

**LOWER WOONASQUATUCKET RIVER
BIOCHEMICAL OXYGEN DEMAND REACTION RATES
AND TIME OF TRAVEL STUDIES**

May, July and October, 1974

**U.S. Environmental Protection Agency
Region I
Surveillance and Analysis Division
240 Highland Avenue
Needham, MA 02194**

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Overview

In response to a request from the Rhode Island Water Pollution Control Agency, Division of Water Supply and Pollution Control, personnel from the United States Environmental Protection Agency's (EPA) Region I, Surveillance and Analysis Division (S & A), conducted a survey on the lower Woonasquatucket River during September, 1974. The purpose of the survey was to augment work done by the State of Rhode Island by determining the biochemical oxygen demand (BOD) reaction rate (K) for that portion of the river between Georgiaville Pond, Georgiaville, and the Eagle Street Bridge, Providence. The Eagle Street Bridge was considered to be the lower-most portion of the river not influenced by tidal actions. During the survey, personnel recorded the gage height at the United States Geological Survey (USGS) Gage at Smith Street, Centerdale, Rhode Island. The flows encountered during the survey are shown in Table 1.

Sampling and Analysis

S & A set up five sampling stations below the Georgiaville Pond outlet (WQTR01 - WQTR05) and one station at the outlet itself (WQTE07). Table 2 and Figure 1 describe and show the sampling station locations. EPA personnel collected water samples at Stations WQTE01 - WQTE05 three times daily and two times daily at Station WQTE07 for three days. The field crew composited the daily samples for each station and hand delivered these to EPA's Needham Laboratory (NERL) for BOD rate analyses.

TABLE 1

FLows AT THE USGS GAGE AT CENTERDALE, RHODE ISLAND - RIVER KILOMETER 10.5
RIVER MILE 6.5

<u>DAY</u>	<u>Flow</u>	
	<u>Cubic Meters Per Second</u> <u>(CMS)</u>	<u>Cubic Feet Per Second</u> <u>(CFS)</u>
October 1, 1974	1.10	39.0
October 2, 1974	1.05	37.0
October 3, 1974	1.00	35.0

Note: The seven consecutive day low flow with a recurrence interval of 10 years (7-10 low flow) for this gage is 0.24 CMS (8.3 CFS).

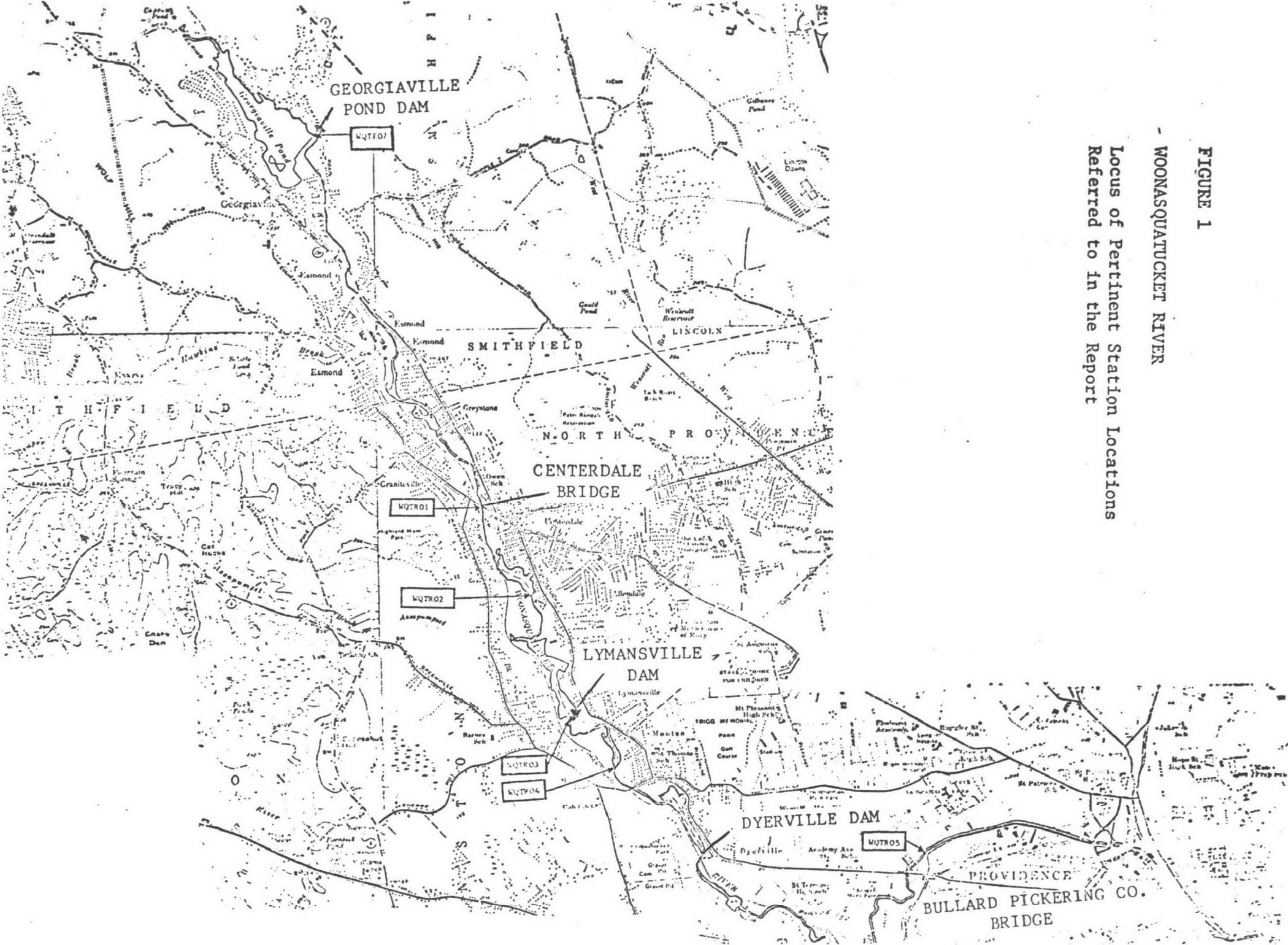
TABLE 2
SAMPLING STATION LOCATIONS AND DESCRIPTIONS

Station	River Distance		Latitude			Longitude			Description
	Kilometer	Mile	°	'	"	°	'	"	
WQTE 07	15.0	9.3	41	53	35	71	30	26	Georgiaville Pond immediately prior to discharge over outlet dam.
WQTR 01	10.5	6.5	41	51	33	71	29	17	Woonasquatucket River by USGS gaging station immediately downstream of the Route 44 bridge at Centerdale, Rhode Island.
WQTR 02	9.4	5.8	41	51	02	71	28	56	Woonasquatucket River immediately upstream of the dam by Allandale Road near Allendale, Rhode Island.
WQTR 03	7.9	4.9	41	50	22	71	28	39	Woonasquatucket River immediately upstream of Lymanville Dam behind the Ronci Industrial Park, Lymanville, Rhode Island.
WQTR 04	6.9	4.3	41	50	06	71	26	11	Woonasquatucket River immediately upstream of Manton Dam, Johnston, Rhode Island
WQTR 05	1.6	1.0	41	49	35	71	24	28	Woonasquatucket River on the upstream side of the Eagle Street Bridge, Providence, Rhode Island.

FIGURE 1

- MOONASQUATUCKET RIVER

Locus of Pertinent Station Locations
Referred to in the Report



In addition, personnel recorded the temperature and preserved a portion of each individual sample making up the composite samples for subsequent dissolved oxygen determinations at NERL. Samples were collected by hand dipping or using a bucket.

EPA's Region I chain of custody procedures were in effect at all times.

Time of Travel Studies

In addition to the BOD K rate studies, EPA personnel conducted two time of travel studies to assist the state in interpreting the significance of the K rates in relation to the actual river. These studies are discussed in Appendix I.

Results

The results of the sampling and analyses efforts are given in Table 3.

TABLE 3
RESULTS OF ANALYSES OF SAMPLES COLLECTED ON THE LOWER WOONASQUATUCKET RIVER

Station	Date	Time (Hours)	Temp (°C)	Dissolved Oxygen (mg/l)	BOD		K (1/Day)		
					5-day (mg/l)	Ult. (mg/l)	Base 10	Base e	
WQTR01	10/01/74	0825	15.0	8.8	---	---	---	---	
		1030	15.5	9.0	---	---	---	---	
		1235	16.0	9.7	---	---	---	---	
	10/02/74	9999*	---	---	---	3	6	0.04426	0.10192
		0830	15.5	9.0	---	---	---	---	
		1005	15.5	9.5	---	---	---	---	
		1300	16.0	9.6	---	---	---	---	
		9999	---	---	---	2	3	0.23496	0.54112
		10/03/74	0815	14.5	9.0	---	---	---	---
	10/03/74	0920	14.5	9.5	---	---	---	---	
		1045	14.5	9.6	---	---	---	---	
		9999	---	---	---	2	5	0.03511	0.08086
		Average	---	---	---	---	---	0.10478	0.24130
	WQTR02	10/01/74	0845	15.5	8.3	---	---	---	---
1045			15.5	8.5	---	---	---	---	
1245			16.0	8.6	---	---	---	---	
9999			---	---	---	3	6	0.07238	0.16669
10/02/74		0845	15.5	8.7	---	---	---	---	
		1015	15.5	8.8	---	---	---	---	
		1310	15.0	8.7	---	---	---	---	
		9999	---	---	---	2	3	0.19821	0.45648
10/03/74		0830	14.5	8.9	---	---	---	---	
		0925	14.5	8.8	---	---	---	---	
		1055	14.5	8.9	---	---	---	---	
		9999	---	---	---	4	4	0.21387	0.49254
Average		---	---	---	---	---	0.16149	0.37190	
WQTR03		10/01/74	0915	17.0	8.6	---	---	---	---
	1055		17.0	9.0	---	---	---	---	
	1300		17.0	8.8	---	---	---	---	
	9999		---	---	---	4	6	0.08055	0.18551
	10/02/74	0900	15.5	8.8	---	---	---	---	
		1035	15.5	8.9	---	---	---	---	
		1320	16.5	9.2	---	---	---	---	
		9999	---	---	---	3	3	0.26219	0.60383
	10/03/74	0840	14.5	9.2	---	---	---	---	
		0935	14.5	9.0	---	---	---	---	
		1105	14.5	9.3	---	---	---	---	
		9999	---	---	---	3	4	0.13429	0.30927
	Average	---	---	---	---	---	0.15901	0.36620	

*9999 denotes composite sample of three previous grab samples.

TABLE 3 (CONT.)
RESULTS OF ANALYSES OF SAMPLES COLLECTED ON THE LOWER WOONASQUATUCKET RIVER

Station	Date	Time (Hours)	Temp (°C)	Dissolved Oxygen (mg/l)	BOD		K (1/Day)	
					5-day (mg/l)	Ult. (mg/l)	Base 10	Base e
WQTR04	10/01/74	0930	17.0	8.1	--	--	--	--
		1110	17.0	9.0	--	--	--	--
		1320	17.0	9.2	--	--	--	--
		9999	--	--	4	7	0.06740	0.15523
	10/02/74	0920	15.5	8.7	--	--	--	--
		1055	16.0	9.1	--	--	--	--
		1325	17.0	9.6	--	--	--	--
		9999	--	--	2	3	0.16806	0.38704
	10/03/74	0850	14.5	9.0	--	--	--	--
		0950	14.5	9.2	--	--	--	--
		1120	14.0	9.6	--	--	--	--
		9999	--	--	3	4	0.11489	0.26459
	Average						0.16783	0.26895
WQTR05	10/01/74	0955	15.0	9.6	--	--	--	--
		1125	15.0	9.8	--	--	--	--
		1335	16.5	9.6	--	--	--	--
		9999	--	--	3	11	0.07341	0.16905
	10/02/74	0940	15.0	9.8	--	--	--	--
		1110	15.5	10.0	--	--	--	--
		1340	--	9.5	--	--	--	--
		9999	--	--	3	3	0.29331	0.67550
	10/03/74	0905	13.5	10.1	--	--	--	--
		1005	13.5	10.2	--	--	--	--
		1130	14.0	10.5	--	--	--	--
		9999	--	--	2	3	0.14730	0.33922
	Average						0.17134	0.39459
WQTE07	10/01/74	1030	18.0	8.6	--	--	--	--
		1345	19.0	8.5	--	--	--	--
		9999	--	--	2	5	0.05823	0.13411
	10/02/74	0935	17.0	8.2	--	--	--	--
		1120	18.0	8.6	--	--	--	--
		9999	--	--	2	3	0.11802	0.27180
	10/03/74	0900	16.0	8.3	--	--	--	--
		1035	16.0	8.9	--	--	--	--
		9999	--	--	1	2	0.09602	0.22114
		Average						0.09756

APPENDIX I
WOONASQUATUCKET RIVER TIME OF TRAVEL

The time of travel studies conducted on the Woonasquatucket River from the Georgiaville Pond outlet to the Park Street Bridge, Providence, Rhode Island, consisted of timing the passage of Rhodamine WT and B dyes using cuvette and recording flow-through fluorometers to detect fluorescence. The time of travel was taken as the peak of the dye mass where sharp normal peaks occurred. When the dye patch passed the pick-up location strung out or excessive skewness occurred, the calculated centroid was used as the time of travel. These time of travel are shown in Table I-1 and Figures I-1 through I-4 for both the May high flow and July low flow dye surveys. The average flows at the Centerdale, Rhode Island, gage during each study are shown below:

<u>Date</u>	<u>Average Flow</u>	
	<u>Cubic Meters per Second (CMS)</u>	<u>Cubic Feet per Second (CFS)</u>
May, 1974	2.21	78
July, 1974	0.75	28.5

From time of travel conducted during high flow and low flow conditions, a logarithmic relation can be developed for different flows in the river (Figures I-1 through I-4). Thus, time of travel for various stretches of the river under various flow conditions can be found from the two time of travel studies data (Figure I-5).

The following example demonstrates how to use Figures I-1 through I-5.

To determine the time of travel at 1.05 cms (37 cfs) measured at the Centerdale gage (the average flow during the water quality survey)

from the dam at Allendale, river kilometer 9.33, to river kilometer 4.02, turn to Figures I-1 through I-4. Determine the time of travel for the established reaches and plot this curve, (unique for 1.05 cms) on Figure I-5. Then determine the time value at river kilometer 9.33 (mile 5.8) (9.7 hours) and subtract this from the time value at river kilometer 4.02 (mile 2.5) (22.0 hours). This tells the time of travel (12.3 hours) from the Allendale Dam to river kilometer 4.02 at a flow of 1.05 cms (37 cfs) measured at the Centerdale gage.

TABLE I-1
WOONASQUATUCKET RIVER TIME OF TRAVEL*

From	Reach	To	Length of Reach Kilometers (Miles)	Average Velocity Meters per Sec. (Feet per Sec.)		Reach Time of Travel (In Hours)		Cumulative Time of Travel (In Hours)	
				May	July	May	July	May	July
Georgiaville Pond Dam		Centerdale Bridge	4.5 (2.8)	0.22 (0.72)	0.22 (0.72)	5.7	5.7	5.7	5.7
Centerdale Bridge		Lymansville Dam	2.6 (1.6)	0.15 (0.48)	0.09 (0.30)	7.9	9.5	13.6	15.2
Lymansville Dam		Dyerville Dam	2.3 (1.45)	0.17 (0.57)	0.13 (0.42)	3.6	5.0	17.2	20.2
Dyerville Dam		Bullard Pickering Co. Bridge (Olneyville R. I.)	2.0 (1.25)	0.35 (1.14)	0.12 (0.38)	1.6	4.8	18.8	25.0

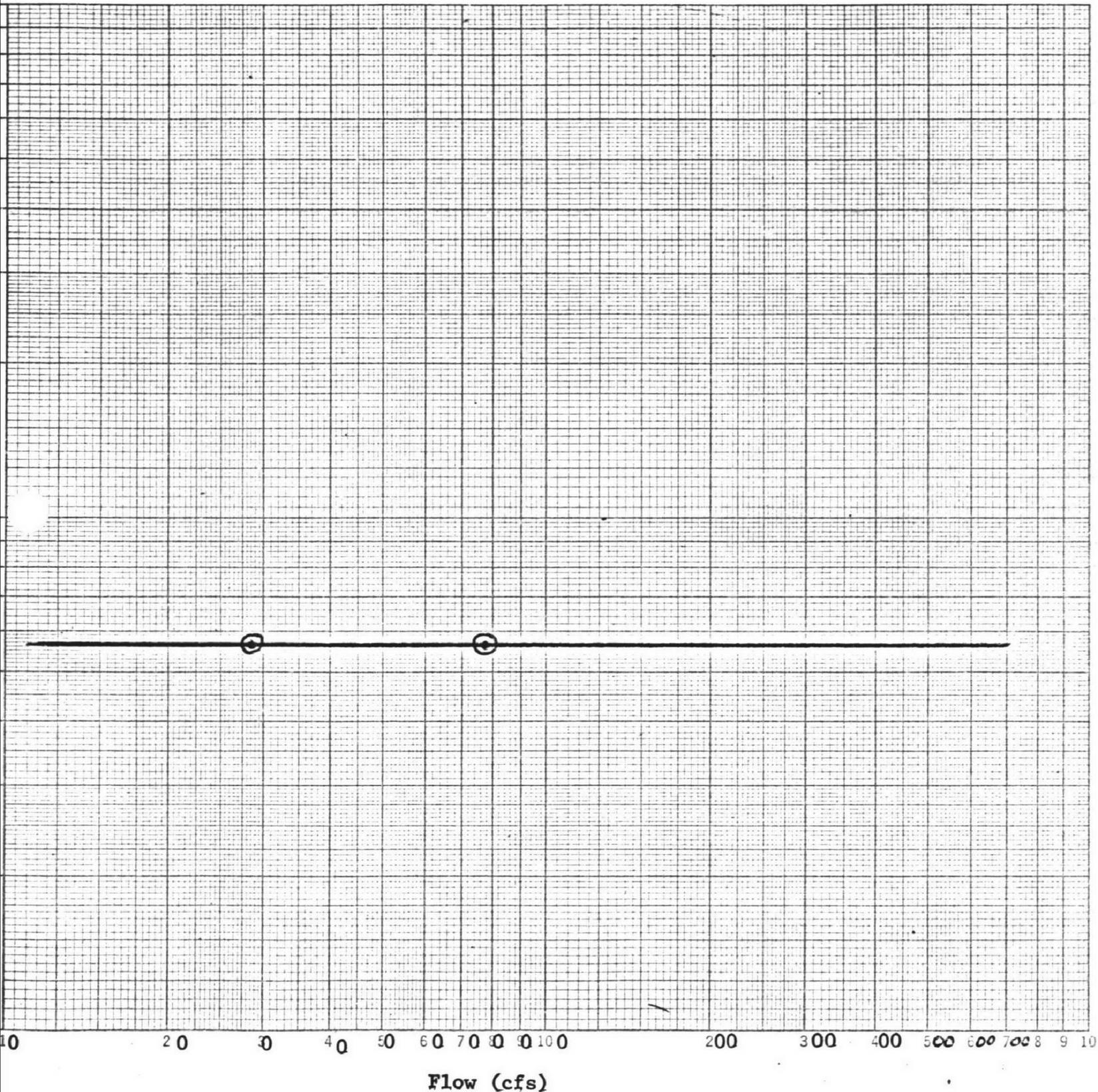
*Average flows in the river during the studies were:

Flow	May	July	7-10 Low Flow
Cubic meters per sec.	2.21	0.75	0.24
Cubic feet per sec.	78.0	28.5	8.3

Figure I-1
WOONASQUATUCKET RIVER

Time of Travel Vs. Flow

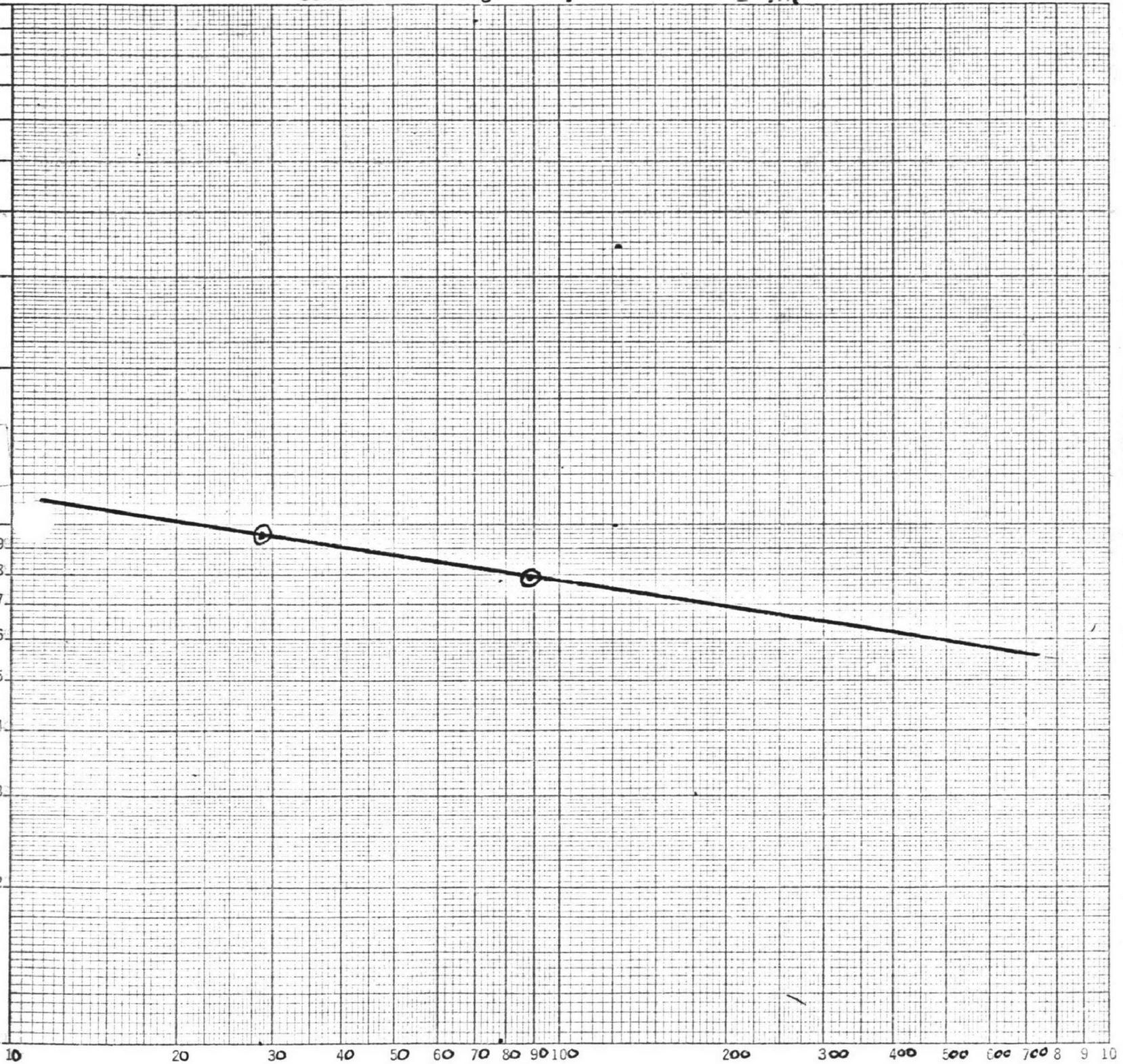
Georgiaville Pond Dam to Centerdale Bridge



NOTE: To convert cfs to cms, multiply by 0.028.

FIGURE I-2
WOONASQUATUCKET RIVER

Time of Travel Vs. Flow
Centerdale Bridge to Lymansville Dam

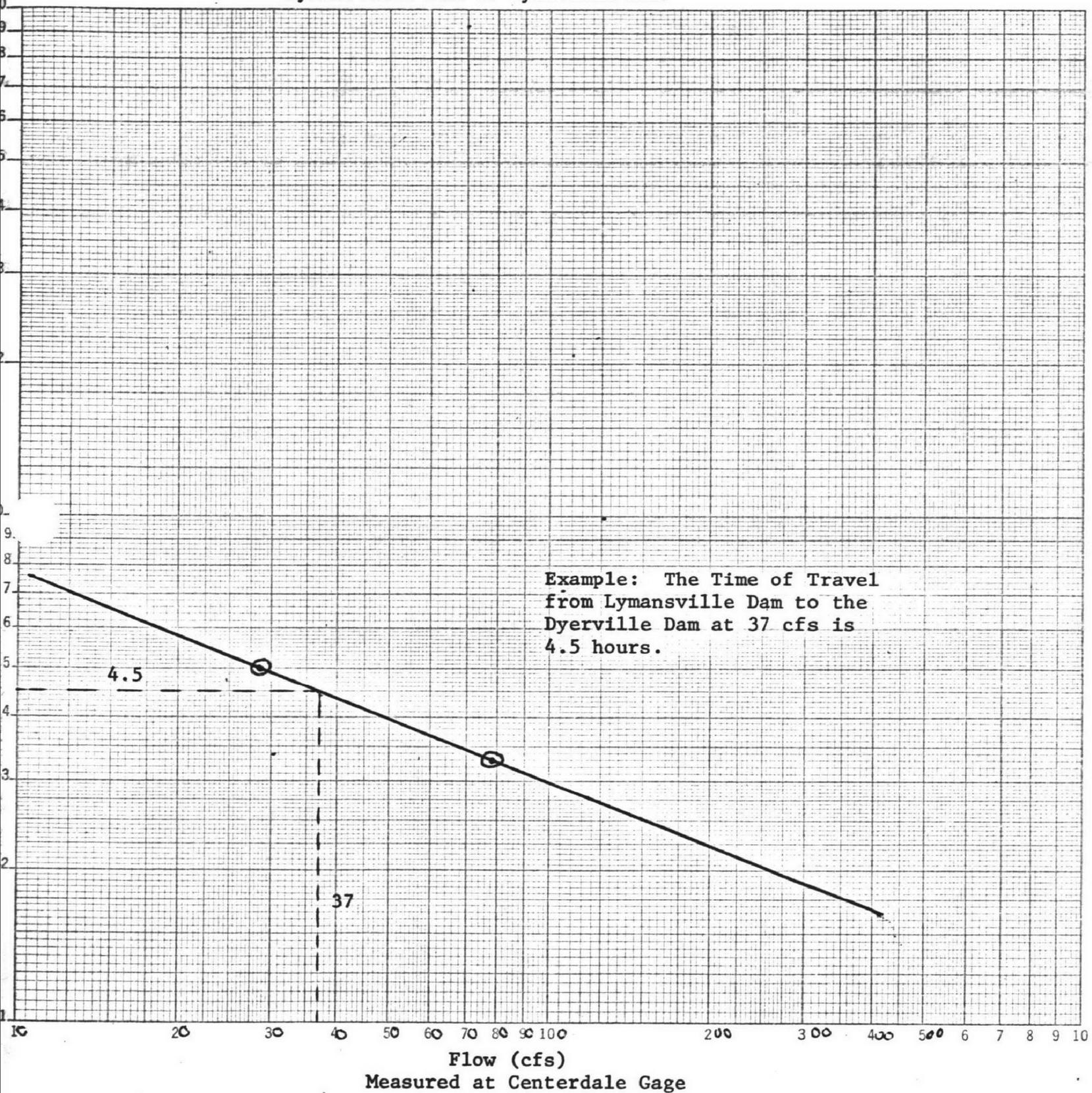


Flow (cfs)
Measured at Centerdale Gage

NOTE: To convert cfs to cms, multiply by 0.028.

FIGURE I-3
WOONASQUATUCKET RIVER

Time of Travel Vs. Flow
Lymansville Dam to Dyerville Dam

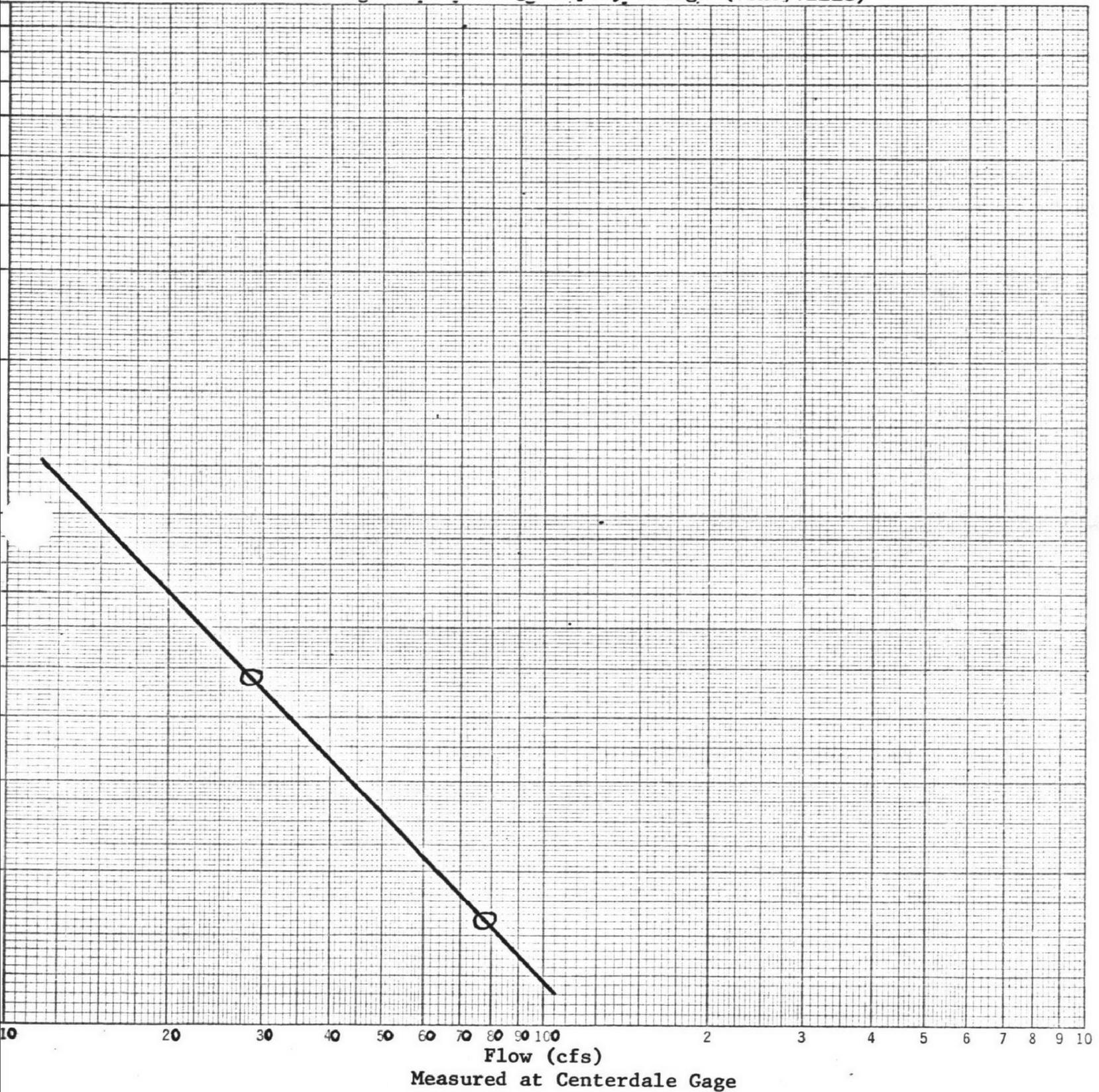


NOTE: To convert cfs to cms, multiply by 0.028.

FIGURE I-4
WOONASQUATUCKET RIVER

Time of Travel Vs. Flow

Dyerville Dam to the Bullard Pickering Company Bridge (Olneyville)



Note: To convert cfs to cms, multiply by 0.028.

FIGURE I-5
 WOONASQUATUCKET RIVER

Time of Travel
 (Flow Measured at Centerdale Gage)

