UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION
HARRISBURG, PENNSYLVANIA

EFFECTS OF ROADWAY AND POND CONSTRUCTION ON SEDIMENT YIELD NEAR HARRISBURG, PENNSYLVANIA

By

Lloyd A. Reed

U. S. GEOLOGICAL SURVEY OPEN-FILE REPORT

Prepared in cooperation with the
State Soil and Water Conservation Commission,
Pennsylvania Department of Environmental Resources
and the Pennsylvania Department of Transportation

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ABSTRACT

This report shows the effects that the construction of half a mile of one-lane roadway during June, July, and August 1970 and construction of a 5-acre pond during August and September 1970, had on sediment concentrations and sediment discharge of a stream draining an area of 0.76 square mile. The effects of the construction are shown by comparing the data collected from the affected basin with data collected from a similar adjacent basin, unaffected by construction.

During the pond construction, base-flow sediment concentrations increased from the expected 6 mg/l (milligrams per liter) to an average of 35 mg/l. Sediment discharge during June through December 1970 attributable to the construction was 55 tons, two-thirds of the amount normally expected during a year.

INTRODUCTION

The U.S. Geological Survey, the Pennsylvania Department of Transportation, and the State Soil and Water Conservation Commission, Department of Environmental Resources, are cooperating in a study to determine the effectiveness of sediment-control measures used during highway construction. The study includes five stream basins just west of Enola, Pa. Streamflow, sediment concentration, and turbidity are being measured at stations on each stream. To date, data have been collected to document the pre-highway construction condition of each of the five streams. Figure 1 shows the area being studied, the basin boundaries, the measuring stations, and the planned route of Interstate 81--the highway under study.

The objective of this report is to present data from two of the five basins; basin 1 is the base or control basin, and basin 2 was subject to the construction of half a mile of one-lane roadway and a 5-acre farm pond. This report presents an analysis of the data collected from October 1, 1969, through December 30, 1970, and shows the effects of the road and pond construction on the sediment concentrations and discharges of the stream draining the affected basin.

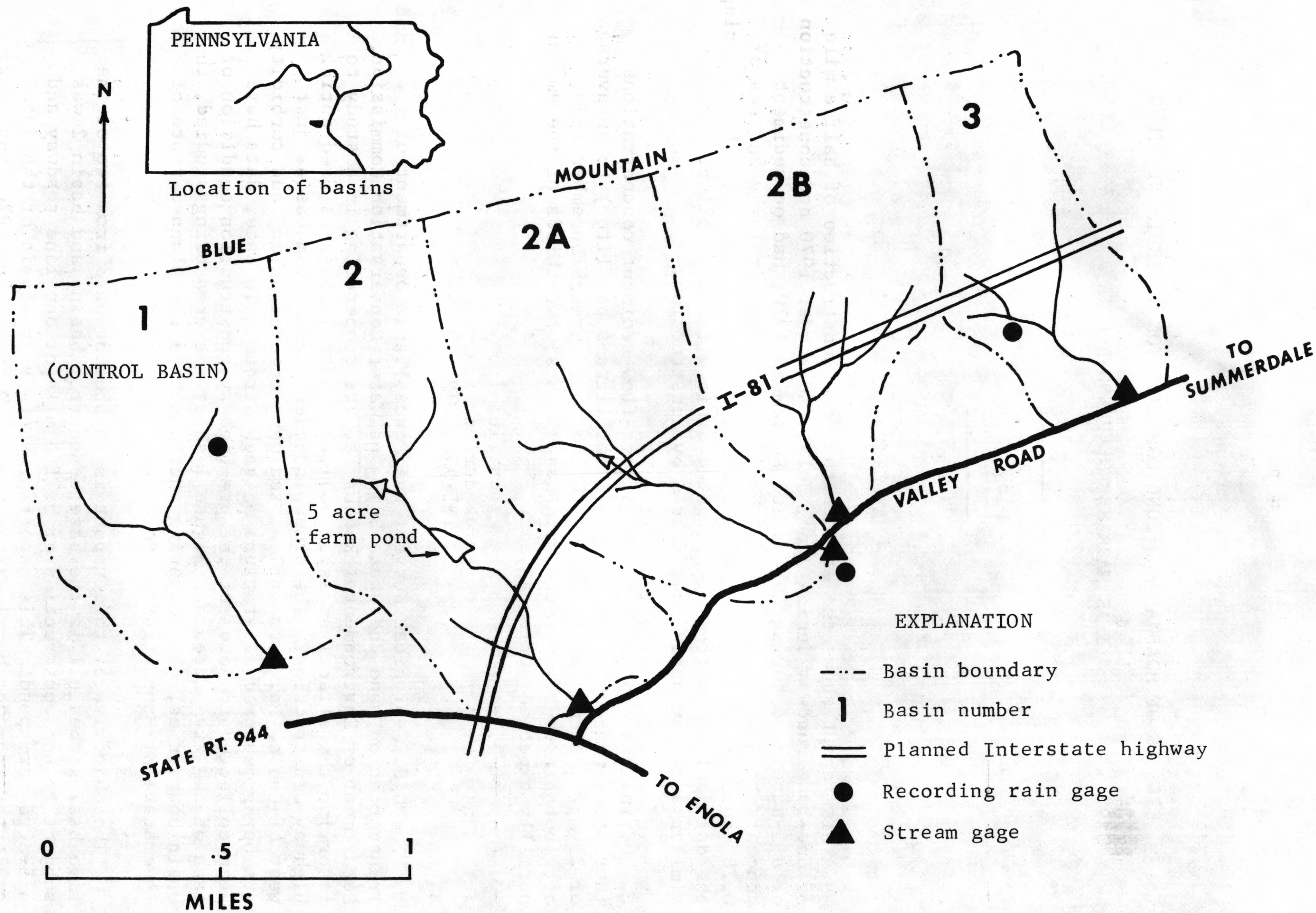


Figure 1.--Sketch map showing location of basins and data-collection sites.

THE BASINS

The length of the two basins extends from the crest of Blue Mountain (fig. 1) in a southeasterly direction, for an average distance of just over 1 mile, to the gaging stations along the Summerdale to Wertzville roadway. The average width of each basin is 0.6 mile. The basins are numbered from west to east and are drained by Conodoguinet Creek tributaries 1 and 2, respectively. Drainage areas at the gaging locations are 0.77 and 0.76 square mile.

Geology

Geology of the basins is similar. Blue Mountain is underlain with shale and sandstone belonging to the Clinton Group and quartzitic sandstone belonging to the Tuscarora Formation, both of Silurian age. The valley, from the base of the mountain, is underlain by shale belonging to the Martinsburg Formation of Ordovician age.

Topography

Topography in the basins ranges from relatively steep to nearly flat. Slopes on Blue Mountain average about 30 percent with some slopes as high as 50 percent. Slopes in the valley from the base of Blue Mountain to the gaging stations average about 4 percent. Stream slopes average about 1 percent in most of the valley area.

Soils

Soils on Blue Mountain are classified from very stony to stony and gravelly loams. The valley soils derived from the Martinsburg are mostly shaly silt loams from 1 to 5 feet thick, though most are 2 to 3 feet thick.

Land Use

Land use in both basins is similar. Forests occupy the mountainous areas and the steeper areas of the valley. The flatter areas in the valley are in open fields, a few are actively farmed, and the rest are in permanent grassland. In addition, 5 acres in basin 1 are used as pasture for 10 head of young stock. During the period of this investigation, there was no permanent population of livestock in either basin. The following table shows the land use in each basin, in acres, as of March 1970.

Land use	Basin 1 (acres)	Basin 2 (acres)
Forest cover-------------------------	320	260
Grassland----------------------------	140	170
Active farmland----------------------	20	50
Buildings and roadway----------------	10	10
Total--------------------------------	490	490

CONSTRUCTION IN BASIN 2

Data were collected from basin 2 (Conodoguinet Creek tributary 2) as part of the pre-construction data-collection program, before, during, and after the construction of a one-lane roadway and a farm pond. An aerial photograph (fig. 2) was taken on March 17, 1970, and shows the area in basin 2 before the roadway and pond construction began. A second aerial photograph was taken of the same area on August 18, 1970 (fig. 3). It shows the roadway when it was just being completed and the pond approximately half completed. The scale of each photograph is approximately 1 inch to 500 feet.

The normal storage capacity of the completed 5-acre pond is about 26 acre-feet. The drainage area above the pond is 302 acres. Construction of the roadway disturbed a 15-acre area, and construction of the pond disturbed a 10.5-acre area. All streamflow was retained by the pond (after its completion) until November, when the pond overflowed.

Construction of the pond was supervised by personnel from the U.S. Soil Conservation Service, and precautions were taken to avoid excess stream sedimentation. The stream was diverted for the clearing and grubbing operation at the dam breast and in the planned flooded area. The area disturbed by the road and pond construction was seeded immediately after the pond was completed.

DATA COLLECTION AND ANALYSIS

Continuous water-discharge data were collected at the gaging site on each stream. Suspended-sediment samples were collected periodically during base-flow periods and every 15 minutes during storm runoff by means of automatic sampling equipment. Water turbidity was measured by a surface-scatter turbidimeter and continuously recorded on a strip chart.

In this report, data collected from Conodoguinet Creek tributary 1, which does not have any construction activities, are used as a control, and are compared with data from tributary 2 to determine the effects of the roadway and pond construction.

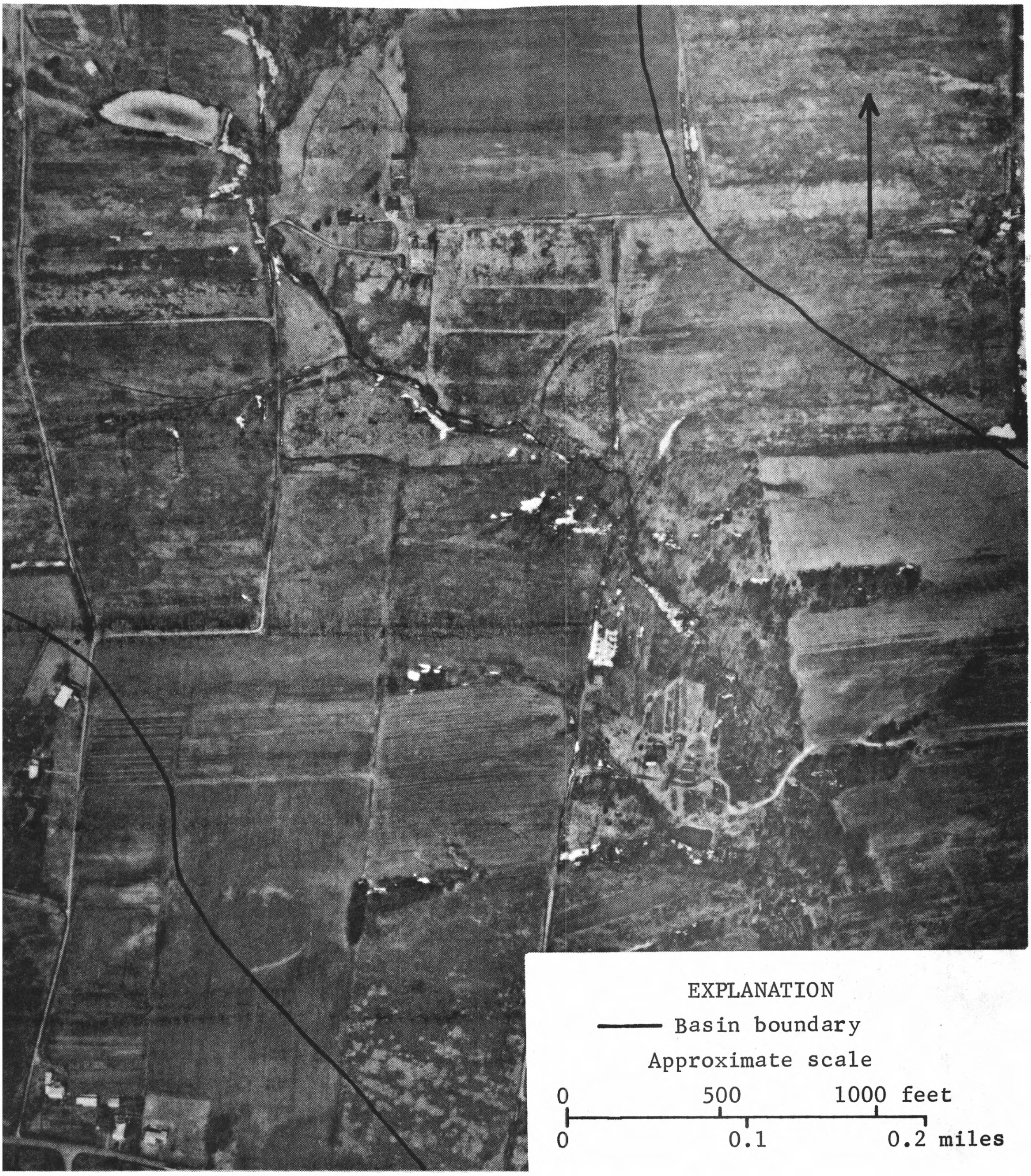


Figure 2.--Aerial photograph of basin 2 taken March 17, 1970 (Berger Associates, Inc.)

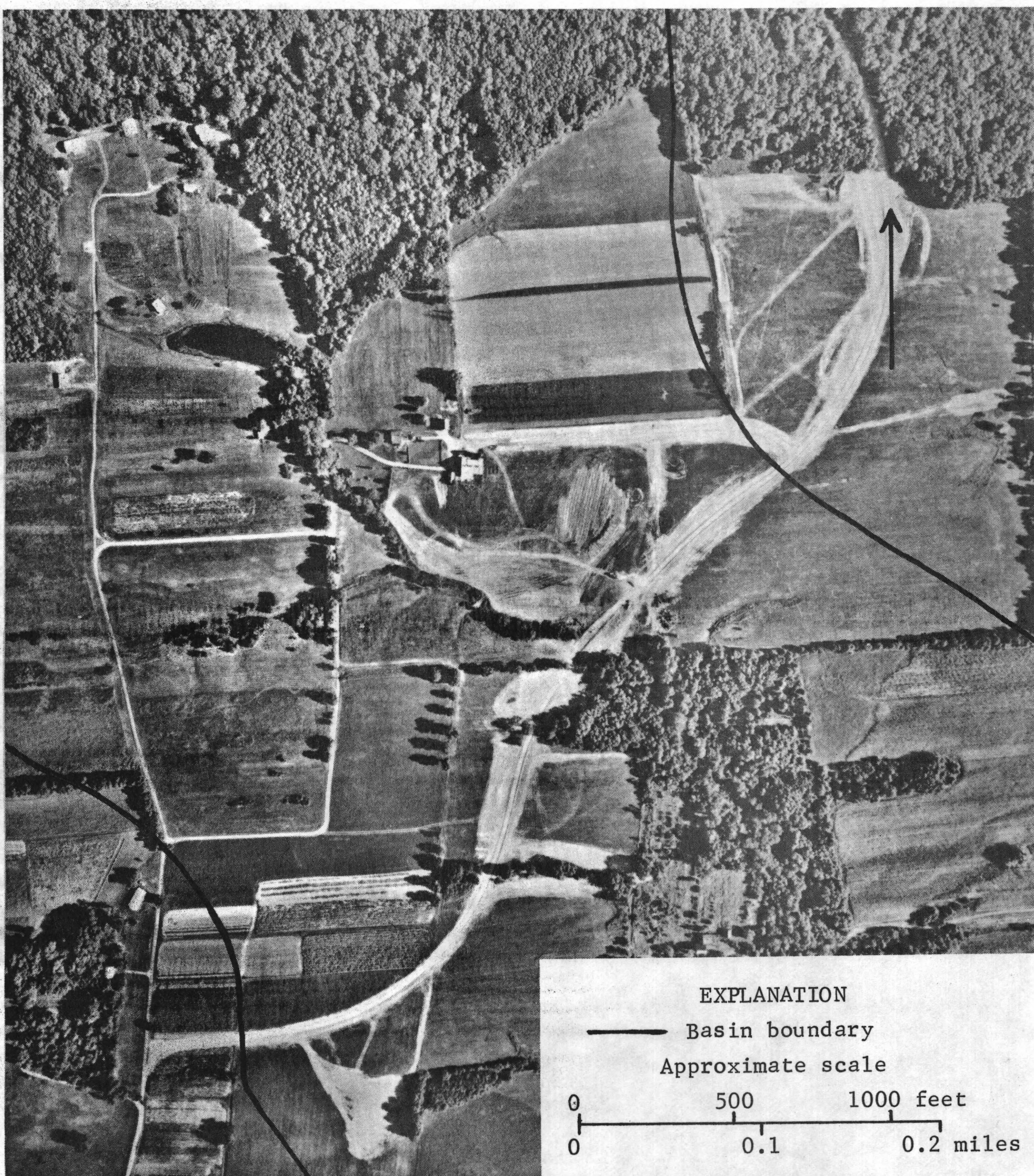


Figure 3.--Aerial photograph of basin 2 taken August 18, 1970 (Berger Associates, Inc.)

The data analysis that follows is divided into four sections. The first section is water discharge, the second is base-flow sediment concentrations, the third is sediment loads, in tons, and the fourth is stream turbidities.

Water Discharge

Water discharge, measured in cubic feet per second (cfs) was quite similar, with respect to total quantities and variability of flow from both basins prior to construction of the pond. During the 11-month period from October 1, 1969, to August 31, 1970, the period not affected by the filling of the pond, 330 and 350 CFS-days (210 and 230 million gallons) of water was discharged from basin 1 and basin 2, respectively. The highest monthly water discharge occurred in April, and the lowest monthly water discharge occurred the previous October. The following table shows the monthly water discharges from both basins in CFS-days and the total discharge for the 11-month period.

Monthly water discharge, in CFS-days, 1969-70

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Total
Basin 1----	2.5	7.8	23	16	78	35	96	32	12	19	4.2	330
Basin 2----	3.2	14	31	19	81	37	100	25	13	26	4.4	350

The effects of the pond on peak streamflows and summer low flows can not be evaluated at this time, as several years of data would be required for the evaluation.

Sediment Concentrations

Sediment concentrations were determined by collecting samples periodically during base-flow periods, when concentrations are normally low, and at more frequent intervals during storms when concentrations are normally high and changing rapidly. Sediment concentrations during base-flow periods are shown on figure 4 for the period October 1, 1969, to December 31, 1970. Figure 4 is a graph of the average base-flow suspended-sediment concentration and corresponding water discharge plotted by 6-day periods.

Figure 4 shows that the average base-flow sediment concentration in tributary 1 was about 5 mg/l (milligrams per liter) during the October 1969 to January 1970 low base-flow period, increased to about 10 mg/l during the February to April 1970 high base-flow period, and was about 6 mg/l during the late spring and early summer period. Average base-flow sediment concentration in tributary 2 was about 5 mg/l during the October 1969 to January 1970 low base-flow period, increased to about 12 mg/l during the February to April 1970 high base-flow period, and was about 6 mg/l during the low base-flow period in May.

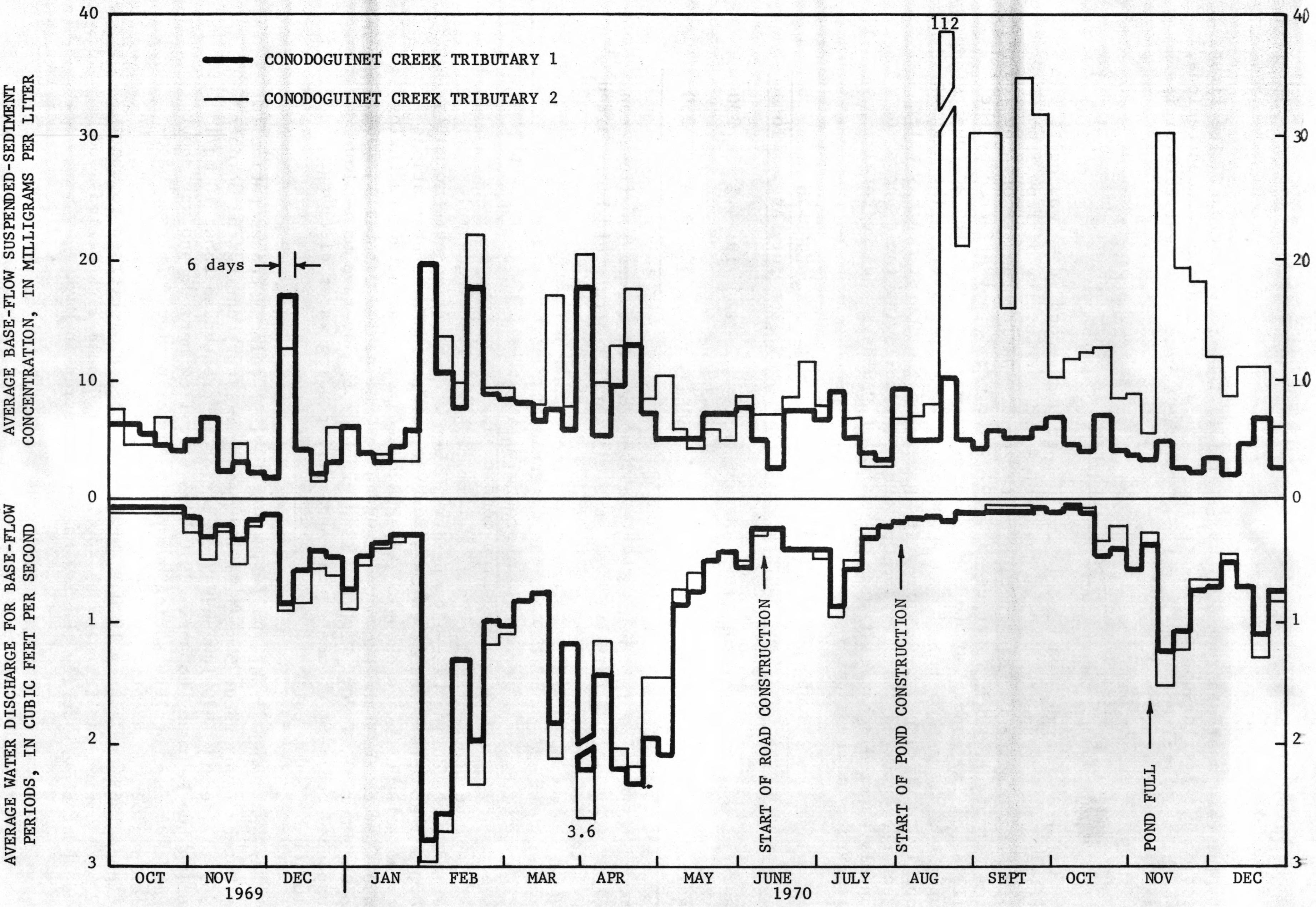


Figure 4.--Hydrograph showing average water discharge for base-flow periods and corresponding suspended-sediment concentrations, Conodoguinet Creek tributaries 1 and 2, October 1, 1969, to December 31, 1970.

Construction of the roadway in June and July to a point about 300 feet on either side of the stream, did not appreciably affect base-flow sediment concentrations, which averaged 7 mg/l for the period. A large storm was required to move material the 300 feet from the construction surface of the roadway to the stream channel. When sufficient rain fell to transport the material to the stream channel in early July, it also increased the base flow, which flushed the sediment laden water through the stream system. The pond was planned for the dual purpose of storing water and permitting the roadway to cross the stream on the dam.

Construction of the pond in August and September affected base-flow sediment concentrations. Base-flow concentrations averaged 35 mg/l during the August and early September period when the pond was being constructed (fig. 4), even though equipment was not operated in the stream. During the construction process, areas of compacted, rather impermeable soils were exposed or created adjacent to the stream. Storms resulting in only half an inch of precipitation caused quantities of sediment laden runoff water to enter the stream, but the stream was in a low base-flow period and there was insufficient flow to flush the sediment laden water rapidly down the stream system. During this period the stream had high sediment concentrations for several days as the sediment resulting from the small storms travelled slowly downstream, dispersing with the available base flow.

In October, when the pond was filling and water from upstream was being stored, the base-flow sediment concentration averaged 10 mg/l, down from the highs in August but above the expected 5 mg/l observed in tributary 1. In November, base-flow sediment concentrations increased to 30 mg/l, when the pond, which had stored sediment laden storm water, started overflowing. By December, sediment concentrations in tributary 2 averaged 10 mg/l, about twice the observed concentrations in tributary 1. High spring base flows should thoroughly flush the pond, and the stream should return to preconstruction conditions.

Figure 5 shows the base-flow sediment-concentration data from figure 4 plotted on a double-mass curve. The change in the sediment-concentration relation that corresponds with the start of pond construction can readily be seen on this graph.

Sediment Yield

Figure 6 shows the cumulative double-mass plot of the computed sediment discharge from basins 1 and 2 from October 1, 1969, to December 31, 1970. The double-mass plot shows graphically that there was roughly a 1 to 1 relation in sediment discharge between the two basins from October 1, 1969 to the start of road construction in June 1970. Example--from October 1, 1969, to April 30, 1970, 58 tons of sediment was discharged by tributary 2, while 62 tons was discharged by tributary 1.

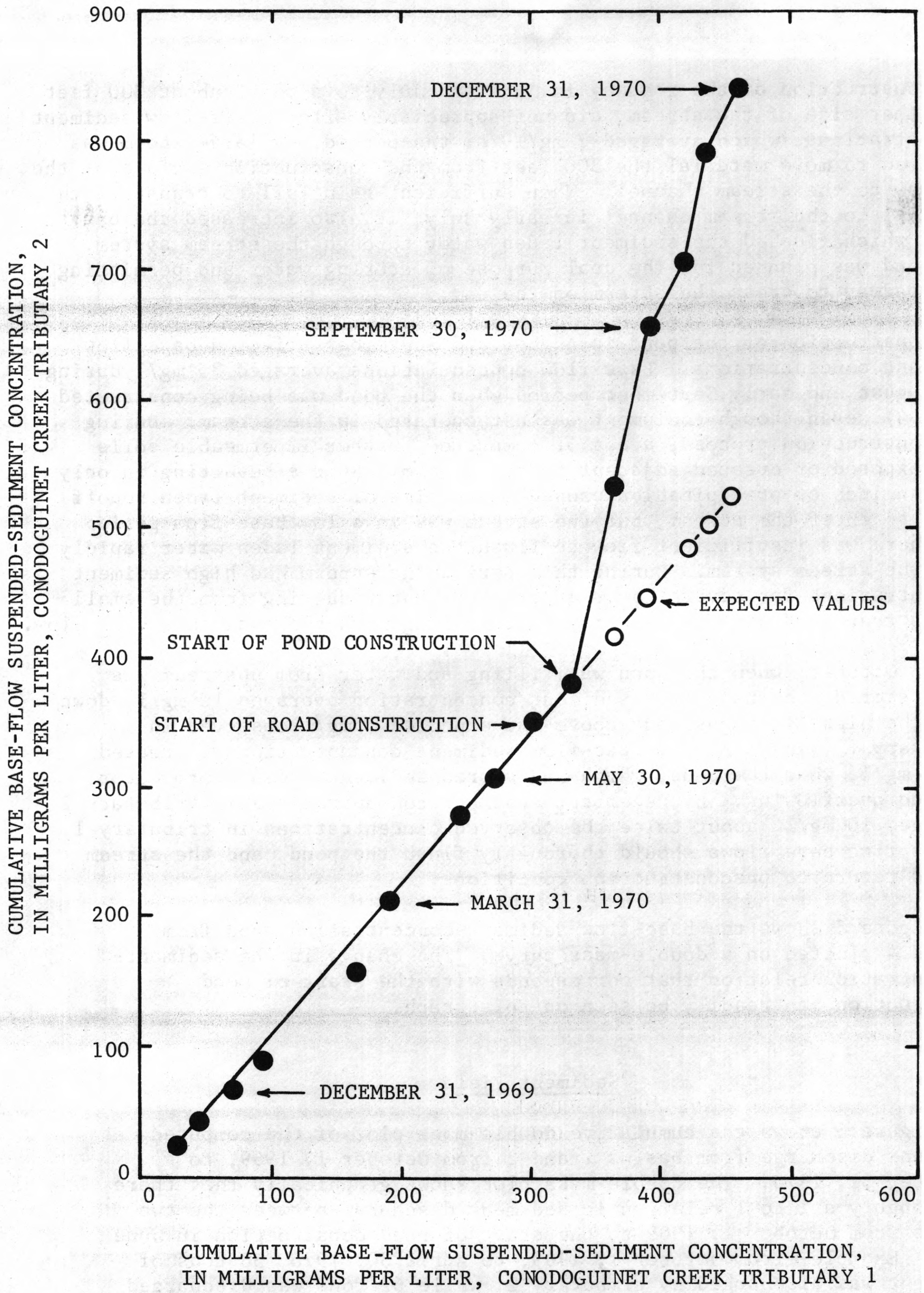
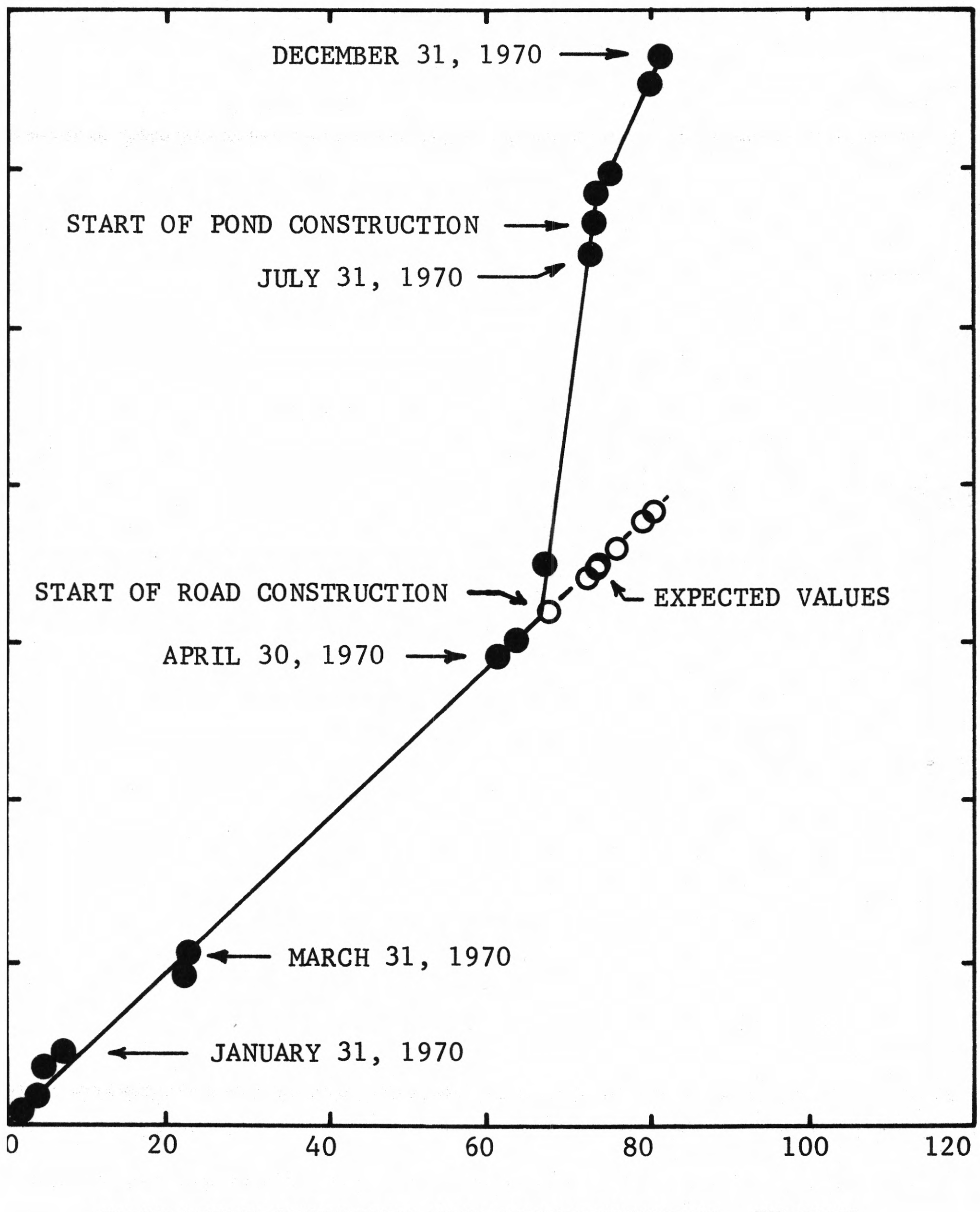


Figure 5.--Double-mass relation of average base-flow suspended-sediment concentrations by 6-day periods, Conodoguinet Creek tributaries 1 and 2, October 1, 1969, to December 31, 1970.



re 6.--Double-mass relation of sediment discharge, Conodoguinet eek tributaries 1 and 2, October 1, 1969, to December 31, 1970.

After the start of road construction the relation changed. From the start of road construction to the end of December 1970, 70 tons of sediment was discharged by tributary 2, while 15 tons was discharged by tributary 1. The increase in sediment yield was 55 tons. Data collected prior to construction indicated that the average sediment discharge from basin 2 was about 85 tons per year.

More than half the sediment discharged from basin 2 after the start of road construction was discharged in July, during two large storms. Only a relatively small amount of sediment was discharged during the construction of the pond, primarily because no large storms occurred.

Turbidity

Turbidity results from the reduction of transparency of water due to the amount of material in suspension. It is an optical property reflecting the size, shape, refractive index, and number of particles in suspension. Turbidity in this report is measured in the Jackson Turbidity Units (JTU). The U.S. Public Health Service (1962, p. 6) has recommended a maximum limit of 5 JTU for water used for human consumption.

Stream water turbidity is continuously measured and recorded at the gaging station on tributary 2 by means of a surface scatter turbidimeter. Continuous turbidity is not recorded at tributary 1. Figure 7 shows the average base-flow turbidity by 6-day periods and the corresponding water discharge, in cubic feet per second, for tributary 2.

Figure 7 shows that the average base-flow turbidity was 4 JTU for the October through January low base-flow period and about 8 JTU for the February through April high base-flow period. During the low base-flow period in May the average turbidity was less than 4 JTU.

During the construction of the roadway in June, July, and early August, the average base-flow turbidity was 7 JTU. After the start of pond construction, average base-flow turbidity increased to 33 JTU for the 1-month period during construction, and the average was 18 JTU for the 2-month period when the pond was filling. During November and December, when the pond was overflowing, the average base-flow turbidity was 15 JTU.

CONCLUSIONS

This report shows the effects that construction of half a mile of one-lane roadway and a 5-acre pond had on sediment concentration and sediment discharge of the stream half a mile below the pond construction, where total drainage area is 0.76 square mile. The roadway was constructed during June, July, and August 1970, and the pond was constructed in August and September 1970. From the middle of September to the first of November the pond was filling, and it stored all the water from its 302 acre (0.46 square mile) drainage area.

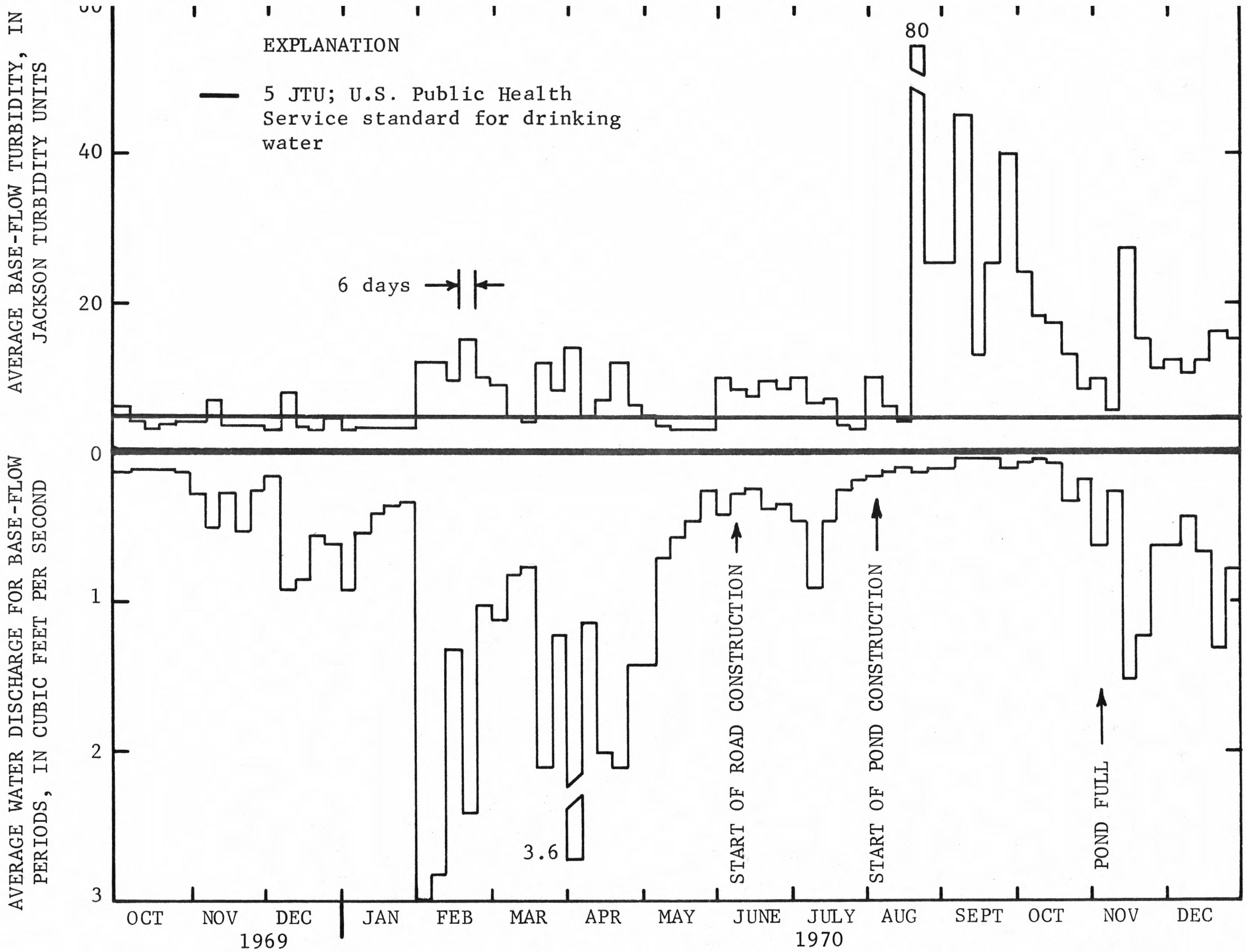


Figure 7.--Average base-flow turbidities and corresponding water discharges, Conodoguinet Creek tributary 2, October 1, 1969 to December 31, 1970.

Water, sediment, and turbidity data are presented in this report from two basins, the one affected by construction and an adjacent basin that was not affected. Data from October 1, 1969, through December 31, 1970, are presented to show the relation between the two basins before, during, and after construction.

Base-flow sediment concentrations increased from the expected 6 mg/l to an average of 35 mg/l during the period of pond construction. In December, after the pond was overflowing for 1 month, the base-flow sediment concentration at the gage was twice what would have been expected under normal conditions. Sediment discharge attributable to the road and pond construction was 55 tons, which is 66 percent of the yearly quantity expected from the basin under normal conditions.

Base-flow turbidity in the stream increased from an average of 6 JTU for the 10-month period prior to construction of the pond to an average of 33 JTU for the 1-month period during pond construction. Turbidity averaged 18 JTU for the 2-month period while the pond was filling and 15 JTU for the 2-month period, November and December, when the pond was overflowing. The high spring flows in 1971 appear to have flushed the pond and stream. Turbidity and sediment concentrations have returned to their pre-construction values.

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