UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WATER-QUALITY INVESTIGATION OF FRANCIS SLOCUM LAKE, LUZERNE COUNTY, PENNSYLVANIA

U.S. GEOLOGICAL SURVEY

Open-File Report 78-819

Prepared in cooperation with the
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Factors for converting SI metric units to U.S. Customary units

To convert from	To	Multiply by
cubic hectometers	acre-ft (acre-feet)	1.233×10^{-3}
square kilometers	acres	4.047×10^{-3}
meters	ft (feet)	3.048×10^{-1}
cubic meters per second	ft^3/s (cubic feet per second)	2.832×10^{-2}
kilometers	mi (miles)	1.609
square kilometers	mi^2 (square miles)	2.590
kilograms per day	lb/d (pounds per day)	0.4536

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ABSTRACT

This report summarizes water-quality data collected in the Francis Slocum Lake drainage basin, Pennsylvania, during an assessment from October 1976 to September 1977. Data were collected for nitrogen, phosphorus, carbon, and fecal coliform and fecal streptococcal bacteria.

Results of the restricted sampling indicate that nutrient recycling within the lake is sufficient to support the periodic luxurient growth of algae and aquatic weeds. Inflows are not contributing high concentrations of nutrients to the ecosystem. Sampling for enteric bacteria indicate the sanitary quality is sufficiently high for water-contact recreation.

Purpose

The purpose of this study was to assess the present state of nutrient enrichment and fecal contamination of Francis Slocum Lake drainage basin for implementing restoration-management programs.

Area Description

Francis Slocum Lake (fig. 1) is 7 miles northwest of Wilkes-Barre. The lake was formed by the construction of a rolled earth-fill dam across Abrahams Creek in 1965 by the Pennsylvania Department of Forests and Waters, Division of Flood Control. The drainage area includes 6 mi^2. At the spillway altitude of 1,070 ft the lake has a surface area of 164 acres and a storage capacity of 1,550 acre-ft. The lake is elliptical, has 4.4 miles of shore, is about 1,000 feet wide, averages 9.5 ft in depth, and is 29 ft deep at the spillway. The lake is used for fishing and boating.

The basin is predominantly forest and pasture with residential home sites scattered along numerous secondary roads. There is at least one dairy farm within the basin.

Methods and Procedures

Quality of water data were collected periodically from October 1976 to August 1977 at inflow tributaries and the lake. The lake sampling included two in each vertical at three surface sites. At each station, temperature, pH, dissolved oxygen, and specific conductance were measured; samples were collected for analysis of nitrogen and phosphorus species; and counts of fecal coliform and fecal streptococcal bacteria were determined. Bottom sediments also were collected at the lake sites for carbon, nitrogen, and phosphorus analyses. In addition, samples were collected at selected sites for determination of total organic carbon (TOC).

Results

Francis Slocum Lake was sampled periodically from October 1976 to August 1977. The locations of the sampling stations are shown in figure 1. The temperature and dissolved oxygen profiles for the lake stations are presented in table 1, and the chemical data from the five stations (inlets and lake stations) are presented in tables 2 and 3.

Stations 1 and 2, inflows: Francis Slocum Lake has two major inflows, both in the northern part of the basin. These streams are small and have a combined drainage area of 3.7 mi^2 and a combined discharge of about 15 ft^3/s during spring runoff and less that 1 ft^3/s during low flow. The annual daily mean estimated surface inflow of 8 ft^3/s gives the lake a mean hydraulic retention time of 98 days if the lake is filled. During low flow there is little or no outflow.

Water quality of the inflows was generally good but somewhat variable because the flow is highly dependent upon precipitation. The pH of both tributaries remained close to 7.0. Both streams tended to be slightly more acidic during higher flow.

Nutrient concentrations in the inflows were generally low and probably represent natural levels of nitrogen and phosphorus from the basin soils. Nitrate nitrogen concentrations ranged from 0.3 to 0.6 mg/L as N, and total phosphorus ranged from 0.03 to 0.09 mg/L as P. Inflow nitrate nitrogen loads ranged from 2.7 lb/d at low flow to 38.5 lb/d at high flow, and total phosphorus loads ranged from 0.32 lb/d to 2.5 lb/d.

Although Abrahams Creek and its unnamed tributary represent the major inflows to the lake, there is constant seepage from numerous springs along the periphery of the lake, particularly the eastern and western shores.

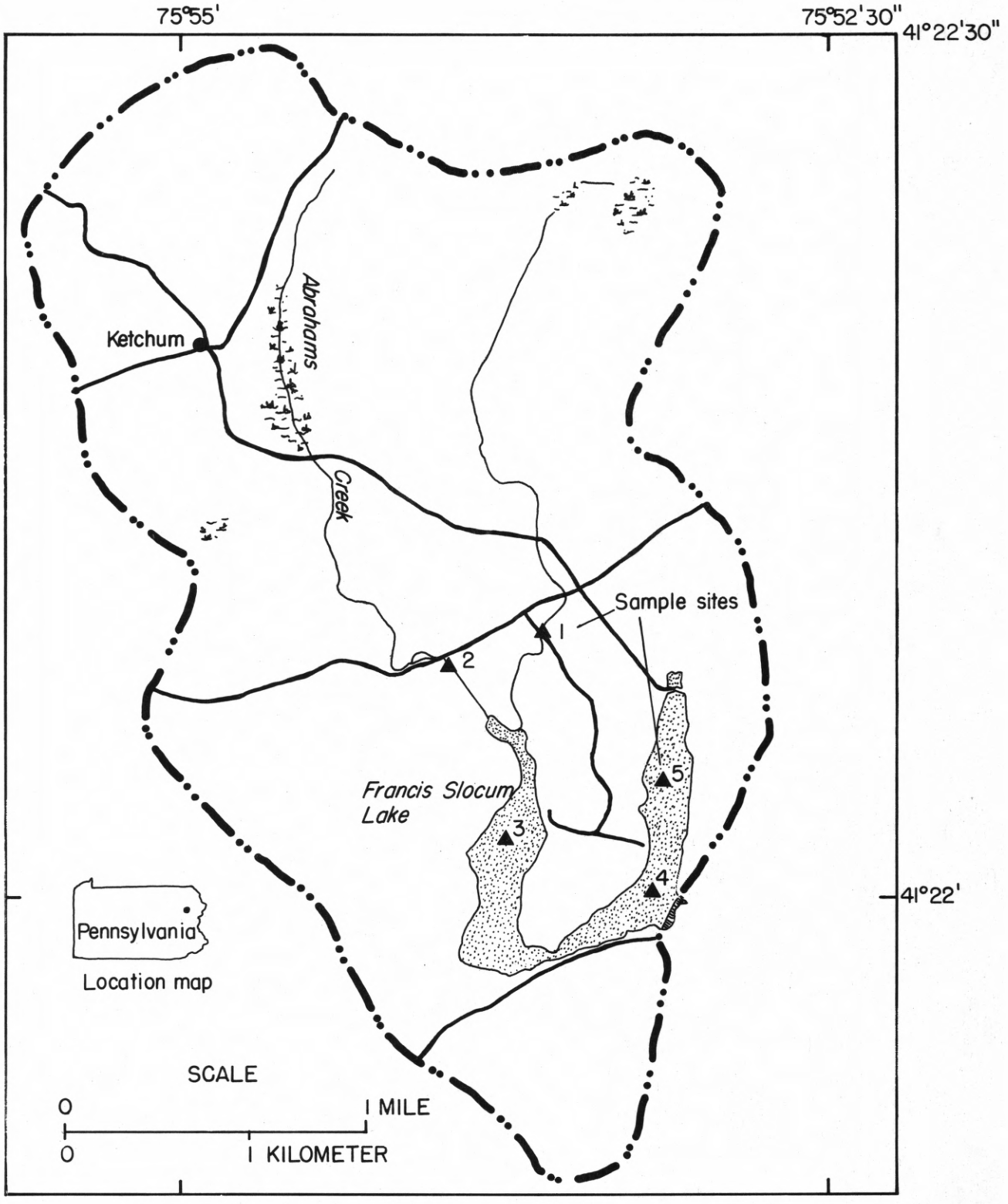

Figure 1.--Francis Slocum Lake basin study area

Table 1.--Vertical Profiles

Depth (Meters)	Temperature (°C)	Dissolved Oxygen (mg/L)
	Station 3	
	September 8, 1976 at 1630 hours	
0	20.0	13.2
1	20.0	9.6
1.5	18.5	8.8
	March 16, 1977 at 1300 hours	
0	5.5	11.8
1	5.5	11.7
2	5.0	11.7
	April 12, 1977 at 1235 hours	
0	12.0	12.4
1	11.2	12.4
2	10.5	12.4
2.1	10.0	11.6
	May 24, 1977 at 1245 hours	
0	24.0	7.4
1	24.0	7.4
1.5	23.5	7.6
1.75	23.0	4.0
2	21.0	1.2
	July 6, 1977 at 1245 hours	
0	26.0	11.8
1	25.5	11.9
2	24.0	2.8
2.5	23.0	2.1
	Station 4	
	September 8, 1976 at 1600 hours	
0	23.0	13.6
1	23.0	13.6
2	21.0	10.8
3	20.0	9.0
4	19.0	5.1
5	18.0	1.2
6	14.0	0
6.5	12.0	0

Table 1.--Vertical Profiles--Continued

Depth (Meters)	Temperature (°C)	Dissolved Oxygen (mg/L)
	Station 4--Continued	
	March 16, 1977 at 1315 hours	
0	6.0	10.3
1	6.0	10.2
2	6.0	10.2
3	5.0	9.5
4	5.0	9.4
5	5.0	9.3
6	5.0	9.3
7	4.5	8.5
8	4.0	3.8
8.5	4.0	2.7
	April 12, 1977 at 1300 hours	
0	10.5	11.5
1	10.0	11.5
2	10.0	11.4
3	10.0	11.4
4	9.5	11.4
5	8.5	11.0
6	8.0	10.6
7	7.0	10.2
8	6.5	9.6
8.2	6.0	9.6
	May 24, 1977 at 1330 hours	
0	23.5	7.2
1	23.5	7.0
2	23.0	6.8
3	17.0	6.4
4	15.0	3.7
5	14.0	2.2
6	13.0	1.0
7	12.0	0
7.5	11.0	0

Table 1.--Vertical Profiles--Continued

Depth (Meters)	Temperature (°C)	Dissolved Oxygen (mg/L)
	Station 4--Continued	
	July 6, 1977 at 1300 hours	
0	25.0	9.5
1	24.5	9.2
2	24.0	8.4
3	22.5	3.8
4	19.5	0
5	16.5	0
6	15.0	0
7	13.5	0
8	12.0	0
9	11.5	0
	Station 5	
	September 8, 1976 at 1500 hours	
0	22.0	13.1
1	21.3	12.7
2	20.3	12.7
3	20.0	11.3
4	19.0	7.2
4.5	18.5	6.9
4.6	18.3	2.4
	March 16, 1977 at 1340 hours	
0	6.0	8.8
1	5.5	8.2
2	5.0	8.1
3	5.0	7.8
4	4.5	7.0
4.5	4.0	6.8
	April 12, 1977 at 1330 hours	
0	11.5	11.2
1	11.0	11.2
2	10.0	11.2
3	9.0	10.8
4	8.5	10.7
4.7	8.0	10.4

Table 1.--Vertical Profiles--Continued

Depth (Meters)	Temperature (°C)	Dissolved Oxygen (mg/L)
	Station 5--Continued	
	May 24, 1977 at 1345 hours	
0	24.5	7.0
1	24.5	6.9
2	24.0	6.9
3	18.0	6.0
4	16.0	3.0
4.5	13.5	0.5
	July 6, 1977 at 1330 hours	
0	25.0	9.2
1	25.0	9.2
2	24.5	9.2
3	24.5	9.2
3.5	22.0	2.2
4	21.0	0
5	17.0	0

Table 2.--Summary of Water Quality Data from Francis Slocum Lake
October 1976 - July 1977

(Units in milligrams per liter except as noted)
S = Surface B = Bottom

Parameter	Tributary to Abrahams Creek (Sta 1) 5 Samples	Abrahams Creek (Sta 2) 6 Samples		Lake (West arm) (Sta 3) 6 Samples*	Lake (at Dam) (Sta 4) 5 Samples*	Lake (East Arm) (Sta 5) 6 Samples*
pH (units)	6.3 - 7.6	6.2 - 7.2	S	5.9 - 9.7	6.2 - 9.5	6.5 - 9.4
			B	6.0 - 9.5	6.3 - 7.5	6.5 - 8.3
Sp Cond (μmho)	110 - 225	99 - 150	S	90 - 125	72 - 100	90 - 108
			B	72 - 110	72 - 120	80 - 104
TOC	4.1 - 7.0	3.2 - 6.3	S	14 - 15	11 --	- -
			B	- -	- -	- -
NO_3 - N	.33- .63	.40- .62	S	0 - 3.1	0 - 2.7	0 - 2.7
			B	.01- .44	0 - .32	0 - .29
TKN - N	.26- .63	.20- .45	S	.5 - 2.0	.40- 1.1	.40- 1.1
			B	.57- 1.8	.50- 1.7	.50- 1.7
NH_4-N	.01- .03	.01- .05	S	.02- .44	.03- .32	.03- .39
			B	.09- .21	.13- 1.1	.14- 1.1
Organic N	.23- .60	.19- .41	S	.42- 1.7	.31- 1.0	.32- 1.1
			B	.39- 1.6	.27- .69	.36- .60
Ortho PO_4 - P	.01- .04	.01- .05	S	0- .04	0- .04	0- .04
			B	.01- .03	.01- .19	.01- .19
Total P	.03- .06	.03- .09	S	.03- .16	.02- .07	.02- .06
			B	.03- .09	.03- .22	.03- .07
Fecal coli(No./100 mL)	120-4000	2-4000	S	0- 10	2- 38	0- 3
			B	0- 13	1- 8	1- 5
Fecal strep (No./100 mL)	370-2000	8-2000	S	1- 360	0- 11	2- 24
			B	2- 280	3- 20	1- 100

* - 4 samples from water near bottom

Table 3.--Concentrations of selected nutrients in the bed material in Francis Slocum Lake.

Station*	Date	Inorganic carbon (g/kg)	Organic carbon (g/kg)	Nitrogen (kjeldahl as N) (mg/kg)	Nitrogen (NO_2 + NO_3 as N) (mg/kg)	Nitrogen (NH_4 as N) (mg/kg)	Phosphorus (Total as P) (mg/kg)
3	9-08-76	0.0	68	5100	18	110	460
	4-12-77	.1	227	13	30	67	820
4	4-12-77	.1	73	6.2	8.2	180	2000
5	9-08-76	.2	88	7700	54	230	640
	4-12-77	.3	70	1.4	1.4	73	1100

* Sample collected from top 2 cm of bed material.

Stations 3, 4 and 5, lake stations: The chemical results from stations 3, 4 and 5 are generally comparable except during periods of thermal stratification, when the hypolimnion is anoxic, and chemical reduction of nutrients is optimized. Field data indicate thermal stratification persists from late May to the fall overturn in October. When an anoxic hypolimnion occurs, generally higher concentrations of nutrients are found in solution, particularly adjacent to the bottom sediments.

Summary

Chemical analyses of water samples collected at inflows and in the lake indicate no excessive sources of nutrients to the lake. Bed samples analyzed for carbon, nitrogen, and phosphorus revealed similar results. The periodic luxurient growth of algae and aquatic weeds is probably in response to a large percentage of lake volume within the trophogenic zone and the availability of recycled nutrients from the sediments.

Several management techniques are available to manipulate the lake biota and environment for enhancement. Some of these techniques produce as effective and satisfactory results as nutrient limitation and are easier to implement. However, deleterious side effects may be associated with manipulating a complex and incompletely understood ecosystem.

Problems at Francis Slocum Lake are associated with high natural fertility, shallowness, and resultant high dissolved oxygen demand in the hypolimnion during thermal stratification. Restoration methods to consider would include hypolimnetic withdrawal, hypolimnetic aeration, lake deepening, winter drawdown, biotic harvesting, nutrient inactivation, and chemical control.

Methods of lake restoration fall into two general categories: (1) limiting fertility and/or sedimentation, and (2) managing the consequences of eutrophication. Limiting nutrient inflow and sedimentation treat the underlying causes of eutrophication, whereas management is basically cosmetic. Many techniques, such as biotic harvesting, do not readily fall into one category because they manage a consequence and reduce the nutrient content at the same time.

The current study of Francis Slocum Lake has shown that the nutrients, sediments, and other undesirable materials are already in the lake and that little can be done to control them or negate the problem source. The only alternative is to manage the lake in order to make it more acceptable and enhance its potential use.

Note that the identification of an undesirable situation is largely subjective. For example, to the fisherman a shallow, weedy lake is desirable for high fish production, but to the boater and bather, weeds are undesirable.

Selected References

Dunst, Russell C. and others, 1974, Survey of lake rehabilitation techniques and experiences: Wisconsin Department of Natural Resources, Technical Bulletin no. 75, 197 p.

Kinney, W.L., and others, 1973, Measures for the restoration and enhancement of quality of freshwater lakes: U.S. Environmental Protection Agency - 4300/9-73-005, 238 p.