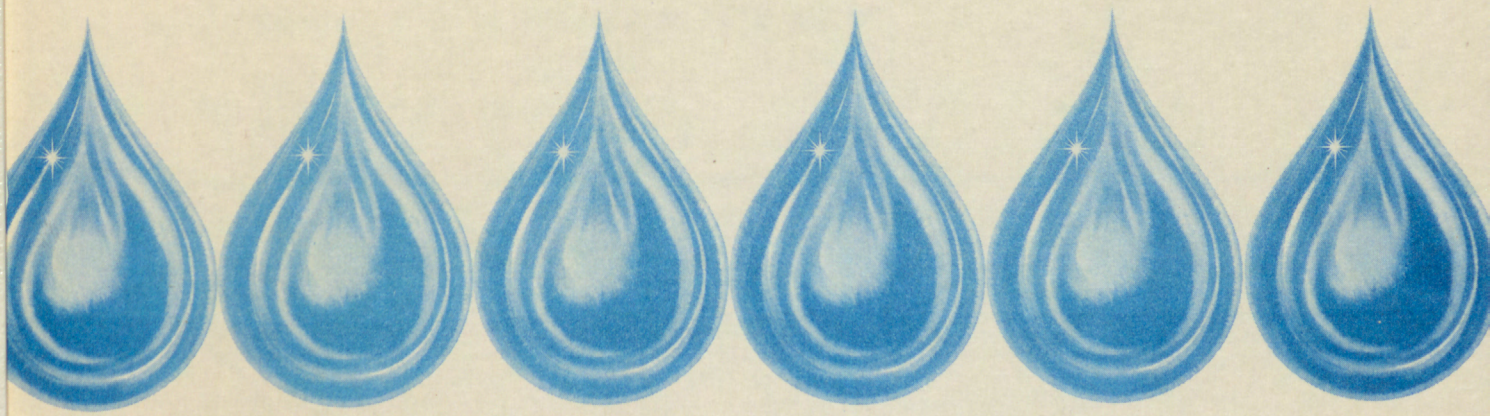
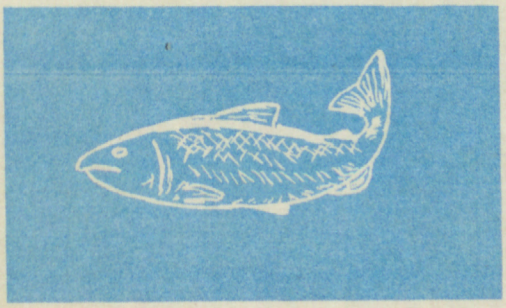


FLOOD ELEVATIONS FOR THE SOOES RIVER AT PROPOSED FISH HATCHERY, CLALLAM COUNTY, WASHINGTON - A SURFACE-WATER SITE STUDY



U.S. GEOLOGICAL SURVEY
Water-Resources Investigations 78-130

Prepared in Cooperation With
U.S. Fish and Wildlife Service

FLOOD ELEVATIONS FOR THE SOOES RIVER AT PROPOSED FISH HATCHERY, CLALLAM COUNTY, WASHINGTON - A SURFACE-WATER SITE STUDY

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Tacoma, Washington
1979

UNITED STATES DEPARTMENT OF THE INTERIOR

CECIL D. ANDRUS, Secretary

GEOLOGICAL SURVEY

H. William Menard, Director

Open-File Report

For additional information write to:

U.S. Geological Survey
1201 Pacific Avenue - Suite 600
Tacoma, Washington 98402

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ILLUSTRATIONS

FLOOD ELEVATIONS FOR THE SOOES RIVER AT PROPOSED FISH HATCHERY, CLALLAM COUNTY, WASHINGTON - A SURFACE-WATER SITE STUDY

By J. H. Bartells

ABSTRACT

Water-surface elevations were derived for various combinations of selected river discharges and tide elevations along a reach of the Sooes River 3 miles upstream from the mouth at the site of a proposed fish hatchery. The study was performed for the Denver Engineering Center of the U.S. Fish and Wildlife Service.

Flood-frequency analyses determined river discharges having exceedence probabilities of 1, 2, 4, 10 and 20 percent (100-, 50-, 25-, 10-, and 5-year recurrence intervals) and tide elevations having exceedence probabilities of 1 and 50 percent (100- and 2-year recurrence intervals). A relationship was developed for determining river water-surface elevation for different combinations of river discharge and tide elevations. Seven different combinations of channel and flood-plain conditions that may be expected to occur during and after construction were simulated and water-surface elevations determined by use of the step-backwater computer program.

INTRODUCTION

This study was performed by the Water Resources Division of the U.S. Geological Survey, Tacoma, Washington, for the Engineering Center of the U.S. Fish and Wildlife Service, Denver, Colorado. The purpose of the study is to derive water-surface elevations for selected flood discharges in the Sooes River for various channel and flood-plain conditions that may be expected to occur during and after construction of a fish hatchery at a site on the west bank of the river. The selected flood events are those having a 1, 2, 4, 10 and 20 percent chance of being equaled or exceeded during any year. They are referred to in this report as floods having recurrence intervals of 100, 50, 25, 10, and 5 years.

For the reach of the Sooes River under study, the U.S. Fish and Wildlife Service furnished aerial photographs at a scale of 1 inch equals 500 feet, distance and elevation data for 12 ground-surveyed cross sections, and a list of seven conditions to be simulated.

The basic data and the computations supporting the data presented in this report are in the files of the U.S. Geological Survey, Water Resources Division, Tacoma, Washington. All elevations given in this report are in feet above mean lower low water (MLLW), which corresponds to -4.3 feet National Geodetic Vertical Datum of 1929 (NGVD).

DESCRIPTION OF SITE

The proposed fish hatchery is located on the west bank of the Sooes River on the Makah Indian Reservation, in the NE¼ sec. 8, T.32 N., R.15 W., 3.0 miles upstream from the river mouth at Mukkaw Bay, and 5.3 miles south of the town of Neah Bay, Clallam County, Wash. (fig. 1). The drainage area upstream from this point is 39 square miles, as determined by the U.S. Geological Survey from the Cape Flattery, Lake Pleasant and Ozette Lake 15-minute quadrangle maps. The basin is timber covered with dense undergrowth, ranges in elevation between sea level and 1,900 feet, and has a mean annual precipitation of 100 inches (U.S. Weather Bureau, 1965).

The river in the vicinity of the hatchery site has a very flat gradient, and water-surface elevations are affected by tidal fluctuations. The flood plain is broad and flat and in its natural state is covered with trees and very dense undergrowth. Some clearing and ground preparation work has already been done at the hatchery site.

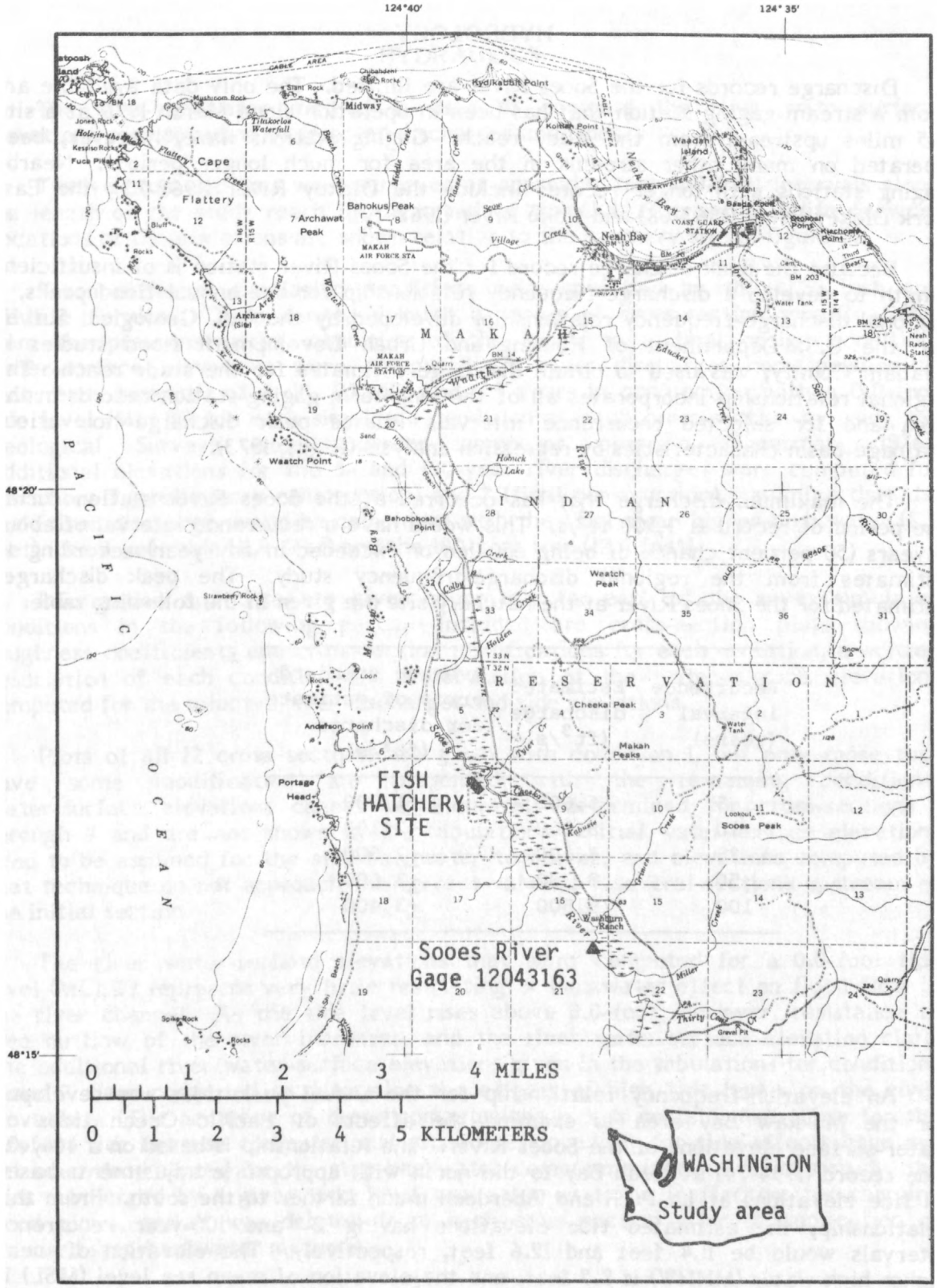


FIGURE 1.--Map showing study area.

HYDROLOGY

Discharge records for the Sooes River are limited. The only data available are from a stream-gaging station that has been in operation since March 1976 at a site 2.5 miles upstream from the study reach. Gaging stations have, however, been operated on many other streams in the area for much longer periods. Nearby gaging stations with longer records include the Dickey River (1962-73), the East Fork Dickey River (1963-68) and Hoko River (1962-74).

Because the peak discharge record for the Sooes River station is of insufficient length to develop a discharge-frequency relationship for the annual flood peaks, a regional discharge-frequency relationship, developed by the U.S. Geological Survey for the U.S. Department of Housing and Urban Development flood studies in Clallam County, was used to obtain discharge estimates for the study reach. The regional relationship incorporates all of the long-term gaging-station records in the area and for selected recurrence intervals relates peak discharge to various drainage-basin characteristics by regression analysis (Riggs, 1973).

The maximum discharge that has occurred at the Sooes River station during the period of record is 3,300 ft^3/s. This would have a recurrence interval of about 2 years (50 percent chance of being equaled or exceeded in any year) according to estimates from the regional discharge-frequency study. The peak discharges estimated for the Sooes River at the hatchery site are given in the following table:

Recurrence interval (years)	Estimated discharge (ft^3/s)	Average standard error of estimate for discharge (ft^3/s)
5	5,000	±1,800
10	5,900	±2,100
25	7,100	±2,600
50	8,300	±3,000
100	9,500	±3,400

An elevation-frequency relationship for the annual peak tides was developed for the Mukkaw Bay area to examine the affects of Pacific Ocean tides on water-surface elevations of the Sooes River. The relationship is based on a 40-year tide record (1934-74) at Neah Bay to the north with appropriate adjustments based on tide elevations at La Push and Aberdeen much farther to the south. From this relationship, the estimated tide elevations having 2- and 100-year recurrence intervals would be 11.4 feet and 12.6 feet, respectively. The elevation of mean higher high water (MHHW) is 8.5 feet, and the elevation of mean sea level (MSL) is 4.3 feet, all referenced to MLLW at 0.0 foot.

HYDRAULICS

The step-backwater method is used to compute the river water-surface elevations corresponding to selected discharges and tides.

Twelve cross sections were surveyed at approximately 600-foot intervals along the length of the study reach by personnel of the U.S. Fish and Wildlife Service. Locations of these sections are shown relative to the hatchery site in figure 2.

Seven different simulation conditions were specified by the U.S. Fish and Wildlife Service. These range, through a series of cross-section modifications, from the pre-construction condition of the reach to a final design condition. Water-surface elevations were computed for river discharges corresponding to recurrence intervals of 5, 10, 25, 50, and 100 years in conjunction with a 0.0-foot tide level (MLLW) for each simulated condition at each cross-section by using the Geological Survey's step-backwater computer program (Shearman, 1976). Additional elevations for the 5- and 100-year river discharges were computed for conditions 3 (preliminary construction) and 7 (final construction), assuming that the peak river discharge would be coincident with the tidal mean higher-high water (8.5 feet), the 2-year tide (11.4 feet) and the 100-year tide (12.6 feet).

Information and data are given separately for each of the seven simulated conditions in the following pages. Included are cross-section plots showing roughness coefficients and cross-section modifications for each condition, a written description of each condition and a tabulation of the water-surface elevations computed for the selected river discharges and tide elevations.

Plots of all 12 cross sections are given with condition 1, but only those that have some modification are presented with the remaining conditions. Water-surface elevations cannot be accurately determined for cross-sections 1 through 4 and are not shown in the tabulations. Initial water-surface elevations need to be assumed for the step-backwater technique, and elevations computed by that technique do not approach the correct values for several sections upstream of the initial section.

The river water-surface elevations that were computed for a 0.0-foot tide level (MLLW) represent very little restricting or backwater effect on flood flow in the river channel. As the tide level rises above 0.0-foot, however, resistance to free outflow of the river increases, and the river water-surface elevation rises. The additional river water-surface elevations given in the tabulations for conditions 3 and 7 were computed to determine the effects of high tide levels on the river elevations. The accuracy of these computations is less certain than those for the 0.0-foot tide because computational procedures to adjust for tide effects have not yet been documented for the step-backwater computer program. In this study, the area submerged by a given tide level was assumed to be ineffective for carrying flood plows, and it was deleted from each cross section prior to application of standard step-backwater methods.

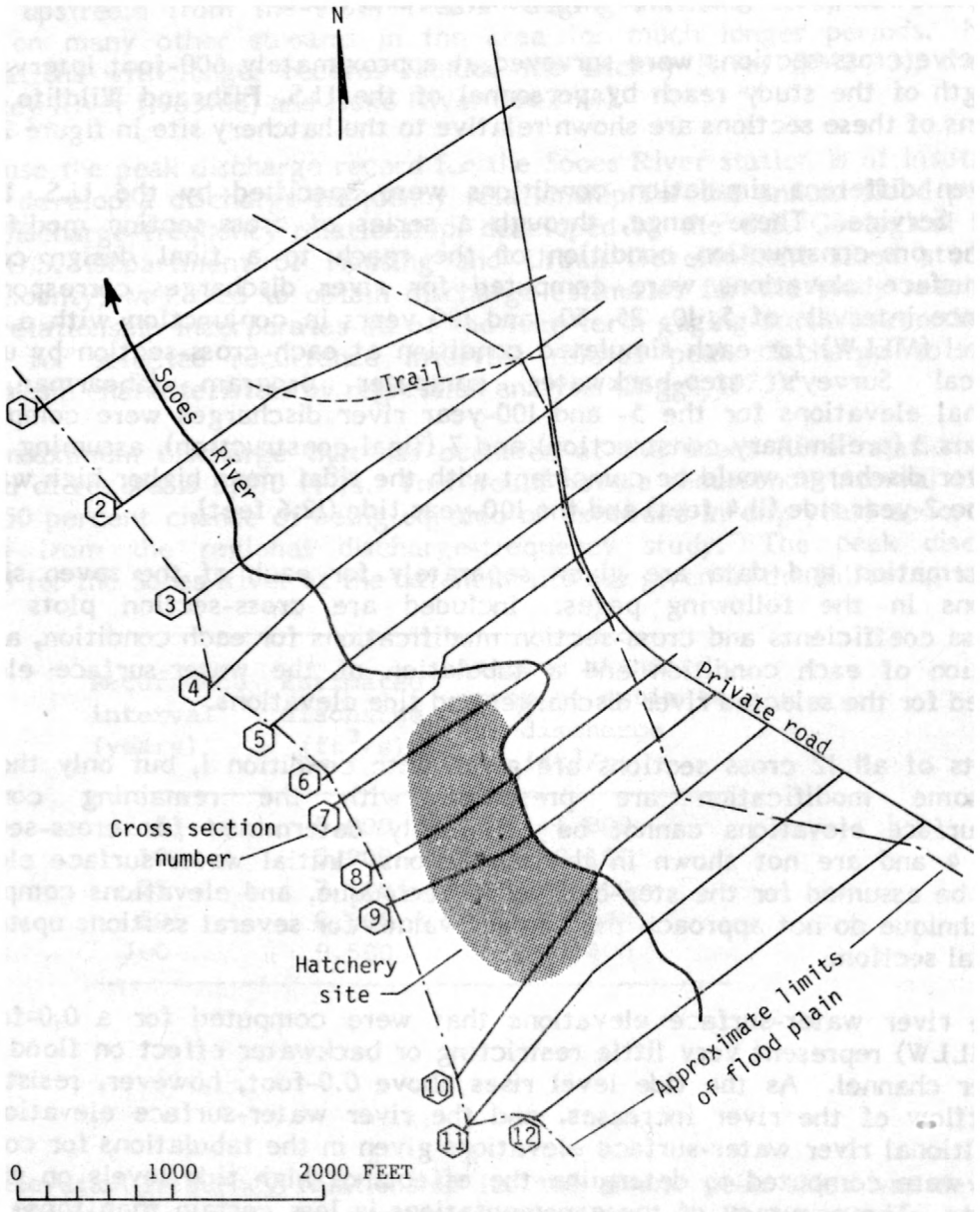
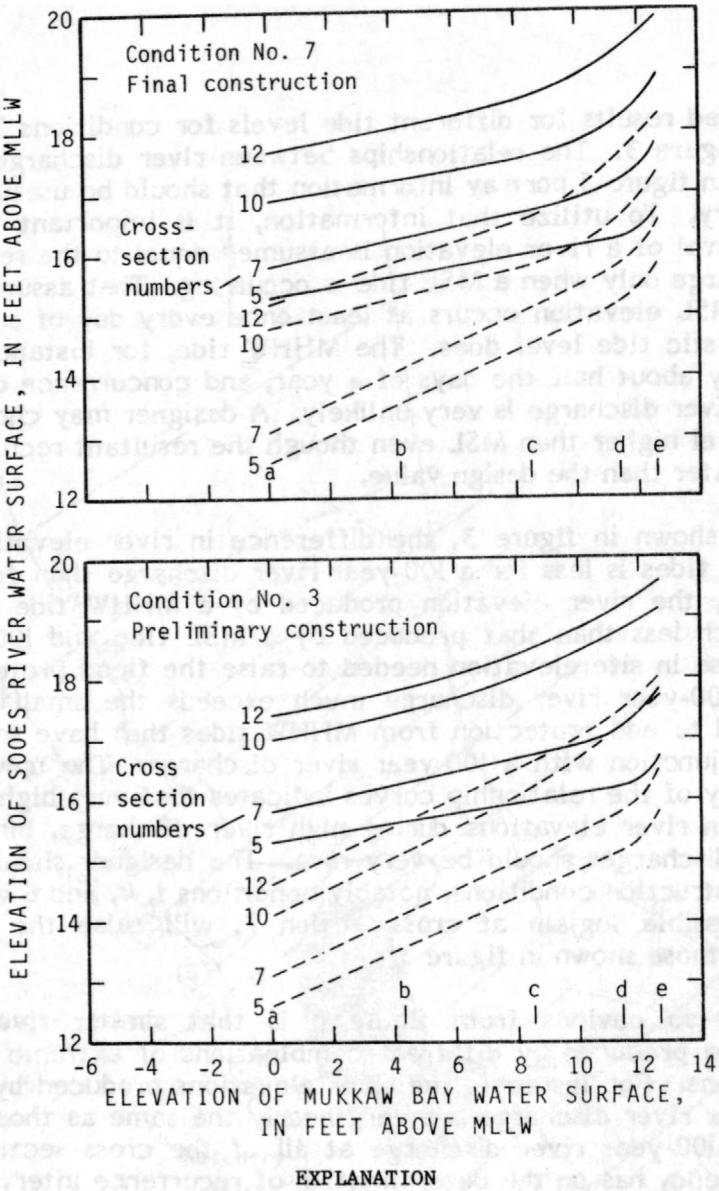


FIGURE 2.--Hatchery site showing cross-section location.

The tabulated results for different tide levels for conditions 3 and 7 are shown graphically in figure 3. The relationships between river discharge, tide level, and river elevation in figure 3 portray information that should be useful in the design of the fish hatchery. To utilize that information, it is important to note that the recurrence interval of a river elevation is assumed equal to the recurrence interval of a river discharge only when a MSL tide is occurring. That assumption is made on the basis that MSL elevation occurs at least once every day of a year and that no other characteristic tide level does. The MHHW tide, for instance, is equalled or exceeded on only about half the days of a year, and concurrence of a 100-year tide and a 100-year river discharge is very unlikely. A designer may choose, however, to select a tide level higher than MSL even though the resultant recurrence interval is known to be greater than the design value.

Notably as shown in figure 3, the difference in river elevations produced by MHHW and MSL tides is less for a 100-year river discharge than for a 5-year river discharge. Also, the river elevation produced by a MHHW tide and 5-year river discharge is much less than that produced by a MSL tide and 100-year discharge. Thus, the increase in site elevation needed to raise the flood protection level from a 5-year to a 100-year river discharge much exceeds the small increase in site elevation needed to add protection from MHHW tides that have some likelihood of occurring in conjunction with a 100-year river discharge. The upward hook at the right end of many of the relationhip curves indicates that very high tides may cause large increases in river elevations during high river discharge, but coincidence of such tides and discharges should be very rare. The designer should also be aware that certain construction conditions, notably conditions 1, 4, and 6 which reflect the effects of a possible logjam at cross-section 7, will raise the river elevations somewhat above those shown in figure 3.

Perhaps not so obvious from figure 3 is that similar river water-surface elevations may be produced by different combinations of extreme river discharges and tide elevations. For instance, the river elevations produced by a 100-year tide level and a 5-year river discharge are very nearly the same as those produced by a MSL tide and a 100-year river discharge at all of the cross sections. The effect that such equivalency has on the determination of recurrence intervals has not been ascertained.



EXPLANATION

1. Curves represent elevation relationships for 100-year river discharge of 9,500 ft^3/s (solid line) and 5-year river discharge of 5,000 ft^3/s (dashed line).
2. Tide elevations in Mukkaw Bay correspond to the following:
   (a) 0.0 ft = MLLW; (b) 4.3 ft = MSL, NGVD; (c) 8.5 ft = MHHW;
   (d) 11.4 ft = 2-year recurrence interval; and
   (e) 12.6 ft = 100-year recurrence interval.
3. The recurrence interval of a Sooes River elevation is assumed equal to the recurrence interval of a Sooes River discharge only during the occurrence of a MSL tide elevation (b), and increases beyond that of a discharge as tide elevations become higher than MSL.

FIGURE 3.--Relationships showing effect of river discharge and tide level on river elevation at selected river cross sections for preliminary and final construction conditions.

Profiles of river water-surface elevation can be prepared for the seven conditions in the study reach from the tabulated data in the following pages. The two profiles shown in figure 4 represent computed elevations for the combination of a 100-year tide level and a 5-year river discharge for construction conditions 3 and 7. Although no 100-year river elevations (corresponding to a 100-year river discharge and MSL tide) were actually computed, the elevations shown in figure 4 should, according to figure 3, be equivalent to 100-year values. The two profiles are also bracketed by river elevations (not shown) computed for MLLW and MHHW tides and a 100-year river discharge. The profiles indicate that higher water-surface elevations will occur in the vicinity of the fish hatchery during construction than after construction is completed.

Due to the flat gradient of the stream, velocities are relatively low even at the 100-year-flood discharge, and the channel modifications do not seriously affect them. At cross-sections 9 and 10 with the original site conditions (condition 2), the average velocity in the main channel and overflow sections would be about 3.0 and 0.4 feet per second, respectively. With the channel modified as in the final design condition (condition 7) those average velocities would be increased about 0.3 feet per second.

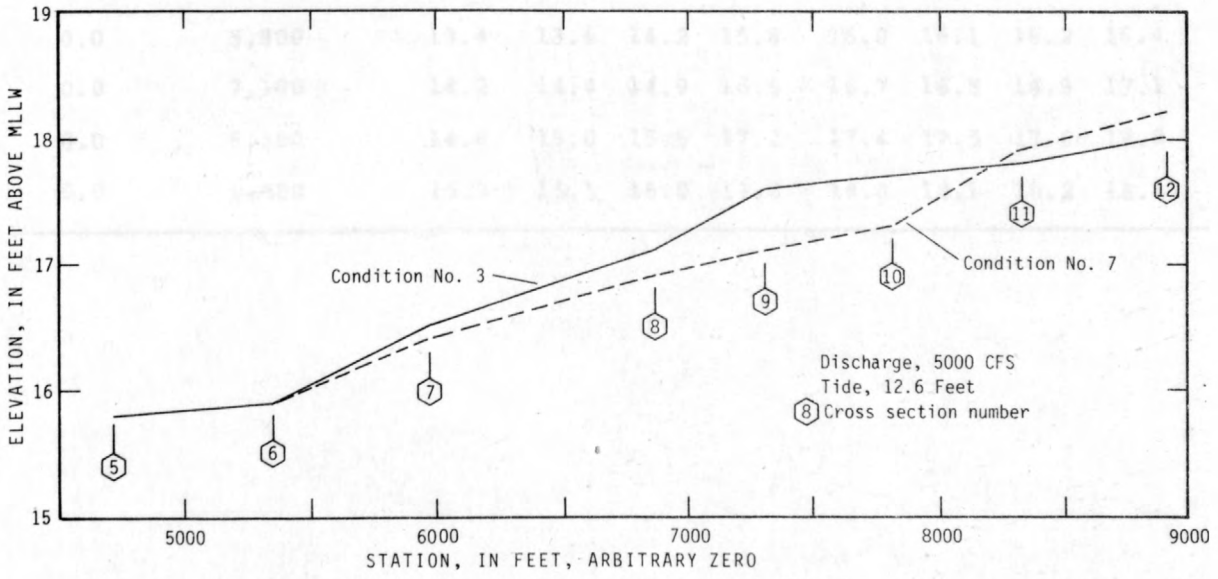


FIGURE 4.--Plot of selected water-surface profiles.

Riggs, H.C., 1968a, Some statistical tools in hydrology: U.S. Geological Survey Water Resources Investigations Techniques, Book 4, chapter A1, 39 p.

-----1968b, Frequency curves: U.S. Geological Survey Water Resources Investigations Techniques, Book 4, chapter A2, 15 p.

-----1973, Regional analysis of stream flow characteristics: U.S. Geological Survey Water Resources Investigations Techniques, Book 4, chapter B3, 15 p.

Shearman, J.O., 1976, Computer applications for step-backwater and floodway analyses: U.S. Geological Survey Open-File Report 76-499, 103 p.

[U.S.] Water Resources Council, 1976, Guidelines for determining flood flow frequency: U.S. Water Resources Council Bulletin 17, 204 p.

U.S. Weather Bureau, 1965, Mean annual precipitation, 1930-57, State of Washington: Portland, Oregon, U.S. Soil Conservation Service Map M-4430.

SUMMARY OF CONDITIONS SIMULATED AND TABULATION OF

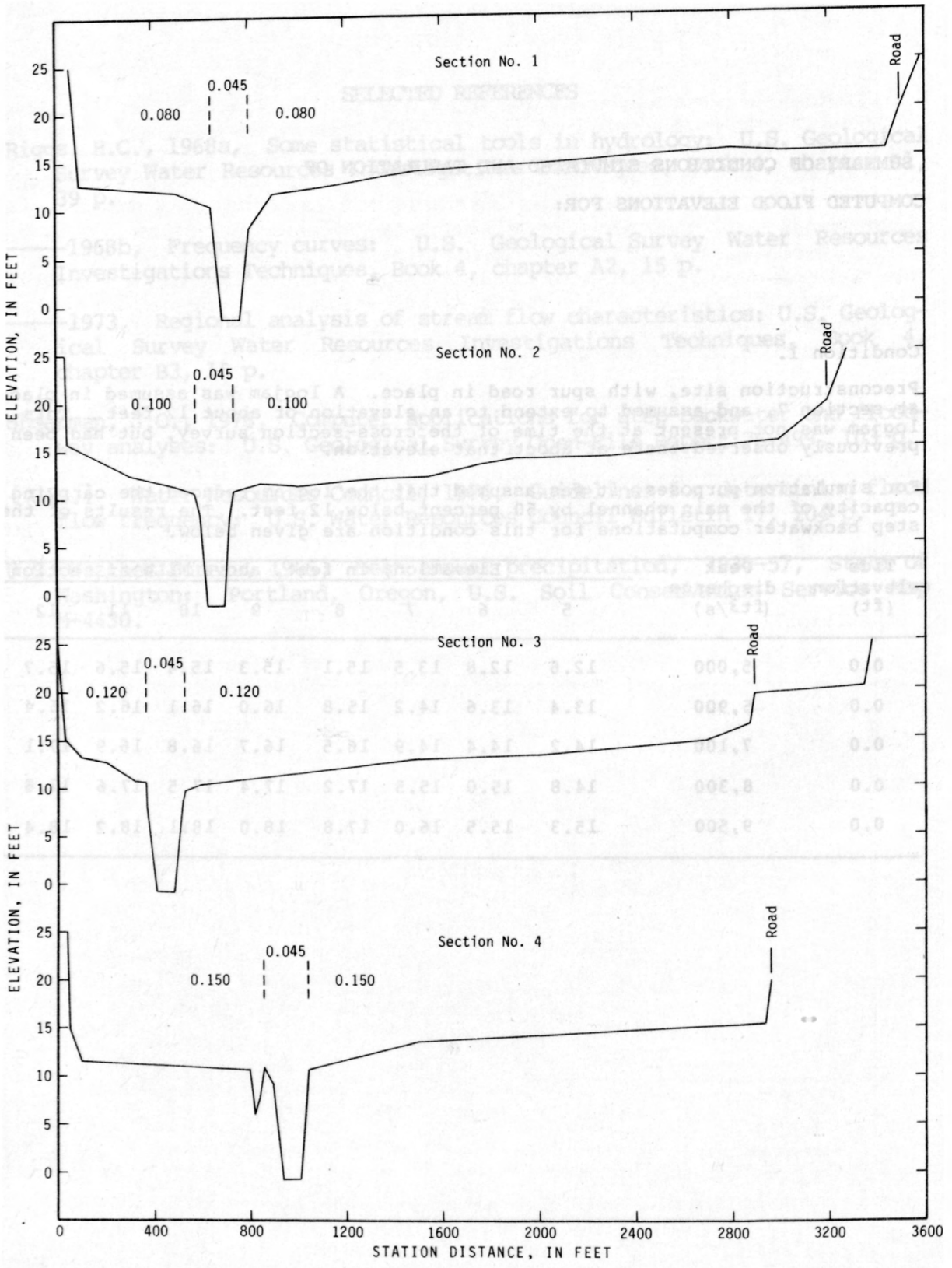
COMPUTED FLOOD ELEVATIONS FOR:

Condition 1.

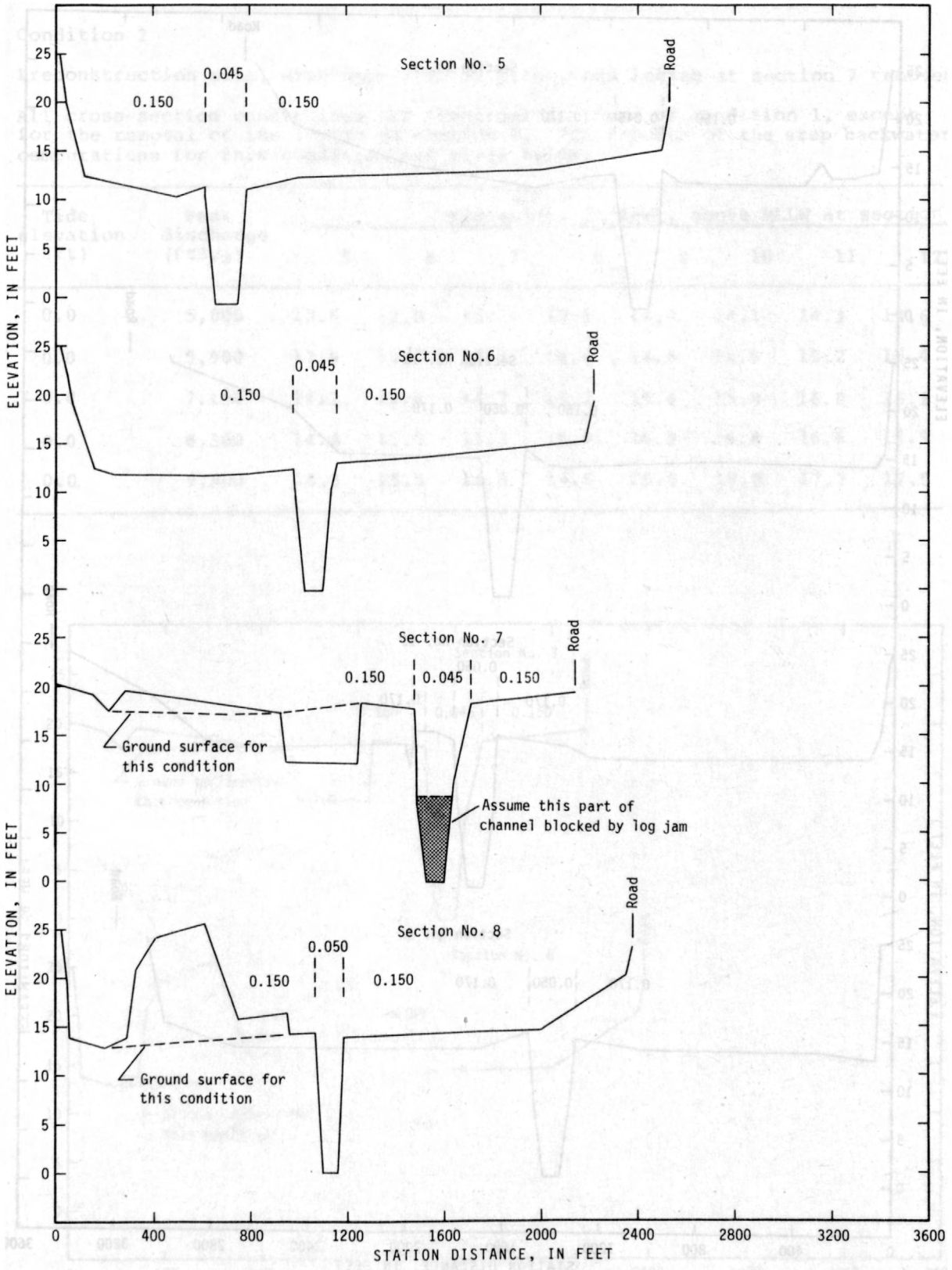
Preconstruction site, with spur road in place. A logjam was assumed in place at section 7, and assumed to extend to an elevation of about 12 feet. This logjam was not present at the time of the cross-section survey, but had been previously observed there at about that elevation.

For simulation purposes, it was assumed that the logjam reduced the carrying capacity of the main channel by 50 percent below 12 feet. The results of the step backwater computations for this condition are given below.

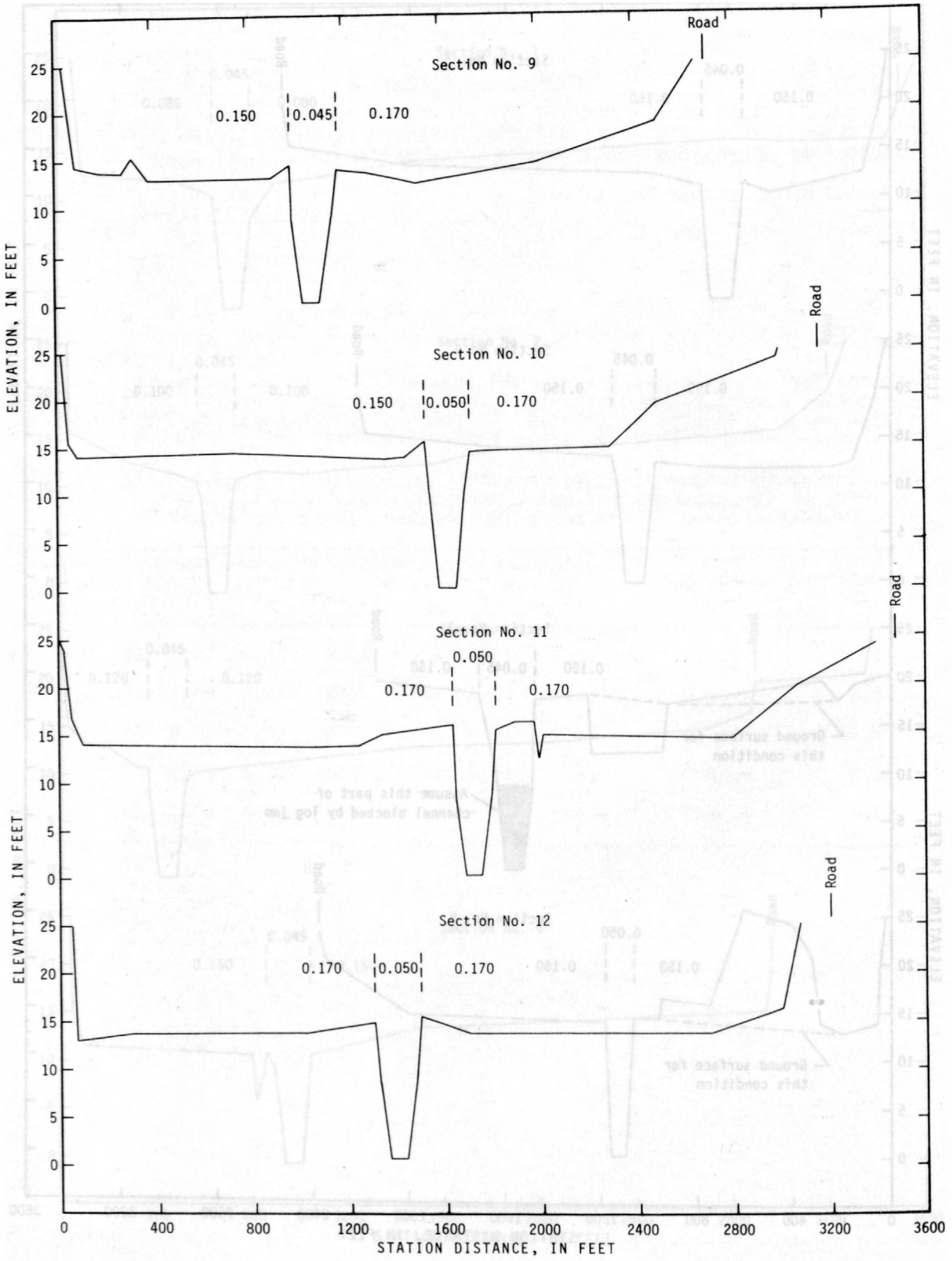
Tide elevation (ft)	Peak discharge (ft^3/s)	Elevation, in feet, above MLLW at section							
		5	6	7	8	9	10	11	12
0.0	5,000	12.6	12.8	13.5	15.1	15.3	15.4	15.6	15.7
0.0	5,900	13.4	13.6	14.2	15.8	16.0	16.1	16.2	16.4
0.0	7,100	14.2	14.4	14.9	16.5	16.7	16.8	16.9	17.1
0.0	8,300	14.8	15.0	15.5	17.2	17.4	17.5	17.6	17.8
0.0	9,500	15.3	15.5	16.0	17.8	18.0	18.1	18.2	18.4



Condition 1 (continued)



Condition 1 (contined)



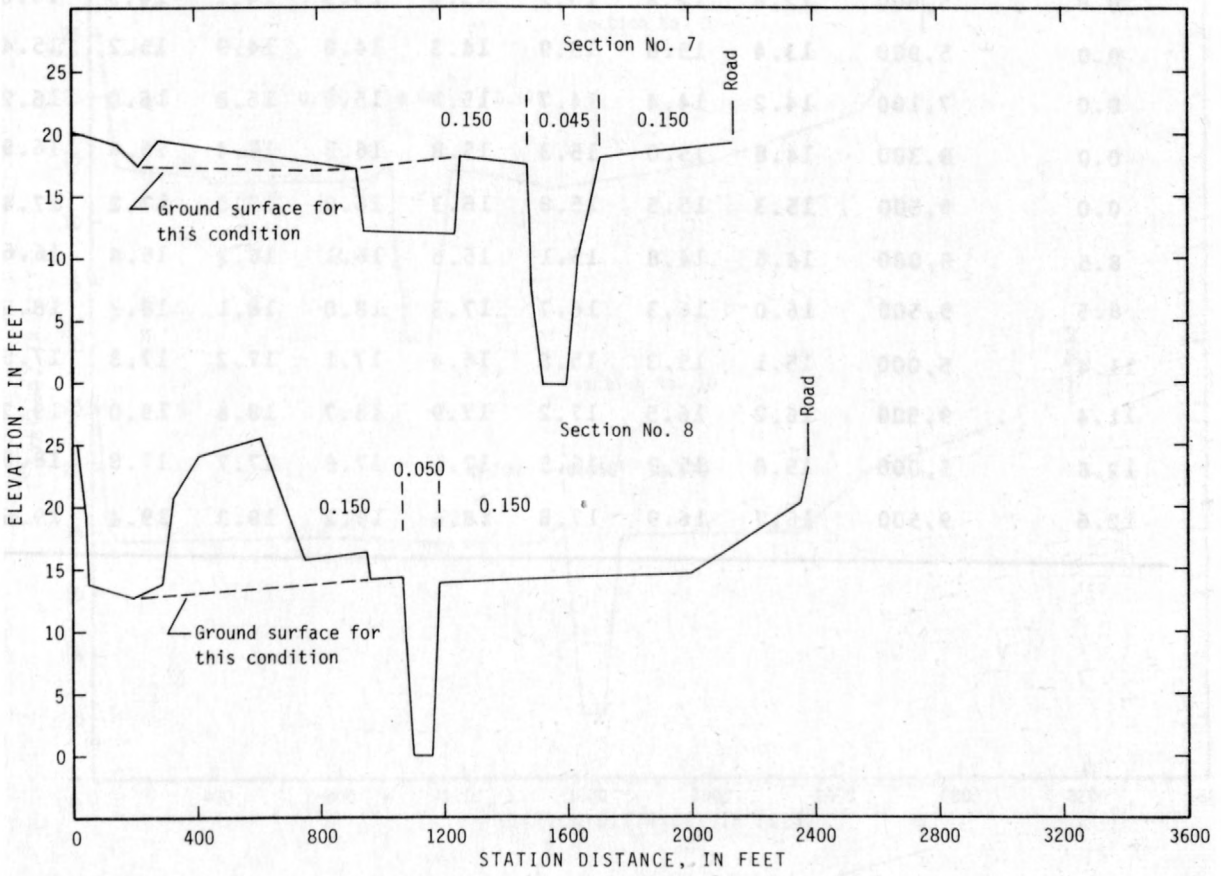
Condition 1 (contined)

Condition 2

Preconstruction site, with spur road in place, and logjam at section 7 removed.

All cross-section constraints are identical to those of condition 1, except for the removal of the logjam at section 7. The results of the step backwater computations for this condition are given below.

Tide elevation (ft)	Peak discharge (ft3/s)	Elevation, in feet, above MLLW at section							
		5	6	7	8	9	10	11	12
0.0	5,000	12.6	12.8	13.1	13.6	14.0	14.1	14.3	14.6
0.0	5,900	13.4	13.6	13.9	14.4	14.8	14.9	15.2	15.4
0.0	7,100	14.2	14.4	14.7	15.2	15.6	15.8	16.0	16.2
0.0	8,300	14.8	15.0	15.3	15.9	16.2	16.4	16.6	16.9
0.0	9,500	15.3	15.5	15.8	16.5	16.8	17.0	17.2	17.5

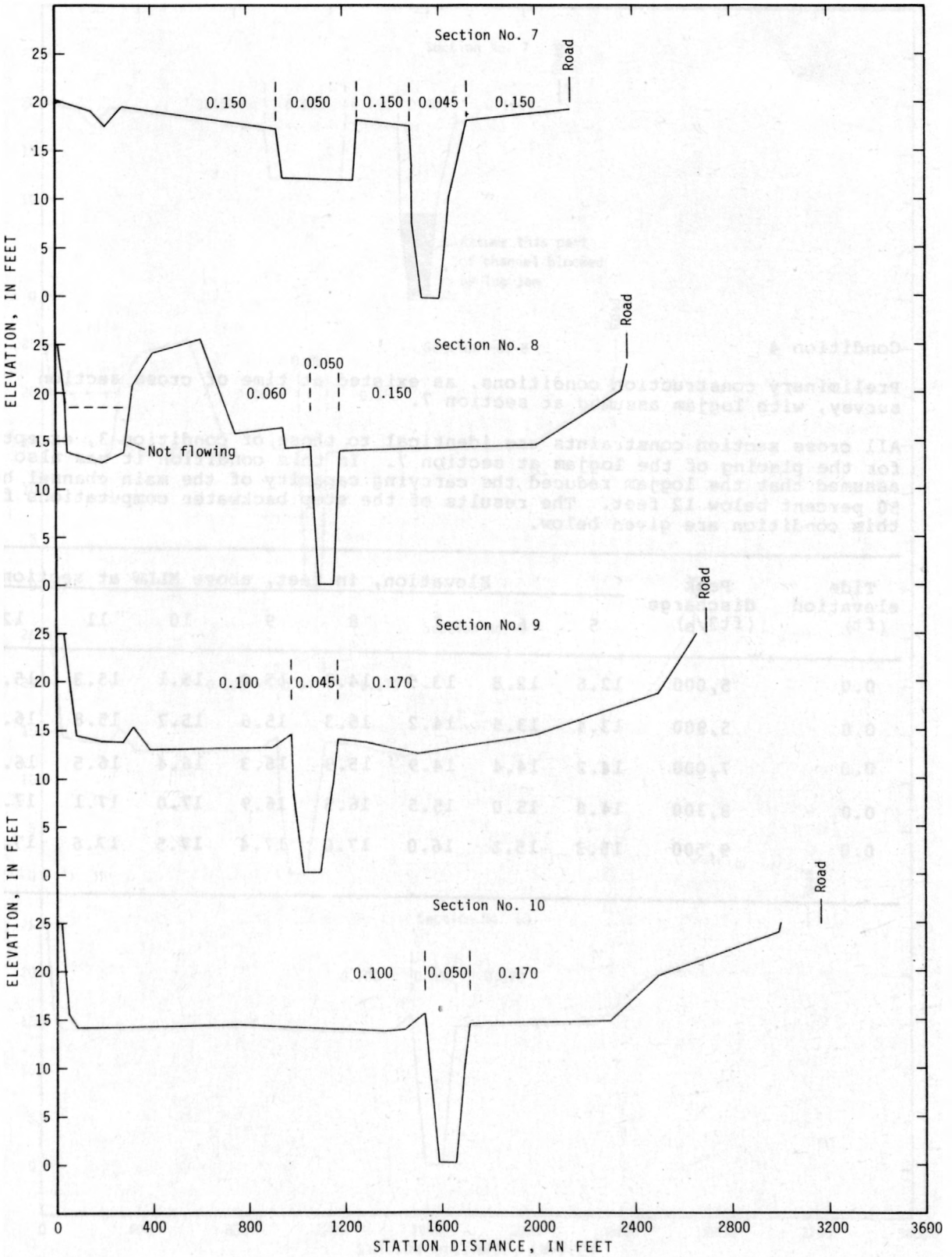


Condition 3

Preliminary construction conditions, as existed at time of cross section survey. No logjam at section 7.

During preliminary site preparation an opening has been cut through the spur road at section 7, some filling has been done at section 8 and some clearing has been done on the left bank at sections 9 and 10. The results of the step backwater computations for this condition are given below.

Tide elevation (ft)	Peak discharge (ft^3/s)	Elevation, in feet, above MLLW at section							
		5	6	7	8	9	10	11	12
0.0	5,000	12.6	12.8	13.1	13.6	13.9	14.1	14.3	14.6
0.0	5,900	13.4	13.6	13.9	14.3	14.8	14.9	15.2	15.4
0.0	7,100	14.2	14.4	14.7	15.1	15.6	15.8	16.0	16.2
0.0	8,300	14.8	15.0	15.3	15.8	16.3	16.4	16.6	16.9
0.0	9,500	15.3	15.5	15.8	16.3	16.9	17.0	17.2	17.4
8.5	5,000	14.6	14.8	15.1	15.6	16.1	16.2	16.4	16.6
8.5	9,500	16.0	16.3	16.7	17.3	18.0	18.1	18.3	18.5
11.4	5,000	15.1	15.3	15.8	16.4	17.1	17.2	17.3	17.5
11.4	9,500	16.2	16.5	17.2	17.9	18.7	18.8	19.0	19.2
12.6	5,000	15.8	15.9	16.5	17.1	17.6	17.7	17.8	18.0
12.6	9,500	16.7	16.9	17.8	18.6	19.2	19.3	19.4	19.6



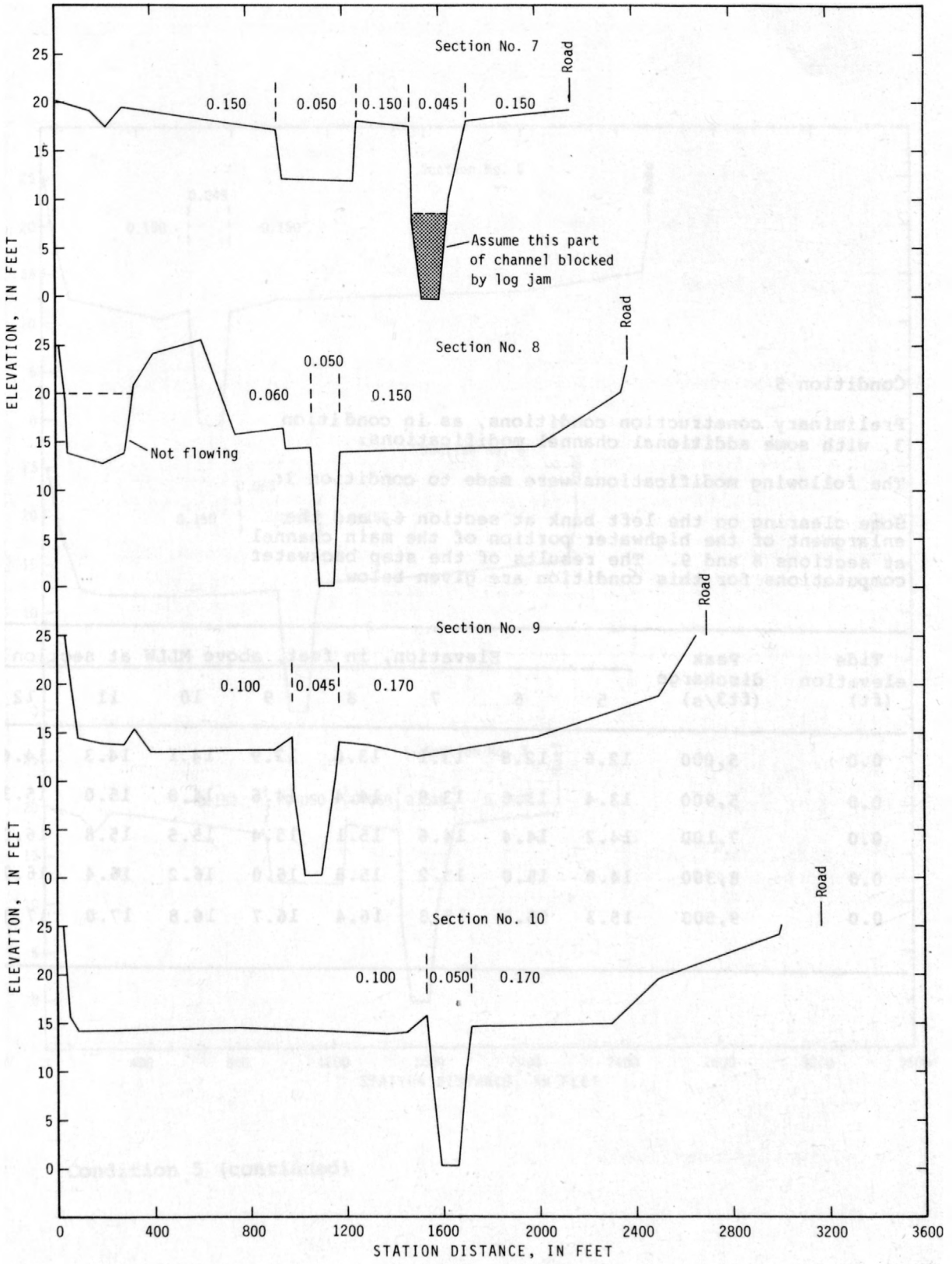
Condition 3 (continued)

Condition 4

Preliminary construction conditions, as existed at time of cross section survey, with logjam assumed at section 7.

All cross section constraints are identical to those of condition 3, except for the placing of the logjam at section 7. In this condition it was also assumed that the logjam reduced the carrying capacity of the main channel by 50 percent below 12 feet. The results of the step backwater computations for this condition are given below.

Tide elevation (ft)	Peak discharge (ft3/s)	Elevation, in feet, above MLLW at section							
		5	6	7	8	9	10	11	12
0.0	5,000	12.6	12.8	13.5	14.8	15.0	15.1	15.3	15.5
0.0	5,900	13.4	13.6	14.2	15.3	15.6	15.7	15.8	16.0
0.0	7,000	14.2	14.4	14.9	15.9	16.3	16.4	16.5	16.7
0.0	8,300	14.8	15.0	15.5	16.5	16.9	17.0	17.1	17.3
0.0	9,500	15.3	15.5	16.0	17.0	17.4	17.5	17.6	17.8



Condition 4 (continued)

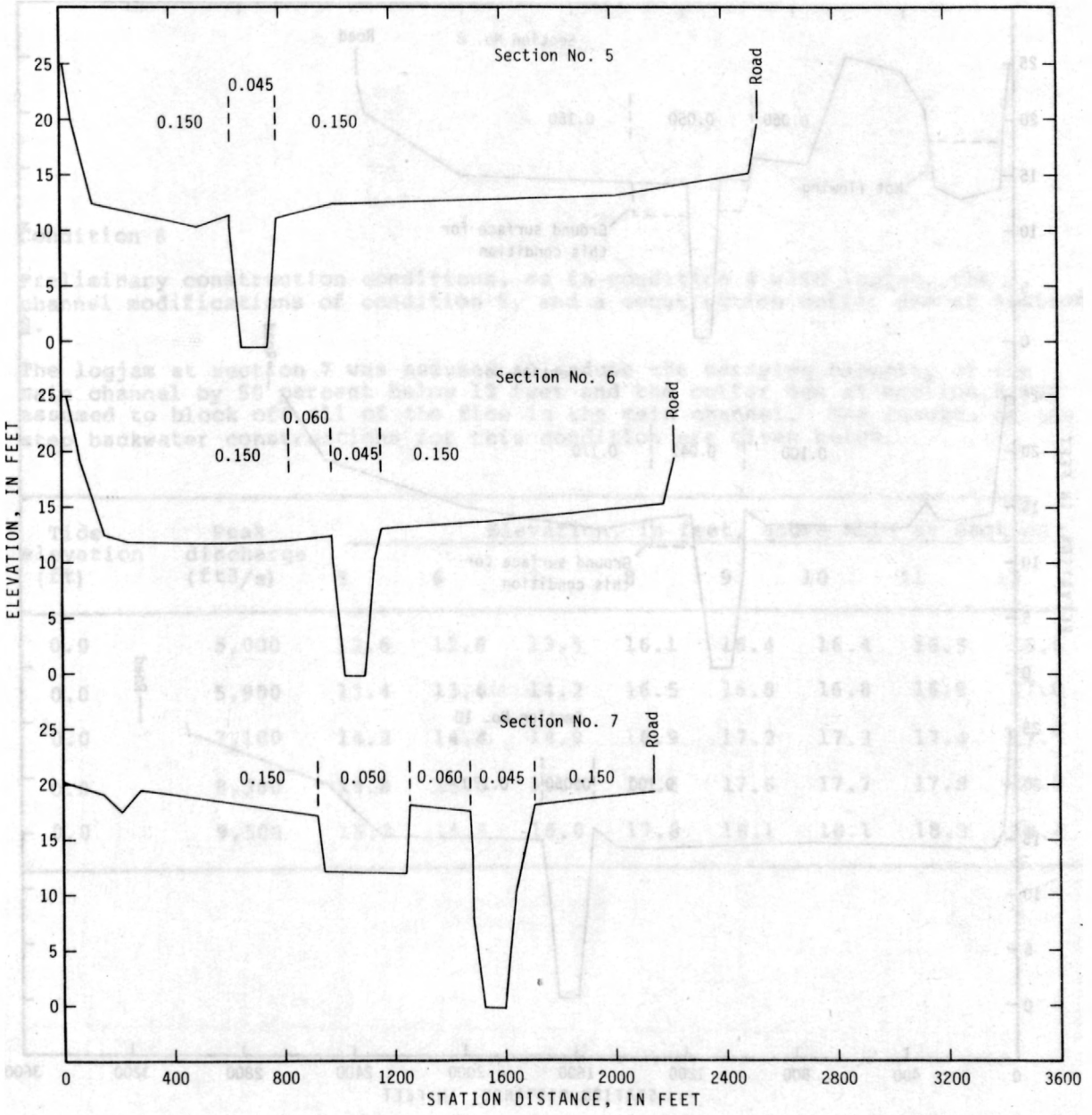
Condition 5

Preliminary construction conditions, as in condition 3, with some additional channel modifications.

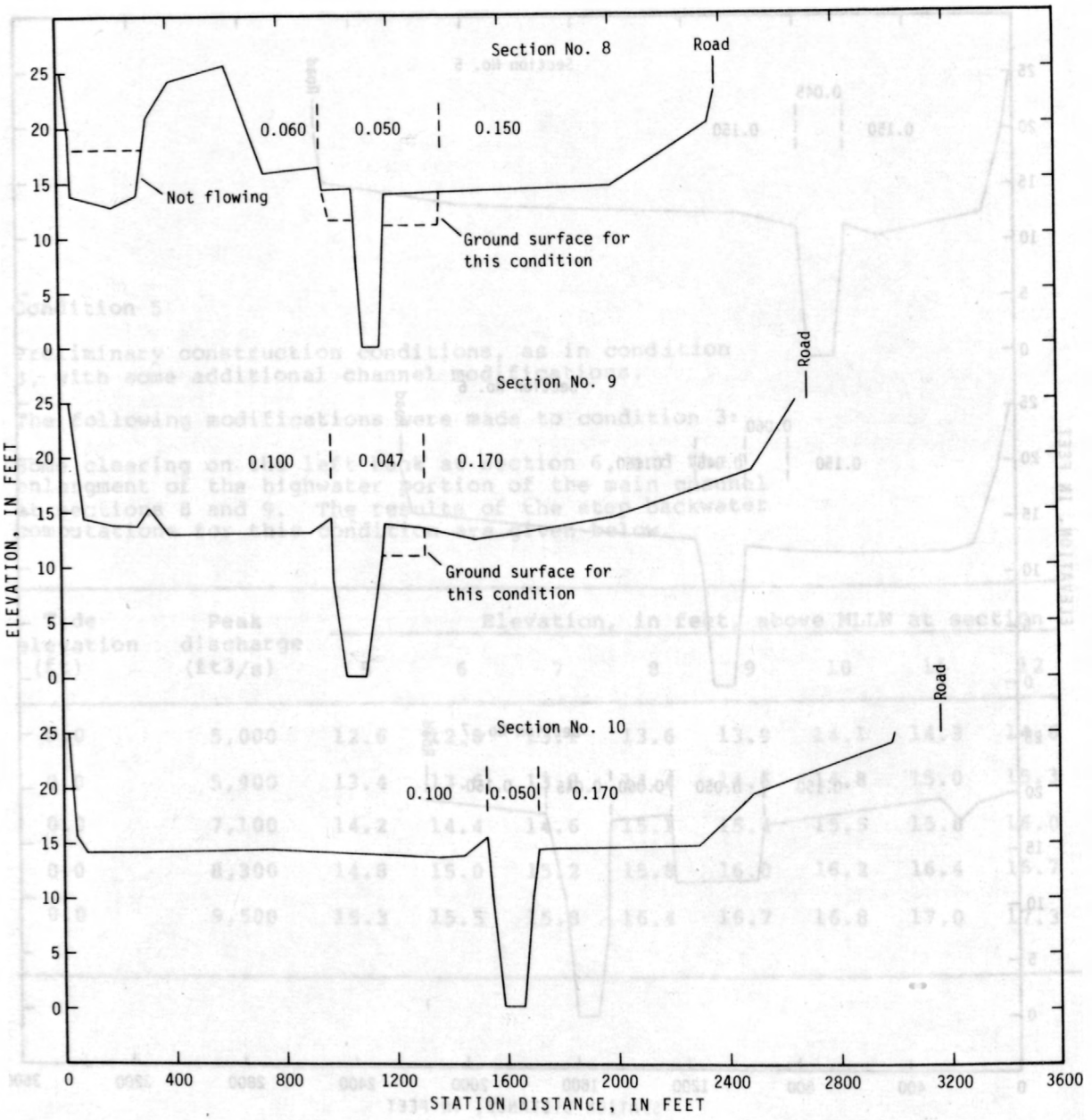
The following modifications were made to condition 3:

Some clearing on the left bank at section 6, and the enlargment of the highwater portion of the main channel at sections 8 and 9. The results of the step backwater computations for this condition are given below.

Tide elevation (ft)	Peak discharge (ft^3/s)	Elevation, in feet, above MLLW at section							
		5	6	7	8	9	10	11	12
0.0	5,000	12.6	12.8	13.1	13.6	13.9	14.1	14.3	14.6
0.0	5,900	13.4	13.6	13.8	14.4	14.6	14.8	15.0	15.3
0.0	7,100	14.2	14.4	14.6	15.1	15.4	15.5	15.8	16.0
0.0	8,300	14.8	15.0	15.2	15.8	16.0	16.2	16.4	16.7
0.0	9,500	15.3	15.5	15.8	16.4	16.7	16.8	17.0	17.3



Condition 5 (continued)



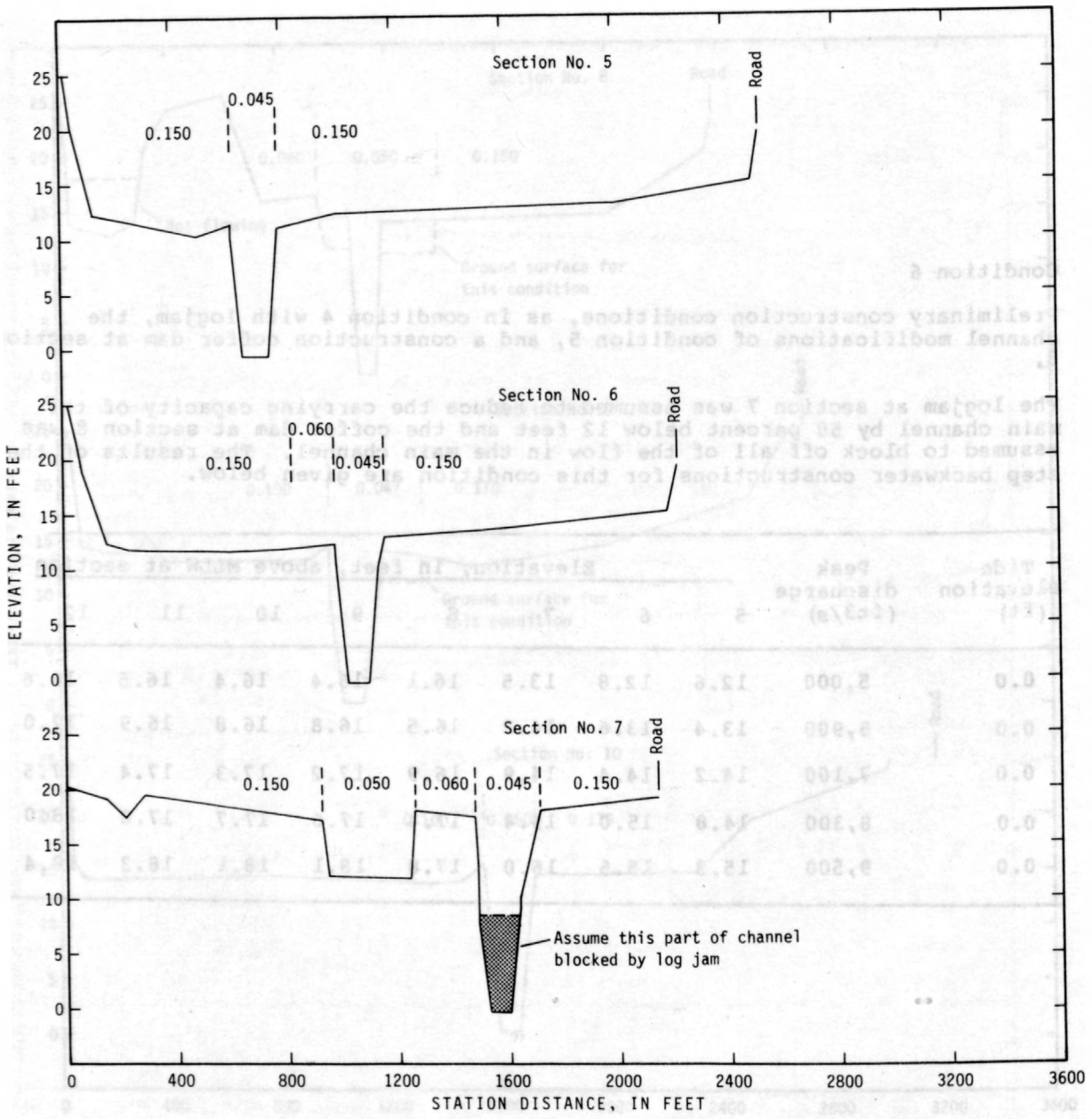
Condition 5 (continued)

Condition 6

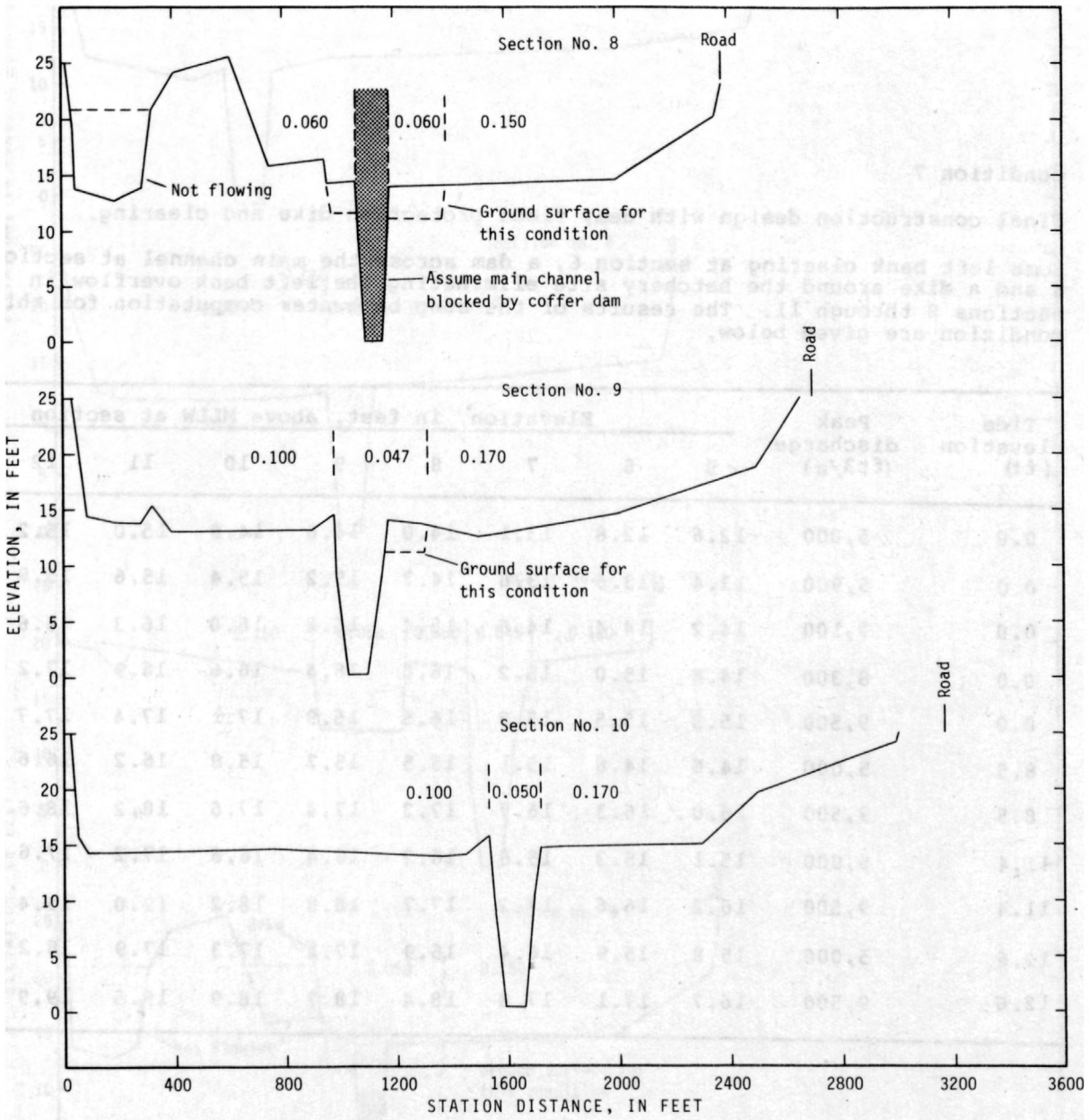
Preliminary construction conditions, as in condition 4 with logjam, the channel modifications of condition 5, and a construction coffer dam at section 8.

The logjam at section 7 was assumed to reduce the carrying capacity of the main channel by 50 percent below 12 feet and the coffer dam at section 8 was assumed to block off all of the flow in the main channel. The results of the step backwater constructions for this condition are given below.

Tide elevation (ft)	Peak discharge (ft^3/s)	Elevation, in feet, above MLLW at section							
		5	6	7	8	9	10	11	12
0.0	5,000	12.6	12.8	13.5	16.1	16.4	16.4	16.5	16.6
0.0	5,900	13.4	13.6	14.2	16.5	16.8	16.8	16.9	17.0
0.0	7,100	14.2	14.4	14.9	16.9	17.2	17.3	17.4	17.5
0.0	8,300	14.8	15.0	15.4	17.4	17.6	17.7	17.8	18.0
0.0	9,500	15.3	15.5	16.0	17.8	18.1	18.1	18.3	18.4



Condition 6 (continued)



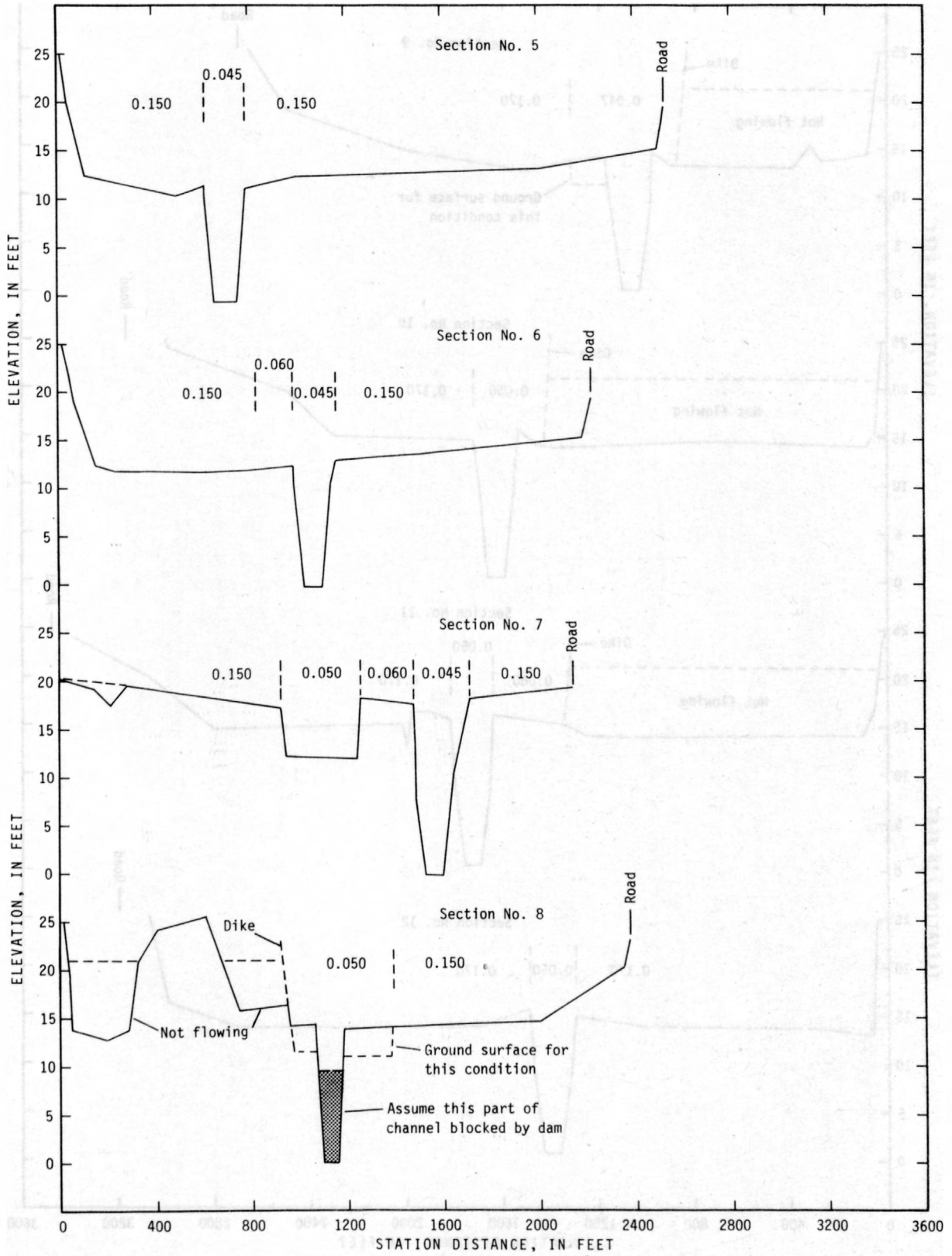
Condition 6 (continued)

Condition 7

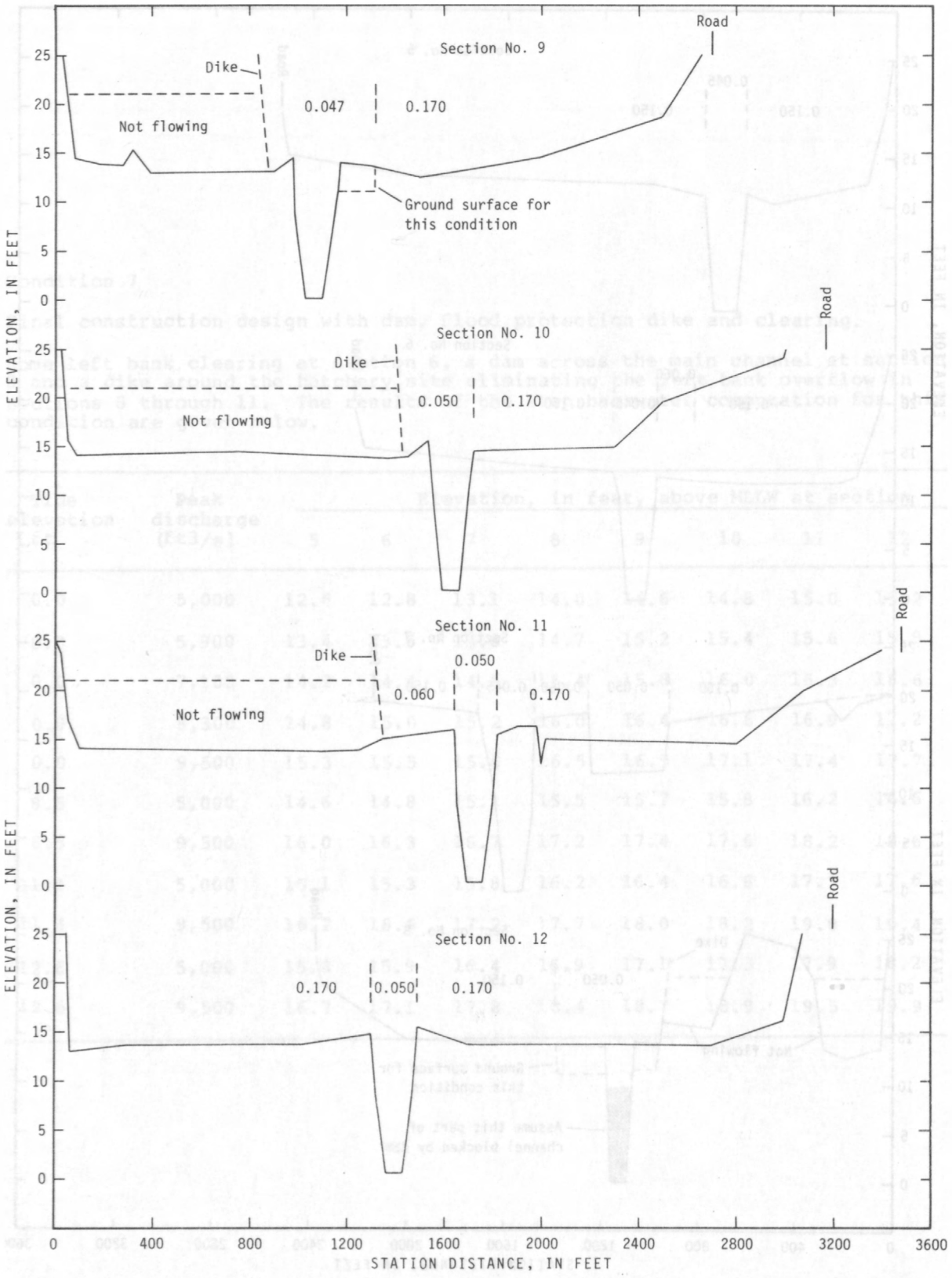
Final construction design with dam, flood protection dike and clearing.

Some left bank clearing at section 6, a dam across the main channel at section 8 and a dike around the hatchery site eliminating the left bank overflow in sections 8 through 11. The results of the step backwater computation for this condition are given below.

Tide elevation (ft)	Peak discharge (ft^3/s)	Elevation, in feet, above MLLW at section							
		5	6	7	8	9	10	11	12
0.0	5,000	12.6	12.8	13.1	14.0	14.6	14.8	15.0	15.2
0.0	5,900	13.4	13.6	13.8	14.7	15.2	15.4	15.6	15.9
0.0	7,100	14.2	14.4	14.6	15.4	15.8	16.0	16.3	16.6
0.0	8,300	14.8	15.0	15.2	16.0	16.4	16.6	16.9	17.2
0.0	9,500	15.3	15.5	15.8	16.5	16.9	17.1	17.4	17.7
8.5	5,000	14.6	14.8	15.1	15.5	15.7	15.8	16.2	16.6
8.5	9,500	16.0	16.3	16.7	17.2	17.4	17.6	18.2	18.6
11.4	5,000	15.1	15.3	15.8	16.2	16.4	16.6	17.2	17.6
11.4	9,500	16.2	16.6	17.2	17.7	18.0	18.2	19.0	19.4
12.6	5,000	15.8	15.9	16.4	16.9	17.1	17.3	17.9	18.2
12.6	9,500	16.7	17.1	17.8	18.4	18.7	18.9	19.5	19.9



Condition 7 (continued)



Condition 7 (continued)