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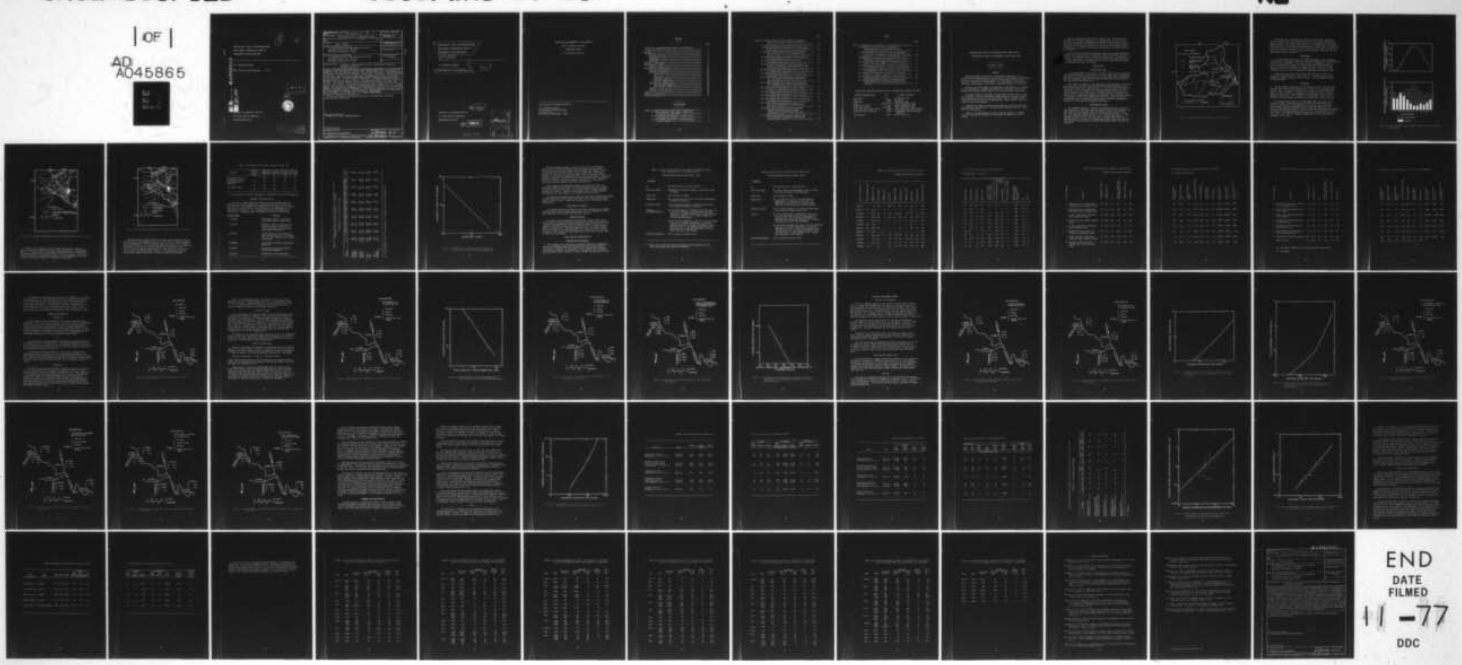

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WATER-QUALITY STUDY OF TULPEHOCKEN CREEK, BERKS COUNTY, PENNSYLVANIA, PRIOR TO IMPOUNDMENT OF BLUE MARSH LAKE

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 77-55

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FACTORS FOR CONVERTING ENGLISH UNITS TO INTERNATIONAL SYSTEM (SI) UNITS

Multiply English units	*By*	*To obtain SI units*
inches (in)	25.4	millimeters (mm)
feet (ft)	.3048	meters (m)
miles (mi)	1.609	kilometers (km)
acres	4.047×10^{-3}	square kilometers (km^2)
square miles (mi^2)	2.590	square kilometers (km^2)
acre-feet (acre-ft)	$1.233.10^{-6}$	cubic kilometers (km^3)
cubic feet per second (ft^3/s)	.02832	cubic meters per second (m^3/s)
pounds per acre (lb/acre)	1.1208	kilograms per square hetometer (kg/hm^2)
tons (short)	.9072	metric tons (t)

WATER-QUALITY STUDY OF TULPEHOCKEN CREEK, BERKS COUNTY, PENNSYLVANIA, PRIOR TO IMPOUNDMENT OF BLUE MARSH LAKE

By James L. Barker

ABSTRACT

Blue Marsh Lake is planned as a multipurpose impoundment to be constructed on Tulpehocken Creek near Bernville, Berks County, Pennsylvania. Prior to construction, samples of water, bed material, and soil were collected through-out the impoundment site to determine concentrations of nutrients, insecticides, trace metals, suspended sediment, and bacteria.

Analyses of water suggest the Tulpehocken Creek basin to be a highly fertile environment. Nitrogen and phosphorus concentrations near the proposed dam site had median values of 4.5 and 0.13 mg/L, respectively.

Suspended sediment discharges average between 100 and 200 tons (90.7 to 181.4 metric tons) per day during normal flows but may exceed 10,000 tons (9,070 metric tons) per day during storm runoff. Highest yields were measured during winter and early spring. Concentrations range from 3 mg/L to more than 500 mg/L.

Bed material samples contain trace quantities of aldrin, DDT, DDD, DDE, dieldrin, and chlordane. Polychlorinated biphyenyls (PCB's) ranged from 10 to 100 μg/kg.

Soils at the impoundment site are of average fertility. However, the silt loam texture is ideal for attachment and growth of aquatic plants.

Bacteria populations indicative of recent fecal contamination are prevelent in the major inflows to the proposed lake. Fecal Coliform exceeded the standards recommended by the Federal Water Pollution Administration Committee on Water Quality Criteria for public water supply in 29 percent of the monthly samples, and exceeded the recommended public bathing waters standard in 83 percent of the samples collected from June to September.

Arsenic from an industrial waste was found in the water, suspended sediment, and bed material of Tulpehocken Creek in concentrations of 0 to 30 μg/l, 2 to 879 μg/l, and 1 to 79 μg/g, respectively. It represents a potential environmental hazard; however, the measured concentrations are less than that known to be harmful to man, fish, or wildlife, according to published water quality criteria.

INTRODUCTION

Purpose and Scope

The preimpoundment investigation of water quality in the Tulpehocken Creek basin was begun at the request of the U.S. Army Corps of Engineers. The purpose of this investigation was to collect base-line water-quality data for Tulpehocken Creek and its major tributaries in the vicinity of the proposed Blue Marsh Lake site.

This report is limited to the presentation and discussion of chemical, physical, and bacteriological data collected within Tulpehocken Creek basin before April 1975. Data include: (1) the type and distribution of nutrients, (2) the variability and trends in nutrient loads, (3) soil characteristics of the lake site, (4) sedimentation characteristics, (5) bacteriological quality and trends, (6) metal analyses of sediment and water, and (7) insecticide analyses of sediments. This report is intended to supplement a 1973 report published by the Corps, which included a comprehensive data evaluation of water-quality, arsenic contamination, mathematical modeling, and management objectives.

Description of Area

The proposed dam site is located on Tulpehocken Creek 5 mi (8 km) upstream from its confluence with the Schuylkill River near Reading. The lake formed by the dam will extend upstream to Bernville, about 8 mi (12.9 km), and will inundate parts of two tributaries, about 1 mi (1.6 km) of Licking Creek and 2.3 mi (3.7 km) of Spring Creek (fig. 1). The drainage includes 175 mi^2 (453 km^2) and is located within Berks and Lebanon Counties. The basin is predominantly agricultural but includes the villages of Wernersville, Robesonia, Womelsdorf, Mount Pleasant, and Bernville.

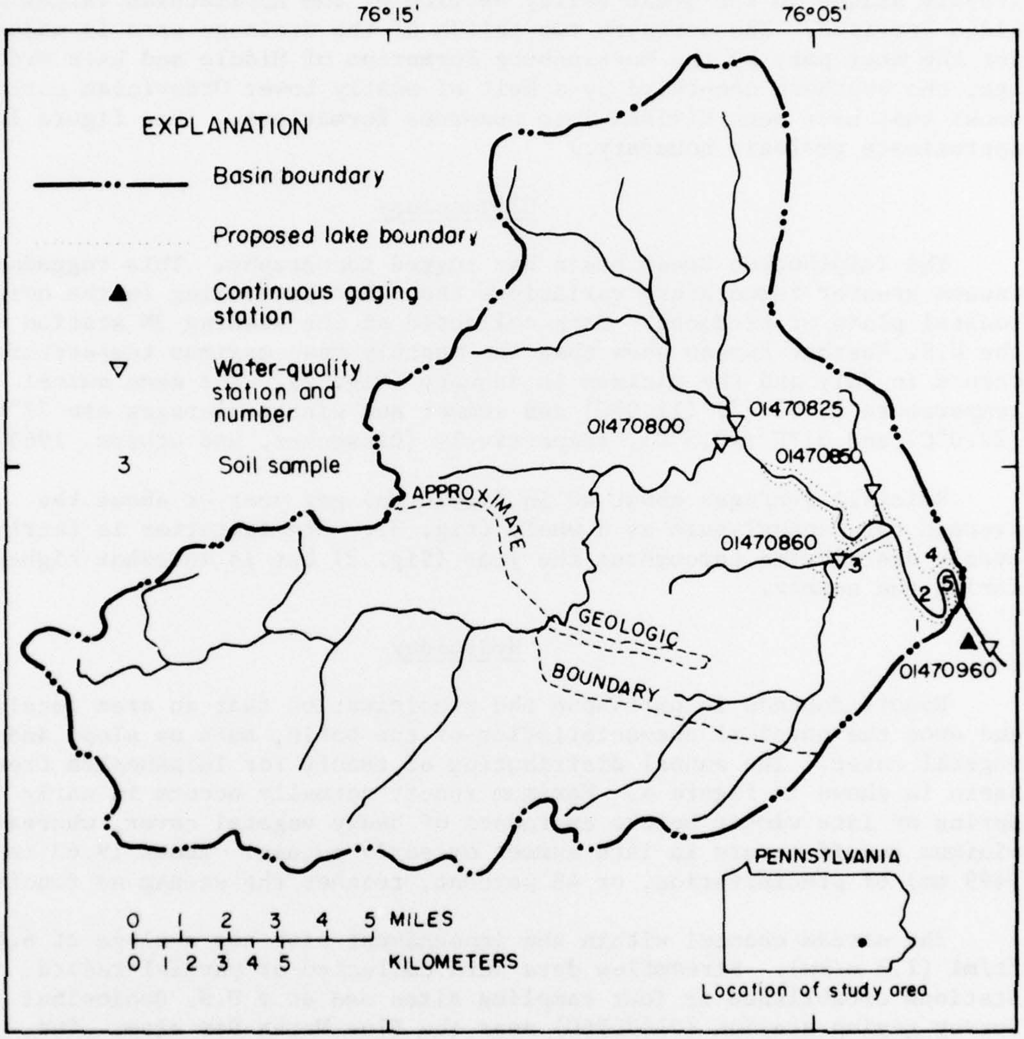

Figure 1.--Map showing Blue Marsh Lake drainage basin.

Tulpehocken Creek drainage flows through a complicated sequence of rocks that have been extensively deformed by folds, faults, and possibly gravity slides in the Great Valley Section of the Appalachian Valley and Ridge Province. The northern two-thirds of the drainage area is underlain for the most part by the Martinsburg Formation of Middle and Late Ordovician age, the southern one-third by a belt of mostly Lower Ordovician carbonate rocks that have been divided into numerous formations. (See figure 1 for approximate geologic boundary.)

Climatology

The Tulpehocken Creek basin has rugged topography. This ruggedness causes greater temperature variations than that prevailing in the neighboring coastal plain or piedmont. Data collected at the Reading 3N station of the U.S. Weather Bureau show that the monthly mean maximum temperature occurs in July and the minimum in January (fig. 2). The mean annual temperature is 53.7°F (12.0°C) and summer and winter averages are 72°F (22.0°C) and 31°F (-0.5°C), respectively (Biesecker, and others, 1968).

Rainfall averages about 40 in (1,016 mm) per year or about the average for Pennsylvania as a whole (fig. 3). Precipitation is fairly evenly distributed throughout the year (fig. 2) but is somewhat higher during the summer.

Hydrology

Runoff depends in part upon the precipitation that an area receives and upon the physical characteristics of the basin, such as slope and vegetal cover. The annual distribution of runoff for Tulpehocken Creek basin is shown in figure 4. Maximum runoff normally occurs in early spring or late winter before emergence of heavy vegetal cover, whereas, minimum runoff occurs in late summer or early autumn. About 19.63 in (499 mm) of precipitation, or 48 percent, reaches the stream as runoff.

The stream channel within the impoundment site has a slope of 6.4 ft/mi (1.2 m/km). Streamflow data were collected at partial-record stations established at four sampling sites and at a U.S. Geological Survey gaging station (01470960) near the Blue Marsh Dam site. The record at the Blue Marsh Dam site station shows the average annual discharge from May 1965 through September 1973 to be 253 ft^3/s (7.16 m^3/s) or 19.63 in (49 mm). The maximum recorded discharge was 16,100 ft^3/s (456 m^3/s) on June 22, 1972, and the minimum discharge was 22 ft^3/s (0.62 m^3/s) on September 11-13, 1966.

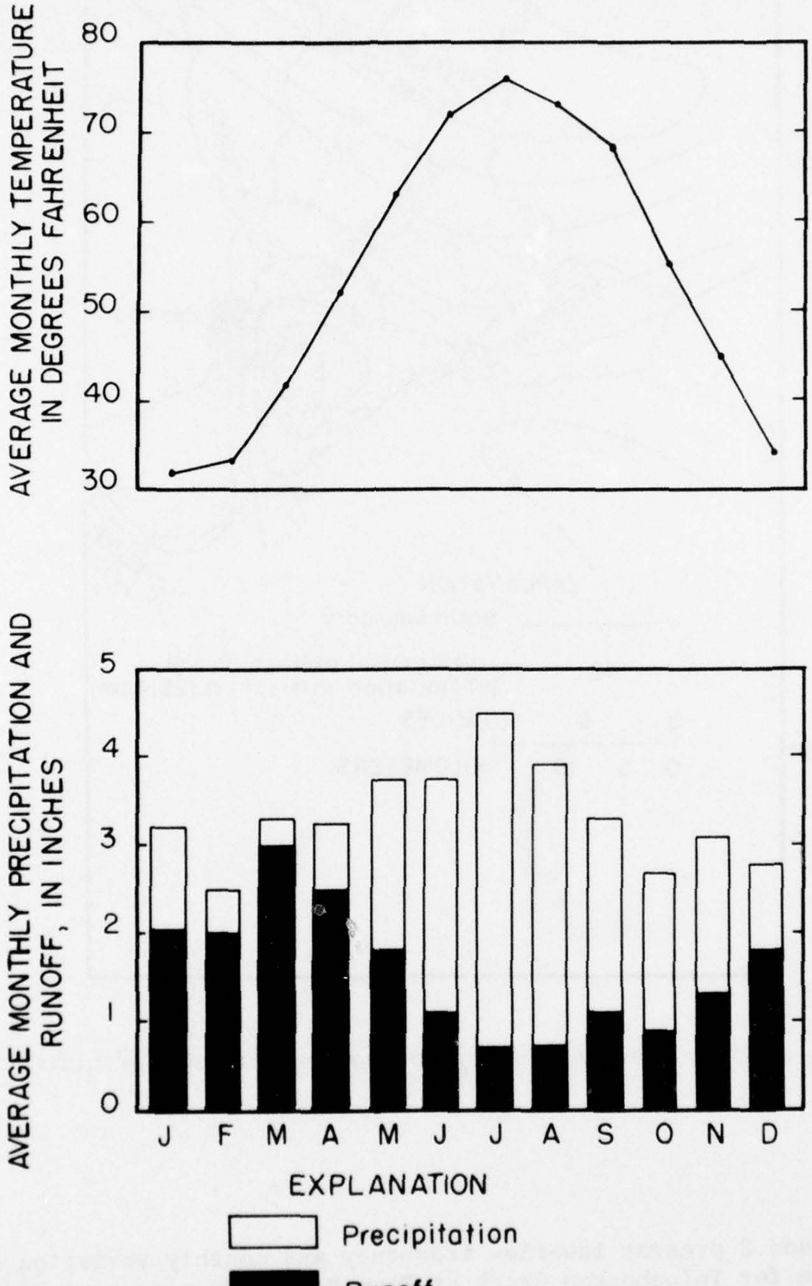

Figure 2.--Graph showing average monthly temperature, precipitation, and runoff.

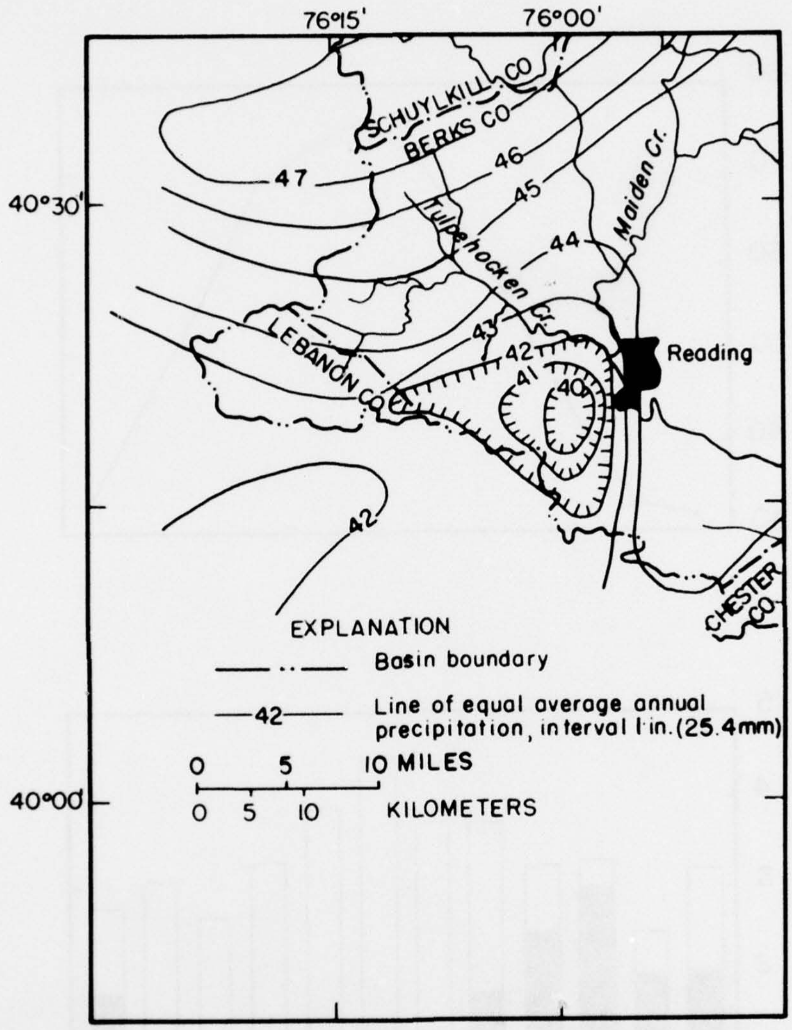

Figure 3.--Map showing distribution of average annual precipitation, 1930-64.

Tables 1 and 2 present low-flow frequency and monthly variation of daily discharge for Tulpehocken Creek at Blue Marsh Dam site near Reading. Table 1 is a tabulation of the minimum discharge that may be expected for selected recurrence intervals and number of consecutive days. The monthly variation (table 2) in streamflow is shown as the percentage of time that a given discharge was equaled or exceeded for each month.

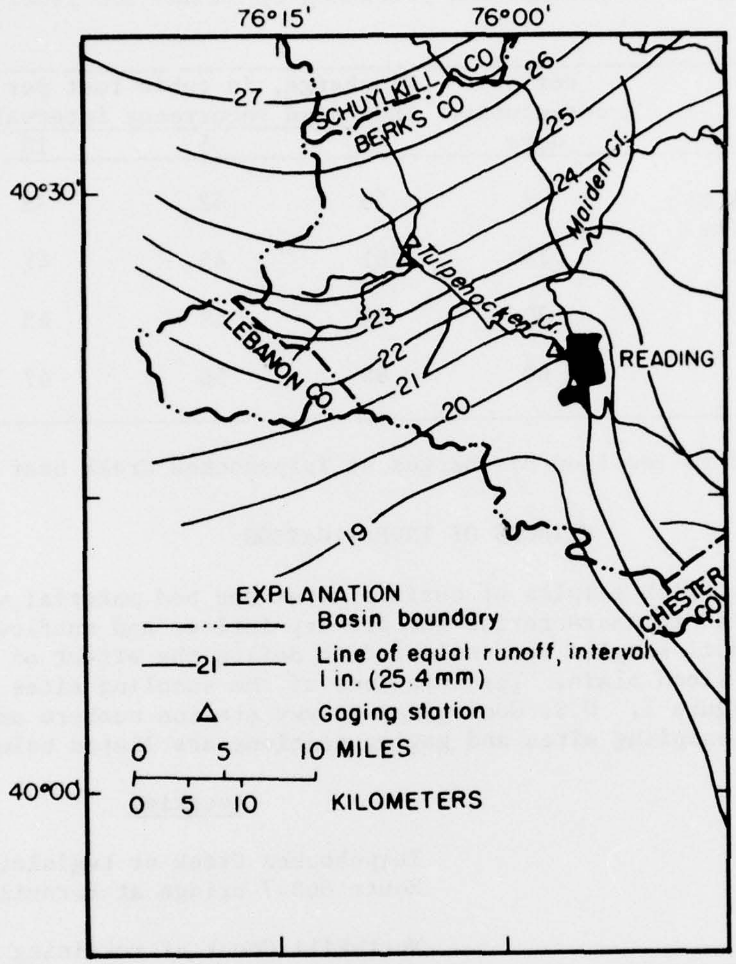

Figure 4.--Map showing distribution of average annual runoff, 1940-64.

Retention time or time-of-travel of solutes can be important in the eutrophication of impoundments as well as to the users of water downstream from an impoundment. Based on the mean runoff for the 175 mi^2 (453 km^2) basin and the capacity of the lake at normal pool elevation, the theoretical retention time or time for total exchange of the water is 25 days. Actual time will range from 125 days at low flow (50 ft^3/s or 1.4 m^3/s) to less than 1 day during floods (fig. 5). The theoretical retention time assumes complete mixing and a volume-for-volume displacement.

Table 1.--*Magnitude and frequency of annual low flow.*[1/]

Station	Period consecutive days	Discharge, in cubic feet per second, for indicated recurrence interval, in years			
		2	5	10	15
Tulpehocken Creek at Blue Marsh Dam site	7	56	42	38	37
near Reading, Pa. (1951-64)	14	61	45	41	49
	30	68	48	43	42
175 square miles	60	88	56	47	46

1/ Flow adjusted to low flow discharges at Tulpehocken Creek near Reading, Pa.

METHODS OF INVESTIGATION

The sites at which samples of surface water and bed material were taken were selected to characterize the primary inflows and outflows of the lake area. Soil samples were selected to define the effect of various land uses on the flood plain. The locations of the sampling sites are illustrated in figure 1. U.S. Geological Survey station numbers and locations of the sampling sites and gaging stations are listed below:

Station number	Location
01470800	Tulpehocken Creek at Legislative Route 06047 bridge at Bernville
01470825	Northkill Creek at retaining wall along left bank of creek, 670 ft (204 m) upstream from Legislative Route 06047 at Bernville
01470850	Licking Creek at steel culvert on Davis Bridge Road, 0.6 mi (0.96 km) north of State Highway 183 on Snyder School Road
01470860	Spring Creek at Peacock Bridge near Bernville
01470960	Tulpehocken Creek at Blue Marsh dam site near Reading
01471000	Tulpehocken Creek near Reading

Table 2.--*Monthly variation of daily discharge for Tulpehocken Creek at Blue Marsh Dam site near Reading, Pa., 1952-64.*1/

[Discharge, in cubic feet per second]

Month	Percent of time indicated discharge was equaled or exceeded									
	1	5	10	20	30	50	70	90	95	99
October	605	356	265	170	148	99	78	50	46	39
November	953	497	365	274	224	149	108	77	67	57
December	1,326	754	564	385	307	195	133	87	75	53
January	1,450	912	655	448	344	228	156	112	95	73
February	2,073	912	622	456	381	261	187	133	120	93
March	1,741	953	738	564	480	211	315	232	203	145
April	1,824	895	638	489	423	410	261	199	178	149
May	1,244	688	480	344	278	199	158	116	108	95
June	589	423	261	199	166	133	108	85	76	46
July	638	274	203	153	128	95	69	56	51	43
August	721	298	203	145	112	87	68	48	43	40
September	1,741	464	203	182	141	93	68	47	44	39

1/ Flow adjusted to low flow discharges at Tulpehocken Creek near Reading, Pa.

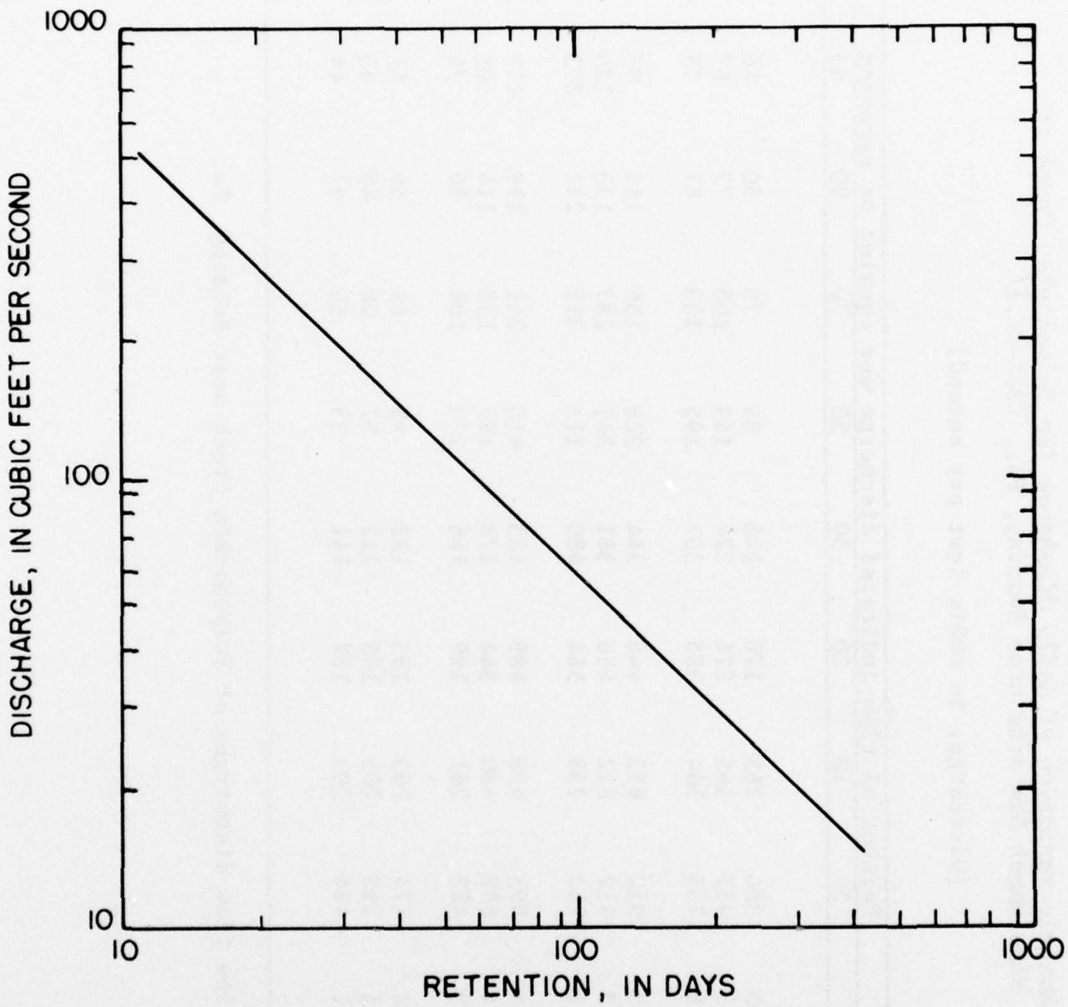

Figure 5.--Graph showing relation between discharge and theoretical retention time in Blue Marsh Lake.

The water sampling began on June 14, 1972, and is continuing at monthly intervals (plus additional samples during selected storms). Initially, five sites were sampled, but the number was reduced to four sites in May 1973 and then to three sites in July 1973. Whole water samples are analyzed for nitrate-nitrogen, organic nitrogen, ammonia nitrogen, total and ortho-phosphorus, and total organic carbon. Additional samples are analyzed for total and fecal coliform and fecal streptococci bacteria densities. Dissolved oxygen, temperature, pH, and specific conductance are determined at the time of collection.

Daily sampling of suspended-sediment began on May 20, 1973. An additional sample was collected for arsenic analysis, when the sediment concentration was visibly heavy. As of April 1975, 83 samples had been analyzed for arsenic. Samples of bed material were collected annually and analyzed for insecticides, trace metals, and particle size.

All sampling and analyses were conducted according to methods prescribed by Brown and others (1970), Slack and others (1973), Georlitz and Brown (1972), and Guy (1969). Samples were analyzed at U.S. Geological Survey laboratories.

WATER QUALITY CRITERIA

The Pennsylvania Sanitary Water Board (1967) developed water-quality criteria specifically for Tulpehocken Creek, from its headwaters to Blue Marsh Lake and for Blue Marsh Lake (tables 3 and 4).

General Criteria

According to the Pennsylvania Sanitary Water Board, (1967), the water shall not contain substances attributable to municipal, industrial, or other waste discharges in concentrations or amounts sufficient to be inimical or harmful to water uses to be protected or to human, animal, plant, or aquatic life. Specific substances to be controlled include, but are not limited to, floating debris, oil, scum, and other floating materials; toxic substances; substances that produce color, taste, odors or settle to form sludge.

WATER QUALITY CHARACTERISTICS

Historical Water Quality

Water samples were collected for chemical analyses on Tulpehocken Creek at the gaging station near Reading from 1947 to 1965 (table 5). In June 1968, the Federal Water Pollution Control Administration made a chemical and biological reconnaissance at 15 sampling sites throughout the Tulpehocken basin. Results of these analyses are presented in table 6.

Table 3.--*Water quality criteria for waters of Tulpehocken Creek from the headwaters to Blue Marsh Lake.*[1/]

[Pennsylvania Sanitary Water Board, 1967]

Criteria	
pH	Not less than 6.0; no more than 8.5.
Dissolved oxygen	Minimum daily average 6.0 mg/L; no value less than 5.0 mg/L.
Total iron	Not to exceed 1.5 mg/L.
Temperature	Not to exceed 58°F (14.4°C) for natural temperature, whichever is greater.
Dissolved solids	Not to exceed 500 mg/L as a monthly average value; not to exceed 750 mg/L at any time.
Bacteria (coliforms/100 mL)	For the period May 15 - September 15 of any year, not to exceed 1,00/100 mL as an arithmetic-average value; not to exceed 1,000/100 mL in more than two consecutive samples; not to exceed 2,400/100 mL in more than one sample.
	For the period September 16 - May 14 of the following year; not to exceed 5,000/100 mL as a monthly average value, nor to exceed this number in more than 20 percent of the samples collected during any month; not to exceed 20,000/100 mL in more than 5 percent of the samples.
Dissolved phosphate	Not to exceed 0.10 mg/L as PO_4.

1/ Water use: Cold water fishes; maintenance and propagation of the family Salmonidae; and fish food organisms.

Table 4.--*Water quality criteria for Blue Marsh Lake.*

[Pennsylvania Sanitary Water Board, 1967]

Criteria	
pH	Not less than 6.0; no more than 8.5.
Dissolved oxygen	For lakes, ponds and impoundments only; no values less than 4.0 mg/L in the epilimnion.
Total iron	Not to exceed 1.5 mg/L.
Temperature	Not to exceed 5°F (2.8°C) rise above ambient temperature or a maximum of 87°F (30.6°C), whichever is less; not to be changed by more than 2°F (1.1°C) during any one hour period.
Dissolved solids	Not to exceed 500 mg/L as a monthly average value; not to exceed 750 mg/L at any time.
Bacteria	For the period May 15 - September 15 of any year; not to exceed 1,000/100 mL as an arithmetic-average vlaue; not to exceed 1,000/100 mL in more than two consecutive samples; not to exceed 2,400/100 mL in more than one sample.
	For the period September 16 - May 14 of the following year; not to exceed 5,000/100 mL as a monthly average value, nor to exceed this number in more than 20 percent of the samples collected during any month; not to exceed 20,000/100 mL in more than 5 percent of the samples.
Dissolved phosphate	Not to exceed 0.10 mg/L as PO_4.

Table 5.--*Summary of historical water quality data*

[Chemical constituents reported

Date of collection	Mean discharge (cfs)	Temperature (°C)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
9/10/47	–	–	7.2	–	.69	0	50	13	3.0	–	170
10/15/57	58	13.9	–	–	–	–	–	–	5.5	–	172
4/22/59	–	11.7	4.5	–	.23	.01	40	9.4	5.0	2.3	126
10/22/59	–	10.6	5.6	–	.15	0	50	14	6.0	3.0	174
4/27/60	–	17.2	4.5	–	–	–	43	13	4.0	2.4	148
6/20/61	147	20.0	–	–	–	–	–	–	6.7	–	174
10/17/62	119	18.9	3.9	–	–	–	42	–	7.6	3.2	152
10/04/63	–	16.1	–	–	–	–	–	–	–	–	184
10/18/63	–	16.1	2.0	–	.12	.01	50	14	8.6	3.6	188
4/01/64	–	5.0	8.5	–	.12	.0	40	8.8	5.5	1.2	124
9/15/64	–	16.1	4.7	–	.09	.0	50	18	8.5	3.7	196
7/01/65	53	–	1.9	–	.22	.07	34	18	8.7	3.2	146

1947-1965 Tulpehocken Creek near Reading, Pa.

in milligrams per liter.]

Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium-Magnesium	Hardness as $CaCO_3$: Non-carbonate	Total acidity as H_2SO_4	Specific conductance (micromhos per centimeter at 25°C)	pH	Color
26	4.8	0.1	3.2	209	178	-	-	348	7.7	4
31	7.8	-	3.2	-	-	-	-	368	7.6	12
26	4.5	.2	2.0	182	139	35	-	280	7.5	3
30	7.5	.3	2.5	212	183	40	-	368	7.5	1
26	6.4	.1	2.5	209	161	40	-	324	7.7	3
28	8.2	-	2.7	235	178	36	-	356	8.1	5
27	9.8	0	1.8	205	163	38	-	339	8.2	10
29	18	-	2.3	-	184	33	-	387	8.2	9
28	11	.1	2.3	236	183	29	-	389	7.7	4
27	8.6	.1	1.8	174	136	35	-	295	7.7	4
33	13	.0	2.7	251	199	39	-	413	7.6	3
35	10	.0	1.8	206	162	40	-	358	7.1	3

Table 6.--*Water quality data summary for Tulpehocken*

[Chemical constituents reported

Station number	Location	Discharge (ft^3/s)	Temperature (°C)	pH	Specific conductance (micromhos/cm @ 25°C)	Carbon dioxide (CO_2)	Alkalinity
1	Tulpehocken Creek above Myerstown Waste Water Treatment Plant	12	16.6	8.1	537	3.4	181
2	Tulpehocken Creek below Myerstown Waste Water Treatment Plant	30	17.8	7.8	616	5.9	185
3	S. Mill Creek above confluence with Tulpehocken Creek	15	20.0	8.3	472	1.4	176
4	Tulpehocken Creek above Charming Forge	47	20.8	8.4	512	2.0	169
5	N. Mill Creek above confluence with Northkill Creek	14	22.5	8.4	324	1.3	113
6	Tulpehocken Creek above confluence with Northkill Creek	64	22.0	8.2	466	1.8	176
7	Little Northkill Creek above confluence with Northkill Creek	14	25.7	9.0	179	0.0	51
8	Northkill Creek above confluence with Little Northkill Creek	13	24.8	8.6	115	0.0	35

Creek basin, date of collection June 24, 25, 1968.[1/]

in milligrans per liter.]

Total hardness (as $CaCO_3$)	Dissolved oxygen (O)	Nitrate nitrogen (NO_3-N)	Total Kjeldahl nitrogen	Total phosphorus	Total organic carbon (TOC)	Chlorophyll	Total coliform per 100 ml	Fecal coliform per 100 ml	Fecal streptococcus per 100 ml
242	10.4	5.2	0.56	0.13	7.2	2.4	3,850	2,020	1,050
249	9.5	5.0	0.94	1.00	8.8	4.6	20,000	12,400	3,670
235	10.3	4.6	1.16	0.28	7.5	7.9	11,700	10,000	1,450
241	10.9	5.0	0.76	0.54	9.0	6.0	5,900	3,200	800
151	10.6	3.3	0.56	0.18	8.0	2.2	5,400	3,700	1,400
231	9.2	4.7	0.67	0.37	9.0	5.0	4,300	2,400	810
73	10.2	1.8	0.66	0.21	5.0	5.8	4,300	2,600	1,300
50	10.6	0.8	0.56	0.14	4.2	2.6	4,800	2,400	880

Table 6.--*Water quality data summary for Tulpehocken Creek*

Station number	Location	Discharge (ft^3/s)	Temperature (°C)	pH	Specific conductance (micromhos/cm @ 25°C)	Carbon dioxide (CO_2)	Alkalinity
9	Northkill Creek above confluence with Tulpehocken Creek	26	24.2	8.7	158	0.6	46
10	Manor Creek above Wernersville State Hospital	6.7	17.7	7.7	300	5.0	101
11	Manor Creek below Wernersville State Hospital	7.2	18.2	7.7	305	7.2	92
12	Spring Creek above Robesonia-Wernersville M. A.	18	16.4	7.9	301	4.0	97
13	Spring Creek below Robesonia-Wernersville M. A.	19	16.6	7.8	301	3.4	98
14	Spring Creek above confluence with Tulpehocken Creek	21	17.8	7.7	307	5.1	101
15	Tulpehocken Creek near Dam site	125	20.7	7.4	367	3.7	138
	Basin Average	29	20.0	8.1	350	2.9	117

1/ Four-sample average for each station except where noted.

2/ One sample.

basin, date of collection June 24, 25, 1968.--continued.[1/]

Total hardness (as $CaCO_3$)	Dissolved oxygen (*O*)	Nitrate nitrogen (NO_3-N)	Total Kjeldahl nitrogen	Total phosphorus	Total organic carbon (TOC)	Chlorophyll	Total coliform per 100 ml	Fecal coliform per 100 ml	Fecal streptococcus per *100* ml
57	10.9	1.3	0.56	0.29	5.7	3.2	3,800	2,200	700
140	8.4	4.4	0.43	0.14	4.5	2.7	7,000	1,400	1,900
135	8.4	6.3	0.96	2.50	3.2	1.0	13,000[2/]	920[2/]	2,800
146	10.0	2.6	0.66	0.17	4.5	5.3	9,500	5,400	2,200
139	9.2	2.8	0.76	0.81	10.5	5.4	14,500	6,100	3,300
143	8.3	3.1	0.78	0.74	5.5	5.6	9,200	4,000	3,600
182	8.2	3.6	0.81	0.45	6.0	6.9	6,700	3,000	950
160	9.6	3.6	0.72	0.53	6.5	4.4			

The median nitrate-nitrogen concentration near Reading of 12 analyses made between 1947 to 1965 was 2.3 mg/L; whereas, the median concentration 5 miles upstream near Blue Marsh Dam site of 40 analyses made between 1972 to 1975 was 4.5 mg/L. Nineteen water samples collected by the Pennsylvania Department of Environmental Resources at Tulpehocken Creek near Reading from 1972 to 1975 had a mean value of 4.5 mg/L. These analyses indicate that there has been a nearly twofold increase in the nitrate-nitrogen concentration in Tulpehocken Creek in the past 10 years.

Physical and Chemical

Temperature

Water temperatures of Tulpehocken Creek during the present study ranged from 32° to 75°F (0.0° to 24.0°C). At all the sites the temperatures were less than the 86°F (30.0°C) maximum allowed by the Pennsylvania Sanitary Water Board's water-quality criteria. Maximum temperatures at Tulpehocken Creek near Bernville and Spring Creek seem to be due to some extent to warming by inflowing springs and possibly sewage-plant effluent. Water temperatures were found to be favorable to the development of a warm-water fishery and to all other intended reservoir uses.

pH

The pH range for the maintenance of good game fish production should be between 6.5 and 8.5 (Cooper, 1967). The State pH standards of 6.0 to 8.5 are being met at all stations, with the exception of that at Tulpehocken Creek near Blue Marsh Dam site, which had a pH of 8.7 during a period of high photosynthetic activity (fig. 6).

Bicarbonate derived from limestone of the upper Tulpehocken and Spring Creek basin is responsible for a high buffering capacity of the water and for maintaining a pH on the main stem generally between 7.5 and 8.5. Northkill and Licking Creeks, which flow over shale of the Martinsburg Formation, have a lower buffering capacity and a pH generally between 7 and 8.

Alkalinity

Alkalinity is a measure of a water's ability to neutralize acid and is due to the presence of carbonate and bicarbonate, and to a lesser extent hydroxides, borates, silicates, phosphates, and organic substances. It is commonly reported in milligrams per liter of $CaCO_3$. The addition of municipal sewage and industrial wastes may increase alkalinity. Alkalinity in excess of 170 mg/L has been reported to be deleterious to stock and wildlife (McKee and Wolf, 1971). Of the waters that support good fish population, 5 percent have bicarbonate concentrations of less than 40 mg/L, 50 percent less than 90 mg/L, and 95 percent less than 180 mg/L (McKee and Wolf, 1971).

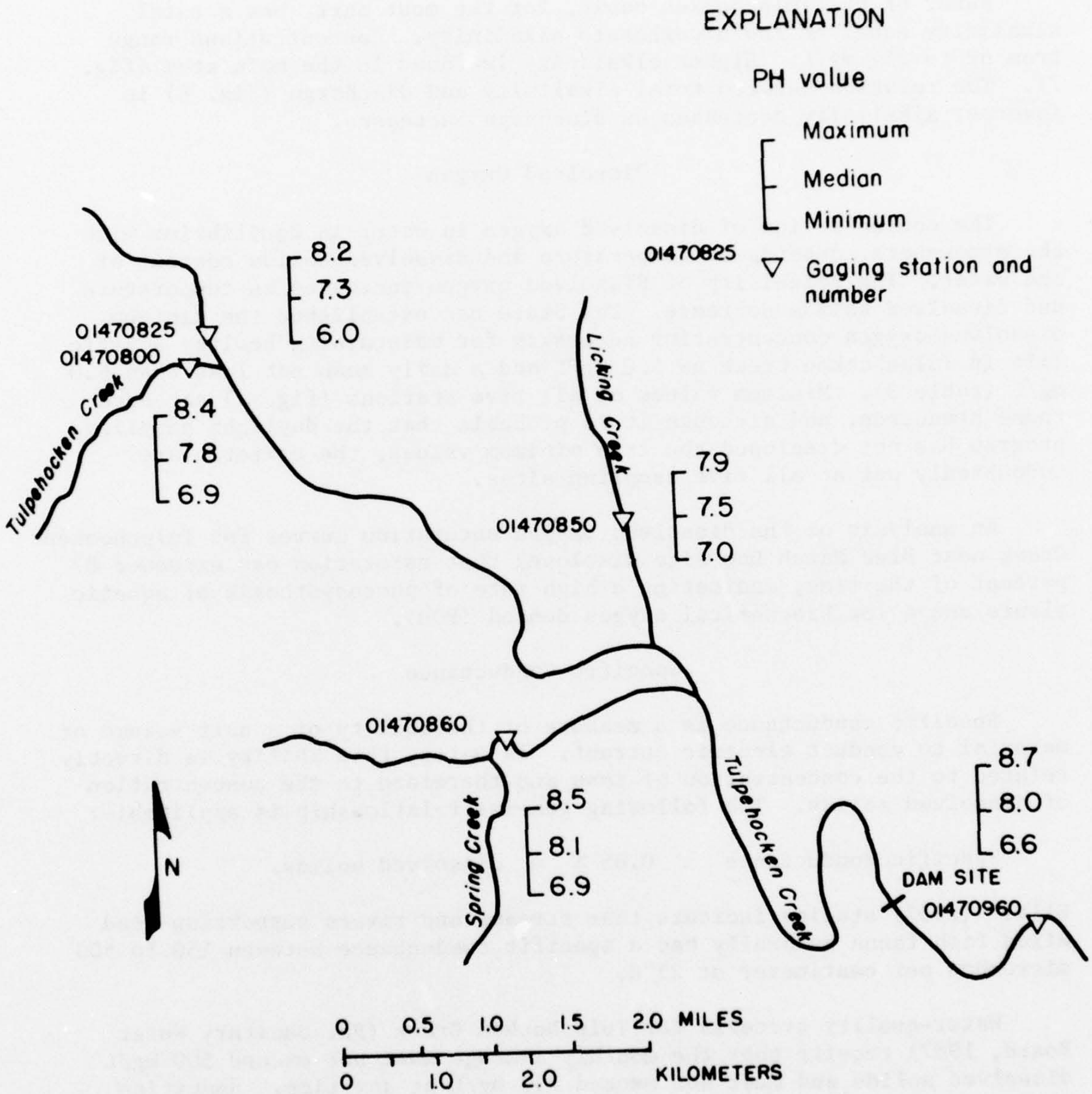

Figure 6.--Map showing pH in the Tulpehocken Creek basin.

Water of the Tulpehocken basin, for the most part, has a total alkalinity equal to the bicarbonate alkalinity. Concentrations range from 62 to 254 mg/L. Higher alkalinity is found in the main stem (fig. 7). The relation between total alkalinity and discharge (fig. 8) is inverse; alkalinity decreases as discharge increases.

Dissolved Oxygen

The concentration of dissolved oxygen in water in equilibrium with the atmosphere, depends on temperature and dissolved-solids content of the water. The solubility of dissolved oxygen increases as temperature and dissolved solids decrease. The State has established the minimum dissolved-oxygen concentration necessary for maintaining healthy aquatic life in Tulpehocken Creek as 5.0 mg/L and a daily mean not less than 6.0 mg/L (table 3). Minimum values at all five stations (fig. 9) exceeded these standards, and although it is probable that the daylight sampling program has not disclosed the true minimum values, the criteria are undoubtedly met at all five sampling sites.

An analysis of the dissolved oxygen saturation curves for Tulpehocken Creek near Blue Marsh Dam site discloses that saturation was exceeded 87 percent of the time, indicating a high rate of photosynthesis of aquatic plants and a low biochemical oxygen demand (BOD).

Specific Conductance

Specific conductance is a measure of the ability of a unit volume of material to conduct electric current. In water, this ability is directly related to the concentration of ions and therefore to the concentration of dissolved solids. The following general relationship is applicable:

Specific conductance x 0.65 ± = dissolved solids.

Ellis' (1937) studies indicate that streams and rivers supporting good mixed fish fauna generally had a specific conductance between 150 to 500 micromhos per centimeter at 25°C.

Water-quality criteria for Tulpehocken Creek (Pa. Sanitary Water Board, 1967) require that the monthly average must not exceed 500 mg/L dissolved solids and must not exceed 750 mg/L at any time. Specific-conductance data indicate that these criteria are being met (fig. 10) at the dam site but were exceeded at Bernville on at least one occasion. As illustrated in figure 11, specific conductance is inversely related to discharge; as flow increases, specific conductance decreases.

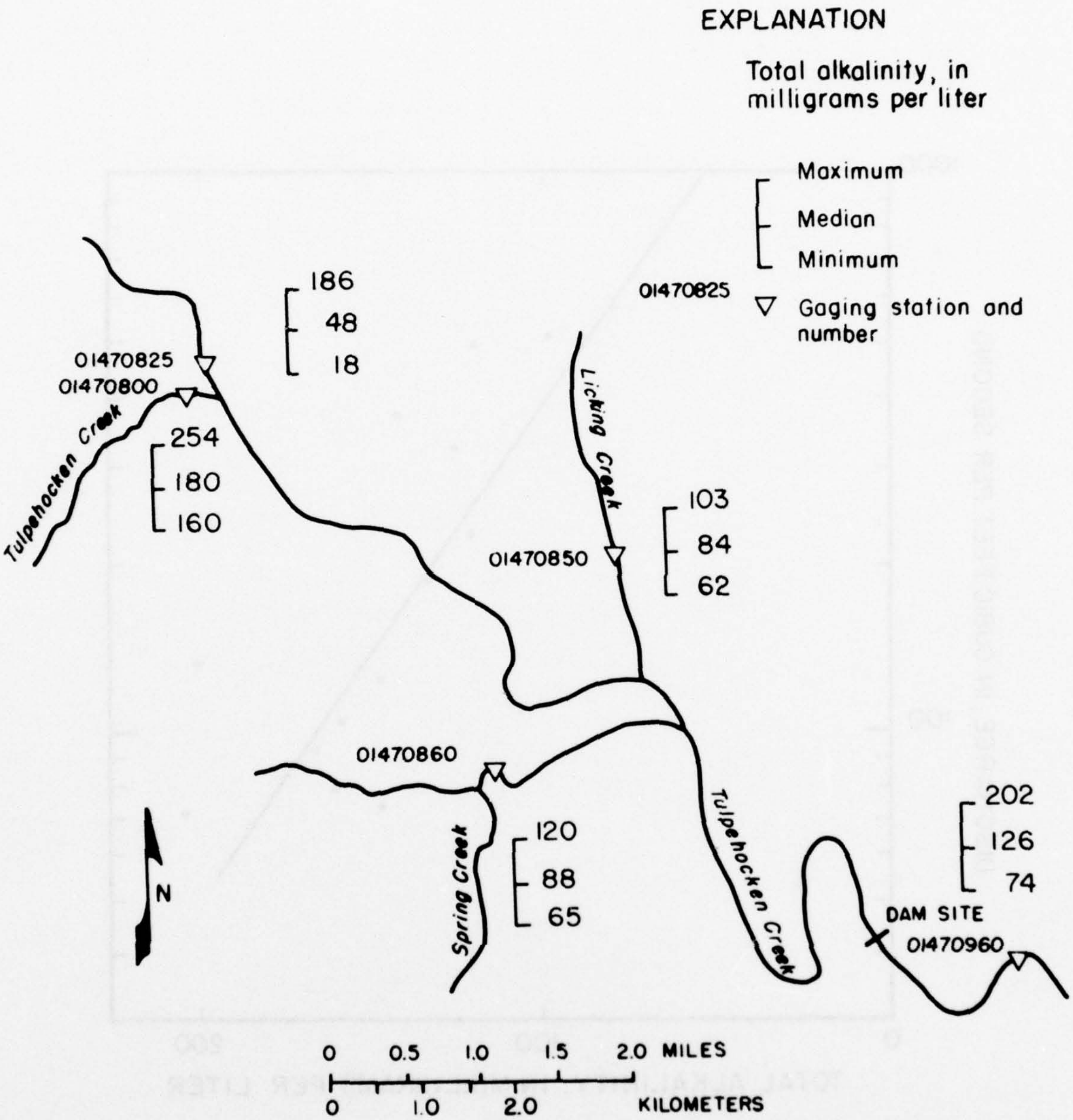

Figure 7.--Map showing total alkalinity in the Tulpehocken Creek basin.

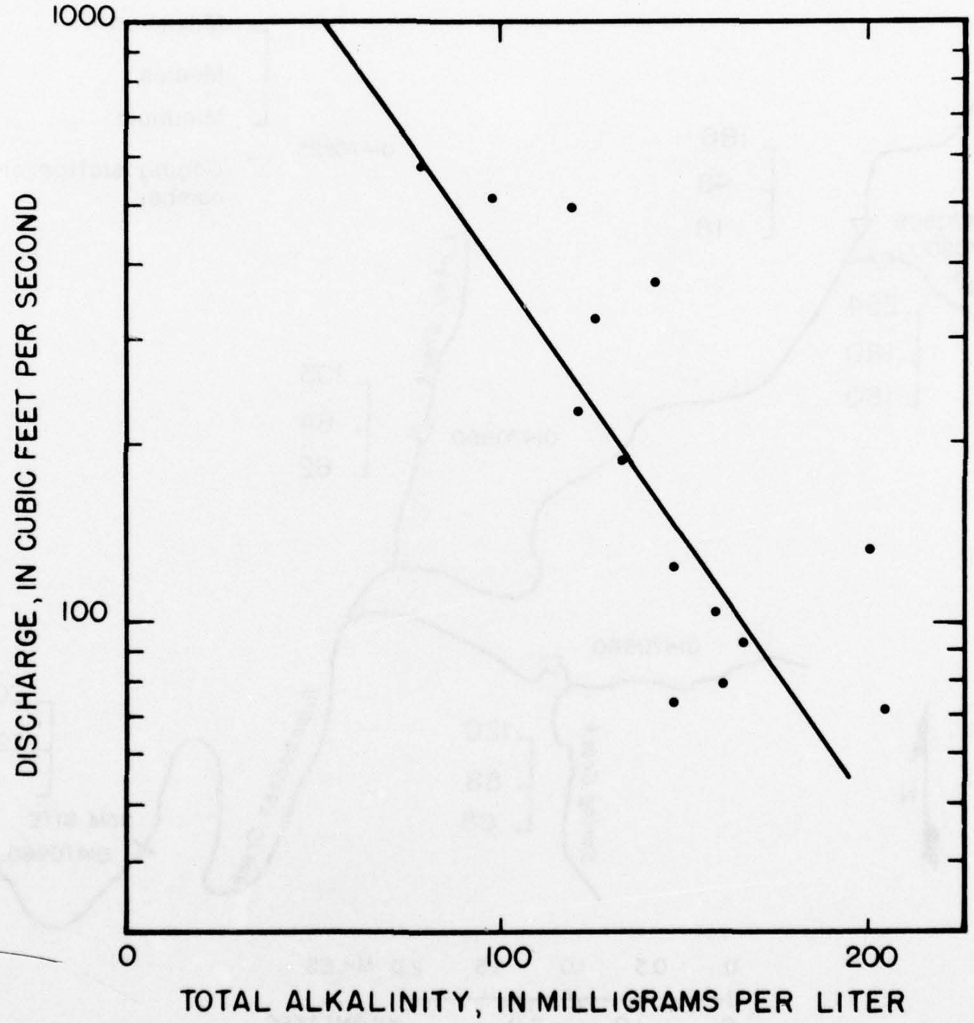

Figure 8.--Graph showing relation between discharge and total alkalinity in the Tulpehocken Creek basin.

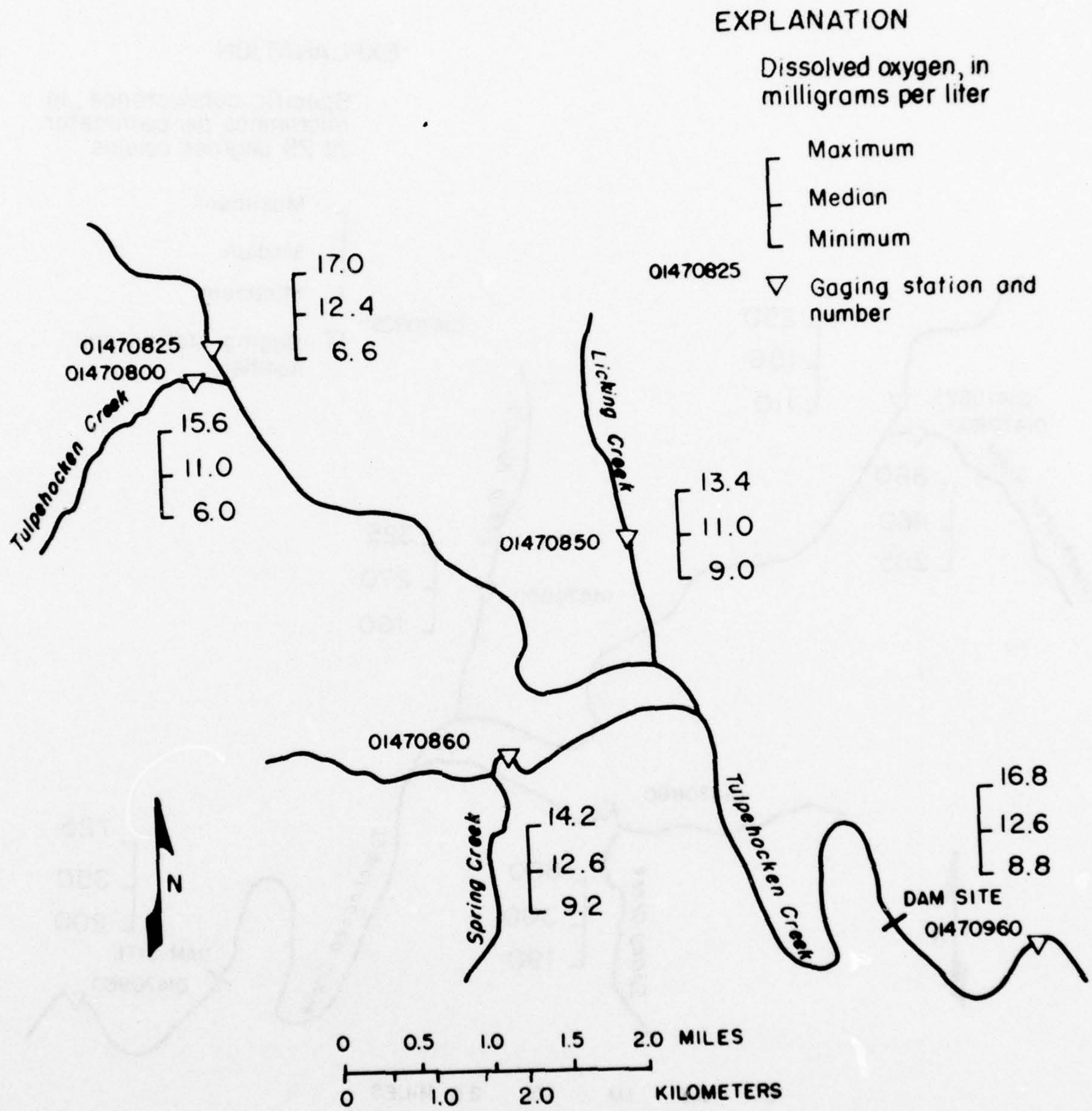

Figure 9.--Map showing dissolved oxygen concentrations in the Tulpehocken Creek basin.

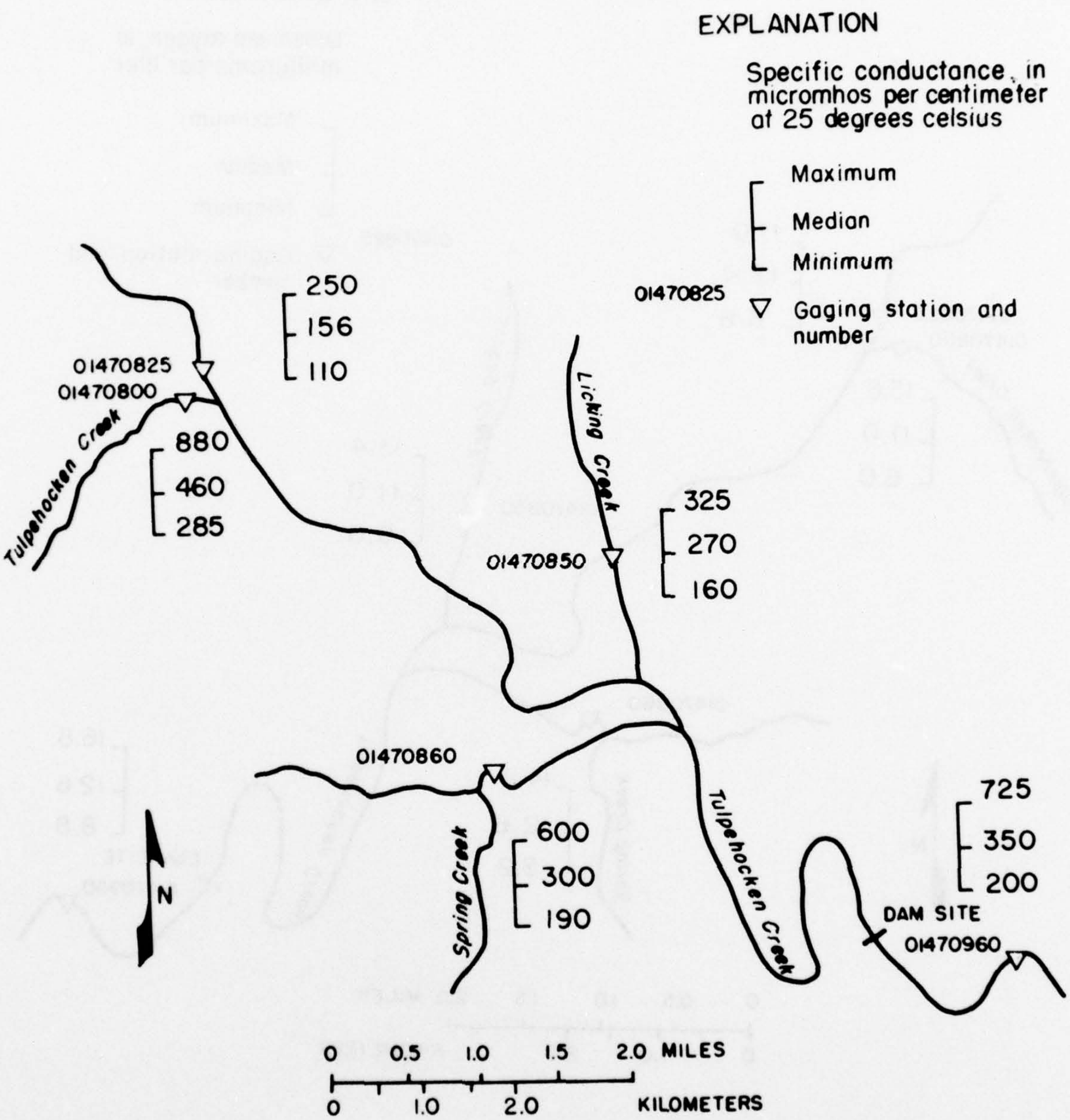

Figure 10.--Map showing specific conductance in the Tulpehocken Creek basin.

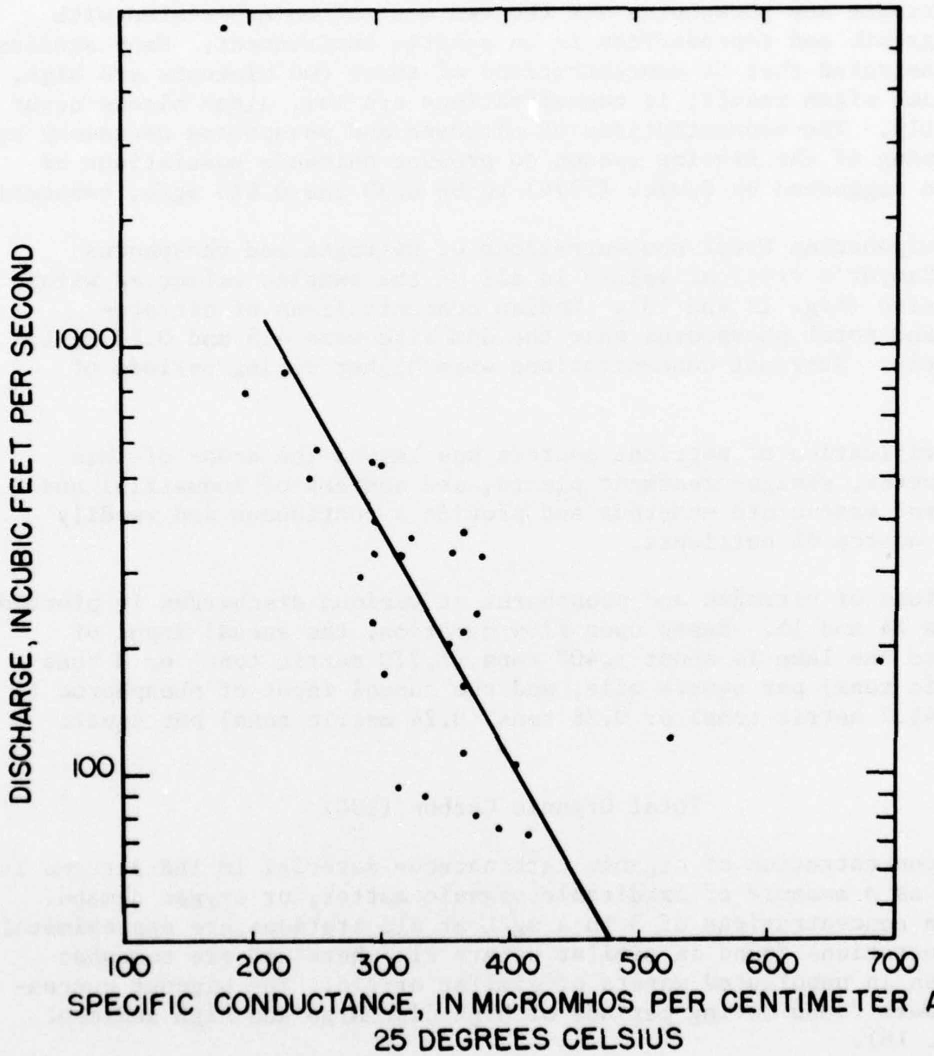

Figure 11.--Graph showing relation between discharge and specific conductance in the Tulpehocken Creek basin near Blue Marsh Lake basin.

Nutrients and Organic Carbon

Nitrogen and Phosphorus

Of the 21 elements known to be essential for plant growth (Greeson, 1971), nitrogen and phosphorus are the two most often associated with limiting growth and reproduction in an aquatic environment. Many studies have demonstrated that if concentrations of these two elements are high, algae blooms often result; if concentrations are low, algae blooms occur infrequently. The concentrations of nitrogen and phosphorus necessary at the beginning of the growing season to produce nuisance populations of algae were suggested by Sawyer (1974) to be 0.30 and 0.015 mg/L, respectively.

In Tulpehocken Creek concentrations of nitrogen and phosphorus exceeded Sawyer's critical values in all of the samples collected within the lake site (fig. 12 and 13). Median concentrations of nitrate-nitrogen and total phosphorus near the dam site were 4.5 and 0.13 mg/L, respectively. Nutrient concentrations were higher during periods of runoff.

Identification of nutrient sources was beyond the scope of this study, however, sewage-treatment plants, and sources of industrial and agricultural wastes are numerous and provide a continuous and readily available source of nutrients.

The load of nitrogen and phosphorus at various discharges is plotted in figures 14 and 15. Based upon flow duration, the annual input of nitrogen to the lake is about 1,400 tons (1,270 metric tons) or 8 tons (7.3 metric tons) per square mile, and the annual input of phosphorus is 46 tons (41.7 metric tons) or 0.26 tons (0.24 metric tons) per square mile.

Total Organic Carbon (TOC)

The concentration of organic carbonaceous material in the streams is evaluated as a measure of oxidizable organic matter, or oxygen demand. The median concentrations of 3 to 4 mg/L at all stations are approximately the concentrations found in similar waters elsewhere and are somewhat higher than in unpolluted waters of similar origin. The highest concentrations were found during periods of high discharge and high sediment load (fig. 16).

Bacteria

The results of membrane filtration for total and fecal coliform and fecal streptococci bacteria are summarized in figures 17 to 19. Populations of fecal bacteria were found in sufficient density to indicate serious fecal contamination. The main-stem stations usually contained the highest bacterial densities.

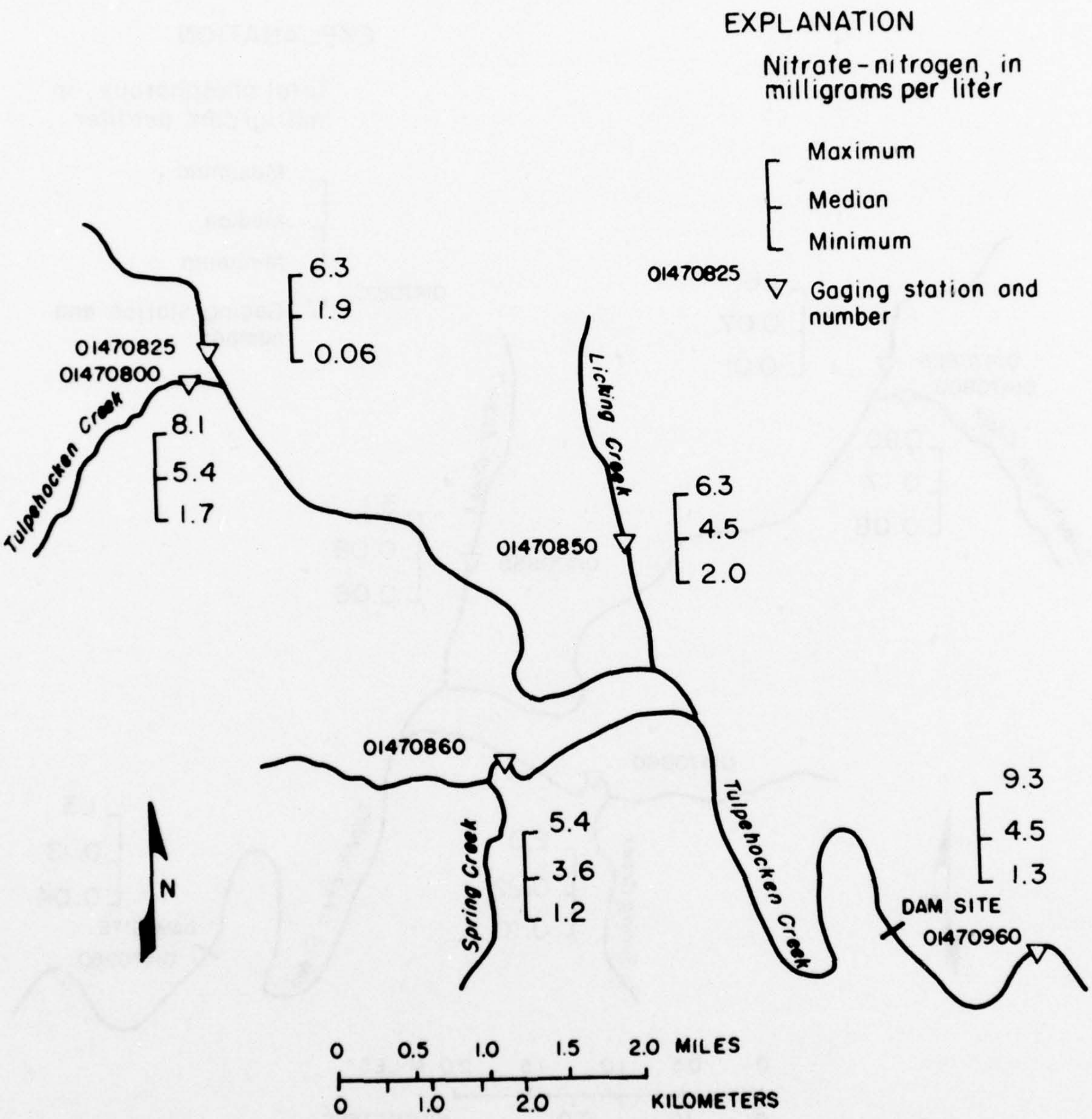

Figure 12.--Map showing nitrate-nitrogen concentrations in the Tulpehocken Creek basin.

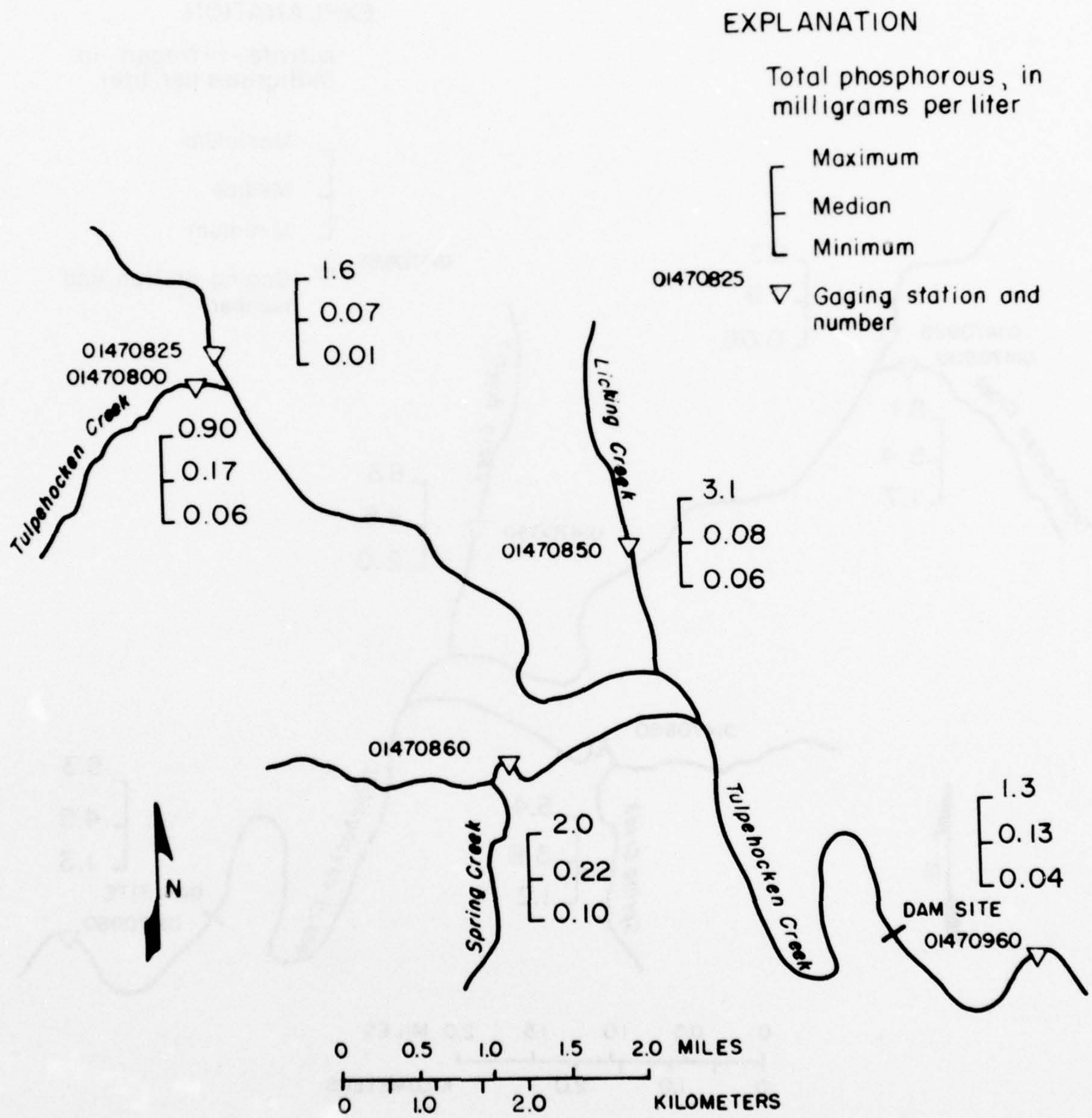

Figure 13.--Map showing total phosphorus concentrations in Tulpehocken Creek basin.

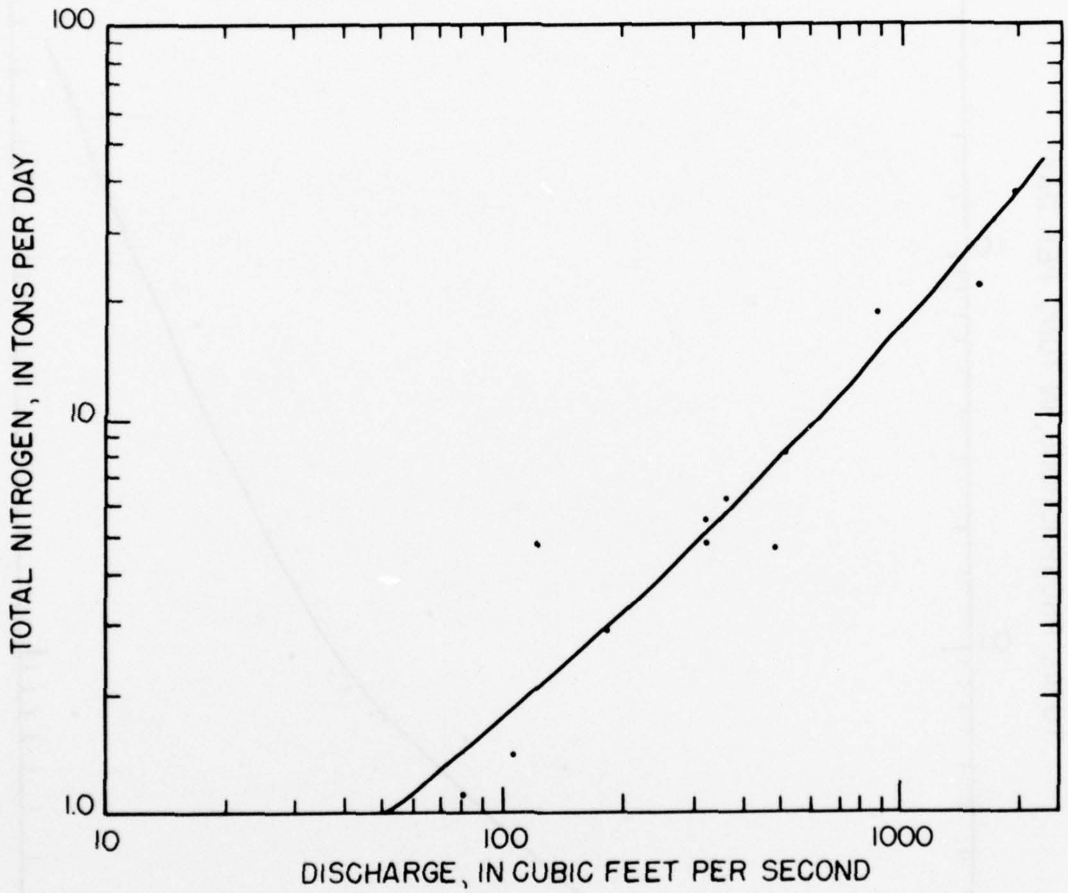

Figure 14.--Graph showing relation between discharge and total nitrogen in Tulpehocken Creek basin near Blue Marsh Dam site.

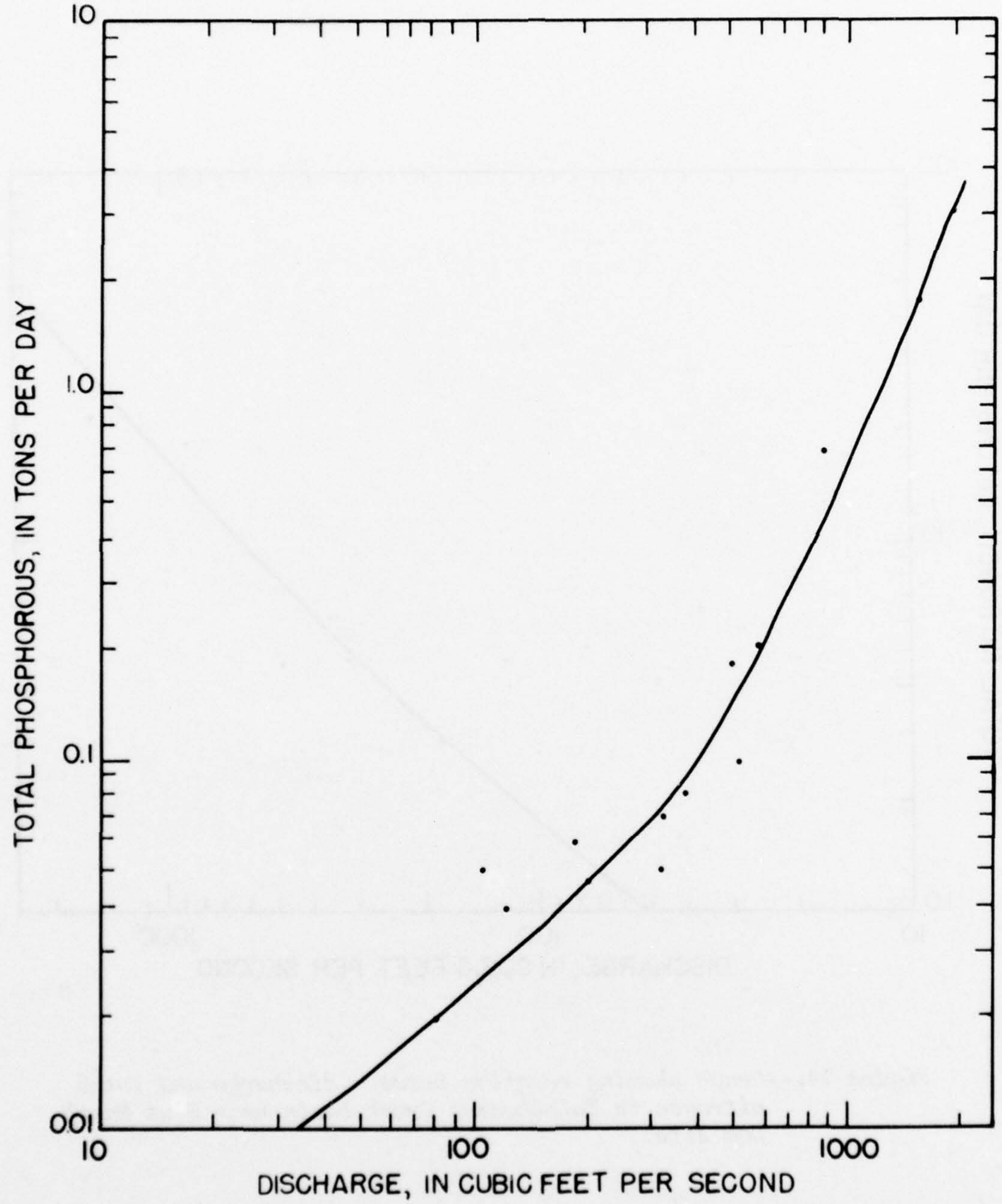

Figure 15.--Graph showing relation between discharge and total phosphorus in Tulpehocken Creek basin near Blue Marsh Dam site.

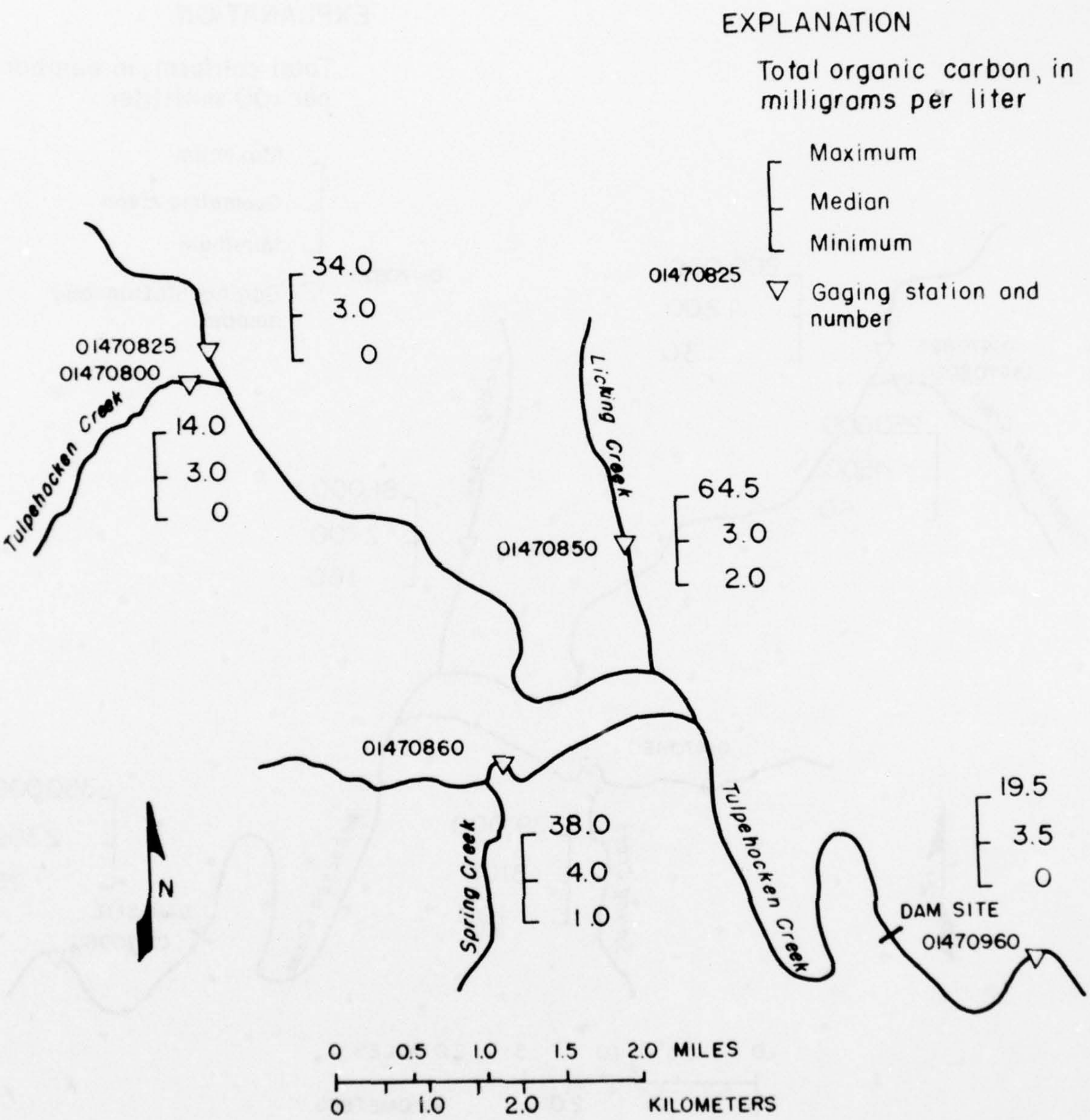

Figure 16.--Map showing concentrations of total organic carbon in Tulpehocken Creek basin.

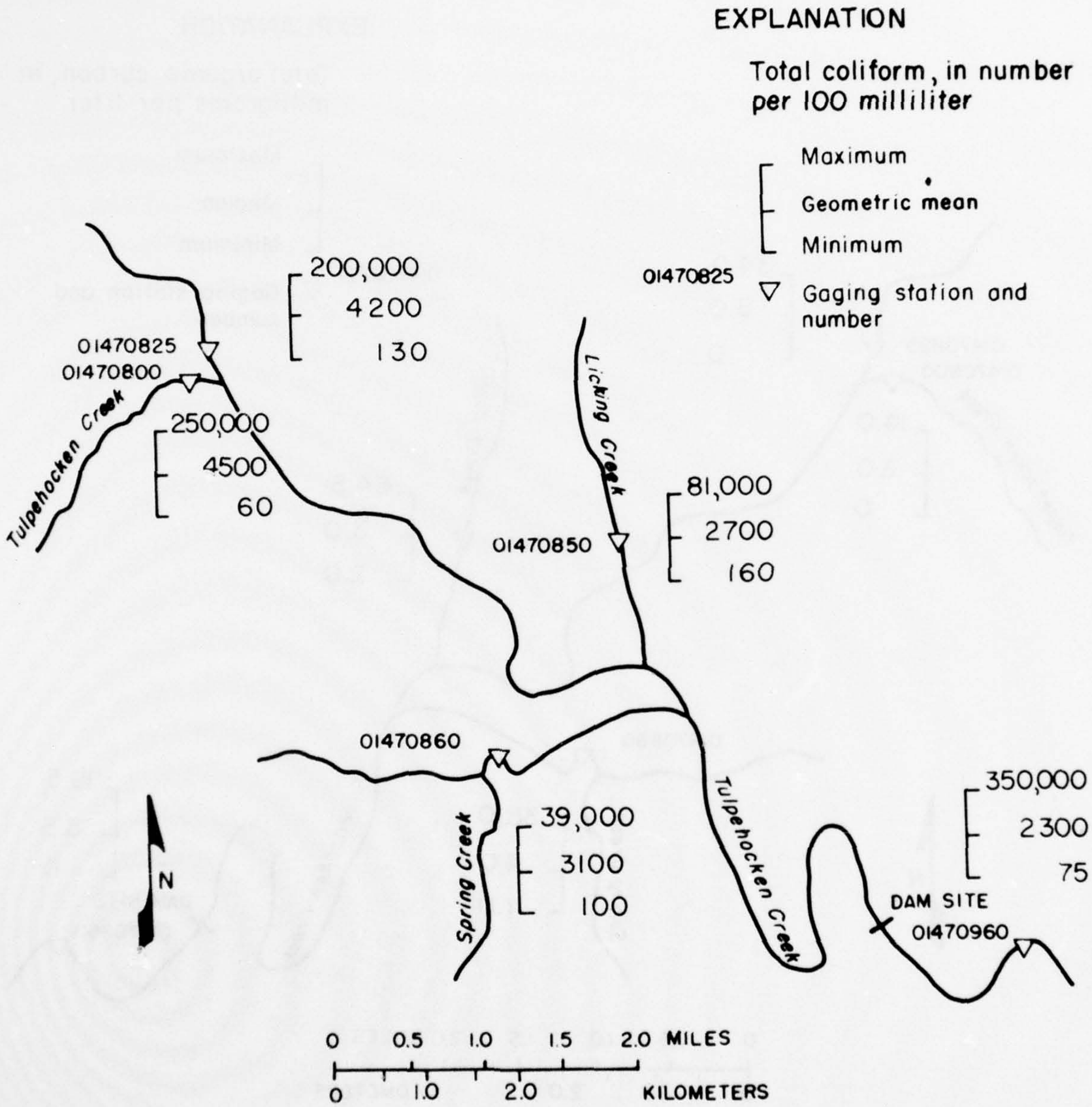

Figure 17.--Map showing concentrations of total coliform in Tulpehocken Creek basin.

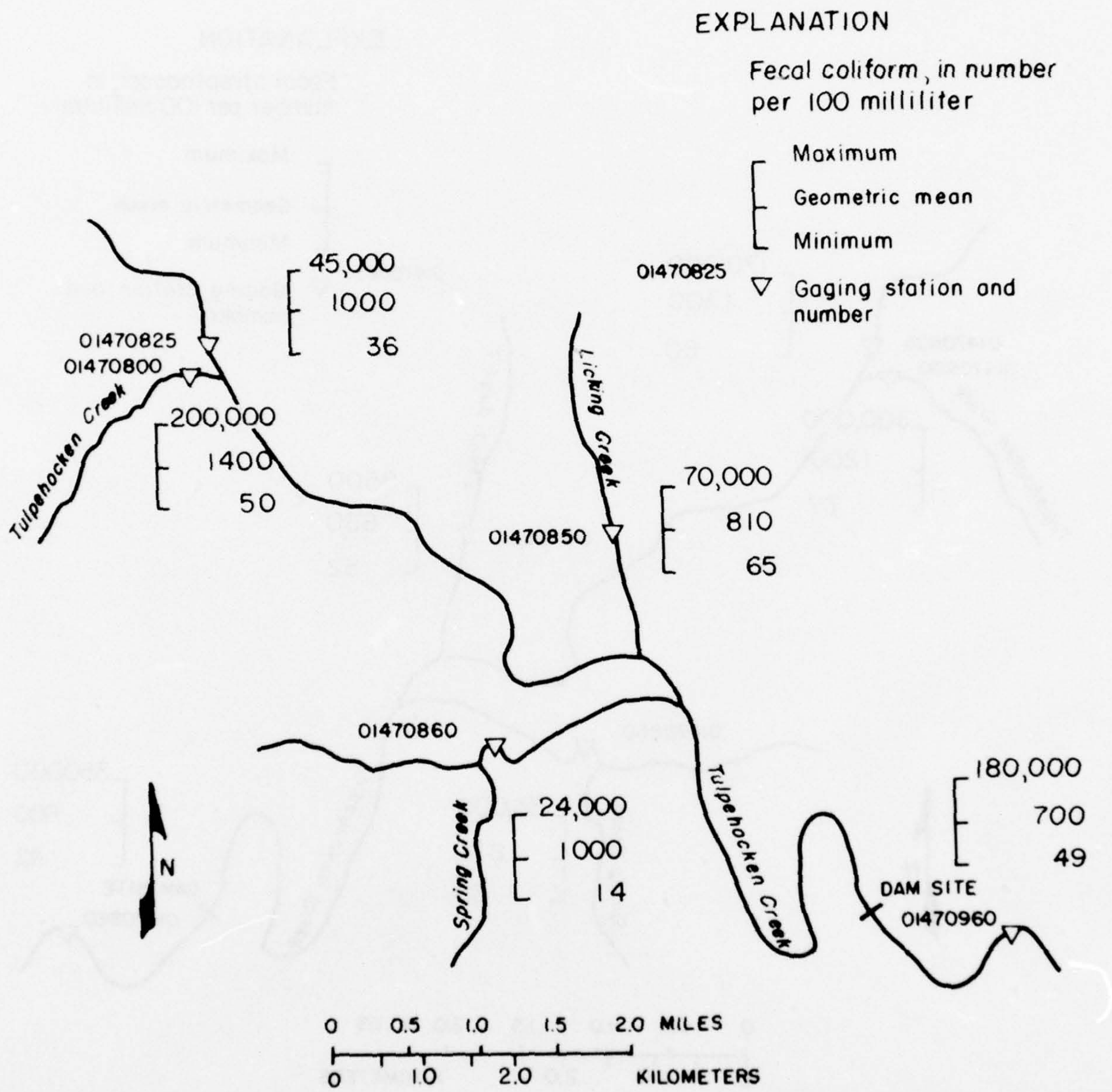

Figure 18.--Map showing concentrations of fecal coliform in Tulpehocken Creek basin.

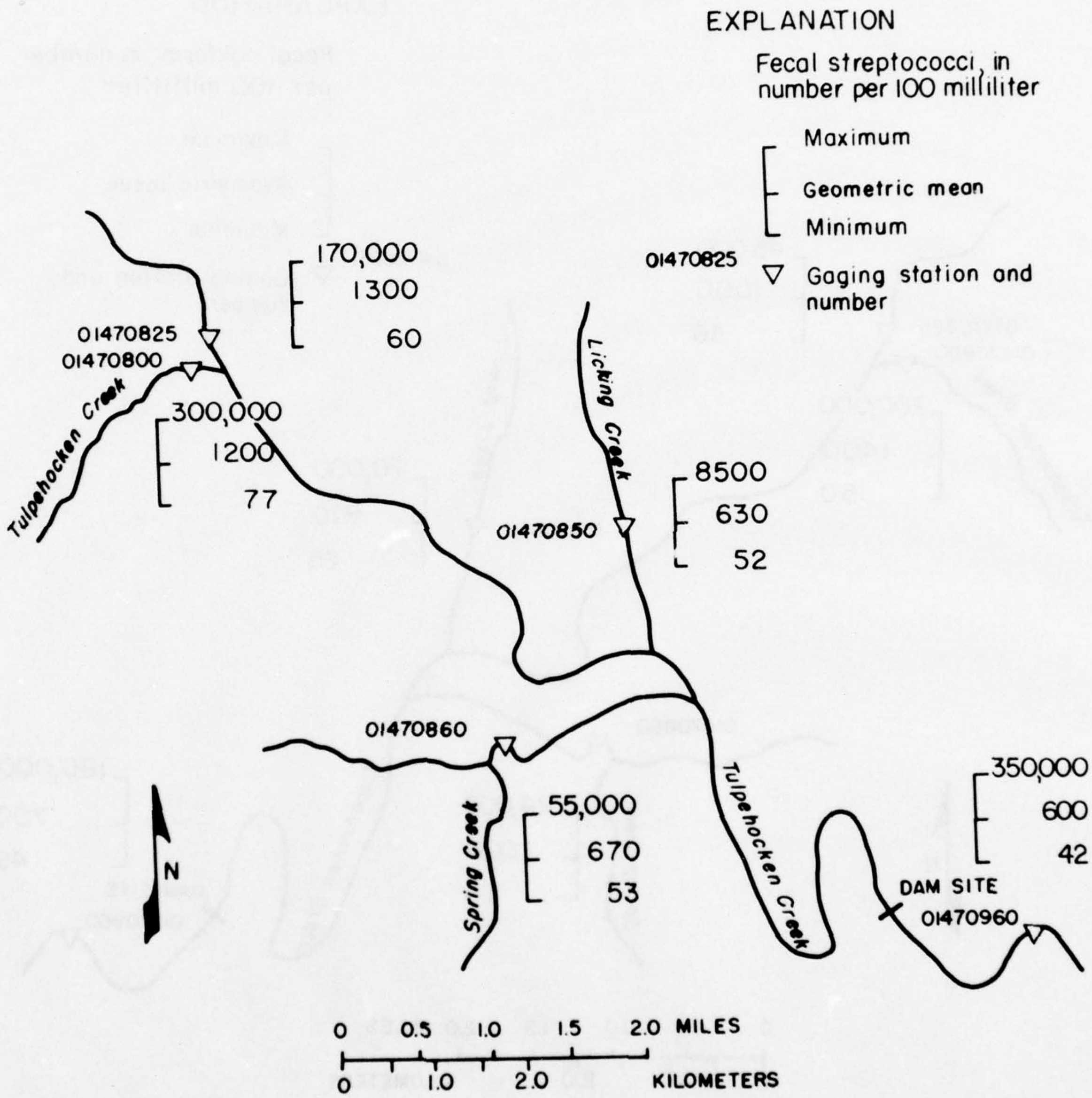

Figure 19.--Map showing concentrations of fecal streptococci in Tulpehocken Creek basin.

Total coliforms exceeded the recommended national water quality standards for public water supply (U.S. Dept. of the Interior, 1968) of 10,000 per 100 mg in 20 percent of the samples collected near the Blue Marsh Dam site. The Pennsylvania bathing-water standard of 1,000 per 100 ml was also exceeded in 10 out of 12 samples collected during the months of June to September. The maximum density of 350,000 per 100 ml was measured after a heavy rain in October 1973.

Fecal coliforms, a better indicator of recent fecal pollution, exceeded the recommended 2,000 per 100 ml for public water supplies (U.S. Dept. of the Interior, 1968) in 29 percent of the samples. Fecal coliforms exceeded the recently accepted 200 per 100 ml bathing-water standard, also, in 10 out of 12 samples collected between June and September. The maximum density of 200,000 fecal coliform per 100 ml was found in those samples that contained the maximum density of total coliforms. Maximum bacterial densities were found to correspond with precipitation and subsequent runoff, whereas minimum densities correspond with prolonged dry periods and occur chiefly during late autumn and winter.

Mean densities of bacteria decreased 50 percent in the 8 mi (13 km) and approximately 12-hour travel time at mean flow between the two stations on the main stem. The degree to which the bacteria are reduced is significant because the utility of the lake, once impounded, may well be determined by its ability to purify itself of the pollutional load.

The bacterial mortality rate for the impounded waters is difficult to predict because of the many environmental factors that affect the population, such as temperature, sedimentation, and predation. A study at Belmont Lake, Michigan, on the Huron River (Smith and Twedt, 1971) indicated that the bacterial mortality from the point of inflow into the lake to the dam, 11 mi (17.7 km) downstream, was 40 percent, 85 percent, and 96 percent, respectively, for total coliform, fecal coliform, and fecal streptococci. The report does not indicate the retention time between inflow and the dam, but, if a similar mortality rate for Blue Marsh Lake is assumed, bacterial water-quality standards for water-contact recreation would be at acceptable levels during periods of normal flow, but may be exceeded 4 out of 10 days during June-September, if the inflows exceed 200 ft^3/s (5.6 m^3/s).

Sediment and Bed Material

Sediment movement in Tulpehocken Creek is a major problem. High sediment discharge deteriorates water and limits its use, shortens the life of impoundments, increases water-treatment costs, alters or destroys aquatic life, and impairs the esthetic value of recreational waters.

Figure 20, commonly called a daily sediment-transport curve, shows the relation of sediment discharge to water discharges greater than 100 ft^3/s ($2.8\ m^3/s$)in Tulpehocken Creek at Blue Marsh Dam site. Monthly discharge of runoff and sediment is highest in winter and early spring (February to April), as the result of rain and snowmelt. Severe storms, such as the hurricanes in 1955 and 1972, also cause high runoff and sediment discharge.

Suspended-sediment concentrations between January 1973 and April 1975 ranged from 7 mg/L, at base flow, to 1,850 mg/L at maximum runoff. Daily sediment discharges ranged from one to 8,350 tons (0.9 and 7,575 metric tons).

Bed-material samples from the top 1 in (2.54 cm) were collected at the five sampling sites in October 1972 and June 1974. Results of the physical and chemical analyses are presented in tables 7, 8, and 9. Bed-material analyses indicate a highly fertile bed material of ideal composition for growing rooted plants. With the exception of mercury, higher concentrations of trace metals were noted in 1972 than 1974.

Insecticide residues were of low level, with trace concentrations of aldrin, dieldrin, chlordane, and DDT plus its metabolites. Polychlorinated biphenyls (PCB) ranged from 10 to 100 μg/kg (microgram per kilogram), suggesting the presence of industrial effluent.

Arsenic concentrations in more than 80 samples of water and suspended sediment were determined during January 4, 1973, to April 26, 1975. (See table 11.) Concentrations ranged from 0 to 30 μg/L in the water and from 2 to 879 μ/g in the suspended sediment. Concentrations of total arsenic ranged from 2.2 to 48.8 μg/L. The data collected to date suggest that total arsenic concentrations have decreased during the past 2 years. Concentrations are highest in the sediment during periods of low sediment concentration (fig. 21), but the total arsenic load is highest during periods of high discharge (fig. 22).

Faust and Clement (1973) and Wood (1973) investigated the arsenic problem and agree that concentrations reaching Blue Marsh Lake will rarely exceed 50 μg/L (micrograms per liter). Although the Environmental Protection Agency (EPA) National Drinking Water Standard of 50 μg/L arsenic was not exceeded in any of the samples analyzed, the annual load of arsenic discharged to Tulpehocken Creek was computed to be 3.9 tons (3.5 metric tons). Its environmental effects, however, have not been fully investigated.

SOILS

The fertility of inundated soils is probably significant in the storage and release of certain nutrients that could be deleterious to a new impoundment. Carbon, nitrogen, and phosphorus are essential to the growth of plant life that are primary in determining soil fertility.

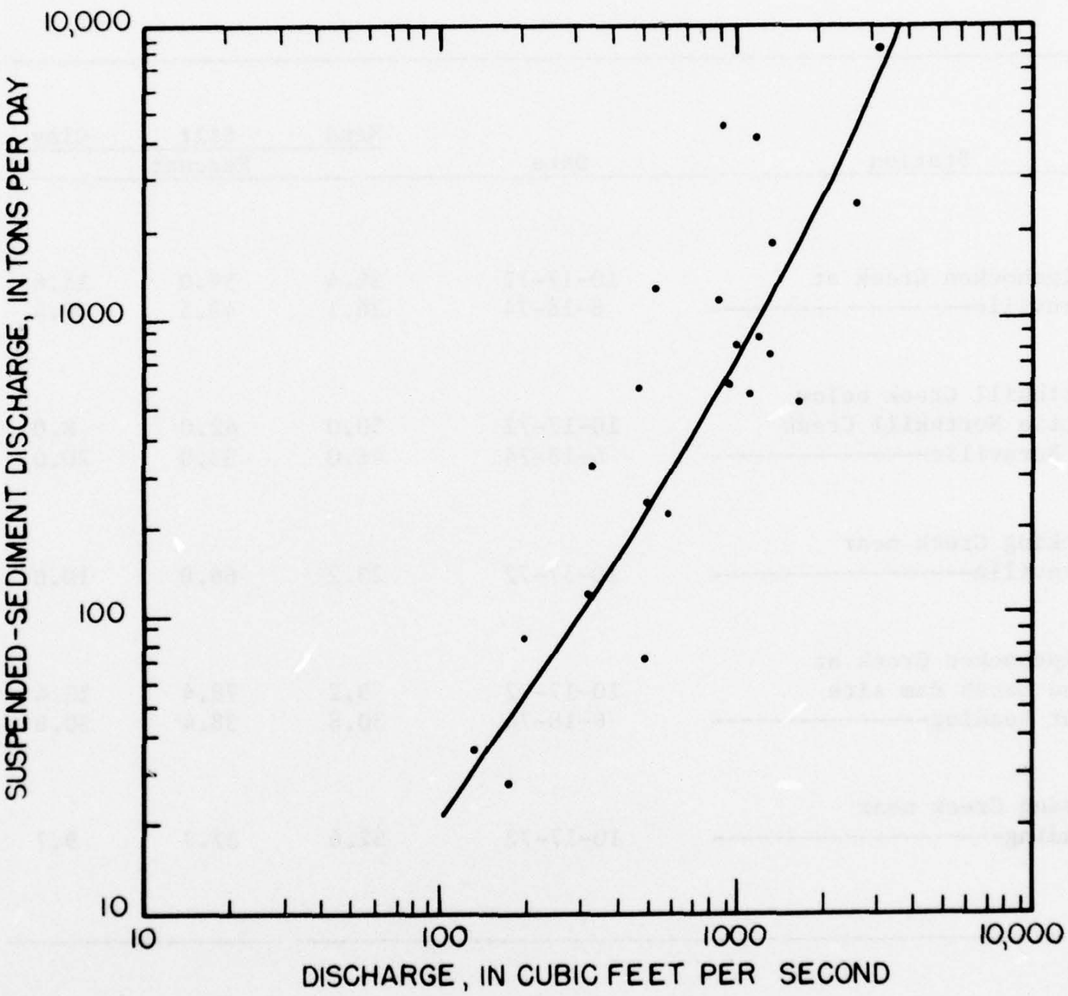

Figure 20.--Graph showing daily sediment transport curve (1973) for Tulpehocken Creek basin near Blue Marsh Dam site.

Table 7.--*Particle-size and nutrient con-*

Station	Date	Sand	Silt	Clay
		Percent		
Tulpehocken Creek at Bernville-------------------	10-17-72	34.4	54.0	11.6
	6-18-74	26.1	43.5	30.4
Northkill Creek below Little Northkill Creek at Bernville---------------	10-17-72	50.0	42.0	8.0
	6-18-74	46.0	33.0	20.0
Licking Creek near Bernville-------------------	10-17-72	23.2	66.8	10.0
Tulpehocken Creek at Blue Marsh dam site near Reading---------------	10-17-72	9.2	78.4	12.4
	6-18-74	30.8	38.4	30.8
Spring Creek near Reading--------------------	10-17-72	52.6	37.7	9.7

tent of bed material in Tulpehocken Creek.

Carbon			Nitrogen			Phosphorus		
Inor-ganic	Organic	Total	Inor-ganic	Organic	Total	Inor-ganic	Organic	Total
Micrograms per Kilogram								
0.3	1.7	2.0	260	2,100	2,360	---	---	790
.4	2.2	2.6	20	2,300	2,320	---	---	386
.0	2.4	2.4	260	2,100	2,360	---	---	550
.0	2.3	2.3	20	2,200	2,220	---	---	219
.1	2.9	3.0	120	4,000	4,120	---	---	1,100
.4	2.6	3.0	520	2,900	3,420	---	---	1,100
.4	2.1	2.5	40	2,880	2,920	---	---	674
.1	1.5	1.6	230	1,700	1,930	---	---	970

Table 8.--*Concentrations of selected*

Station	Date	Iron (Fe)	Manga-nese (Mn)	Copper (Cu)	Nickel (Ni)
Tulpehocken Creek at Bernville------------	10-17-72	16,500	1,300	20	15
	6-18-74	5,600	910	12	8
Northkill Creek below Little Northkill Creek at Bernville------------	10-17-72	21,000	630	21	18
	6-18-74	7,500	670	10	9
Licking Creek near Bernville---------------	10-17-72	18,000	960	19	14
Tulpehocken Creek at Blue Marsh dam site near Reading------------	10-17-72	18,000	1,000	25	12
	6-18-74	4,600	690	7	6
Spring Creek near Reading-----------------	10-17-72	19,000	900	18	13

elements in bed material in Tulpehocken Creek.

Extractable						Total		
Lead (Pb)	Zinc (Zn)	Cad-mium (Cd)	Cobalt (Co)	Chrom-ium (Cr)	Alum-inum (Al)	Selen-ium (Se)	Mer-cury (Hg)	Arse-nic (As)
Micrograms per Gram								
69	77	1	12	13	7,700	2	0.1	79
25	39	0	7	4	---	.1	23	1
61	82	1	13	14	8,660	3	.1	17
30	49	0	6	0	---	.2	2.6	3
75	75	1	12	15	7,800	0	.1	10
150	85	1	12	14	8,700	2	.2	32
18	34	1	4	3	---	0	17	26
69	83	1	13	14	6,800	6	.1	9

Table 9.--*Insecticide analyses of bed material collected October 17, 1972.*

[Results in micrograms per kilogram]

Station	Aldrin	DDD	DDE	DDT	Dieldrin	Endrin	Heptachlor	Lindane	Chlordane[1]	PCB[1]
Tulpehocken Creek at Bernville	0.0	3.3	1.2	1.6	3.2	0.0	0.0	0.0	30	50
Northkill Creek below Little Northkill Creek at Bernville	9.5	4.7	2.5	1.0	23	.0	.0	.0	20	80
Licking Creek near Bernville	.9	2.0	2.5	1.4	1.8	.0	.0	.0	4	10
Tulpehocken Creek at Blue Marsh Dam site near Reading	.0	4.8	2.0	.9	14	.0	.0	.0	10	100
Spring Creek near Reading	.7	.5	.3	.0	.7	.0	.0	.0	1	10

1/ Estimate.

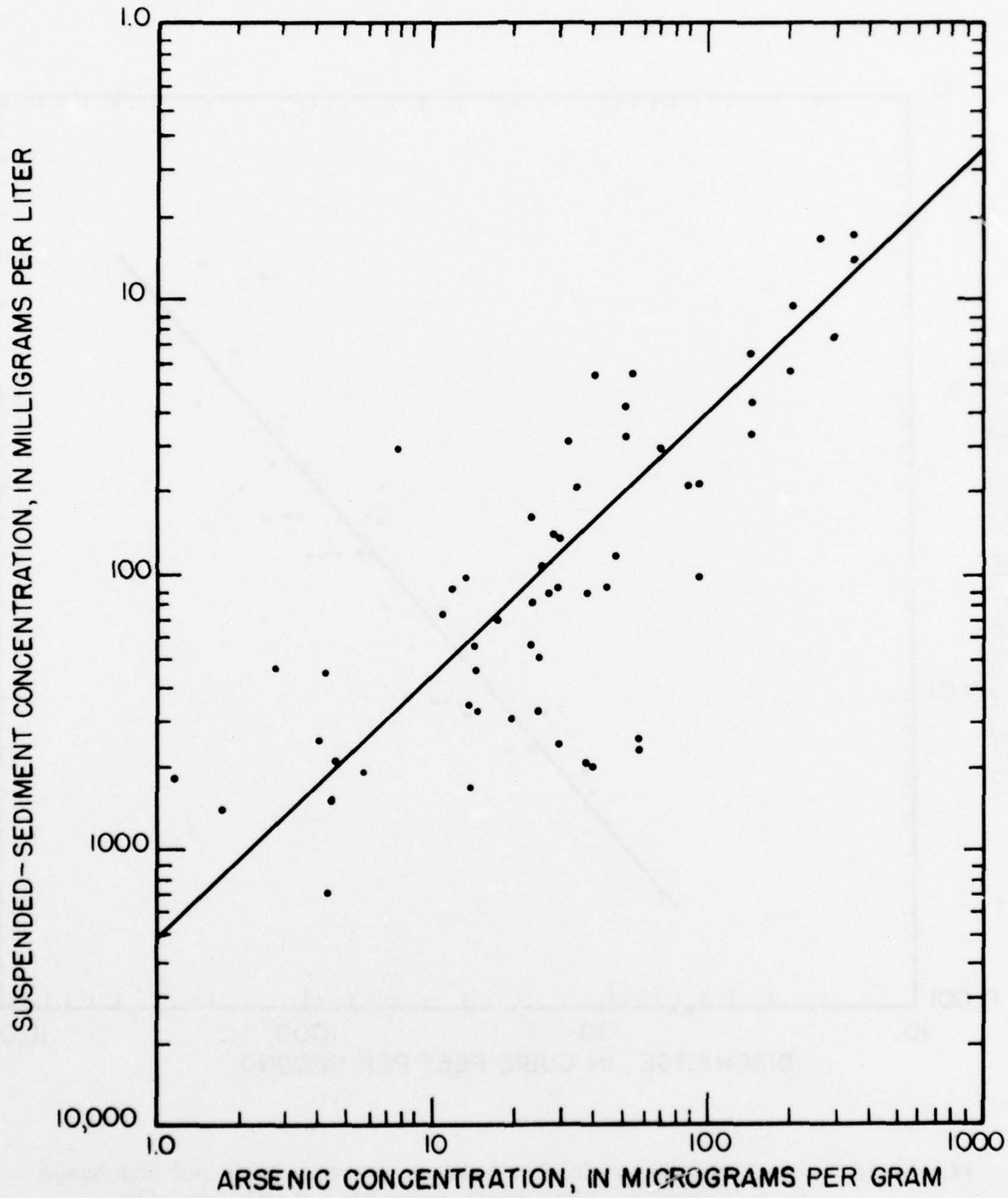

Figure 21.--Graph showing relation between suspended-sediment concentration and arsenic concentration in Tulpehocken Creek near Blue Marsh Dam site.

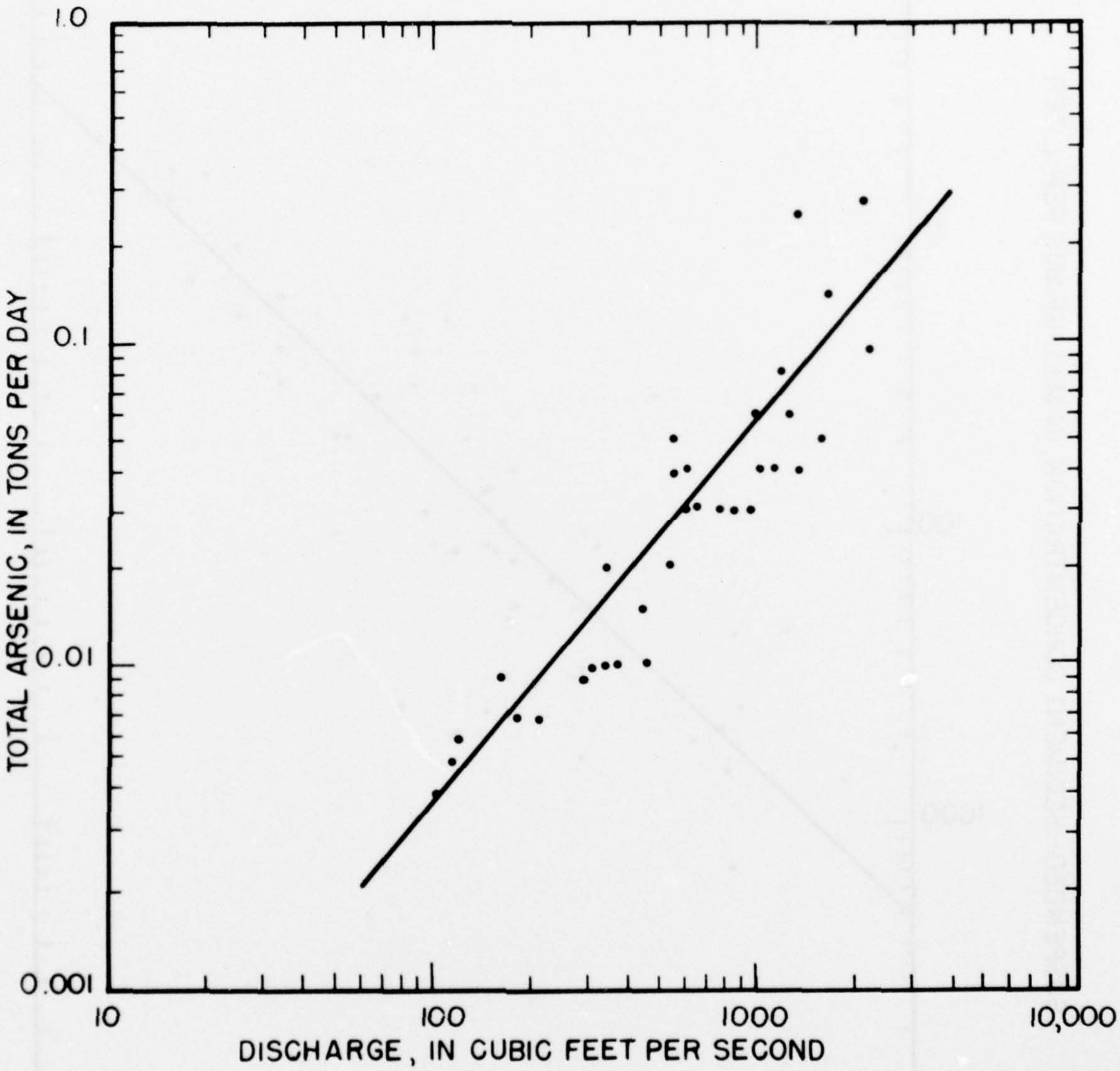

Figure 22.--Graph showing relation between arsenic load and discharge in Tulpehocken Creek basin near Blue Marsh Dam site.

Samples of the upper 3 in (7.6 cm) of soil material were collected at five sites on the flood plain of Tulpehocken and Spring Creeks (fig. 1). The sites were selected as representative of the different depositional environments within the impoundment area. Three sites are, or have been, tilled; one is in pasture, and one appeared undisturbed. The results of the physical and nutrient analyses are presented in table 10.

Soils sampled in the Tulpehocken basin flood plain are classified by Ackerman (1970) as belonging to the Atkins, Berks, and Werkert-Berks series and are silt loam or shaly silt loam in texture. He lists productivity of these soils as medium to medium-high based upon an estimated yield in an average growing season. Carbon content ranged from 1.3 to 2.8 percent, nitrogen from 0.13 to 0.46 percent, and phosphorus from 0.002 to 0.024 percent. Carbon-nitrogen ratios ranged from 5.0 to 14.2. According to Lyon and others (1952), this range of carbon-nitrogen ratios is average for mineral soils in a temperate climate.

Perhaps of greater significance to the ecology of the proposed lake is the silt loam texture of the soil, which is ideal for the attachment and growth of aquatic plants. As stated by Sculthorpe (1967, p. 56), "***The highest population densities and most varied submerged floras occur on fine inorganic silts and clays and organic muds,***".

RESULTS AND CONCLUSIONS

The current investigation of the preimpoundment quality of water and the aquatic environment in the Tulpehocken Creek basin supports the findings of previous studies by the Environmental Protection Agency (formerly the Federal Water Pollution Control Administration) (Geismar, 1968, written communication), and the Pennsylvania Department of Environmental Resources (Brezina, et al, 1974), which found that the watershed contained high concentrations of essential plant nutrients, bacteria of fecal origin, and industrial arsenical wastes.

Concentrations of nitrogen and phosphorus exceeded the minimum values suggested by Sawyer (1947) as critical for the nuisance growth of aquatic plants at all stations and in all samples, and was highest after storm runoff. Based upon estimates from a flow duration curve, the annual input of nitrogen and phosphorus to the lake is about 1,400 tons (1,270 metric tons) and 46 tons (41.7 metric tons), respectively.

Bacterial populations, indicative of the sanitary quality, generally exceed the State (Pa. Sanitary Water Board, 1967) and Federal (U.S. Dept. of the Interior, 1968) recommended standards for potable and water contact recreational use. The utility of the impoundment for the intended use of the water will be determined by how effectively bacterial populations are reduced by disinfection of waste waters and(or) by self purification. Given present bacterial populations and predicted retention time, the bacterial population will probably be at acceptable levels during periods of normal flow, but may exceed these levels when the inflows are above normal.

Table 10.--*Physical and chemical analyses of soils*

Site Description	Soil Type	Sand	Silt	Clay	Carbon Inorganic	Carbon Organic	Carbon Total
		P E R C E N T					
Old field------	Atkins	26.0	25.0	49.0	0.1	1.5	1.6
Corn field-----	Berks	51.0	25.0	24.0	0.1	2.6	2.7
Pasture--------	Atkins	29.0	41.0	30.0	0.0	2.8	2.8
Wooded area----	Atkins	17.0	51.0	32.0	0.2	2.1	2.3
Old field------	Werkert-Berks	40.0	31.0	29.0	0.0	1.3	1.3

in the Tulpehocken Creek flood plain, June 13, 1973.

Nitrogen			Phosphorus				Nitrogen-phosphorus ratio
Inorganic	Organic	Total	Inorganic	Organic	Total	Carbon-nitrogen ratio	
P E R C E N T							
---	---	0.13	---	---	0.002	12.3	65
---	---	0.19	---	---	0.014	14.2	13.6
---	---	0.36	---	---	0.020	7.8	18
---	---	0.46	---	---	0.024	5.0	19
---	---	0.13	---	---	0.012	10.0	10.8

Arsenic in the water, sediment, and bed material of Tulpehocken Creek represents a potential environmental hazard. Although concentrations of arsenic have been declining and did not exceed the National Interim Primary Drinking Water Standard of 50 μg/L nor the limits to be harmful to fish and wildlife, impoundment and anaerobic reduction of bottom mud could result in higher arsenic concentrations being released to the water column.

Table 11.--*Suspended sediment and arsenic concentration in Tulpehocken Creek at Blue Marsh Dam site near Reading, Pa.*

Date	Time	Discharge ft^3/s	Sediment Sed conc mg/L	Sediment As conc μg/g	Water As conc μg/L	Total As μg/L
1/04/73	0925	1,326	89	85	30	37.6
	1250	887	116	22	20	22.6
1/23	1000	625	315	20	10	16.3
	1425	526	314	7	10	12.2
	1600	526	167	86	0	14.4
1/24	1050	446	39	36	10	11.4
	1350	430	30	52	10	11.6
	1650	423	32	70	10	12.2
1/28	1600	543	286	7	10	12.0
1/29	1000	1,550	210	12	10	12.5
	1600	1,310	214	11	10	12.4
1/30	1600	761	55	44	10	12.4
2/02	1600	1,230	412	20	10	18.2
3/08	1600	288	15	123	10	11.8
3/26	0900	667	73	91	20	26.6
	1200	589	75	58	20	24.4
	1600	493	80	44	20	23.5
3/27	0900	340	25	126	10	13.2
	1200	335	14	157	20	22.2
3/30	1600	326	7	240	10	11.9
4/01	1600	537	288	15	30	34.3
4/03	1600	983	85	28	20	22.4

Table 11.--*Suspended sediment and arsenic concentration in Tulpehocken Creek at Blue Marsh Dam site near Reading, Pa.*--continued.

			Sediment		Water	Total
Date	Time	Discharge ft³/s	Sed conc mg/L	As conc µg/g	As conc µg/L	As µg/L
4/04/73	1300	819	136	35	10	14.8
	1600	1,190	136	39	20	25.3
4/05	1600	1,102	98	77	<5	12.6
4/08	1600	1,086	45	71	10	13.2
4/10	1000	2,396	301	52	10	25.7
	1300	2,261	304	33	<5	15.0
	1600	1,685	536	19	20	30.2
4/26	1600	499	34	75	20	22.6
4/27	1600	376	17	74	10	11.3
4/28	1600	1,015	19	180	10	13.4
5/09	1600	314	32	42	10	11.3
5/21	0850	420	88	38	10	13.3
	1250	372	56	71	10	14.0
	1800	349	44	244	10	20.7
5/22	0925	314	21	229	10	14.8
5/25	1900	358	45	368	0	16.6
5/27	1850	326	18	879	0	15.8
5/29	1325	2,081	283	137	10	48.8
	1750	1,595	207	30	10	16.2
	1950	1,478	161	44	10	17.1
5/30	0850	1,094	107	41	10	14.4
	1350	987	98	11	10	11.1
	1950	866	90	24	0	2.2

Table 11.--*Suspended sediment and arsenic concentration in Tulpehocken Creek at Blue Marsh Dam site near Reading, Pa.*--continued.

			Sediment		Water	Total
Date	Time	Discharge ft^3/s	Sed conc mg/L	As conc µg/g	As conc µg/L	As µg/L
5/31/73	1900	915	108	36	10	13.9
6/06	2000	381	61	69	10	14.2
6/07	1150	1,510	1,680	3	10	15.0
	1600	1,150	1,370	3	10	14.1
6/13	1850	440	1,850	2	10	13.7
6/22	0850	1,086	1,680	4	0	6.7
	1800	372	498	8	0	3.9
6/23	1850	340	69	58	10	14.0
6/24	2050	292	49	42	10	12.1
6/29	1600	4,300	1,330	0	0	0
6/30	1850	735	83	37	10	13.1
7/03	1450	482	86	23	10	12.0
	2000	868	393	24	10	19.4
7/05	1100	625	149	44	10	16.6
	1500	521	193	48	10	19.3
	1900	482	91	46	10	14.2
1/17/74	1700	360	24	81	8	9.9
1/21	1900	1,302	492	10	6	10.9
2/20	0900	369	98	66	6	12.5
	1300	333	51	67	7	10.4
	1600	555	36	69	7	9.5

Table 11.--*Suspended sediment and arsenic concentration in Tulpehocken Creek at Blue Marsh Dam site near Reading, Pa.*--continued.

			Sediment		Water	Total
Date	Time	Discharge ft^3/s	Sed conc mg/L	As conc µg/g	As conc µg/L	As µg/L
2/22/74	1800	500	99	36	8	11.6
3/09	1550	355	72	35	4	6.5
3/21	1650	555	54	72	5	8.9
3/31	1350	940	186	39	8	15.3
	1850	891	145	80	9	20.6
4/04	1550	1,712	707	36	7	32.5
	1800	1,595	549	51	8	36.0
	2000	1,510	459	63	9	37.9
4/05	1600	1,390	181	57	6	16.3
	1850	1,542	301	53	5	20.9
	2000	1,518	285	50	6	20.3
4/06	1000	1,066	129	63	7	15.1
	1600	975	71	75	8	13.3
	2000	913	66	64	8	12.2
4/09	1650	773	47	98	8	12.6
5/13	1700	567	100	24	14	16.4
7/30	1600	204	58	19	13	14.1
8/03	1200	239	166	16	11	13.6
	1600	180	60	14	14	14.8
	2000	157	53	27	20	21.4
8/04	1250	204	60	22	20	21.3
	1700	192	47	29	15	16.4
8/05	1500	135	24	35	16	16.8
	1850	119	21	28	17	17.6

Table 11.--*Suspended sediment and arsenic concentration in Tulpehocken Creek at Blue Marsh Dam site near Reading, Pa.*--continued.

Date	Time	Discharge ft^3/s	Sediment: Sed conc mg/L	Sediment: As conc µg/g	Water: As conc µg/L	Total As µg/L
8/10/74	1350	119	104	19	11	13.0
	1600	113	52	24	17	18.2
	2050	107	36	33	17	18.2
8/17	1900	166	167	15	15	17.5
8/18	0900	119	69	19	14	15.1
8/30	2000	101	20	27	18	18.5
9/03	1050	135	55	23	15	16.3
	1500	139	42	24	22	23.0
9/04	0850	252	119	20	15	17.4
	1350	219	58	17	18	19.0
	1800	200	60	19	17	18.1
9/05	0850	145	45	31	21	22.4
	1300	135	26	31	14	14.8
9/07	1550	298	163	22	11	14.6
	1900	307	162	19	11	14.1
9/08	1250	177	202	24	14	18.8
	1700	170	38	22	18	18.8
9/09	1200	152	87	24	17	19.0
11/07	1700	84	420	7	4	6.9
11/13	0900	170	60	14	5	5.8
	1250	170	24	23	5	5.6
	1700	149	20	15	4	4.3
12/08	1100	190	425	8	5	8.0
	1400	266	636	7	5	9.5
	1700	438	933	5	5	9.7

Table 11.--*Suspended sediment and arsenic concentration in Tulpehocken Creek at Blue Marsh Dam site near Reading, Pa.*--continued.

Date	Time	Discharge ft³/s	Sediment: Sed conc mg/L	Sediment: As conc µg/g	Water: As conc µg/L	Total As µg/L
12/09/74	0900	664	195	13	6	8.5
	1300	578	110	22	5	7.4
	1700	529	82	10	3	3.8
12/10	0900	395	43	17	6	6.7
	1300	375	33	21	7	7.7
	1700	358	41	13	7	7.5
12/11	0900	312	30	23	10	10.7
	1300	296	25	17	10	10.4
	1700	281	23	18	8	8.4
12/16	1250	256	84	14	7	8.2
	1500	354	190	13	7	9.5
	1700	741	556	7	5	8.9
12/17	0900	963	155	26	7	11.0
	1300	629	110	17	7	8.9
	1650	578	91	10	7	7.9
12/18	0900	483	54	18	8	9.0
	1250	474	48	11	8	8.5
	1650	461	45	18	7	7.8
1/09/75	0900	247	172	27	4	8.6
	1250	545	513	26	4	17.3
	1600	1,100	327	29	3	12.5
1/10	0950	642	89	43	4	7.8
1/11	1600	600	58	44	7	9.6
1/12	1700	474	40	54	10	12.2
2/25	0900	798	272	32	9	17.7

Table 11.--*Suspended sediment and arsenic concentration in Tulpehocken Creek at Blue Marsh Dam site near Reading, Pa.*--continued.

Date	Time	Discharge ft^3/s	Sediment: Sed conc mg/L	Sediment: As conc µg/g	Water: As conc µg/L	Total As µg/L
2/26/75	0900	1,042	92	37	6	9.4
2/27	0900	798	49	46	9	11.3
3/19	1800	458	124	39	5	9.8
3/20	1000	1,752	380	39	6	20.8
3/21	0900	1,048	77	51	8	11.9
4/05	1450	720	67	52	5	8.5
4/26	0950	756	63	19	6	7.2

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16. Abstracts Blue Marsh Lake is planned as a multipurpose impoundment to be constructed on Tulpehocken Creek near Bernville, Berks County, Pennsylvania. Prior to construction, samples of water, bed material, and soil were collected through-out the impoundment site to determine concentrations of nutrients, insecticides, trace metals, suspended sediment and bacteria. Analyses of water suggest the Tulpehocken Creek basin to be a highly fertile environment. Nitrogen and phosphorus concentrations near the proposed dam site had median values of 4.5 and 0.13 mg/L, respectively. Suspended sediment discharges average between 100 and 200 tons per day. Concentrations range from 3 mg/L to more than 500 mg/L. Bed material samples contain trace quantities of aldrin, DDT, DDD, DDE, dieldrin, and chlordane. Polychlorinated biphyenyls (PCB's) ranged from 10 to 100 µg/kg Fecal Coliform bacteria exceeded the recommended standards in 29 percent of the monthly samples, and exceeded the recommended public bathing water standard in 83 percent of the samples collected from June to September. Arsenic from an industrial waste was found in the water, suspended sediment, and bed material of Tulpehocken Creek in concentrations of 0 to 30 µg/l, 2 to 879 µg/l, and 1 to 79 µg/g, respectively.

17. Key Words and Document Analysis. 17a. Descriptors

*Aquatic environment, *limnology, *water quality, *microbiology, arsenicals, stream pollution, *nutrients

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