HYDROLOGY, HYDRAULICS & FISH PASSAGE PERFORMANCE OF ARCTIC GRAYLING (Thymallus Arcticus) AT FISH CREEK, DENALI HIGHWAY NEAR CANTWELL ALASKA

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HYDROLOGY, HYDRAULICS AND FISH PASSAGE PERFORMANCE OF ARCTIC GRAYING (*THYMALLUS ARCTICUS*) AT FISH CREEK, DENALI HIGHWAY NEAR CANTWELL ALASKA

Final Report

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16. Abstract
A two year study of fish passage through the Fish Creek culvert, located at Mile 132.2 of the Denali Highway, was carried out by an interdisciplinary task force. The purposes of this study were: monitor the interaction of the spawning Arctic grayling (Thymallus Arcticus) and the existing culvert, and document variables of watershed hydrology (primarily runoff) and hydraulic behavior of the culvert that may impact fish passage.
In summary, Arctic grayling encountered minimal difficulty in passing upstream through the culvert. The major areas of difficulty for the fish were entering the slightly perched culvert and exiting where nonuniform flow rates of movement through the culvert barrel varied from less than a minute to over 80 minutes. Generally, larger fish moved through more rapidly than smaller fish. All fish stayed as close to the boundary of the culvert as possible, and they oriented themselves normal to this boundary; meaning that they were not alwasy swimming in a vertical position.

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ABSTRACT

A two year study of fish passage through the Fish Creek culvert, located at Mile 132.2 of the Denali Highway, was carried out by an interdisciplinary task force. The purposes of this study were multifaceted: study the behavior of spawning Arctic grayling (*Thymallus arcticus*) in this drainage, monitor the interaction of the spawning Arctic grayling and the existing culvert, and document variables of watershed hydrology (primarily runoff) and hydraulic behavior of the culvert that may impact fish passage. Weirs were placed across the stream to determine the temporal distribution of fish movement, to measure both fish length and weight, and to capture fish for tagging. Measurements of water temperature, water chemistry and discharge were made. Numerous velocity measurements at various cross-sections within the culvert and water surface slopes upstream, through the culvert and downstream were also made. The performance of fish passing through the culvert was visually observed at the inlet and outlet of the culvert in 1987 and at the inlet, outlet and through the barrel in 1988. Experimentation with radio-tagged fish was carried out both years. In summary, Arctic grayling (for the two years of the study) encountered minimal difficulty in passing upstream through the culvert. The major areas of difficulty for the fish were entering the slightly perched culvert and exiting where nonuniform flow existed. The peak runoff events were below the mean annual flood. Because the snowmelt floods were low, researchers were able to construct scaffolding in the culvert to visually evaluate fish performance. Rates of movement through the culvert barrel varied from less than a minute to over 80 minutes.

Generally, larger fish moved through more rapidly than smaller fish. In any case, all fish stayed as close to the boundary of the culvert as possible, and they orientated themselves normal to this boundary; meaning that they were not always swimming in a vertical position. The radio tagging experiment was only minimally successful the first year. During the second year, much better results were obtained.

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INTRODUCTION

An interdisciplinary fish passage study was conducted by the State Interagency Fish Passage Task Force in 1987 and 1988 at the existing highway culvert at Fish Creek located at Milepost 132.2 near Cantwell, Alaska. These studies were completed in direct response to the Alaska Department of Transportation and Public Facilities (ADOT&PF) proposal to rebuild the west end of the Denali Highway and to replace the existing lower Fish Creek culvert which has been deemed inadequate for fish passage by the Alaska Department of Fish and Game (ADF&G) and U.S. Fish and Wildlife Service (USFWS). The purpose of the investigation was to study, both analytically and in the field, the fish passage capabilities of the existing culvert and the swimming capabilities and requirements of Arctic grayling (*Thymallus arcticus*), which pass through the culvert on their spring upstream migration during breakup. Coupled with the results obtained by the State Fish Passage Task Force at Poplar Grove Creek in 1985 and 1986 (Tilsworth and Travis, 1987; Behlke et al., 1988; and Behlke et al., 1989), this study was intended to provide a basis for maximizing design economics of the new culvert.

BACKGROUND

A review of the literature relating to fish passage through drainage structures revealed that the engineering and, quite frequently, the biological community have erroneously accepted the concept that fish are capable of negotiating any man-made barriers to their passage so long as given swimming velocities can be maintained for defined, fixed time periods (Bell, 1986; Brett, 1963; Jones et al., 1974; and Beamish,

1978). Thus, engineers and biologists have recognized only the fish's profile drag as a deterrent to its passage through a hydraulic structure. However, Ziemer and Behlke (1966) showed that if horizontal pressure gradients exist in a fish passage structure, fish must also contend with an additional adverse force that may restrict or totally block fish passage, even in the presence of traditionally acceptable water velocities.

Behlke (1987) described the forces that a fish must be capable of overcoming when passing through pressure gradients having horizontal components and in passing through hydraulic structures exhibiting sloping hydraulic grade lines. Behlke also estimated, by integrating the forces acting on a swimming fish, the net energy and power levels necessary for fish to generate if they are to successfully negotiate uniform, steady flow in sloping open channels or steady flow in pipe type facilities.

Similar studies have been carried out at Poplar Grove Creek, both by researchers involved in this study and other researchers. In 1985, Tilsworth and Travis (1987) studied the interaction of the upstream migrating Arctic grayling at the culvert where the Richardson Highway crosses Poplar Grove Creek. It was fortuitous that they performed the study that year because of the high runoff peak and volume. Fish were delayed as much as eight days because of high velocities through the structure. The next year, Behlke et al. (1988) pursued a similar study; however, with more manpower to measure numerous hydrologic and hydraulic variables. The peak spring runoff that year was much lower and fish were only minimally delayed relative to the previous year.

OBJECTIVES

The primary purpose of this interdisciplinary study was to gather additional information on the effects of fish size, water temperature, measurable hydraulic conditions and their relationship to the passage rate of Arctic grayling through the lower Fish Creek culvert. Specific objectives included:

(1) further examination of a visual technique first utilized by Tilsworth and Travis (1987) and subsequently modified by Behlke et al. (1988) for the study of fish passage through existing culvert structures;

(2) a comparison of observed swimming abilities of various size classes of Arctic grayling with the experimental results originally obtained by MacPhee and Watts (1976), Tilsworth and Travis (1987), and Behlke et al. (1988);

(3) collection of more detailed data on culvert hydraulic and installation variables, including adverse horizontal pressure gradients and virtual mass forces, that may affect successful fish passage;

(4) preliminary field assessment of the culvert velocity known as the "Velocity Occupied Zone" (V-occupied) referenced in the literature by Morsell et al. (1981) and Kane and Wellen (1985); and

(5) further evaluation of the applicability and usefulness of radio telemetry for culvert/fish passage studies.

(6) Observations of where fish entered the outlet, traveled through the barrel and exited the culvert.

PROJECT ORGANIZATION

Personnel and Agencies

Project personnel came from the ADOT&PF, the ADF&G and the University of Alaska Fairbanks' (UAF) Institute of Northern Engineering's (INE) Water Research Center and the Alaska Cooperative Fishery Research Unit (ACRFU). The ADOT&PF and ADF&G provided professional resource personnel and overall project management. The UAF provided fishery, hydrology, and hydraulic engineering personnel, graduate students and technicians to assist in the field work and data analysis.

Project Planning

The interdisciplinary team met often during the initial phases of the project. These meetings provided the strategic and tactical directions for the project. Many of the interdisciplinary discussions resulted in a much better understanding by the entire team of the methods, problems, and expectations of the various disciplines involved.

SITE DESCRIPTION

Stream Basin

Fish Creek is a second-order tributary of the Jack River located in the Alaska Range near Cantwell, Alaska (Figure 1). The drainage area is approximately 100 km^2 (38.5 mi^2) and contains extensive muskeg and marsh

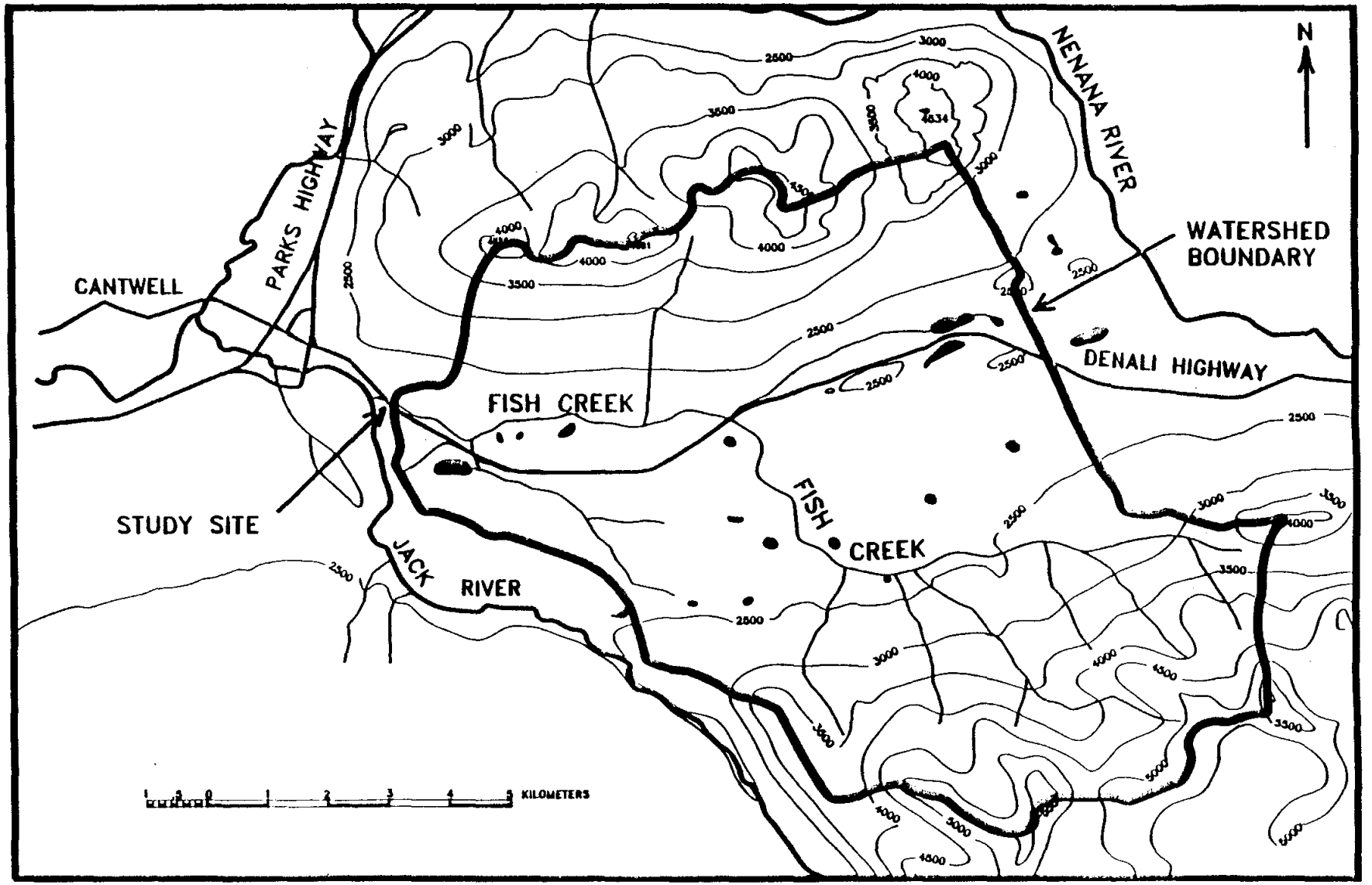

Figure 1: Delineation of Fish Creek watershed.

areas in the valley bottom. The elevations of the drainage basin vary from 670 m (2,200 ft) at the outlet to about 1,830 m (6,000 ft) at the headwaters. The stream supports an annual spring migration of Arctic grayling upstream from overwintering areas in the Jack and Nenana Rivers to spawning and summer rearing habitats in upper Fish Creek. Fish Creek offers a variety of habitats; its lower sections include a series of small shallow interconnected lakes, and its headwaters are comprised of two branches: a lake-fed branch and a mountain runoff branch. Above the culvert, the stream channel is narrow and deeply incised at low stream stages. On the mountain branch, the channel is much wider and the depth of flow much less, typical of braided streams.

Drainage Structure

The Fish Creek culvert is located at Mile 132.2 of the Denali Highway (Figure 1). The multiplate culvert is 18.1 m (~60 ft) long, 2.9 m (9.6 ft) in diameter, and is constructed of corrugated steel with 15.2 cm (6 in) between corrugations with a height of 3.5 cm (1.375 in.). A plan view of the culvert is presented in Figure 2. The invert elevations of the culvert are shown in Figure 3; at the upstream inlet, the slope is obviously steeper than the average slope and at the downstream outlet, an adverse slope exists for the last 2 m (6 ft). These conditions are typical of many culverts that have been in place for some time.

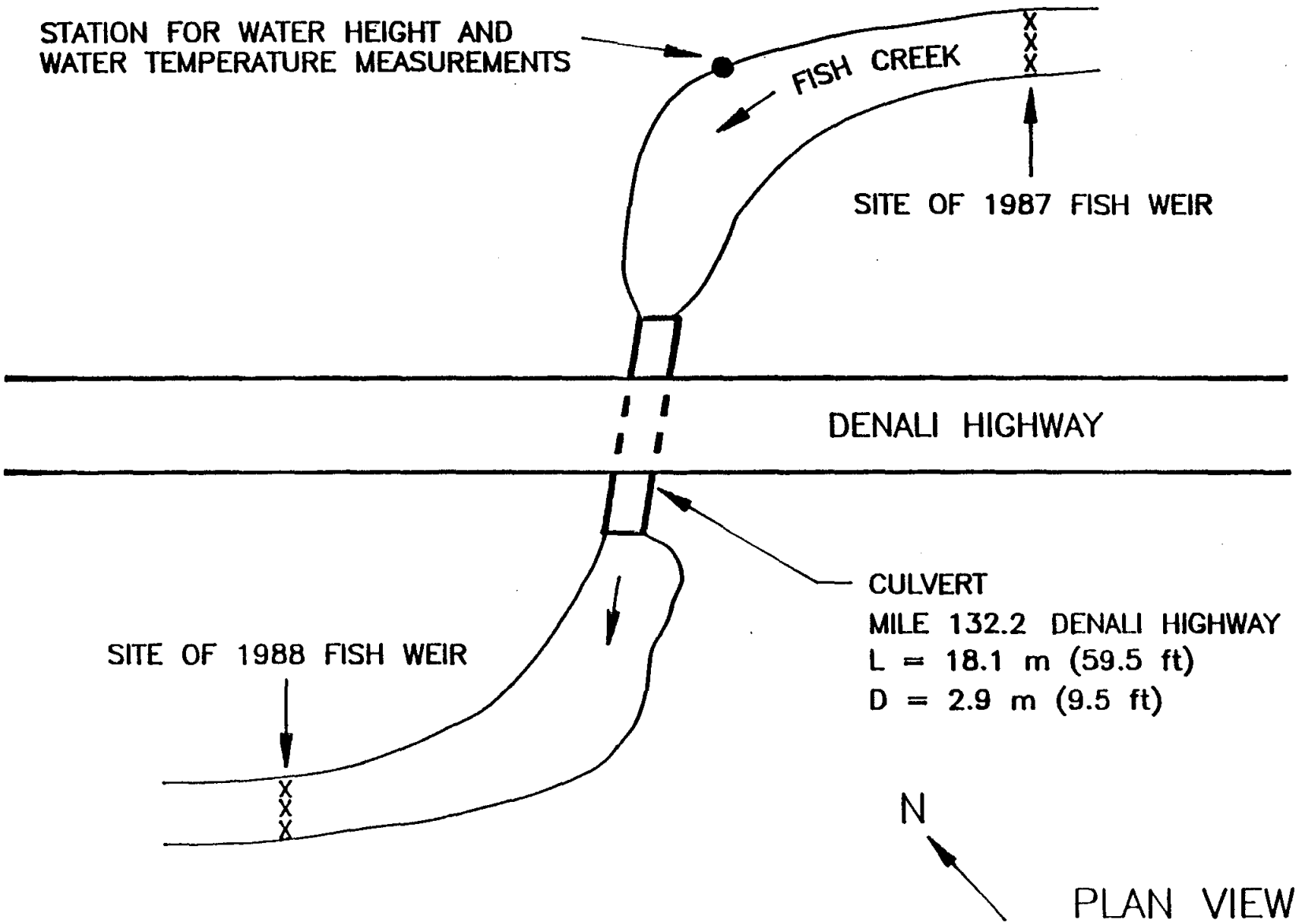

Figure 2: Plan view of culvert crossing (not to scale).

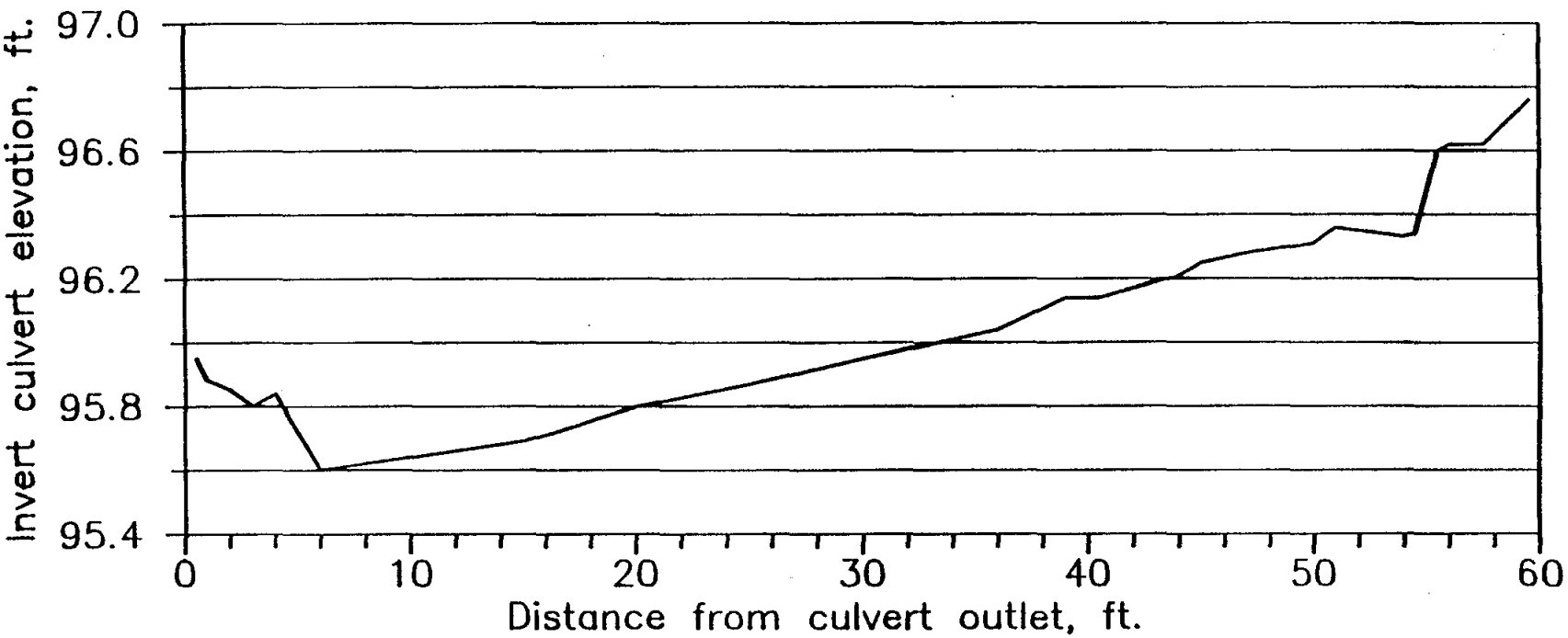

Figure 3: Invert elevation of culvert on Fish Creek, mile 132.2 Denali Highway.

HYDROLOGY

Watershed Description

Fish Creek is a west-draining stream located between Reindeer Hills on the north with a maximum elevation of 1550 m (5100 ft): and the 1800 m (6000 ft) Talkeetna Mountains to the south. The main stem of Fish Creek flows along the base of Reindeer Hills, and about 1/2 of the distance up the basin from its mouth, a fork contributes water collected from the mountains to the south (see Figure 1). Two small lakes are located at the headwaters of the main stem of the creek, and numerous small ponds can be found along its lower two miles. A rather large lake, Drashner, is located in the lower portion of the watershed. However, hydrologically, this lake is only important during high flows and does not appear to play any role in the local fisheries.

Streamflow Hydrographs

Stage-discharge relationships were developed by measuring the stage continuously and the discharge daily. An Envirolabs PT105-V pressure transducer connected to an Omnidata CR-21X electronic data logger was used to record the change in stage, and a Montedoro-Whitney electromagnetic current meter to obtain flow velocities. Discharge measurements were made downstream of the lower culvert, and the quality of the measurements for both years was good.

The 1987 hydrograph (Figure 4) shows that the discharge increased steadily in early May to reach a peak of 153 cfs (4.3 m^3/sec) on May 10. A typical recession followed the peak flow. The small blips evident on

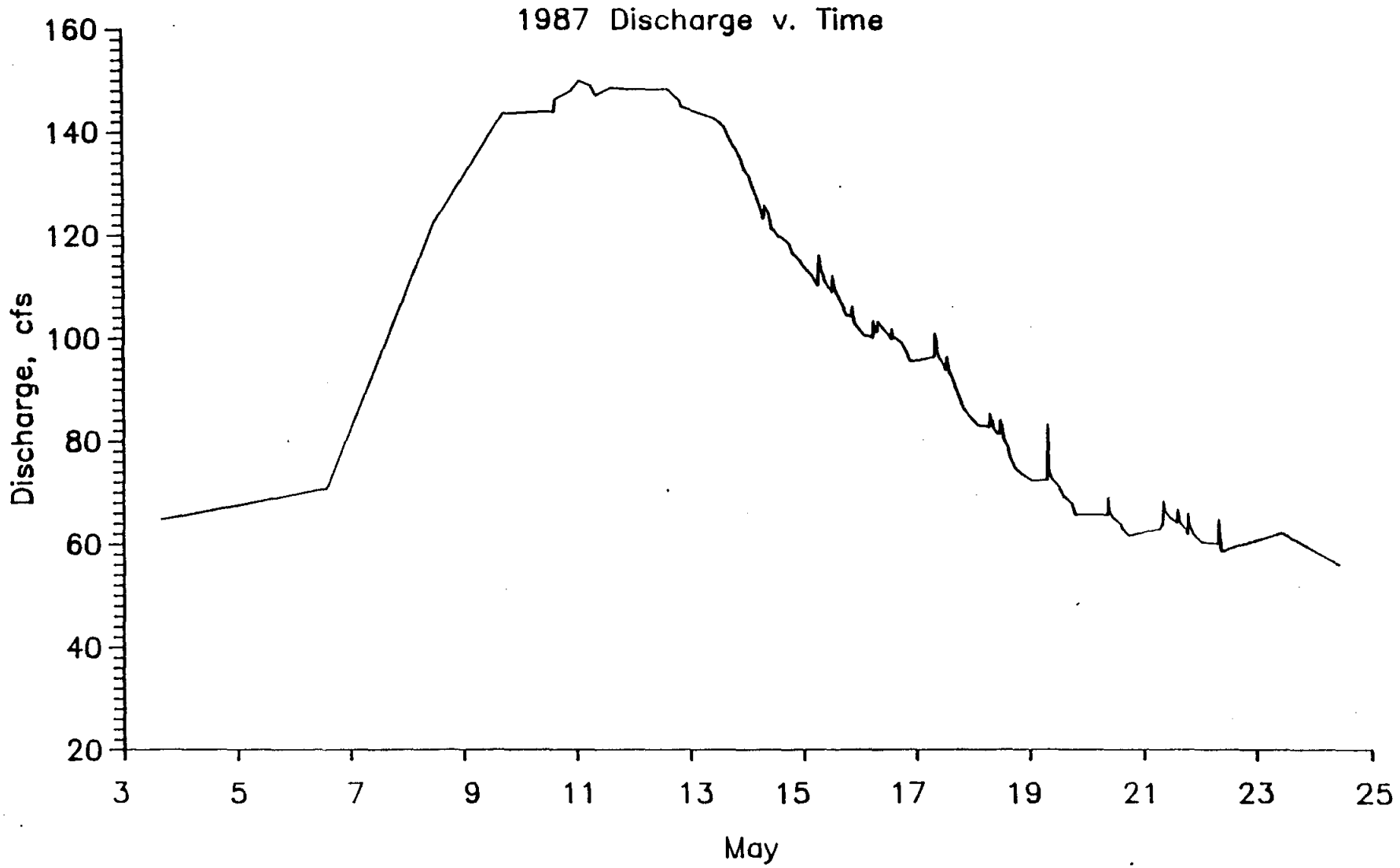

Figure 4: Snowmelt runoff hydrograph, Fish Creek, 1987.

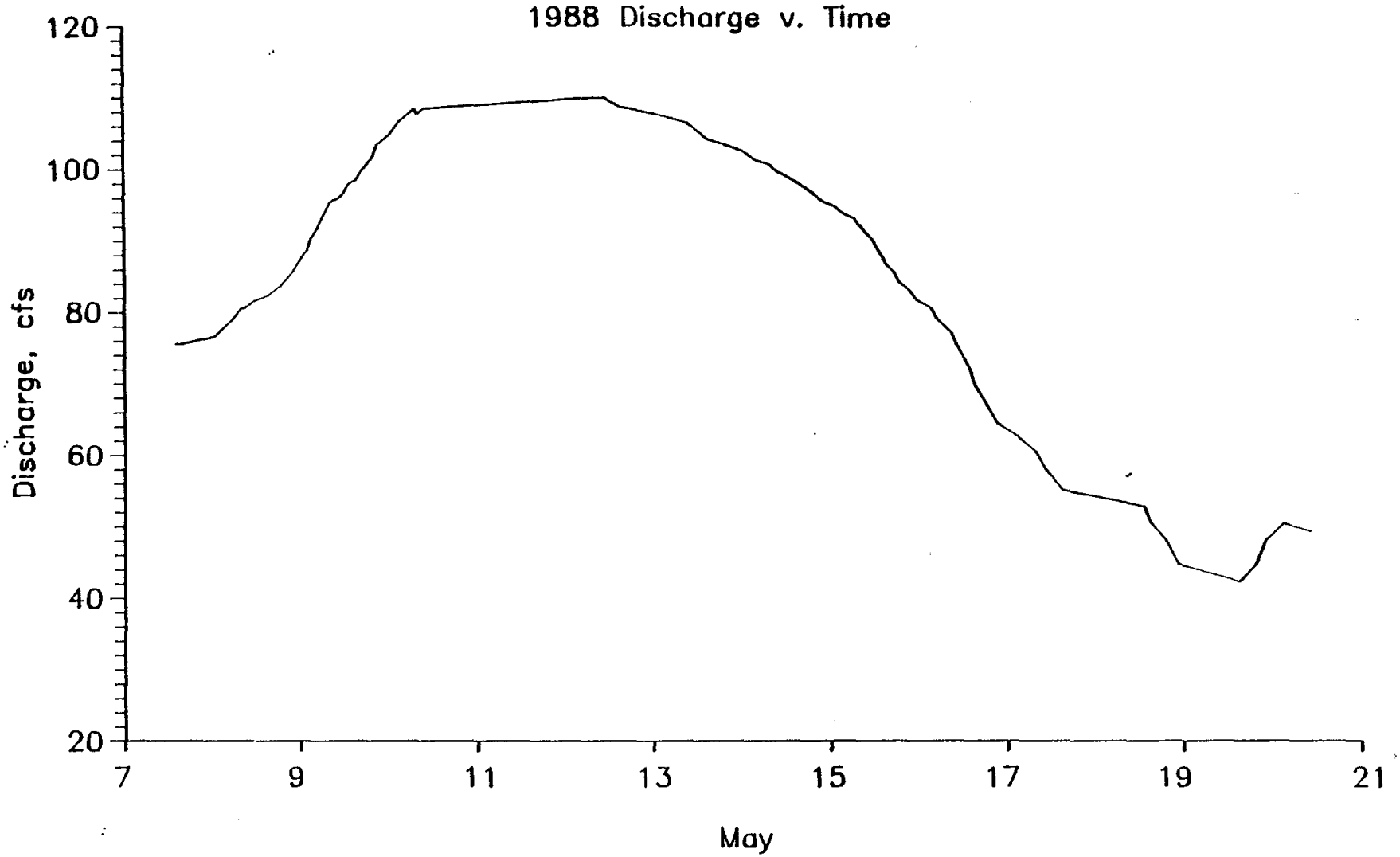

Figure 5: Snowmelt runoff hydrograph, Fish Creek, 1988.

the recession part of the curve were caused when the upstream weir, used to capture fish, was cleaned of debris. Similarly, the 1988 hydrograph (Figure 5) shows a relatively steady increase in discharge in early May leading to a peak of 110 cfs (3.1 m^3/sec) on May 12, 1988. Since in 1988 the fish weir was located downstream of the water level measurements, the effects of weir cleaning events on the falling limb of the hydrograph were minimized.

Flood Frequency Analysis

Runoff data from small streams are very limited in Alaska. However, at or near this site several streams have been instrumented with crest gages. Slime Creek, with a drainage of 17.9 km^2 (6.9 mi^2), was instrumented for 20 years and Lily Creek, with a drainage area of 14.5 km^2 (5.6 mi^2), was instrumented for 15 years. These data were utilized to evaluate Kane and Janowicz's (1989) method of flood frequency estimation for this region. The results were compared with standard flood frequency analysis done by the two-parameter log-normal method for Lily and Slime Creeks. Estimates of floods for various return periods are shown in Figure 6 by Kane and Janowicz.

The mean annual flood for Fish Creek, with a drainage area 38.5 square miles, is about 400 cfs by the method of Kane and Janowicz. Since the mean annual flood has a return period of 2.33 years, the maximum flow of 153 cfs for the spring snowmelt of 1987, and 110 cfs for 1988 are both well below the mean annual flood.

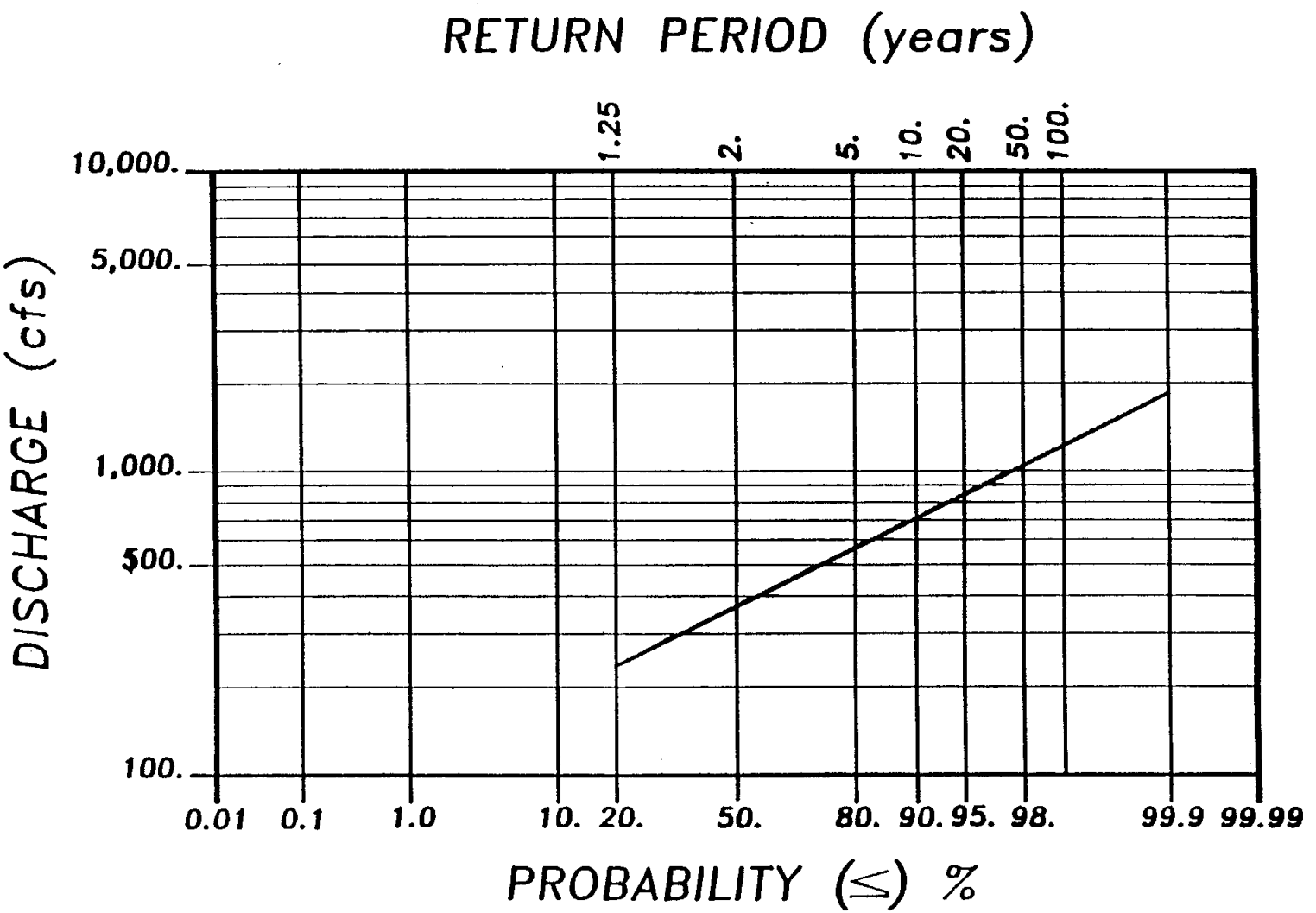

Figure 6: Flood estimates for Fish Creek based on method of Kane and Janowicz (1989).

Snow Hydrology

Because of the variability in elevation within the watershed (4,000 ft, 1,200 m), there is substantial variation in the water content of the snow on the ground. We did not make any field measurements, however the USDA Soil Conservation Service operates two stations nearby at elevations similar to the outlet of the basin. At Fog Lakes, elevation 650 m (2,120 ft), the maximum water content of the snowpack was 10.7 cm (4.2 in) in 1987, and was 12.0 cm (4.7 in) in 1988. At Monohan Flat, elevation 830 m (2,710 ft), the maximum 1987 water content was estimated from aerial markers as 18.5 cm (7.3 in). The 1988 maximum water content at Fog Lakes was 20.6 cm (8.1 in). These values are probably fair indicators of the water content in the Fish Creek basin, although much higher values can be found at the upper elevations.

Water Quality During Snowmelt Runoff

Dissolved oxygen, turbidity, and color were measured daily from the 14th to the 24th of May, 1987, and from the 10th to the 17th of May, 1988. Dissolved oxygen and apparent color were measured using a Hach DL-ER/4 water testing kit. A Hach 16800 portable turbidimeter was used for turbidity. Although water temperature was measured at the same time with a hand-held thermometer, it was also recorded continuously during both years with measurements taken every minute using a YSI thermistor that was connected to a Campbell CR-21X programmable electronic data logger.

Dissolved oxygen and turbidity levels were basically constant throughout the 1987 study period (Figure 7): oxygen levels averaged about 8.2 ppm and turbidity averaged around 2.2 NTU. However, color showed considerable variation (Figure 7) with the shape of the plot similar to the 1987 hydrograph, except the peak of 140 UNITS lags the hydrograph peak by 6 days. The water temperature was monitored continuously for 15 days in 1987 (Figure 8). Minimum daily water temperatures for the 1987 study period occurred between 6 to 8 am AST and ranged from 0.0 to 3.3°C. The 14-day mean minimum water temperature was 1.8°C at 0712 AST. Maximum daily water temperatures occurred between 5 to 9 pm AST and ranged from 3.2 to 7.3°C. The 14-day mean maximum water temperature was 5.5°C, occurring at 1912 AST.

Dissolved oxygen levels for the 1988 study period were also approximately constant, with a mean value of 7.6 ppm (Figure 9). Turbidity dropped from an initial high of 8.2 NTU on May 10, 1988, and decreased slowly to level off at a mean value of 3.6 NTU thereafter. Color displayed considerable variation, as in 1987, with the peak of 110 UNITS occurring the same day as the peak discharge for the study period. Water temperatures for 1988 were quite similar to 1987 (Figure 10).

Data are presented in Appendix A for measured discharge, computed discharge, water chemistry and temperature.

HYDRAULICS

Our previous observations of fish swimming in and around culverts have lead us to believe that fish understand the hydraulic conditions which

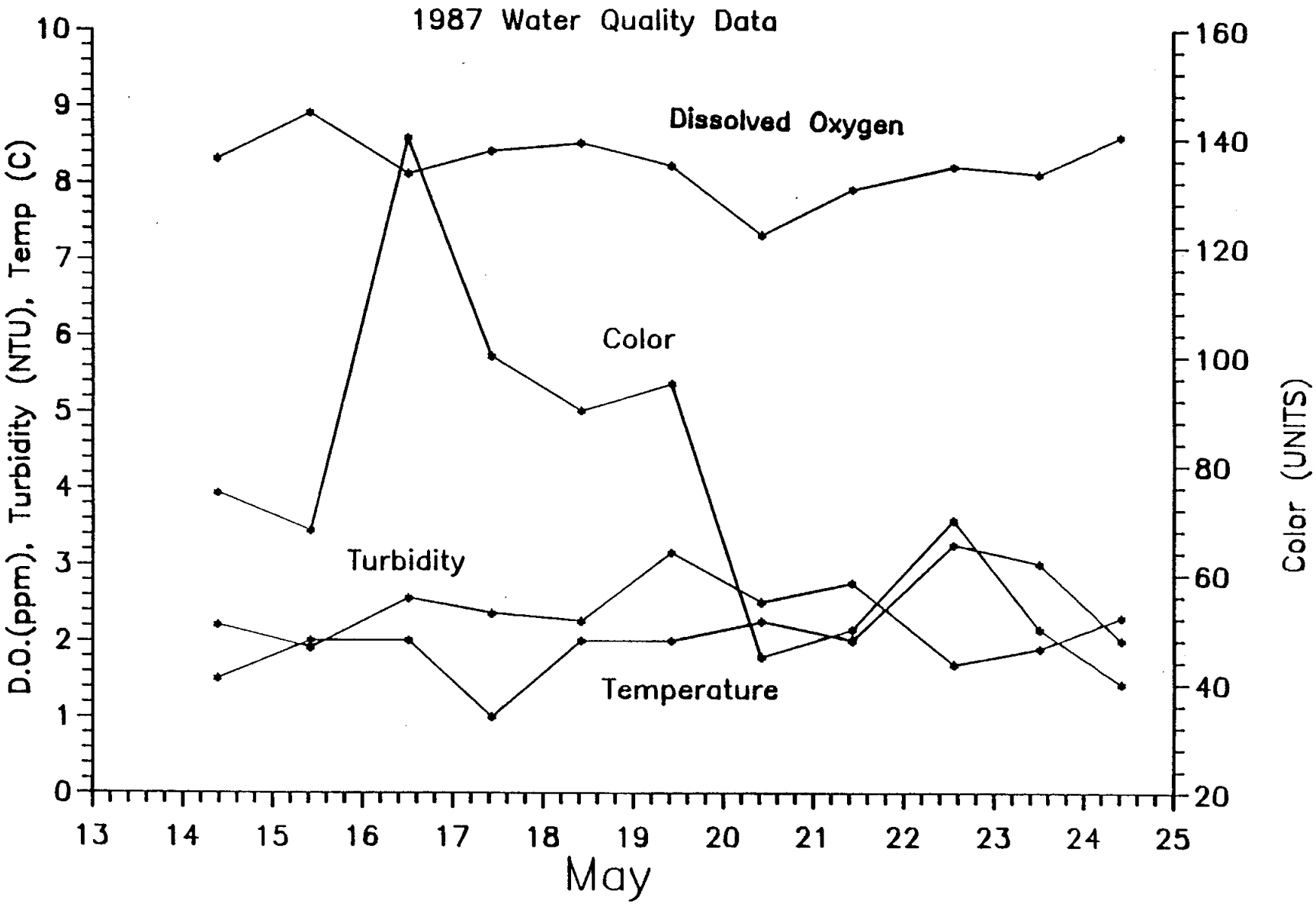

Figure 7: Water quality parameters, Fish Creek, 1987.

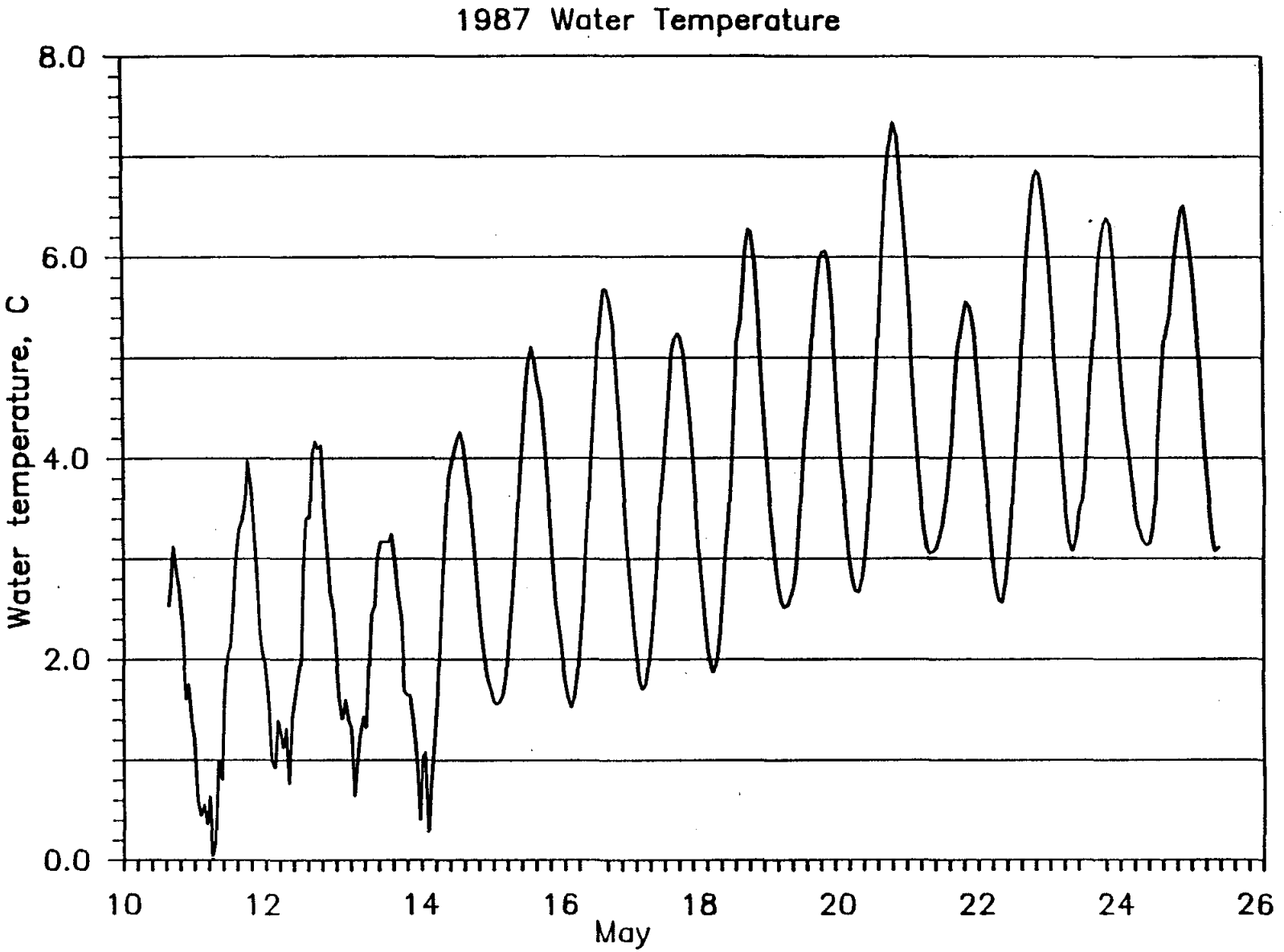

Figure 8: Water temperatures, Fish Creek, 1987.

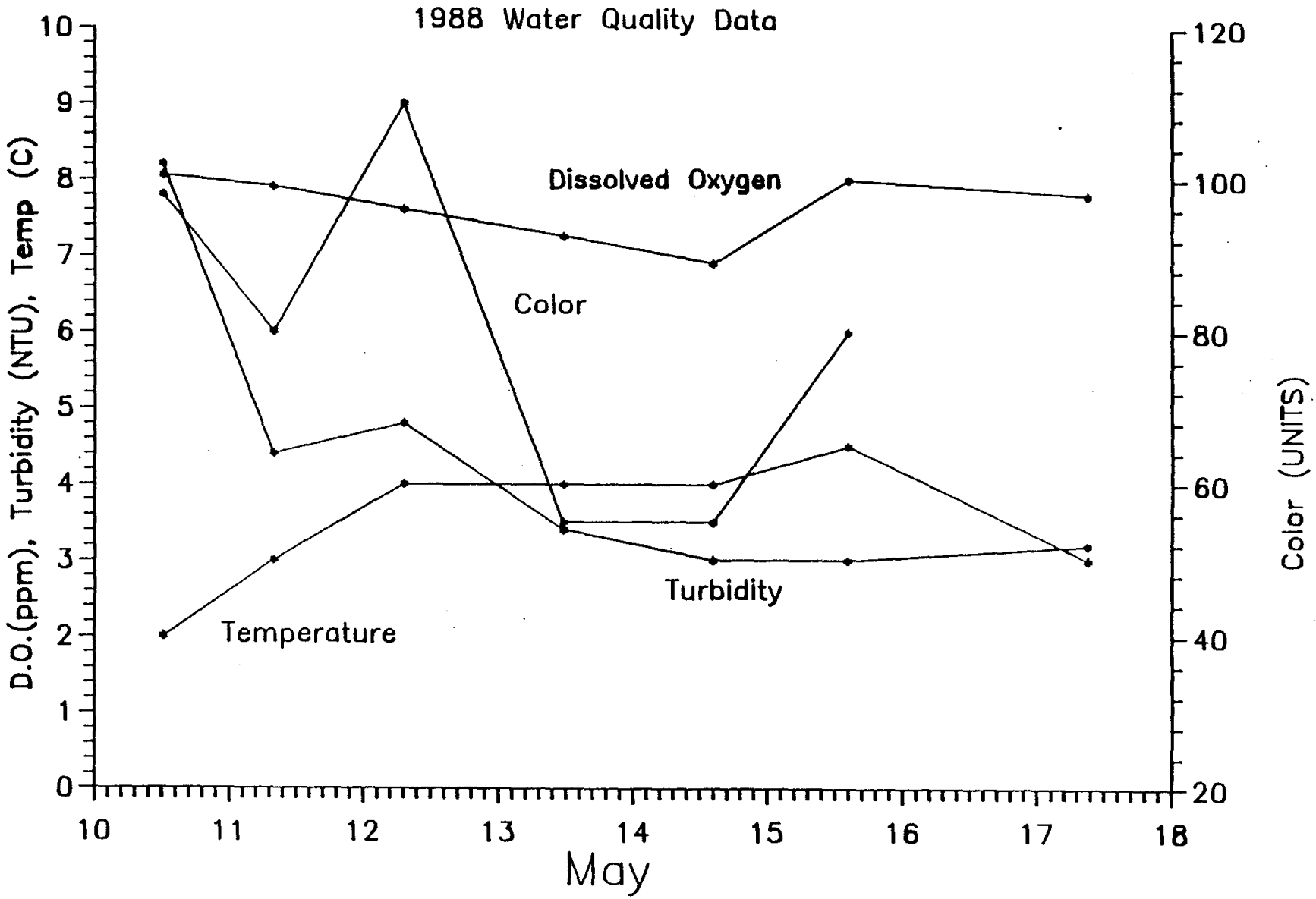

Figure 9: Water quality parameters, Fish Creek, 1988.

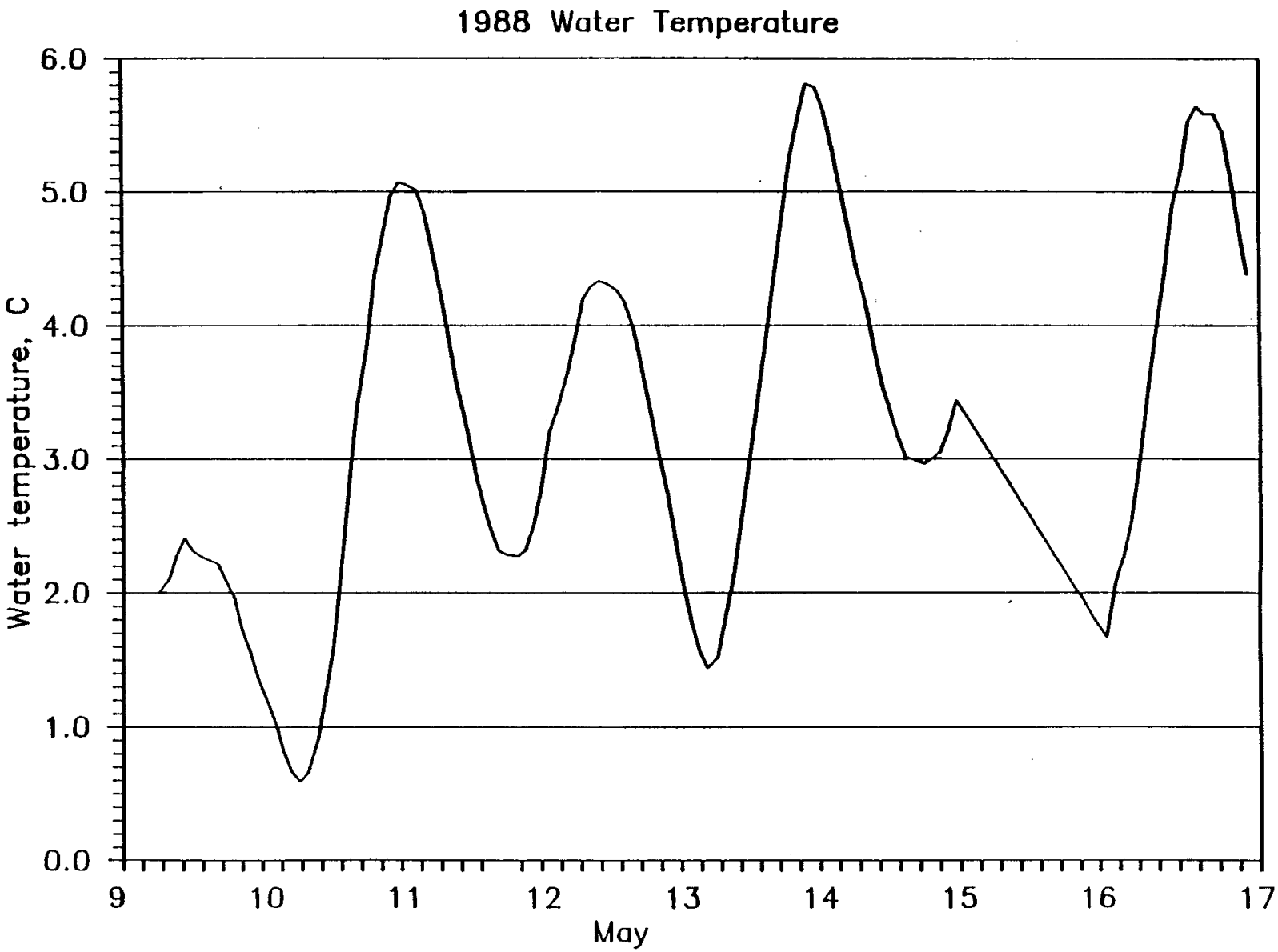

Figure 10: Water temperatures, Fish Creek, 1988.

make it difficult or easy for them to swim. It is well known that profile drag, which for a specific fish is dependent on its velocity with respect to the surrounding water, is an important force which hinders forward progress. In addition, the "gradient force," which is the resultant of buoyant and weight forces, hinders forward progress. Finally, the virtual mass force, which results from the relative acceleration of the fish in relation to the surrounding water, usually hinders forward progress.

In order to determine the magnitude of these forces, it is necessary to know: (1) the hydraulic conditions where the fish swim, and (2) the velocity of the fish with respect to a fixed reference system. The hydraulic conditions consist of velocity, acceleration, and pressure gradients in the water where the fish swim.

This section presents the 1987 and 1988 hydraulic data which were obtained in and nearby the existing Fish Creek culvert. Of great importance to the studies are the velocity profiles which were obtained at several cross-sections (summarized in Tables 1 and 2) and at selected points in the culvert on different days and at various discharges (Figures 11 to 35 and Appendix B). Water surface profile data (see Appendix B) are important for a determination of mean velocities within the culvert and the gradient forces on the fish, and the calculation of water acceleration at the inlet and outlet of the culvert since they relate to virtual mass forces on swimming fish.

Water velocity data were also taken at locations near the water surface close to the perimeter of the culvert, an action prompted by

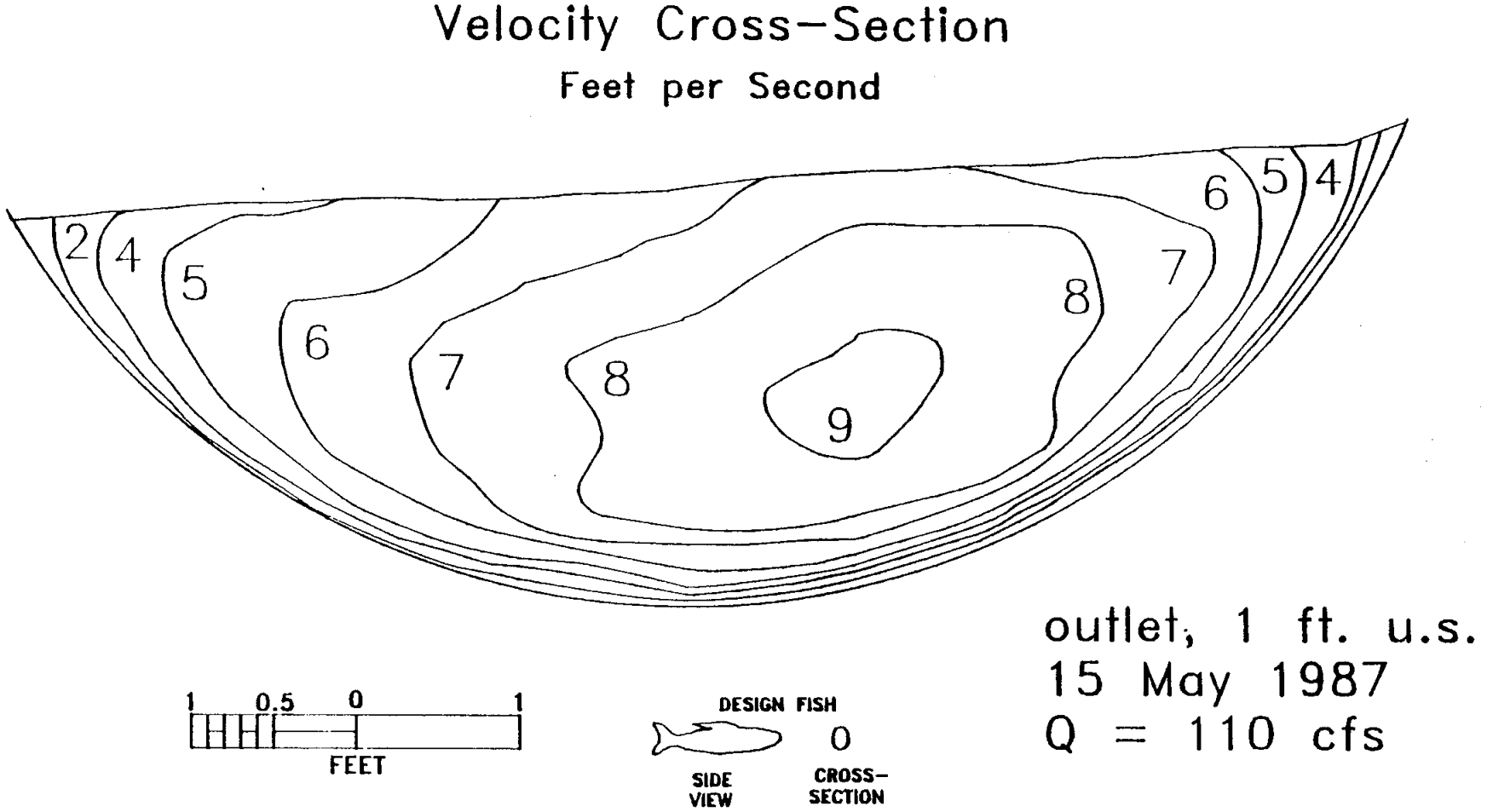

Figure 11: Velocity contours for Fish Creek culvert, 1 ft upstream of outlet, May 15, 1987.

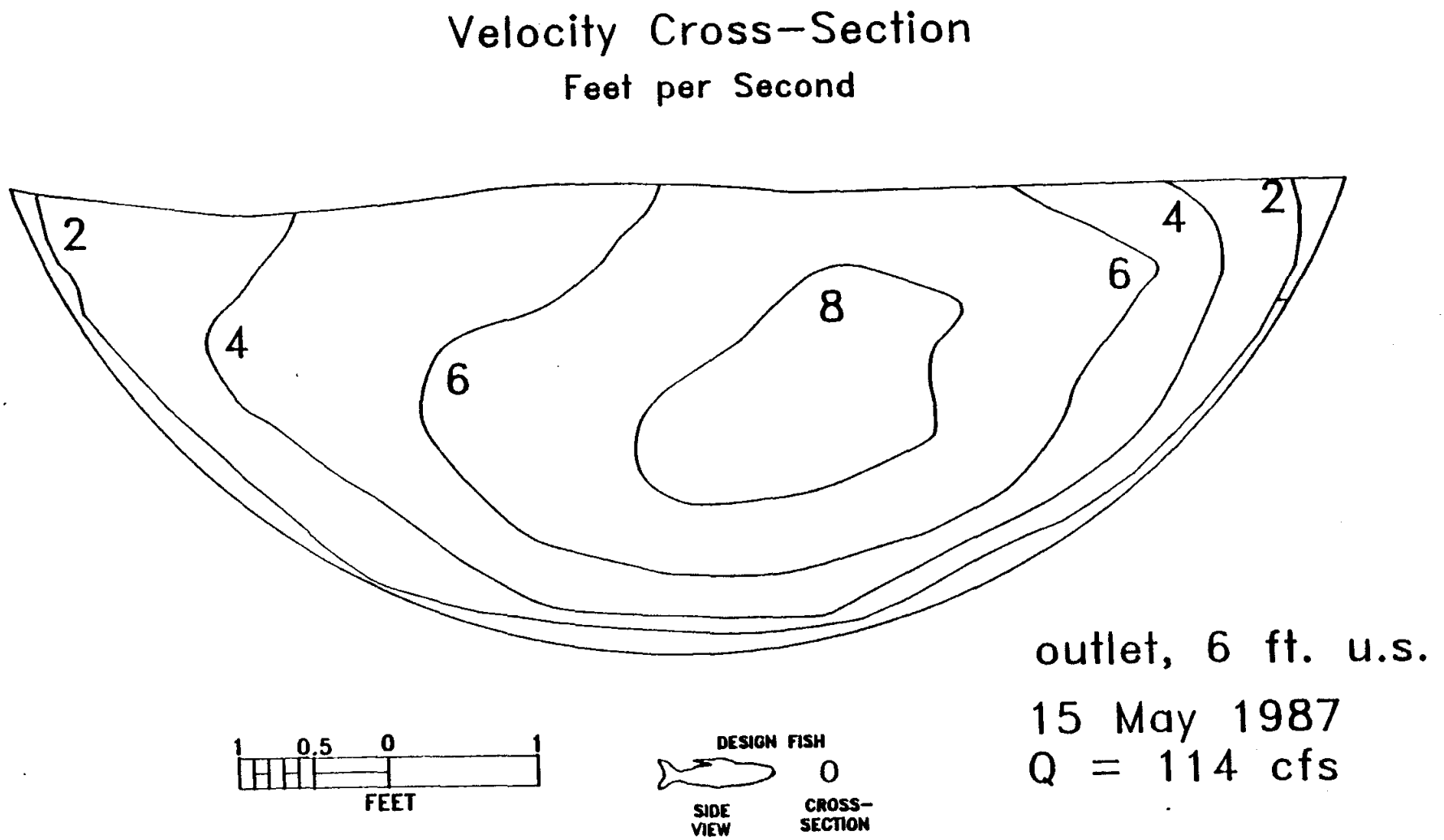

Figure 12: Velocity contours for Fish Creek culvert, 6 ft upstream of outlet, May 15, 1987.

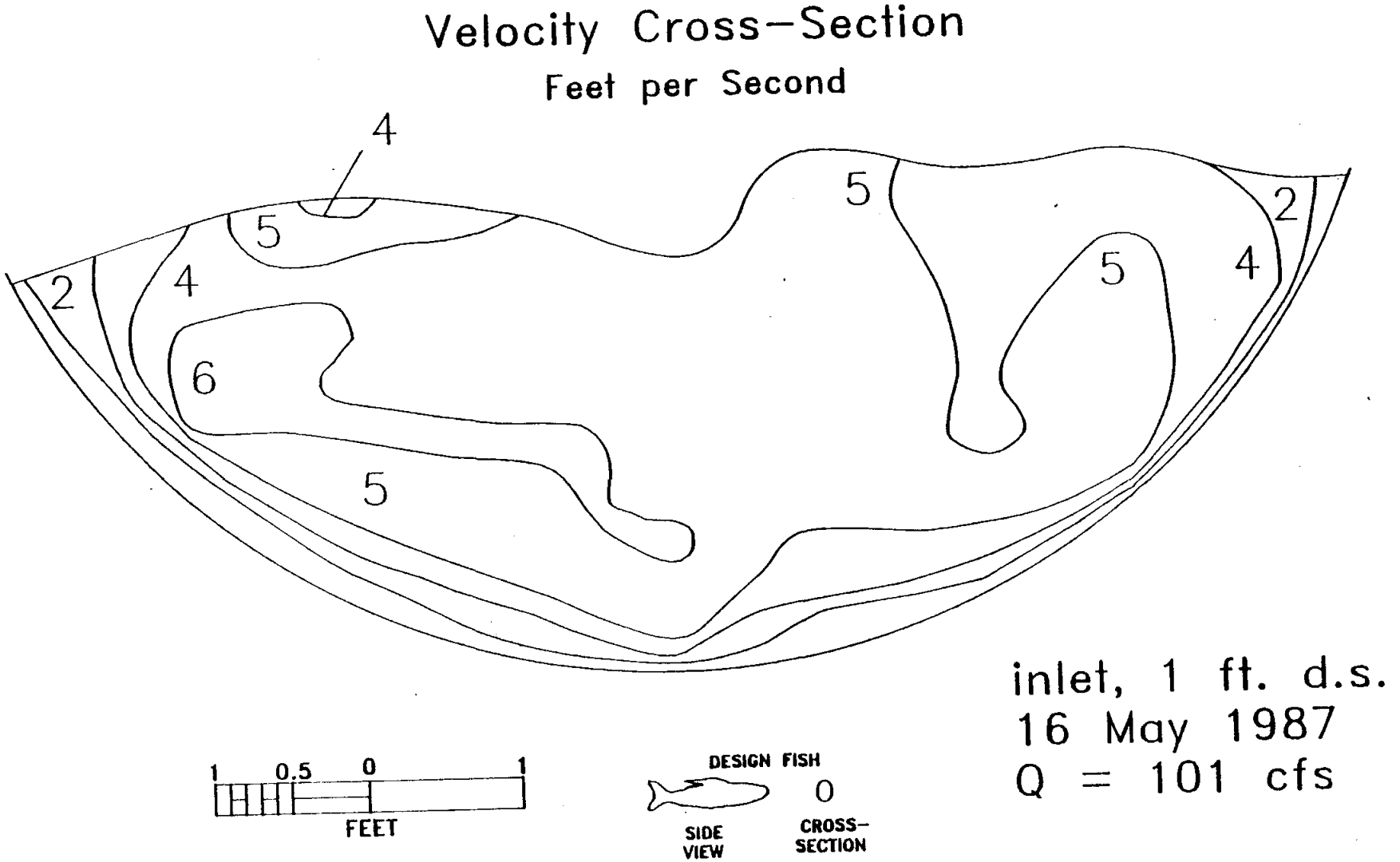

Figure 13: Velocity contours for Fish Creek culvert, 1 ft downstream of inlet, May 16, 1987.

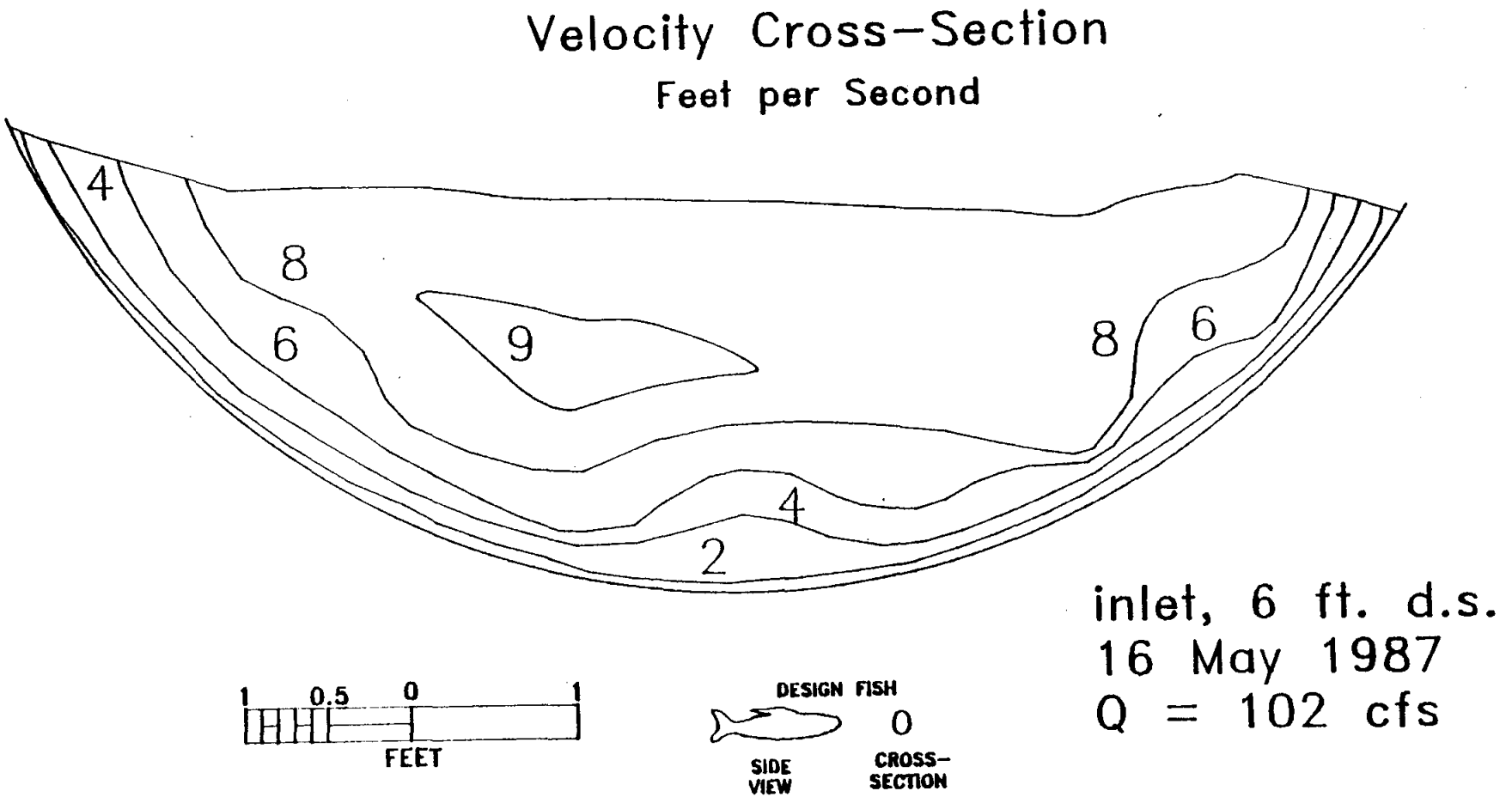

Figure 14: Velocity contours for Fish Creek culvert, 6 ft downstream of inlet, May 16, 1987.

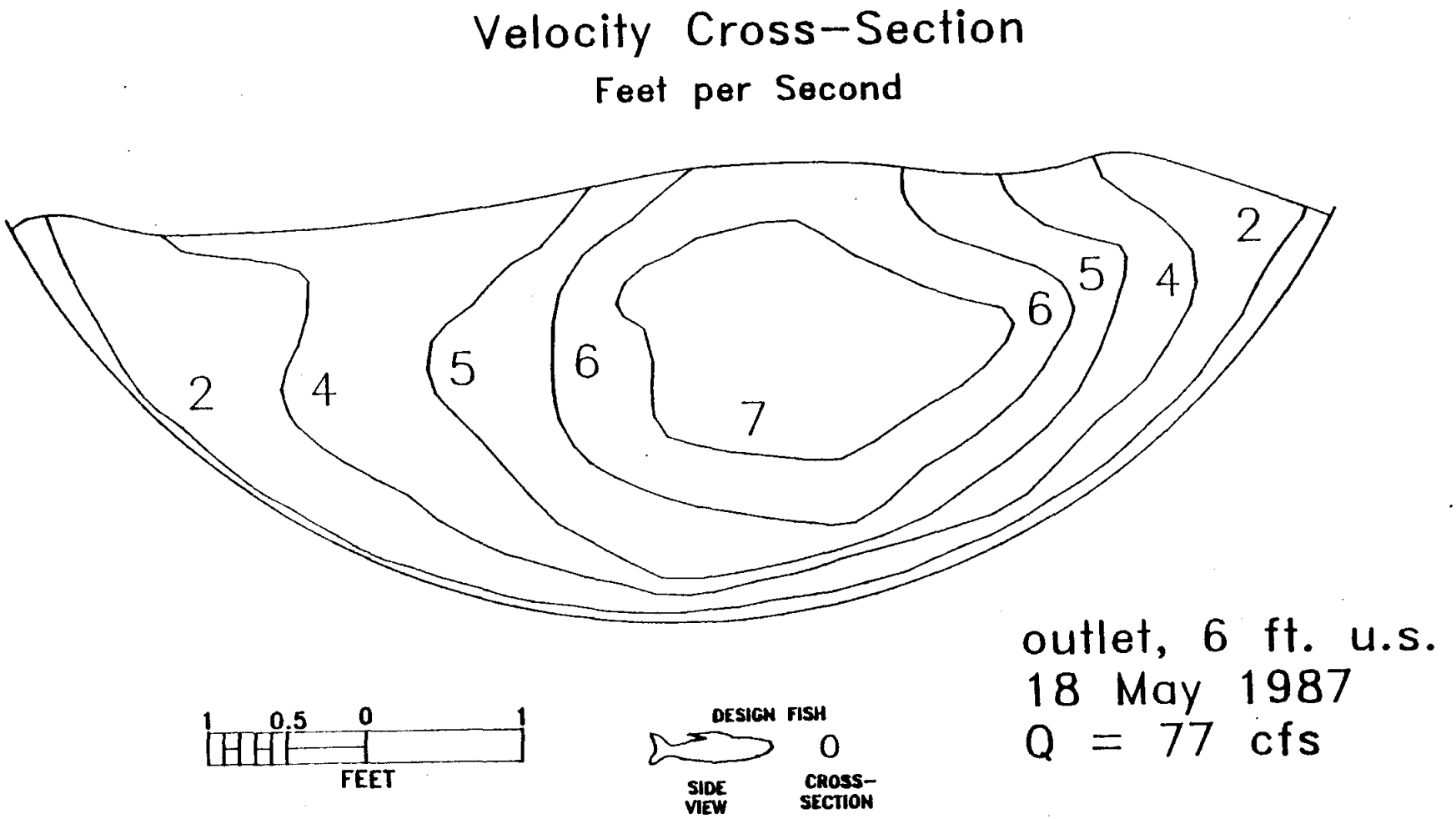

Figure 15: Velocity contours for Fish Creek culvert, 6 ft upstream of outlet, May 18, 1987.

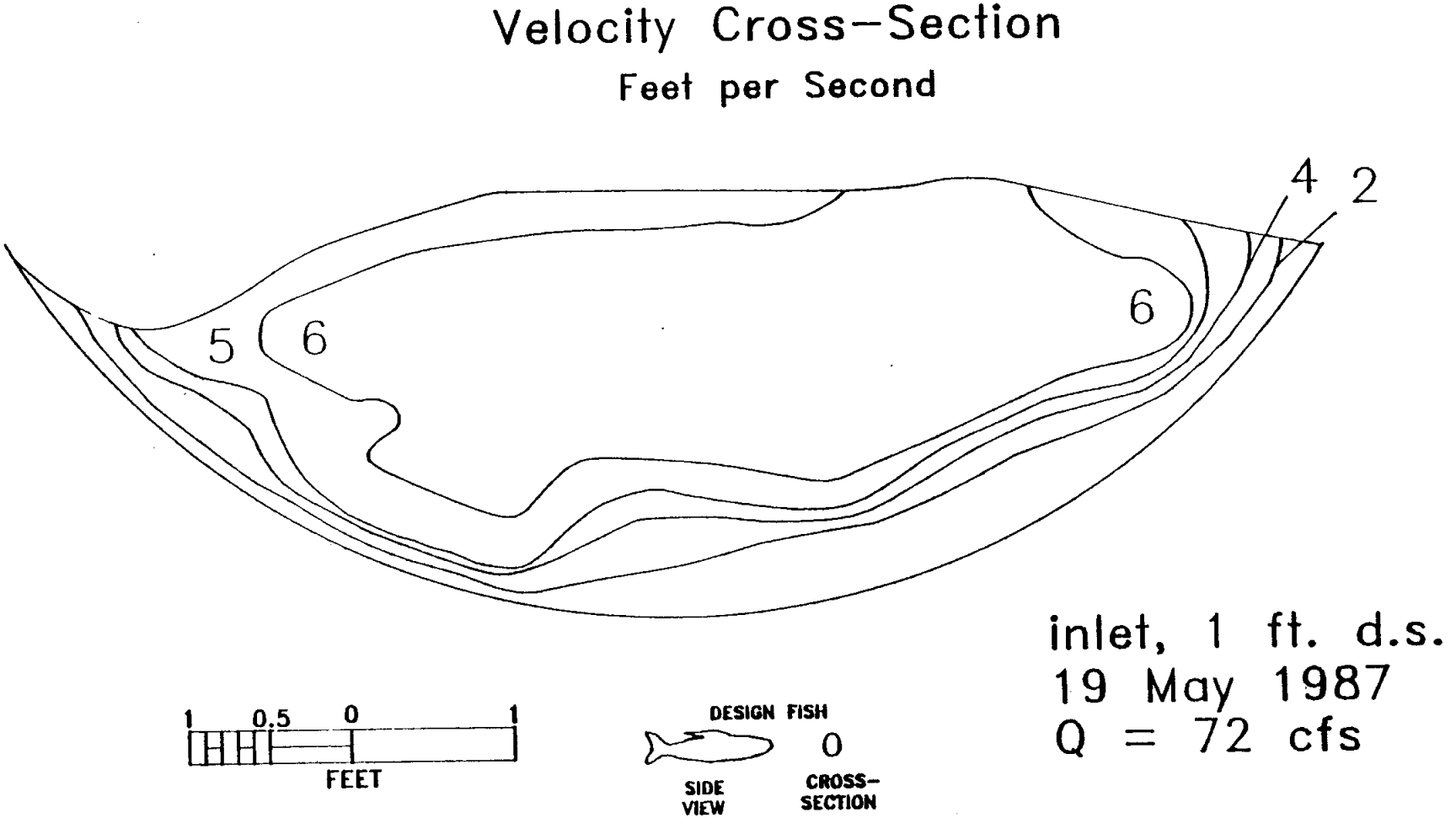

Figure 16: Velocity contours for Fish Creek culvert, 1 ft downstream of inlet, May 19, 1987.

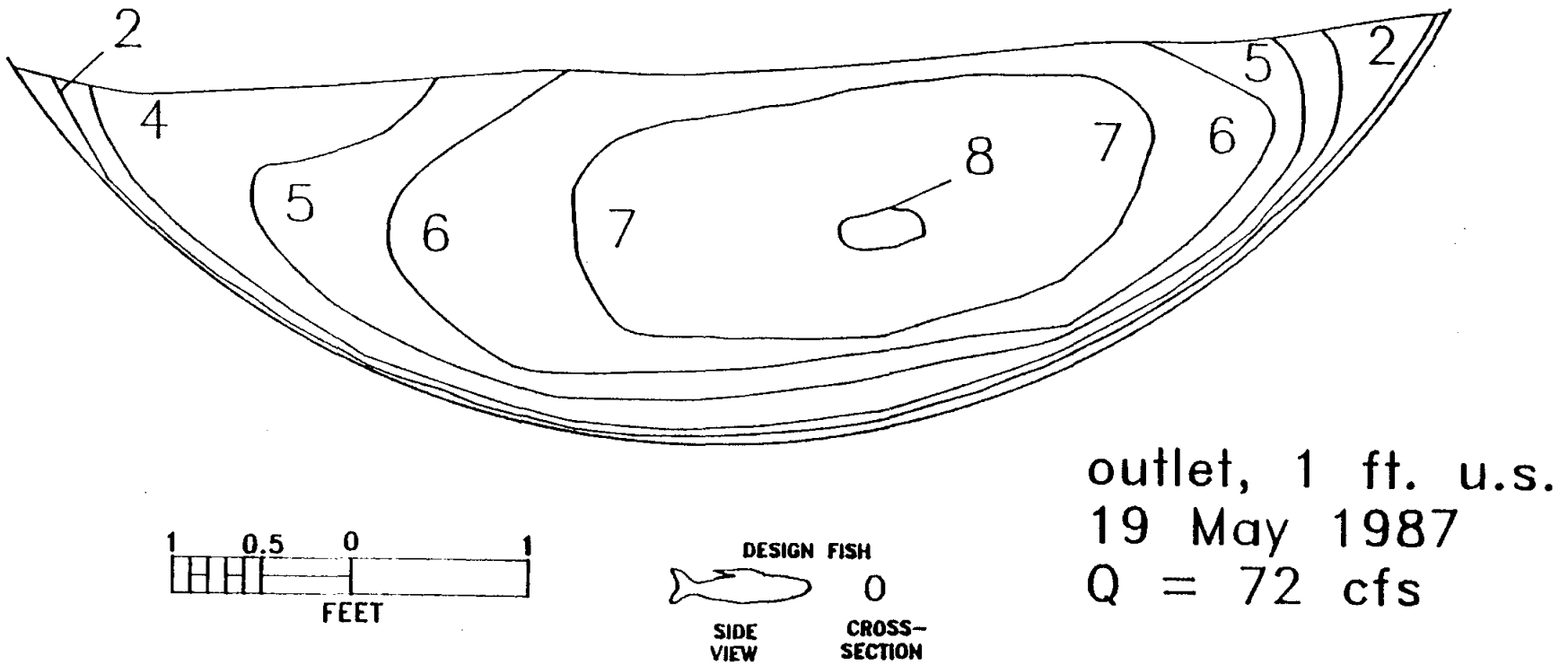

Figure 17: Velocity contours for Fish Creek culvert, 1 ft upstream of outlet, May 19, 1987.

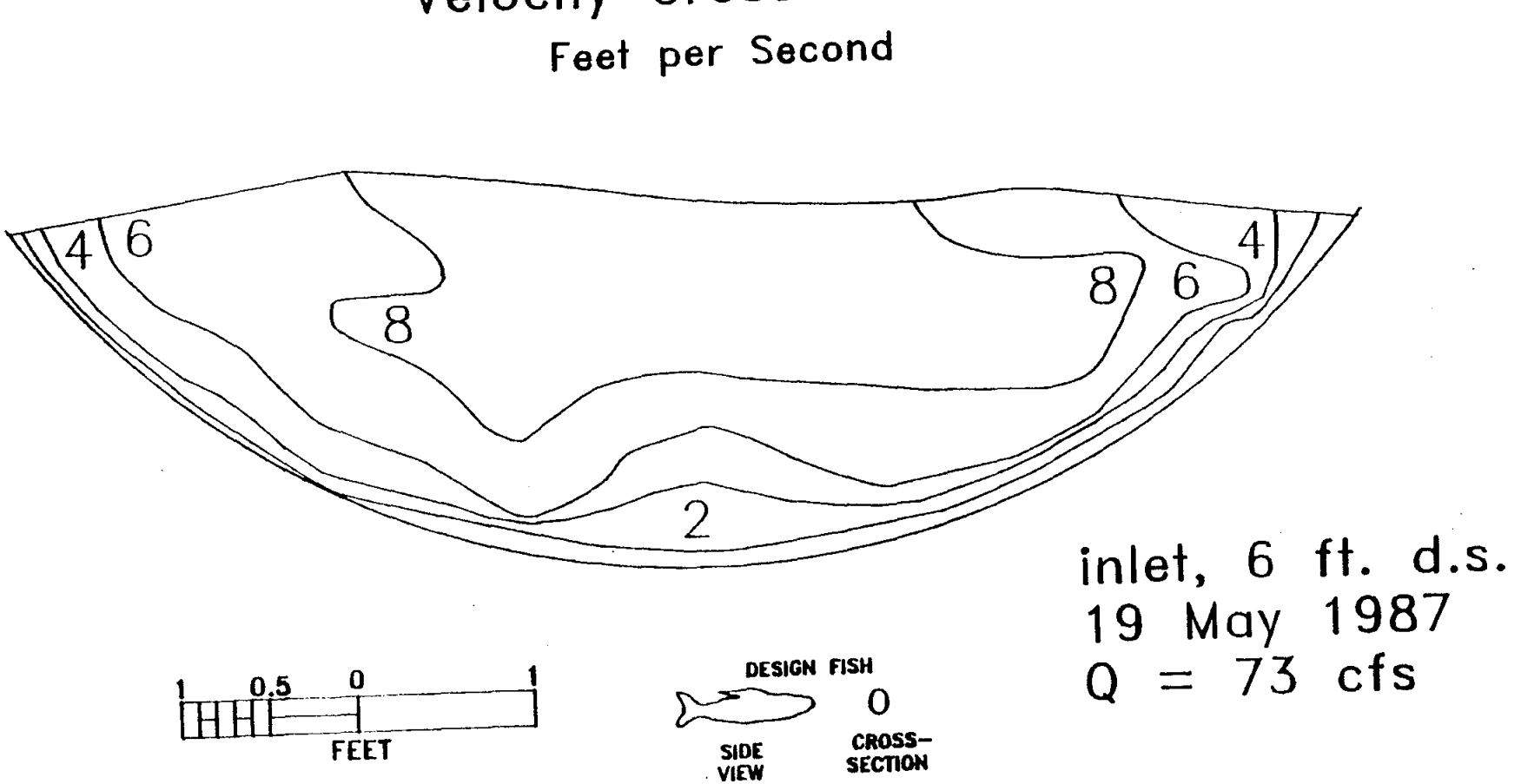

Figure 18: Velocity contours for Fish Creek culvert, 6 ft downstream of inlet, May 19, 1987.

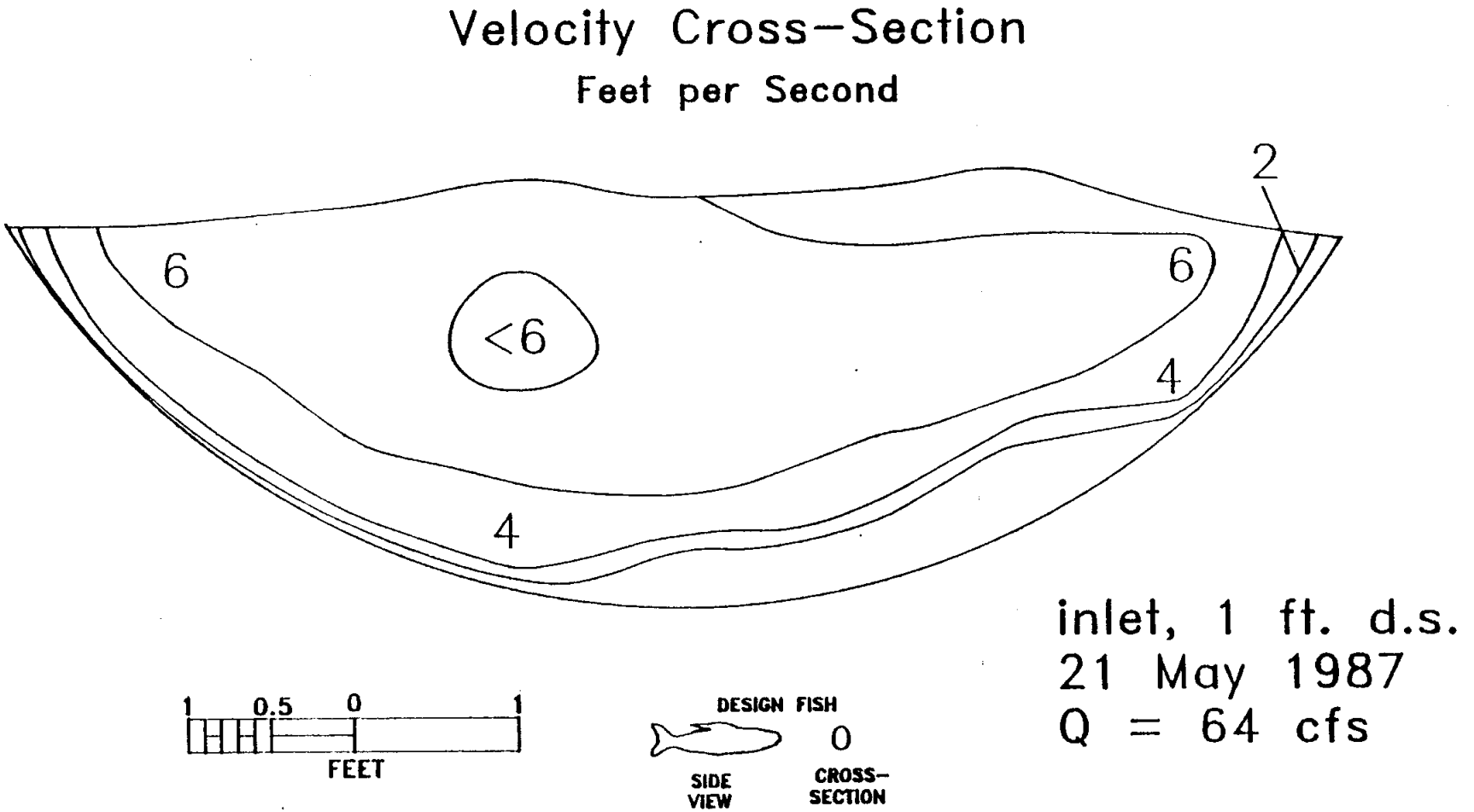

Figure 19: Velocity contours for Fish Creek culvert, 1 ft downstream of inlet, May 21, 1987.

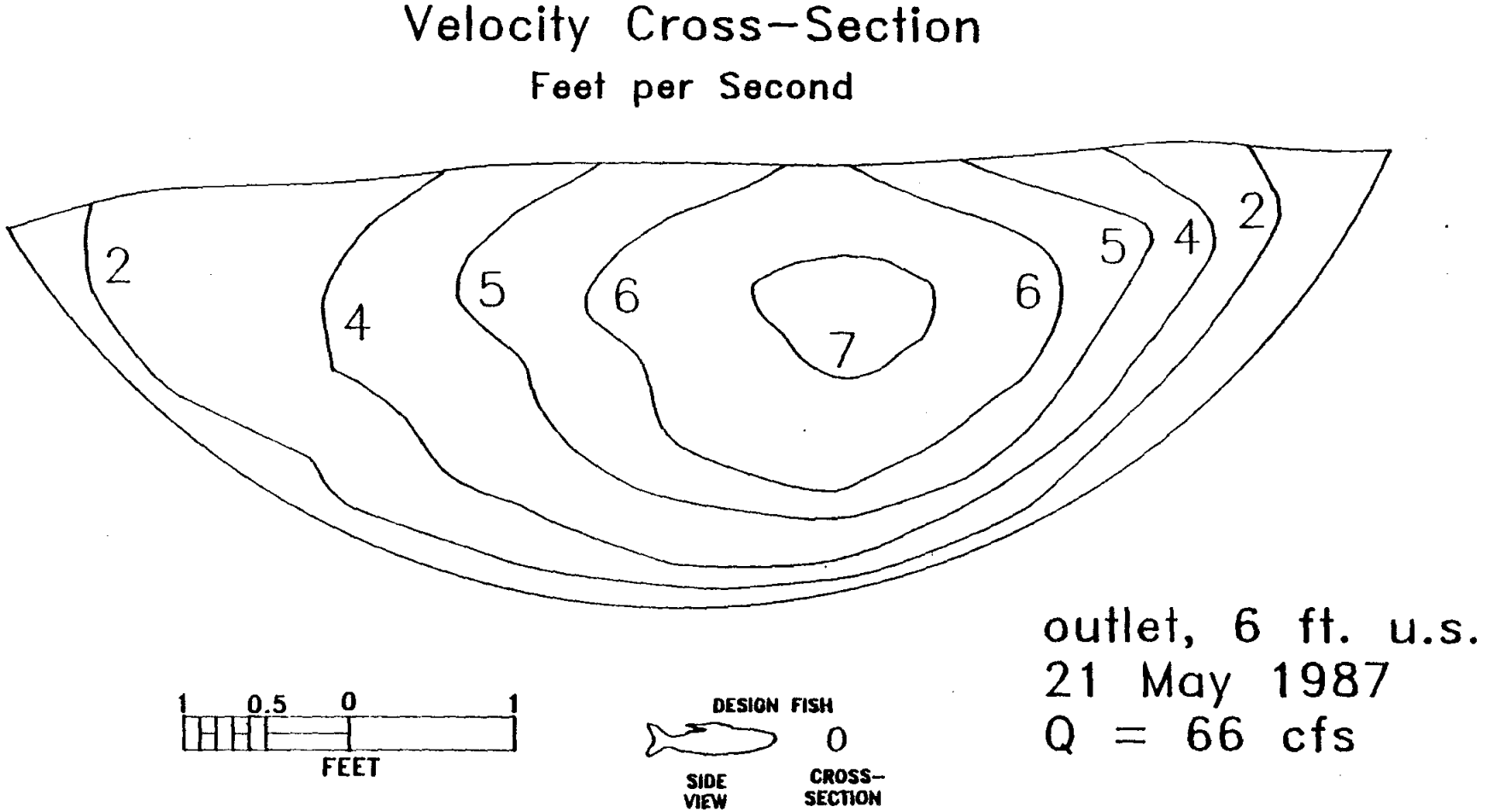

Figure 20: Velocity contours for Fish Creek culvert, 6 ft downstream of inlet, May 21, 1987.

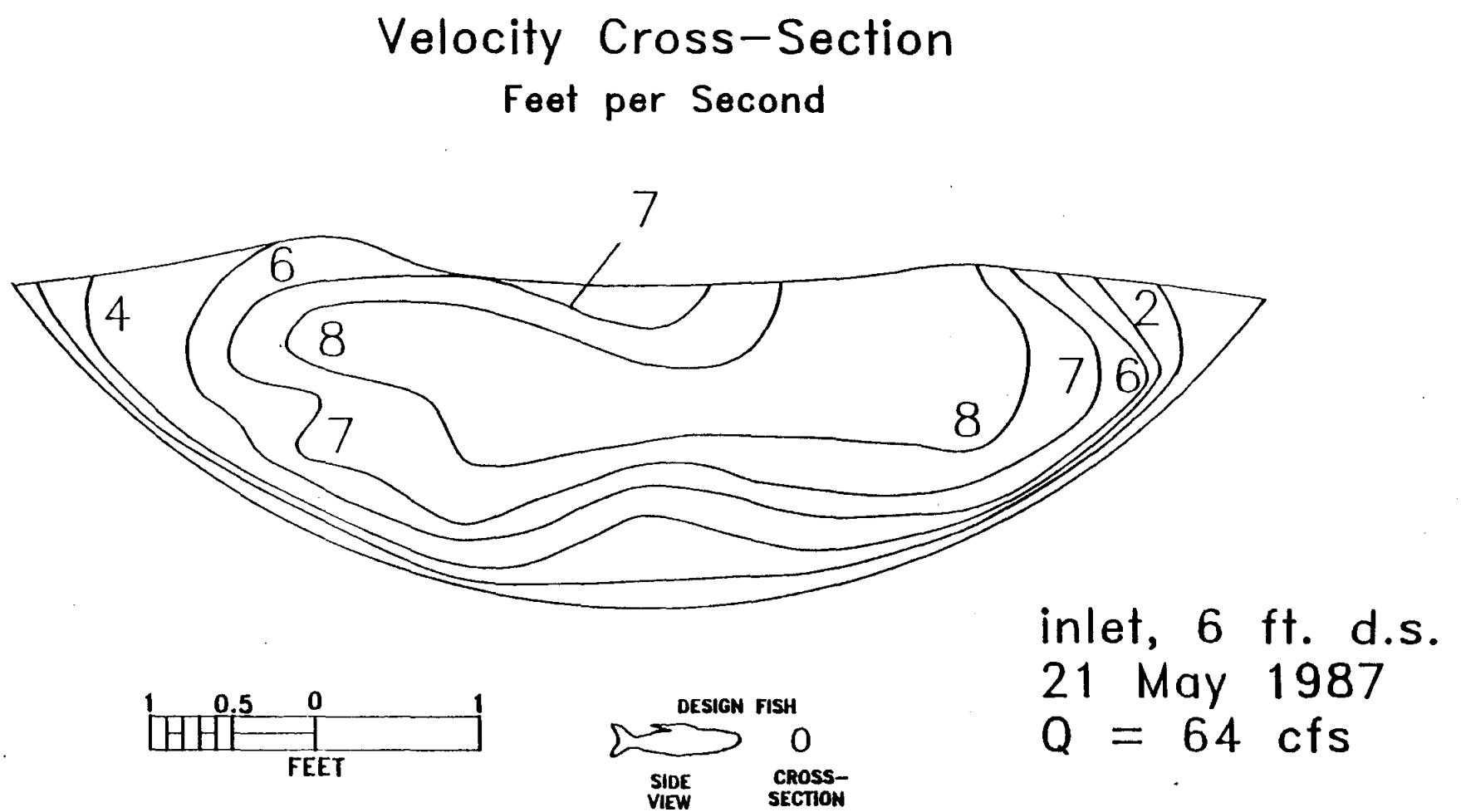

Figure 21: Velocity contours for Fish Creek culvert, 6 ft upstream of outlet, May 21, 1987.

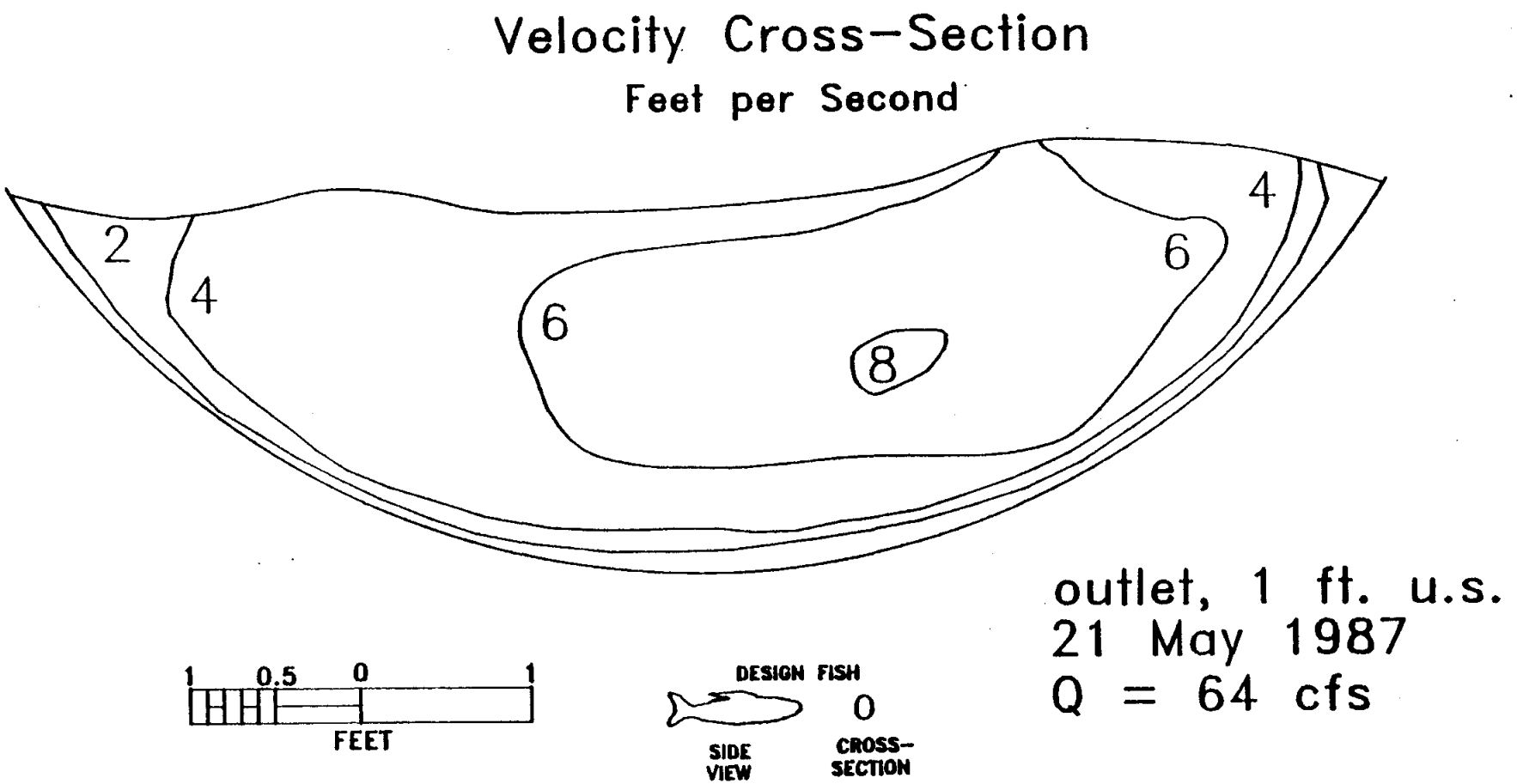

Figure 22: Velocity contours for Fish Creek culvert, 1 ft upstream of outlet, May 21, 1987.

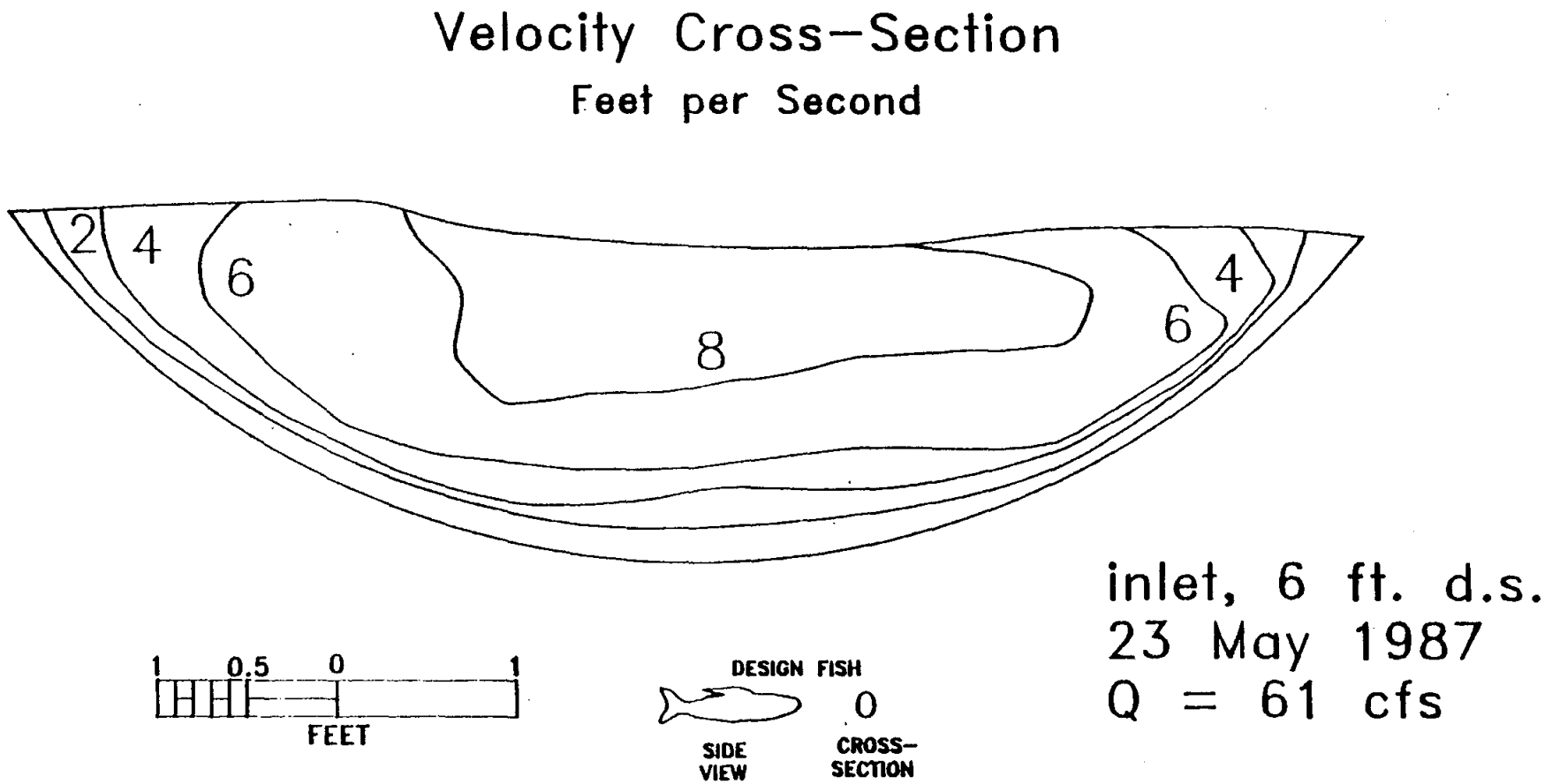

Figure 23: Velocity contours for Fish Creek culvert, 6 ft downstream of inlet, May 23, 1987.

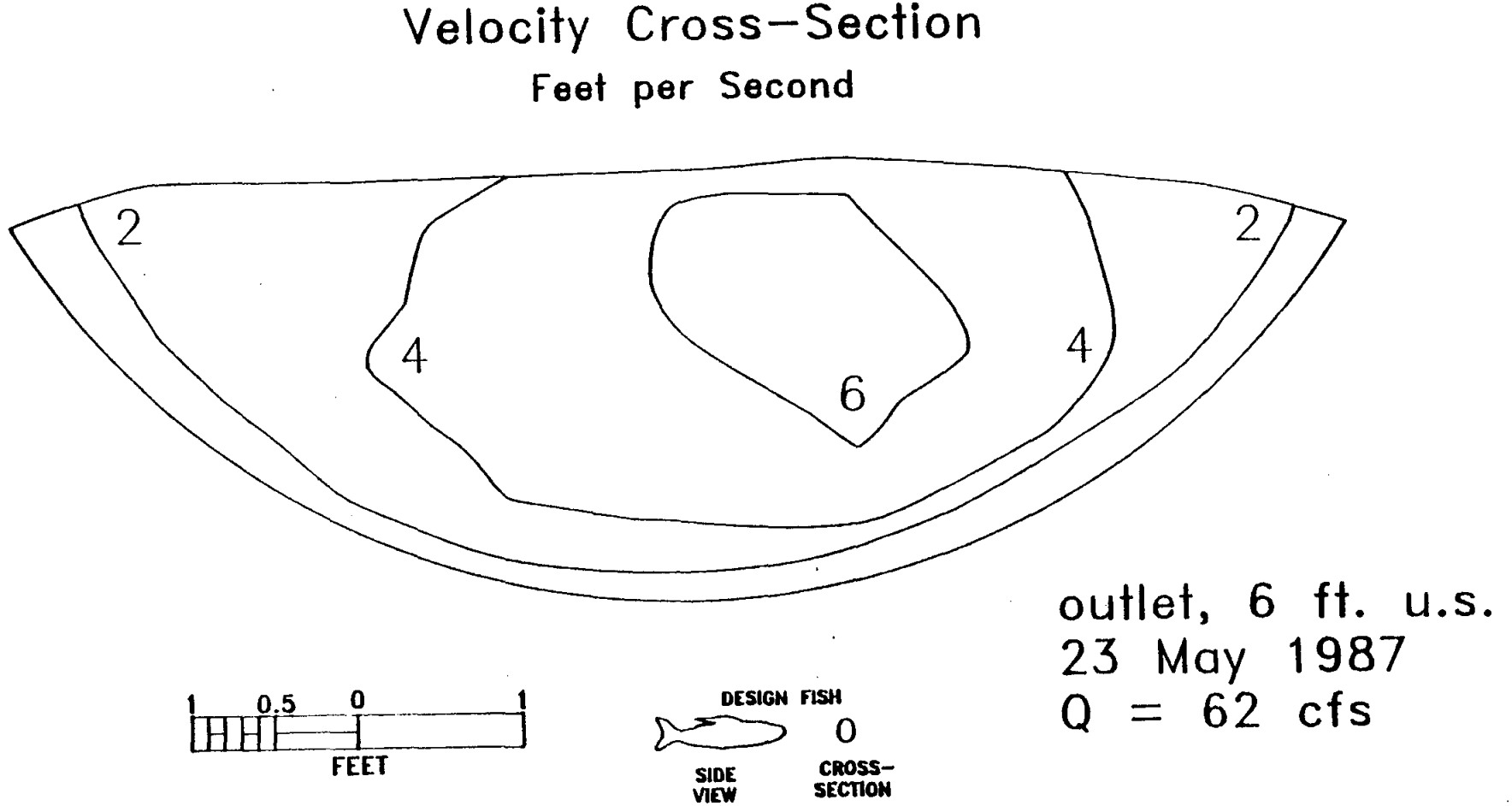

Figure 24: Velocity contours for Fish Creek culvert, 6 ft upstream of outlet, May 23, 1987.

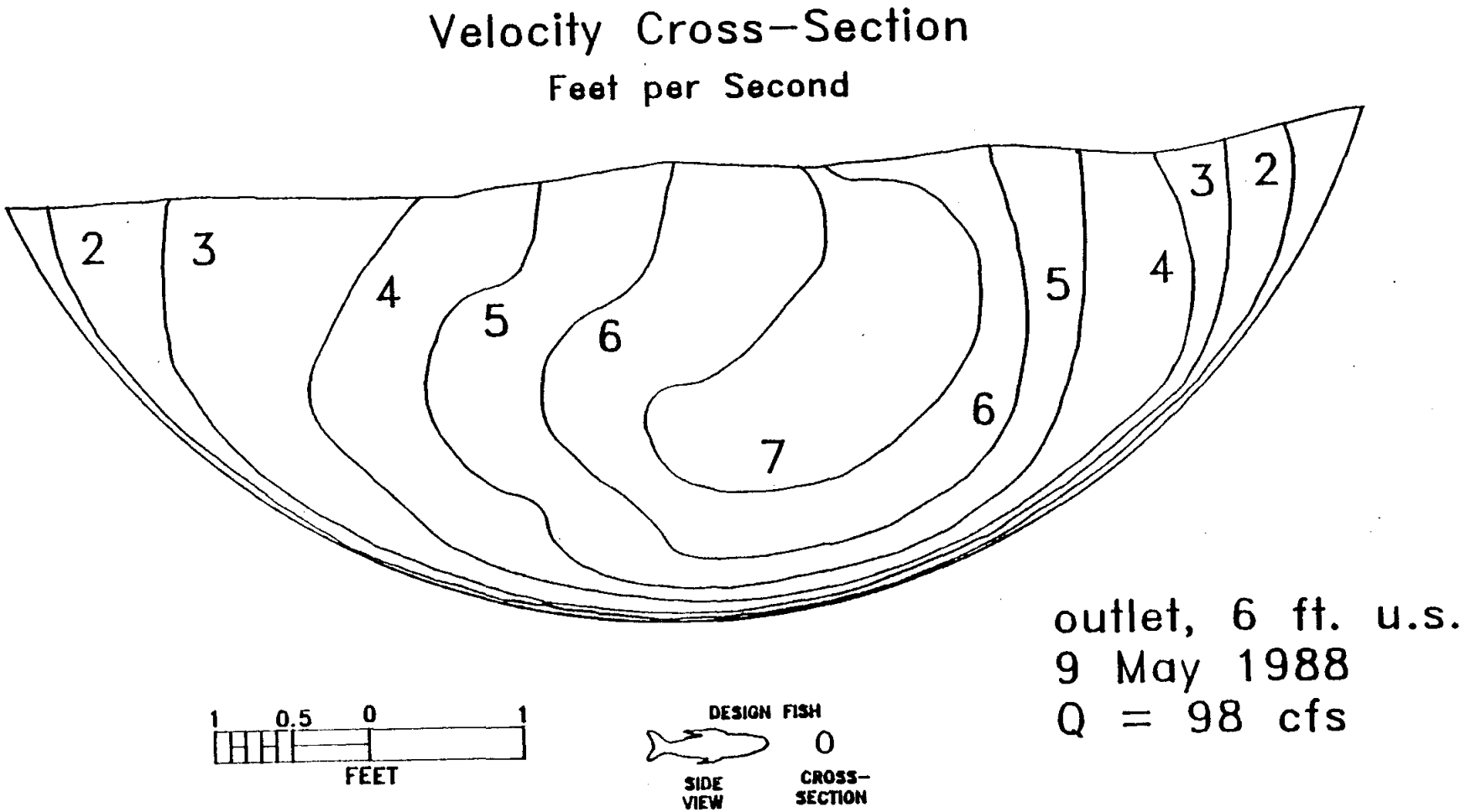

Figure 25: Velocity contours for Fish Creek culvert, 6 ft upstream of outlet, May 9, 1988.

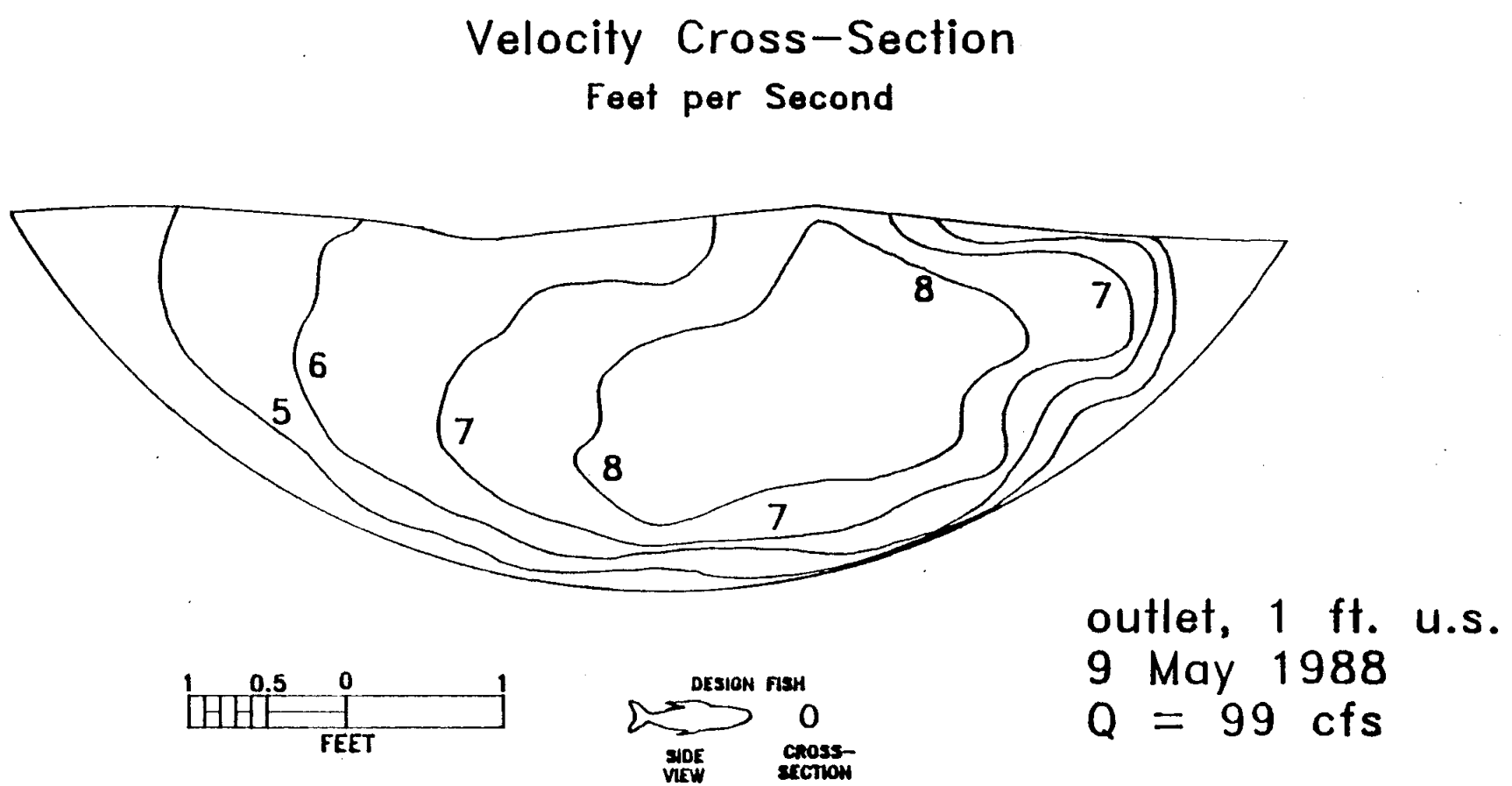

Figure 26: Velocity contours for Fish Creek culvert, 1 ft upstream of outlet, May 9, 1988.

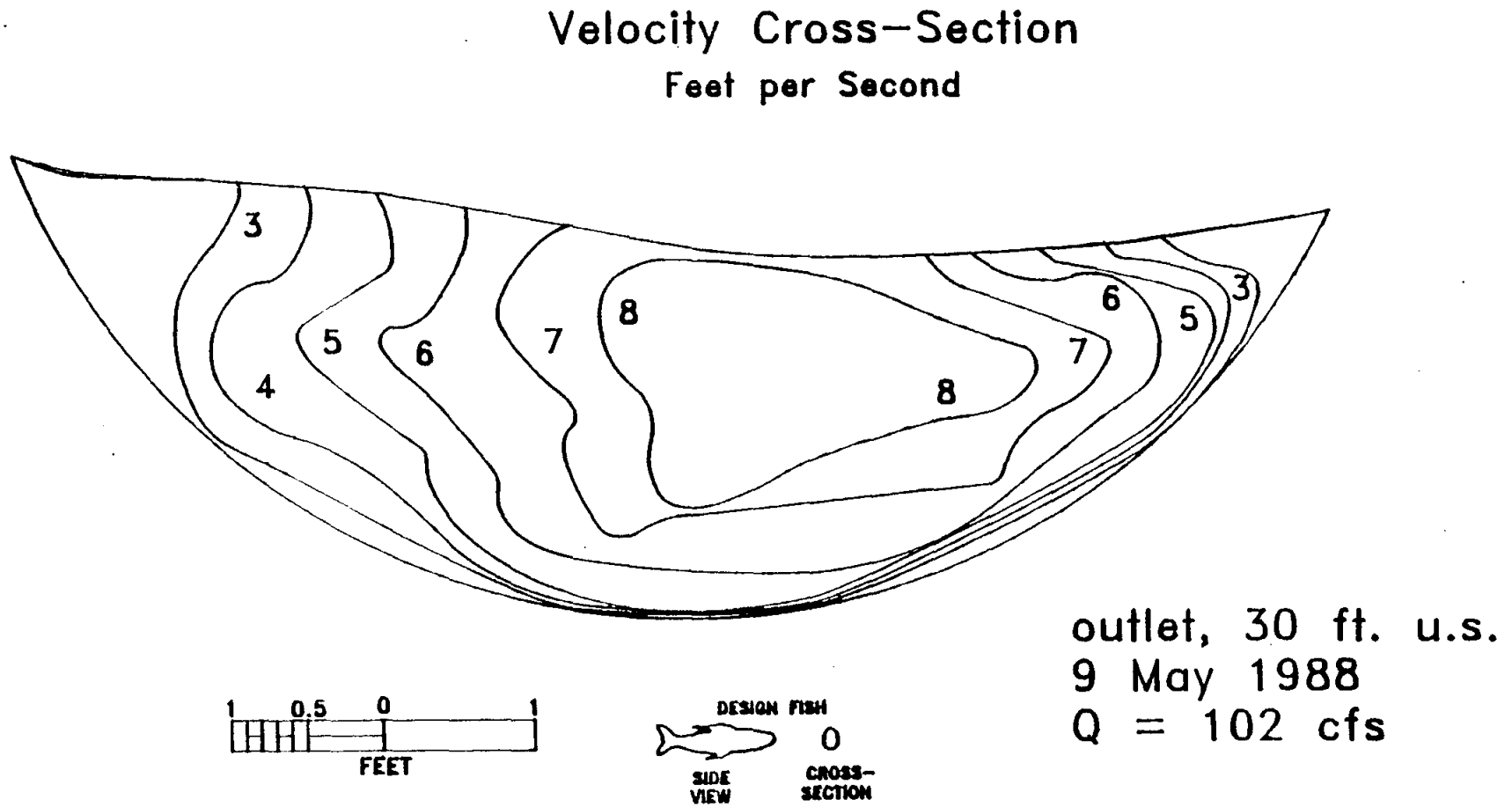

Figure 27: Velocity contours for Fish Creek culvert, 30 ft upstream of outlet, May 9, 1988.

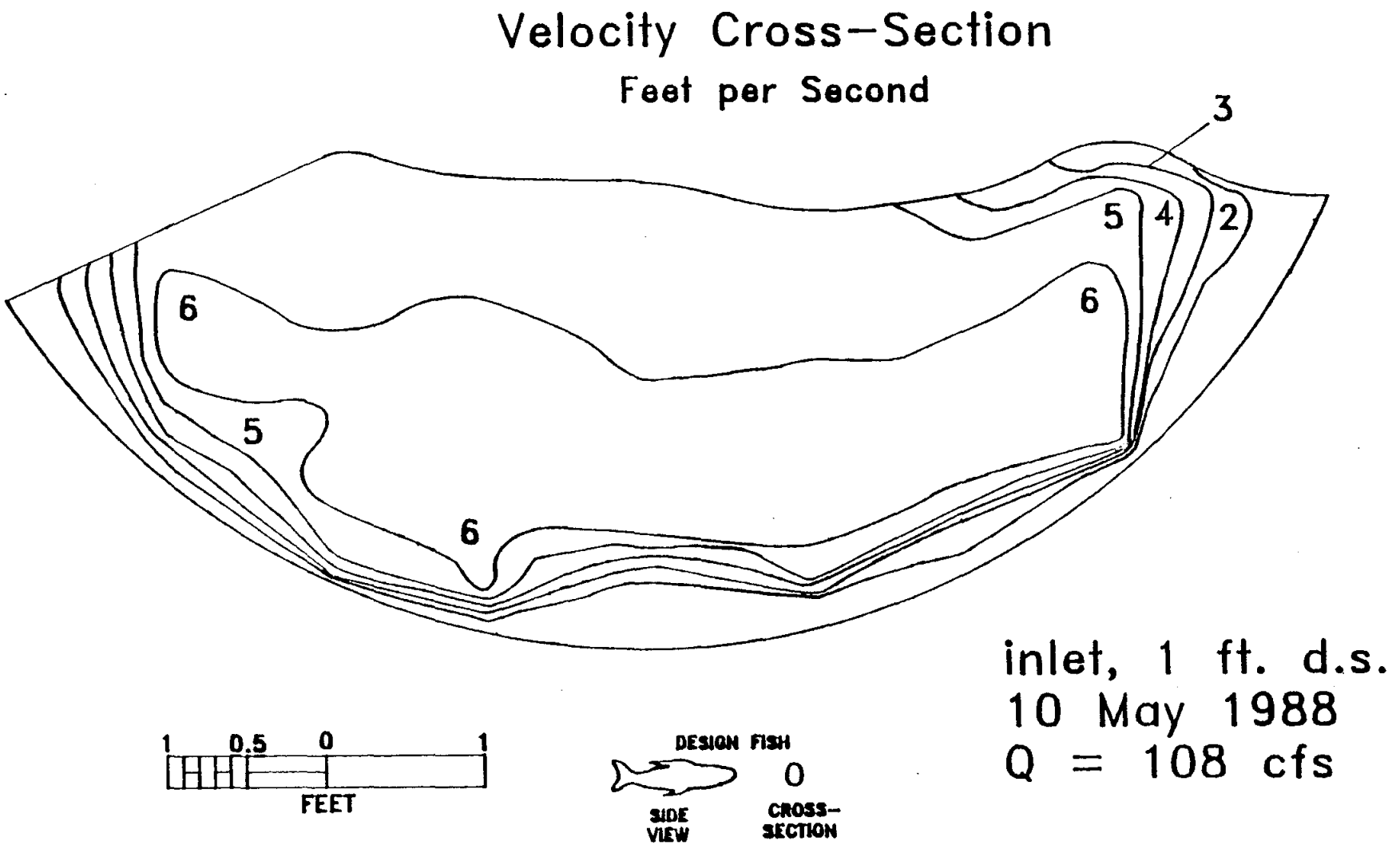

Figure 28: Velocity contours for Fish Creek culvert, 1 ft downstream of inlet, May 10, 1988.

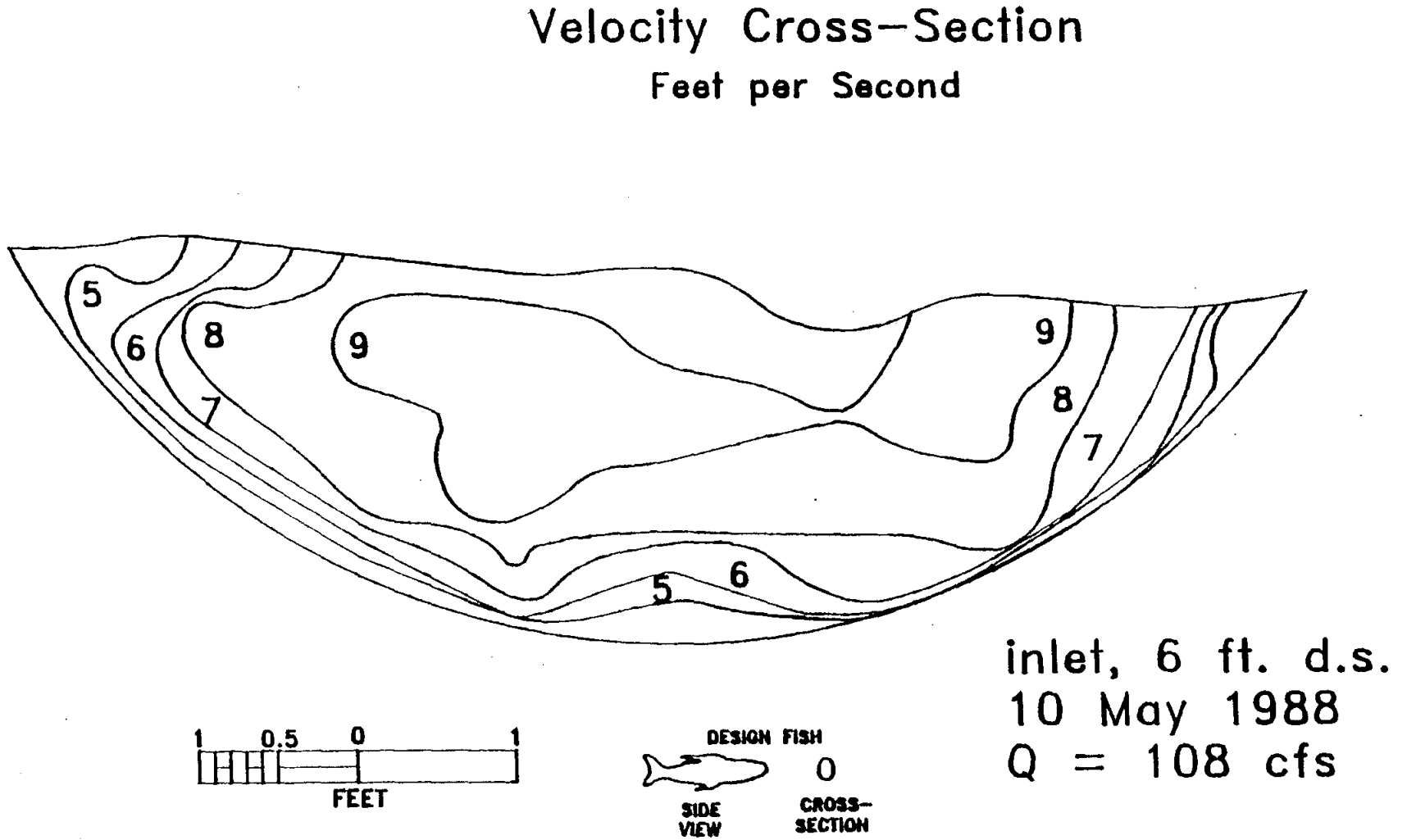

Figure 29: Velocity contours for Fish Creek culvert, 6 ft downstream of inlet, May 10, 1988.

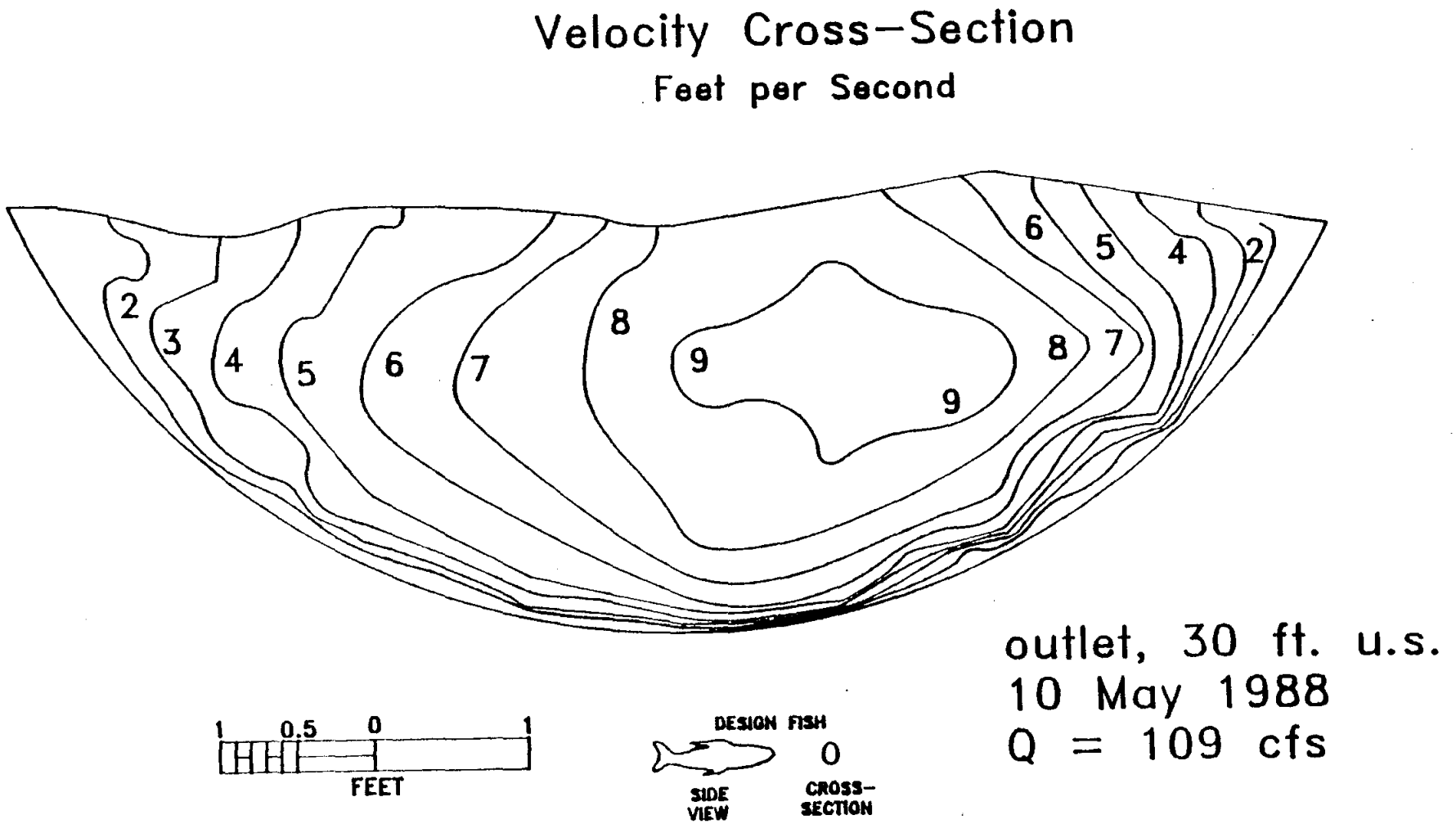

Figure 30: Velocity contours for Fish Creek culvert, 30 ft upstream of outlet, May 10, 1988.

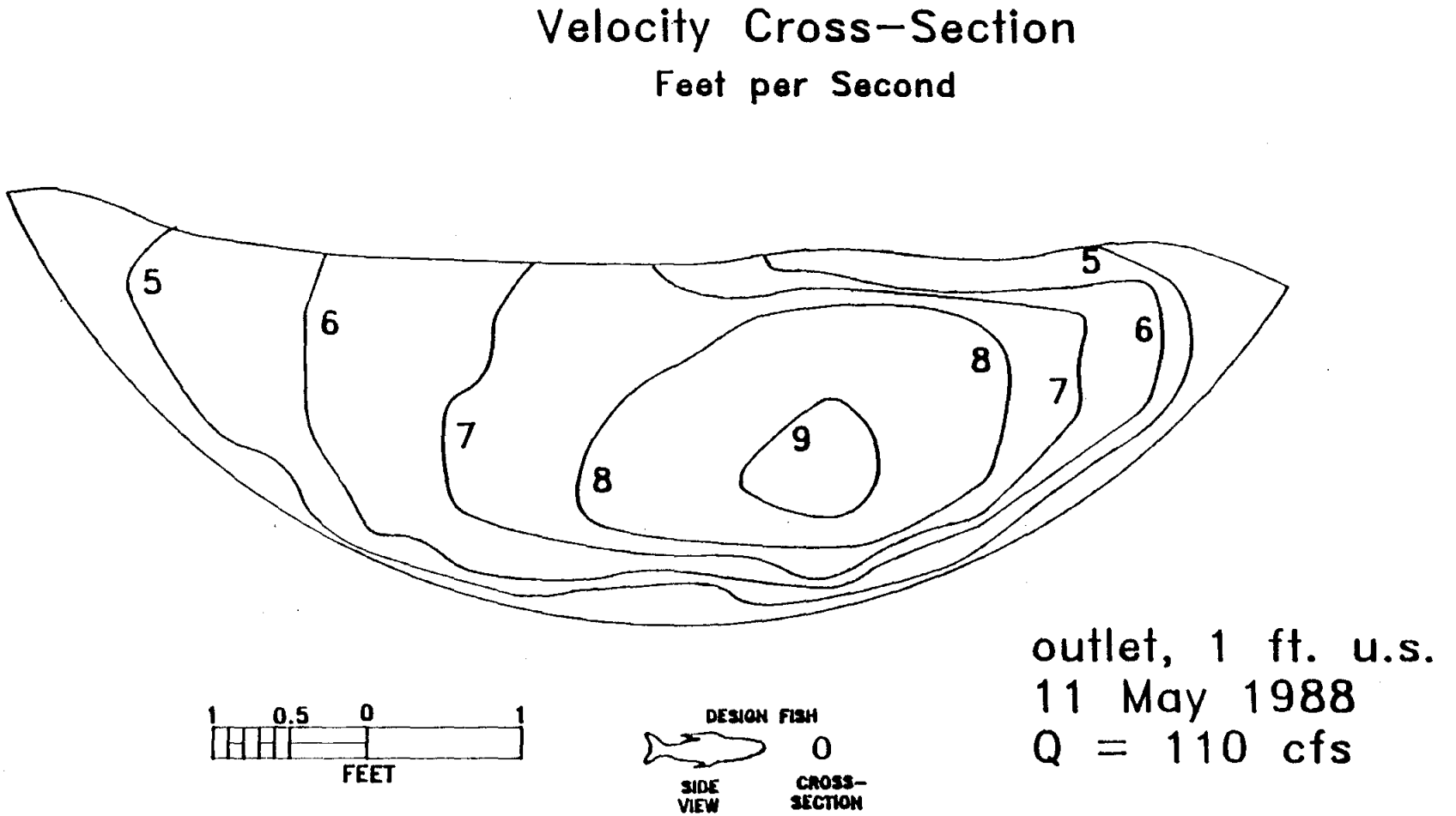

Figure 31: Velocity contours for Fish Creek culvert, 1 ft upstream of outlet, May 11, 1988.

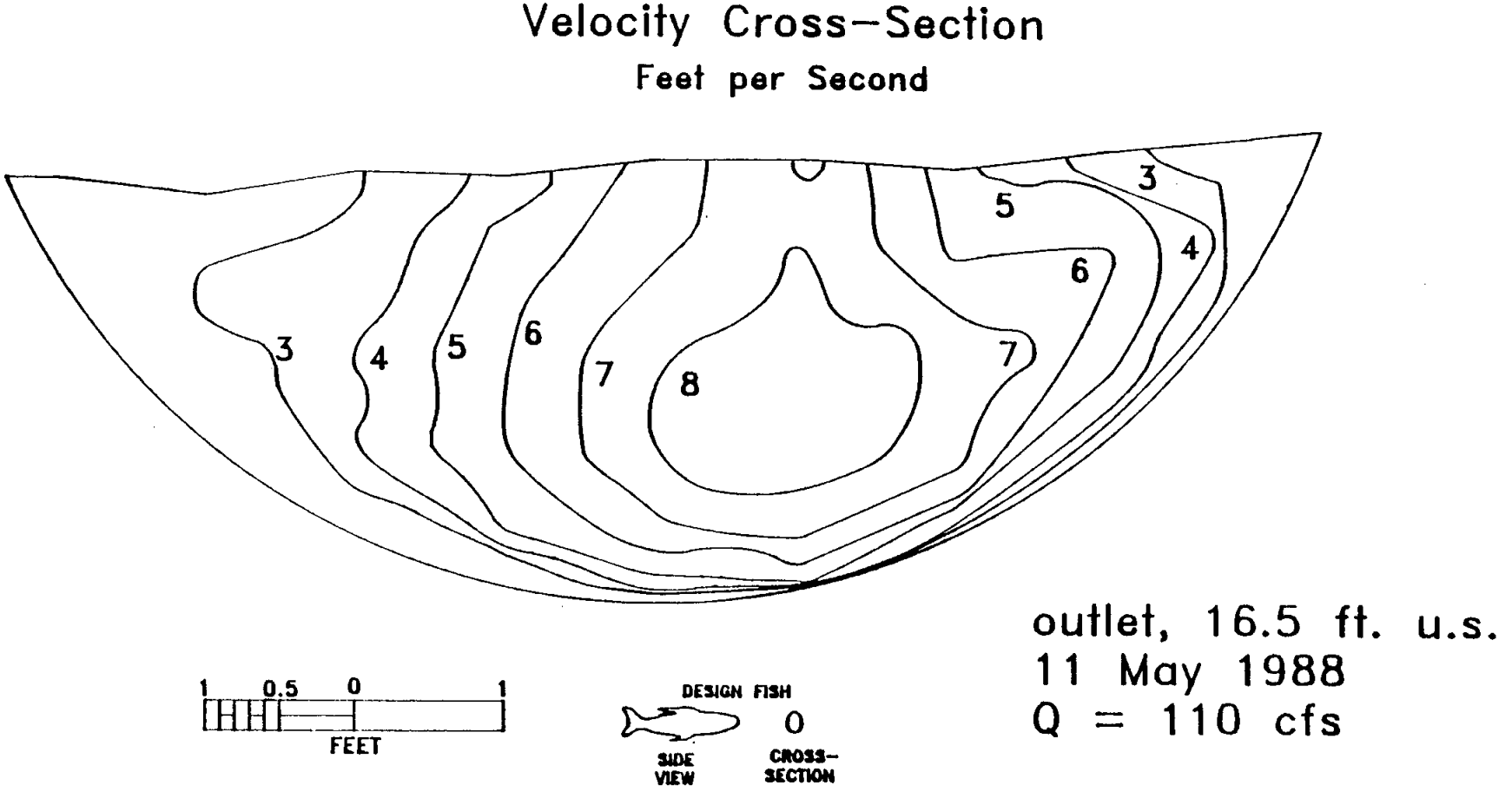

Figure 32: Velocity contours for Fish Creek culvert, 16.5 ft upstream of outlet, May 11, 1988.

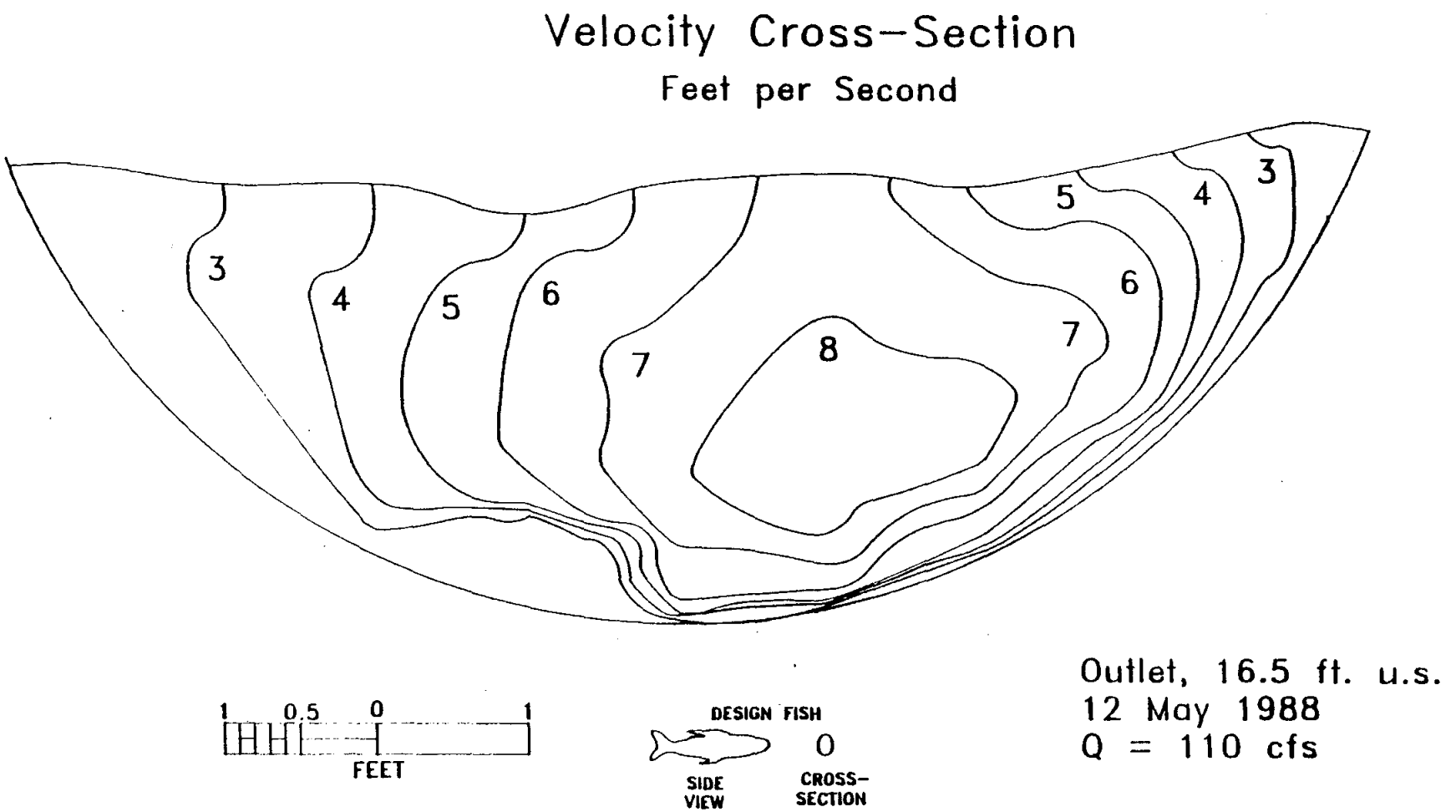

Figure 33: Velocity contours for Fish Creek culvert, 16.5 ft upstream of outlet, May 12, 1988.

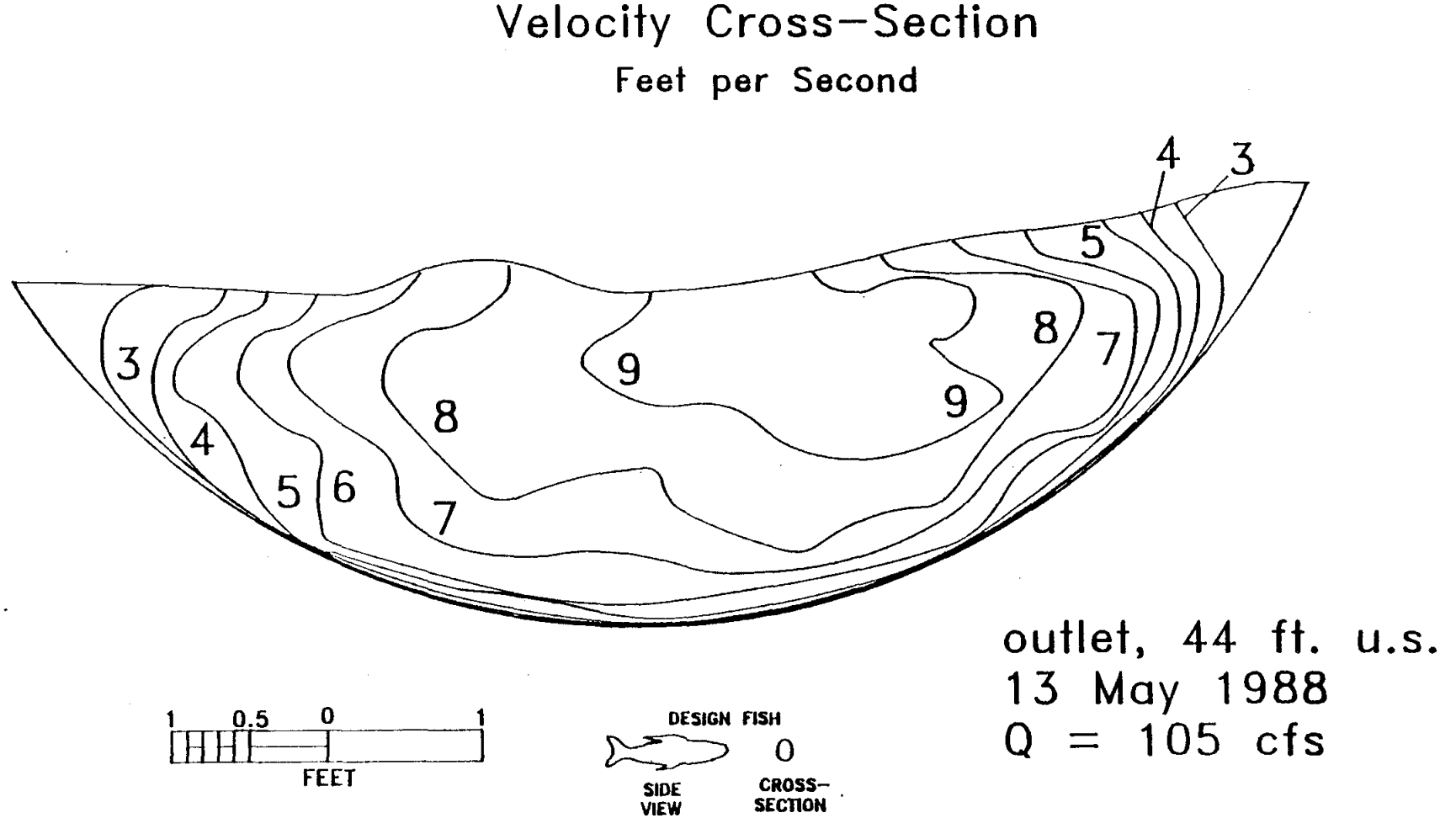

Figure 34: Velocity contours for Fish Creek culvert, 44 ft upstream of outlet, May 13, 1988.

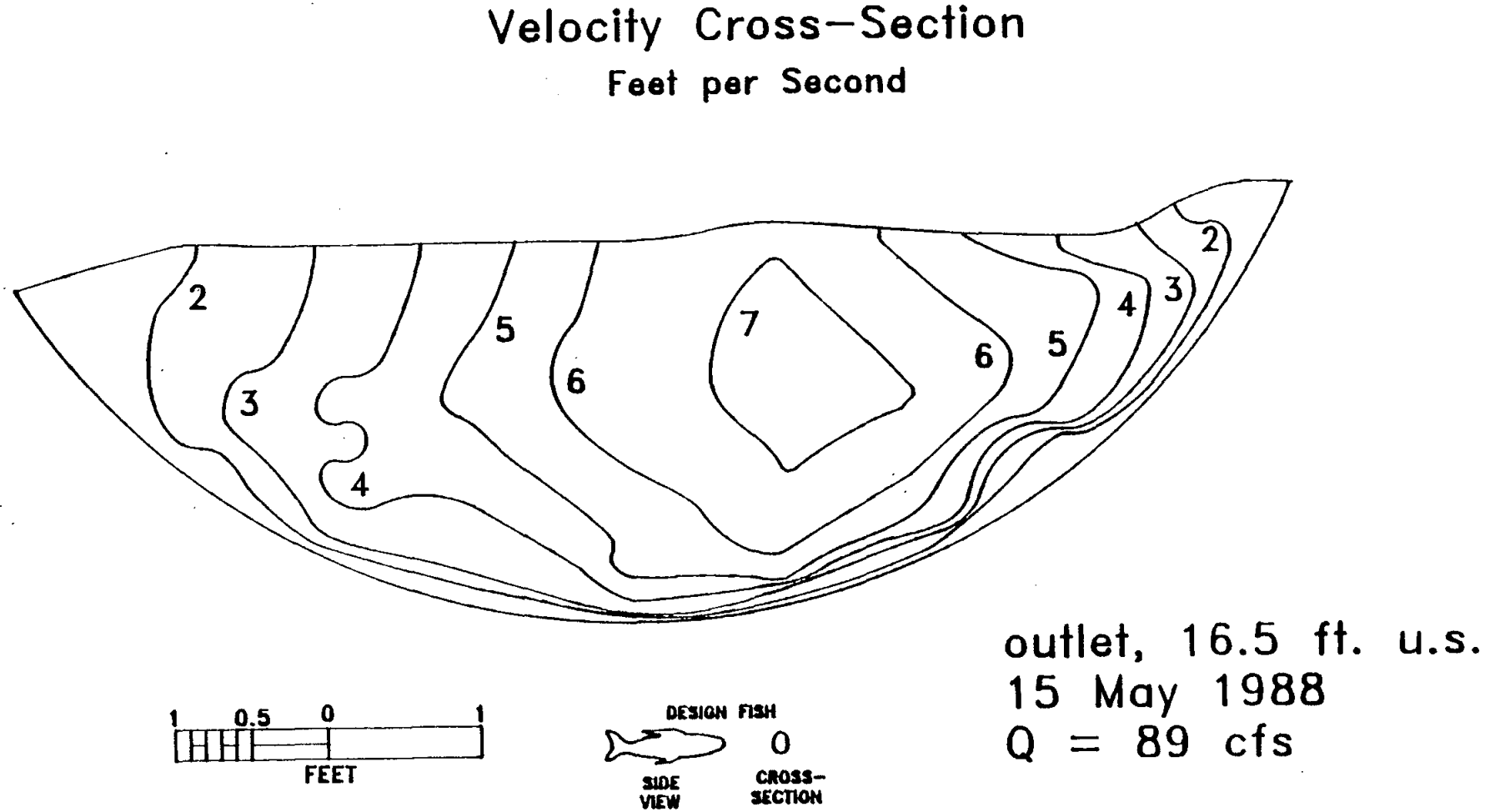

Figure 35: Velocity contours for Fish Creek culvert, 16.5 ft upstream of outlet, May 15, 1988.

observations made in the 1987 studies of fish swimming in this region in preference to all other regions of the culvert. Burbot (*Lota lota*), grayling (*Thymallus arcticus*), dolly varden (*Salvelinus malma*), round whitefish (*Prosopium cylindraceum*) and slimy sculpen (*Cottus cognatus*) all preferred to swim and to rest in this area. These data, which are quite revealing, are also presented in Table 3.

Much of these data require little comment. Many who study it will find their previous beliefs altered regarding where the water goes and at what speed. As we observed fish swimming and compared that with the detailed culvert hydraulics, we realized that they would swim where it was easiest, unless the conditions elsewhere were clearly not a challenge to an individual fish. For example, large round whitefish could easily swim in locations where smaller grayling did not even try to swim. Further, the reader who understands the various hydraulic

Table 1: Summary of 1987 velocity cross-sections, Fish Creek near Cantwell, Alaska

Date, AST	Station	Figure #	Discharge (CFS)
15 May, 1000	Outlet, 1 foot upstream	11	110
15 May, 0730	Outlet, 6 feet upstream	12	114
16 May, 1115	Inlet, 1 foot downstream	13	101
16 May, 0900	Inlet, 6 feet downstream	14	102
18 May, 1625	Outlet, 6 feet upstream	15	77
19 May, 1100	Inlet 1 foot downstream	16	72
19 May, 0730	Outlet, 1 foot upstream	17	72
19 May, 0925	Inlet, 6 feet downstream	18	73
21 May, 1630	Inlet, 1 foot downstream	19	64
21 May, 1430	Inlet 6 feet downstream	20	64
21 May, 1030	Outlet 6 feet upstream	21	66
21 May, 0830	Outlet 1 foot upstream	22	64
23 May, 0050	Inlet 6 feet downstream	23	61
23 May, 1030	Outlet, 6 feet upstream	24	62

Table 2: Summary of 1988 velocity cross-sections, Fish Creek near Cantwell, Alaska

Date, AST	Station	Figure #	Discharge (CFS)
9 May, 1355	Outlet, 6 feet upstream	25	98
9 May, 1635	Outlet, 1 foot upstream	26	99
9 May, 2000	Outlet, 30 feet upstream	27	102
10 May, 0855	Inlet, 1 foot downstream	28	108
10 May, 1236	Inlet, 6 feet downstream	29	108
10 May, 1400	Outlet, 30 feet upstream	30	109
11 May, 1645	Outlet, 1 foot upstream	31	110
11 May 1425	Outlet, 16.5 feet upstream	32	110
12 May, 1030	Outlet, 16.5 feet upstream	33	110
13 May, 1310	Outlet, 44 feet upstream	34	105
15 May, 1330	Outlet, 16.5 feet upstream	35	89

implications to the fish will be able to predict from these data just where the fish could be found swimming successfully in the culvert and where attempts at swimming will not be successful.

In addition to the hydraulic data, observations of fish swimming locations and swimming velocities were made when and where possible. These data in combination with the hydraulic data can be used to estimate the fish-delivered power at various locations in the culvert, and the energy expended in passing through the culvert. The methods for performing such calculations are explained in detail in Behlke et al, 1988 report entitled "Fish Passage Through Poplar Grove Creek Culvert," and were used as guidelines for the design replacement culverts at this location.

The collection of the hydraulic data of this report represents a great deal of time spent by the collectors in a cold, often windy, culvert during spring runoff in May near the divide of the Alaska Range. These

Table 3. Comparison of the mean culvert velocities with the left and right culvert wall velocities (0.2 ft depth, 0.2 ft. from wall) Fish Creek Culvert, May 15-16, 1988.

Distance Upstream of Outlet	Mean Velocity (fps)	RIGHT WALL			LEFT WALL		
		May 15	May 16	Average	May 15	May 16	Average
.0	7.42	4.17	4.67	4.42	3.93	3.48	3.71
1.0	6.62						
2.0		3.40		3.40	3.76		3.76
3.0	5.92		2.42	2.42		2.89	2.89
4.0		2.54		2.54	2.55		2.55
4.5			2.38	2.38		1.93	1.93
6.0	4.88	2.19		2.19	2.02		2.02
7.0			1.66	1.66		1.58	1.58
8.0		1.77		1.77	1.60		1.60
10.0	4.88		1.34	1.34		1.14	1.14
11.0		1.63		1.63	1.08		1.08
13.0		1.74	2.17	1.96	.98	.99	.99
15.0		1.53		1.53	.96		.96
16.5	4.99		1.62	1.62		.70	.70
17.0		3.11		3.11	.85		.85
20.0	5.22		1.58	1.58		.78	.78
21.0		1.89		1.89	.52		.52
22.5		1.09		1.09	.51		.51
24.0		2.22		2.22	.55		.55
25.0			1.08	1.08		.61	.61
26.0		1.91		1.91	.36		.36
28.0		2.10		2.10	.61		.61
30.0	5.92	2.51	1.14	1.83	.67	.99	.83
32.0		1.85		1.85	.60		.60
33.0		1.86		1.86			
34.0		1.86		1.86	.31		.31
35.0			1.28	1.28		.32	.32
36.0	6.23	1.48		1.48	.23		.23
38.0		3.00		3.00	.94		.94
39.0			2.46	2.46		.90	.90
40.5		2.02		2.02	2.25		2.25
42.5		3.04		3.04	3.01		3.01
44.0	7.95		2.25	2.25		2.91	2.91
45.0		2.94		2.94	2.51		2.51
46.0			2.97	2.97		1.82	1.82
50.0			2.90	2.90		5.08	5.08
54.0		4.46	5.12	4.79	4.88	6.21	5.55
56.0	8.28	5.93		5.93	4.11		4.11
57.5			6.22	6.22		3.24	3.24
58.0		7.45		7.45	4.61		4.61
60.0	6.11	6.43	6.13	6.28	4.12	3.18	3.65

data were the most tedious and bone chilling of the data collected for this report, and our appreciation is extended to all who worked carefully and did the job.

FISH BEHAVIOR AND SWIMMING PERFORMANCE

In this section, fish population, history and behavioral patterns of Arctic grayling in this watershed are examined. More importantly, passage rates of Arctic grayling through the culvert drainage structure during the spawning migration are studied.

Hydraulic Considerations Affecting Fish Passage (1987)

Arctic grayling visually observed entering the culvert outlet predominantly swam close to the left side of the culvert (oriented facing downstream) approximately 0.09 to 0.15 m (0.3 to 0.5 ft) below the water surface and within 6 to 9 cm (0.2 to 0.3 ft) of the culvert wall. Most of the grayling exhibited relative difficulty in the immediate vicinity of the culvert outlet, swimming with a short, rapid body flutter until they had passed a point between 1 and 1.5 m (3 to 5 ft) upstream from the culvert outlet lip. Fish which were able to get to that point generally appeared to begin to swim more easily (less vigorous body movement) as they passed further upstream. Culvert outlet mean velocities decreased during the fish migration period (May 13 to 22, 1987); ranging from 2.93 to 1.68 m/s (9.61 to 5.51 fps).

Water velocities were much slower in the barrel of the culvert (not including the culvert inlet) than they were at the location of the fish's entrance to the culvert. Mean culvert barrel velocities during

the fish migration period (May 13 to 22, 1987) ranged from 2.13 to 1.7 m/s (6.99 to 5.6 fps). A survey of the culvert barrel indicated no abrupt depressions or other places where fish could stop swimming to rest in the culvert. However, the culvert was constructed of bolted corrugated metal plates with the nut end of the bolts projecting inside the culvert. Some fish were observed to swim very close to the line of protruding nuts and bolts, suggesting that the protruding nuts and bolts may have created a localized zone of reduced water velocities.

It is not conclusively known whether the fish maintained a virtually constant forward movement with respect to the ground or, at times, just maintained their positions in the culvert barrel. Nonetheless, numerous (30-50) small Arctic grayling (75 to 150 mm) were observed on May 15, 1988 ascending the left wall of the culvert 3.4 to 8.2 m (11 to 27 feet) upstream of the culvert outlet. At periodic intervals, most of these fish were observed swimming into and holding stationary (resting) without fin movement within the corrugation itself; suggesting that a backwater eddy had formed within the corrugation. Whether these observations suggest an intentional attempt by the fish to reduce its profile drag, rest, and recharge their anaerobic white muscles (utilized for higher velocity burst speeds) or whether it simply reflects an attempt by the fish to minimize its energy expenditures is not presently known.

Fisheries (1987)

Upstream Spawning Migration: Arctic grayling were observed migrating up Fish Creek between May 13th and May 22, 1987. Observations were

terminated on May 22nd when the spawning migration and data collection efforts were completed. Arctic grayling first were observed in Fish Creek approximately 0.5 km (0.31 miles) below the culvert outlet on the afternoon of May 13th. The water temperature in Fish Creek reached a maximum of 3.01°C (minimum 0.3°C). Although several attempts were made to dipnet fish along the cut banks of the creek, no fish were captured. By the afternoon of May 14th maximum stream water temperature had risen to 3.17°C and the spawning migration appeared to begin in earnest. Three fish were recovered in the weir holding pen, located approximately 110 m (350 ft) upstream from the culvert inlet, the morning of May 14th.

Length, Weight and Condition Factor Relationships: Length frequency distributions by day for Arctic grayling captured in the weir holding pen are depicted in Figure 36 and Table 4 (also see Table C1 in Appendix).

Fish Population Estimates and Sex Composition: A total of 1,267 grayling were visually counted as they passed through the culvert between May 13th and May 22, 1987. 1,074 Arctic grayling were subsequently recovered at the upstream weir. The discrepancy between these two values is attributed to fish possibly bypassing the weir and to an unknown number of small fish passing through the 2.5 cm (1 in) wire mesh panel of the weir livebox. The livebox meshed panel was replaced with plywood on May 20 after a large number of grayling, approximately fork length of 210 mm (8 in), were observed caught in the wire mesh. Of the Arctic grayling recovered at the upstream weir, 295 were ripe males, 515 ripe females, 220 immatures, and 44 unknown sex (Table C2 in Appendix).

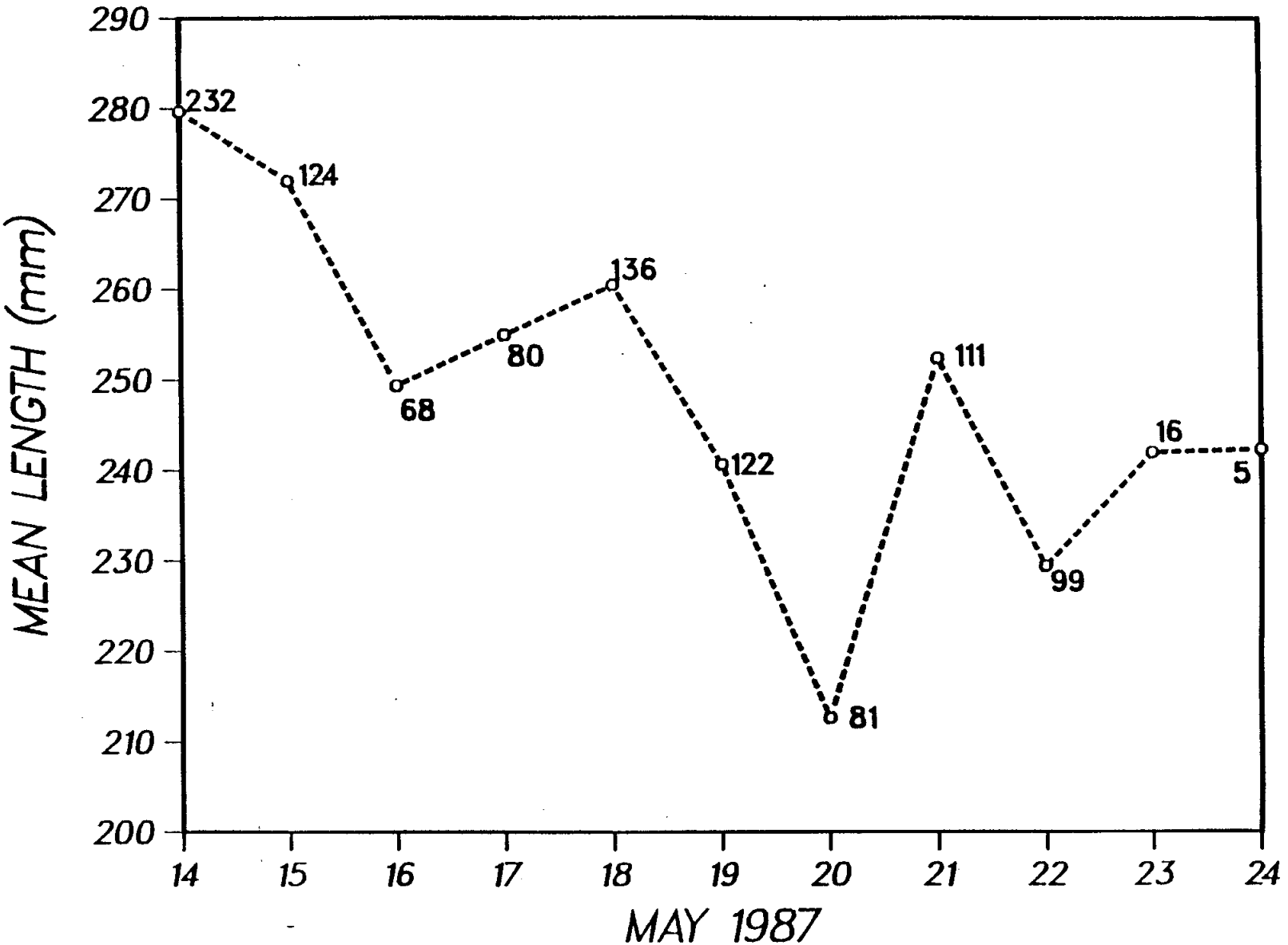

Figure 36: Mean length of Arctic grayling for Fish Creek (numbers, indicate the number of fish comprising the daily sample.)

. Arctic grayling mean daily length
icy for successful culvert migrants based on
icoveries at the upstream weir, Fish Creek
:, May 1987.

Number	Mean Length (mm)	Std. Dev. (mm)
232	279.7	26.5
124	272.0	33.1
68	249.4	23.8
80	255.0	37.6
136	260.5	30.6
122	240.7	44.4
81	212.7	59.7
111	252.4	32.9
99	229.4	50.0
16	242.0	27.1
5	242.4	54.0

74

fish movement, including observed passage
y through the culvert, primarily occurred
1500 hrs and 2400 hrs ADT. Since the
ir and livebox were located approximately 350
stream of the culvert, a variable delay was
ced between observed culvert passage and
ent recovery at the livebox. Visual
tion and radio telemetry data indicated
ccessful migrants through the culvert from
vious evening remained in the sluggish, backwater
cated between the culvert and the weir for 2 to
s before resuming their upstream migration and
ent capture at the upstream weir. Similarly,
sh were first observed beginning to move through
vert in mid-afternoon, the first recoveries at
tream weir were delayed by several hours. The
d movement pattern clearly suggested that fish
ed at the upstream weir after 1500 hrs ADT were
day culvert migrants while fish recovered
1500 hrs ADT were most likely successful culvert
s from the previous evening.

ngly, fish recovered at the upper weir between
s ADT on the date of passage and 1500 hrs ADT
following day were recorded as a successful
migrant on the initial day.

PROBIT analysis of the frequency of mature samples at age and length categories suggest that the Fish Creek Arctic grayling stock is typical of other fish stocks found within the Tanana River drainage. The preliminary estimate of mean age at maturity (AM_{50}) was 6.1 years and the mean length at maturity (LM_{50}) was 293 mm. Fiducial limits for these estimates were not calculated because of the small sample size. Males tended to mature earlier than females, but no significant differences were detected among the two maturity sample groups. Seventy-five percent of the sampled fish were mature at age 7. All fish were mature at age 8. Twenty-nine percent of the 136 fish sampled in 1987 were mature fish. Within this sample, the male-female ratio was 1.44.

The age composition and mean length at age of Arctic grayling tagged in 1987 were similar to various stocks within the Tanana River drainage (e.g., Chatanika River). The predominant age class was 4 year old fish, comprising 41% of the 112 fish that had legible scales (Table 5). The mean fork length of the 112 Arctic grayling sampled was 258 mm. Relative Stock Density (RSD) indices tended to support the general hypothesis that Arctic grayling in the Fish Creek drainage begin to spawn at a fork length of 270 mm (Table 6). Twenty-nine percent of the sample were of "Quality Category" or greater size, while 29 percent of the sample were mature. The discrepancy between the LM50 estimate of 293 mm and these two percentages suggest that these percentages were not derived from the same fish.

Table 5. Proportional contribution of each age class, mean fork length (mm) at age, and 95% confidence intervals for Arctic grayling in the weir sample from the Fish Creek (near Cantwell) spawning stock, 15 and 16 May, 1987.

	Age Composition			Fork Length (mm)		
Age	n[1]	p[2]	+/-CI[3]	Mean	SE[4]	+/-CI[5]
3	6	0.05	0.04	213	2	5
4	46	0.41	0.09	243	3	6
5	38	0.34	0.09	263	2	5
6	13	0.12	0.06	281	4	9
7	8	0.07	0.05	318	6	15
8	1	0.01	0.02	331	--	--
Total	112	1.00		258	3	5

1 n = sample size
2 p = proportion of sample
3 95% Confidence interval based on normal theory approximation to the binomial distribution
4 SE = standard error of mean fork length (mm)
5 Confidence interval based on t-distribution with n-1 degrees of freedom

Table 6. Relative Stock Density (RSD) indices and 95% confidence intervals calculated from weir samples taken from the Fish Creek spawning stock, 15 and 16 May, 1987.

	Minimum Length			
Category	(mm)	inches	RSD1	+/-CI2
Stock	150	5.9	71	8
Quality	270	10.6	29	8
Preferred	340	13.4	0	--
Memorable	450	17.7	0	--
Trophy	560	22.0	0	--
Sample Size			136	

1 RSD = Relative Stock Density expressed as a percentage.
2 +/-CI = 95% confidence interval calculated from the normal theory approximation to the bionomial distribution

A total of 112 fish were tagged with white Floy internal anchor tags and released (Table C3). Between May and September 1987, 4 tags were returned by anglers. Two of the recaptured fish were angled from the Nenana River in September, indicating the use of this river for overwintering or as a migration corridor to overwintering areas. The remaining two tags were angled from Fish Creek.

Visual Fish Passage Observations (1987): Arctic grayling were first observed attempting to transit through the lower Fish Creek culvert on May 13, 1987. A total of 90 attempts by Arctic grayling to enter the Fish Creek culvert and 43 successes were observed between 1521 hours and 2130 hours ADT. Inlet observations were made for only two hours from 1930 to 2130 hours, 10 attempts to exit the culvert with three successes were observed. Hourly percent success for fish entering the culvert outlet ranged from 20 to 58 percent. Mean water temperature was 3.13°C during the period of fish passage (0.3 to 4.3°C was the temperature range throughout the day); mean culvert outlet water velocity (Q/A) was 2.93 m/s (9.61 fps); and weighted mean culvert barrel water velocity was 2.13 m/s (6.99 fps).

On May 14th, active fish movement was again first observed in mid-afternoon (1500 hrs ADT). A total of 513 attempts by Arctic grayling to enter the Fish Creek culvert outlet and 437 successes were observed between 1500 hours and 2040 hours ADT. A total of 221 fish were observed trying to exit the upstream end of the culvert with 175 successes. The total success, expressed as the percent of total successes to total attempts each day, was 85 percent for fish entering the culvert outlet and 79 percent for fish exiting the culvert inlet.

Compared to the previous day, the success rate for passage through the culvert outlet significantly increased, suggesting that the outlet velocity and/or adverse hydraulic gradients at the culvert outlet may have dropped below some critical level during that 24 hour interval. Mean water temperature was 4.06° C during the period of fish passage (1.6 to 5.1° C was the temperature range throughout the day); mean culvert outlet water velocity (Q/A) was 2.6 m/s (8.52 fps); and the weighted mean culvert barrel water velocity was 2.02 m/s (6.62 fps) with considerable variation along the culvert.

On May 15th, active fish movement was first observed at 1400 hrs ADT. A total of 618 attempts by Arctic grayling to enter the Fish Creek culvert outlet and 557 successes were observed between 1400 hours and 2340 hours ADT. A total of 157 fish were observed trying to exit the upstream end of the culvert with 99 successes. Therefore, 90 percent of the fish were successful at entering the culvert outlet and 63 percent were successful at exiting the upstream end of the culvert inlet. While the percentage of fish successfully entering the culvert outlet increased from the previous day, the percentage that successfully exited the culvert decreased. Mean water temperature was 4.49° C during the period of fish passage (1.6 to 5.7° C was temperature range throughout the day); mean culvert outlet water velocity (Q/A) was 2.4 m/s (7.87 fps); and the weighted mean culvert barrel water velocity was 1.95 m/s (6.4 fps).

On May 16th, active fish movement was first observed at 1400 hrs ADT. A total of 295 attempts by Arctic grayling to enter the Fish Creek culvert outlet and 272 successes were observed between 1400 hours and 2323 hours

ADT. The 133 fish were observed exiting the culvert with 72 succeeding. So, 92 percent of the migratory fish entered the culvert outlet successfully and 54 percent successfully exited the inlet end. We continued to see an increase in success for fish entering the culvert, but a decrease in success for those fish trying to exit the culvert inlet end. Mean water temperature was 5.01° C during the period of fish passage (1.8 to 5.7° C was the temperature range throughout the day); mean culvert outlet water velocity (Q/A) was 2.29 m/s (7.5 fps); and the weighted mean culvert barrel water velocity was 1.91 m/s (6.28 fps).

On May 17th, active fish movement was first observed at 1500 hrs ADT. A total of 653 attempts by Arctic grayling to enter the Fish Creek culvert outlet and 576 successes were observed between 1300 hours and 2334 hours ADT. A total of 109 fish were observed attempting to exit the upstream end of the culvert, 74 fish were successful. So, 88 percent of the fish successfully entered the culvert outlet and 68 percent successfully exited the inlet end of the culvert. Mean water temperature was 4.54° C during the period of fish passage (1.9 to 5.2° C was the temperature range throughout the day); mean culvert outlet water velocity (Q/A) was 2.13 m/s (7 fps); and the weighted average culvert barrel water velocity was 1.86 m/s (6.11 fps). Mean fork length of successful migrants recovered at the upstream weir was 249 mm (9.8 in), which was 11 and 8 percent respectively smaller than the successful migrants on May 14th and May 15th.

Visual observations on May 18th commenced at the culvert outlet at 1535 hours ADT (1600 hours ADT at culvert inlet) and continued until 2300 hours ADT. A daily total of 208 attempts and 193 successes were

observed at the culvert outlet. A total of 130 fish were observed trying to exit the upstream end of the culvert with 103 successes. So, 93 percent of the fish successfully entered the culvert outlet and 79 percent successfully exited at the inlet end of the culvert. Mean water temperature was 5.67° C during the period of fish passage (2.5 to 6.3° C was the temperature range throughout the day); mean culvert outlet water velocity (Q/A) was 1.91 m/s (6.27 fps); and the weighted mean culvert barrel water velocity was 1.79 m/s (5.86 fps).

The initial period of fish activity on May 19th was similar to that observed on the 18th. Visual observations commenced at the culvert outlet at 1521 hours ADT (1445 hours ADT at culvert inlet) and continued until 2300 hours ADT. A daily total of 557 attempts and 542 successes was observed at the culvert outlet. A total of 261 fish were observed attempting to leave the culvert with 174 successfully exiting the upstream end of the culvert. On this date, 97 percent of the fish successfully entered the culvert outlet and 67 percent successfully exited the culvert inlet. Mean water temperature was 5.41° C during the period of fish passage (2.6 to 6.0° C was the temperature range throughout the day); mean culvert outlet water velocity (Q/A) was 1.78 m/s (5.83 fps); and the weighted mean culvert barrel water velocity was 1.74 m/s (5.71 fps).

Visual observations were conducted on May 20th between 1630 hours ADT and 2300 hours ADT. A daily total of 788 attempts and 722 successes were observed at culvert outlet. Approximately 40 percent of the fish observed were 140 mm or less in length. Although the mean fork length of successful migrants was 12 percent smaller than the previous day's

migrants, the success rate at the culvert outlet was 92 percent and at the culvert inlet was 68 percent. This reflected a 5 percent drop at the culvert outlet and a 1 percent increase at the culvert inlet when compared to the previous day. Mean water temperature was 6.72° C during the period of fish passage (3 to 7.3° C was the temperature range throughout the day); mean culvert outlet water velocity (Q/A) was 1.71 m/s (5.61 fps); and the weighted mean culvert barrel water velocity was 1.72 m/s (5.64 fps).

Visual observations on May 21st commenced at the culvert inlet and outlet at 2000 hours ADT and continued until 2300 hours ADT. Virtually no fish were observed prior to 2000 hrs ADT attempting to transit the culvert. A daily total of 186 attempts and 183 successes were observed at culvert outlet for a success rate of 98 percent. This time, 92 fish were observed attempting to exit the culvert with 85 percent or 77 fish being successful. Mean water temperature was 5.5° C during the period of fish passage (2.6 to 5.6° C was the temperature range throughout the day); mean culvert outlet water velocity (Q/A) was 1.69 m/s (5.55 fps); and the weighted mean culvert barrel water velocity was 1.72 m/s (5.63 fps).

Visual observations on May 22nd commenced at the culvert at 1620 hours ADT and continued until 2200 hours ADT. Virtually no fish were observed prior to 1620 hrs ADT attempting to transit the culvert. A daily total of 232 attempts and 232 successes were observed at the culvert outlet. So the success rate was 100 percent. At the culvert inlet, 20 fish of a total of 147 failed, giving a success rate of 82 percent. Mean water temperature was 6.29° C during the period of fish passage (3 to 6.9° C

was the temperature range throughout the day); mean culvert outlet water velocity (Q/A) was 1.68 m/s (5.51 fps); and the weighted mean culvert barrel water velocity was 1.71 m/s (5.6 fps).

Table 7 presents a summary of the total culvert fish passage attempts, failures, and success by hourly period for May 13th through May 22th. Only summaries of fish performance are presented in Table 8. Appendix Table C.2 presents the total culvert fish passage attempts, failures, and success by hourly period for each individual day between May 13th through May 22th, including the temperature and hydraulic conditions.

During the study, observers were placed both at the upstream inlet of the culvert and the downstream outlet. At the outlet, the observers were supposed to count each attempt at entering the culvert and also count each failure at entering the culvert. An attempt was defined as any fish getting within 0.6m (2 ft) of the culvert entrance. A failure was determined to be any fish attempting to enter the culvert, but one that did not make it more than 0.6m (2 ft into the culvert). In reality, this was the field of view of the observer. The observer at the outlet noted one other statistic, the number of washouts coming down through the barrel of the culvert. These were fish that had ascended out of the field of view of the observer, but subsequently failed either in the barrel or at the culvert inlet. At the inlet of the culvert, the observer noted the number of fish that successfully exited the culvert and the number of failures.

Ideally, one should be able to divide the number of attempts by the fish to enter the culvert by the number of successes exiting the culvert to

TABLE 7. Summary of Visual Fish Passage Observations through Lower Fish Creek Culvert, May 13-22, 1987.

Date	Hourly Period ADT	Water Temp (C)	Mean Outlet Velocity (Q/A) (fps)	Centerline Outlet Velocity (.6D) (fps)	Mean Barrel Velocity (fps)	OUTLET PERFORMANCE Hourly Attempts No.	Hourly Failures No.	Hourly Successes No.	Hourly Success %	BARREL FAILURES Washout Observed No.	INLET PERFORMANCE Hourly Attempts No.	Hourly Failures No.	Hourly Successes No.	Hourly Success %
May 13	1521-1600	3.01	9.79	9.52	7.05	5	4	1	20%	0	n/o	n/o	n/o	n/o
	1600-1700	3.17	9.70	9.47	7.02	15	8	7	47%	0	n/o	n/o	n/o	n/o
	1700-1800	3.17	9.63	9.42	7	23	13	10	43%	1	n/o	n/o	n/o	n/o
	1800-1900	3.17	9.59	9.40	6.99	18	9	9	50%	7	n/o	n/o	n/o	n/o
	1900-2000	3.17	9.59	9.40	6.99	19	8	11	58%	1	n/o	n/o	n/o	n/
	2000-2100	3.25	9.48	9.33	6.95	9	4	5	56%	0	n/o	n/o	n/o	n/
	2100-2130	2.97	9.48	9.33	6.95	1	1	0	0%	0	n/o	n/o	n/o	n/
May 14	1500-1600	3.81	8.62	8.80	6.66	263	53	210	80%	5	72	13	59	82%
	1600-1700	4.11	8.60	8.79	6.65	177	10	167	94%	0	124	19	105	85%
	1700-1800	4.2	8.50	8.73	6.62	48	7	41	85%	6	18	8	10	56%
	1800-1900	4.26	8.49	8.72	6.61	23	4	19	83%	2	6	6	0	0%
	1900-2000	4.14	8.45	8.69	6.6	n/o	n/o	n/o	n/o	n/o	1	0	1	100%
	2000-2040	3.87	8.44	8.69	6.59	2	2	0	0%	1	0	0	0	n/a
May 15	1400-1500	3.36	8.06	8.45	6.47	4	1	3	75%	0	1	1	0	0%
	1500-1600	3.83	7.98	8.40	6.44	20	4	16	80%	0	9	2	7	78%
	1600-1700	4.33	7.96	8.39	6.43	168	18	150	89%	0	58	12	46	79%
	1700-1800	4.74	7.88	8.34	6.4	22	0	22	100%	1	25	9	16	64%
	1800-1900	5	7.86	8.33	6.4	43	3	40	93%	2	20	6	14	70%
	1900-2000	5.11	7.85	8.33	6.4	99	11	88	89%	1	15	11	4	27%
	2000-2100	4.97	7.96	8.39	6.43	78	2	76	97%	4	17	13	4	24%
	2100-2200	4.76	7.78	8.28	6.37	19	0	19	100%	1	4	3	1	25%
	2200-2300	4.59	7.72	8.24	6.35	97	18	79	81%	0	1	0	1	100%
	2300-2340	4.25	7.65	8.20	6.33	68	4	64	94%	4	7	1	6	86%

Note: Velocities within the boundary (V-occupied) zone where Arctic grayling were observed ranged between 20% to 40% of the mean culvert barrel velocities (May 15-16, 1988 measurements).

* Time of observation 1540 to 1600

TABLE 7. Continued

Date	Hourly Period ADT	Water Temp (C)	Mean Outlet Velocity (Q/A) (fps)	Centerline Outlet Velocity (.6D) (fps)	Mean Barrel Velocity (fps)	OUTLET PERFORMANCE				BARREL FAILURES	INLET PERFORMANCE			
						Hourly Attempts No.	Hourly Failures No.	Hourly Successes No.	Hourly Success %	Washout Observed No.	Hourly Attempts No.	Hourly Failures No.	Hourly Successes No.	Hourly Success %
May 16	1400-1500	3.56	7.63	8.19	6.32	19	3	16	84%	2	0	0	0	n/a
	1500-1600	4.11	7.61	8.17	6.31	47	5	42	89%	2	14	2	12	86%
	1600-1700	4.65	7.58	8.16	6.31	107	3	104	97%	0	39	18	21	54%
	1700-1800	5.09	7.58	8.15	6.3	51	3	48	94%	5	35	20	15	43%
	1800-1900	5.43	7.53	8.13	6.29	11	2	9	82%	0	5	1	4	80%
	1900-2000	5.68	7.48	8.10	6.27	2	0	2	100%	0	0	0	0	n/a
	2000-2100	5.68	7.40	8.04	6.24	15	3	12	80%	0	7	1	6	86%
	2100-2200	5.58	7.39	8.04	6.24	19	3	16	84%	0	13	3	10	77%
	2200-2300	5.33	7.39	8.04	6.24	11	1	10	91%	0	10	6	4	40%
	2300-2323	4.97	7.39	8.04	6.24	13	0	13	100%	1	0	0	0	n/a
May 17	1300-1340	3.03	7.26	7.96	6.2	0	0	0	n/a	0	n/o	n/o	n/o	n/o
	1400-1500	3.62	7.26	7.96	6.2	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
	1500-1600	3.89	7.19	7.91	6.17	3	0	3	100%	0	0*	0*	0*	n/a
	1600-1700	4.33	7.11	7.87	6.15	16	2	14	88%	0	3	1	2	67%
	1700-1800	4.71	7.02	7.81	6.11	37	1	36	97%	4	4	3	1	25%
	1800-1900	5.06	6.97	7.78	6.1	51	1	50	98%	0	15	8	7	47%
	1900-2000	5.19	6.92	7.75	6.08	76	7	69	91%	2	17	8	9	53%
	2000-2100	5.24	6.86	7.71	6.06	135	23	112	83%	0	16	2	14	88%
	2100-2200	5.19	6.84	7.70	6.05	141	15	126	89%	0	36	3	33	92%
	2200-2300	5.03	6.81	7.68	6.04	176	24	152	86%	0	12	7	5	42%
	2300-2334	4.7	6.76	7.65	6.03	18	4	14	78%	0	6	3	3	50%

Note: Velocities within the boundary (V-occupied) zone where Arctic grayling were observed ranged between 20% to 40% of the mean culvert barrel velocities (May 15-16, 1988 measurements).

* Time of observation 1540 to 1600

TABLE 7. Continued

Date	Hourly Period ADT	Water Temp (C)	Mean Outlet Velocity (Q/A) (fps)	Centerline Outlet Velocity (.6D) (fps)	Mean Barrel Velocity (fps)	OUTLET PERFORMANCE				BARREL FAILURES	INLET PERFORMANCE			
						Hourly Attempts No.	Hourly Failures No.	Hourly Successes No.	Hourly Success %	Washout Observed No.	Hourly Attempts No.	Hourly Failures No.	Hourly Successes No.	Hourly Success %
May 18	1535-1600	4.48	6.40	7.43	5.9	5	0	5	100%	0	n/o	n/o	n/o	n/o
	1600-1700	5.24	6.35	7.39	5.89	30	3	27	90%	2	20	3	17	85%
	1700-1800	5.37	6.29	7.36	5.87	26	2	24	92%	2	15	2	13	87%
	1800-1900	5.73	6.26	7.34	5.86	46	3	43	93%	1	28	4	24	86%
	1900-2000	6.1	6.25	7.33	5.85	55	3	52	95%	0	34	7	27	79%
	2000-2100	6.28	6.21	7.31	5.84	23	0	23	100%	2	27	10	17	63%
	2100-2200	6.25	6.19	7.30	5.83	18	4	14	78%	1	2	0	2	100%
	2200-2300	5.94	6.18	7.29	5.83	5	0	5	100%	0	4	1	3	75%
May 19	1521-1600	4.26	5.96	7.16	5.76	19	2	17	89%	0	9	1	8	89%
	1600-1700	4.62	5.94	7.14	5.75	34	5	29	85%	0	16	2	14	88%
	1700-1800	5.06	5.92	7.13	5.74	17	1	16	94%	1	17	1	16	94%
	1800-1900	5.46	5.82	7.07	5.71	33	2	31	94%	0	25	5	20	80%
	1900-2000	5.78	5.81	7.06	5.7	24	2	22	92%	0	12	2	10	83%
	2000-2100	5.98	5.81	7.06	5.7	86	3	83	97%	2	64	14	50	78%
	2100-2200	6.05	5.81	7.06	5.7	136	0	136	100%	10	61	34	27	44%
	2200-2300	6.06	5.61	6.94	5.64	208	0	208	100%	40	55	28	27	49%
May 20	1630-1700	5.55	5.59	6.93	5.63	110	10	100	91%	0	53	13	40	75%
	1700-1800	6.13	5.60	6.93	5.63	198	22	176	89%	16	96	36	60	63%
	1800-1900	6.61	5.60	6.94	5.63	44	2	42	95%	3	64	23	41	64%
	1900-2000	7.02	5.61	6.94	5.64	84	6	78	93%	4	76	29	47	62%
	2000-2100	7.18	5.61	6.94	5.64	104	10	94	90%	8	79	30	49	62%
	2100-2200	7.34	5.62	6.95	5.64	107	9	98	92%	4	82	16	66	80%
	2200-2300	7.21	5.60	6.94	5.64	141	7	134	95%	24	100	28	72	72%

Note: Velocities within the boundary (V-occupied) zone where Arctic grayling were observed ranged between 20% to 40% of the mean culvert barrel velocities (May 15-16, 1988 measurements).

* Time of observation 1540 to 1600

TABLE 7. Continued

Date	Hourly Period ADT	Water Temp (C)	Mean Outlet Velocity (Q/A) (fps)	Centerline Outlet Velocity (.6D) (fps)	Mean Barrel Velocity (fps)	OUTLET PERFORMANCE				BARREL FAILURES	INLET PERFORMANCE			
						Hourly Attempts No.	Hourly Failures No.	Hourly Successes No.	Hourly Success %	Washout Observed No.	Hourly Attempts No.	Hourly Failures No.	Hourly Successes No.	Hourly Success %
May 21	2000-2100	5.42	5.59	6.93	5.63	22	0	22	100%	5	10	1	9	90%
	2100-2200	5.56	5.57	6.91	5.63	37	0	37	100%	8	34	2	32	94%
	2200-2300	5.51	5.50	6.87	5.62	127	3	124	98%	26	57	11	46	81%
May 22	1620-1700	5.35	5.50	6.87	5.6	117	0	117	100%	5	72	10	62	86%
	1700-1800	5.91	5.51	6.88	5.6	59	0	59	100%	2	42	5	37	88%
	1800-1900	6.25	5.51	6.88	5.6	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
	1900-2000	6.58	5.53	6.89	5.6	0	0	0	n/a	0	0	0	0	n/a
	2000-2100	6.79	5.54	6.90	5.61	22	0	22	100%	1	20	9	11	55%
	2100-2200	6.86	5.44	6.90	5.61	34	0	34	100%	3	13	2	11	85%

Note: Velocities within the boundary (V-occupied) zone where Arctic grayling were observed ranged between 20% to 40% of the mean culvert barrel velocities (May 15-16, 1988 measurements).

* Time of observation 1540 to 1600

TABLE 8. Summary of Visual Fish Passage and Upper Weir Observations at the Lower Fish Creek Culvert, May 13-22, 1987.

	OUTLET PERFORMANCE				BARREL FAILURES	INLET PERFORMANCE				UPPER WEIR	
Date	Daily Attempts No.	Daily Failures No.	Daily Successes No.	Daily Success %	Washout Observed No.	Daily Attempts No.	Daily Failures No.	Daily Successes No.	Daily Success %	Fish Count No.	Mean Fish Length (mm)
May 13	90	47	43	48%	9	10	7	3	30%	n/o	n/o
May 14	513	76	437	85%	14	221	46	175	79%	232	279.7
May 15	616	61	555	90%	13	157	58	99	63%	124	272.0
May 16	295	23	272	92%	10	133	61	72	54%	68	249.4
May 17	653	77	576	88%	6	109	35	74	68%	80	255.0
May 18	208	15	193	93%	8	130	27	103	79%	136	260.5
May 19	557	15	542	97%	43	261	87	174	67%	122	240.7
May 20	788	66	722	92%	59	550	175	375	68%	81	212.7
May 21	186	3	183	98%	39	91	14	77	85%	111	252.4
May 22	232	0	232	100%	11	147	26	121	82%	99	229.4
May 23	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	16	242.0
May 24	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	5	242.4
TOTAL	4138	383	3755		212	1809	536	1273		1074	
AVERAGE				91%					70%		254.9

get an indication of the percentage that successfully passed through the culvert for the given hydraulic conditions in the culvert at that time. This statistic would account for fish that failed at the entrance, barrel and exit of the culvert. However, one point should be made: an individual fish could be responsible for numerous failures because of multiple attempts at getting through the culvert.

When we perform a count balance on our observations, we see that on certain days we have a large number of fish that cannot be accounted. If we accurately counted the number of fish successfully entering the culvert and those exiting the culvert, the difference should be the number of washouts, plus the number of fish still in transit in the culvert.

The data implies that a large number of fish were not accounted for either entering or exiting the culvert. Reflecting back on the conditions that existed at the time of the observations, several possible explanations can be conjectured. First, it is generally agreed by the observers that lighting conditions were much better at the outlet end of the culvert than at the inlet end. This means that the absolute number of fish entering the culvert, the number of fish failing to get into the culvert, and the number of washouts should have been counted with greater confidence than fish at the upstream end of the culvert. It should be noted that washouts were difficult to count, even under good lighting conditions, because of the high exit velocities. At the culvert outlet, the observers could stand outside the culvert and therefore had a much wider field of view without having to move their eyes.

At the culvert inlet, lighting was poor and to improve visibility, the observers positioned themselves within the culvert. This had the effect of reducing the field of view, so that the observer essentially had to scan back and forth across the culvert. At both ends of the culvert, a corrugated section of culvert that was painted white was put in place on the culvert insert to enhance visibility. At the inlet end, this corrugated section did not extend sufficiently up the sidewall. It was readily apparent that fish were passing along the rusty left side just below the water surface. Without the white background, it was very difficult to see these fish. A large number of fish passed through the culvert late in the evening when lighting conditions were very poor at the inlet. This could have accounted for a large number of uncounted fish.

For 1987, the number of fish successfully passing the culvert was compared with the number of fish captured in the upstream weir. For most of the days, the data indicate that many more fish got through the culvert than were observed at the culvert inlet. On May 20, significantly more fish were observed than captured. On this day, the average size of the fish was abnormally low; it is believed that they may have escaped through the wire mesh on the weir livebox. The integrity of the weir was generally good, however, there were times when some fish probably slipped through, particularly when the weir was cleaned each morning.

It should be pointed out that the performance of fish at the culvert inlet was based on what was observed in the first 1.2 m (4 ft) or so of the culvert at the outlet. In fact, as the fish moved upstream and

approached the inlet of the culvert, they encountered difficulty, because of steep culvert slope, about 3 to 3.7 m (10 to 12 ft) from the culvert inlet. Some of the fish may have failed in their attempts to exit the inlet end of the culvert but not while in the field of view of the observers and were, therefore, not counted as failed attempts.

In Tables 7 and 8, the number of washouts are indicated. Often these failures originated in the culvert barrel. However, occasionally fish swam back into the culvert from the upstream pool and were swept down through the culvert and counted as washouts.

It is obvious from the data that there are problems with the visual counting procedure used. Far more fish were counted entering the culvert than exiting. Some of the possible reasons have been presented here. However, we believe that the percentages for successes, both at the outlet and the inlet of the culvert, are approximately correct, and these data can be used to further our understanding of fish performance.

Miscellaneous Swimming Performance Observations: Several miscellaneous measurements of swimming performance of Arctic grayling were obtained in both 1987 and 1988 (Table 9). "Burst Speed" (Watts, 1974) swimming performance observations were made at the culvert outlet by timing the observed forward progression of three Arctic grayling fish for known distances across the white culvert outlet corrugated insert. Estimated burst swimming velocities with respect to the water (V_{fw}) were then calculated by adding the observed forward velocity of the fish with respect to a fixed reference to the known culvert water velocities where fish swam at the time of observation. These ranged between 1.62 to 2.13

TABLE 9. Miscellaneous fish swimming performance observations, lower Fish Creek culvert, May 1987 and 1988.

May 14, 1987 (1500-1600 hours ADT). An isolated pulse of Arctic grayling entering the culvert (18.3 m) at 1500 hours remained in the culvert for approximately 40 minutes before exiting the inlet.

May 18, 1987 (1715 hours ADT). One medium (<254 mm) grayling leaped out of the water at the culvert outlet (west side) and landed 0.3 m up on the adjacent bank. Fish slid back into the water.

May 18, 1987 (1950 hours ADT). One small (~150 mm) grayling ascended 0.61 m past the culvert outlet lip in 2 seconds. Relative velocity with respect to the culvert = 0.3 m/s (1 fps). Approximate water velocity in the zone used by the fish = 1.3 m/s (4.3 fps).

May 18, 1987 (1950 hours ADT). One medium (180-200 mm) grayling ascended 0.61 m past the culvert outlet lip in 1.5 seconds. Relative velocity with respect to the culvert = 0.41 m/s (1.33 fps). Approximate water velocity in the zone used by the fish = 1.3 m/s (4.3 fps).

May 18, 1987 (2000 hours ADT). One medium (~254 mm) grayling ascended 0.61 m past the culvert outlet lip in 0.74 seconds. Relative velocity with respect to the culvert = 0.82 m/s (2.7 fps). Approximate water velocity in the zone used by the fish = 1.3 m/s (4.3 fps).

May 21, 1987 (2100-2300 hours ADT). Passage times through culvert (18.3 m) were measured for the following fish. (NOTE: Lengths are visual estimates.)

	Transit Time	Forward Vel. (fps)	Mean Water Vel. (fps)
300 mm grayling	5 min 44 sec	0.17	3.7
300 mm grayling	6 min 3 sec	0.16	3.7
300 mm grayling	1 min 50 sec	0.54	3.7
250 mm grayling	5 min 10 sec	0.19	3.7
230 mm grayling	2 min 40 sec	0.33	3.7
410 mm round WF	55 sec	1.09	3.7
410 mm round WF	1 min 48 sec	0.55	3.7
380 mm round WF	43 sec	1.39	3.7
380 mm round WF	3 min 25 sec	0.29	3.7
380 mm round WF	2 min 25 sec	0.41	3.7
300 mm round WF	44 sec	1.36	3.7
300 mm round WF	2 min 58 sec	0.34	3.7

(continued)

TABLE 9. Miscellaneous fish swimming performance observations (Continued).

May 22, 1987. Passage times through culvert (18.3 m) were measured for the following fish. (NOTE: Lengths are visual estimates.)

	Transit Time	Forward Vel. (fps)	Mean Water Vel. (fps)
380 mm round WF	49 sec	1.22	3.7
300 mm round WF	1 min 23 sec	0.72	3.7
250 mm grayling	3 min 19 sec	0.30	3.7
200 mm grayling	4 min 24 sec	0.23	3.7
380 mm round WF	1 min 40 sec	0.60	3.7

May 12, 1988. One medium (267 mm) grayling ascended along the left culvert wall approximately 0.5 feet below the surface and 0.2 to 0.3 feet away from the culvert wall from a point 17 feet upstream of the culvert outlet to a point 45 feet upstream in 19 minutes and 34 seconds. Mean culvert water velocity in this region was 2.5 feet per second. Relative velocity of the fish with respect to the culvert = 0.73 cm/sec (0.024 fps).

May 12, 1988. One small (178 mm) grayling ascended along the left culvert wall approximately 0.5 feet below the surface and 0.2 to 0.3 feet away from the culvert wall from a point 17 feet upstream of the culvert outlet to a point 32 feet upstream in 29 minutes and 15 seconds. Mean culvert water velocity in this region was 1.36 feet per second. Relative velocity of the fish with respect to the culvert = 0.26 cm/sec (0.00854 fps).

May 15, 1988. One medium-large (305 mm) grayling ascended along the left culvert wall approximately 0.5 feet below the surface and 0.2 to 0.3 feet away from the culvert wall from a point 10 feet upstream of the culvert outlet to a point 39 feet upstream in 2 minutes and 3 seconds. Mean culvert water velocity in this region was 2.1 feet per second. Relative velocity of the fish with respect to the culvert = 4.71 cm/sec (0.1544 fps).

May 15, 1988. One medium-small (203 mm) grayling ascended along the left culvert wall approximately 0.5 feet below the surface and 0.2 to 0.3 feet away from the culvert wall from a point 20 feet upstream of the culvert outlet to a point 30 feet upstream in 2 minutes and 24 seconds. Mean culvert water velocity in this region was 1.36 feet per second. Relative velocity of the fish with respect to the culvert = 2.11 cm/sec (0.0694 fps).

TABLE 9. Miscellaneous fish swimming performance observations (Continued).

May 15, 1988. One small (114 mm) grayling ascended along the left culvert wall approximately 0.3 feet below the surface and 0.2 feet away from the culvert wall from a point 11 feet upstream of the culvert outlet to a point 27 feet upstream in 5 minutes and 12 seconds. Mean culvert water velocity in this region was 1.64 feet per second. Relative velocity of the fish with respect to the culvert = 1.56 cm/sec (0.0513 fps).

May 15, 1988. One medium (229 mm) grayling ascended along the left culvert wall approximately 0.5 feet below the surface and 0.2 feet away from the culvert wall from a point 7 feet upstream of the culvert outlet to a point 25 feet upstream in 2 minutes and 9 seconds. Mean culvert water velocity in this region was 1.7 feet per second. Relative velocity of the fish with respect to the culvert = 4.25 cm/sec (0.1395 fps).

May 15, 1988. One medium-large (279 mm) grayling ascended along the left culvert wall approximately 0.5 feet below the surface and 0.3 feet away from the culvert wall from a point 7 feet upstream of the culvert outlet to a point 42 feet upstream in 2 minutes and 1 seconds. Mean culvert water velocity in this region was 2.98 feet per second. Relative velocity of the fish with respect to the culvert = 8.81 cm/sec (0.289 fps).

m/s (5.3 to 7.0 fps) for fish ranging between 150 and 254 mm in fork length (Table 9). Since it is not known whether these fish were unable to maintain this level of energy expenditure or whether they simply gave up and washed back downstream, the calculated burst speeds should be considered strictly an approximation of the obtainable burst speed velocity for Arctic grayling of this size range.

"Sustained Speed" (Watts, 1974) swimming performance observations were made for 24 Arctic grayling (114 to 305 mm in fork length) within the culvert barrel by timing the observed forward progression of the fish for known distances along the culvert barrel. Estimated sustained swimming velocities with respect to the water ($*_{Vfw}$) were then calculated by adding the observed forward velocity of the fish with respect to the ground to the known culvert water velocities at the time of observation. These ranged between 0.42 to 1.25 m/s (1.38 to 5.13 fps) (Table 9).

Miscellaneous Round Whitefish Observations: Fork lengths (mm) were measured and recorded for 257 round whitefish collected in the 1987 weir livebox (upstream of the lower Fish Creek culvert) between May 14 and May 25, 1987. Weights (gm) were taken for 34 round whitefish on May 20 and 22, 1987. These data are presented in Table C4. The average condition factor for the 34 weighed fish was 0.845 (Condition Factor = 100*Weight (grams)/(length $(cm)^3$).

Fish Radio Telemetry Tagging

During this study, one of the objectives was to insert transmitters into captured grayling downstream of the culvert to monitor their upstream migrational performance through the culvert. Two 15-channel tracking receivers (Smith-Root, Inc.) were used; one each at the outlet and inlet of the culvert. If we could record the time of passage at culvert outlet and inlet, then we would be able to determine the residence time in the culvert barrel.

This experiment is much easier to visualize than to perform. It was obvious that the handling and insertion of the transmitter stressed the fish. Once released, the tagged fish stopped all upstream movement for at least 24 hours. In some cases, the fish actually retreated downstream some distance. Also, the performance of the radio tags was inconsistent, although our effort was much more successful the second year. The radio tags were intentionally made as small as possible (2 grams) to reduce injury to the fish, however this limits the size of the battery for transmitting. When many of the transmitters were placed in the fish and immersed, the signal became very weak or not detectable.

The performance of the receiver was not at the level hoped. Possibly, local fields from power lines interfered with the transmitted signals. Before each transmitter was placed in a fish it was tested by activating it and taping it to a pole that could be inserted in the stream. There were positions in the stream in front of the culvert where the receiver did not pick up the transmitted signal, even though the distance between transmitter and antennae was only 2.4 m (8 ft) and with nothing but

water between the two. The receiver was connected to a data logger and programmed so that all of the channels were scanned once every second. We used 30 transmitters, divided into two sets with each transmitter set having its own frequency between 40.604 and 40.744 MHz.

It is possible, although unlikely, that fish moved past the antennae without its detecting at least one signal. The antennae were stationed directly over the culvert entrance and exit. To determine the travel time through the culvert, the last downstream signal and the first upstream signal were used. From Table 10, it can be seen that residence time in the culvert ranged from 0.83 minutes to 80.4 minutes.

Table 10: Radio-tagging results for Fish Creek near Cantwell, Alaska, 1988.

Fish Radio Tag #	Date	Length cm	Weight gm	Entrance Time 24 hr	Exit Time 24 hr	Time in Culvert (min)	Relative velocity (fps)
12	12 May	295	248	2012.61	2022.89	10.28	0.10
7	13 May	296	340	1881.94	1893.89	11.94	0.08
3	13 May	272	216	1969.33	1977.33	8.00	0.13
10	14 May	297	260	1962.50	1963.72	1.22	0.82
10	14 May	297	260	1980.22	1983.22	3.00	0.33
11	15 May	280	222	1513.33	1519.61	6.28	0.16
14	15 May	242	144	1595.94	1596.78	0.83	1.20
4	15 May	282	242	1741.17	1743.22	2.06	0.49
5	15 May	244	160	1800.72	1809.56	8.83	0.11
15	15 May	247	145	1851.78	1932.17	80.39	0.01

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APPENDIX A

HYDROLOGIC DATA

Table A1: 1987 measured discharge data for Fish Creek near Cantwell, Alaska.

Date	Julian time	Discharge, cfs	Observed stage, ft.
5-3	123.67	64.8	
5-6	126.58	70.8	
5-8	128.5	122.6	
5-9	129.72	143.6	
5-10	130.64	153.1	2.11
5-11	131.92	142.5	
5-12	132.63		2.14
	132.83	144.8	
5-13	133.79	143.8	
5-14	134.48	117.6	
	134.62		1.69
5-15	135.45		1.54
	135.52	104.5	
5-16	136.31		1.43
	136.39	100.7	
5-17	137.39		1.34
	137.42	96.8	
5-18	138.35		1.15
	138.43	83.7	
5-19	139.33		1.01
	139.35	79.5	
5-20	140.33		.88
	140.39	64.2	
5-21	141.33		.85
	141.39	67.2	
5-22	142.43	58	
	142.84		.72
5-23	143.35		.62
	143.43	62.1	
5-24	144.38		.52
	144.46	55.8	

Table A2: 1987 computed discharge data Fish Creek near Cantwell, Alaska.

Date	Julian time	Q, cfs	Date	Julian time	Q, cfs	Date	Julian time	Q, cfs	Date	Julian time	Q, cfs	Date	Julian time	Q, cfs
3 May	123.67	64.8	15 May	135.05	113.2	17 May	137.31	96.3	19 May	139.04	72.2	22 May	142.05	60.2
6 May	126.58	70.8		135.15	112.0		137.32	100.9		139.30	72.4		142.33	59.9
8 May	128.50	122.6		135.25	110.1		137.35	99.7		139.31	83.2		142.34	64.7
9 May	129.72	143.6		135.27	116.0		137.36	97.1		139.33	74.5		142.36	61.3
10 May	130.62	144.0		135.32	112.8		137.39	96.5		139.35	73.8		142.40	58.5
	130.64	146.3		135.35	112.2		137.42	95.8		139.40	72.4		142.43	58.4
	130.92	147.9		135.38	110.9		137.43	95.8		139.51	71.1		142.55	59.1
11 May	131.07	149.9		135.45	109.6		137.50	94.4		139.60	69.0		142.56	59.1
	131.28	148.8		135.47	109.6		137.52	93.7		139.62	69.0		142.60	59.3
	131.36	147.0		135.50	108.9		137.54	96.3		139.75	67.7		142.62	59.3
	131.62	148.5		135.51	112.1		137.59	92.9		139.80	65.6		142.68	59.6
	131.92	148.2		135.52	111.4		137.61	92.9	20 May	140.33	65.6		142.77	59.9
12 May	132.62	148.2		135.58	108.7		137.66	91.5		140.37	65.6		142.82	60.0
	132.63	148.2		135.62	107.9		137.70	90.1		140.38	69.0		142.84	60.1
	132.75	146.8		135.68	106.5		137.77	88.0		140.39	67.7		142.86	60.2
	132.83	146.0		135.77	104.3		137.85	85.9		140.40	66.3		142.99	60.6
	132.87	144.7		135.85	104.1		137.97	84.4		140.47	64.9	23 May	143.35	61.8
13 May	133.44	142.5		135.86	106.1	18 May	138.09	82.9		140.61	63.6		143.37	61.9
	133.62	140.9		135.91	102.7		138.29	82.6		140.62	62.9		143.38	61.9
	133.70	138.9	16 May	136.08	100.3		138.30	85.3		140.74	61.5		143.39	62.0
	133.79	136.8		136.22	100.0		138.33	83.2	21 May	141.29	62.9		143.41	62.0
	133.80	136.8		136.23	103.3		138.35	83.9		141.33	63.6		143.43	62.1
	133.90	134.7		136.28	101.2		138.36	82.5		141.35	63.6		143.45	62.0
	133.96	132.7		136.30	101.1		138.43	81.3		141.37	68.3		143.54	4.0
14 May	134.05	131.3		136.31	102.4		138.44	81.3		141.39	66.9		143.55	61.4
	134.11	129.2		136.32	103.1		138.47	81.3		141.40	66.3		143.56	61.3
	134.18	127.2		136.39	102.0		138.48	84.0		141.50	64.8		143.59	61.1
	134.24	125.2		136.52	100.3		138.50	83.3		141.60	64.0		143.62	60.9
	134.30	123.1		136.55	99.7		138.55	80.0		141.62	66.7		143.70	60.5
	134.31	125.7		136.56	101.7		138.62	78.7		141.66	64.0		143.79	59.9
	134.38	124.3		136.59	99.8		138.67	76.7		141.78	62.5		143.96	58.9
	134.42	122.9		136.62	99.9		138.75	74.7		141.79	61.8	24 May	144.35	56.5
	134.45	120.9		136.74	98.9		138.85	73.5		141.80	65.9		144.36	56.4
	134.48	120.9		136.82	97.1					141.82	63.8		144.38	56.3
	134.57	119.5		136.90	95.3					141.90	61.7		144.42	56.0
	134.62	119.4											144.46	55.8
	134.75	118.2												
	134.81	116.3												
	134.92	115.1												

Table A3: 1988 measured discharge data for Fish Creek near Cantwell, Alaska.

Date	Julian time	Discharge, cfs	Observed stage, ft.
*5-12	133.44	107.8	
	133.46		1.72
5-13	134.37		1.65
	134.38	93.5	
	134.60		1.61
5-14	135.38	102.3	
	135.42		1.52
	135.63	99.0	
5-15	136.33	95.2	1.38
5-16	137.28	74.4	
	137.42		1.08
5-17	138.33		.82
	138.44	56.4	
	138.64		.73
5-20	141.43	51.1	
	141.73		.60
5-21	142.43	52.3	
5-22	143.57	51.2	.09

* measurements prior affected by variable backwater, not shown.

Table A4: 1988 computed discharge data for Fish Creek near Cantwell, Alaska.

Date	Julian time	Q, cfs	Date	Julian time	Q, cfs	Date	Julian time	Q, cfs	Date	Julian time	Q, cfs
7 May	128.59	75.5	10 May	131.02	104.8	14 May	135.07	102.1	16 May	137.13	80.6
	128.64	75.5		131.13	106.6		135.18	101.1		137.20	79.1
8 May	129.03	76.6		131.25	107.8		135.33	100.5		137.28	78.1
	129.13	77.8		131.31	108.5		135.38	99.9		137.37	77.1
	129.23	78.9		131.34	107.7		135.42	99.5		137.42	75.5
	129.34	80.6		131.41	108.5		135.52	98.9		137.51	73.5
	129.35	80.6		131.64	108.7		135.60	98.3		137.59	71.6
	129.38	80.6	11 May	132.64	109.5		135.63	98.0		137.64	69.6
	129.50	81.8		132.82	109.6		135.64	98.0		137.74	67.6
	129.64	82.4	12 May	133.02	109.8		135.72	97.4		137.88	64.5
	129.78	83.7		133.30	110.0		135.79	96.8	17 May	138.13	62.5
	129.91	85.5		133.36	110.0		135.88	95.8		138.33	60.4
	129.98	86.8		133.39	110.0		135.96	95.2		138.44	58.0
9 May	130.08	88.6		133.44	110.0	15 May	136.07	94.6		138.64	55.0
	130.13	90.4		133.46	110.0		136.17	93.6		138.64	55.0
	130.20	91.7		133.53	109.3		136.28	93.0	18 May	139.57	52.7
	130.27	93.5		133.64	108.6		136.33	92.1		139.64	50.4
	130.32	94.7		133.95	107.8		136.34	92.1		139.81	48.1
	130.35	95.3	13 May	134.19	107.1		136.40	91.1		139.96	44.6
	130.40	95.8		134.37	106.4		136.48	90.1	19 May	140.64	42.2
	130.42	95.8		134.38	106.4		136.54	88.6		140.83	44.6
	130.43	95.8		134.39	106.4		136.59	87.6		140.94	48.1
	130.48	96.4		134.56	104.8		136.64	86.6	20 May	141.13	50.4
	130.56	98.0		134.60	104.3		136.72	85.6		141.43	49.3
	130.64	98.5		134.64	104.0		136.78	84.1			
	130.72	100.1		134.81	103.3		136.89	83.1			
	130.73	100.1		134.96	102.7		136.98	81.6			
	130.83	101.7									
	130.83	101.7									
	130.89	103.5									

Table A5: 1987 water quality data for Fish Creek near Cantwell, Alaska.

Date	time, AST	temp, C	dissolved oxygen, ppm	turbidity, NTU	color, UNITS
14 May	900	1.5	8.3	2.2	75
15 May	1000	2	8.9	1.9	68
16 May	1230	2	8.1	2.55	140
17 May	1030	1	8.4	2.35	100
18 May	1015	2	8.5	2.25	90
19 May	1000	2	8.2	3.15	95
20 May	1000	2.25	7.3	2.5	45
21 May	1030	2	7.9	2.75	50
22 May	1315	3.25	8.2	1.69	70
23 May	1200	3	8.1	1.9	50
24 May	1015	2	8.6	2.3	40

Table A6: 1988 water quality data for Fish Creek near Cantwell, Alaska.

Date	time, AST	temp, C	dissolved oxygen, ppm	turbidity, NTU	color, UNITS
10 May	1230	2	8.05	8.2	98
11 May	800	3	7.9	4.4	80
12 May	700	4	7.6	4.8	110
13 May	1140	4	7.25	3.4	55
14 May	1415	4	6.9	3	55
15 May	1405	4.5	8	3	80
17 May	922	3	7.8	3.2	---

Table A7: 1987 culvert inlet water temperatures, Fish Creek near Cantwell, Alaska.

Date	Julian time	Water temp, C	Date	Julian time	Water temp, C	Date	Julian time	Water temp, C	Date	Julian time	Water temp, C
10 May	130.63	2.5	11 May	131.00	1.2	12 May	132.00	1.9	13 May	133.00	2.0
	130.64	2.5		131.04	.6		132.04	1.6		133.04	1.6
	130.64	2.5		131.08	.4		132.08	1.0		133.08	1.4
	130.67	2.7		131.13	.6		132.13	.9		133.13	1.6
	130.71	3.1		131.17	.4		132.17	1.4		133.17	1.4
	130.75	2.9		131.21	.6		132.21	1.3		133.21	1.3
	130.79	2.7		131.25	.0		132.25	1.1		133.25	.6
	130.83	2.4		131.29	.2		132.29	1.3		133.29	1.0
	130.88	1.6		131.33	1.0		132.33	.8		133.33	1.2
	130.92	1.8		131.38	.8		132.38	1.4		133.38	1.4
	130.96	1.4		131.42	1.6		132.42	1.6		133.42	1.3
				131.46	2.0		132.46	1.8		133.46	1.9
				131.50	2.1		132.50	2.0		133.50	2.4
				131.54	2.5		132.54	2.9		133.54	2.5
				131.58	3.0		132.58	3.4		133.58	3.0
				131.63	3.3		132.63	3.4		133.63	3.2
				131.67	3.4		132.67	4.1		133.67	3.2
				131.71	3.5		132.71	4.2		133.71	3.2
				131.75	4.0		132.75	4.1		133.75	3.2
				131.79	3.8		132.79	4.1		133.79	3.2
				131.83	3.5		132.83	3.6		133.83	3.0
				131.88	2.9		132.88	3.0		133.88	2.6
				131.92	2.3		132.92	2.6		133.92	2.4
				131.96	2.0		132.96	2.5		133.96	1.7

Table A7: Continued.

Date	Julian time	Water temp, C	Date	Julian time	Water temp, C	Date	Julian time	Water temp, C	Date	Julian time	Water temp, C
14 May	134.00	1.6	15 May	135.00	2.6	16 May	136.00	3.4	17 May	137.00	4.1
	134.04	1.6		135.04	2.2		136.04	3.0		137.04	3.6
	134.08	1.4		135.08	2.0		136.08	2.6		137.08	3.1
	134.13	1.0		135.13	1.8		136.13	2.3		137.13	2.7
	134.17	.4		135.17	1.7		136.17	2.0		137.17	2.3
	134.21	1.0		135.21	1.6		136.21	1.8		137.21	2.0
	134.25	1.1		135.25	1.6		136.25	1.6		137.25	1.8
	134.29	.3		135.29	1.6		136.29	1.5		137.29	1.7
	134.33	.8		135.33	1.6		136.33	1.6		137.33	1.7
	134.38	1.2		135.38	1.9		136.38	1.9		137.38	2.0
	134.42	1.6		135.42	2.2		136.42	2.3		137.42	2.3
	134.46	2.2		135.46	2.6		136.46	2.6		137.46	2.6
	134.50	2.8		135.50	2.9		136.50	3.1		137.50	3.0
	134.54	3.3		135.54	3.4		136.54	3.6		137.54	3.6
	134.58	3.8		135.58	3.8		136.58	4.1		137.58	3.9
	134.67	4.1		135.63	4.3		136.63	4.7		137.63	4.3
	134.71	4.2		135.67	4.7		136.67	5.1		137.67	4.7
	134.75	4.3		135.71	5.0		136.71	5.4		137.71	5.1
	134.79	4.1		135.75	5.1		136.75	5.7		137.75	5.2
	134.83	3.9		135.79	5.0		136.79	5.7		137.79	5.2
	134.88	3.6		135.83	4.8		136.83	5.6		137.83	5.2
	134.92	3.3		135.88	4.6		136.88	5.3		137.88	5.0
	134.96	2.9		135.92	4.2		136.92	5.0		137.92	4.7
				135.96	3.8		136.96	4.5		137.96	4.4

Table A7: Continued.

Date	Julian time	Water temp, C	Date	Julian time	Water temp, C	Date	Julian time	Water temp, C	Date	Julian time	Water temp, C
18 May	138.00	4.04	19 May	139.00	4.48	20 May	140.00	5.00	21 May	141.00	6.06
	138.04	3.58		139.04	4.01		140.04	4.43		141.04	5.51
	138.08	3.11		139.08	3.56		140.08	3.99		141.08	4.84
	138.13	2.74		139.13	3.21		140.13	3.61		141.13	4.28
	138.17	2.38		139.17	2.91		140.17	3.26		141.17	3.87
	138.21	2.08		139.21	2.69		140.21	2.96		141.21	3.56
	138.25	1.94		139.25	2.56		140.25	2.77		141.25	3.28
	138.29	1.87		139.29	2.51		140.29	2.67		141.29	3.11
	138.33	1.98		139.33	2.53		140.33	2.66		141.33	3.05
	138.38	2.26		139.38	2.63		140.38	2.81		141.38	3.07
	138.42	2.63		139.42	2.73		140.42	3.04		141.42	3.10
	138.46	3.10		139.46	2.96		140.46	3.37		141.46	3.20
	138.50	3.40		139.50	3.41		140.50	3.86		141.50	3.31
	138.54	3.87		139.54	3.86		140.54	4.43		141.54	3.52
	138.58	4.48		139.58	4.26		140.58	4.90		141.58	3.80
	138.63	5.24		139.63	4.62		140.63	5.55		141.63	4.17
	138.67	5.37		139.67	5.06		140.67	6.13		141.67	4.70
	138.71	5.73		139.71	5.46		140.71	6.61		141.71	5.05
	138.75	6.10		139.75	5.78		140.75	7.02		141.75	5.25
	138.79	6.28		139.79	5.98		140.79	7.18		141.79	5.42
	138.83	6.25		139.83	6.05		140.83	7.34		141.83	5.56
	138.88	5.94		139.88	6.06		140.88	7.21		141.88	5.51
	138.92	5.48		139.92	5.93		140.92	6.84		141.92	5.38
	138.96	4.97		139.96	5.55		140.96	6.45		141.96	5.14

Table A7: Continued.

Date	Julian time	Water temp, C	Date	Julian time	Water temp, C	Date	Julian time	Water temp, C	Date	Julian time	Water temp, C
22 May	142.00	4.8	23 May	143.00	5.9	24 May	144.00	5.1	25 May	145.00	6.1
	142.04	4.4		143.04	5.4		144.04	4.7		145.04	5.8
	142.08	4.1		143.08	4.9		144.08	4.4		145.08	5.3
	142.13	3.7		143.13	4.5		144.13	4.1		145.13	4.9
	142.17	3.3		143.17	4.0		144.17	3.8		145.17	4.4
	142.21	3.0		143.21	3.6		144.21	3.5		145.21	3.9
	142.25	2.7		143.25	3.3		144.25	3.3		145.25	3.5
	142.29	2.6		143.29	3.2		144.29	3.3		145.29	3.2
	142.33	2.6		143.33	3.1		144.33	3.2		145.33	3.1
	142.38	2.8		143.38	3.2		144.38	3.1		145.38	3.1
	142.42	3.0		143.42	3.5		144.42	3.2			
	142.46	3.4		143.46	3.6		144.46	3.3			
	142.50	3.8		143.50	3.8		144.50	3.6			
	142.54	4.2		143.54	4.3		144.54	4.2			
	142.58	4.7		143.58	4.8		144.58	4.7			
	142.63	5.4		143.63	5.2		144.63	5.2			
	142.67	5.9		143.67	5.6		144.67	5.3			
	142.71	6.2		143.71	6.0		144.71	5.4			
	142.75	6.6		143.75	6.2		144.75	5.7			
	142.79	6.8		143.79	6.3		144.79	6.0			
	142.83	6.9		143.83	6.4		144.83	6.3			
	142.88	6.8		143.88	6.3		144.88	6.5			
	142.92	6.6		143.92	6.0		144.92	6.5			
	142.96	6.3		143.96	5.6		144.96	6.3			

Table A8: 1988 culvert inlet water temperatures, Fish Creek near Cantwell, Alaska.

Date	Julian time	Water temp, C	Date	Julian time	Water temp, C	Date	Julian time	Water temp, C	Date	Julian time	Water temp, C
10 May	131.58	2.0	11 May	132.00	1.7	12 May	133.00	4.3	13 May	134.00	3.71
	131.63	2.1		132.04	1.6		133.04	3.9		134.04	3.41
	131.67	2.3		132.08	1.4		133.08	3.6		134.08	3.09
	131.71	2.4		132.13	1.2		133.13	3.2		134.13	2.75
	131.75	2.3		132.17	1.0		133.17	2.9		134.17	2.4
	131.79	2.3		132.21	.8		133.21	2.7		134.21	2.07
	131.83	2.2		132.25	.7		133.25	2.5		134.25	1.79
	131.88	2.2		132.29	.6		133.29	2.3		134.29	1.57
	131.96	2.0		132.33	.7		133.33	2.3		134.33	1.44
				132.38	.9		133.38	2.3		134.38	1.52
				132.42	1.3		133.42	2.3		134.42	1.82
				132.46	1.6		133.46	2.5		134.46	2.1
				132.50	2.2		133.50	2.8		134.75	5.27
				132.54	2.8		133.54	3.2		134.83	5.81
				132.58	3.4		133.58	3.4		134.88	5.78
				132.63	3.9		133.63	3.6		134.92	5.62
				132.67	4.4		133.67	3.9		134.96	5.35
				132.71	4.7		133.71	4.2			
				132.75	5.0		133.75	4.3			
				132.79	5.1		133.79	4.3			
				132.83	5.1		133.83	4.3			
				132.88	5.0		133.88	4.3			
				132.92	4.9		133.92	4.2			
				132.96	4.6		133.96	4.0			

Table A8: Continued.

Date	Julian time	Water temp, C	Date	Julian time	Water temp, C	Date	Julian time	Water temp, C
14 May	135.00	5.1	15 May	136.33	1.7	16 May	137.00	4.7
	135.04	4.8		136.38	2.1		137.04	4.4
	135.08	4.5		136.42	2.3			
	135.13	4.2		136.46	2.5			
	135.17	3.9		136.50	2.9			
	135.21	3.6		136.54	3.4			
	135.25	3.4		136.58	3.9			
	135.29	3.2		136.63	4.4			
	135.33	3.0		136.67	4.9			
	135.38	3.0		136.71	5.1			
	135.42	3.0		136.75	5.5			
	135.46	3.0		136.79	5.6			
	135.50	3.1		136.83	5.6			
	135.54	3.2		136.88	5.6			
	135.58	3.4		136.92	5.5			
				136.96	5.1			

APPENDIX B

HYDRAULIC DATA

Table B1: 1988 culvert invert elevation for lower Fish Creek near Cantwell, Alaska.

Distance from culvert outlet ft.	Elevation ft.	Slope
.5	95.95	
1.0	95.88	-.140
2.0	95.85	-.030
3.0	95.80	-.050
4.0	95.84	.040
6.0	95.60	-.120
10.0	95.64	.010
15.0	95.69	.010
16.5	95.72	.020
20.0	95.80	.023
25.0	95.87	.014
30.0	95.95	.016
36.0	96.04	.015
39.0	96.14	.033
40.5	96.14	.000
44.0	96.21	.020
45.0	96.25	.040
47.0	96.28	.015
50.0	96.31	.010
51.0	96.36	.050
54.0	96.33	-.010
54.5	96.34	.020
55.5	96.60	.260
56.0	96.62	.040
57.5	96.62	.000
59.5	96.76	.070
	Mean slope:	.0142

Table B2: Summary of velocity cross-sectional data for Fish Creek near Cantwell, Alaska, 1987.

Date, Time AST	Station
15 May, 1000	outlet,1'u.s.
15 May, 0730	outlet,6'u.s.
16 May, 1115	inlet,1'd.s.
16 May, 0900	inlet,6'd.s.
18 May, 1625	outlet,6'u.s.
19 May, 1100	inlet,1'd.s.
19 May, 0730	outlet,1'u.s.
19 May, 0925	inlet,6'd.s.
21 May, 1630	inlet,1'd.s.
21 May, 1430	inlet, 6'd.s.
21 May, 1030	outlet,6'u.s.
21 May, 0830	outlet,1'u.s.
23 May, 0050	inlet,6'd.s.
23 May, 1030	outlet,6'u.s.

Table 83: 1987 cross-sectional field data of velocity measurements at Fish Creek culvert.

15 May 1987, outlet, 1'u.s., Q = 110 cfs.
1000 AST

Station, ft.	Velocity in fps Depth, ft.: .1	.2	.3	.5	.75	1	1.3	1.7	2	total depth ft.
* left 4	lb=4.0'									
* left 3	3.77	4.40	4.78	5.12	5.51	5.36	6.00	5.09		.80
* left 2	4.63	5.50	5.57	6.50	6.81	6.58	6.29	7.07	4.84	1.95
* left 1	2.97	5.56	6.05	7.56	7.42	7.56	7.77	7.94	6.57	2.30
* CL	5.18	5.90	6.51	8.03	8.75	8.50	8.53	8.65	7.24	2.45
* right 1	4.81	6.49	7.57	8.49	9.05	9.50	9.14	8.17	8.29	2.40
* right 2	3.96	6.79	7.97	8.28	8.38	8.89	8.64	4.68	7.01	2.15
* right 3	3.98	5.42	6.16	6.69	7.34	7.44	6.59	5.08		1.50
* right 4	3.65	4.67	4.43	4.76						.55

15 May 1987, outlet, 6' u.s., Q = 114 cfs.
0730 AST

Station, ft.	Velocity in fps Depth, ft.: .1	.2	.3	.5	.75	1	1.3	1.7	2	2.5	total depth ft.
	lb=4.4'										
* left 4	1.97	1.25	2.34	2.45	2.38						.80
* left 3	1.30	1.79	3.00	3.66	4.25	4.33	3.87	3.62			1.80
* left 2	2.21	3.29	3.71	3.85	5.00	5.45	5.55	5.66	4.84		2.50
* left 1	.76	3.54	4.19	5.42	6.48	6.83	7.39	6.55	6.14	5.16	2.90
* CL	.53	2.30	4.81	5.94	7.18	8.12	8.33	8.08	7.82	6.95	3.05
* right 1	3.74	4.51	5.00	6.27	7.59	8.17	7.73	8.84	8.19	7.93	2.80
* right 2	1.46	2.79	4.72	6.19	7.36	7.64	7.47	7.97	7.32	6.45	2.50
* right 3	3.21	3.24	4.33	4.89	5.48	5.79	6.52	5.08			1.90
* right 4	2.13	2.79	2.68	3.20	2.32						.85
	rb=4.5'										

16 May 1987, inlet, 1' d.s., Q = 101 cfs.
1115 AST

Station, ft.	Velocity in fps Depth, ft.: .1	.2	.3	.5	.75	1	1.3	1.7	2	2.5	3	total depth ft.
	lb=4.3'											
* left 4	3.28											.25
* left 3	.29	1.39	4.66	6.15	6.23	6.31	5.79	5.32				1.75
* left 2	.71	2.13	4.24	5.08	5.94	6.00	5.93	5.99	5.81	3.83		2.50
* left 1	2.53	3.09	4.49	5.25	5.65	5.77	6.13	5.77	5.90	5.67		2.80
* CL	4.81	5.13	5.79	5.85	6.10	5.93	5.92	5.83	5.78	5.26		2.55
* right 1	.61	1.24	3.93	4.29	5.11	5.38	5.79	5.94	5.86	5.70	5.35	3.10
* right 2	2.97	4.28	4.94	5.14	5.09	4.81	4.90	4.79	4.71			2.20
* right 3	4.27	5.41	5.39	5.85	5.84	5.47	5.22	4.83	4.60			2.10
* right 4	3.52	4.02	3.99	3.94	3.15							.85

Table B3: Continued.

16 May 1987, inlet, 6 ft. d.s., Q = 102 cfs
0900 AST

Station, ft.	Velocity in fps Depth, ft.: .1	.2	.3	.5	.75	1	1.3	1.7	1.8	2	total depth ft.
	lb=4.5'										
* left 4	3.64	3.74	3.96								.45
* left 3	3.66	4.82	5.43	6.50	7.91	8.70					1.30
* left 2	2.25	5.07	5.69	7.93	8.72	8.88	8.98	8.67			1.95
* left 1	2.20	4.36	7.22	7.73	8.76	9.10	9.21	8.80		8.98	2.20
* CL	2.22	2.25	3.03	4.48	6.22	8.32	9.02	8.93		8.98	2.30
* right 1	3.73	4.94	5.66	7.23	7.94	8.87	8.83	8.92	9.30		2.10
* right 2	3.31	4.51	8.26	8.60	8.86	8.95	8.77				1.70
* right 3	3.92	4.60	6.07	6.16	8.31	8.36					1.25
* right 4	rb=4.0'										

18 May 1987, outlet, 6' u.s., Q = 77 cfs.
1625 AST

Station, ft.	Velocity in fps Depth, ft.: .1	.2	.3	.5	.75	1	1.3	1.7	2	2.5	total depth ft.
	lb=4.15'										
* left 4	1.35	1.66									.30
* left 3	2.06	2.90	3.47	3.55	3.42	3.17	2.68				1.35
* left 2	2.58	3.13	3.66	3.91	4.41	4.48	4.30	4.26			2.00
* left 1	2.64	3.25	4.17	4.69	5.03	5.24	5.62	5.54	5.02		2.45
* CL	3.06	4.42	5.24	5.60	6.09	6.88	7.29	7.29	6.82	6.38	2.75
* right 1	2.98	4.48	5.50	6.32	6.91	7.48	7.69	7.60	7.28	6.84	2.70
* right 2	3.79	4.25	4.77	5.39	6.23	6.90	7.23	6.19	5.21		2.20
* right 3	3.33	3.37	3.83	4.38	4.64	4.79	4.05				1.70
* right 4	1.87										.15
	rb=4.1'										

19 May 1987, inlet, 1' d.s., Q = 72 cfs.
1100 AST

Station, ft.	Velocity in fps Depth, ft.: .15	.2	.3	.5	.75	1	1.3	1.7	2	2.5	total depth ft.
* left 4	lb=4.0'										
* left 3	2.39	2.69	3.71	5.67							.75
* left 2	2.35	5.35	5.63	5.95	5.81	6.23	6.33				1.85
* left 1	3.60	5.02	5.62	6.05	6.28	6.34	6.34	6.23	6.12		2.40
* CL		.69	1.95	3.35	5.34	6.33	6.39	6.37	6.30	5.79	2.55
* right 1	.05	.01	.06	5.50	6.33	6.44	6.66	6.40	6.18		2.40
* right 2	.09	.30	.59	2.80	6.11	6.43	6.55	6.33	6.09		2.10
* right 3	.63	1.99	4.86	6.68	5.49						1.25
* right 4	rb=4.0'										

Table B3: Continued.

19 May 1987, outlet, 1' u.s., Q = 72 cfs.
0730 AST

Station,ft.	Velocity in fps Depth,ft.: .1	.2	.3	.5	.75	1	1.3	1.7	total depth ft.
* left 4	lb=3.9'								
* left 3	3.39	4.18	4.27	4.23	3.18				.80
* left 2	4.17	4.71	5.43	5.79	5.82	5.52	4.29	6.04	1.50
* left 1	4.66	5.17	6.04	6.46	6.57	6.75	6.72	7.25	1.90
* CL	4.05	4.82	5.54	6.84	7.73	7.74	7.73	7.35	2.00
* right 1	4.42	4.78	5.63	7.06	7.69	8.09	7.87	6.59	1.95
* right 2	4.42	6.11	6.61	7.14	7.64	7.54	7.56		1.75
* right 3	4.26	5.34	5.77	6.23	6.08				1.10
* right 4	2.13								.20
	rb=4.1'								

19 May 1987, inlet 6' d.s., Q = 73 cfs.
0925 AST

Station,ft.	Velocity in fps Depth,ft.: .15	.2	.3	.5	.75	1	1.3	1.7	total depth ft.
* left 4	lb=4.0'								
* left 3	2.35	4.81	5.13	6.04	7.14				1.00
* left 2	5.11	5.12	5.63	7.31	7.80	8.18	7.94	7.93	1.80
* left 1	2.49	6.28	6.75	7.80	8.33	8.30	8.44	8.46	2.00
* CL	3.43	3.42	2.76	4.52	5.99	7.90	8.60	8.60	2.00
* right 1	2.59	5.67	6.70	7.42	7.95	8.49	8.58	8.43	1.80
* right 2	3.97	7.16	7.51	8.29	8.47	8.67	6.80		1.55
* right 3	.91	5.05	7.28	5.69					.75
* right 4	rb=3.75'								

21 May 1987, inlet, 1' d.s., Q = 64 cfs.
1630 AST

Station,ft.	Velocity in fps Depth,ft.: .15	.2	.3	.5	.75	1	1.3	1.7	2	2.25	total depth ft.
* left 4	lb=4.0'										
* left 3	3.77	5.01	5.21	5.60	6.46	6.81					1.20
* left 2	4.05	5.33	5.57	5.90	6.26	6.31	6.14	6.02			1.90
* left 1	4.19	4.36	5.39	5.86	6.15	6.09	5.91	5.99	6.01	5.81	2.35
* CL	.10	.43	1.46	5.16	6.24	6.36	6.20	6.10	6.14	5.72	2.40
* right 1	.06	.05	.46	5.70	5.79	6.65	6.58	6.25	5.95	5.73	2.30
* right 2	.02	.69	.48	2.16	6.24	6.48	6.35	5.99			2.05
* right 3	4.10	4.89	4.99	5.66	6.59						1.20
* right 4	rb=4.0'										

Table B3: Continued.

21 May 1987, inlet, 6' d.s., Q = 64 cfs.
1430 AST

Station, ft.	Velocity in fps Depth, ft.: .15	.2	.3	.5	.75	1	1.3	1.5	1.7	total depth ft.
* left 4	lb=4.1'									
* left 3	3.39	4.67	5.73	6.57	5.13					.90
* left 2	2.48	5.57	6.14	7.74	8.16	8.10	7.95	7.98		1.75
* left 1	4.12	5.38	6.53	7.56	8.07	8.55	8.34		8.40	1.80
* CL	.14	3.24	3.52	3.68	6.40	8.21	8.66		6.29	1.85
* right 1	3.67	4.02	5.46	6.79	7.83	8.40	8.75	8.76		1.75
* right 2	5.71	6.39	7.45	8.24	8.46	8.68	8.26			1.45
* right 3	5.28	6.44	6.32	3.73						.70
* right 4	rb=3.6'									

21 May 1987, outlet, 6' u.s., Q = 66 cfs.
1030 AST

Station, ft.	Velocity in fps Depth, ft.: .15	.2	.3	.5	.75	1	1.3	1.5	1.7	2	2.25	2.5
* left 4	lb=4.0'											
* left 3	.92	2.04	2.09	2.82	2.88	2.78	2.57					
* left 2	.71	3.15	2.93	3.32	3.64	4.13	4.14		3.96	3.38		
* left 1	1.05	2.96	3.77	3.93	4.64	4.78	4.82		5.40	5.21	4.80	
* CL	3.00	3.85	4.18	4.82	5.18	6.08	6.32		6.68	6.52	6.18	5.56
* right 1	3.85	4.71	4.45	5.90	6.47	6.80	7.14		7.39	6.84	6.77	
* right 2	3.36	3.64	4.14	5.27	5.82	6.56	6.66		6.03	5.08		
* right 3	1.85	1.11	1.56	3.54	4.09	4.84	4.13	3.26				
* right 4	rb=4.0'											

21 May 1987, outlet, 1' u.s., Q = 64 cfs.
0830 AST

Station, ft.	Velocity in fps Depth, ft.: .15	.2	.3	.5	.75	1	1.3	1.7	2	total depth ft.
* left 4	lb=4.0'									
* left 3	2.24	2.78	3.96	4.12	4.02					.95
* left 2	3.23	4.53	5.00	5.09	5.22	5.36	4.96			1.75
* left 1	3.23	4.13	4.68	5.42	5.83	5.85	5.98	5.59		1.90
* CL	1.31	2.06	4.50	5.53	6.68	6.99	7.77	6.50	5.58	2.10
* right 1	1.78	5.35	5.81	5.88	7.92	8.12	7.89	6.34		2.00
* right 2	3.21	5.93	6.99	7.28	7.78	7.86	7.16	6.19		1.95
* right 3	3.56	4.84	4.71	5.86	6.14	5.66				1.30
* right 4	rb=4.0'									

Table 83: Continued.

23 May 1987, inlet, 6. d.s., Q = 61 cfs.
0050 AST

Station, ft.	Velocity in fps Depth, ft.: .15	.2	.3	.5	.75	1	1.25	1.3	1.5	total depth ft.
* left 4	lb=3.8'									
* left 3	2.09	3.35	4.45	5.47	4.95					.85
* left 2	.21	3.93	5.91	7.43	7.82	7.65		7.67		1.50
* left 1	.62	4.14	5.55	6.83	8.08	8.09		8.12	8.34	1.65
* CL	.46	2.52	2.57	6.00	7.30	8.31		8.42		1.70
* right 1	1.97	3.52	4.86	6.45	6.81	8.18		8.52	8.35	1.55
* right 2	4.61	6.59	6.72	7.60	8.21	8.44	7.08			1.35
* right 3	2.33	5.96	5.32	4.95						2.00
* right 4	rb=3.6'									

23 May 1987, outlet, 6' u.s., Q = 62 cfs.
1030 AST

Station, ft.	Velocity in fps Depth, ft.: .15	.2	.3	.5	.75	1	1.3	1.7	2	2.25	total depth ft.
* left 4	lb=4.0'										
* left 3		.76	1.84	2.45	2.59	2.40	2.41				1.45
* left 2	1.19	2.92	3.27	3.78	3.72	3.93	3.52	3.28			2.00
* left 1	2.06	2.66	3.37	4.12	4.10	4.57	5.14	4.97	4.87	4.28	2.35
* CL	.58	2.86	3.27	4.20	4.99	5.09	5.76	6.10	6.25	6.13	2.50
* right 1	1.22	3.04	4.09	5.30	6.09	6.28	6.74	6.57	6.15	2.95	2.40
* right 2	1.15	1.14	3.48	4.70	5.15	5.69	5.38	4.91			2.00
* right 3	1.55	1.66	2.80	2.92	2.87	2.79					1.30
* right 4	rb=4.0'										

Table B4: Summary of velocity cross-sectional data for Fish Creek near Cantwell, Alaska, 1988.

Date, Time AST	Station
9 May, 1355	outlet,6'u.s.
9 May, 1635	outlet,1'u.s
9 May, 2000	outlet,30'u.s.
10 May, 0855	inlet,1'd.s.
10 May, 1236	inlet,6'd.s.
10 May, 1400	outlet,30'u.s.
11 May, 1645	outlet,1'u.s.
11 May, 1425	outlet,16.5'u.s.
12 May, 1030	outlet,16.5'u.s.
13 May, 1310	outlet,44'u.s.
15 May, 1330	outlet,16.5'u.s.
16 May, 1205	outlet,44'u.s.
16 May, 1245	outlet,30'u.s.

Table 85: 1988 cross-sectional field data of velocity measurements at Fish Creek culvert.

9 May 1988, outlet, 6'u.s., Q = 98 cfs.
1355 AST

Station, ft.	Velocity in fps Depth, ft: .1	.2	.3	.5	.75	1	1.3	1.7	2	2.5	w.s.	total depth ft.
* left 4	lb=4.3'										2.18	
* left 3	2.62	2.77	3.18	3.27	3.31						3.27	1.70
* left 2	2.97	3.34	3.56	3.88	4.35	4.41	4.29	4.11			3.60	2.30
* left 1	3.30	3.97	4.28	4.75	5.01	5.53	5.78	5.63	5.40	4.57	4.80	2.70
* CL	3.86	4.80	5.16	6.07	6.44	7.16	7.27	6.74	6.37	6.03	5.99	2.95
* right 1	3.56	4.74	5.43	6.54	6.94	7.53	7.82	7.50	7.12	6.90	7.11	2.80
* right 2	2.30	4.28	5.26	5.78	6.49	6.73	7.21	7.48			6.17	2.60
* right 3	2.27	3.32	4.21								4.37	1.90
* right 4	rb=4.5'										2.08	

9 May 1988, outlet, 1'u.s., Q = 99 cfs.
1635 AST

Station, ft.	Velocity in fps Depth, ft: .1	.2	.3	.5	.75	1	1.3	1.7	2	w.s.	total depth ft.
* left 4	lb=4.1'										
* left 3	3.83	4.74	4.93	5.28	5.47	5.59				5.41	1.35
* left 2	4.90	5.72	5.76	6.17	6.45	6.34	6.13	6.06		5.96	1.90
* left 1	5.07	5.87	6.34	7.01	7.50	7.37	7.22	6.85	6.93	6.05	2.10
* CL	4.88	5.25	7.34	8.34	8.61	8.39	8.49	7.79	6.63	6.41	2.30
* right 1	5.66	6.32	7.30	7.59	9.02	8.91	8.75	8.14	8.05	8.07	2.30
* right 2	6.05	6.65	7.17	7.91	7.92	8.52	8.37	7.42		5.84	1.85
* right 3	4.05	5.33	5.43	6.99	7.01	6.27				6.22	1.20
* right 4	rb=4'										

9 May 1988, outlet, 30'u.s., Q = 102 cfs.
2000 AST

Station, ft.	Velocity in fps Depth, ft: .1	.2	.3	.5	.75	1	1.3	1.7	2	w.s.	total depth ft.
*	lb=4.75'										
* left 4	.88	1.42	1.03	.98						.91	.70
* left 3	3.17	3.92	3.64	4.56	4.27	4.04	3.27	2.88		2.88	1.80
* left 2	2.66	3.05	3.03	4.20	4.48	5.49	6.05	5.28	4.52	4.96	2.35
* left 1	4.76	5.29	5.50	6.52	6.53	6.65	6.48	7.40	7.72	6.85	2.50
* CL	5.37	5.83	5.86	7.48	8.15	8.37	8.37	8.67	8.37	8.09	2.45
* right 1	4.98	5.92	7.03	7.87	7.53	8.00	8.74	8.38	8.90	7.82	2.25
* right 2	2.36	4.61	6.25	7.50	7.58	8.20	8.41	6.87		6.01	1.95
* right 3	4.48	5.26	5.26	6.43	6.66	6.51	3.79			3.79	1.40
* right 4	1.83										
.	rb=4.24'										

Table B5: Continued.

10 May 1988, inlet, 1'd.s., Q = 108 cfs.
0855 AST

Station, ft.	Velocity in fps Depth, ft: .1	.2	.3	.5	.75	1	1.3	1.7	2	2.5	w.s.	total depth ft.
	lb=4.0'											
* left 4	2.37	1.30	4.47	5.04	6.30	6.27	5.99				.97	1.60
* left 3	4.75	5.14	5.39	6.10	6.21	6.02	6.17	5.88	5.54	5.50	5.50	2.65
* left 2	2.99	5.70	6.04	6.37	6.45	6.53	6.37	6.37	6.08	5.35	5.44	2.85
* left 1	2.03	1.31	.83	2.75	6.57	6.48	6.40	5.97	5.76	5.39	5.36	2.95
* CL	2.91	1.82	5.04	5.90	6.29	6.45	6.38	5.94	5.59	5.56	5.56	2.65
* right 1	.83	4.42	2.25	5.42	6.94	6.78	6.27	5.75	5.37		5.37	2.40
* right 2	.26	5.85	7.08	7.06	6.74	6.27	6.04	5.69	2.37		2.37	2.10
* right 3	3.91										.15	.65
* right 4	rb=4.5'											

10 May 1988, inlet, 6'd.s., Q = 108 cfs.
1236 AST

Station, ft.	Velocity in fps Depth, ft: .1	.2	.3	.5	.75	1	1.3	1.7	2	w.s.	total depth ft.
	lb=4.3'										
* left 4	4.44	2.91								2.91	.30
* left 3	4.95	5.96	6.87	7.81	8.04	8.06	5.41			6.58	1.50
* left 2	4.75	5.68	6.98	8.26	8.77	8.68	9.14	8.96		8.96	2.00
* left 1	6.61	7.47	7.79	8.28	9.16	9.24	9.31	9.35	9.39	9.39	2.20
* CL	3.00	4.16	5.27	6.14	8.16	8.78	9.22	9.19	7.48	8.01	2.35
* right 1	6.76	7.00	7.47	7.68	8.13	8.62	9.01	8.73		9.41	1.85
* right 2	7.96	8.55	8.54	8.89	9.26	9.40	9.44			9.33	1.70
* right 3	6.43	6.17	6.06	7.16	8.78					?	1.00
* right 4	rb=4.0'										

10 May 1988, outlet, 30'u.s., Q = 109 cfs.
1400 AST

Station, ft.	Velocity in fps Depth, ft: .1	.2	.3	.5	.75	1	1.3	1.7	2	2.5	w.s.	total depth ft.
	lb=4.5'											
* left 4	1.24	1.42	1.07	1.38							1.38	.60
* left 3	2.45	3.03	3.45	3.91	4.23	3.90	2.81				2.96	1.50
* left 2	1.26	3.83	4.49	5.03	5.09	6.04	6.03	5.46	4.22		4.86	2.30
* left 1	3.08	4.35	5.17	5.68	6.47	7.07	7.65	7.84	7.34	5.54	5.54	2.60
* CL	3.17	5.73	6.41	7.55	8.17	8.57	8.42	9.21	8.81	8.33	8.33	2.65
* right 1	5.07	6.25	6.72	7.63	8.78	9.04	9.19	9.01	9.17	7.46	8.71	2.50
* right 2	1.36	5.10	6.56	7.42	8.55	9.07	9.33	8.76	7.62		6.88	1.70
* right 3	1.29	3.22	5.25	6.32	7.17	5.93	4.85				4.11	.40
* right 4											1.44	
	rb=4.5'											

Table B5: Continued.

11 May 1988, outlet, 1'u.s., Q = 110 cfs.
1645 AST

Station,ft.	Velocity in fps Depth,ft: .15	.2	.3	.5	.75	1	1.3	1.7	2	2.5	w.s.	total depth ft.
	lb=4.5'											
* left 4	3.36	3.69	4.47	4.64								.70
* left 3	3.75	4.18	4.99	5.13	5.44	5.68	5.30				5.30	1.50
* left 2	5.58	5.65	6.00	6.41	6.52	6.59	6.41	6.23			6.36	2.00
* left 1	4.65	5.36	6.35	6.60	7.53	7.52	7.44	7.18	7.17		6.99	2.30
* CL	2.54	4.41	4.19	6.22	8.70	8.74	8.60	8.13	7.60		6.98	2.40
* right 1	1.48	5.77	7.11	8.37	9.10	9.38	9.19	8.72	8.46	5.39	5.39	2.40
* right 2	.45	6.02	5.97	7.83	8.20	8.31	8.37	7.86			4.23	2.00
* right 3	3.69	3.82	5.77	6.23	6.11	6.53	5.96				5.09	1.55
* right 4	rb=4.0'											

11 May 1988, outlet, 16.5'u.s., Q = 110 cfs.
1425 AST

s. Station,ft.	Velocity in fps Depth,ft: .15	.2	.3	.5	.75	1	1.3	1.7	2	2.5	w.s.	total depth ft.
	lb=4.5'											
* left 4	1.18	1.34	1.71	1.67							1.57	.70
* left 3	1.71	1.25	2.49	2.23	2.36	3.32	2.94				2.39	1.70
* left 2		.73	2.55	3.52	4.01	3.87	4.05	3.39	3.22		2.95	2.50
* left 1	2.17	2.11	3.01	5.35	5.54	5.97	6.04	5.89	5.76	5.26	4.41	2.80
* CL	2.30	4.61	5.09	6.18	7.07	7.89	8.02	7.90	7.48	6.73	6.47	3.00
* right 1	5.32	5.65	6.28	7.50	7.93	8.85	8.89	8.76	8.22	7.91	8.04	2.90
* right 2		4.81	5.56	6.85	7.38	7.70	7.76	6.80	5.91		5.61	2.50
* right 3		2.91	4.45	5.01	6.34	6.46	6.19	5.54			3.65	2.00
* right 4		2.53	3.20	2.49	2.60							1.00
	rb=4.7'											

12 May 1988, outlet, 16.5'u.s., Q = 110 cfs.
1030 AST

s. Station,ft.	Velocity in fps Depth,ft: .2	.3	.4	.6	.8	1.1	1.4	1.8	2.1	2.6	w.s.	total depth ft.
	lb=4.5'											
* left 4	1.24	1.44	1.80	1.57	1.35						1.35	.90
* left 3	1.40	1.91	2.44	2.76	2.91	3.40	3.48	2.92			2.92	1.90
* left 2	.91	3.89	3.84	4.20	4.60	4.69	4.42	4.04	4.05		3.20	2.50
* left 1	.16	.08	.03	.10	5.38	6.24	6.12	6.23	6.13	5.01	5.01	2.65
* CL	5.60	6.17	6.64	7.20	7.63	7.94	7.80	7.82	7.09	6.40	6.40	2.95
* right 1	5.75	6.30	7.02	7.90	8.58	8.75	8.62	8.11	7.94	7.77	7.61	2.90
* right 2	4.53	5.90	5.85	7.45	8.17	8.58	7.83	7.42	6.61		5.79	2.50
* right 3	3.15	4.70	5.40	6.41	6.72	6.72	6.29	5.20			4.57	2.05
* right 4	2.00	2.93	3.51	3.38	3.48	2.71					2.71	1.15
r.												

Table B5: Continued.

13 May 1988, outlet, 44'u.s., Q = 105 cfs.
1310 AST

Station,ft.	Velocity in fps Depth,ft: .2	.3	.4	.6	.8	1.1	1.4	1.8	2.1	w.s.	total depth ft.
	lb=4.0'										
* left 4											
* left 3	3.20	4.35	4.44	4.92	4.53	2.85				2.85	1.20
* left 2	5.94	6.55	7.17	7.05	6.11	7.34	7.70			6.43	1.75
* left 1	4.85	6.21	6.77	7.37	7.95	8.90	8.95	8.34	7.82	7.49	2.30
* CL	5.70	6.36	6.28	7.13	7.61	7.94	8.81	9.34	8.96	8.96	2.20
* right 1	5.71	6.08	7.72	8.45	8.94	8.98	9.12	9.31	9.48	9.48	2.20
* right 2	6.02	6.34	7.48	8.52	8.95	9.30	8.97	9.17		7.35	2.10
* right 3	4.80	6.23	7.27	8.35	7.66	7.81	5.16			5.18	1.60
* right 4	1.68	1.59	1.57	.80						.80	.70
	rb=4.2'										

15 May 1988, outlet, 16.5'u.s., Q = 89 cfs.
1330 AST

s. Station,ft.	Velocity in fps Depth,ft: .2	.3	.4	.6	.8	1.1	1.4	1.8	2.1	w.s.	total depth ft.
	lb=4.0'										
* left 4											
* left 3.5	1.02	1.43	1.15	1.36	.95					.95	.90
* left 3	.99	2.23	2.60	2.39	2.28	2.14	1.80			1.80	1.50
* left 2	2.85	3.34	3.20	4.07	3.73	4.10	3.28	3.10		3.05	2.10
* left 1	1.66	2.80	3.59	3.49	4.40	4.79	5.23	5.10	4.78	4.59	2.45
* CL	3.85	4.43	5.00	5.32	5.55	6.04	6.65	6.96	6.65	6.46	2.55
* right 1	2.87	5.08	5.75	6.51	6.87	7.14	7.24	7.19	7.20	6.87	2.55
* right 2	2.53	4.52	4.95	5.83	6.62	6.94	6.82	6.02	5.44	5.44	2.15
* right 3	.48	3.01	4.19	4.49	4.96	5.20	3.71			3.71	1.50
* right 4	1.90	2.20	1.81	.86						.86	.70
	rb=4.5'										

16 May 1988, outlet, 44'u.s., Q = 74 cfs.
1205 AST

Station,ft.	Velocity in fps Depth,ft: .2	.3	.4	w.s.	total depth ft.
	lb=3.75'				
* left 4					
* left 3	2.50	3.27	3.13	3.03	.65
* left 2	3.67	4.32	4.39	6.02	1.2
* left 1	5.91	4.00	7.36	7.66	1.55
* CL	3.00	4.60	4.75	8.38	1.85
* right 1	3.24	5.76	5.74	7.87	1.85
* right 2	5.97	5.82	6.43	7.56	1.55
* right 3	3.50	4.38	6.37	3.64	1.1
* right 4	3.48	3.82	3.62	2.64	.85
	rb=4.0'				

Table 85: Continued.

16 May 1988, outlet, 30'u.s., Q = 73 cfs.
1245 AST

Station, ft.	Velocity in fps Depth, ft: .2	.3	.4	w.s.	total depth ft.
	lb=4.0'				
* left 3.5	.68	.70	.97	1.15	.75
* left 3	1.35	1.46	1.49	1.89	1.15
* left 2	2.18	4.59	4.60	3.82	1.80
* left 1	3.99	4.80	5.40	5.82	2.05
* CL	3.61	4.32	4.68	7.20	2.05
* right 1	4.82	5.61	6.10	7.29	2.10
* right 2	4.37	5.44	5.96	4.87	1.80
* right 3	2.88	3.78	3.75	3.32	1.25
* right 3.5	2.77	2.65	2.43	1.94	.70
	rb=4.0'				

Table B6: Summary of velocity profiles along centerline of Fish Creek culvert, 1987.

OUTLET:

Date	time, AST	feet u.s. of outlet	discharge CFS
22 Aug (1986)		4	50
3 May	1800	1	64.8
6 May	1135	1	70.8
13 May	1945	1	136.8
17 May	815	lip	99.7
17 May	815	1	99.7
17 May	815	6	99.7
18 May	950	lip	81.3
18 May	950	1	81.3
18 May	830	6	83.9
20 May	1430	1	63.6
20 May	1430	6	63.6
22 May	1000	1	58.4
22 May	1000	6	58.4
23 May	1015	1	62.1
24 May	1100	1	55.8
24 May	1100	6	55.8

INLET:

Date	time, AST	feet d.s. of inlet	CFS
22 Aug (1986)		16	50
3 May	1800	1	64.8
6 May	1115	1	70.8
13 May	1600	1	139.7
17 May	900	1	96.5
17 May	900	6	96.5
18 May	1035	1	81.3
18 May	1035	6	81.3
20 May	1505	1	62.9
20 May	1505	6	62.9
22 May	1330	1	59.1
22 May	1330	6	59.1
23 May	1250	1	61.4
24 May	1100	1	55.8
24 May	1100	6	55.8

Table B7: Field data of velocity profiles, Fish Creek culvert at outlet, 1987.

OUTLET:

	*										**						
Date:	22 Aug	3 May	6 May	13 May	17 May	17 May	17 May	18 May	18 May	18 May	18 May	20 May	20 May	22 May	22 May	23 May	24 May	24 May
Time, AST:		1800	1135	1945	815	815	815	950	950	830	830	1430	1430	1000	1000	1015	1100	1100
Site:	4'u.s.	1'u.s.	1'u.s.	1'u.s.	lip	1'u.s.	6'u.s.	lip	1'u.s.	6'u.s.	6'u.s.	1'u.s.	6'u.s.	1'u.s.	6'u.s.	1'u.s.	1'u.s.	6'u.s.
Flow, cfs:	50	64.8	70.8	136.8	99.7	99.7	99.7	81.3	81.3	83.9	83.9	63.6	63.6	58.4	58.4	62.1	55.8	55.8
Total depth, ft:	3.00	2.10	2.00	2.45	2.10	2.30	2.95	1.90	2.00	2.80	2.80	2.05	2.60	1.90	2.50	1.95	1.95	2.40
Depth (ft):																		
.10		4.29	3.54	4.88	3.99	3.21	2.83	2.91	2.98	2.92								
.15												4.13	3.31	.07	1.58	1.70	.01	.90
.20	1.93	4.89	3.63		5.30	4.24	4.87	5.39	4.13	3.64	3.89	4.20	3.72	.48	3.25	1.40	.32	2.22
.30	2.03		5.19	7.02	6.18	5.82	5.35	6.04	5.30	4.49	4.55	4.66	4.31	4.46	4.39	2.98	2.81	3.32
.40	2.61	5.86	5.74							5.22	5.32							
.50	2.80			9.34	7.53	7.13	5.64	7.20	6.82	5.45	5.64	5.28	5.21	5.57	4.57	4.69	4.74	4.02
.60	2.80	6.25	6.10															
.70																		
.75					8.83	8.34	6.67	8.22	7.62	6.00	6.67	6.48	5.99	6.30	5.16	6.07	5.79	4.74
.80	2.74	6.46	6.38															
.90																		
1.00		6.85	7.36	10.39	8.85	8.23	7.33	8.09	7.97	6.38	7.26	6.63	6.34	6.73	5.64	6.33	6.13	5.12
1.10	3.26																	
1.20												7.01	6.38					
1.25										6.36	7.18							
1.30		6.53	6.47		8.66	8.18	7.42	7.85	7.60			6.82	6.48	6.78	5.73	6.46	6.28	5.77
1.40	3.34																	
1.50				9.24						6.66	7.18	6.70	6.83			6.55	5.87	5.78
1.60		6.35	6.58															
1.70					7.91	7.62	7.24	6.46	6.57					6.60	6.32	6.19	5.37	5.69
1.75										6.73	6.67	6.50	6.75					
1.80	3.49																	
1.90		4.81	5.14											4.74				
2.00		4.83		8.88	4.57	6.49	7.20		5.40	6.96	7.11	5.73	6.61		6.21			5.30
2.10																		
2.20	3.34																	
2.25										6.75	6.81		6.43		5.88			5.02
2.40				4.45														
2.50							6.72			6.25	6.81		4.60					
2.60	3.10																	
3.00																		
3.50																		

* 1986

** Cup-type current meter; all others electromagnetic current meter.

Table B8: Field data of velocity profiles, Fish Creek culvert at inlet.

INLET:

Date:	22 Aug*	3 May	6 May	13 May	17 May	17 May	18 May	18 May	18 May**	20 May	20 May	22 May	22 May	23 May	24 May	24 May
Time, AST:		1800	1115	1600	900	900	1035	1035	1035	1505	1505	1330	1330	1250	1100	1100
Site:	16'd.s.	1'd.s.	1'd.s.	1'd.s.	1'd.s.	6'd.s.	1'd.s.	6'd.s.	6'd.s.	1'd.s.	6'd.s.	1'd.s.	6'd.s.	1'd.s.	1'd.s.	6'd.s.
Flow, cfs:	50	64.8	70.8	139.7	96.5	96.5	81.3	81.3	81.3	62.9	62.9	59.1	59.1	61.4	55.8	55.8
Total depth, ft:	2.5	2.3	2.2	3.8	2.4	2.2	2.2	2	2	2.3	1.85	2.3	1.8	2.2	2.1	1.65
Depth (ft):																
.10		3.89	4.27		4.81	2.06	4.49	2.76	3.16							
.15											2.42	.22	1.33	2.01	.03	.80
.20	3.83	5.01	4.40		5.14	3.39	5.09	3.83	4.55	.95	2.47	.79	2.17	1.17	.31	2.66
.30	3.98		4.49		5.80	4.06	5.34	3.94	5.46	2.02	3.29	1.65	2.19	1.84	2.27	2.68
.40	4.28	5.11	5.11													
.50	4.20			.65	5.84	5.42	5.56	5.29	5.68	3.75	5.71	3.89	3.70	2.62	3.76	6.31
.60	4.96	5.27	5.38													
.70																
.75					5.82	6.77	5.70	6.76	6.81	6.34	6.68	6.09	6.69	5.42	5.88	6.88
.80	5.20	5.39	5.81													
.90																
1.00		5.43	6.20	4.85	5.89	8.58	5.73	8.25	8.22	6.44	8.18	6.42	7.61	6.18	6.04	7.89
1.10	5.33															
1.20										6.51	8.62					
1.25																
1.30		5.61	5.97		5.87	8.86	5.59	8.79	9.26	6.40	8.75	6.35	8.47	6.07	5.96	7.67
1.40	5.45															
1.50				6.06						6.22	8.77			5.98	5.70	5.33
1.60		5.31	5.77													
1.70	5.20				5.78	9.07	5.39	8.81	9.26			6.07	8.11	5.95	5.69	
1.75										6.18	8.46					
1.80																
1.90		5.00	1.90					8.67								
2.00				6.19	5.72	9.05	5.31					5.87		5.80	5.30	
2.10	3.80		6.23													
2.20		4.99														
2.25												5.68				
2.40																
2.50				5.97												
2.60																
3.00				5.69												
3.50				5.40												

* 1986

** Cup-type current meter; all others electromagnetic current meter.

Table B9: 20-second mean velocity at 0.2 ft. and 0.5 ft. depths measured 0.2 ft. out from culvert wall at Fish Creek near Cantwell, Alaska, 1988.

15 May, 1630 AST
Q = 86 cfs

	outlet lip	Velocity in fps										
Feet u.s. of lip	0	2	4	6	8	11	13	15	36	38	40.5	42.5
depth left:												
0.2 ft.	3.93	3.76	2.55	2.02	1.60	1.08	.98	.96	.23	.94	2.25	3.01
0.5 ft.	5.13	4.74	3.02	2.58	2.38	1.90	1.75	1.56	1.92	2.75	3.51	3.65
depth right:												
0.2 ft.	4.17	3.40	2.54	2.19	1.77	1.63	1.74	1.53	1.48	3.00	2.02	3.04
0.5 ft.	4.36	3.82	3.89	3.16	2.66	2.95	2.99	2.94	4.31	4.99	5.46	5.96

16 May, 1630 AST
Q = 69 cfs

	outlet lip	Velocity in fps															inlet lip
Feet u.s. of lip	0	3	4.5	7	10	13	16.5	20	25	30	35	39	44	46	50	54	57.5	59.5
depth left:																		
0.2 ft.	3.48	2.89	1.93	1.58	1.14	.99	.70	.78	.60	.99	.32	.90	2.91	1.82	5.08	6.21	3.24	3.18
0.5 ft.	4.19	2.37	2.46	1.75	1.52	1.47	1.00	.91	.90	1.34	1.91	2.27	3.61	3.44	5.05	5.91	6.22	3.67
depth right:																		
0.2 ft.	4.67	2.42	2.38	1.66	1.34	2.17	1.62	1.58	1.00	1.14	1.28	2.46	2.25	2.97	2.90	5.12	6.22	6.13
0.5 ft.	4.69	4.18	3.07	2.53	2.74	2.55	2.80	2.47	3.10	3.24	3.27	4.58	4.51	5.46	5.17	5.61	7.71	6.50

Table 10: 1987 and 1988 water-surface profile leveling data for Fish Creek near Cantwell, Alaska.

Centerline elevation with respect to BM #2:

INLET: 1987

Date	time AST	discharge cfs	200 ft. u.s. of inlet	inlet pool	inlet lip	0.5 ft. d.s.	1 ft. d.s.	2 ft. d.s.	4 ft. d.s.	6 ft. d.s.
6 May	1530	77	99.74	99.56	99.13					
14 May	900	123	100.68	100.53	100.05	100.05		98.80	99.33	98.84
15 May	740	108	100.46	100.34			99.83			98.79
16 May	1350	98	100.34	100.11	99.70					98.70
17 May		92	100.14	99.89	99.51					98.51
18 May	1100	81	99.94	99.68	99.33					98.49
19 May	1300	73	99.81	99.64	99.25					98.35
21 May	730	69	99.65	99.48	99.14					98.24
23 May		59	99.46	99.30	99.01					97.99

OUTLET: 1987

Date	time AST	6 ft. u.s.	3 ft. u.s.	1 ft. u.s.	outlet lip	outlet pool	200 ft. d.s.
6 May	1530				98.00	97.92	96.86
14 May	900	98.80	98.71	98.55	98.42	98.12	96.84
15 May	740	98.69		98.42		98.08	96.76
16 May	1350	98.54			98.32	98.11	96.58
17 May		98.35			98.22	97.97	96.57
18 May	1100	98.36			98.14	97.95	96.54
19 May	1300	98.30					
21 May	730	98.25					
23 May		98.01			97.89	97.85	96.57

Table B10: Continued.

Centerline elevation with respect to BM #2:

INLET: 1988

Date	time AST	discharge cfs	200 ft. u.s. of inlet	inlet pool	1 ft. u.s.	inlet lip	1 ft. d.s.	3 ft. d.s.	6 ft. d.s.
7 May		69.5	99.82	99.63		99.12	99.07		98.17
8 May	1340	70.9	99.92	99.73		99.23	99.21		98.31
9 May	817	81.7	100.11	99.97		99.43	99.44		98.43
10 May	1535	88.1	100.32	100.19		99.88	99.72		98.68
11 May	1316	104.0	100.41	100.26	99.59	99.82	99.71	99.34	98.70
12 May	752	93.5	100.38	100.23	99.80	99.75	99.61	99.27	98.64
13 May	910	99.9	100.07	100.61	100.14	99.59	99.51	99.19	99.53
14 May	826	95.2	100.04	99.90	99.50	99.42	99.32	99.02	98.40
15 May	824	74.6	99.80	99.65	99.26	99.19	99.07	98.74	98.24
16 May	1520	65.0	99.43	99.29	99.01	98.86	98.82	98.44	98.01
17 May	1300	51.0		99.15		98.66			
18 May		51.4							
20 May		50.8					58.50		

OUTLET: 1988

Date	time AST	44 ft. u.s.	30 ft. u.s.	20 ft. u.s.	16.5 ft. u.s.	6 ft. u.s.	1 ft. u.s.	lip	1 ft. d.s.	pool
7 May						98.26		98	99.07	97.94
8 May	1340					98.36	98.09	97.99		97.97
9 May	817		98.49			98.47	98.19			98.01
10 May	1535		98.67	98.82		98.72	98.43	98.22		98.11
11 May	1316		98.59	98.84	98.71	98.71	98.39	98.25	98.1	
12 May	752		98.61	98.78	98.66	98.65	98.37	98.21	98.06	98.05
13 May	910	98.4	98.56		98.61	98.57	99.69	99.59	98.09	98.01
14 May	826	98.3	98.55	98.4	98.55	98.46	98.17	98.09	97.95	97.99
15 May	824	98.1	98.39	98.37	98.29	98.27	98.06	97.97	97.86	97.94
16 May	1520	98.1	98.07	98.03	98.15	98.05	97.82	97.82	97.77	97.86
17 May	1300							97.84		97.81

Table B11: Centerline and lateral water surface elevations in the vicinity of Fish Creek culvert near Cantwell, Alaska, 1987.

Elevation with respect to BM #2:

INLET

Date	time AST	discharge cfs	200 ft. u.s. of inlet	inlet pool	inlet lip	0.5 ft. d.s.			1 ft. d.s.							2 ft. d.s.		
						LEW	CL	REW	L3	L2	L1	CL	R1	R2	R3	LEW	CL	REW
14 May	900	123	100.68	100.53	100.05	99.97	100.05	99.99								99.12	98.80	99.13
15 May	740	108	100.46	100.34					99.80	99.77	99.81	99.83	99.86	99.86	99.87			

INLET (continued)

Date	time AST	4 ft. d.s.			6 ft. d.s.							
		LEW	CL	REW	LEW	L3	L2	L1	CL	R1	R2	R3	REW
14 May	900	99.19	99.33	99.13	99.05				98.84				99.04
15 May	740					98.92	98.78	98.81	98.79	98.69	98.71	98.95	

OUTLET

Date	time AST	6 ft. u.s.							3 ft. u.s.	1 ft. u.s.							outlet lip	outlet pool	200 ft. d.s.
		L3	L2	L1	CL	R1	R2	R3	CL	L3	L2	CL	R1	R2	R3	R4			
14 May	900				98.80				98.71			98.55					98.49	98.12	96.84
15 May	740	98.64	98.60	98.63	98.69	98.61	98.62	98.65		98.32	98.34	98.42	98.44	98.44	98.43	98.42		98.08	96.76

LEW = left edge of water, REW = right edge of water

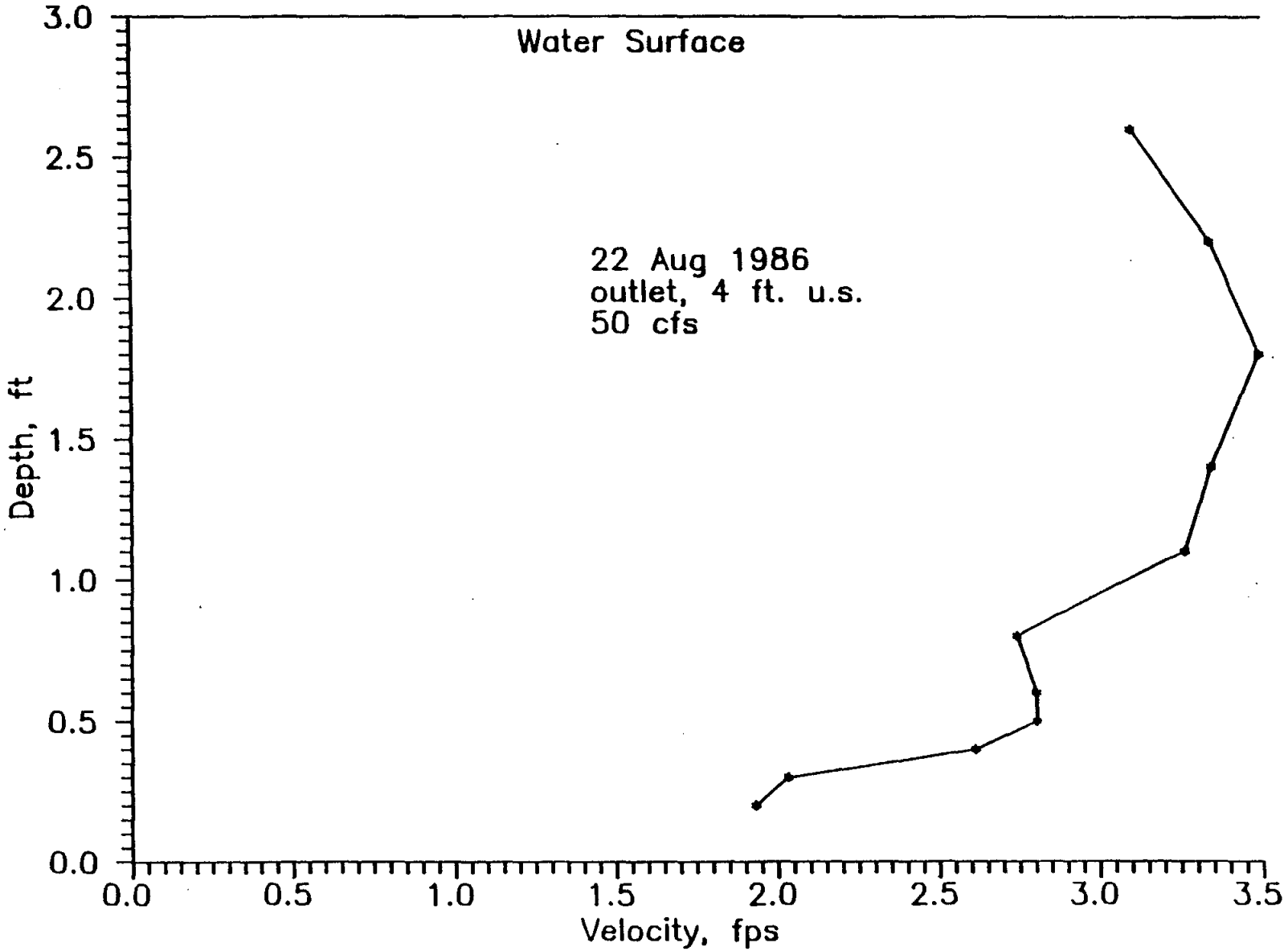

Figure B1: Plot of velocity profiles, 4 ft. upstream of outlet, August 22, 1986.

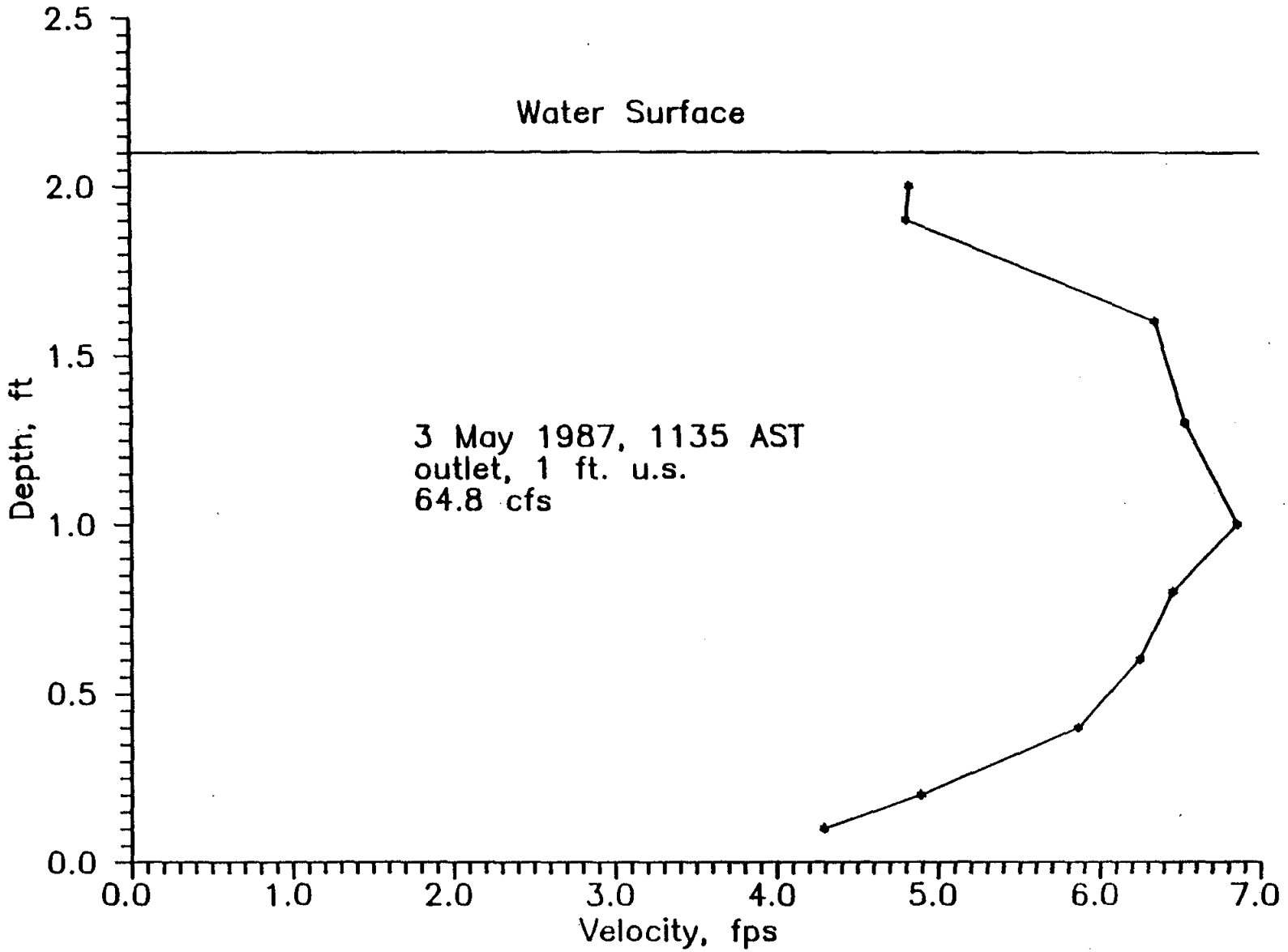

Figure B2: Plot of velocity profiles, 1 ft. upstream of outlet, May 3, 1987.

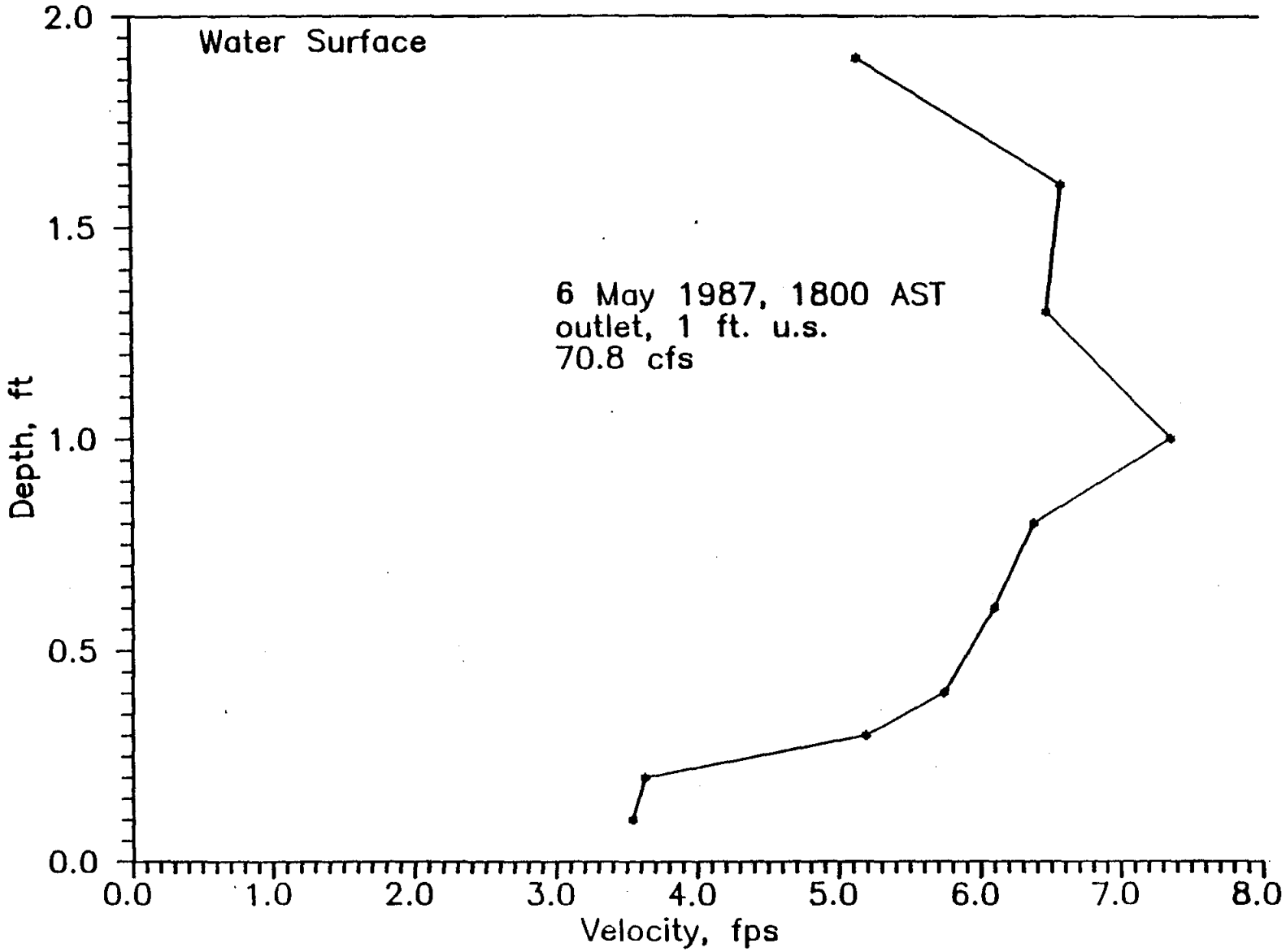

Figure B3: Plot of velocity profiles, 1 ft. upstream of outlet, May 6, 1987.

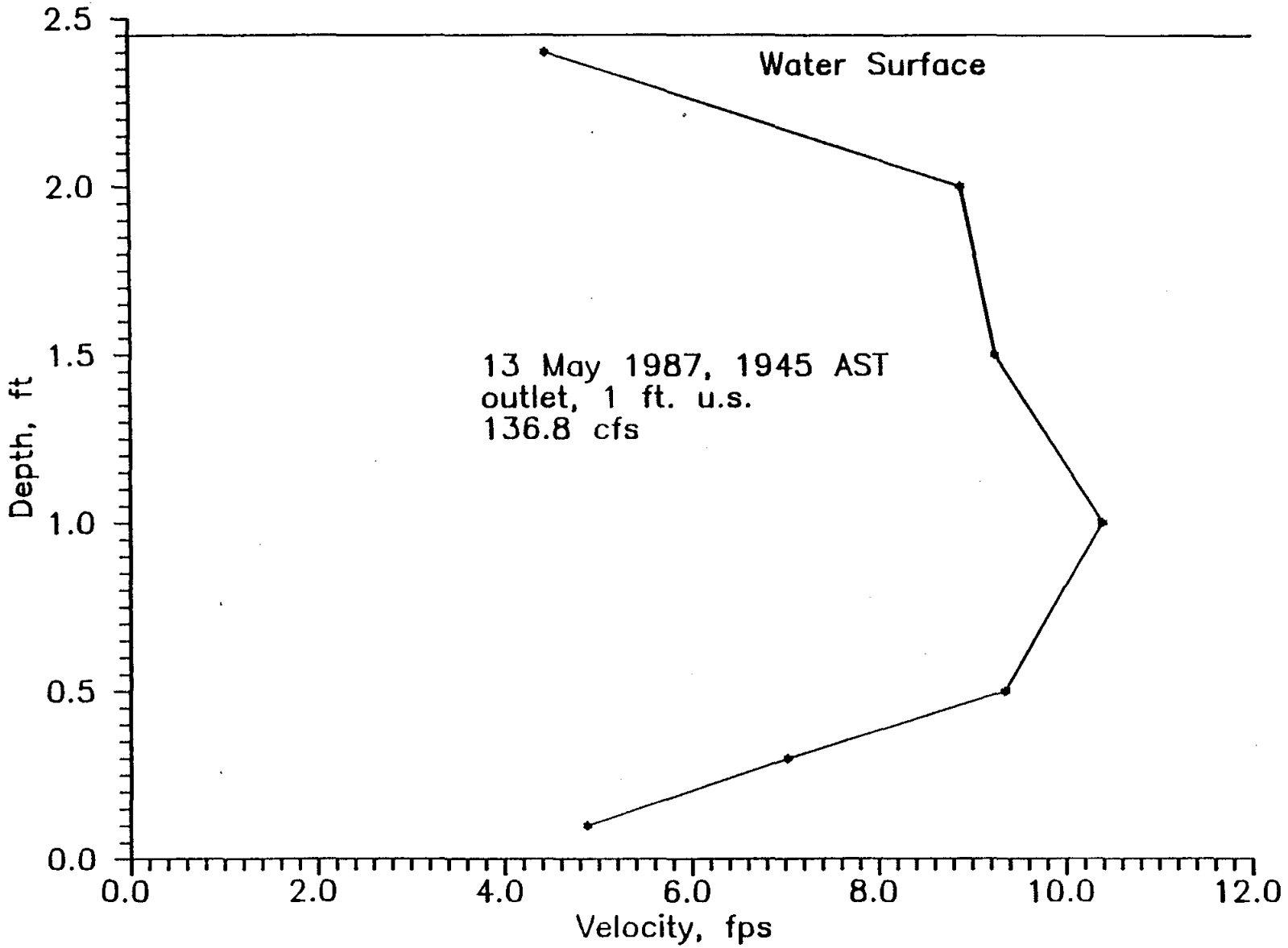

Figure B4: Plot of velocity profiles, 1 ft. upstream of outlet, May 13, 1987.

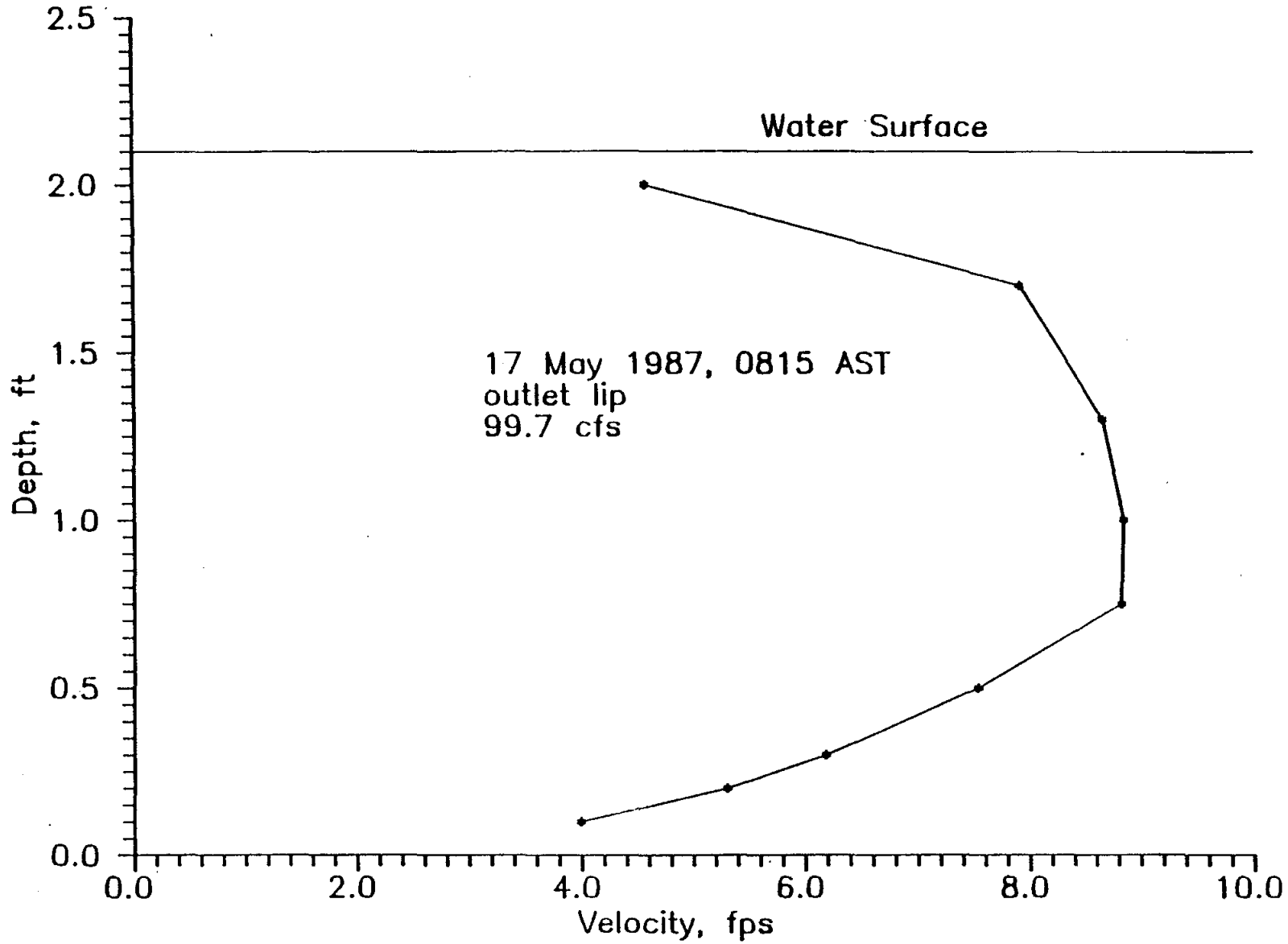

Figure B5: Plot of velocity profiles, outlet lip, May 17, 1987.

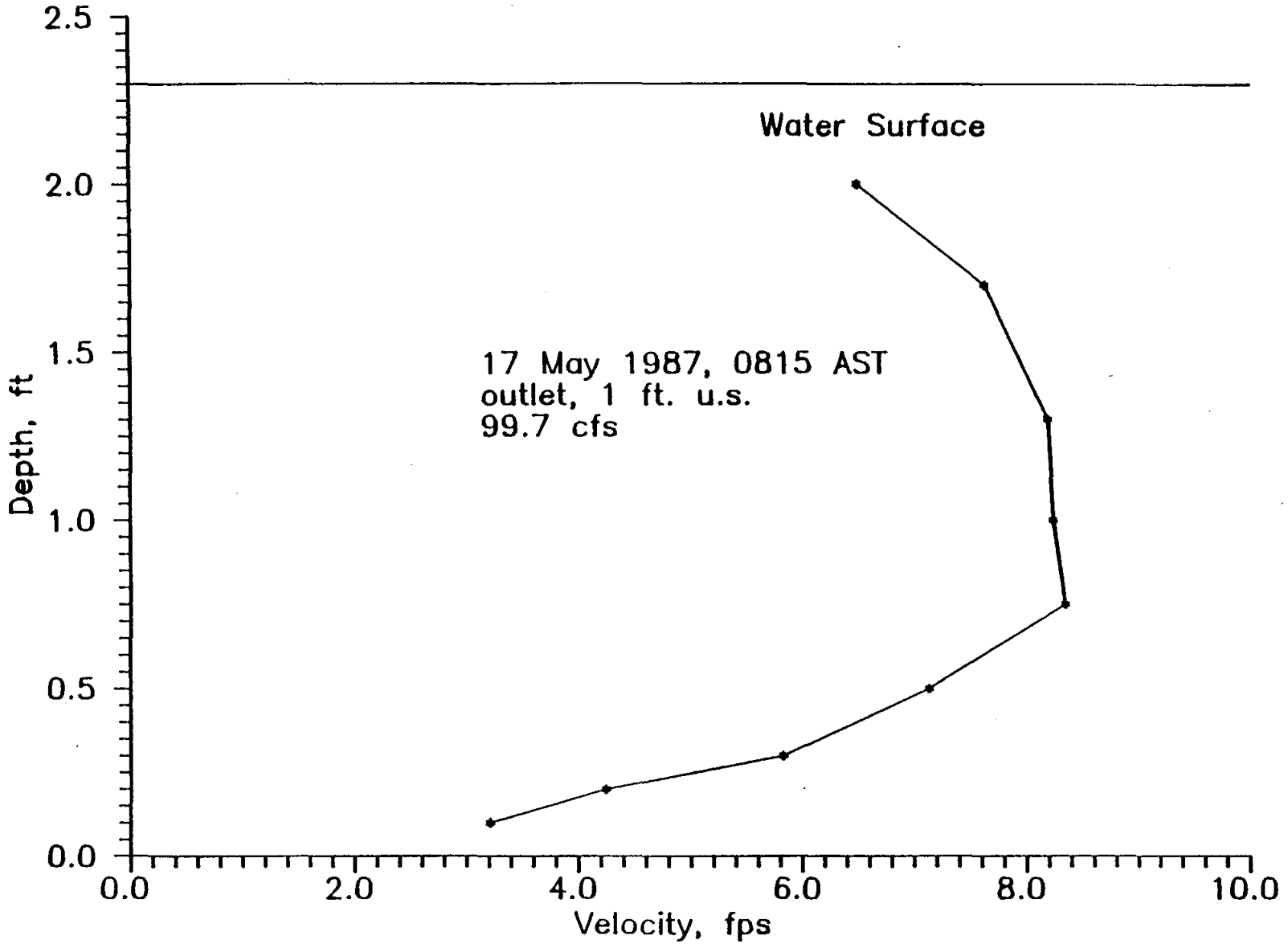

Figure B6: Plot of velocity profiles, 1 ft. upstream of outlet, May 17, 1987.

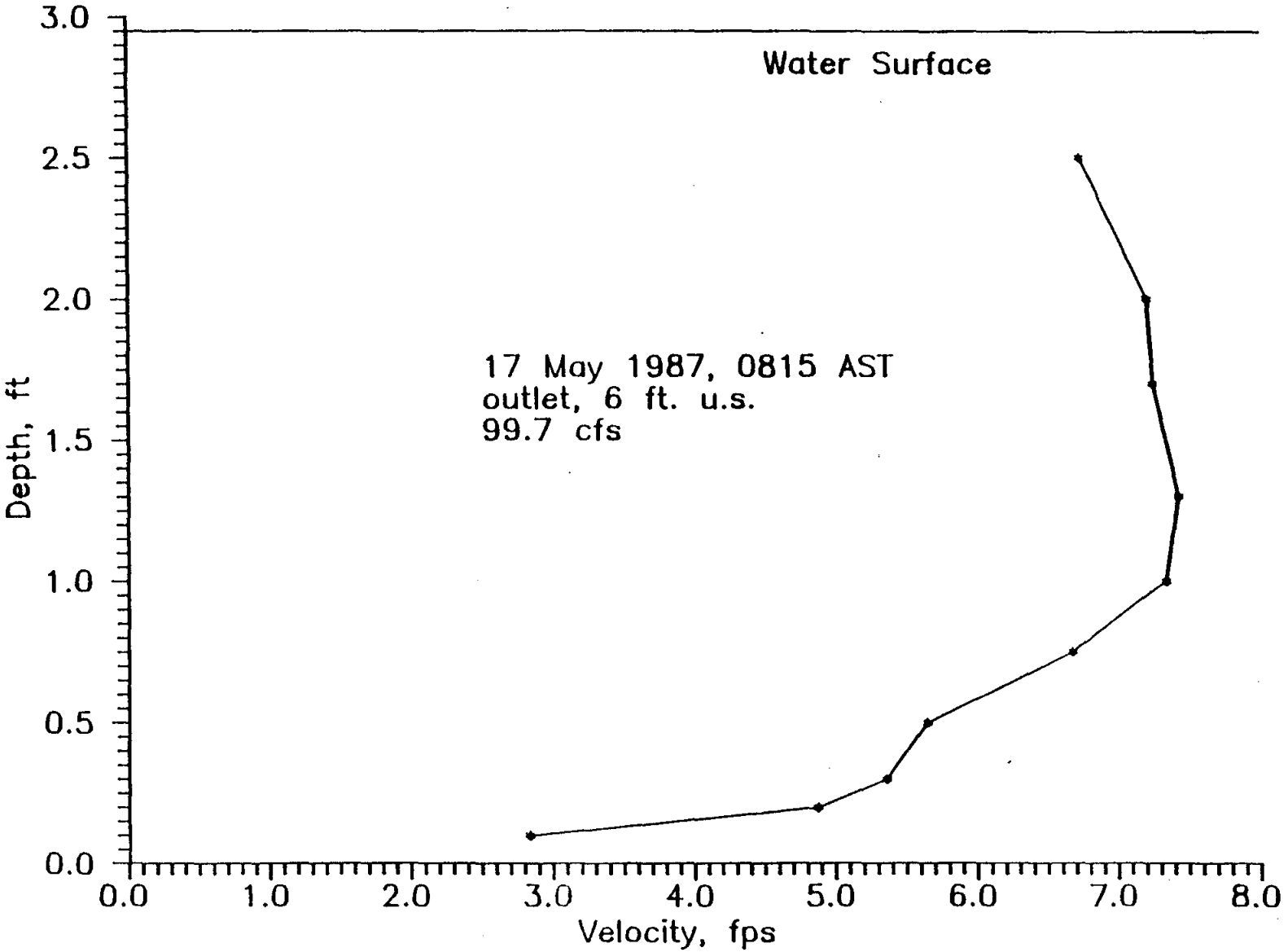

Figure B7: Plot of velocity profiles, 6 ft. upstream of outlet, May 17, 1987.

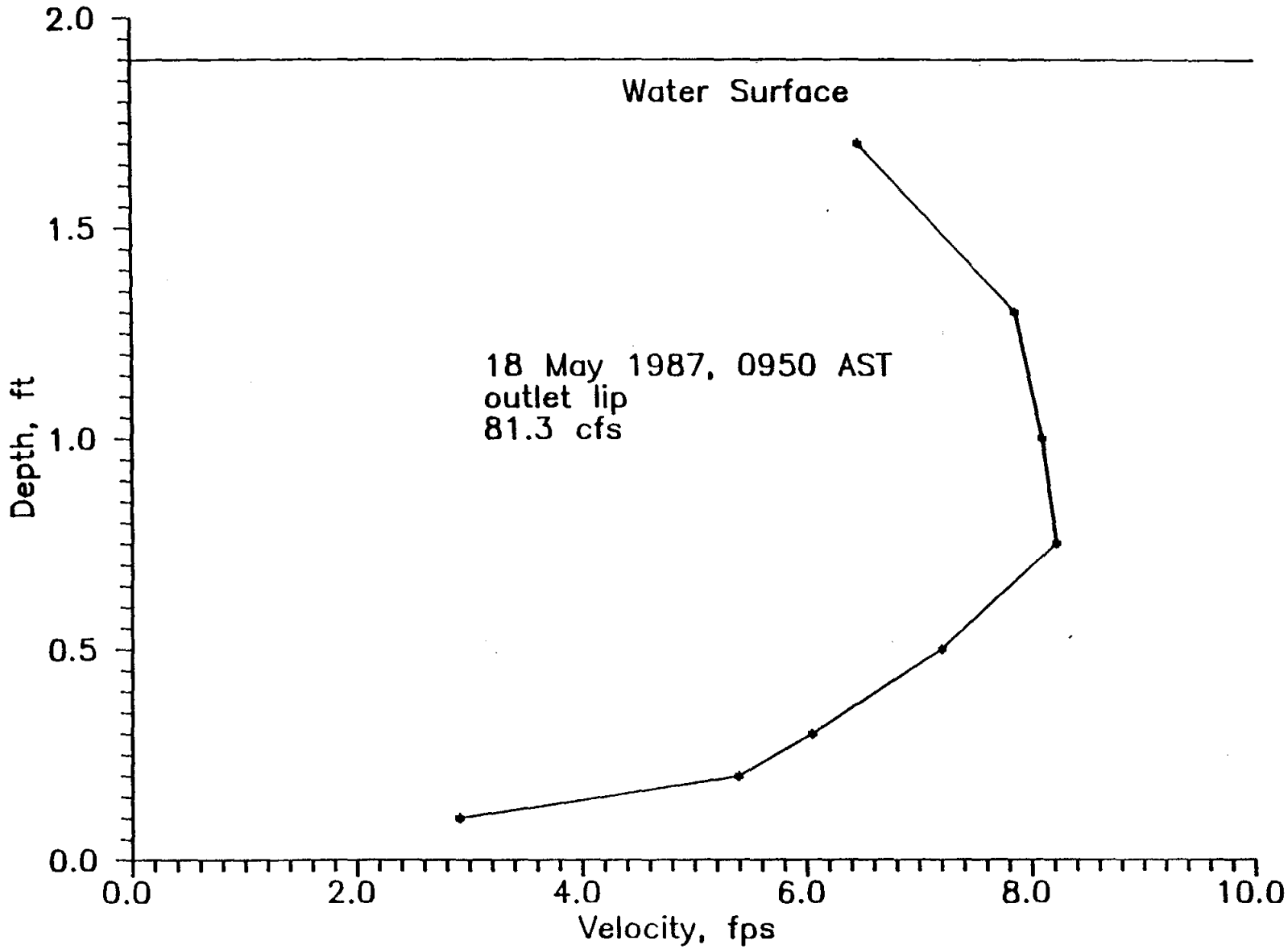

Figure B8: Plot of velocity profiles, outlet lip, May 18, 1987.

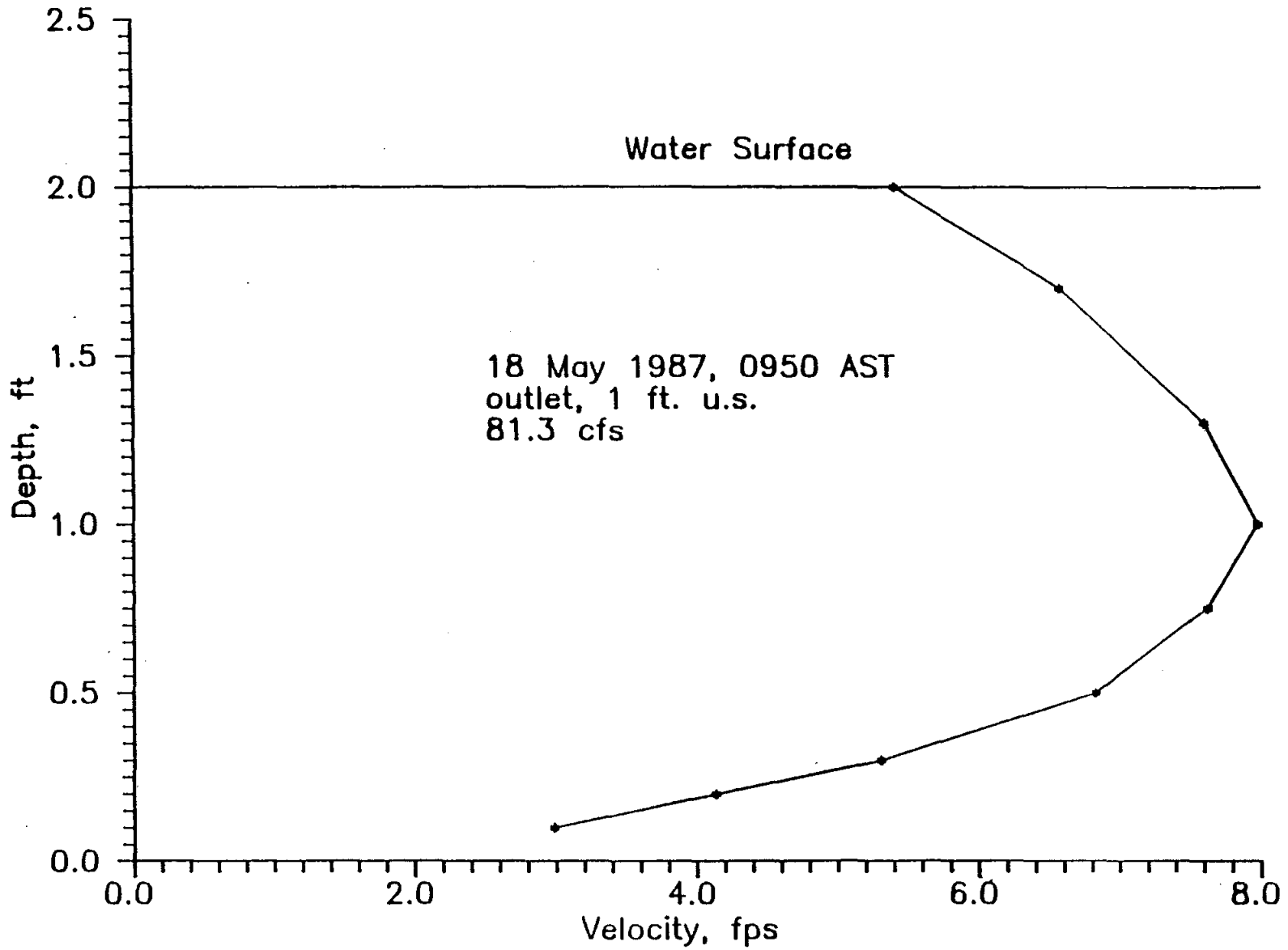

Figure B9: Plot of velocity profiles, 1 ft. upstream of outlet, May 18, 1987.

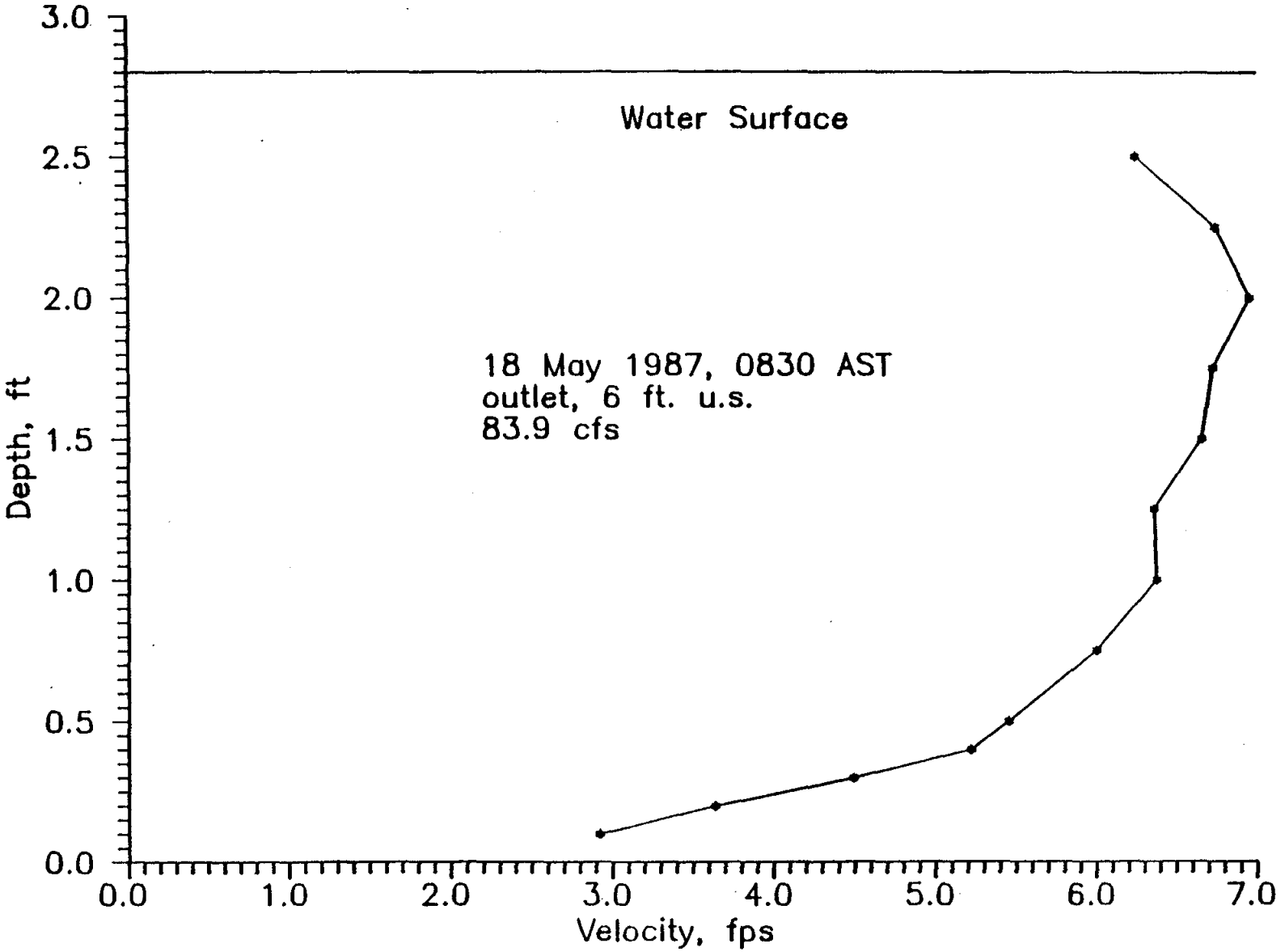

Figure B10: Plot of velocity profiles, 6 ft. upstream of outlet, May 18, 1987.

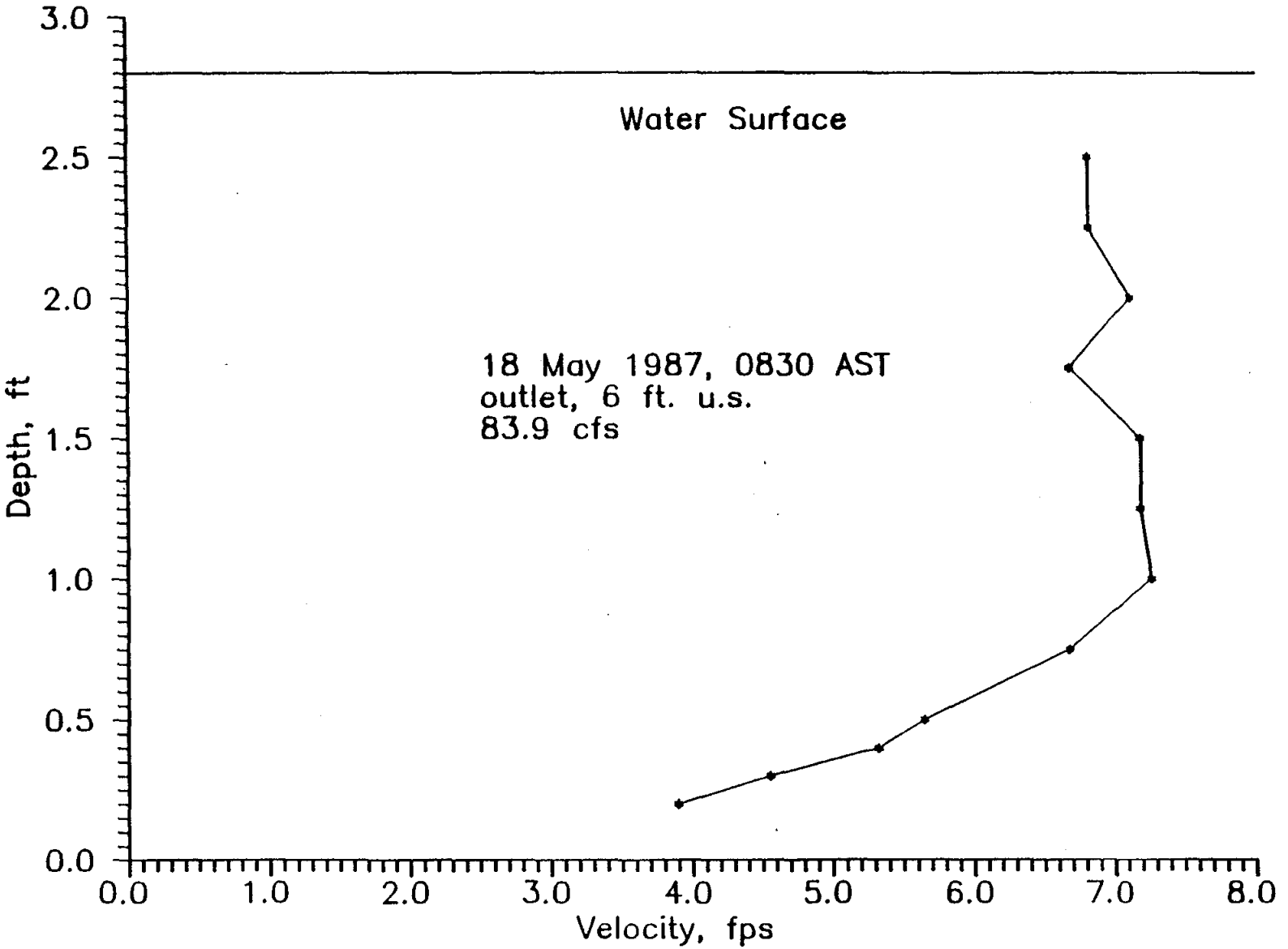

Figure B11: Plot of velocity profiles, 6 ft. upstream of outlet, May 18, 1987.

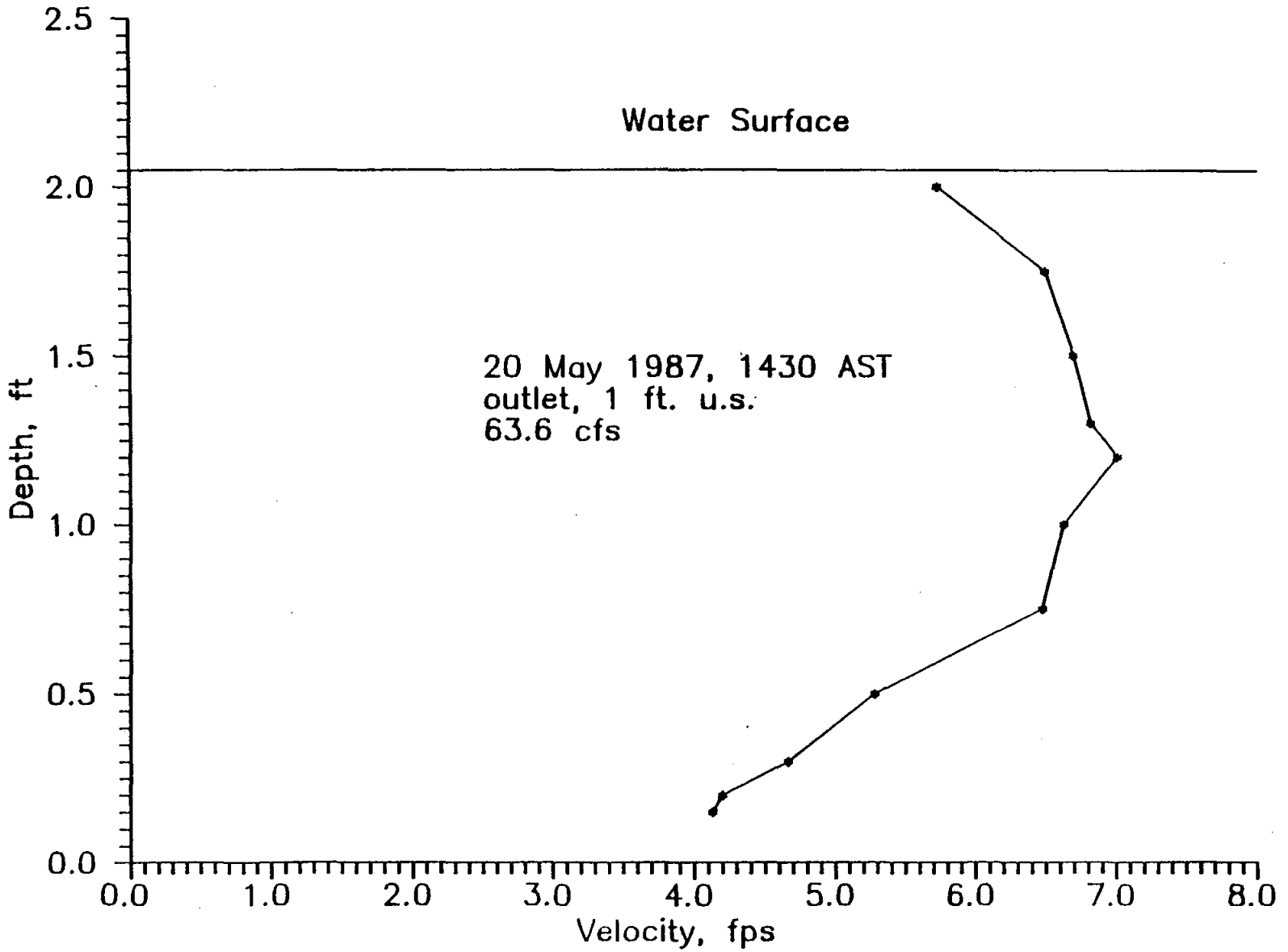

Figure B12: Plot of velocity profiles, 1 ft. upstream of outlet, May 20, 1987.

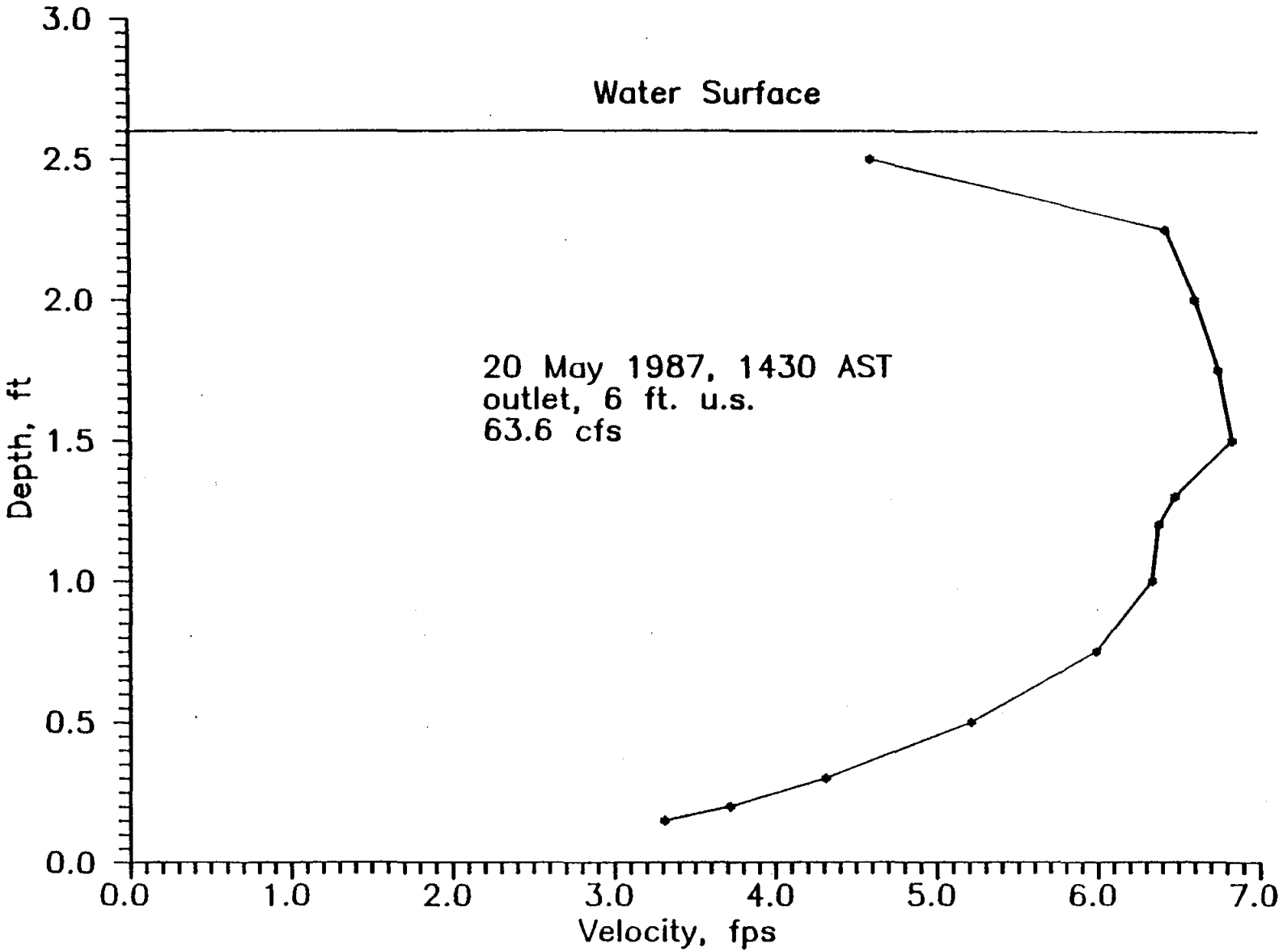

Figure B13: Plot of velocity profiles, 6 ft. upstream of outlet, May 20, 1987.

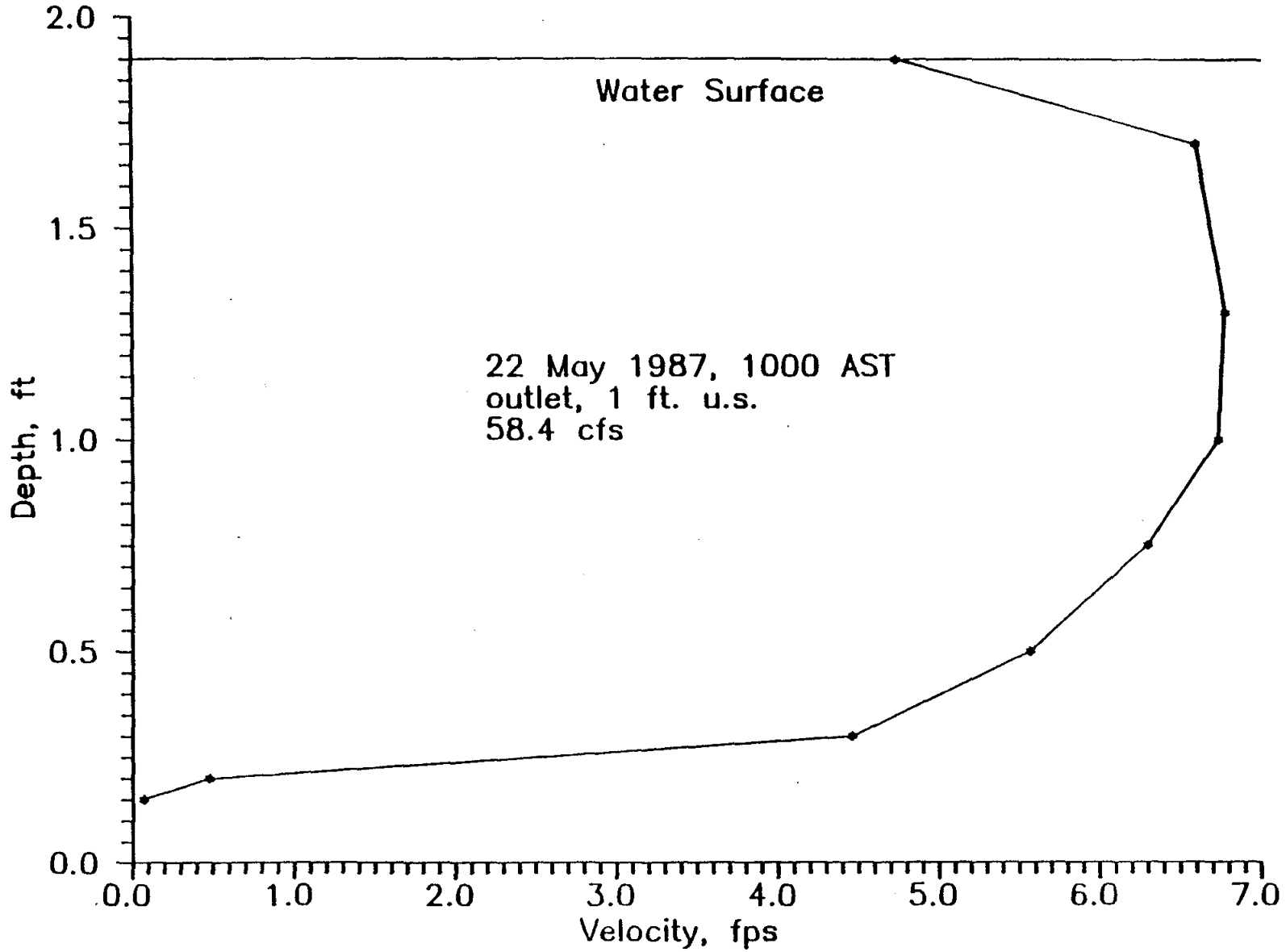

Figure B14: Plot of velocity profiles, 1 ft. upstream of outlet, May 22, 1987.

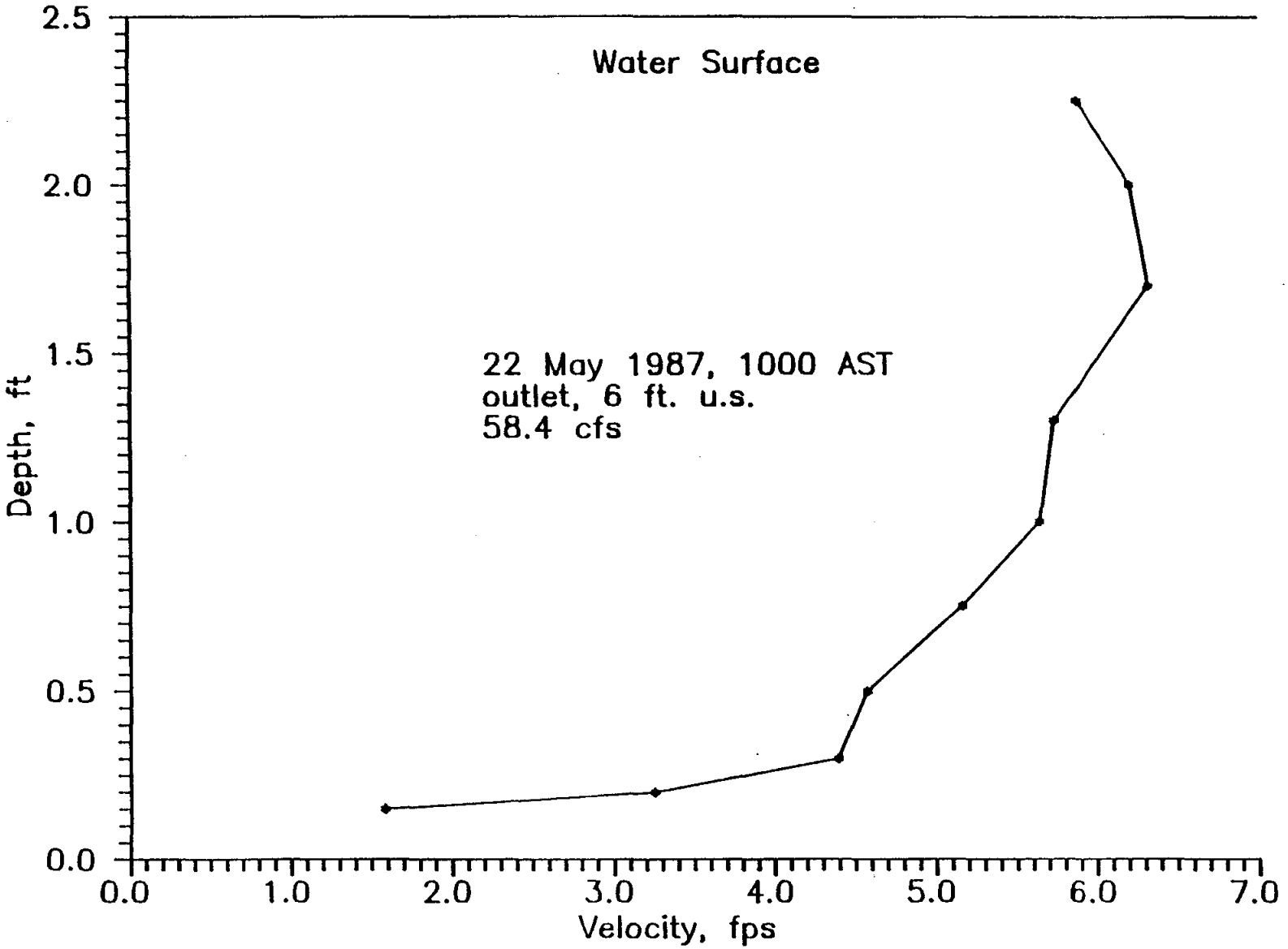

Figure B15: Plot of velocity profiles, 6 ft. upstream of outlet, May 22, 1987.

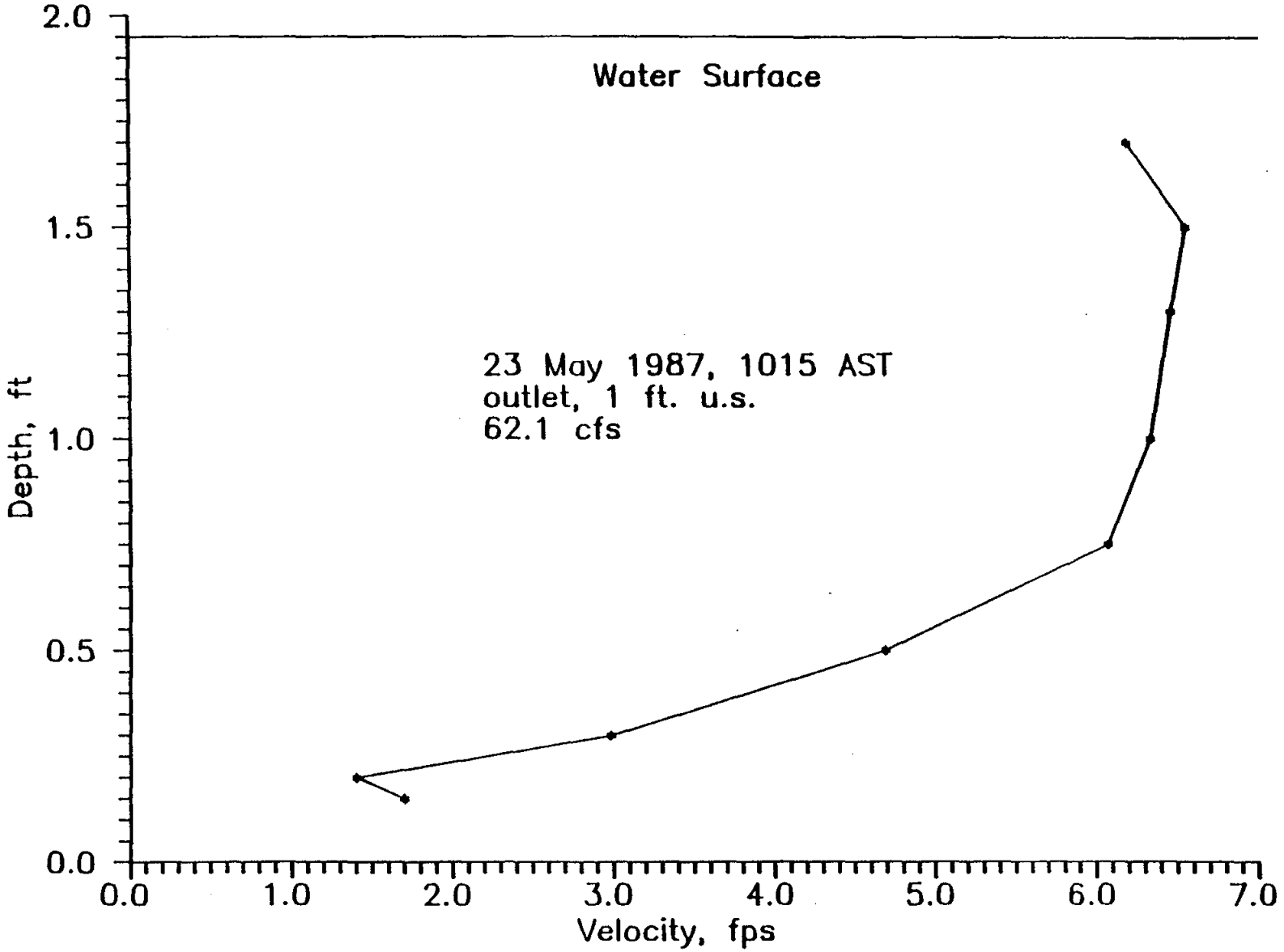

Figure B16: Plot of velocity profiles, 1 ft. upstream of outlet, May 23, 1987.

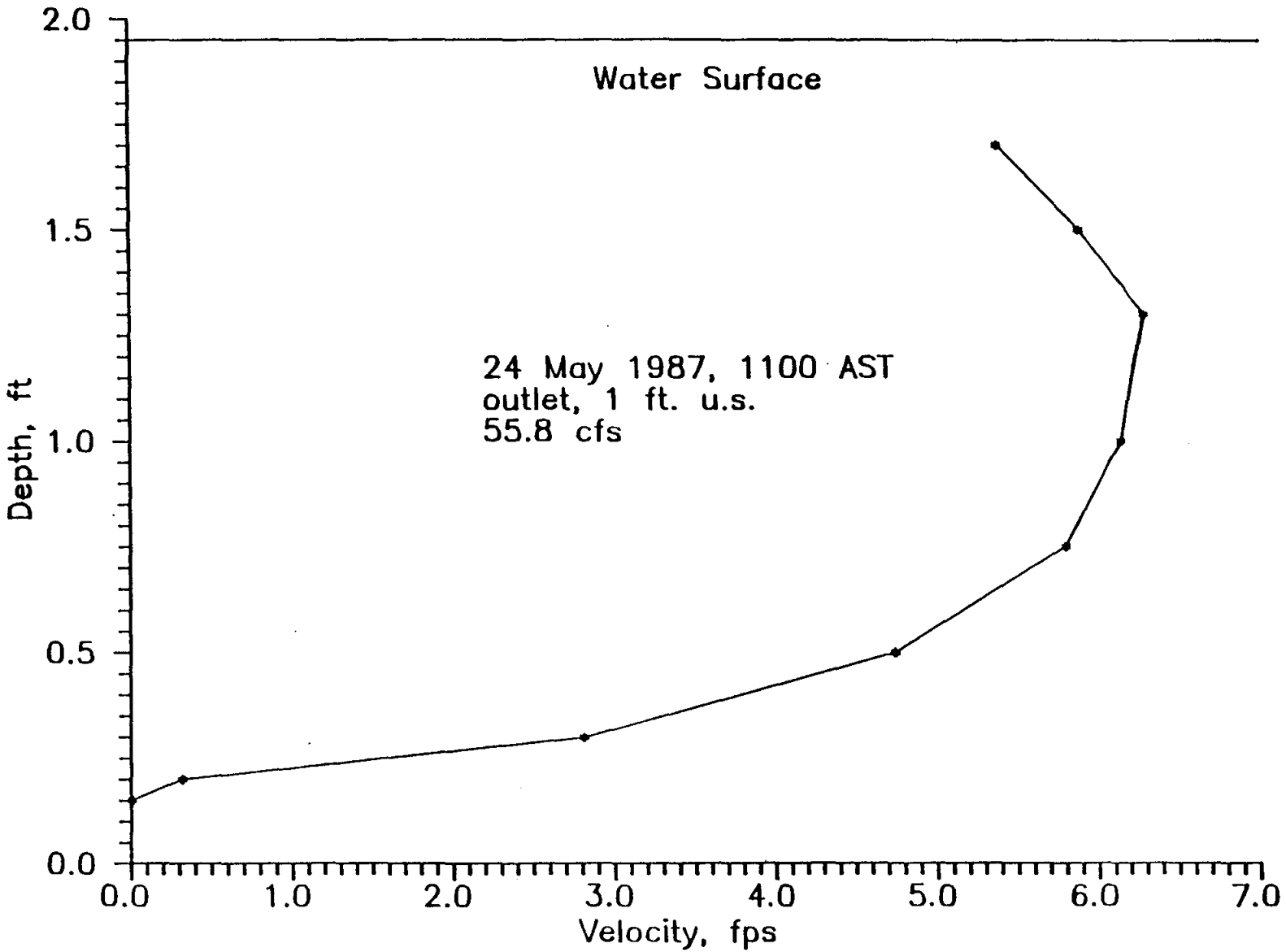

Figure B17: Plot of velocity profiles, 1 ft. upstream of outlet, May 24, 1987.

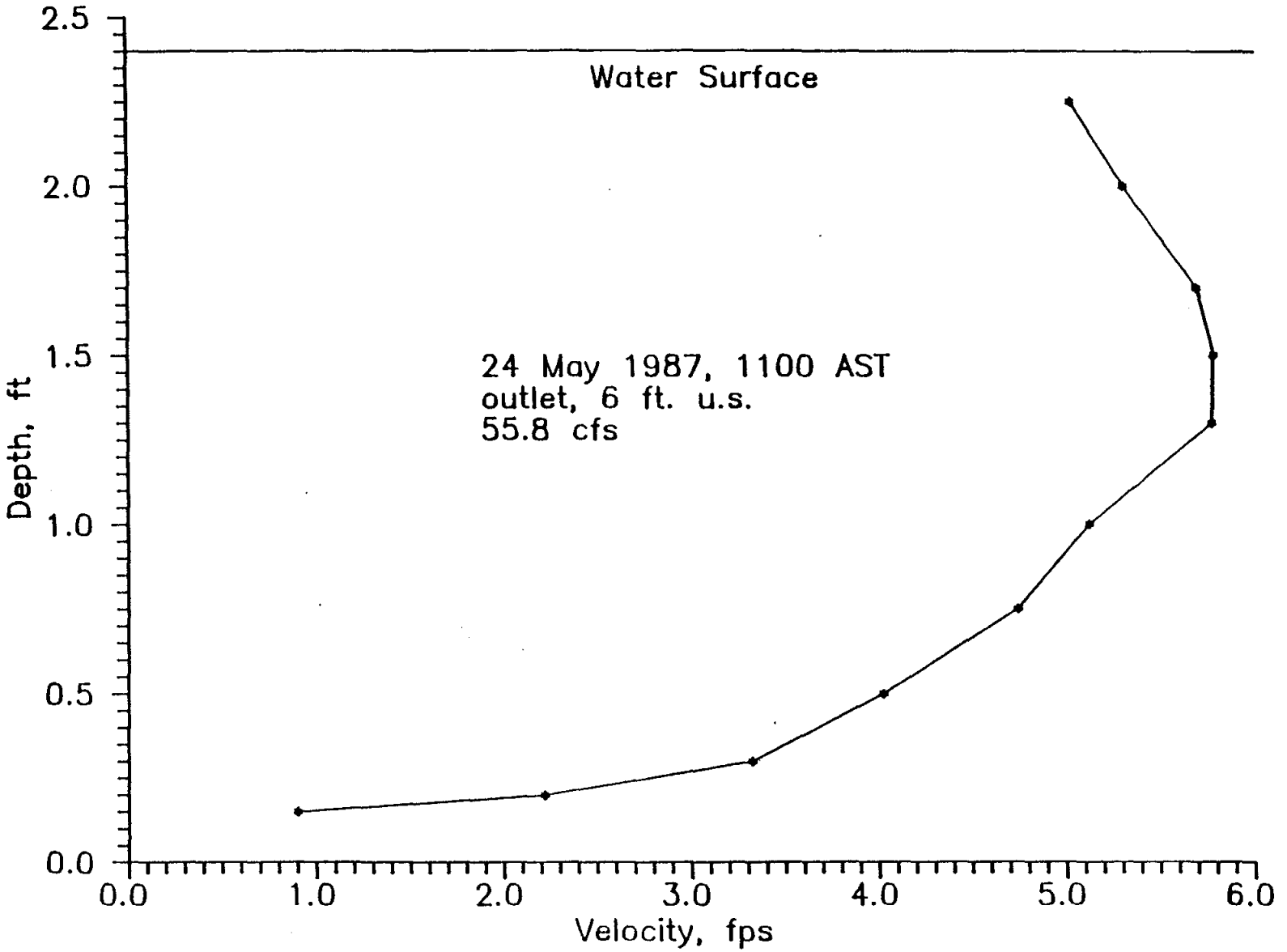

Figure B18: Plot of velocity profiles, 6 ft. upstream of outlet, May 24, 1987.

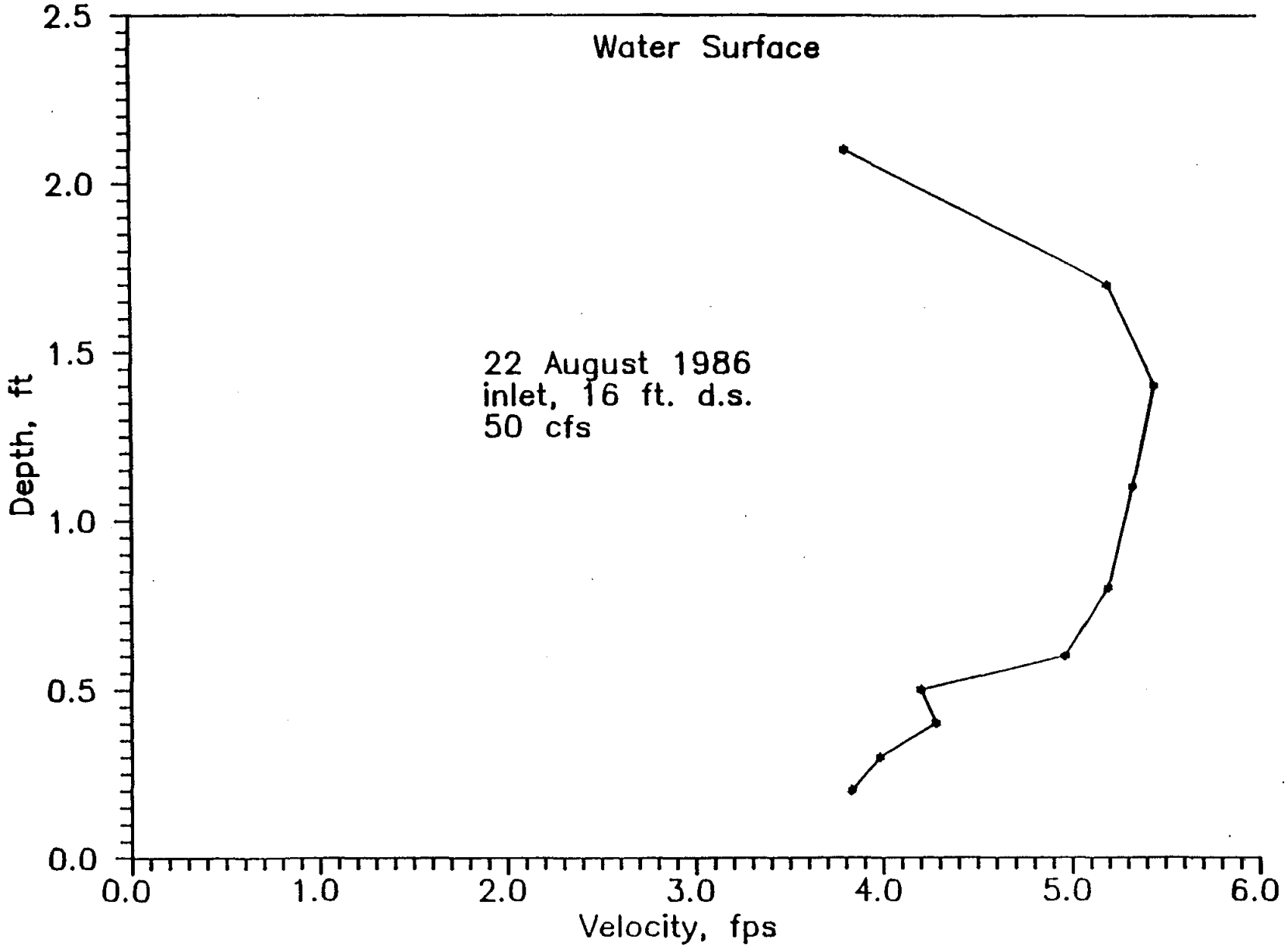

Figure B19: Plot of velocity profiles, 16 ft. downstream of inlet, August 22, 1986.

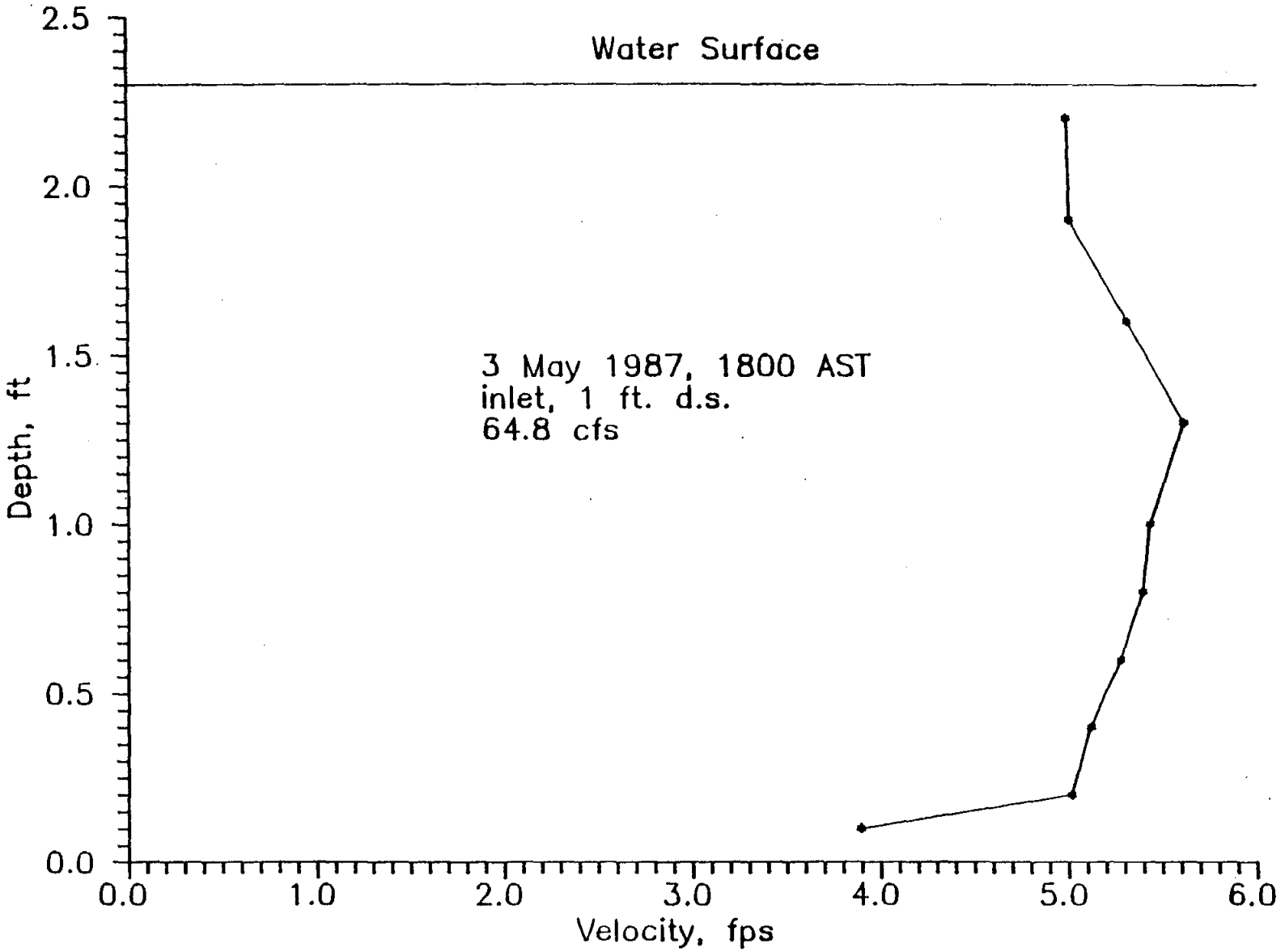

Figure B20: Plot of velocity profiles, 1 ft. downstream of inlet, May 3, 1987.

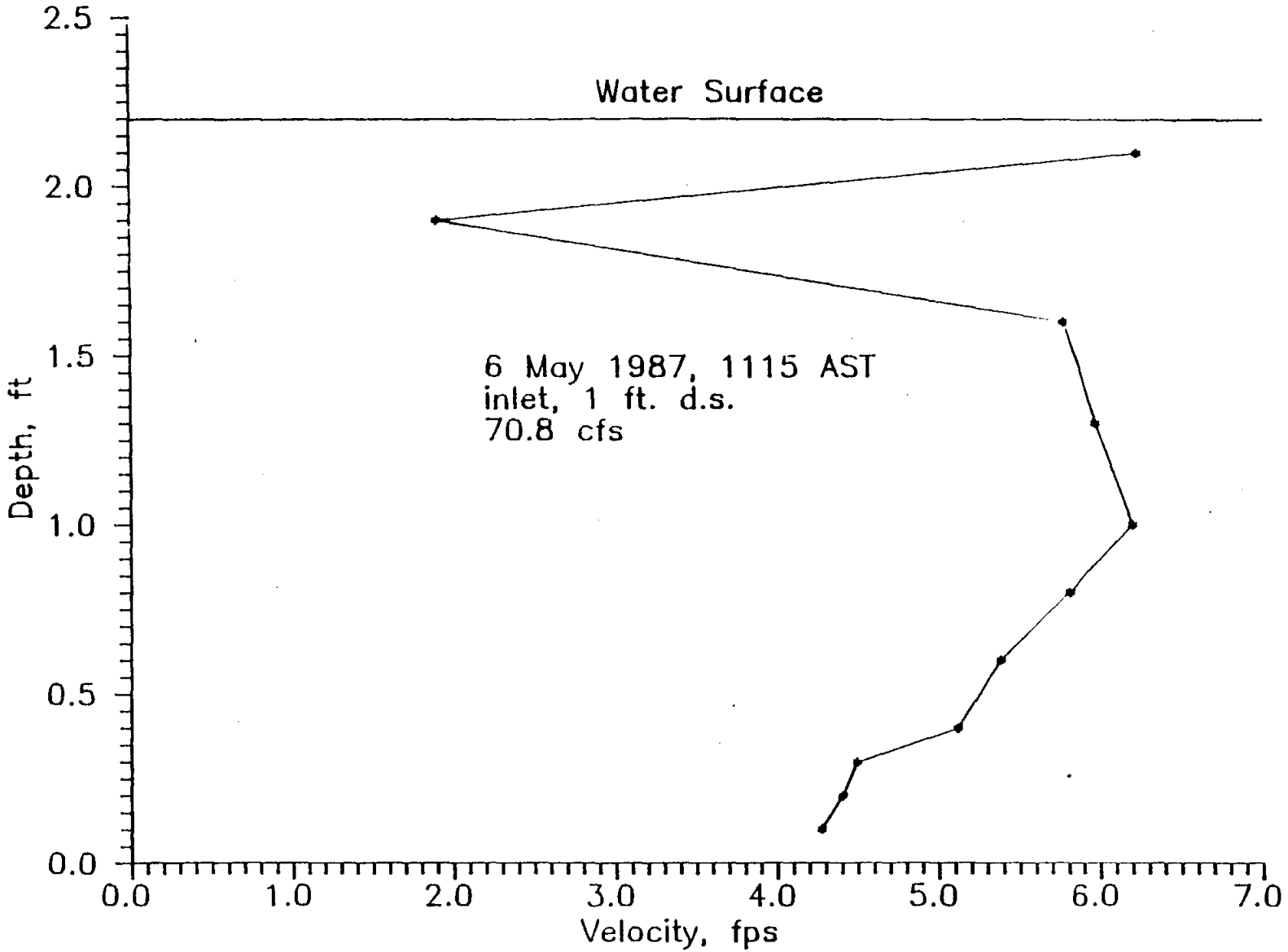

Figure B21: Plot of velocity profiles, 1 ft. downstream of inlet, May 6, 1987.

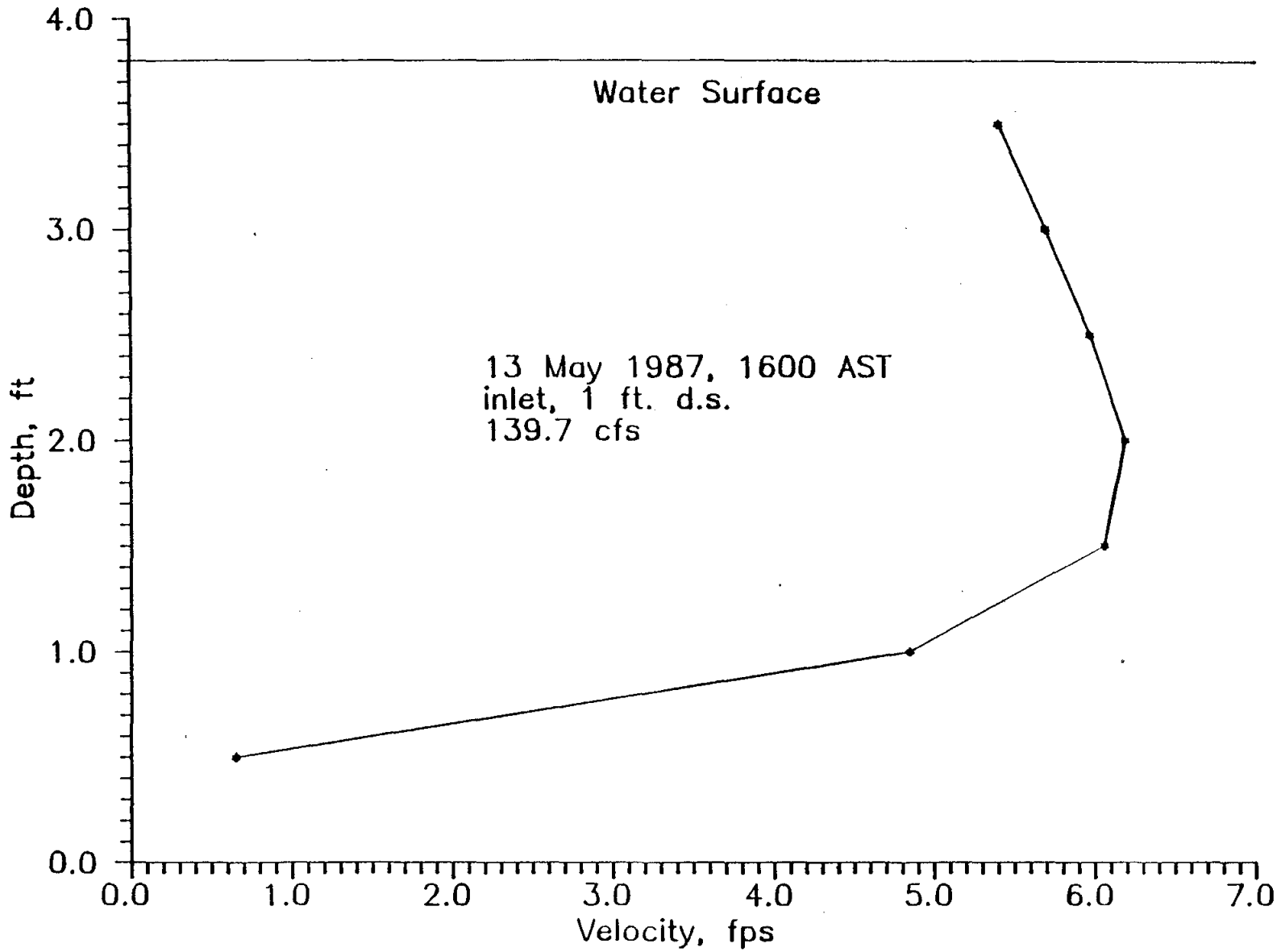

Figure B22: Plot of velocity profiles, 1 ft. downstream of inlet, May 13, 1987.

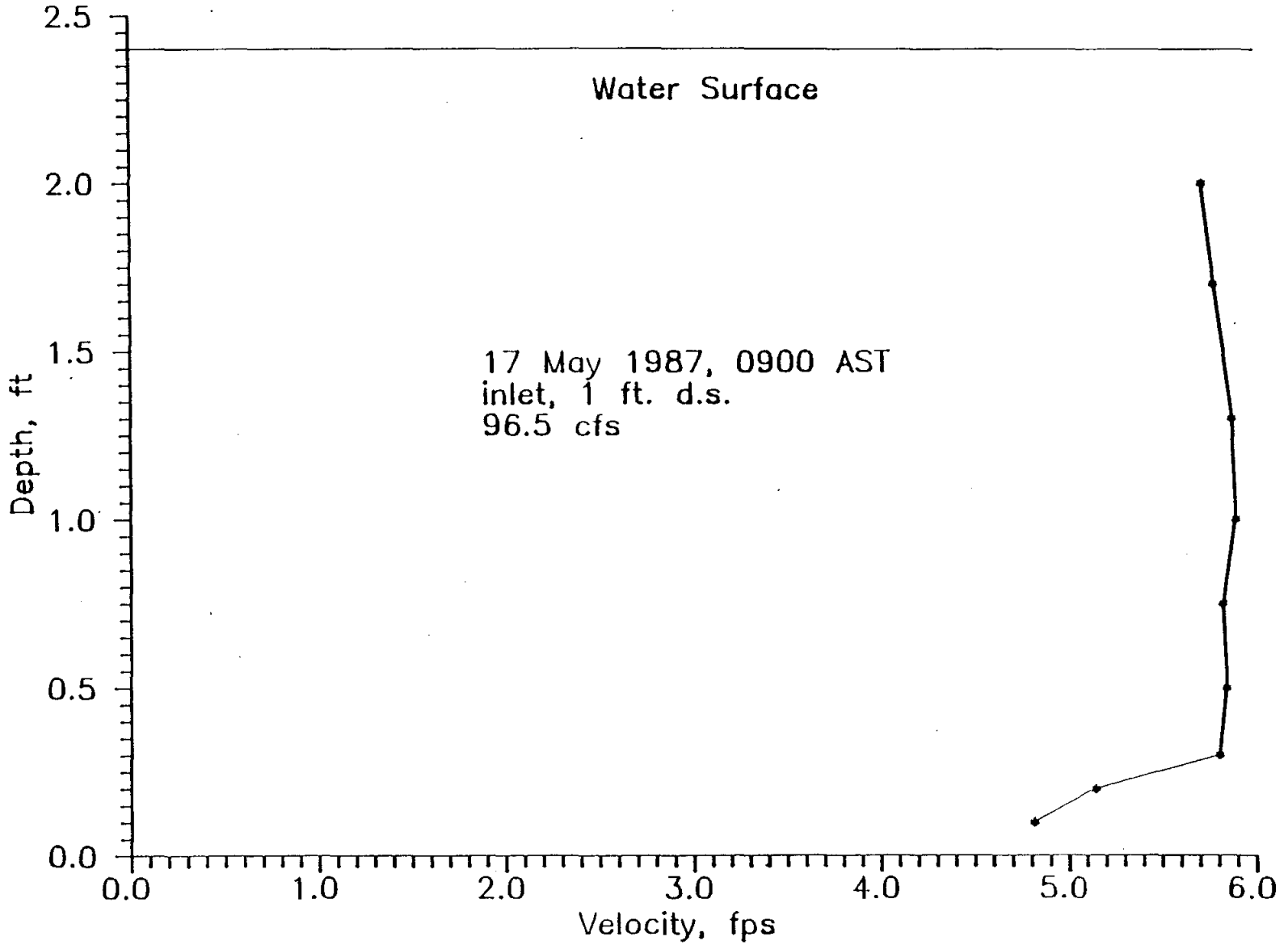

Figure B23: Plot of velocity profiles, 1 ft. downstream of inlet, May 17, 1987.

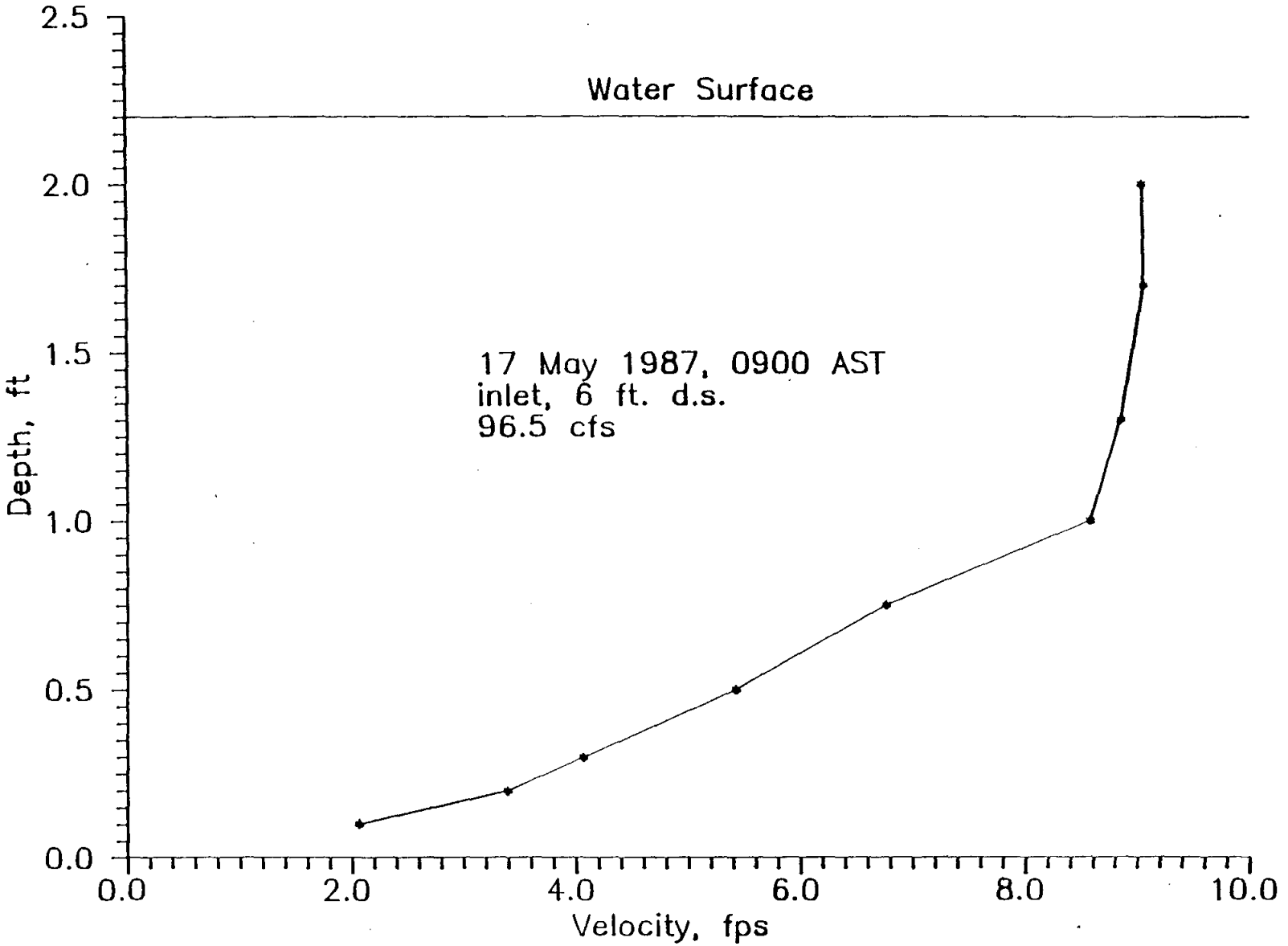

Figure B24: Plot of velocity profiles, 6 ft. downstream of inlet, May 17, 1987.

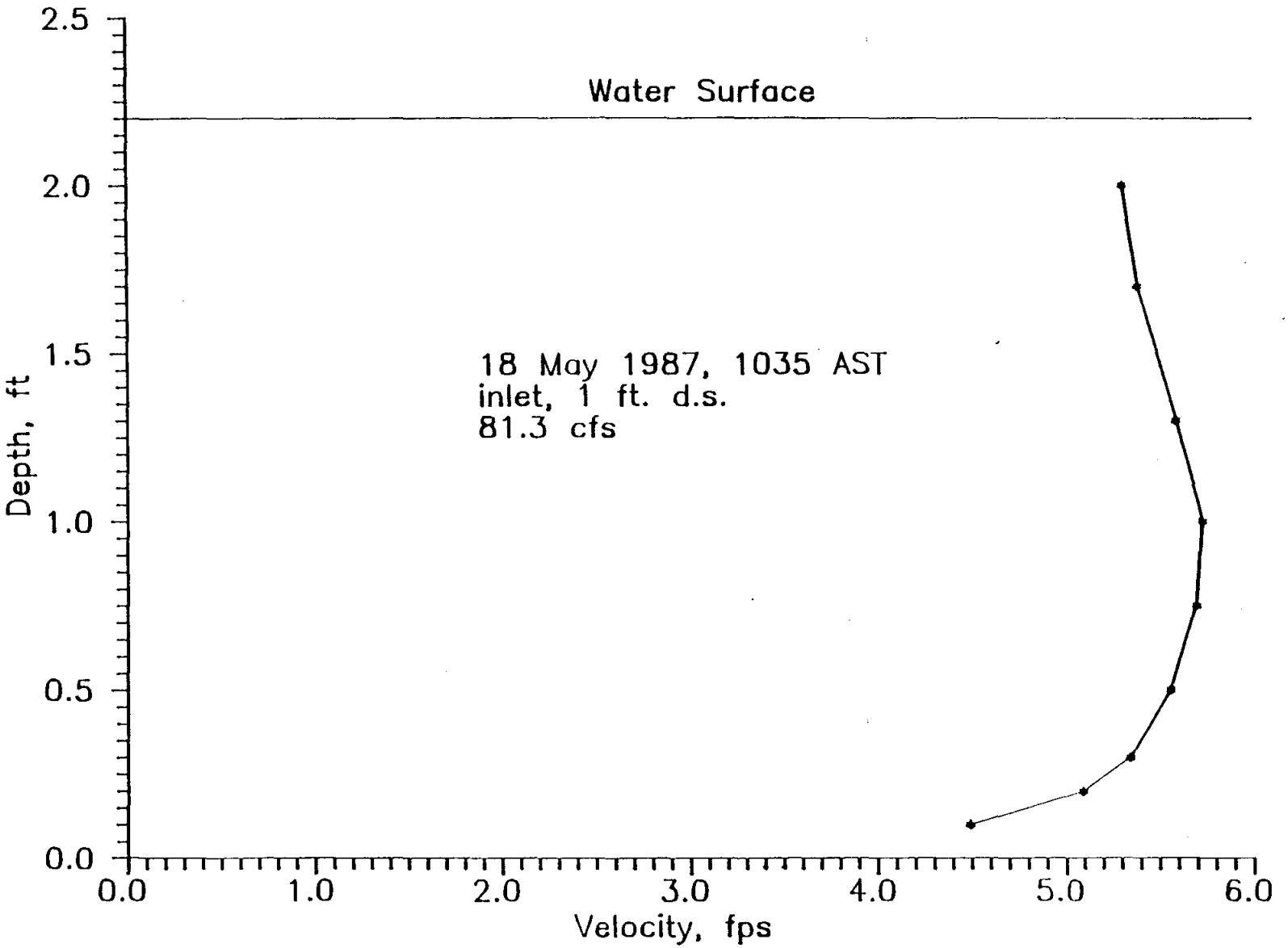

Figure B25: Plot of velocity profiles, 1 ft. downstream of inlet, May 18, 1987.

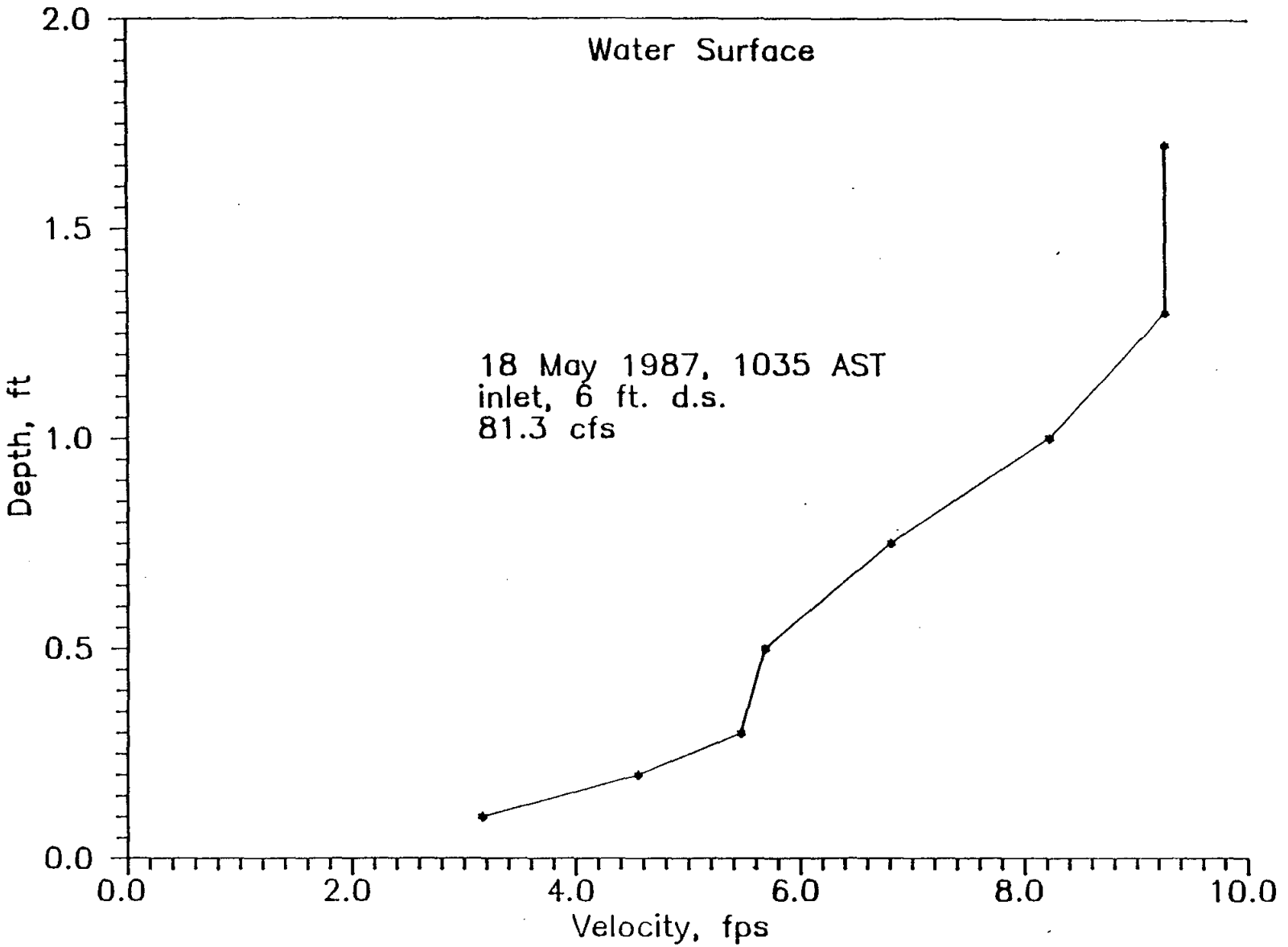

Figure B26: Plot of velocity profiles, 6 ft. downstream of inlet, May 18, 1987.

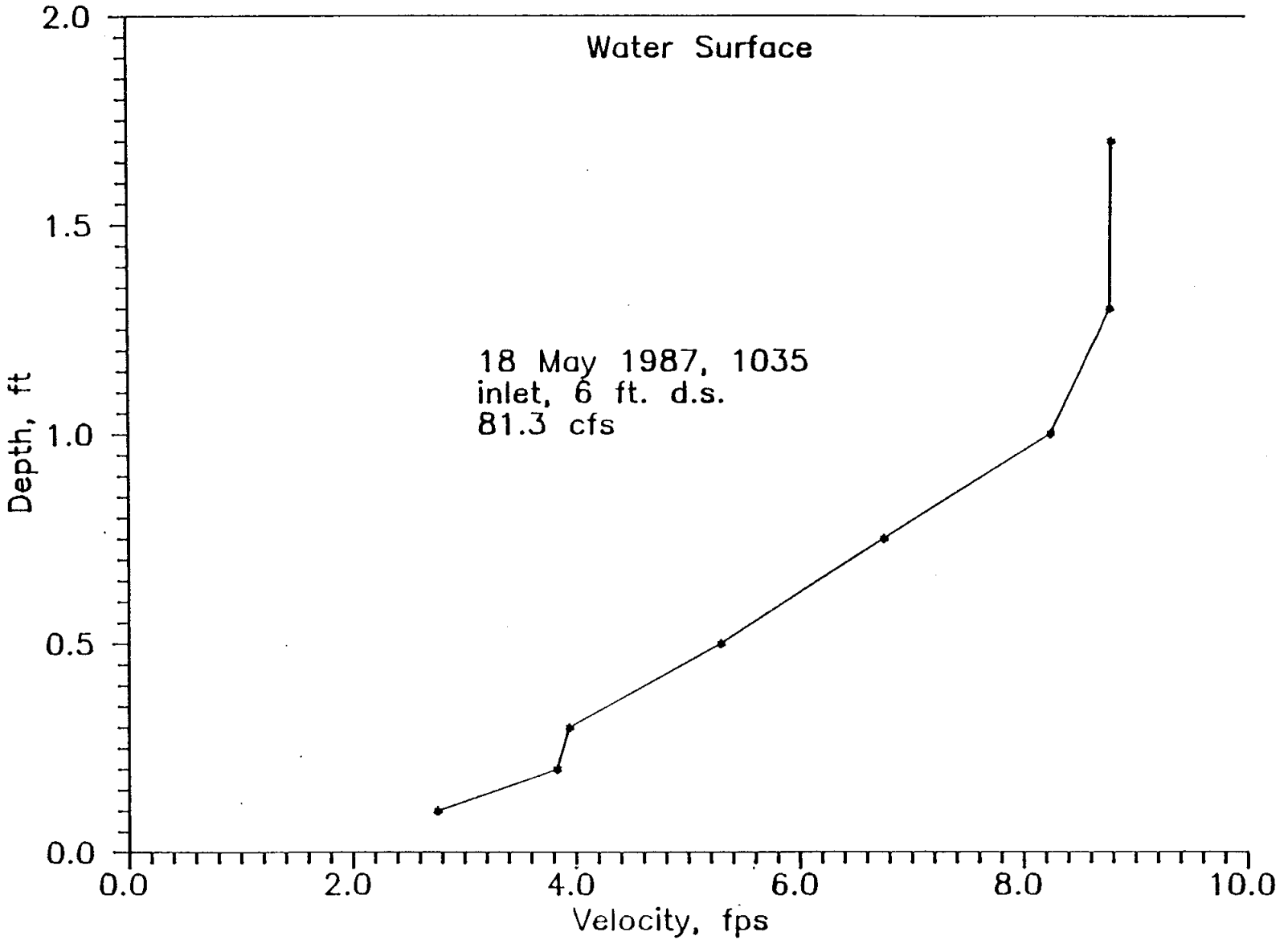

Figure B27: Plot of velocity profiles, 6 ft. downstream of inlet, May 18, 1987.

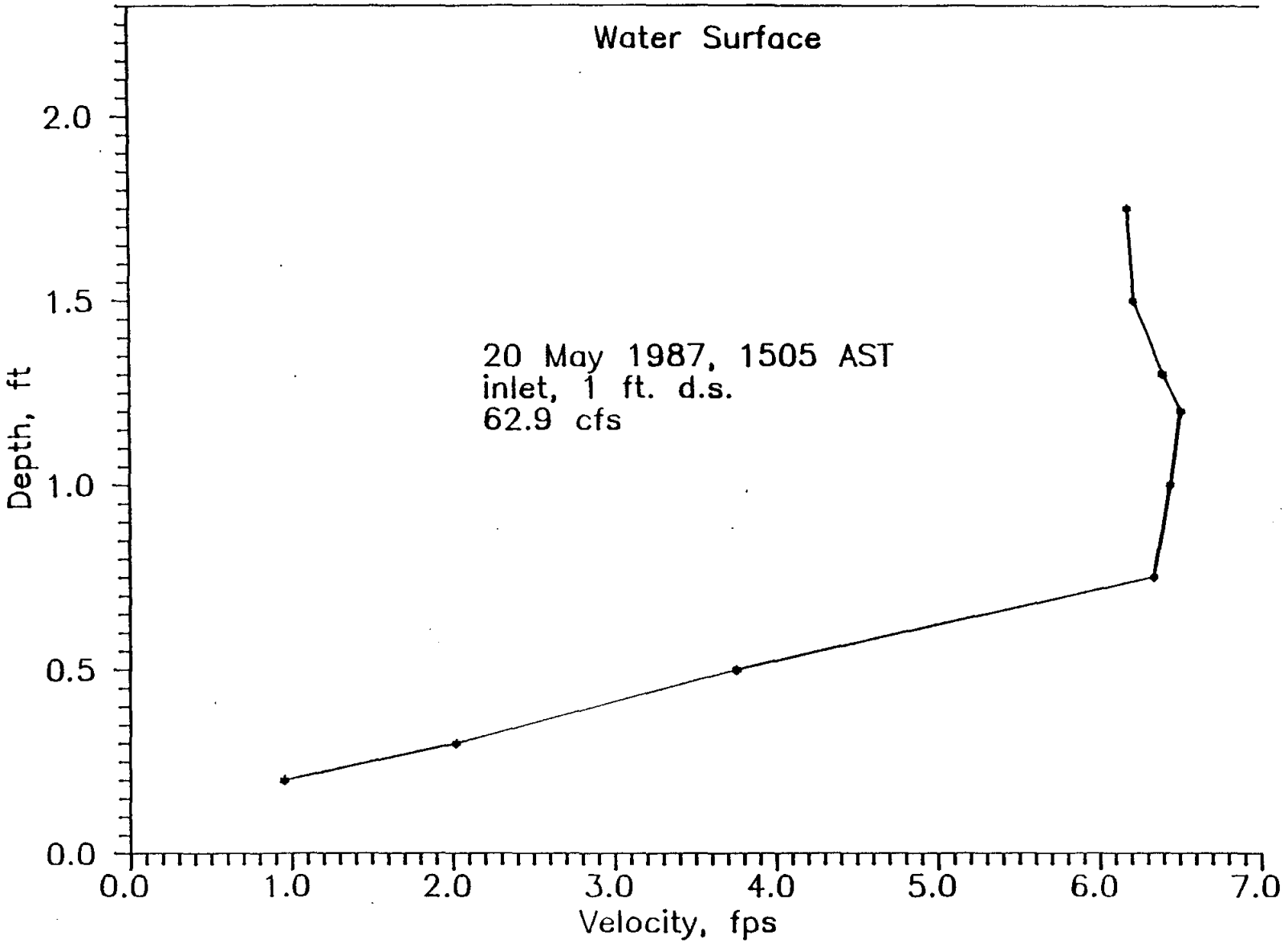

Figure B28: Plot of velocity profiles, 1 ft. downstream of inlet, May 20, 1987.

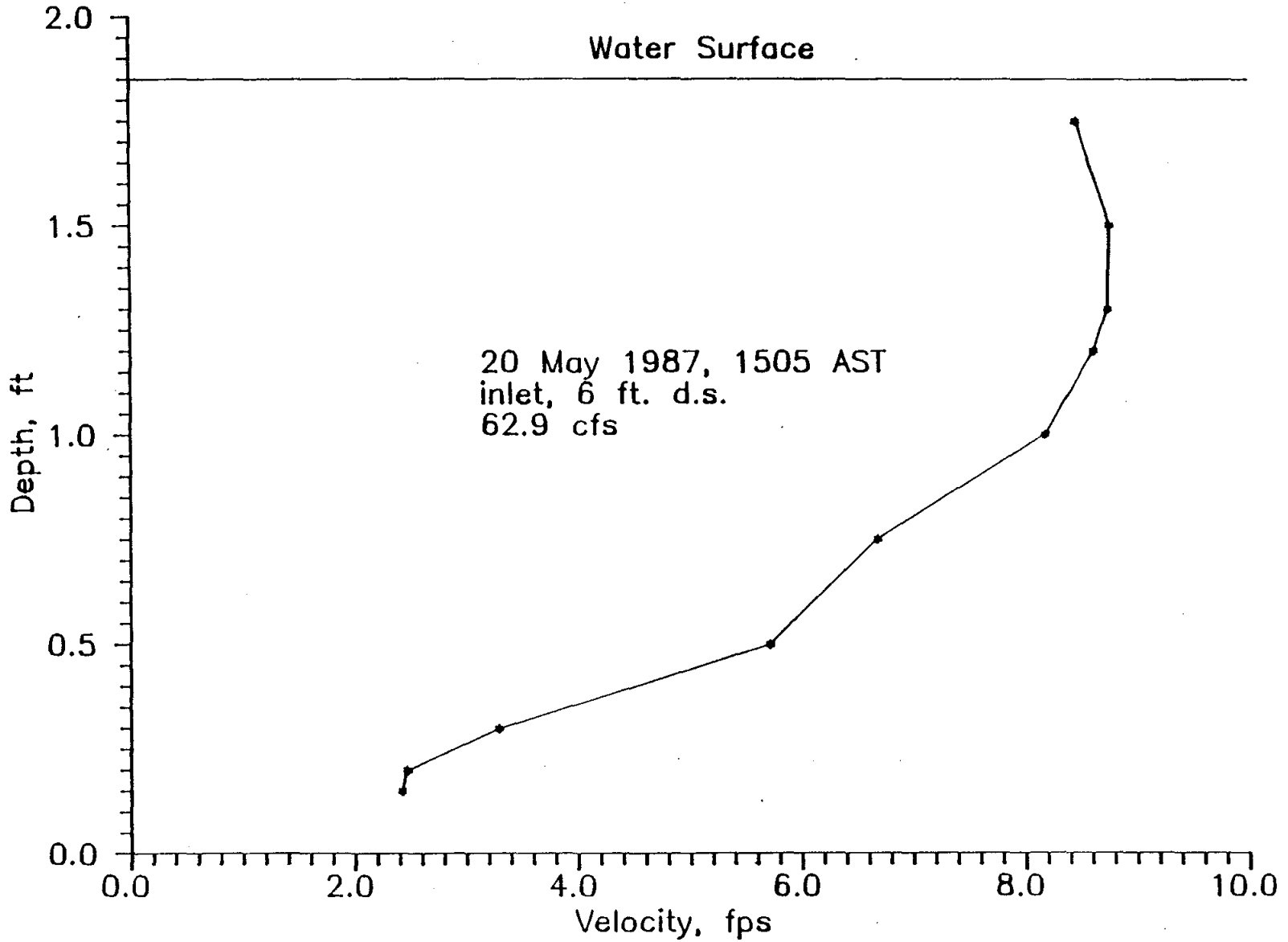

Figure B29: Plot of velocity profiles, 6 ft. downstream of inlet, May 20, 1987.

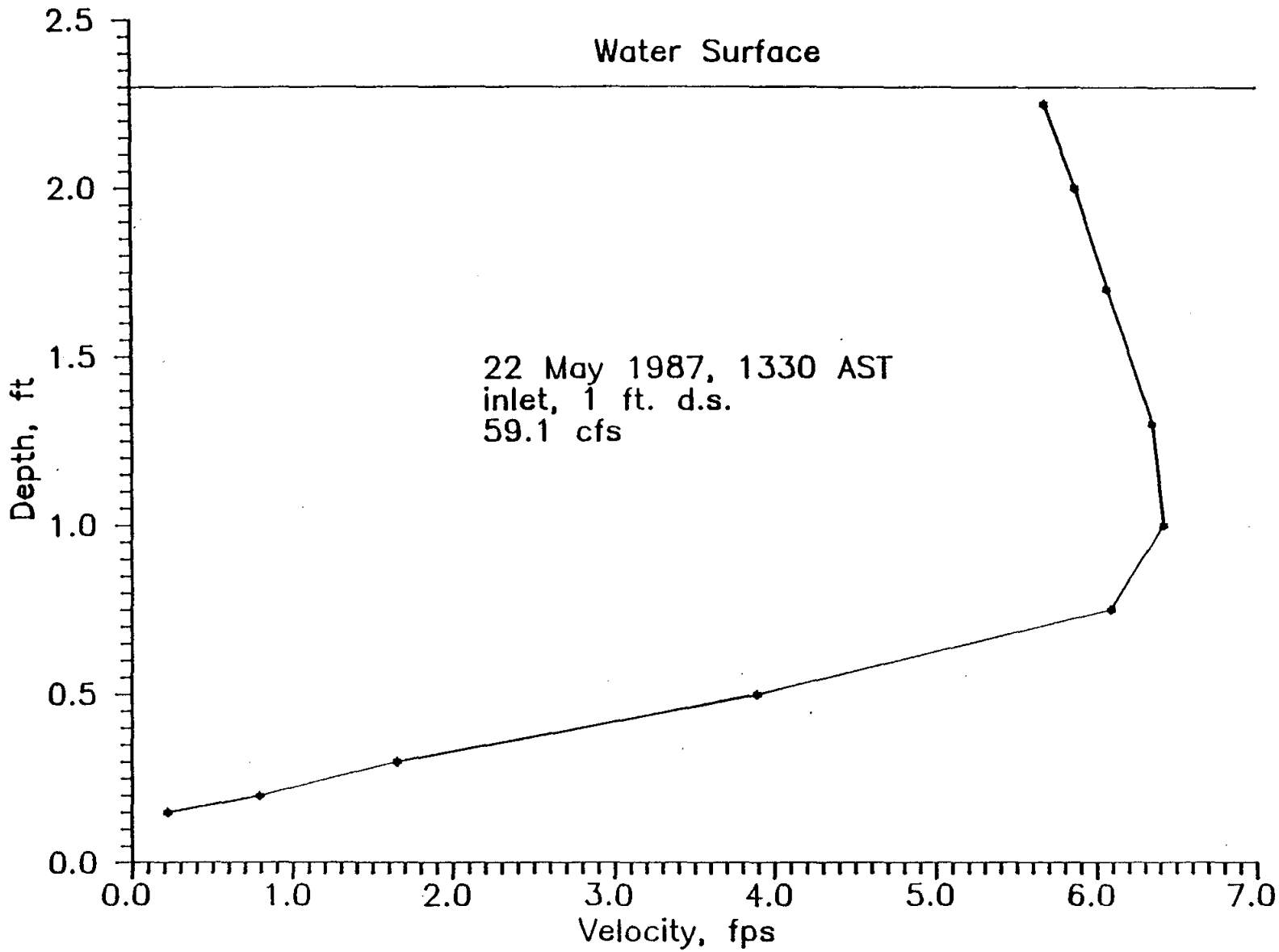

Figure B30: Plot of velocity profiles, 1 ft. downstream of inlet, May 22, 1987.

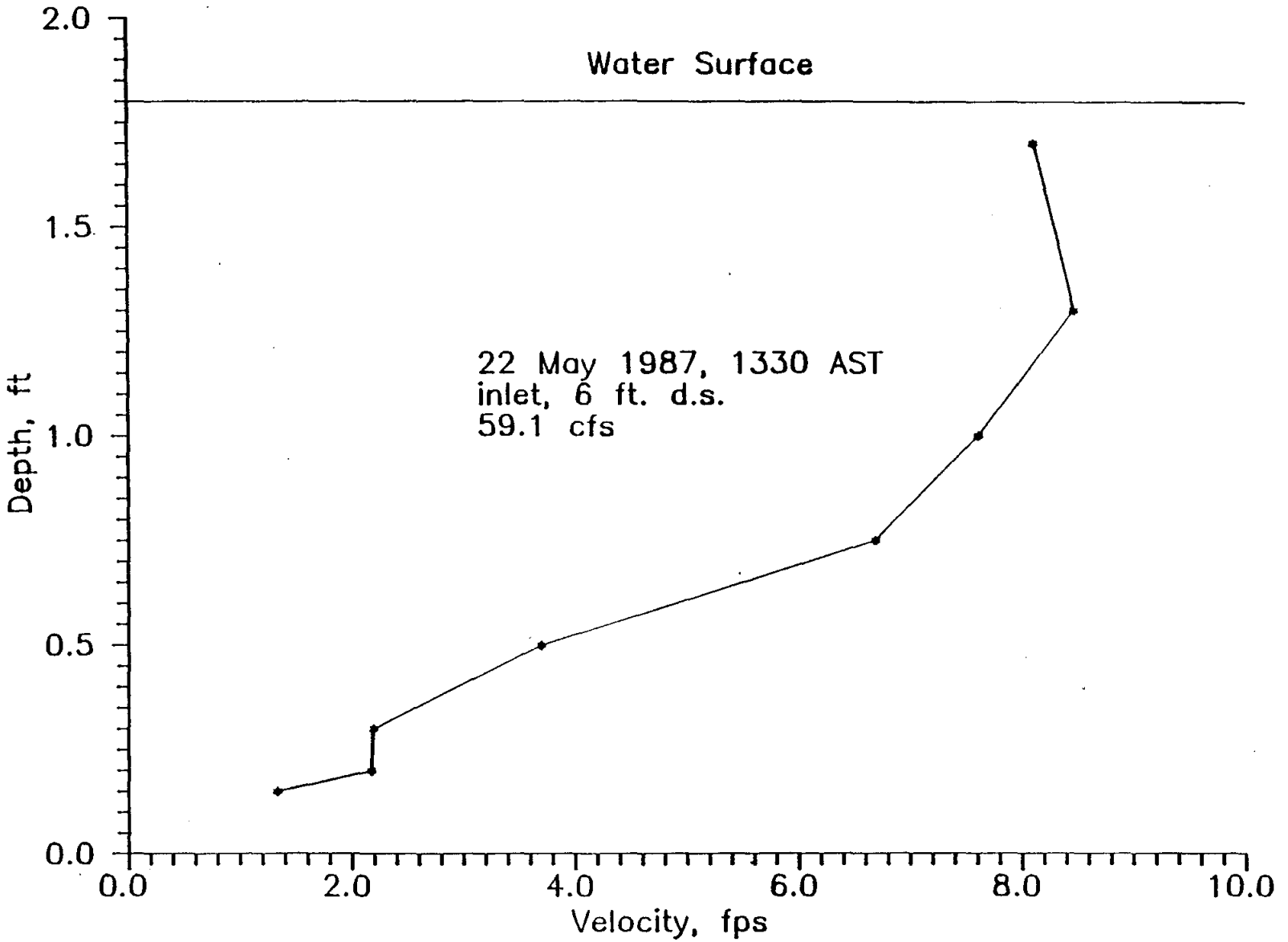

Figure B31: Plot of velocity profiles, 6 ft. downstream of inlet, May 22, 1987.

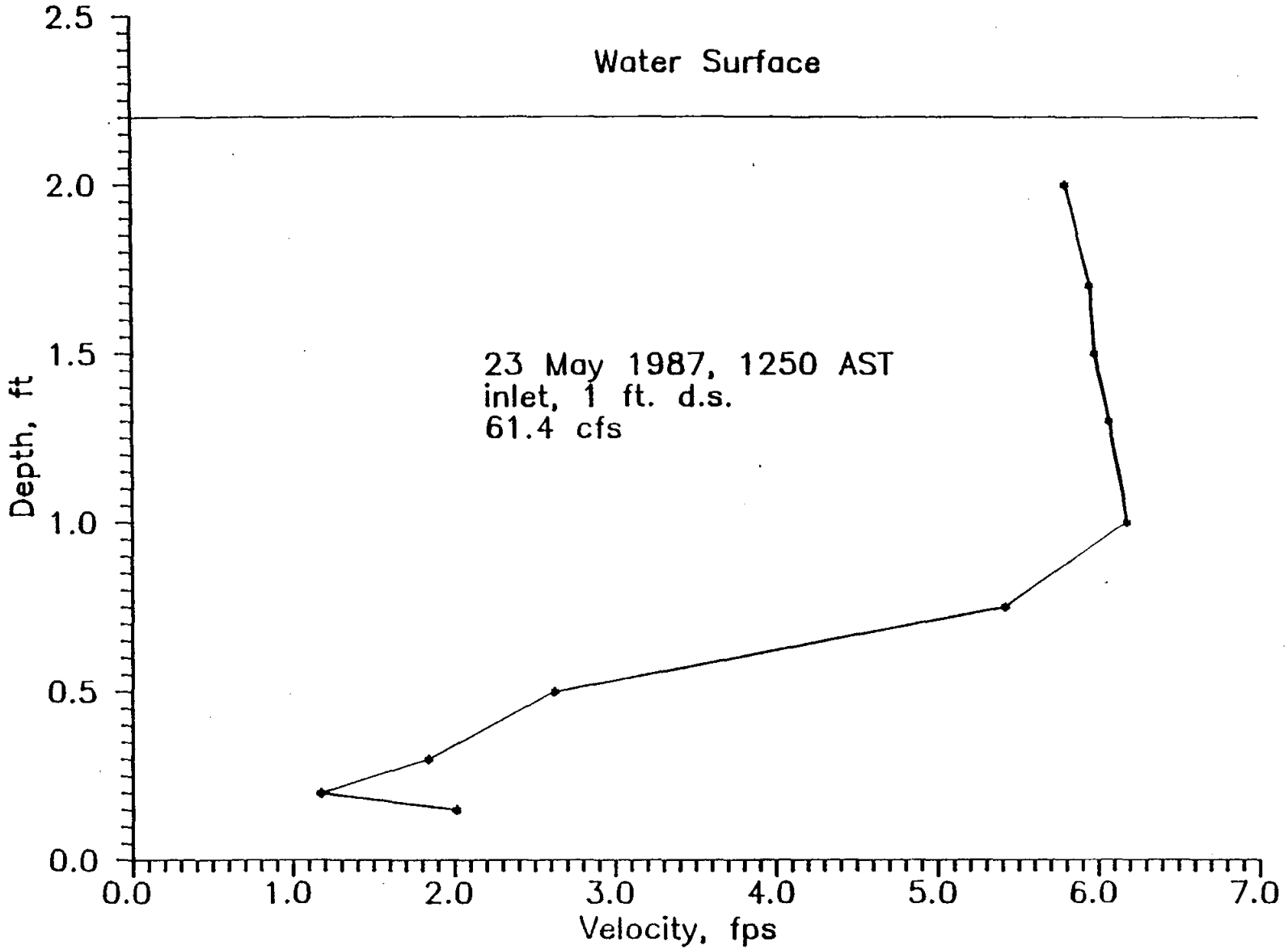

Figure B32: **Plot of velocity profiles, 1 ft. downstream of inlet, May 23, 1987.**

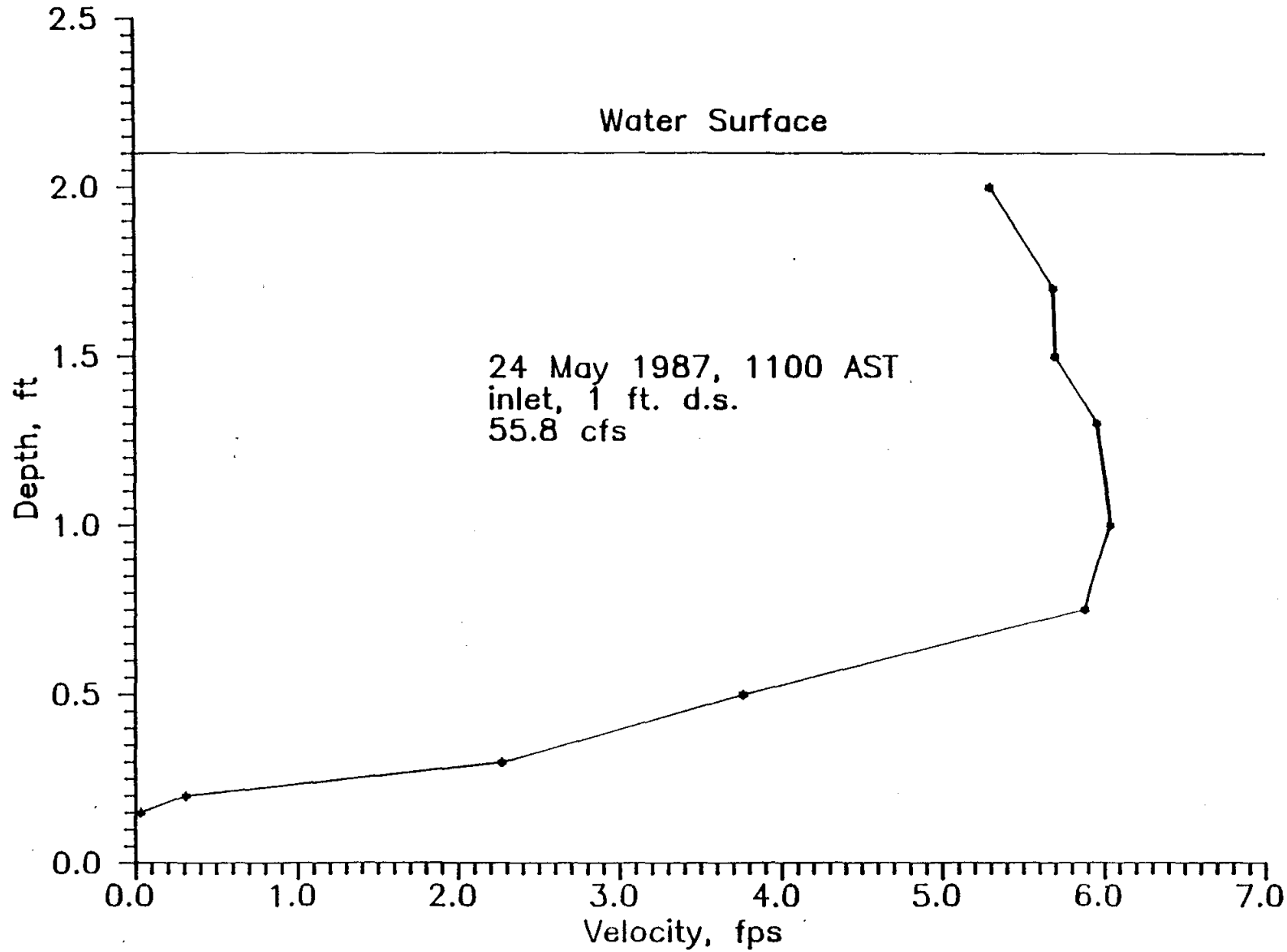

Figure B33: Plot of velocity profiles, 1 ft. downstream of inlet, May 24, 1987.

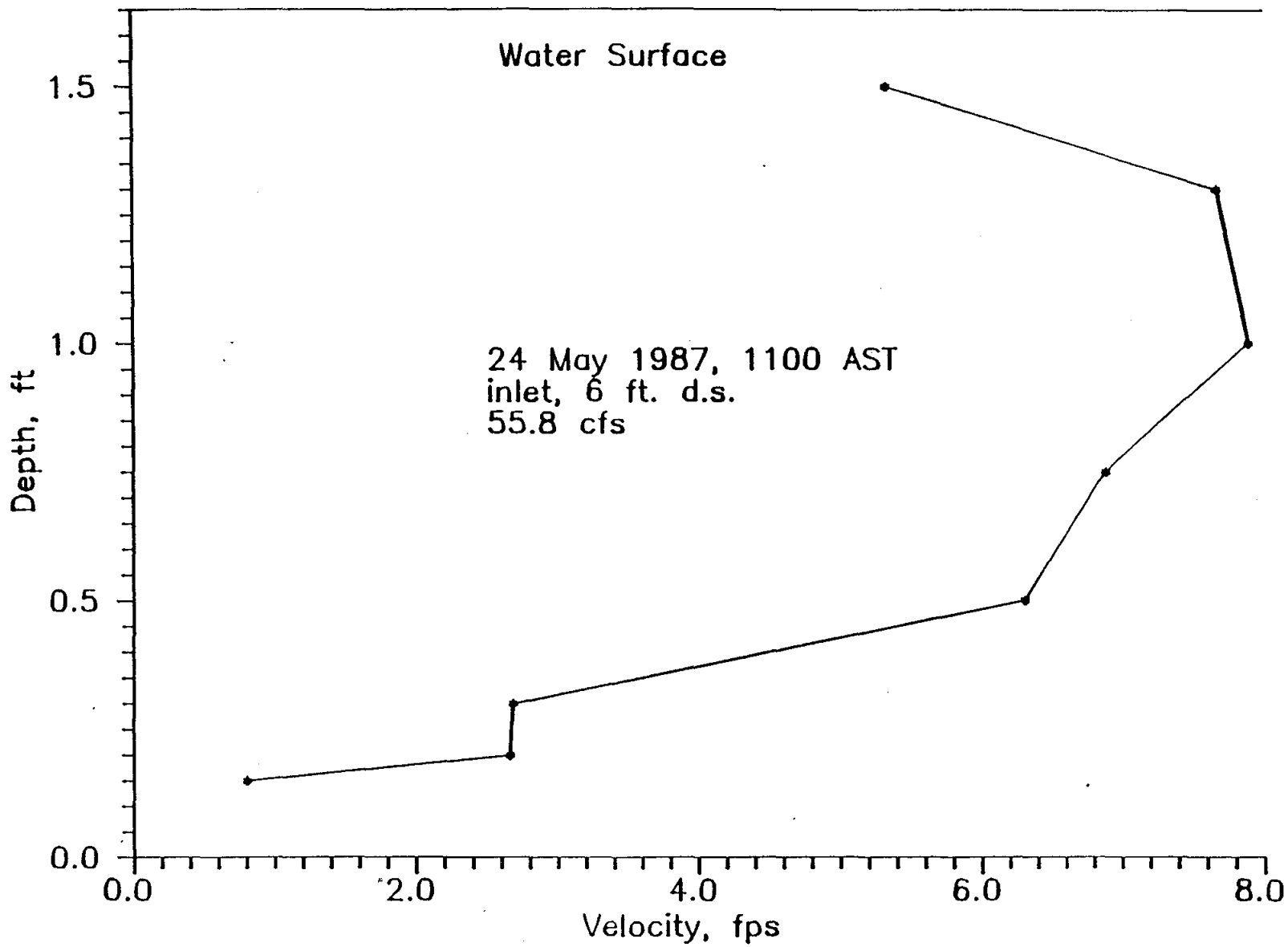

Figure B34: Plot of velocity profiles, 6 ft. downstream of inlet, May 24, 1987.

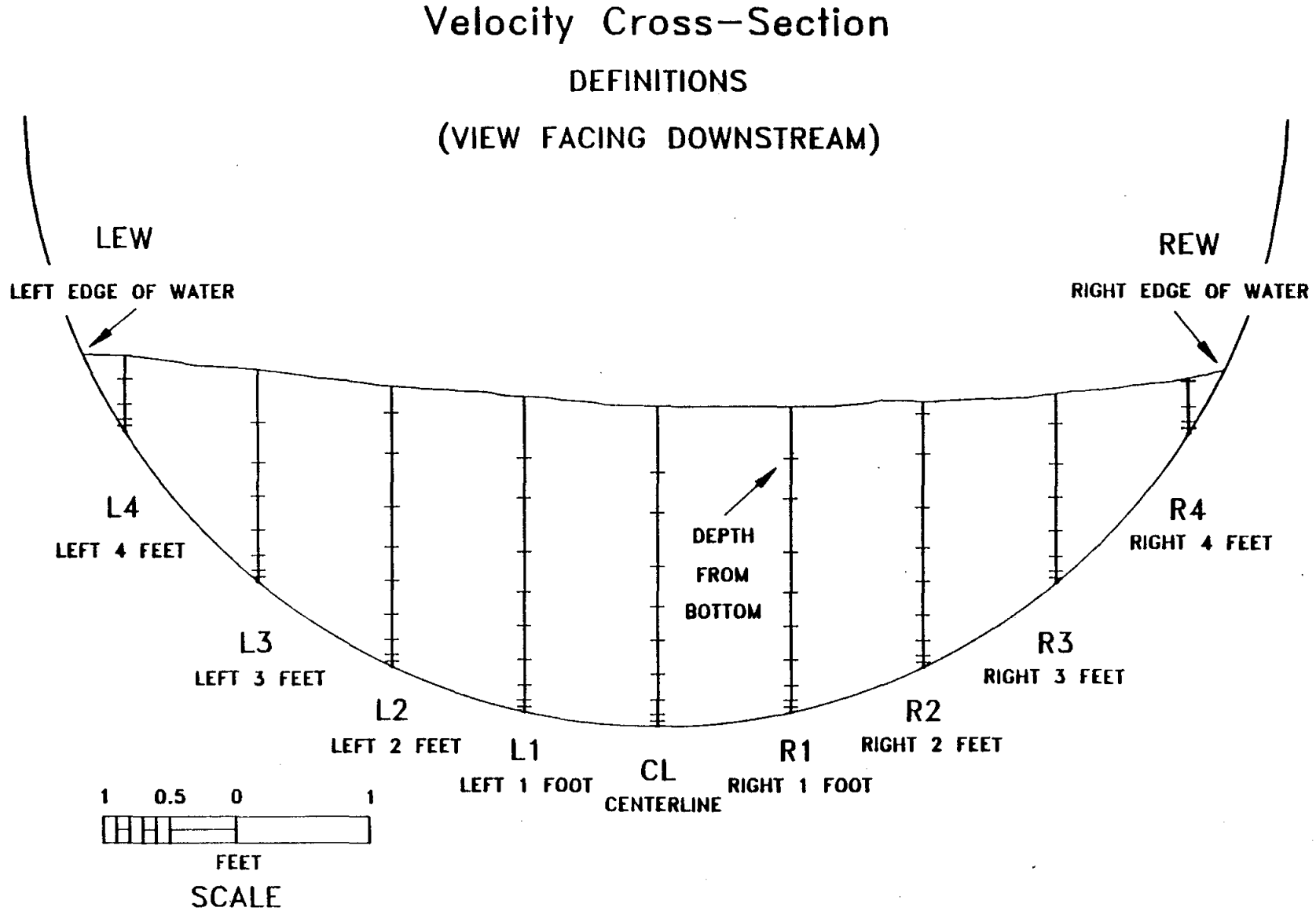

Figure B35. Description of culvert terminology.

APPENDIX C

FISH DATA

Table C1. Arctic grayling length frequency distributions for successful upstream migrants through the lower Fish Creek Culvert, May 14, 1987. *

Length Range (mm)	Number	Percent of Total
100-119	0	0.0%
120-139	0	0.0%
140-159	0	0.0%
160-179	0	0.0%
180-199	0	0.0%
200-219	1	0.4%
220-239	7	3.0%
240-259	46	19.8%
260-279	66	28.4%
280-299	72	31.0%
300-319	21	9.1%
320-339	11	4.7%
340-359	5	2.2%
360-379	2	0.9%
380-399	1	0.4%
Totals	232	100.0%

Average Length (mm) = 279.7
Std. Deviation = 26.54

* See footnote on table 4.

Table C1. Continued. May 15, 1987. *

Length Range (mm)	Number	Percent of Total
100-119	0	0.0%
120-139	1	0.8%
140-159	0	0.0%
160-179	0	0.0%
180-199	0	0.0%
200-219	4	3.2%
220-239	13	10.5%
240-259	21	16.9%
260-279	38	30.6%
280-299	24	19.4%
300-319	12	9.7%
320-339	10	8.1%
340-359	1	0.8%
360-379	0	0.0%
380-399	0	0.0%
Totals	124	100.0%

Average Length (mm) = 272.0
Std. Deviation = 33.06

* See footnote on table 4.

Table C1. Continued. May 16, 1987. *

Length Range (mm)	Number	Percent of Total
100-119	0	0.0%
120-139	0	0.0%
140-159	0	0.0%
160-179	0	0.0%
180-199	0	0.0%
200-219	8	11.8%
220-239	14	20.6%
240-259	29	42.6%
260-279	10	14.7%
280-299	4	5.9%
300-319	2	2.9%
320-339	1	1.5%
340-359	0	0.0%
360-379	0	0.0%
380-399	0	0.0%
Totals	68	100.0%

Average Length (mm) = 249.4
Std. Deviation = 23.8

* See footnote on table 4.

Table C1. Continued. May 17, 1987. *

Length Range (mm)	Number	Percent of Total
100-119	0	0.0%
120-139	0	0.0%
140-159	0	0.0%
160-179	1	1.3%
180-199	5	6.3%
200-219	9	11.3%
220-239	13	16.3%
240-259	14	17.5%
260-279	13	16.3%
280-299	16	20.0%
300-319	6	7.5%
320-339	1	1.3%
340-359	2	2.5%
360-379	0	0.0%
380-399	0	0.0%
Totals	80	100.0%

Average Length (mm) = 255.0
Std. Deviation = 37.6

* See footnote on table 4.

Table C1. Continued. May 18, 1987. *

Length Range (mm)	Number	Percent of Total
100-119	0	0.0%
120-139	0	0.0%
140-159	0	0.0%
160-179	0	0.0%
180-199	2	1.5%
200-219	10	7.4%
220-239	23	16.9%
240-259	30	22.1%
260-279	30	22.1%
280-299	34	25.0%
300-319	4	2.9%
320-339	2	1.5%
340-359	0	0.0%
360-379	1	0.7%
380-399	0	0.0%
Totals	136	100.0%

Average Length (mm) = 260.5
Std. Deviation = 30.6

* See footnote on table 4.

Table C1. Continued. May 19, 1987. *

Length Range (mm)	Number	Percent of Total
100-119	1	0.8%
120-139	2	1.6%
140-159	8	6.6%
160-179	2	1.6%
180-199	2	1.6%
200-219	14	11.5%
220-239	29	23.8%
240-259	20	16.4%
260-279	23	18.9%
280-299	12	9.8%
300-319	7	5.7%
320-339	1	0.8%
340-359	1	0.8%
360-379	0	0.0%
380-399	0	0.0%
Totals	122	100.0%

Average Length (mm) = 240.7
Std. Deviation = 44.4

* See footnote on table 4.

Table C1. Continued. May 20, 1987. *

Length Range (mm)	Number	Percent of Total
100-119	2	2.5%
120-139	9	11.1%
140-159	10	12.3%
160-179	7	8.6%
180-199	6	7.4%
200-219	11	13.6%
220-239	6	7.4%
240-259	5	6.2%
260-279	11	13.6%
280-299	11	13.6%
300-319	1	1.2%
320-339	1	1.2%
340-359	1	1.2%
360-379	0	0.0%
380-399	0	0.0%
Totals	81	100.0%

Average Length (mm) = 212.7
Std. Deviation = 59.7

* See footnote on table 4.

Table C1. Continued. May 21, 1987. *

Length Range (mm)	Number	Percent of Total
100-119	0	0.0%
120-139	1	0.9%
140-159	2	1.8%
160-179	1	0.9%
180-199	3	2.7%
200-219	6	5.4%
220-239	16	14.4%
240-259	32	28.8%
260-279	33	29.7%
280-299	13	11.7%
300-319	2	1.8%
320-339	1	0.9%
340-359	1	0.9%
360-379	0	0.0%
380-399	0	0.0%
Totals	111	100.0%

Average Length (mm) = 252.4
Std. Deviation = 32.9

* See footnote on table 4.

Table C1. Continued. May 22, 1987. *

Length Range (mm)	Number	Percent of Total
100-119	1	1.0%
120-139	5	5.1%
140-159	7	7.1%
160-179	7	7.1%
180-199	4	4.0%
200-219	9	9.1%
220-239	18	18.2%
240-259	17	17.2%
260-279	18	18.2%
280-299	10	10.1%
300-319	1	1.0%
320-339	0	0.0%
340-359	1	1.0%
360-379	1	1.0%
380-399	0	0.0%
Totals	99	100.0%

Average Length (mm) = 229.4
Std. Deviation = 50.0

* See footnote on table 4.

Table C1. Continued. May 23, 1987. *

Length Range (mm)	Number	Percent of Total
100-119	0	0.0%
120-139	0	0.0%
140-159	0	0.0%
160-179	0	0.0%
180-199	2	12.5%
200-219	1	6.3%
220-239	3	18.8%
240-259	4	25.0%
260-279	5	31.3%
280-299	1	6.3%
300-319	0	0.0%
320-339	0	0.0%
340-359	0	0.0%
360-379	0	0.0%
380-399	0	0.0%
Totals	16	100.0%

Average Length (mm) = 242.0
Std. Deviation = 27.1

* See footnote on table 4.

Table C1. Continued. May 24, 1987. *

Length Range (mm)	Number	Percent of Total
100-119	0	0.0%
120-139	1	20.0%
140-159	0	0.0%
160-179	0	0.0%
180-199	0	0.0%
200-219	0	0.0%
220-239	0	0.0%
240-259	1	20.0%
260-279	2	40.0%
280-299	1	20.0%
300-319	0	0.0%
320-339	0	0.0%
340-359	0	0.0%
360-379	0	0.0%
380-399	0	0.0%
Totals	5	100.0%

Average Length (mm) = 242.0
Std. Deviation = 54.0

* See footnote on table 4.

Table C2. Arctic grayling fork lengths, weight, sex and maturity for successful culvert migrants, Fish Creek Fish Passage Study, May 14 to May 23, 1987.

Date	Time (ADT)	Length (mm)	Weight (grams)	Condition Factor	Sex (M/F/I)	Release Status	Comments
May 14	1711	304			F		
May 14	1711	327			M		
May 14	1711	283			M		Ripe
May 14	1711	269			M		
May 14	1711	274			M		
May 14	1711	281			F		
May 14	1711	278			M		
May 14	1711	286			F		
May 14	1711	277			M		
May 14	1711	269			M		
May 14	1711	289			M		
May 14	1711	283			F		
May 14	1711	228			M		
May 14	1711	258			F		
May 14	1711	282			F		
May 14	1711	255			M		
May 14	1711	241			M		
May 14	1711	294			F		
May 14	1711	383			M		
May 14	1711	310			M		Ripe
May 14	1722	274			M		
May 14	1722	263			M		
May 14	1722	281			M		
May 14	1722	279			F		
May 14	1722	263			M		
May 14	1722	265			F		
May 14	1722	289			M		
May 14	1722	258			M		
May 14	1722	278			F		
May 14	1722	285			M		
May 14	1722	318			M		Ripe
May 14	1722	269			M		
May 14	1722	295			M		
May 14	1722	257			M		
May 14	1722	225			M		
May 14	1722	293			F		
May 14	1722	284			M		Ripe
May 14	1722	290			F		
May 14	1722	275			M		
May 14	1722	262			M		
May 14	1735	300			F		
May 14	1735	281			F		
May 14	1735	254			M		
May 14	1735	256			M		
May 14	1735	278			M		
May 14	1735	279			M		
May 14	1735	329			F		
May 14	1735	295			M		
May 14	1735	299			M		
May 14	1735	270			M		
May 14	1735	286			M		
May 14	1735	249			M		
May 14	1735	292			M		
May 14	1735	279			M		
May 14	1735	291			M		
May 14	1735	244			M		
May 14	1735	260			M		
May 14	1735	297			M		
May 14	1735	256			M		
May 14	1750	247			M		
May 14	1750	289			F		
May 14	1750	290			M		

Table C2. Continued.

Date	Time (ADT)	Length (mm)	Weight (grams)	Condition Factor	Sex (M/F/I)	Release Status	Comments
May 14	1750	252			F		
May 14	1750	297			M		Ripe
May 14	1750	247			M		
May 14	1750	259			M		
May 14	1750	267			M		
May 14	1750	280			M		
May 14	1750	249			M		
May 14	1750	284			M		Ripe
May 14	1750	232			F		
May 14	1750	215			M		
May 14	1750	302			F		
May 14	1750	235			M		
May 14	1750	327			F		
May 14	1750	265			M		
May 14	1750	329			M		Ripe
May 14	1750	297			M		
May 14	1750	275			F		
May 14	1757	254			M		
May 14	1757	274			F		
May 14	1757	276			M		
May 14	1757	307			M		
May 14	1757	307			M		
May 14	1757	299			M		
May 14	1757	261			M		
May 14	1757	310			M		Ripe
May 14	1757	279			F		
May 14	1757	258			M		
May 14	1757	289			M		
May 14	1757	254			M		
May 14	1757	282			M		
May 14	1757	292			M		
May 14	1757	271			M		
May 14	1757	255			M		
May 14	1757	263			M		
May 14	1757	268			M		
May 14	1757	301			F		
May 14	1757	264			M		
May 14	2110	278			F		
May 14	2110	293			M		Ripe
May 14	2110	285			M		
May 14	2110	287			M		
May 14	2110	262			M		
May 14	2110	254			F		
May 14	2110	259			M		
May 14	2110	292			M		
May 14	2110	312			M		
May 14	2110	299			M		
May 14	2110	255			M		
May 14	2110	293			M		
May 14	2110	288			M		
May 14	2110	257			F		
May 14	2110	275			F		
May 14	2110	269			F		
May 14	2110	223			F		
May 14	2110	258			M		
May 14	2110	280			F		
May 14	2110	328			M		
May 14	2110	283			F		
May 14	2110	317			M		
May 14	2110	254			F		
May 14	2110	304			M		
May 14	2110	302			M		
May 14	2110	263			F		
May 14	2110	253			F		

Table C2. Continued.

Date	Time (ADT)	Length (mm)	Weight (grams)	Condition Factor	Sex (M/F/I)	Release Status	Comments
May 14	2110	275			F		
May 14	2110	253			F		
May 14	2110	328			F		
May 14	2110	238			F		
May 14	2110	249			M		
May 14	2110	252			M		
May 14	2110	269			M		
May 14	2110	247			M		
May 14	2110	267			F		
May 14	2110	262			M		
May 14	2110	245			F		
May 14	2110	320			F		Ripe
May 14	2110	267			F		
May 14	2110	268			F		
May 14	2140	247			M		
May 14	2140	294			M		
May 14	2140	288			M		
May 14	2140	256			F		
May 14	2140	242			M		
May 14	2140	248			F		
May 14	2140	287			M		
May 14	2140	298			F		
May 14	2140	280			F		
May 14	2140	274			M		
May 14	2140	261			F		
May 14	2140	265			F		
May 14	2140	252			F		
May 14	2140	287			F		
May 14	2140	231			M		
May 14	2140	345			M		
May 14	2140	295			F		
May 14	2140	300			M		
May 14	2140	270			F		
May 14	2140	265			M		
May 14	2140	280			F		
May 14	2140	310			M		Ripe
May 14	2140	265			M		
May 14	2140	260			M		
May 14	2140	275			F		
May 14	2230	265			M		
May 14	2230	290			M		Ripe
May 14	2230	245			M		
May 14	2230	360			M		
May 14	2230	285			M		Ripe
May 14	2230	285			F		
May 14	2230	280			M		
May 14	2230	355			M		Ripe
May 14	2230	355			F		
May 14	2230	290			F		
May 14	2230	260			F		
May 14	2230	250			M		
May 14	2230	255			M		
May 14	2230	285			M		
May 14	2230	285			M		
May 14	2230	290			M		
May 14	2230	270			M		
May 14	2230	295			M		
May 14	2230	280			M		
May 14	2230	320			F		
May 14	2230	285			F		
May 14	2230	340			F		
May 14	2230	305			F		
May 14	2230	285			M		
May 14	2230	310			M		

Table C2. Continued.

Date	Time (ADT)	Length (mm)	Weight (grams)	Condition Factor	Sex (M/F/I)	Release Status	Comments
May 14	2230	275			M		
May 14	2230	265			F		
May 14	2230	275			F		
May 14	2230	300			M		Ripe
May 14	2230	290			F		
May 14	2230	280			F		
May 14	2230	280			F		
May 14	2230	260			M		
May 14	2230	245			M		
May 14	2230	255			F		
May 14	2230	295			M		Ripe
May 14	2230	270			M		
May 14	2230	320			F		
May 14	2230	250			M		
May 14	2230	275			M		
May 15	1030	255	170	1.03	F	N	
May 15	1030	299	295	1.10	F	N	
May 15	1030	319	334	1.03	F	N	
May 15	1030	295	244	.95	M	N	
May 15	1030	310	324	1.09	F	N	
May 15	1030	295	260	1.01	F	N	
May 15	1030	298	240	.91	M	N	
May 15	1030	280	220	1.00	M	N	
May 15	1030	275	200	.96	F	N	
May 15	1030	245	136	.92	F	N	
May 15	1030	255	160	.96	F	N	
May 15	1030	295	244	.95	F	N	
May 15	1030	320	355	1.08	F	N	
May 15	1030	268	190	.99	F	N	
May 15	1030	335	356	.95	M	N	
May 15	1030	265	188	1.01	F	N	
May 15	1030	275	220	1.06	F	N	
May 15	1030	290	276	1.13	F	N	
May 15	1030	290	260	1.07	F	N	
May 15	1030	315	296	.95	M	N	
May 15	1030	273	198	.97	M	N	
May 15	1030	274	206	1.00	F	N	
May 15	1030	252	150	.94	F	N	
May 15	1030	270	204	1.04	F	N	
May 15	1030	268	188	.98	M	N	
May 15	1030	366	440	.90	N/A		
May 15	1030	340	320	.81	N/A		
May 15	1820	332			F		
May 15	1820	254			F		
May 15	1820	247			F		
May 15	1820	282			F		
May 15	1820	289			M		
May 15	1820	308			F		
May 15	1820	262			M		
May 15	1820	281			M		
May 15	1820	268			M		
May 15	1820	303			F		
May 15	1820	275			M		
May 15	1820	274			F		
May 15	1820	303			F		
May 15	1820	271			F		
May 15	1820	288			F		
May 15	1820	273			F		
May 15	1820	290			M		
May 15	1820	279			M		
May 15	1820	292			M		Ripe
May 15	1820	268			M		
May 15	1820	253			F		
May 15	1820	279			F		

Table C2. Continued.

Date	Time (ADT)	Length (mm)	Weight (grams)	Condition Factor	Sex (M/F/I)	Release Status	Comments
May 15	1820	281			F		
May 15	1820	307			M		Ripe
May 15	1820	334			F		
May 15	1820	258			F		
May 15	1820	289			F		
May 15	1820	292			M		
May 15	1820	338			M		Ripe
May 15	1820	275			F		
May 15	1820	334			F		
May 15	1820	287			F		
May 15	1820	343			F		
May 15	1820	322			M		
May 15	1820	245			F		
May 15	1820	289			F		
May 15	1820	267			F		
May 15	1820	262			F		
May 15	1820	275			M		
May 15	1820	261			F		
May 15	1820	285			F		
May 15	1820	267			F		
May 15	1820	289			M		
May 15	1820	274			F		
May 15	1820	302			F		
May 15	1820	317			F		
May 15	1820	302			F		
May 15	1820	242			F		
May 15	1820	252			F		
May 15	1820	248			F		
May 15	1820	233			F		
May 15	1820	299			M		Ripe
May 15	1820	245			F		
May 15	1820	230			F		
May 15	1820	251			F		
May 15	1820	241			M		
May 16	925	249			I		
May 16	925	255			I		
May 16	925	302			F		
May 16	1000	127			I		
May 16	1000	296			F		
May 16	1000	329			M		
May 16	1000	302			F		
May 16	1000	274			I		
May 16	1000	265			I		
May 16	1000	290			F		
May 16	1000	286			F		
May 16	1000	303			M		
May 16	1000	270			I		
May 16	1000	284			M		
May 16	1000	281			F		
May 16	1000	274			N/A		
May 16	1000	265			N/A		
May 16	1000	261			N/A		
May 16	1000	224			N/A		
May 16	1000	220			N/A		
May 16	1000	239			N/A		
May 16	1000	223			N/A		
May 16	1000	208			N/A		
May 16	1000	229			N/A		
May 16	1000	267			F		
May 16	1000	269			F		
May 16	1000	333			M		
May 16	1000	290			F		
May 16	1000	274			N/A		
May 16	1000	267			F		

Table C2. Continued.

Date	Time (ADT)	Length (mm)	Weight (grams)	Condition Factor	Sex (M/F/I)	Release Status	Comments
May 16	1000	265			M		
May 16	1000	331			F		
May 16	1000	336			F		
May 16	1015	250			I		
May 16	1015	279			F		
May 16	1015	295			M		
May 16	1015	277			F		
May 16	1015	313			F		
May 16	1015	278			M		
May 16	1015	314			F		
May 16	1015	249			N/A		
May 16	1015	253			I		
May 16	1015	294			F		
May 16	1015	253			I		
May 16	1015	334			M		
May 16	1015	261			I		
May 16	1015	276			F		
May 16	1015	296			F		
May 16	1015	262			I		
May 16	1015	249			I		
May 16	1015	265			N/A		
May 16	1015	232			I		
May 16	1015	229			I		
May 16	1015	228			I		
May 16	1015	212			I		
May 16	1015	220			I		
May 16	1015	215			I		
May 16	1015	275			M		
May 16	1015	268			F		
May 16	1015	255			I		
May 16	1015	244			I		
May 16	1015	237			I		
May 16	1015	224			I		
May 16	1500	286			M		
May 16	1500	258			I		
May 16	1500	270			I		
May 16	1500	264			I		
May 16	1500	218			I		
May 16	1600	252			I		
May 16	1700	284			N/A		
May 16	1700	268			N/A		
May 16	1700	254			I		
May 16	1700	260			I		
May 16	1700	214			I		
May 16	1800	255			I		
May 16	1800	237			I		
May 16	1800	235			I		
May 16	1800	241			I		
May 16	1800	224			I		
May 16	1800	246			I		
May 16	1800	244			I		
May 16	1800	243			I		
May 16	1800	255			I		
May 16	1800	289			N/A		
May 16	1800	259			N/A		
May 16	1800	283			N/A		
May 16	1800	329			N/A		
May 16	1800	218			M	M	
May 16	1800	215			M	M	
May 16	1800	216			F	M	
May 16	1900	245			I		
May 16	1900	238			I		
May 16	1900	231			I		
May 16	1900	253			I		

Table C2. Continued.

Date	Time (ADT)	Length (mm)	Weight (grams)	Condition Factor	Sex (M/F/I)	Release Status	Comments
May 16	1900	265			I		
May 16	1900	266			N/A		
May 16	1900	234			I/M	M	
May 16	1900	259			I		
May 16	2000	236			I		
May 16	2000	255			I		
May 16	2000	256			I		
May 16	2000	318			F		
May 16	2000	257			I		
May 16	2200	245			I		
May 16	2200	242			I		
May 16	2200	245			I		
May 16	2200	265			I		
May 16	2200	280			N/A		
May 16	2200	255			I		
May 16	2200	258			I		
May 16	2200	258			I		
May 16	2200	262			I		
May 16	2200	259			I		
May 16	2200	271			I		
May 16	2200	258			I		
May 16	2200	246			I		
May 16	2200	255			I		
May 16	2200	224			I		
May 16	2200	220			I		
May 16	2200	224			N/A		
May 16	2200	261			I		
May 16	2200	237			I		
May 16	2200	234			I		
May 16	2200	216			I		
May 16	2200	211			I		
May 16	2200	219			I/M	M	
May 16	2200	205			M	M	
May 17	900	246			I		
May 17	900	223			I		
May 17	900	240			I		
May 17	900	220			I		
May 17	900	261			N/A		
May 17	900	302			M		
May 17	900	270			F		
May 17	900	254			N/A		
May 17	900	257			I		
May 17	1715	216			F		
May 17	1715	314			M		
May 17	1715	285			M		Ripe
May 17	1715	309			F		
May 17	1715	302			M		Ripe
May 17	1715	278			N/A		
May 17	1715	302			M		Ripe
May 17	2000	267			F		Tag #34713
May 17	2000	296			F		
May 17	2000	251			F		
May 17	2000	280			M	N	
May 17	2000	341			F	N	
May 17	2000	228			F		
May 17	2222	288			F		Y-tag 18
May 17	2222	216			I		
May 17	2222	297			M		Ripe
May 17	2222	197			I		
May 17	2222	223			F		
May 17	2222	280			F		
May 17	2222	225			F		
May 17	2222	186			I		
May 17	2222	215			F		

Table C2. Continued.

Date	Time (ADT)	Length (mm)	Weight (grams)	Condition Factor	Sex (M/F/I)	Release Status	Comments
May 17	2222	195			I		
May 17	2222	181			I		
May 17	2222	172			I		
May 17	2222	289			N/A		
May 17	2222	275			F		
May 17	2222	230			F		
May 17	2229	226			F		
May 17	2229	182			F		
May 17	2229	245			F		
May 17	2229	282			F		
May 17	2229	240			F	M	
May 17	2229	297			M		Ripe
May 17	2229	241			M		O-tag 138
May 17	2229	250			F		
May 17	2229	235			F		
May 17	2229	249			F		
May 17	2229	294			F		
May 17	2229	227			F		
May 17	2229	269			F		
May 17	2229	221			I		
May 17	2229	212			I	M	
May 17	2229	220			F	M	
May 17	2229	245			F		
May 17	2229	235			F		
May 17	2229	241			F		
May 17	2229	234			F		
May 17	2229	291			M		
May 17	2229	261			F		
May 17	2229	242			F		
May 17	2229	242			F		
May 17	2229	231			F		
May 18	818	268			F	N	
May 18	818	265			F		
May 18	818	269			F	N	
May 18	818	249			F		
May 18	818	262			F		
May 18	818	289			M	N	
May 18	818	244			F	N	
May 18	818	345			F	N	
May 18	818	300			F	N	
May 18	818	212			F	M	
May 18	818	214			N/A	M	
May 18	818	230			F		
May 18	818	210			F		
May 18	818	263			F		Y-tag 118
May 18	1125	240			N/A	M	
May 18	1125	322			M	N	
May 18	1125	293			M		
May 18	1125	308			M	N	
May 18	1125	285			F	N	
May 18	1125	277			F	N	
May 18	1507	256			F	N	
May 18	1507	291			M	N	
May 18	1507	278			F	N	
May 18	1507	280			F	N	
May 18	1507	217			F		
May 18	1507	264			F	N	
May 18	1507	218			F	N	
May 18	1706	285			M	N	
May 18	1706	254			F		
May 18	1706	334			F	N	
May 18	1706	297			F	N	
May 18	1706	312			F	N	
May 18	1706	273			F	N	

Table C2. Continued.

Date	Time (ADT)	Length (mm)	Weight (grams)	Condition Factor	Sex (M/F/I)	Release Status	Comments
May 18	1706	296			M	N	Ripe
May 18	1706	243			M		
May 18	2012	292			F	N	
May 18	2012	243			F	N	
May 18	2012	214			F		
May 18	2012	290			M	N	
May 18	2012	281			F	N	
May 18	2012	274			F	N	
May 18	2012	224			F		
May 18	2012	248			F		
May 18	2012	285			F	N	
May 18	2012	286			F	N	Ripe
May 18	2012	247			N/A		
May 18	2012	245			F		
May 18	2012	280			N/A		
May 18	2012	295			F	N	
May 18	2012	275			F	N	
May 18	2012	291			F	N	
May 18	2012	287			F	N	
May 18	2012	243			F	N	Ripe
May 18	2012	214			F		
May 18	2012	279			F	N	
May 18	2012	223			F		
May 18	2012	244			N/A		
May 18	2213	218			N/A	M	
May 18	2213	218			F	M	
May 18	2213	266			F	N	
May 18	2213	273			M	N	Ripe
May 18	2213	242			M		
May 18	2213	240			F		
May 18	2213	224			F		
May 18	2213	182			N/A		
May 18	2213	215			F	M	
May 18	2213	205			F	M	
May 19	909	295			F	N	
May 19	909	244			F		Tag #34778
May 19	909	271			F	N	
May 19	909	271			M	N	
May 19	909	298			F		Y-tag 128
May 19	909	207			F		
May 19	909	259			F	N	
May 19	909	230			F		
May 19	909	204			F		
May 19	909	244			N/A		
May 19	909	295			N/A		
May 19	909	270			F	N	
May 19	909	252			F	N	
May 19	909	248			F		
May 19	909	268			F	N	
May 19	909	252			F	N	
May 19	909	281			F		
May 19	909	302			F	N	
May 19	909	261			F		
May 19	909	235			F		
May 19	909	236			F		
May 19	909	315			F	N	
May 19	909	270			F	N	
May 19	909	286			F	N	
May 19	909	316			F	N	Ripe
May 19	909	234			F		
May 19	909	229			F		
May 19	909	275			M	N	Ripe
May 19	909	242			F	N	
May 19	909	295			F	N	

Table C2. Continued.

Date	Time (ADT)	Length (mm)	Weight (grams)	Condition Factor	Sex (M/F/I)	Release Status	Comments
May 19	909	297			M	N	
May 19	909	365			M	N	Ripe
May 19	909	267			F	N	
May 19	909	261			F	N	
May 19	909	285			M	N	Ripe
May 19	909	243			F		
May 19	909	253			F		O-tag 12A
May 19	1130	286			F	N	
May 19	1130	279			M	N	Ripe
May 19	1130	262			F	N	
May 19	1130	245			F	N	
May 19	1130	255			F	N	
May 19	1130	267			F	N	
May 19	1130	230			F		
May 19	1130	229			F		
May 19	1130	185			N/A		
May 19	1130	288			F	N	
May 19	1130	244			F	N	
May 19	1130	288			M	N	Ripe
May 19	1130	283			M	N	Ripe
May 19	1130	221			F		
May 19	1130	262			F	N	
May 19	1130	297			M		
May 19	1130	280			M	N	Ripe
May 19	1130	249			F	N	
May 19	1130	269			F	N	
May 19	1130	239			F		
May 19	1130	253			F	N	
May 19	1130	230			F		
May 19	1130	273			F	N	
May 19	1130	295			F	N	
May 19	1130	283			F	N	
May 19	1130	250			F	N	
May 19	1130	299			F	N	
May 19	1130	286			M	N	Ripe
May 19	1130	231			F		
May 19	1130	258			F	N	
May 19	1130	226			F	M	
May 19	1130	234			F	M	
May 19	1130	225			F	M	
May 19	1130	232			F	M	
May 19	1130	252			F	M	
May 19	1130	261			F	N	
May 19	1130	273			F		
May 19	1130	230	106	.87	F		
May 19	1130	273			F	N	
May 19	1130	219			F	N	
May 19	1430	338			M	N	Ripe
May 19	1430	255			F	N	
May 19	1430	283			M	N	Ripe
May 19	1430	283			F	N	
May 19	1130	245			F		
May 19	1130	272			M	N	Ripe
May 19	1130	273			F	N	
May 19	1430	294			F	N	
May 19	1430	277			F	N	
May 19	1430	275			F	N	
May 19	1430	269			F		
May 19	1430	263			M		
May 19	1430	218			F		
May 19	1430	228			F		
May 19	1430	231			M		
May 19	1445	234			F		
May 19	1445	284			F	N	

Table C2. Continued.

Date	Time (ADT)	Length (mm)	Weight (grams)	Condition Factor	Sex (M/F/I)	Release Status	Comments
May 19	1445	225			F		
May 19	1445	252			M		
May 19	1700	278			F		
May 19	1700	231			F		
May 19	1700	232			F		
May 19	2020	278			F	N	
May 19	2020	235			F		
May 19	2020	152			I		
May 19	2020	230			F	M	
May 19	2020	236			F	M	
May 19	2215	278			F		
May 19	2215	242			F		
May 19	2215	269			F		
May 19	2215	161			I		
May 19	2215	163			I		
May 19	2215	158			I		
May 19	2215	292			F		
May 19	2215	239			F		
May 19	2215	254			M	N	Ripe
May 19	2215	231			F		
May 19	2215	143			I		
May 19	2215	153			I		
May 19	2215	134			I		
May 19	2215	151			I		
May 19	2215	142			I		
May 19	2215	124			I		
May 19	2215	150			I		
May 19	2215	240			F		
May 19	2215	277			F		
May 19	2215	266			F		
May 19	2215	277			F		
May 19	2215	233			F		
May 19	2215	233			F		
May 19	2215	228			F		
May 19	2215	228			N/A		
May 19	2215	227			F		
May 19	2215	237			F		
May 19	2215	185			I		
May 19	2215	200			I		
May 19	2215	222			F		
May 19	2215	118			I		
May 19	2215	252			N/A		
May 19	2215	153			I		
May 20	930	338			M		Ripe
May 20	930	271			F		
May 20	930	294			M		Ripe
May 20	930	317			F		
May 20	930	346			F		
May 20	930	288			F		Tag 34711
May 20	930	281			M		Ripe
May 20	930	248			M		
May 20	930	220			F		
May 20	930	240			F		
May 20	930	292			F		
May 20	930	271			F		
May 20	930	275			M	N	Ripe
May 20	930	273			F	N	
May 20	930	269			M		
May 20	930	252			M		
May 20	930	264			F		
May 20	930	273			F	N	
May 20	930	235			F		
May 20	930	223	117	1.06	F		
May 20	930	313			M	N	Ripe

Table C2. Continued.

Date	Time (ADT)	Length (mm)	Weight (grams)	Condition Factor	Sex (M/F/I)	Release Status	Comments
May 20	930	229			F		
May 20	930	265			F		
May 20	930	300			F	N	Ripe
May 20	930	280			M	N	Ripe
May 20	930	308			M	N	Ripe
May 20	930	228			N/A		O-tag 48
May 20	930	300			F	N	Ripe
May 20	930	262			F	N	
May 20	930	256			F	N	
May 20	930	232			F		
May 20	930	257			M		
May 20	930	286			M	N	Ripe
May 20	930	248			F		
May 20	930	262			F		
May 20	930	240			F		
May 20	930	252			F		
May 20	930	248			F		
May 20	930	242			F		
May 20	930	190	52	.76	I		
May 20	1043	269			M		Ripe
May 20	1043	270			F	N	
May 20	1043	280			M	N	Ripe
May 20	1043	308			M	N	Ripe
May 20	1043	287			F	N	
May 20	1043	297			F	N	
May 20	1043	265			F		
May 20	1043	246			F		
May 20	1043	259			F		
May 20	1043	260			M		
May 20	1043	263			F	N	
May 20	1043	257			F		
May 20	1043	225	103	.90	F		
May 20	1043	240			N/A		
May 20	1043	273			M	N	Ripe
May 20	1043	247			F		
May 20	1043	216	98	.97	F		
May 20	1043	292	278	1.12	F	N	
May 20	1043	210	98	1.06	I		
May 20	1043	225	100	.88	F		
May 20	1043	223	100	.90	I		
May 20	1338	284			F	N	
May 20	1338	302			M	N	Ripe
May 20	1338	253			F		
May 20	1338	227	118	1.01	F	M	
May 20	1338	209	100	1.10	I	M	
May 20	1338	228	124	1.05	F	M	
May 20	1338	222	118	1.08	F	M	
May 20	1338	214	100	1.02	F	M	
May 20	1338	238	132	.98	F	M	
May 20	1338	207	98	1.10	I	M	
May 20	1338	219	120	1.14	F	M	
May 20	1338	213	100	1.03	F	M	
May 20	1338	210	105	1.13	F	M	
May 20	1338	234	120	.94	N/A	M	
May 20	1338	233	124	.98	F	M	
May 20	1338	217	108	1.06	F	M	
May 20	1348	211	101	1.08	F	M	
May 20	1348	215	104	1.05	F	M	
May 20	1348	211	105	1.12	F	M	
May 20	1348	212	108	1.13	F	M	
May 20	2045	258			M		
May 20	2045	243			F		
May 20	2045	269			F	N	
May 20	2045	265			F	N	

Table C2. Continued.

Date	Time (ADT)	Length (mm)	Weight (grams)	Condition Factor	Sex (M/F/I)	Release Status	Comments
May 20	2045	213			F		
May 20	2045	235			F		
May 20	2045	205			F		
May 20	2045	205	80	.93	I		
May 20	2045	172	50	.98	I		
May 20	2045	192	71	1.00	I		
May 20	2045	140	28	1.02	I		
May 20	2045	184	59	.95	I		
May 20	2045	204	80	.94	I		
May 20	2045	132	28	.00	I		
May 20	2045	196	76	1.01	I		
May 20	2045	207	92	1.04	I		
May 20	2045	168	48	1.01	I		
May 20	2045	174	52	.99	I		
May 20	2045	193	74	1.03	I		
May 20	2045	135	22	.89	I		
May 20	2045	128	20	.95	I		
May 20	2045	134	22	.91	I		
May 20	2045	131	25	1.11	I		
May 20	2045	160	39	.95	I		
May 20	2045	141	28	1.00	I		
May 20	2045	144	34	1.14	I		
May 20	2045	148	35	1.08	I		
May 20	2045	139	30	1.12	I		
May 20	2045	115	15	.99	I		
May 20	2045	147	28	.88	I		
May 20	2045	127			I		
May 20	2045	270			M		
May 20	2045	284			M		
May 20	2045	272			M	N	Ripe
May 20	2045	205	80	.93	I		
May 20	2045	202	80	.97	I		
May 20	2045	150	38	1.13	I		
May 20	2045	160	45	1.10	I		
May 20	2045	178	58	1.03	I		
May 20	2045	155	44	1.18	I		
May 20	2045	121	20	1.13	I		
May 21	1000	229			N/A		
May 21	1000	298	275	1.04	M		
May 21	1000	288			F		
May 21	1000	344			F	N	
May 21	1000	285			M	N	
May 21	1000	255			F		
May 21	1000	290			F	N	
May 21	1000	290			M	N	Ripe
May 21	1000	273			F		
May 21	1000	273			M	N	Ripe
May 21	1000	270			F		
May 21	1000	218			I		
May 21	1000	225			I		
May 21	1000	156			I		
May 21	1000	210			I		
May 21	1000	145			I		
May 21	1000	117			I		
May 21	1000	147			I		
May 21	1000	135			I		
May 21	1000	305			F	N	
May 21	1000	333			M	N	Ripe
May 21	1000	298			M	N	
May 21	1000	289			M	N	Ripe
May 21	1000	264			F		
May 21	1000	222			F		
May 21	1000	240			F		Tag 34774
May 21	1000	282			F	N	

Table C2. Continued.

Date	Time (ADT)	Length (mm)	Weight (grams)	Condition Factor	Sex (M/F/I)	Release Status	Comments
May 21	1000	269			F	N	
May 21	1000	261			F		
May 21	1000	223			F		
May 21	1000	213			F		
May 21	1000	181			I		
May 21	1000	196			I	M	
May 21	1000	227			I	M	
May 21	1052	285			M	N	
May 21	1052	290			F	N	
May 21	1052	275			F	N	
May 21	1052	258			M	N	Ripe
May 21	1052	205			I		
May 21	1052	161			I		
May 21	1645	262			M	N	Ripe
May 21	1645	264			F		
May 21	1645	261			F	N	
May 21	1645	227			F		
May 21	1645	285			M	N	Ripe
May 21	1645	281			M	N	Ripe
May 21	1645	243			N/A		
May 21	1645	292			M	N	Ripe
May 21	1645	279			F	N	
May 21	1645	269	190	.98	F	N	
May 21	1645	252			F		
May 21	1645	240			I		
May 21	1645	146			I		
May 21	1645	341	435	1.10	F	N	
May 21	1956	320			F	N	Ripe
May 21	1956	259			M		
May 21	1956	305			M	N	Ripe
May 21	1956	266			M		
May 21	1956	192			I		
May 21	1956	244			I		
May 21	1956	245			I		
May 22	915	290			F	N	
May 22	915	265			I		
May 22	915	260			F		
May 22	915	258			I		
May 22	915	279			F	N	
May 22	915	277			M	N	Ripe
May 22	915	212			I		
May 22	915	268			F	N	
May 22	915	224			I		
May 22	915	248			I		
May 22	915	238			I		
May 22	915	254			I		
May 22	915	162			F		
May 22	915	248			I		
May 22	915	262			I		
May 22	915	128			I		
May 22	915	280			F		Y-tag 108
May 22	915	258			I		Tag 34793
May 22	915	290			F		
May 22	915	274			F		
May 22	915	252			I		
May 22	915	280			M	N	Ripe
May 22	915	227			I		
May 22	915	250			I		
May 22	915	257			I		
May 22	915	208			I		
May 22	915	277			F	N	Ripe
May 22	915	290			F	N	Ripe
May 22	915	258			I		

Table C2. Continued.

Date	Time (ADT)	Length (mm)	Weight (grams)	Condition Factor	Sex (M/F/I)	Release Status	Comments
May 22	915	292			M	N	Ripe
May 22	915	260			F		
May 22	915	238			I		
May 22	915	277			I		
May 22	915	238			I		
May 22	915	238			I		
May 22	915	267			F	N	
May 22	915	271			M	N	
May 22	915	276			F	N	
May 22	915	228			I		
May 22	915	260			I		
May 22	915	195			I		
May 22	915	222			I		
May 22	915	252			I		
May 22	915	275			M	N	Ripe
May 22	915	276			F		
May 22	915	205			I		
May 22	915	270			I		
May 22	915	253			I		
May 22	915	238			I		
May 22	915	227			I		
May 22	1400	274	205	1.00	I		
May 22	1400	275			M	N	Ripe
May 22	1400	247			M	N	Ripe
May 22	1400	265			F		
May 22	1400	251			F		
May 22	1400	300			F		
May 22	1400	232			F		
May 22	1400	241			F		
May 22	1400	218			I		
May 22	1400	149			I		
May 22	1400	262			M	N	
May 22	1400	251			F		
May 22	1400	244			M		
May 22	1400	257			M		
May 22	1400	254			F		
May 22	1400	284			F	N	
May 22	1400	265			M	N	Ripe
May 22	1400	296			M	N	
May 22	1400	251			F		
May 22	1400	222			M		
May 22	1400	244			M		
May 22	1400	198			I		
May 22	1400	289			M	N	Ripe
May 22	1400	258			F		
May 22	1400	259			F		
May 22	1400	290			M	N	Ripe
May 22	1400	236			F		
May 22	1400	267			F	N	
May 22	1400	261			M		
May 22	1400	266			F	N	
May 22	1400	248			F		
May 22	1400	248			M		
May 22	1400	257			F		
May 22	1400	240			F		
May 22	1400	206			I		
May 22	1400	278			M	N	Ripe
May 22	1400	260			M		
May 22	1400	232			F		
May 22	1400	232			M	N	Ripe
May 22	1400	204			I		
May 22	1945	187			I		
May 22	1945	251			F	N	
May 22	1945	256			F		
May 22	1945	267			F		

Table C2. Continued.

Date	Time (ADT)	Length (mm)	Weight (grams)	Condition Factor	Sex (M/F/I)	Release Status	Comments
May 22	1945	236			F		
May 22	1945	274			F	N	
May 22	1945	241			F	N	
May 22	1945	263			F	N	
May 22	1945	243			F		
May 22	1945	200			I		
May 22	1945	225			F		
May 22	1945	178			I		
May 22	1945	151			I		
May 22	1945	168			I		
May 22	1945	160			I		
May 22	1945	158			I		
May 22	1945	128			I		
May 22	1945	146			I		
May 22	1945	137			I		
May 22	1945	267			F	N	
May 22	1945	217			F		
May 22	1945	282			M	N	Ripe
May 22	1945	252			F		
May 22	1945	268			M		
May 22	1945	231			F		
May 22	1945	227			M		
May 22	1945	246			F		
May 22	1945	237			F		
May 22	1945	219			F		
May 22	1945	239			M		
May 22	1945	240			F		
May 22	1945	226			F		
May 22	1945	212			F		
May 22	1945	204			I		
May 22	1945	213			I		
May 22	1945	134			I		
May 22	1945	169			I		
May 22	1945	170			I		
May 22	1945	265			M	N	Ripe
May 22	1945	286			F	N	
May 22	1945	283			F	N	
May 22	1945	284			F	N	
May 22	1945	218			F		
May 22	1945	226			F		
May 22	1945	196			I		
May 22	1945	222			F		
May 22	1945	227			F		
May 22	1945	231			F		
May 22	1945	230			F		
May 22	1945	265			I		
May 22	1945	157			I		
May 23	1025	367			F	N	Ripe
May 23	1025	348			F	N	Ripe
May 23	1025	246			F		
May 23	1025	280			M	N	Ripe
May 23	1025	265			F	N	
May 23	1025	259			F	N	
May 23	1025	267			F	N	
May 23	1025	190			I		
May 23	1025	145			I		
May 23	1025	128			I		
May 23	1025	145			I		
May 23	1025	302			M	N	
May 23	1025	280			M	N	
May 23	1025	291			F	N	
May 23	1025	257			F		
May 23	1025	264			F		
May 23	1025	245			M		

Table C2. Continued.

Date	Time (ADT)	Length (mm)	Weight (grams)	Condition Factor	Sex (M/F/I)	Release Status	Comments
May 23	1025	228			F		
May 23	1025	193			I		
May 23	1025	204			F		
May 23	1025	117			M		
May 23	1025	141			I		
May 23	1025	178			I		
May 23	1025	283			F	N	
May 23	1025	256			F		
May 23	1025	270			F	N	
May 23	1025	295			F	N	
May 23	1025	254			F		
May 23	1025	275			M	N	
May 23	1025	277			M	N	Ripe
May 23	1025	251			M		
May 23	1025	257			F		
May 23	1025	280			F	N	
May 23	1025	258			F		
May 23	1025	265			M	N	Ripe
May 23	1025	234			M		
May 23	1025	272			M	N	Ripe
May 23	1025	238			F		
May 23	1025	261			M		
May 23	1025	224			F		
May 23	1025	263			M		
May 23	1025	252			F		
May 23	1025	260			F	N	
May 23	1025	225			F		
May 23	1025	225			F		
May 23	1025	205			I		
May 23	1025	160			I		
May 23	1025	121			I		
May 23	1540	246			F		
May 23	1540	246			F		
May 23	1540	286			F	N	
May 23	1540	191			I		
May 23	1540	260			M		
May 23	1540	266			M		
May 23	1540	249			F		
May 23	1540	222			F		
May 23	1540	204			I		
May 24	1000	275			F	N	
May 24	1000	234			M		
May 24	1000	225			F		
May 24	1000	263			F		
May 24	1000	265			F	N	
May 24	1000	198			I		
May 24	1000	242			F		
May 25	910	270			M	N	
May 25	910	291			F	N	
May 25	910	248			M		
May 25	910	265			M		
May 25	910	138			I		

Total Number of Grayling = 1,074
Average Length (mm) of Grayling = 255 mm

Total Number of Males = 295
Average Length (mm) of Males = 277.7 mm (117 to 383 mm)

Total Number of Females = 515
Average Length (mm) of Females = 262.9 mm (162 to 367 mm)

Table C2. Continued.

Total Number of Immatures = 220
Average Length of Immatures = 206.4 mm (115 to 277 mm)

Total Number of Unknown Sex = 44
Average Length of Unknown Sex = 254.6 mm (182 to 366 mm)

Total Number of Grayling Released Back to System = 803 (75% See Note)
Total Number of Grayling Released to ACFRU = 228
Average Length of Grayling Released to ACFRU = 280.9 mm (218 to 367 mm)

Total Number of Mortalities = 42 (3.9%)
Average Length (mm) of Mortalities = 220.9 mm (196 to 252 mm)

NOTES: Condition Factor (K) = 100*Weight (gm)/(Length (cm)^3)

Sex Codes:
F = Female
I = Immature
N/A = Unknown

Release Codes:
Blank = upstream release
N = transferred to ACFRU for spawning migration delay study; fish scheduled for eventual release
M = mortality

Table C3. Arctic grayling fork lengths, age, sex, and maturity status, Sport Fish Tagging Project, Fish Creek, May 1987.

Tag Number	Tag Color	Tagging Date	Time (ADT)	Length (mm)	Age	Sex (M/F/I)	Status	Comments
1140	White	May 16	925	249		I		
1141	White	May 16	925	255		I		
1144	White	May 16	925	302		F		
34700	White	May 16	1000	127		I		
34701	White	May 16	1000	296		F		
34702	White	May 16	1000	329		M		
34703	White	May 16	1000	302		F		
34704	White	May 16	1000	274		I		
34705	White	May 16	1000	265		I		
34706	White	May 16	1000	290		F		
34707	White	May 16	1000	286		F		
34708	White	May 16	1000	303		M		
34709	White	May 16	1000	270		I		
34710	White	May 16	1000	284		M		
34711	White	May 16	1000	281		F		
34712	White	May 16	1000	274		N/A		
34713	White	May 16	1000	265		N/A		
34714	White	May 16	1000	261		N/A		
34715	White	May 16	1000	224		N/A		
34716	White	May 16	1000	220		N/A		
34717	White	May 16	1000	239		N/A		
34718	White	May 16	1000	223		N/A		
34719	White	May 16	1000	208		N/A		
34720	White	May 16	1000	229		N/A		
34721	White	May 16	1000	267		F		
34722	White	May 16	1000	269		F		
34723	White	May 16	1000	333		M		
34724	White	May 16	1000	290		F		
34725	White	May 16	1000	274		N/A		
34726	White	May 16	1000	267		F		
34727	White	May 16	1000	265		M		
34728	White	May 16	1000	331		F		
34729	White	May 16	1000	336		F		
34730	White	May 16	1015	250		I		
34731	White	May 16	1015	279		F		
34732	White	May 16	1015	295		M		
34733	White	May 16	1015	277		F		
34734	White	May 16	1015	313		F		
34735	White	May 16	1015	278		M		
34736	White	May 16	1015	314		F		
34737	White	May 16	1015	249		N/A		
34738	White	May 16	1015	253		I		
34739	White	May 16	1015	294		F		
34740	White	May 16	1015	253		I		
34741	White	May 16	1015	334		M		
34742	White	May 16	1015	261		I		
34743	White	May 16	1015	276		F		
34744	White	May 16	1015	296		F		
34745	White	May 16	1015	262		I		
34746	White	May 16	1015	249		I		
34747	White	May 16	1015	265		N/A		
34748	White	May 16	1015	232		I		
34749	White	May 16	1015	229		I		
34750	White	May 16	1015	228		I		
34751	White	May 16	1015	212		I		
34752	White	May 16	1015	220		I		
34753	White	May 16	1015	215		I		
34754	White	May 16	1015	275		M		
34755	White	May 16	1015	268		F		
34756	White	May 16	1015	255		I		
34757	White	May 16	1015	244		I		
34758	White	May 16	1015	237		I		
34759	White	May 16	1015	224		I		

Table C3. Continued.

Tag Number	Tag Color	Tagging Date	Time (ADT)	Length (mm)	Sex Age (M/F/I)	Status	Comments
34760	White	May 16	1500	286	M		
34761	White	May 16	1500	258	I		
34762	White	May 16	1500	270	I		
34763	White	May 16	1500	264	I		
34764	White	May 16	1500	218	I		
34765	White	May 16	1600	252	I		
34766	White	May 16	1700	284	N/A		
34767	White	May 16	1700	268	N/A		
34768	White	May 16	1700	254	I		
34769	White	May 16	1700	260	I		
34770	White	May 16	1700	214	I		
34771	White	May 16	1800	255	I		
34772	White	May 16	1800	237	I		
34773	White	May 16	1800	235	I		
34774	White	May 16	1800	241	I		
34775	White	May 16	1800	224	I		
34776	White	May 16	1800	246	I		
34777	White	May 16	1800	244	I		
34778	White	May 16	1800	243	I		
34779	White	May 16	1800	255	I		
34780	White	May 16	1800	289	N/A		
34781	White	May 16	1800	259	N/A		
34782	White	May 16	1800	283	N/A		
34783	White	May 16	1800	329	N/A		
		May 16	1800	218	M	Mortality	
		May 16	1800	215	M	Mortality	
		May 16	1800	216	F	Mortality	
34784	White	May 16	1900	245	I		
34785	White	May 16	1900	238	I		
34786	White	May 16	1900	231	I		
34787	White	May 16	1900	253	I		
34788	White	May 16	1900	265	I		
34789	White	May 16	1900	266	N/A		
		May 16	1900	234	I/M	Mortality	
34790	White	May 16	1900	259	I		
34791	White	May 16	2000	236	I		
34792	White	May 16	2000	255	I		
34793	White	May 16	2000	256	I		
34794	White	May 16	2000	318	F		
34795	White	May 16	2000	257	I		
34796	White	May 16	2200	245	I		
34797	White	May 16	2200	242	I		
34798	White	May 16	2200	245	I		
34799	White	May 16	2200	265	I		
34800	White	May 16	2200	280	N/A		
34801	White	May 16	2200	255	I		
34802	White	May 16	2200	258	I		
34803	White	May 16	2200	258	I		
34804	White	May 16	2200	262	I		
34805	White	May 16	2200	259	I		Rcv. 5/25 L.Twin Lk.outlet
34806	White	May 16	2200	271	I		
34807	White	May 16	2200	258	I		
34808	White	May 16	2200	246	I		
34809	White	May 16	2200	255	I		
34810	White	May 16	2200	224	I		
34811	White	May 16	2200	220	I		
34812	White	May 16	2200	224	N/A		
34813	White	May 16	2200	261	I		
34814	White	May 16	2200	237	I		
34815	White	May 16	2200	234	I		
34816	White	May 16	2200	216	I		
34817	White	May 16	2200	211	I		
		May 16	2200	219	I/M	Mortality	
		May 16	2200	205	M	Mortality	

Table C3. Continued.

Tag Number	Tag Color	Tagging Date	Time (ADT)	Length (mm)	Sex Age (M/F/I)	Status	Comments
34818	White	May 17	900	246	I		
34819	White	May 17	900	223	I		
34820	White	May 17	900	240	I		
34821	White	May 17	900	220	I		
34822	White	May 17	900	261	N/A		
34823	White	May 17	900	302	M		
34824	White	May 17	900	270	F		
34825	White	May 17	900	254	N/A		
34826	White	May 17	900	257	I		

Total Number of Arctic Grayling = 136
Total Number of Arctic Grayling Tagged = 130

TABLE C4. May 1987, round whitefish fork lengths and weights at Fish Creek.

Date	Time (ADT)	Length (mm)	Weight (gm)	Date	Time (ADT)	Length (mm)	Weight (gm)
May 14	2230	365		May 18	2012	247	
May 15	1820	318		May 18	2012	250	
May 15	1820	375		May 18	2012	309	
May 15	1820	252		May 18	2012	241	
May 15	1820	320		May 18	2012	344	
May 15	2055	388		May 18	2012	247	
May 16	1030	353		May 18	2012	345	
May 16	1030	370		May 18	2012	299	
May 16	1030	359		May 18	2012	322	
May 16	1030	325		May 18	2012	343	
May 16	1030	336		May 18	2213	352	
May 16	1030	379		May 19	909	327	
May 16	1500	357		May 19	909	352	
May 16	1700	313		May 19	909	315	
May 16	1800	349		May 19	909	317	
May 16	1800	348		May 19	909	313	
May 16	1800	327		May 19	909	314	
May 16	2000	319		May 19	909	347	
May 16	2000	357		May 19	909	313	
May 16	2200	338		May 19	1130	245	
May 16	2200	345		May 19	1130	319	
May 16	2200	349		May 19	1130	324	
May 16	2200	330		May 19	1130	312	
May 16	2200	333		May 19	1130	301	
May 16	2200	347		May 19	1130	353	
May 16	2200	366		May 19	1130	352	
May 16	2200	321		May 19	1130	348	
May 16	2200	342		May 19	1130	329	
May 16	2200	350		May 19	1430	340	
May 17	900	338		May 19	1430	338	
May 17	900	364		May 19	1430	318	
May 17	900	358		May 19	1430	353	
May 17	900	322		May 19	1445	320	
May 17	900	358		May 19	1700	328	
May 17	1715	354		May 19	1700	298	
May 17	1715	332		May 19	1700	338	
May 17	1715	319		May 19	1700	296	
May 17	1715	342		May 19	1700	325	
May 17	1715	315		May 19	1700	300	
May 17	1715	298		May 19	1700	287	
May 17	1715	278		May 19	1700	288	
May 17	1715	329		May 19	1800	361	
May 17	2000	361		May 19	1800	364	
May 17	2000	368		May 19	1800	332	
May 17	2000	338		May 19	2020	345	
May 17	2000	308		May 19	2020	352	
May 17	2222	362		May 19	2020	354	
May 17	2229	310		May 19	2020	379	
May 18	818	371		May 19	2020	306	
May 18	818	383		May 19	2020	280	
May 18	1125	370		May 19	2215	357	
May 18	1125	350		May 19	2215	368	
May 18	1125	356		May 19	2215	364	
May 18	1125	330		May 19	2215	265	
May 18	1507	350		May 19	2215	367	
May 18	1706	372		May 19	2215	342	
May 18	1706	370		May 19	2215	354	
May 18	1706	331		May 19	2215	337	
May 18	1706	321		May 19	2215	363	
May 18	1706	318		May 20	930	345	
May 18	1706	332		May 20	930	322	
May 18	2012	238		May 20	930	354	

TABLE C4. Continued.

Date	Time (ADT)	Length (mm)	Weight (gm)	Date	Time (ADT)	Length (mm)	Weight (gm)
May 20	930	353		May 21	1956	303	
May 20	930	371		May 22	915	315	
May 20	930	353		May 22	915	335	
May 20	930	360		May 22	915	302	
May 20	930	370	405	May 22	915	413	
May 20	930	378	330	May 22	915	332	
May 20	930	374	362	May 22	915	354	
May 20	930	319	278	May 22	1400	354	410
May 20	930	319	284	May 22	1400	333	318
May 20	930	338	357	May 22	1400	331	290
May 20	930	346	345	May 22	1400	305	
May 20	930	344	340	May 22	1400	357	
May 20	930	349	374	May 22	1400	291	
May 20	930	337	320	May 22	1945	338	
May 20	930	344	312	May 22	1945	383	
May 20	930	395	505	May 22	1945	320	
May 20	930	273	178	May 22	1945	302	
May 20	1043	351	358	May 22	1945	323	
May 20	1043	357	382	May 22	1945	294	
May 20	1043	363	395	May 23	1025	378	
May 20	1043	350	345	May 23	1025	350	
May 20	1043	330	392	May 23	1025	355	
May 20	1043	325	310	May 23	1025	354	
May 20	1043	334	307	May 23	1025	335	
May 20	1043	332	302	May 23	1025	315	
May 20	1043	340	324	May 23	1025	304	
May 20	1043	348	375	May 23	1025	309	
May 20	1043	346	354	May 23	1025	380	
May 20	1043	337	310	May 23	1025	251	
May 20	1043	281	175	May 23	1540	343	
May 20	1338	395	506	May 24	1000	320	
May 20	1338	334	332	May 24	1000	338	
May 20	1338	353	416	May 24	1000	341	
May 20	1338	335	320	May 24	1000	357	
May 20	1348	316	296	May 24	1000	312	
May 20	2045	357		May 24	1000	342	
May 20	2045	337		May 24	1000	348	
May 20	2045	310		May 24	1000	330	
May 20	2045	312		May 24	1000	310	
May 20	2045	331		May 24	1000	334	
May 20	2045	350		May 24	1000	366	
May 20	2045	378		May 24	1000	330	
May 20	2045	335		May 24	1000	395	
May 20	2045	364		May 24	1000	377	
May 20	2045	328		May 24	1000	335	
May 20	2045	318		May 24	1000	321	
May 20	2045	328		May 25	910	350	
May 20	2045	340		May 25	910	356	
May 21	1000	353		May 25	910	350	
May 21	1000	349		May 25	910	342	
May 21	1000	355		May 25	910	354	
May 21	1000	377		May 25	910	335	
May 21	1000	333		May 25	910	321	
May 21	1000	343		May 25	910	343	
May 21	1000	315		May 25	910	360	
May 21	1052	290		May 25	910	355	
May 21	1645	349		May 25	910	315	
May 21	1645	343		May 25	910	283	
May 21	1645	344		May 25	910	286	
May 21	1645	338		May 25	910	356	
May 21	1645	287		May 25	910	361	
May 21	1956	395		May 25	910	335	
May 21	1956	337		May 25	910	325	

TABLE C4. Continued.

Date	Time (ADT)	Length (mm)	Weight (gm)	Date	Time (ADT)	Length (mm)	Weight (gm)
May 25	910	380					
May 25	910	350					
May 25	910	338					
May 25	910	342					
May 25	910	304					
May 25	910	316					
May 25	910	267					