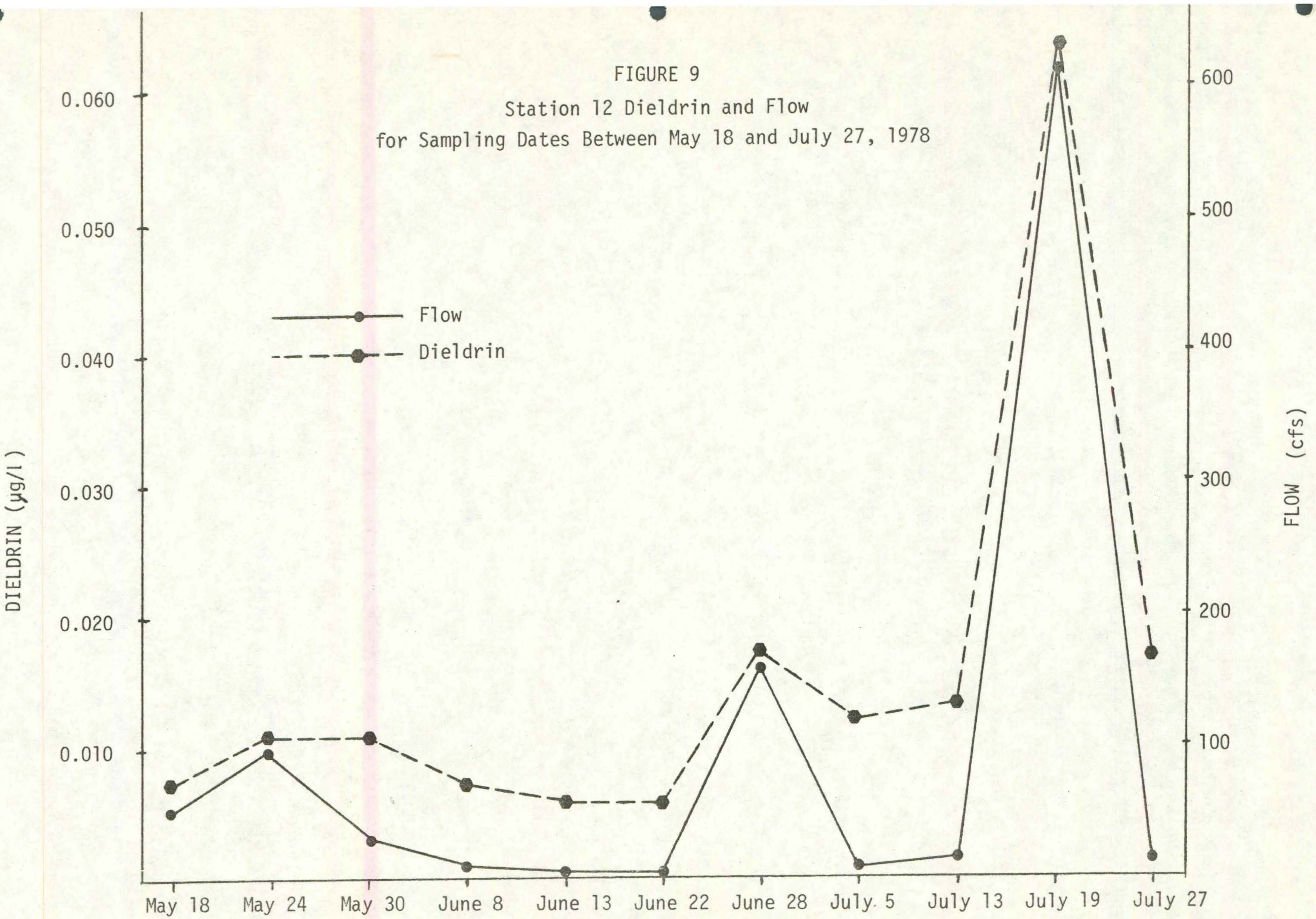


FIGURE 9
Station 12 Dieldrin and Flow
for Sampling Dates Between May 18 and July 27, 1978

The dieldrin content of water discharged from Lake Rathbun has not appeared to have changed significantly since 1974. Previous data on the Lake Rathbun discharge (12) gave an eight month average dieldrin value of 0.004 ppb compared to the 1978 average of 0.006 ppb. A comparison of DDE in the release water from that same study indicated a decline in average value from 0.132 ppb in 1974 to ≤0.004 ppb during 1978, a substantial decrease in DDE. The decline in DDE may be a result of the banning from usage of DDE demonstrating a gradual decrease in concentrations in the environment.

Although pesticide concentrations are not addressed in the Iowa Water Quality Standards (13), the EPA's Quality Criteria for Water (14) recommends a maximum water concentration of 0.003 ppb aldrin - dieldrin and 0.001 ppb DDT to provide an adequate level of protection for freshwater aquatic life. While dieldrin found in all water samples within the lake (average 0.005 ppb) and the discharge water (average 0.006 ppb) exceeded the EPA recommended levels, they are comparable to background values found in Iowa surface waters (15). Dieldrin values for the tributaries had a much higher average (station 11 - 0.018 ppb; station 12 - 0.015 ppb) than the lake and its discharge and was five to six times greater than recommended (14). The maximum dieldrin levels reported (station 11 - 0.057 ppb and station 12 - 0.063 ppb) are comparable to concentrations of dieldrin in the Des Moines River that ranged up to 0.050 ppb during a three year period (16) and in the Iowa River where a value of 0.70 ppb was recorded during a rainfall runoff event (11).

Table 11 represents values for the two major herbicides, Atrazine and Lasso, which were found most frequently and recorded the highest values. Compared to the chlorinated hydrocarbons, herbicides are much less toxic, less persistent and more water soluble. Because they are more water soluble and not adsorbed in soil particles they do not settle out as readily as the chlorinated hydrocarbons and thus are found throughout the lake. One reason Atrazine and Lasso are found with such regularity is that they represent the bulk of herbicide usage in Iowa (15). Normally, high herbicide levels as late as mid-July are not expected, but due to a very wet spring in south central Iowa during 1978, planting and pesticide application were delayed. For example, corn and soybean planting in south central Iowa on June 5 was respectively 59% and 24% complete as compared to a state average of 95% and 77% complete; and as of June 25 precipitation was 2.3 inches above normal (17). A relatively high Lasso value (101 ppb) was recorded on July 19 at station 11 when a rainfall of almost four inches occurred in the Chariton River watershed. This heavy rain and corresponding runoff was most probably responsible for the high Lasso value.

In addition to Atrazine and Lasso, the herbicides Bladex, Sencor and Sutan were frequently measured at stations 11 and 12. Values for these herbicides were also flow related, increasing as flow increased and decreasing as flow decreased. Sutan was found at stations 2, 4 and 11 on July 28. The lack of Sutan at station 12 on July 28 indicates that it entered the lake via the Chariton River (station 11) and/or

TABLE 11

Chariton River - Lake Rathbun
Atrazine and Lasso Data

May 15 - July 28, 1978

(All values in μg/l or ppb)

	Station 2		Station 4		Station 11		Station 12	
Date	Atrazine	Lasso	Atrazine	Lasso	Atrazine	Lasso	Atrazine	Lasso
May 18	<0.15	<0.025	<0.15	<0.025	<0.15	<0.025	<0.15	<0.025
May 24	NC	NC	NC	NC	<0.15	0.10	<0.15	0.21
May 30	0.69	<0.025	*	*	0.25	<0.025	0.36	0.33
June 8	NC	NC	NC	NC	0.49	9.3	0.55	0.68
June 13	0.84	<0.025	1.2	<0.025	0.54	2.6	0.66	0.28
June 22	NC	NC	NC	NC	0.85	1.6	0.55	0.14
June 28	1.1	0.78	0.76	0.013	10	7.8	14	14
July 5	NC	NC	NC	NC	10	5.8	3.4	2.4
July 13	0.71	0.34	0.96	0.26	5.3	3.0	5.4	0.98
July 19	NC	NC	NC	NC	13	101	4.7	1.3
July 28	0.48	0.24	0.65	0.12	2.2	3.4	1.8	0.24
Mean	≤0.66	≤0.23	≤0.74	≤0.089	≤3.9	≤12	≤2.9	≤1.9

*Sample container broken in transit

NC - Not Collected

from direct runoff to the lake. The heavy rain on July 19 and subsequent runoff was most probably responsible for the July 28 Sutan value.

Two organophosphates, Dyfonate and Mocap, were reported at stations 11 and 12 and occurred during periods of elevated stream flow. Dyfonate and Mocap were not reported at stations 2 and 4, probably because they are not persistent pesticides and were diluted to nondectable levels within Lake Rathbun.

Because Lake Rathbun is a source of water supply, the water pesticide data were reviewed in regards to four of the organic compounds listed in the Safe Drinking Water Act - Interim Drinking Water Standards (18). Based on the methods of pesticide analyses utilized in this study, the presence of Lindane - MCL of 0.004 ppm, Endrin - MCL of 0.002 ppm, Methoxychlor - MCL of 0.1 ppm and Toxaphene - MCL of 0.005 ppm, at the maximum contaminant level specified in the SDWA would have been detected. None were found.

Fish Pesticide Data

Physical and chemical characteristics and pesticide residues from the four species of fish (walleye *Stizostedion vitreum vitreum*; white crappie, *Pomoxis annularis*; carp, *Cyprinus carpio*; and channel catfish, *Ictalurus punctatus*) collected will be found in Tables 12 and 13 respectively. A total of six pesticides (dieldrin, DDE, DDD, Heptachlor Epoxide, cis Chlordane and trans Chlordane) were reported in the fish

TABLE 12

Physical and Chemical Characteristics of Fish from Lake Rathbun Collected in May and July, 1978

Specie	Average Length (mm)		Average Weight (gm)		Age Class (Yr.)		Oil Content (%)		Number of Fish Composited	
	May 15	July 19	May 15	July 19	May 15	July 19	May 15	July 19	May 15	July 19
Carp (*Cyprinus carpio*)	363	317	558	524	3	3	1.50	2.82	5	5
Channel Catfish (*Ictalurus punctatus*)	329	391	329	530	2-3	2-3	7.52	4.20	5	4
Walleye (*Stizostedion vitreum vitreum*)	457	330	907	363	3-4	2-3	0.67	0.62	3	3
White Crappie (*Pomoxis annularis*)	255	205	201	150	3-4	3-4	0.35	0.22	5	4

TABLE 13

Fish Pesticide Residues from Lake Rathbun

Collected in May and July, 1978

(All values in µg/kg or ppb)

Specie	Dieldrin		DDT		DDD		DDE		Heptachlor Epoxide		cis Chlordane		trans Chlordane	
	May 15	July 19	May 15	July 19	May 15	July 19	May 15	July 19	May 15	July 19	May 15	July 19	May 15	July 19
Carp (*Cyprinus sp.*)	25	33	<1.5	1.9	<1.5	<1.5	12	8	17	13	8	6.5	13	7.9
Channel Catfish (*Ictalurus sp.*)	134	79	<1.5	11	18	<1.5	42	34	61	52	24	25	40	29
Walleye (*Stizostedion sp.*)	13	7.4	<1.5	<1.5	<1.5	<1.5	5	3	4	5.8	2	2.4	3	2.9
White Crappie (*Pomoxis sp.*)	6	2.6	<1.5	<1.5	<1.5	<1.5	4	2.6	5	0.7	<0.5	0.4[1]	<0.5	0.5

[1] Pesticide values for certain selected samples were obtained below the usual detection limits by non-routine analytical techniques for the purpose of confirming pesticide identification and have been included in the table.

from Lake Rathbun. Low levels of five pesticides (no DDD) were found during May in the walleye and white crappie (Table 13) and were even lower in the July sample. Compared to the walleye and white crappie, pesticide residues in the carp (Table 13) were slightly higher with a slight decrease in residues except for dieldrin and DDT from May to July. Pesticide residues in the channel catfish were substantially higher (Table 13) as compared to the other fish species and also demonstrated a noticeable decline in values from May to July. The most noticeable change was observed in channel catfish where dieldrin declined from 134 ppb in May to 79 ppb in July.

Chlorinated hydrocarbon insecticides are generally considered to be lipid partitioning and can concentrate in the fats and oils of fish. Generally the higher the fish oil content the greater the pesticide accumulation. That trend was evident during this study with channel catfish having the highest oil and pesticide content, carp the next highest, then walleye and lastly, crappie.

Although several pesticides were found in the fish from Lake Rathbun, the values are typical of low levels found in most fish in Iowa (19). High dieldrin fish residues have been found in the Nishnabotna River (15) and Coralville Reservoir (20). In fact, Coralville Reservoir was closed to commercial fishing in October, 1976 due to dieldrin residue levels found in fish flesh which exceeded the Food and Drug Administration's acceptable concentration of 300 ppb. The Iowa

Conservation Commission has also found Lake Red Rock contains fish with high dieldrin residues and is a "borderline" situation for closing to commercial fishing. Dieldrin levels in Lake Rathbun fish were far below 300 ppb and would not be considered a hazard to the consumer. Compared to Coralville Lake, Lake Red Rock and Saylorville Lake (16) dieldrin concentrations in carp, channel catfish, white crappie and walleye from Lake Rathbun were much lower.

Sediment Pesticide Data

Pesticide residues found in Lake Rathbun sediments are listed in Table 14. Those compounds identified from the sediment were the durable chlorinated hydrocarbons; dieldrin, DDE and Chlordane. Dieldrin values were relatively low for the three transects with a significant decline in levels observed at transects 5 and 7 from May to July. The reason for the decline is unexplainable at this time. As a point of comparison, Bulkley (16) has reported dieldrin sediment values from the recently impounded Saylorville Lake averaging 3 ppb during a four month period.

While DDE values were similar to dieldrin values, DDE demonstrated only a minor change in levels from May to July. Chlordane, both cis and trans, were reported only in the July samples and at very low levels. Chlordane may have been present in the May samples but at the very low

TABLE 14

Sediment Pesticide Residues from Lake Rathbun
May 15 - July 27, 1978

(All values in μg/l or ppb)

Pesticides	Station 4 Transect May	Station 4 Transect July	Station 4 Transect Mean	Station 5 Transect May	Station 5 Transect July	Station 5 Transect Mean	Station 7 Transect May	Station 7 Transect July	Station 7 Transect Mean
Dieldrin	1.8	1.3	1.5	3.0	0.6	1.8	2.8	0.7	1.7
DDE	2.4	1.9	2.1	1.7	1.1	1.4	2.0	1.8	1.9
trans Chlordane	<0.3	0.5	≤0.4	<0.3	0.5	≤0.4	<0.3	1.0	≤0.6
cis Chlordane	<0.3	0.3	≤0.3	<0.3	0.3	≤0.3	<0.3	1.2	≤0.7

levels reported they could have been masked by other organic compounds during the identification process. Although limited data are available for comparative purposes, the levels of chlorinated hydrocarbons found in Lake Rathbun sediments are relatively low and at current levels do not appear to present a problem to fish and aquatic life within the lake.

SUMMARY

Lake Rathbun, its outflow and its two major tributaries, the Chariton River and the South Fork Chariton River, were sampled for water pesticide content from May 15 to July 27. Results of the analyses indicated relatively low levels of pesticides within Lake Rathbun and its outflow. Higher and more variable pesticide results were obtained from the two tributaries and were directly related to stream discharge, i.e., as stream discharge increased, pesticide levels increased. Turbidity and suspended solids exhibited the same flow related pattern as the pesticides. The reduction in pesticide as water passed through the lake may be attributed to two factors (1) the lake acting as a sediment trap, allowing soil particles with the adsorbed pesticide to settle out, and (2) the large volume of lake water diluting the pesticides. A review of the lake water and outflow data for selected organic compounds listed in the Safe Drinking Water Act indicated none present above the maximum contaminant level during the study period.

Fish samples collected for pesticide analysis exhibited low levels of the persistent chlorinated hydrocarbons - dieldrin, DDE, Heptachlor Epoxide and Chlordane. Although pesticide residues in fish have caused concern in other lakes in Iowa, the residues in Lake Rathbun are well below the FDA Standards and present no hazard to the consumer. Dieldrin residues in fish from Lake Rathbun varied from 800 times (white crappie) to 20,000 times (channel catfish) the dieldrin level occurring in the water, which is somewhat less than the 100,000 times reported from Lake Michigan (14). Lake Rathbun DDE residues in fish ranged from 800 times (white crappie) to 10,000 times (channel catfish) the water concentration.

Pesticide residues in Lake Rathbun sediments were also composed of the more durable chlorinated hydrocarbons at relatively low levels. The levels in the sediments indicated only minor changes during the sampling period. The majority of the sedimentation occurring within the lake is probably in the upper arms of the lake where a change in values over time might be expected. When compared to the water concentration, sediment samples exhibited a 300 - 500 fold increase for dieldrin and DDE respectively. At the low pesticide levels observed in Lake Rathbun there appears to be no impact on the designated and potential project uses. Although no modifications in project operation are recommended at this time, continued monitoring of pesticide levels in water, fish and sediment is recommended annually.

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