WILLOW AND DECEPTION CREEKS INSTREAM FLOW DEMONSTRATION STUDY

By

Christopher Estes
Kelly Hepler
Andrew Hoffmann

Alaska Department of Fish and Game
Habitat Protection and Sport Fish Divisions

for the

USDA - Soil Conservation Service
Interagency Cooperative Susitna River
Basin Study (Agreement # 58 04368 16)

1981

Volume One

WILLOW AND DECEPTION CREEKS INSTREAM FLOW DEMONSTRATION STUDY

By

Christopher Estes
Kelly Hepler
Andrew Hoffmann

Alaska Department of Fish and Game
Habitat Protection and Sport Fish Divisions

for the

USDA - Soil Conservation Service
Interagency Cooperative Susitna River
Basin Study (Agreement # 58 04368 16)

1981

Volume One

VOLUME ONE
TABLE OF CONTENTS

TABLE OF CONTENTS-continued

LIST OF FIGURES

LIST OF FIGURES-continued

LIST OF TABLES

INTRODUCTION

INTRODUCTION

This study was undertaken by the Alaska Department of Fish and Game (ADF&G), as part of the ongoing Susitna River Basin Study (Estes and Lehner-Welch 1980), to:

1. evaluate the feasibility of applying the Incremental Methodology* procedures of the U.S. Fish and Wildlife Service (USFWS) Instream Flow Group (IFG) to collect and analyze instream flow** data from Willow and Deception Creeks (Figure 1); and

2. augment baseline fishery studies conducted on Willow and Deception Creeks by the ADF&G in 1978 (Watsjold and Engel 1978).

The 1978 studies provided preliminary information on fish species composition, areas of fish spawning and rearing, aquatic habitat characteristics, and recreational angling. They did not, however, address instream flow requirements of the fishery resources in these two systems.***

---

*"The Incremental Methodology is based on the premise that the suitability of a species' habitat can be described by measuring selected physical variables in the stream, making it possible to quantify the changes in habitat suitability by quantifying the changes in these instream variables" (IFG 1980a).

**An instream flow is the quantity of flow occurring within a stream channel during a given period of time whether or not subject to flow regulation.

***A discussion of the importance of instream flows to fish and wildlife resources is presented in the ADF&G publication: A synthesis and evaluation of fish and wildlife resources information for the Willow and Talkeetna Sub-basins (Estes and Lehner-Welch 1980).

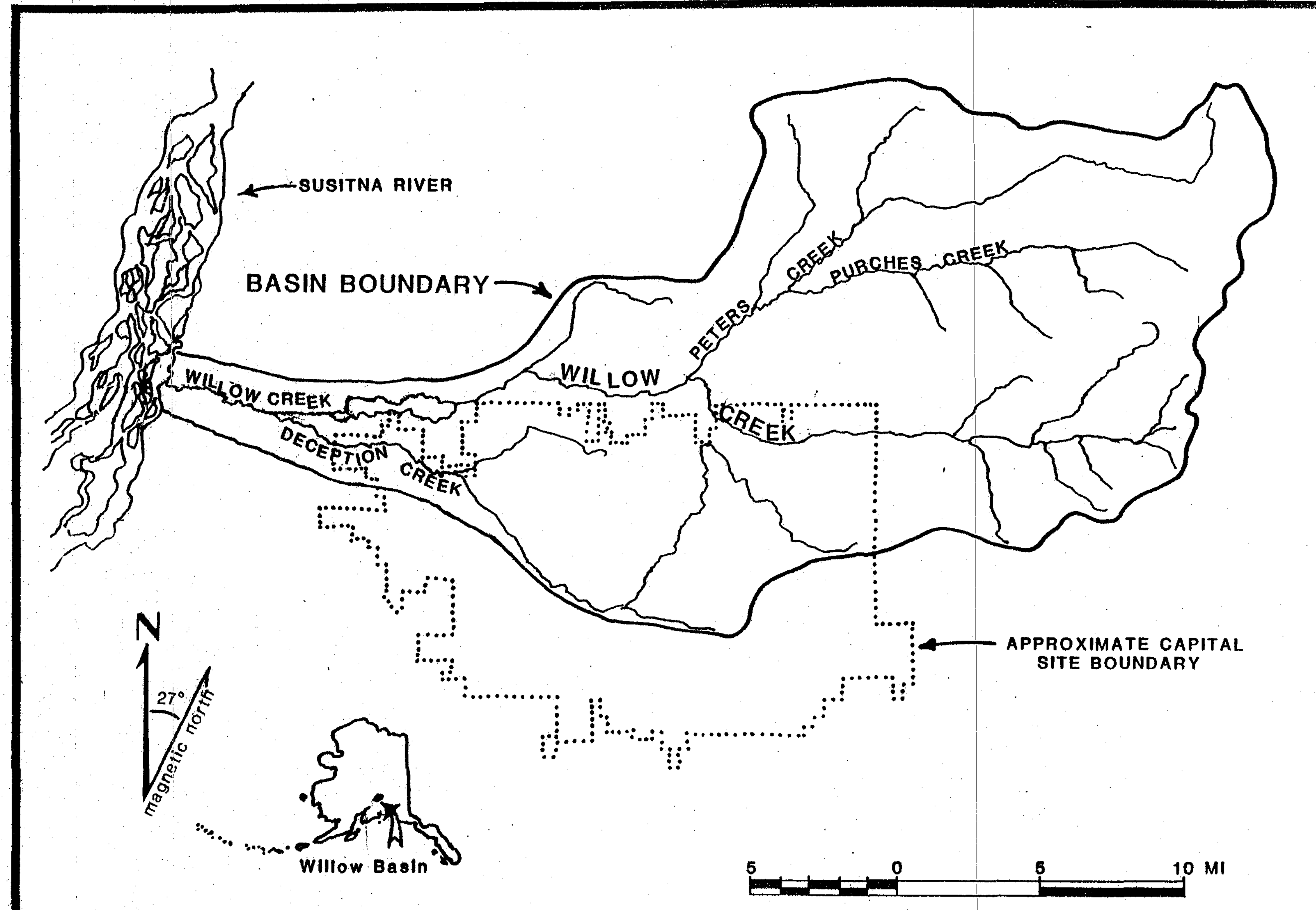


Figure 1. Study area.

The ADF&G, with the assistance of the U.S Department of Agriculture Soil Conservation Service (SCS), U.S. Geological Survey (USGS), and Alaska Department of Natural Resources (ADNR), initiated both portions of this study in the spring of 1979. The ADF&G, USGS, and ADNR continued collecting supplemental data through the fall of 1980. Computer analysis of the instream flow data collected from Willow Creek was completed in December 1980. Additional analysis, comparing computer analysis techniques and the effects of integrating spawning habitat data collected by other investigators (Watsjold and Engel 1978; AEIDC 1980) with the Willow Creek hydraulic model, was completed in February 1981. Funding for this study was provided by the SCS through the Interagency Cooperative Susitna River Basin Study, the ADF&G, and a Title III grant from the U.S. Water Resources Council administered by the Division of Land and Water Management of the ADNR.

Willow Creek is one of the major recreational waters within the Upper Cook Inlet Drainage. It is located within 2 hours driving distance from Anchorage, the major population center of Alaska, and receives extensive angling effort by sport fishermen. The high productivity and variety of fish species, and the high angler success rate make Willow Creek one of the most important sport fisheries in the lower Susitna Basin (Mills 1981). Willow Creek also serves as an access corridor to other fishing and hunting areas within the Susitna River drainage and is used extensively by boaters for this purpose.

Major land use activities (e.g., mining and residential development) are occurring in the Willow Creek drainage. A portion of this area has been selected as the future site for the new State Capital (Figure 1). This report is an attempt to evaluate one of the tools for assessing the ability of the fishery resources to withstand these varied impacts. It is intended also to provide interested agencies, planners, managers, developers, and individuals with baseline fishery, hydraulic, and water quality information. These data, with subsequent investigations, can be used to evaluate the potential impacts of future developments proposed for this area.

OBJECTIVES

OBJECTIVES

Instream Flow Study

Six study objectives were established:

1. train personnel to collect and analyze instream flow data based on the IFG Incremental Methodology;

2. develop cross-sectional profiles in selected areas of Willow and Deception Creeks and characterize the types and amounts of salmon habitat available in terms of depth, velocity, and substrate characteristics.

3. determine spawning habitat characteristics for pink (*Oncorhynchus gorbuscha*), and chinook (*O. tshawytscha*) salmon in selected areas of Willow and Deception Creeks;*

4. determine characteristics of chinook salmon rearing habitats;

5. compute the availability of salmon habitat at various streamflows using the IFG computer programs; and

---

*The selection of these species was based on their relative abundance.

6. evaluate the feasibility of applying the Incremental Methodology to Willow and Deception Creeks.

Supplemental Biological, Water Quantity and Quality Study

Objectives of these investigations were to:

1. identify fish populations in Peters and Purches Creeks (tributaries to Willow Creek);

2. identify water quantity and quality characteristics associated with fish populations observed in Peters and Purches Creeks; and

3. collect miscellaneous water quantity and quality data in the upper Willow Creek drainage.

DESCRIPTION OF STUDY AREA

DESCRIPTION OF THE STUDY AREA

The study area is located within the 214-square-mile Willow Creek drainage (Figure 1) in the southwestern foothills of the Talkeetna Mountains. Elevations in this area range from approximately 5,500 feet mean sea level (MSL) in the upper portion of the watershed to 100 feet MSL at the confluence of Willow Creek with the Susitna River.

Approximately 25 percent of the study area is part of a 100-square mile site selected by Alaskan voters as the location for a new State Capital. The remainder of the study area adjoins Willow Creek both upstream and downstream of its confluence with Deception Creek. The portion of the study area that is contained within the proposed Capital site is owned almost entirely by the State of Alaska and is virtually undeveloped. Lands adjacent to Willow Creek, however, are in private or Borough ownership and have been developed to a limited extent. In recent years, the Willow Creek drainage has become a focal point for increasing recreational activities (e.g., fishing, hunting, boating, hiking, cross-country skiing, and snowmobiling) primarily because of the area's aesthetic qualities and its proximity to Anchorage. This increased recreational use, along with speculation on land in the Capital Site proximity, have led to tremendous increases in the rate of development, especially of recreational lots in the Willow Creek area.

Instream Flow Study Reaches

Four reaches were selected for the collection of instream flow, water quality, and supporting biological data (Figure 2; Table 1). Three of these were located on Willow Creek and the fourth on Deception Creek.

Table 1. Geographic locations of Willow/Deception Creeks Instream Flow Study reaches (Figure 2).*

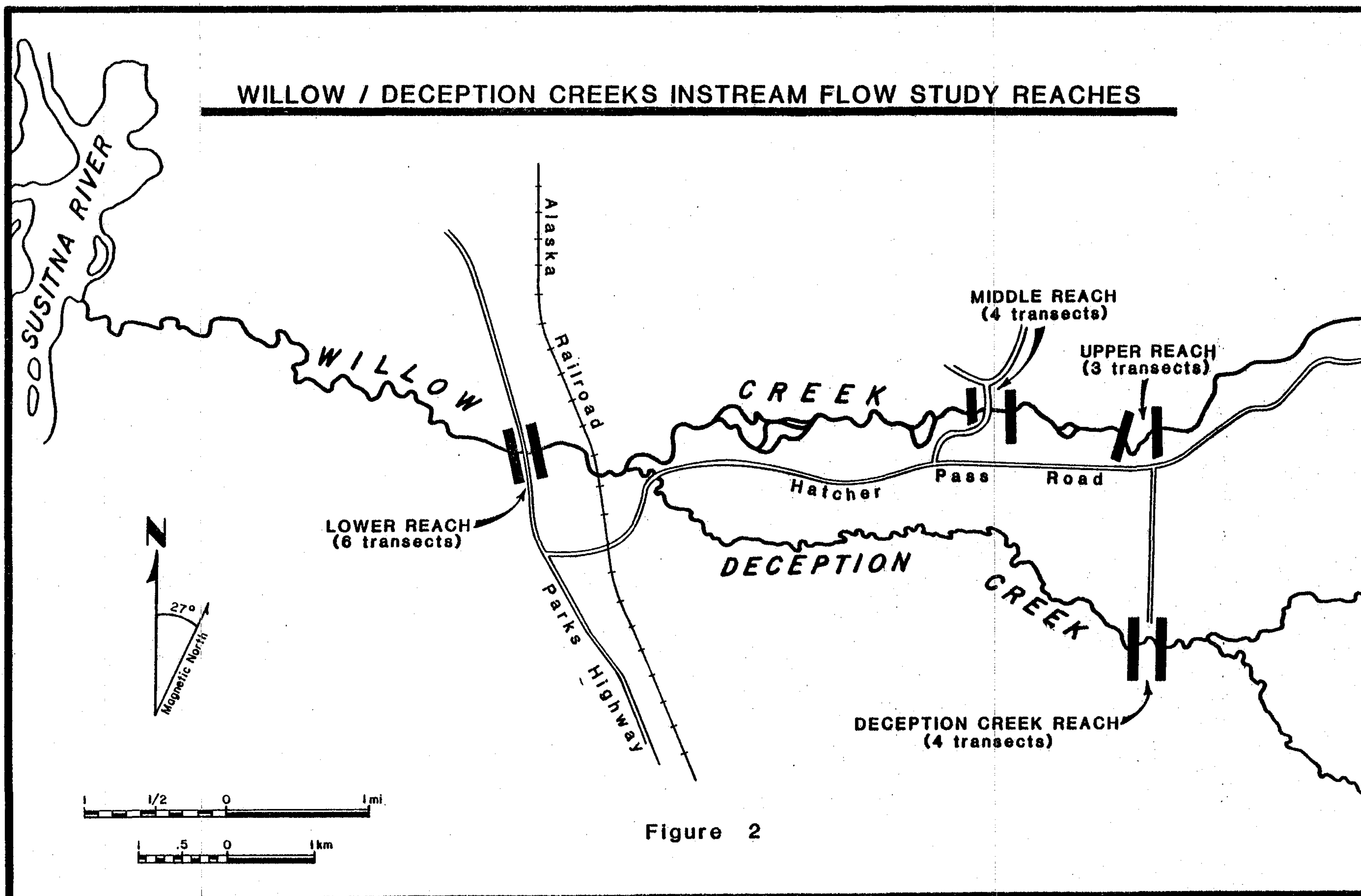
Reach	ADF&G Geographic Location
Lower Willow	19N04W06ACD6
Middle Willow	19N04W02BBC4
Upper Willow	19N04W02ADC3
Deception	19N04W11DAA4

*Refer to Methods section for a description of the ADF&G Geographic Location System.

Descriptions of study reaches follow:

1. The lower Willow Creek reach was located at the Parks Highway Bridge. Six transects were established within this reach which

*Refer to Methods section for a description of reach selection techniques.



WILLOW / DECEPTION CREEKS INSTREAM FLOW STUDY REACHES
SUSITNA RIVER
WILLOW
CREEK
Alaska
Railroad
Parks Highway
Hatcher Pass Road
DECEPTION
CREEK
MIDDLE REACH
(4 transects)
UPPER REACH
(3 transects)
LOWER REACH
(6 transects)
DECEPTION CREEK REACH
(4 transects)
N
27°
Magnetic North
1 1/2 0 1 mi
1 .5 0 1 km

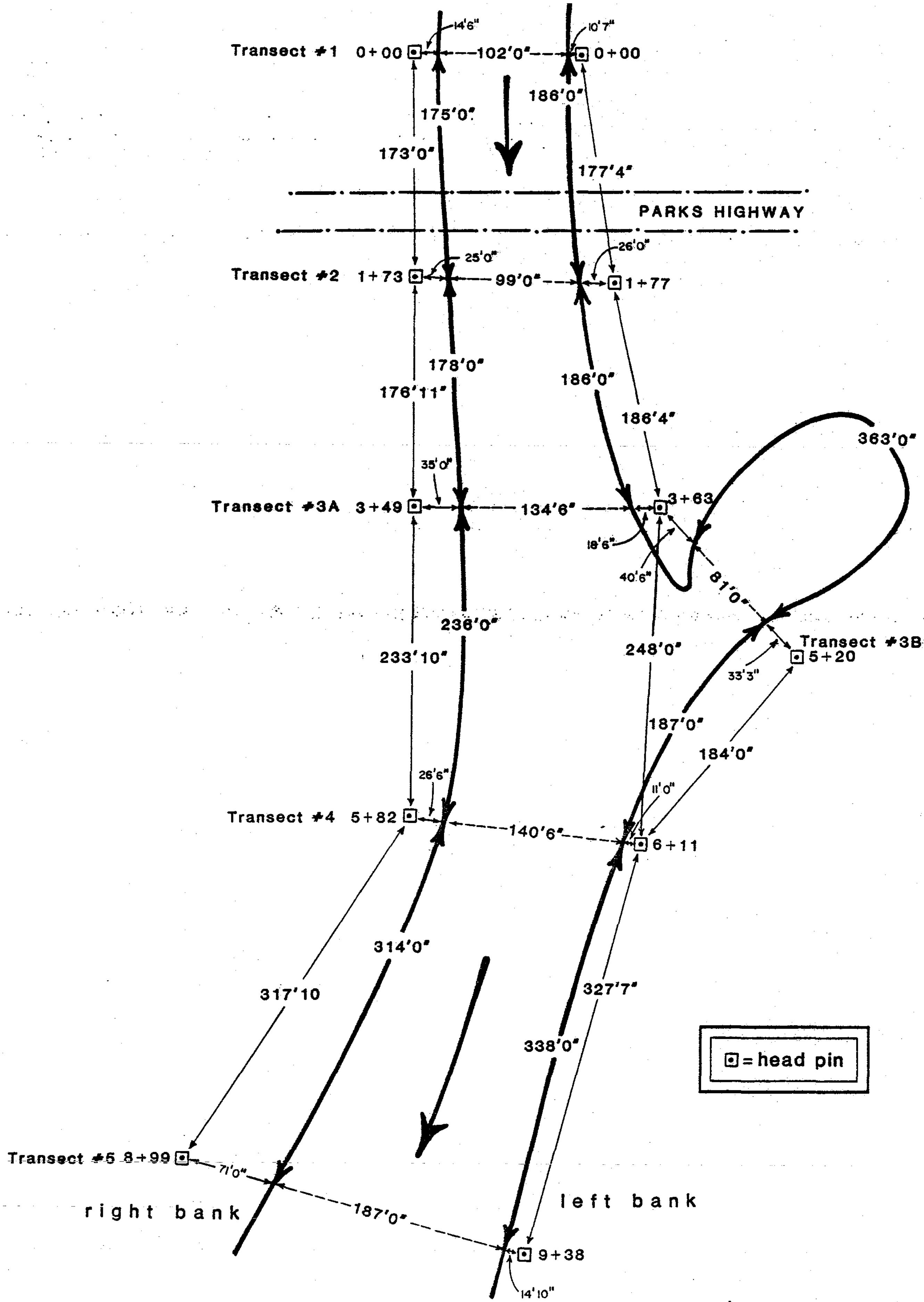
Figure 2

was channelized in 1963 to permit construction of the Parks Highway Bridge (Figures 3-9). Major pink salmon spawning areas are located throughout this reach.

2. The middle reach was located 4.5 road miles upstream from the Parks Highways Bridge. Four transects were established within this reach (Figures 10-14). Both chinook and pink salmon use this area for spawning.

3. The upper Willow Creek reach was located 5.5 road miles upstream from the Parks Highway bridge on a large bend of a braided portion of Willow Creek. This reach was confined to the southernmost channel adjacent to the left bank (looking downstream) and thus represents only a portion of the flow for this stretch of Willow Creek. Three transects were established within this reach (Figures 15-18). A USGS gaging station (No. 152940.05) was located approximately 1 mile upstream of this braided stretch of river. Chinook salmon are the predominant species which utilize this reach for spawning.

4. The Deception Creek reach was located immediately downstream of a USGS gaging station (No. 152940.10). Four transects were established within this reach (Figures 19-23). Coho (Oncorhynchus kisutch), chinook, and pink salmon spawn in this area.

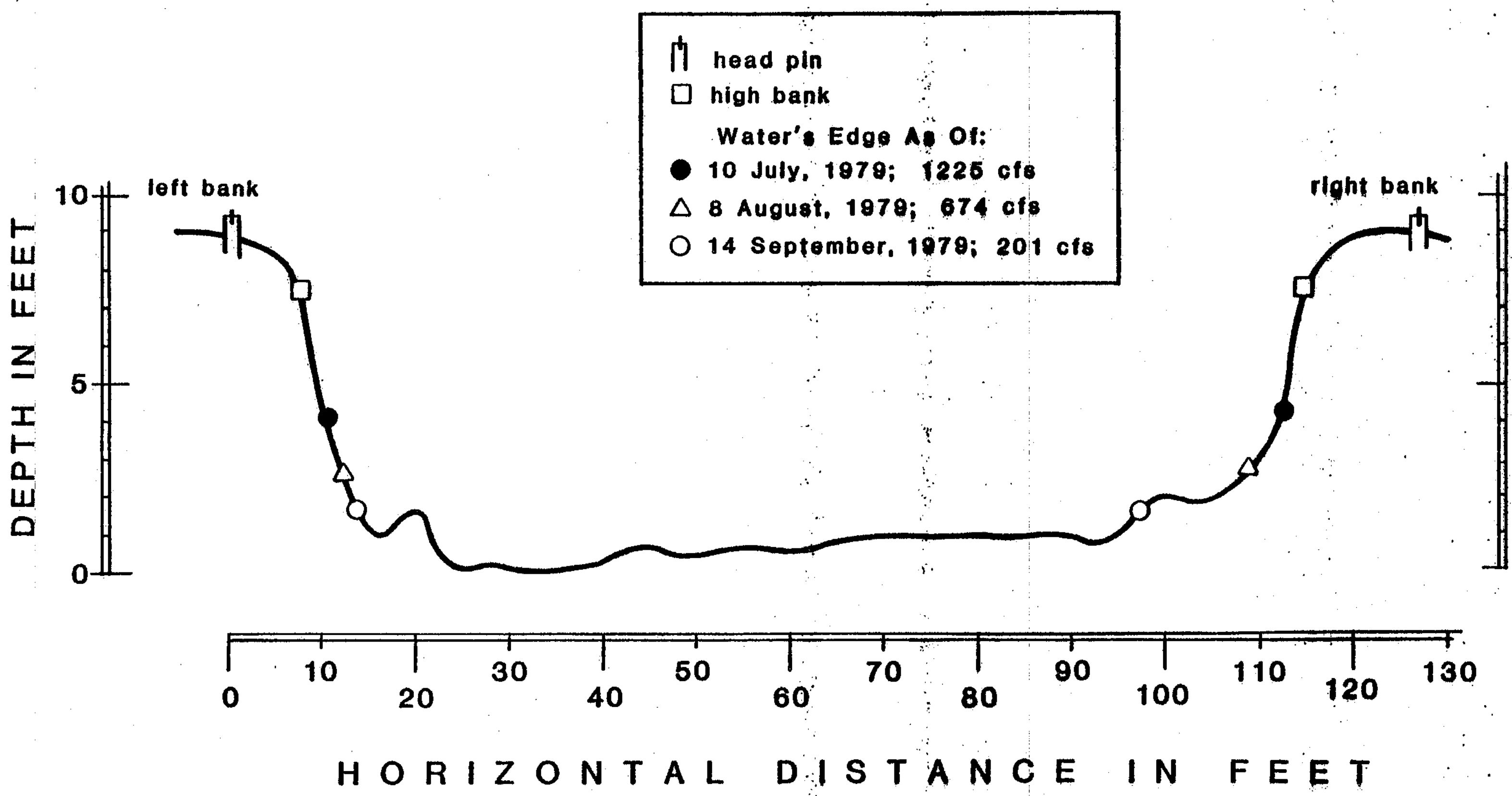


(scale approximate)

LOWER WILLOW CREEK WATER'S EDGE & HEAD PIN STATIONING MAP
13 July, 1979
Average discharge 1163 cfs

Figure 3

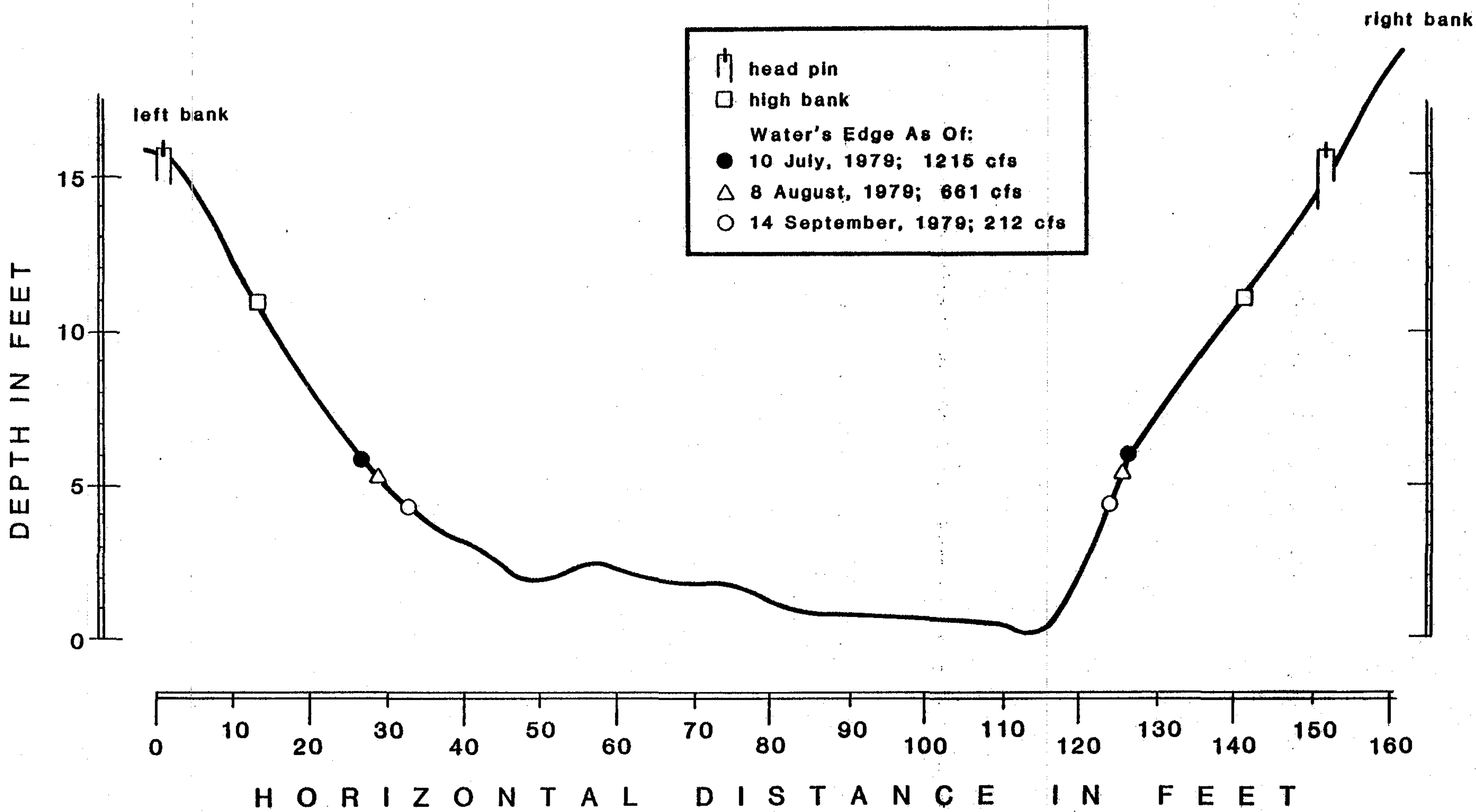
Figure 4



CROSS-SECTIONAL PROFILE OF WILLOW CREEK LOWER REACH, TRANSECT #1.

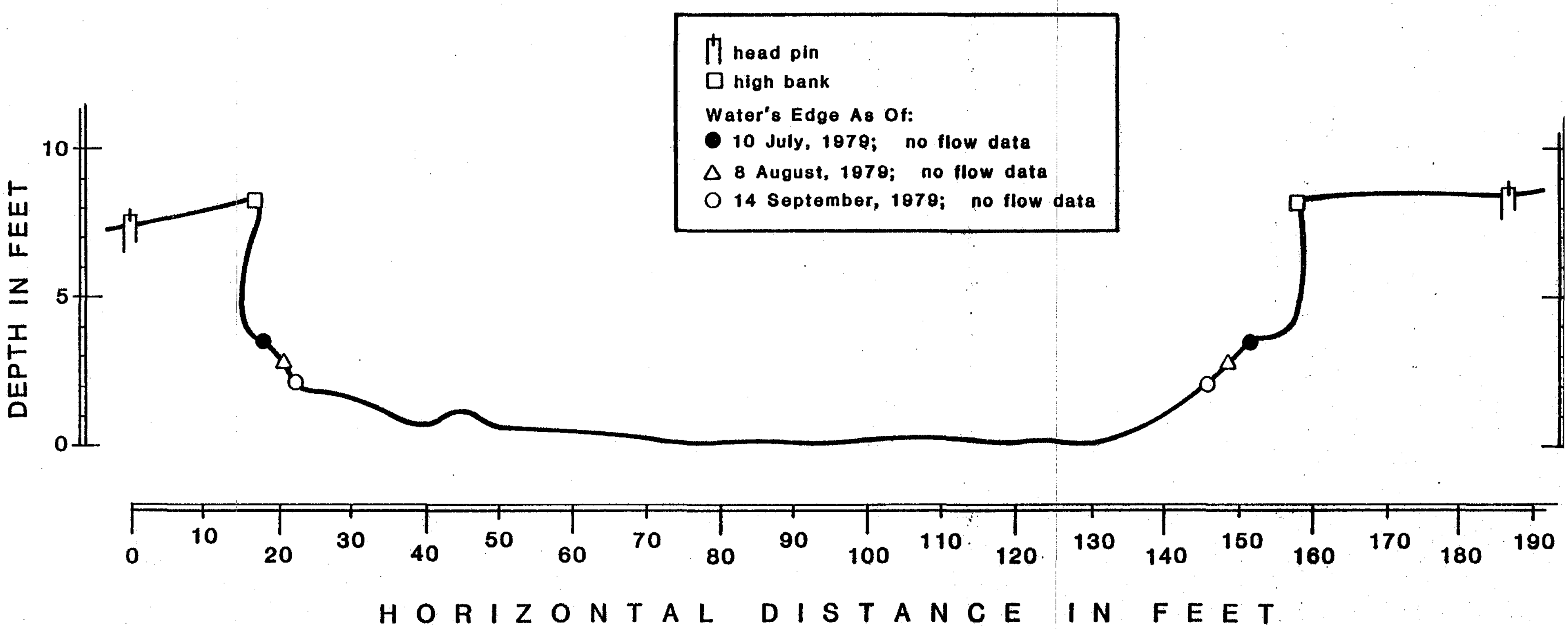
(1 vertical foot equals 4 horizontal feet)

Figure 5



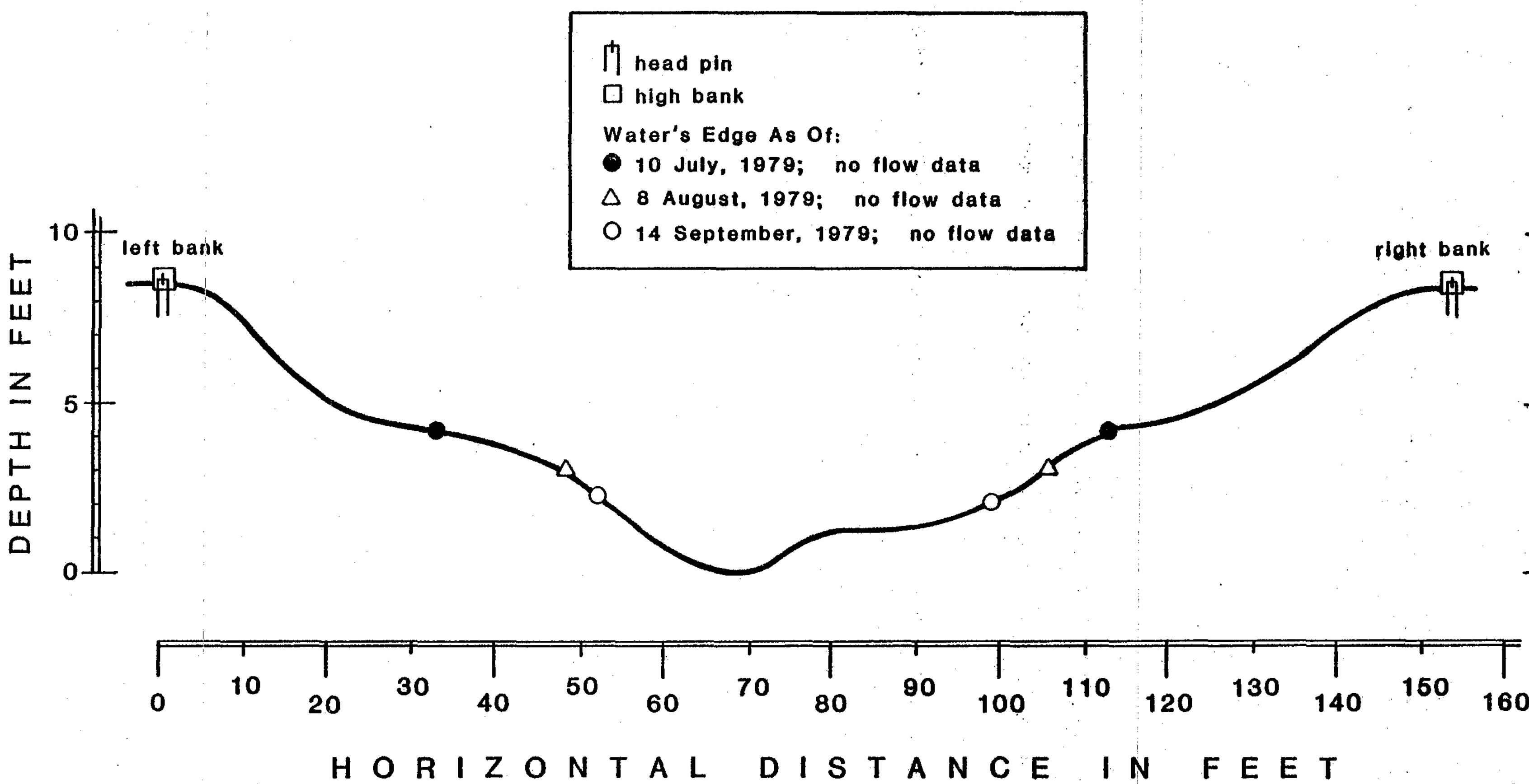
CROSS-SECTIONAL PROFILE OF WILLOW CREEK LOWER REACH, TRANSECT #2.
(1 vertical foot equals 4 horizontal feet)

Figure 6



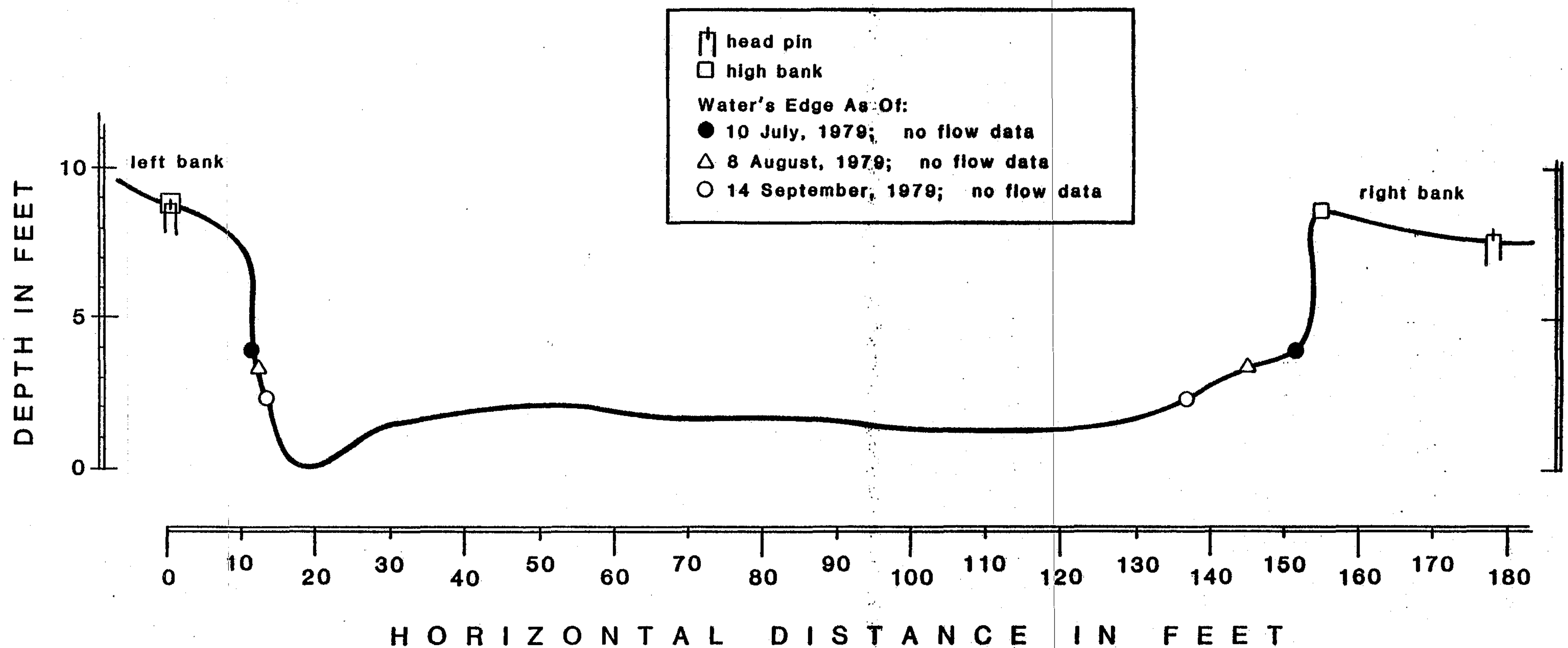
CROSS-SECTIONAL PROFILE OF WILLOW CREEK LOWER REACH, TRANSECT #3A.
(1 vertical foot equals 4 horizontal feet)

Figure 7



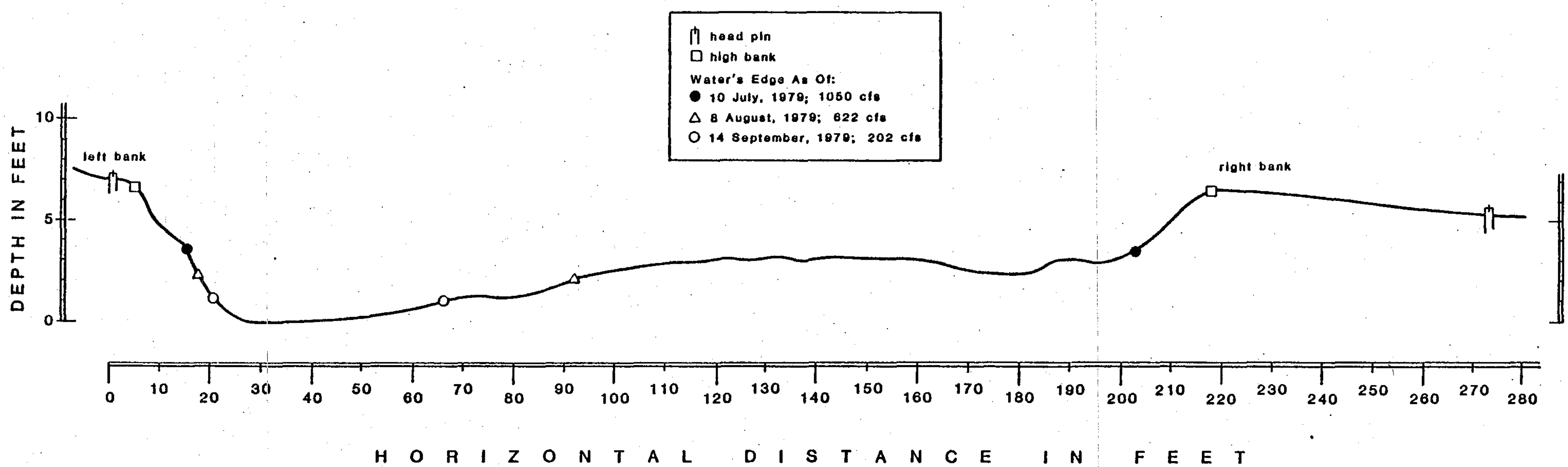
CROSS-SECTIONAL PROFILE OF WILLOW CREEK LOWER REACH, TRANSECT #3B.
(1 vertical foot equals 4 horizontal feet)

Figure 8

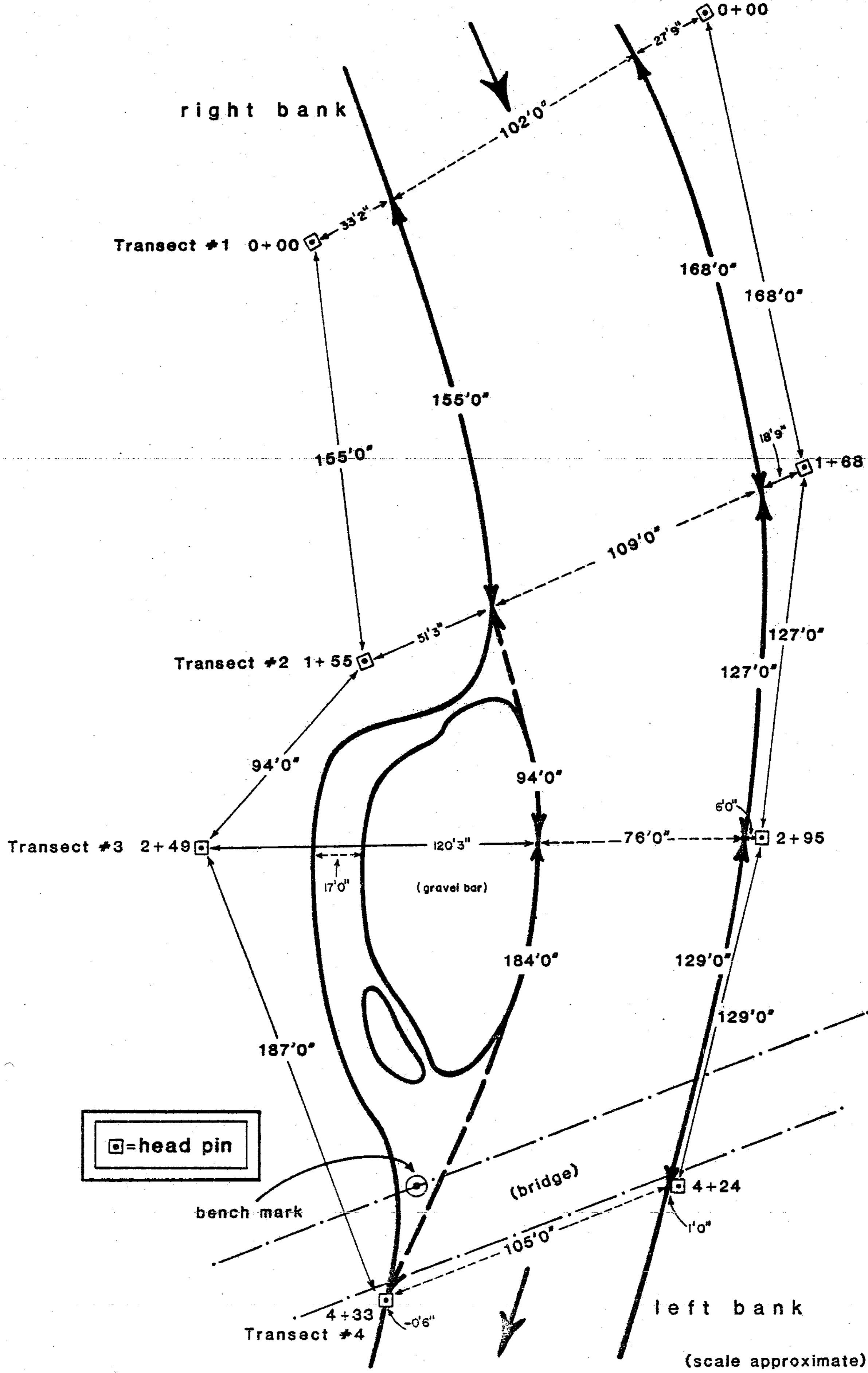


CROSS-SECTIONAL PROFILE OF WILLOW CREEK LOWER REACH, TRANSECT #4.
(1 vertical foot equals 4 horizontal feet)

Figure 9

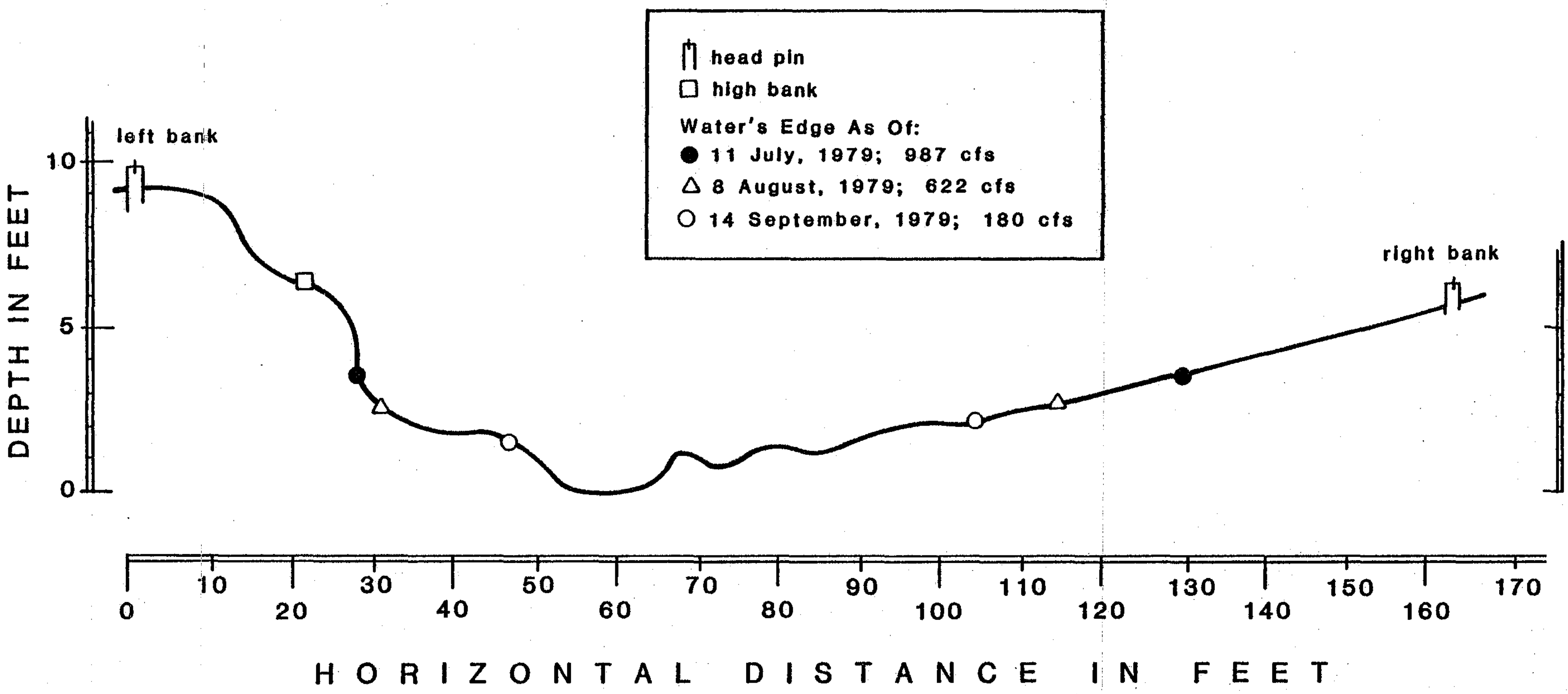


CROSS-SECTIONAL PROFILE OF WILLOW CREEK LOWER REACH, TRANSECT #5.
(1 vertical foot equals 4 horizontal feet)



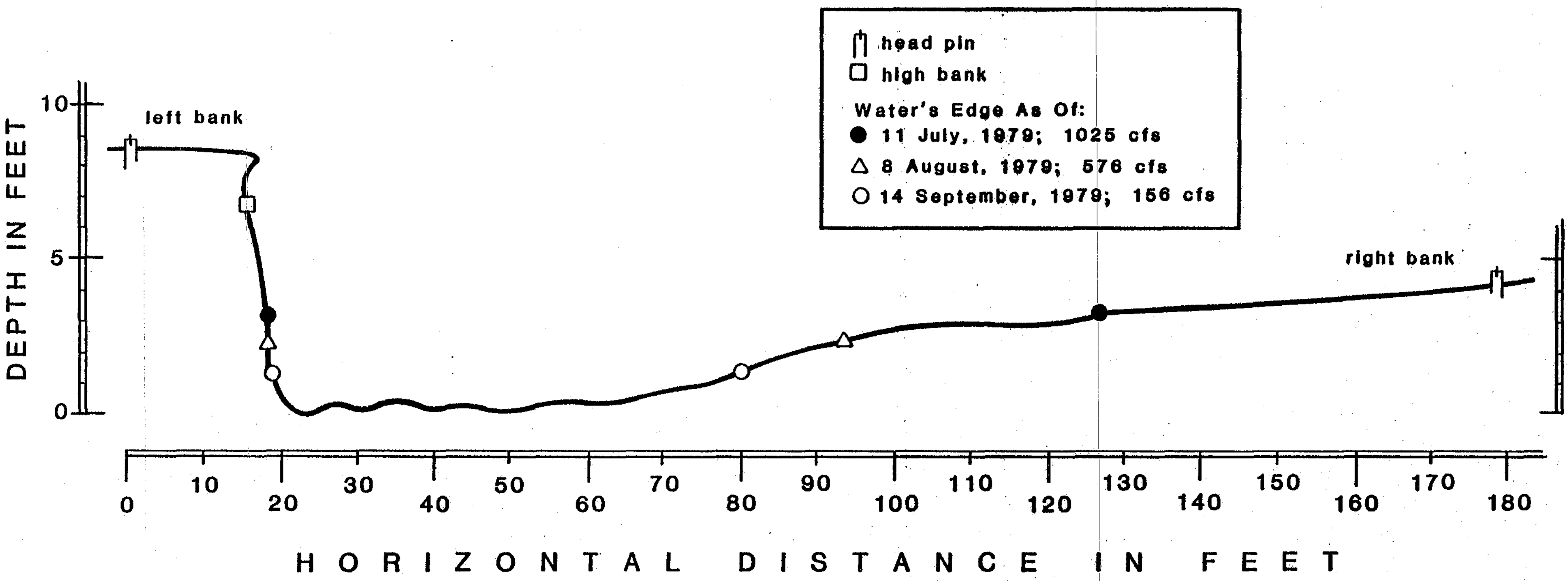
MIDDLE WILLOW CREEK WATER'S EDGE & HEAD PIN STATIONING MAP
11 July, 1979
Average discharge 990 cfs
Figure 10

Figure 11



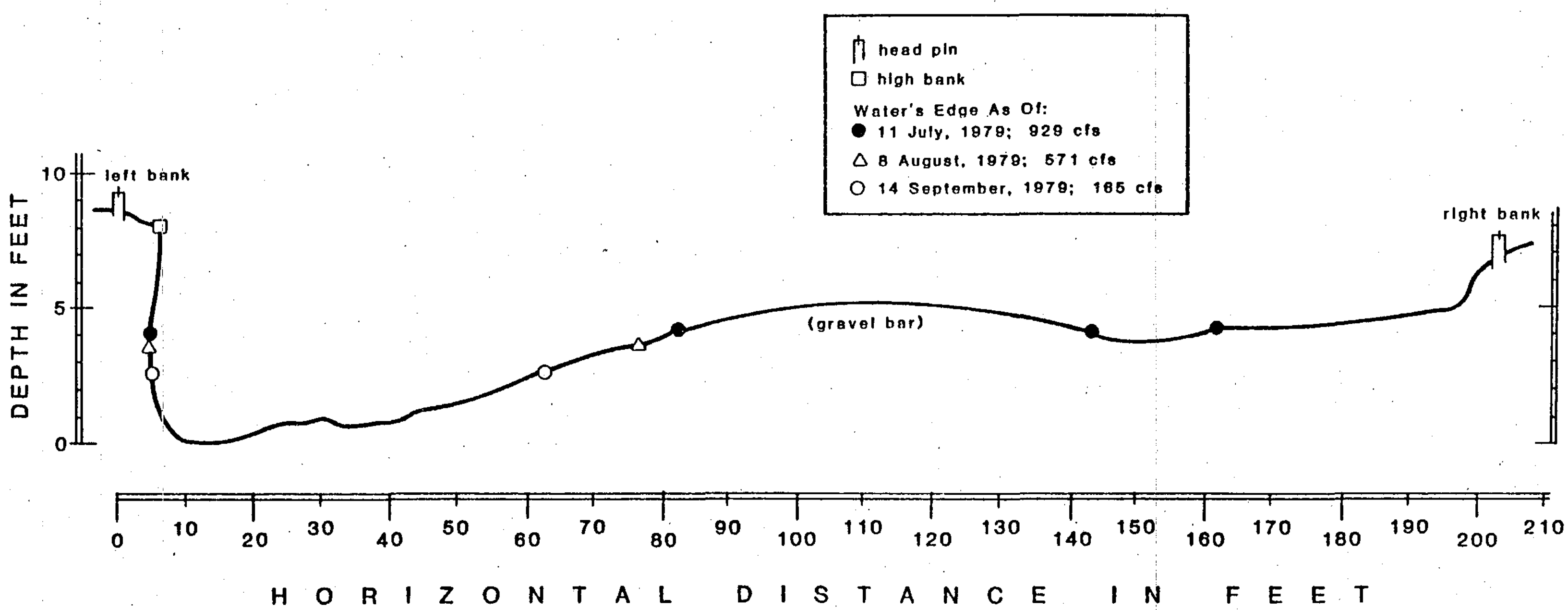
CROSS-SECTIONAL PROFILE OF WILLOW CREEK MIDDLE REACH, TRANSECT #1.
(1 vertical foot equals 4 horizontal feet)

Figure 12



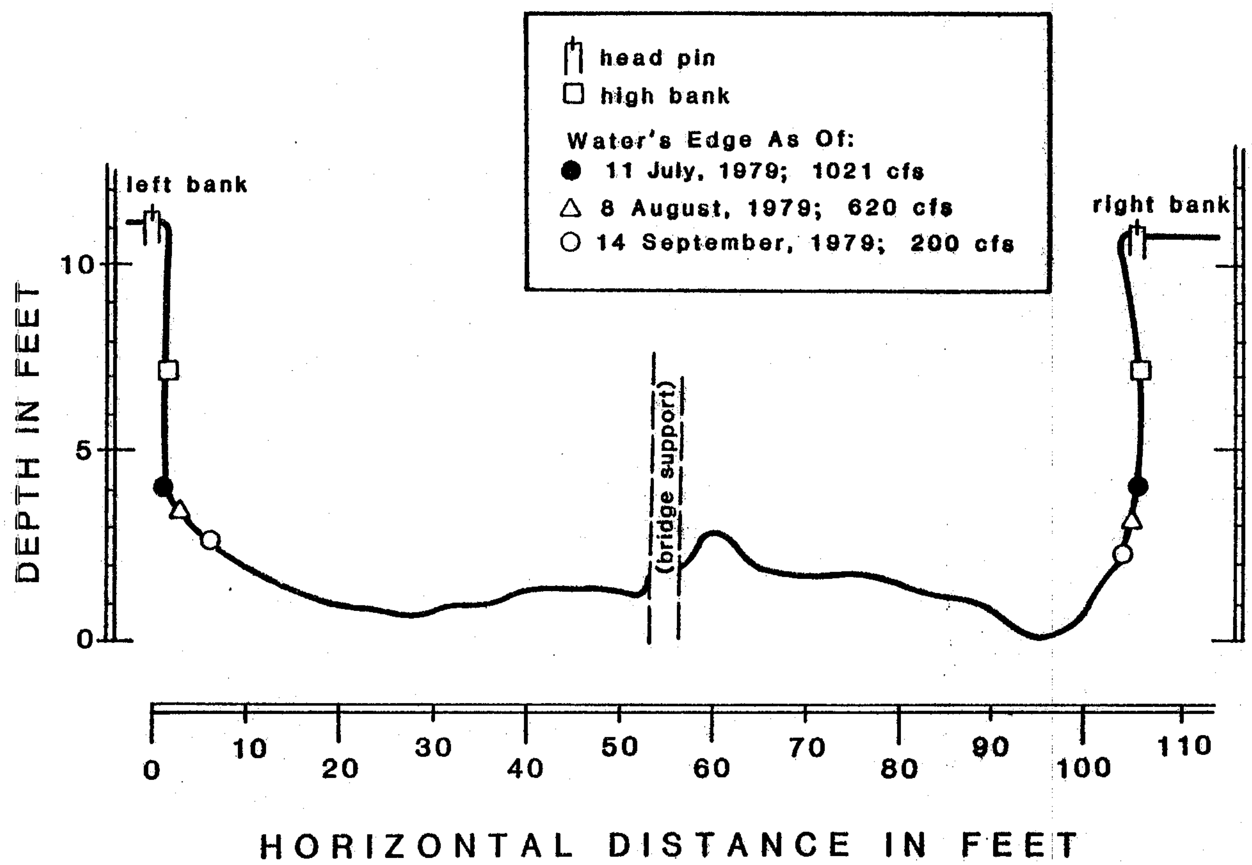
CROSS-SECTIONAL PROFILE OF WILLOW CREEK MIDDLE REACH, TRANSECT #2.
(1 vertical foot equals 4 horizontal feet)

Figure 13

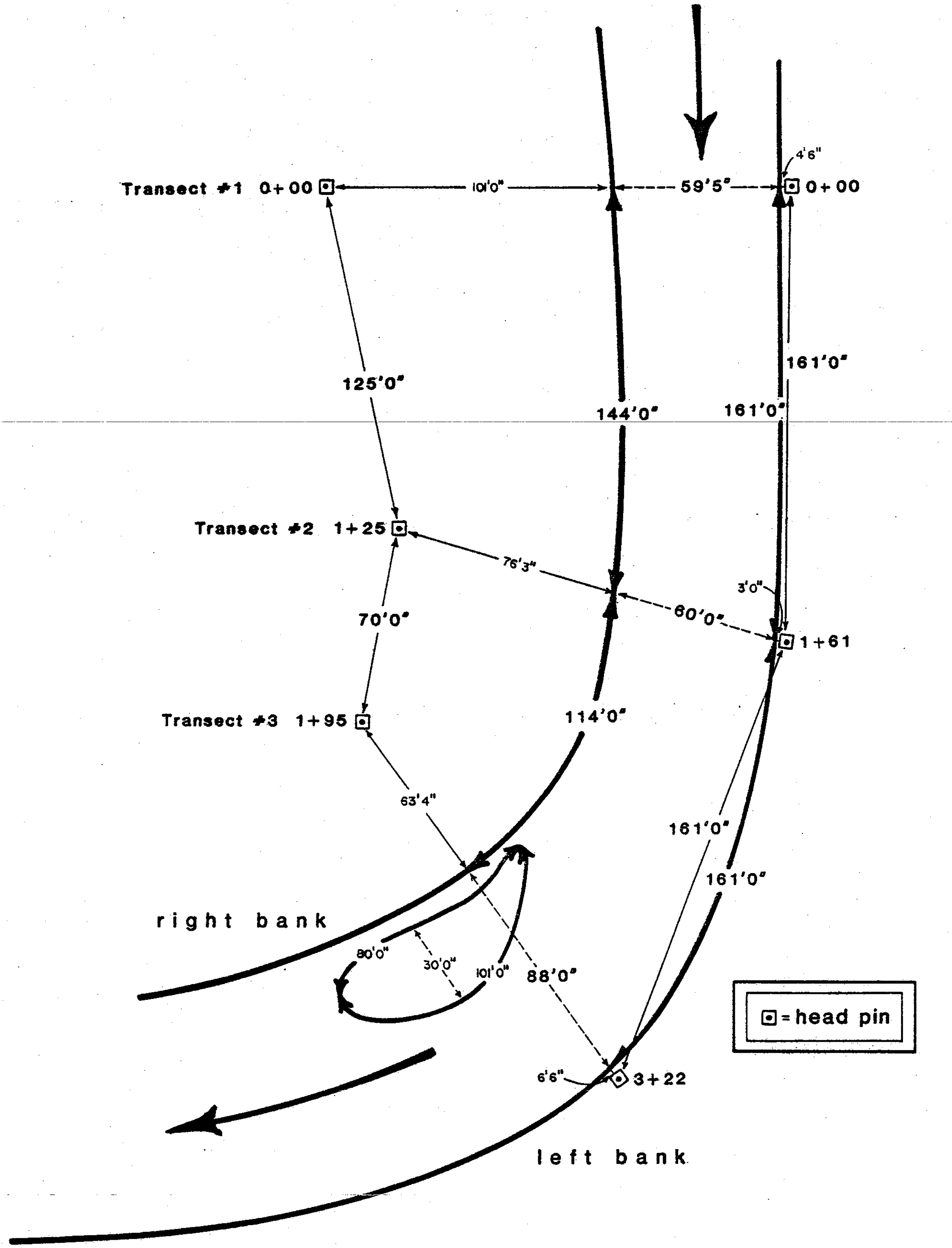


CROSS-SECTIONAL PROFILE OF WILLOW CREEK MIDDLE REACH, TRANSECT #3.
(1 vertical foot equals 4 horizontal feet)

Figure 14



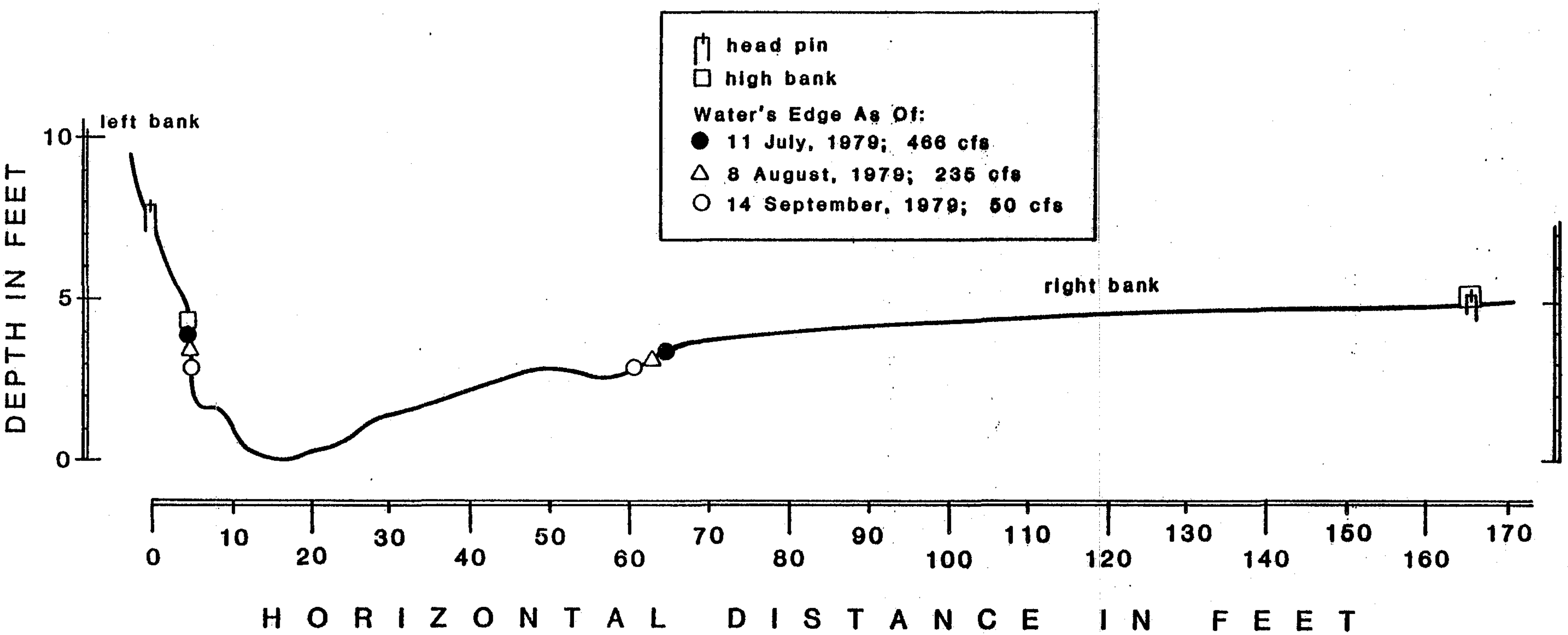
CROSS-SECTIONAL PROFILE OF WILLOW CREEK MIDDLE REACH, TRANSECT #4.
(1 vertical foot equals 4 horizontal feet)



UPPER WILLOW CREEK WATER'S EDGE & HEAD PIN STATIONING MAP
11 July 1979
Average discharge 476 cfs

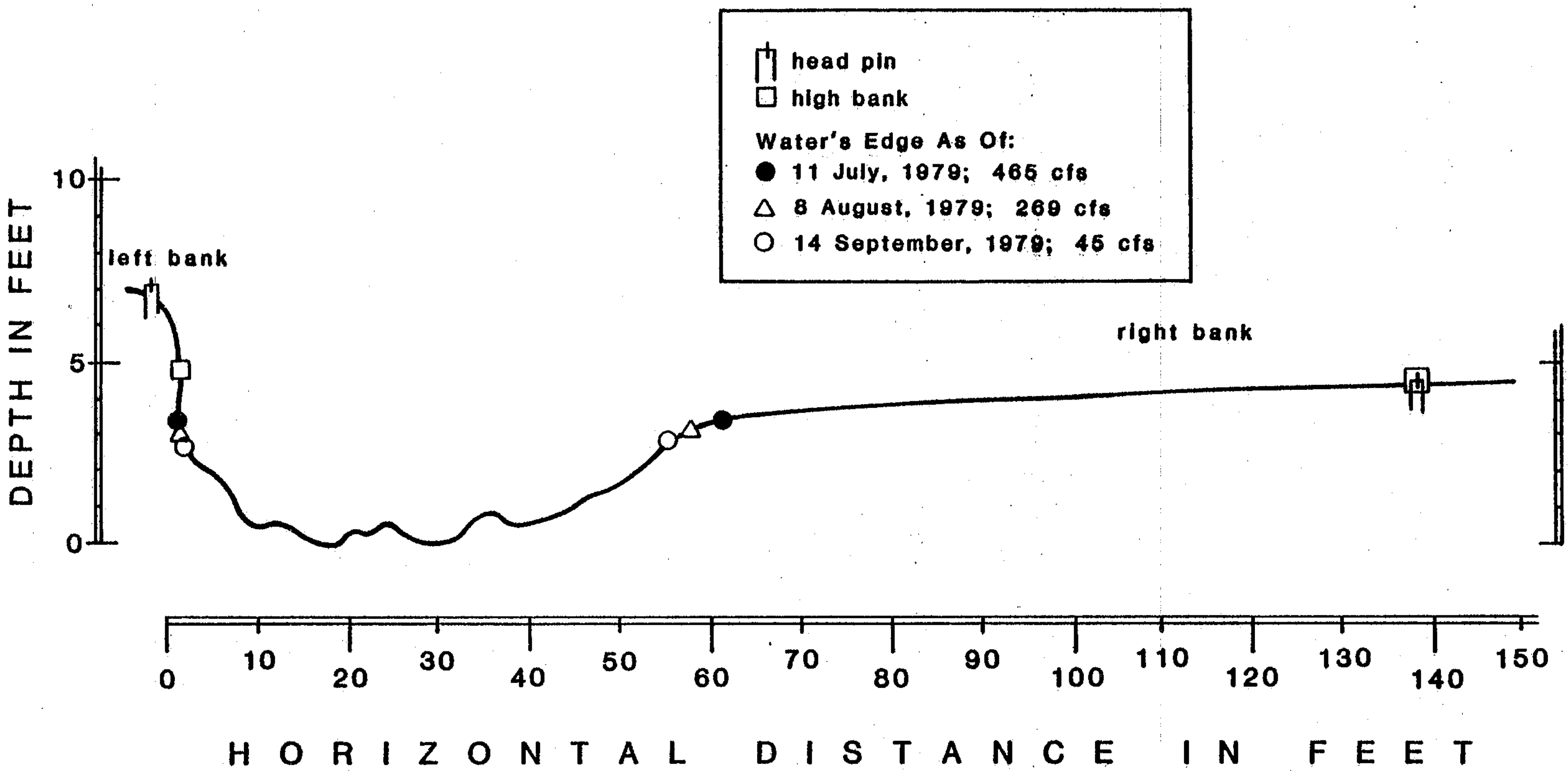
Figure 15

Figure 16



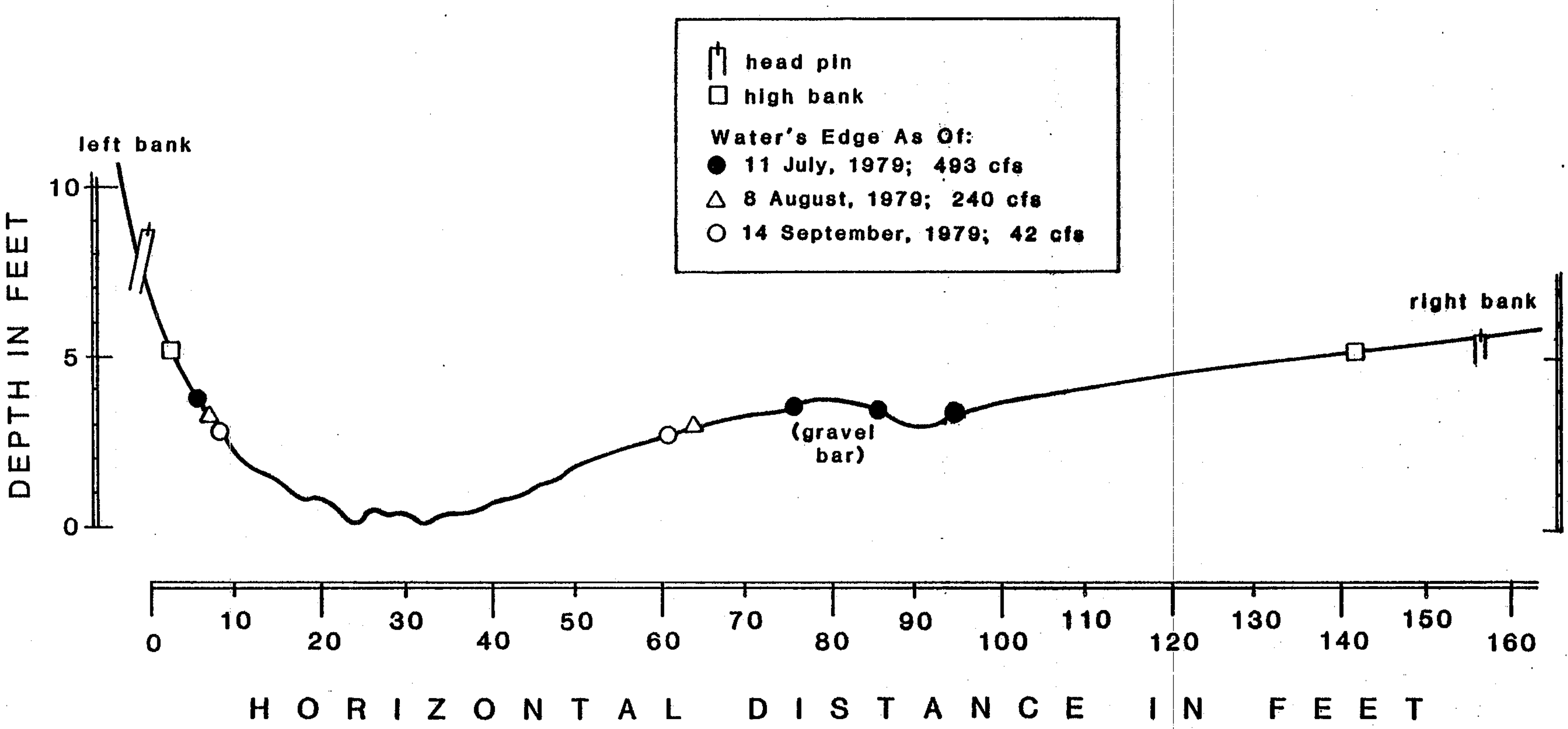
CROSS-SECTIONAL PROFILE OF WILLOW CREEK UPPER REACH, TRANSECT #1.
(1 vertical foot equals 4 horizontal feet)

Figure 17

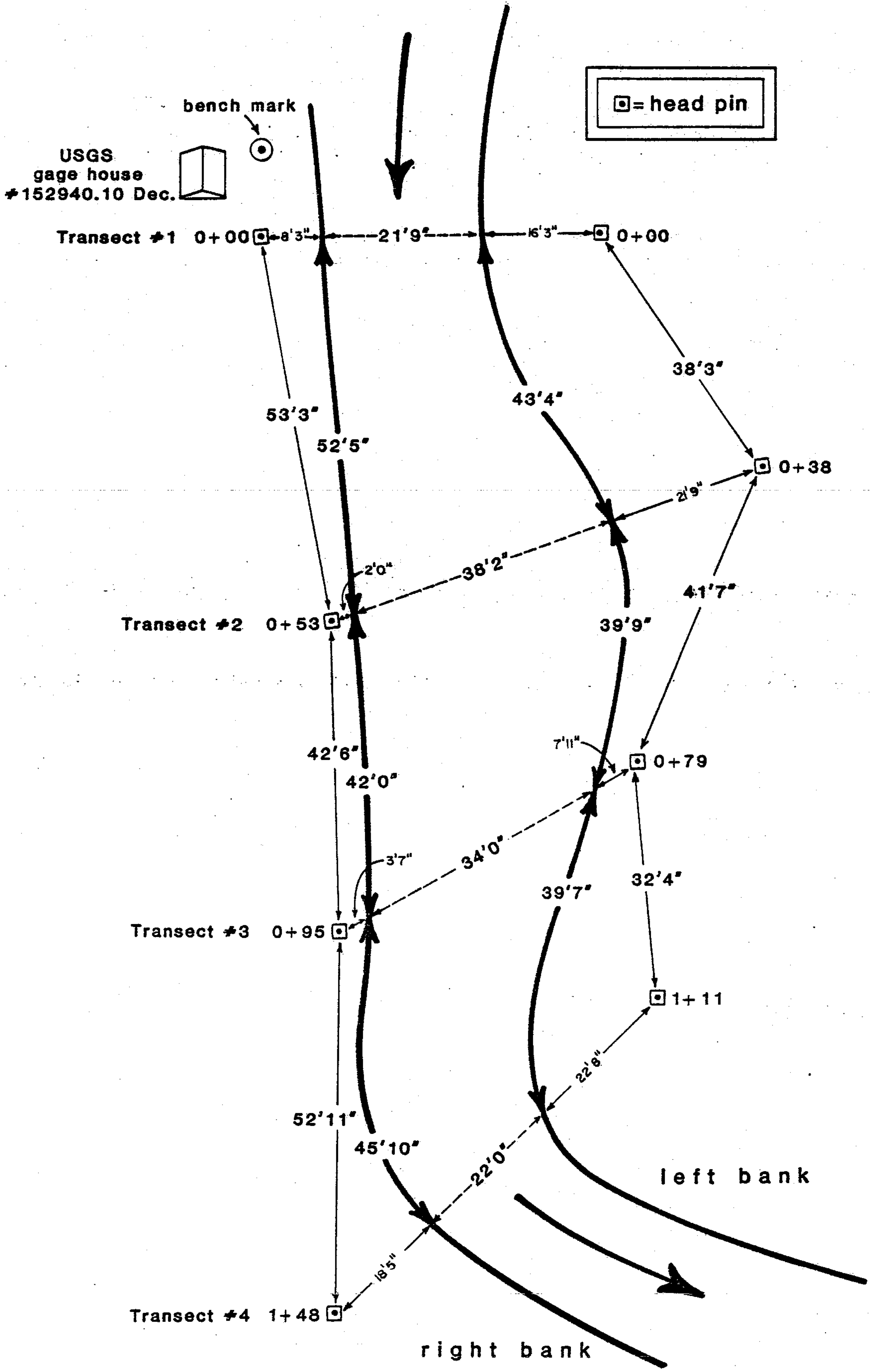


CROSS-SECTIONAL PROFILE OF WILLOW CREEK UPPER REACH, TRANSECT #2.
(1 vertical foot equals 4 horizontal feet)

Figure 18



CROSS-SECTIONAL PROFILE OF WILLOW CREEK UPPER REACH, TRANSECT #3.
(1 vertical foot equals 4 horizontal feet)



(scale approximate)

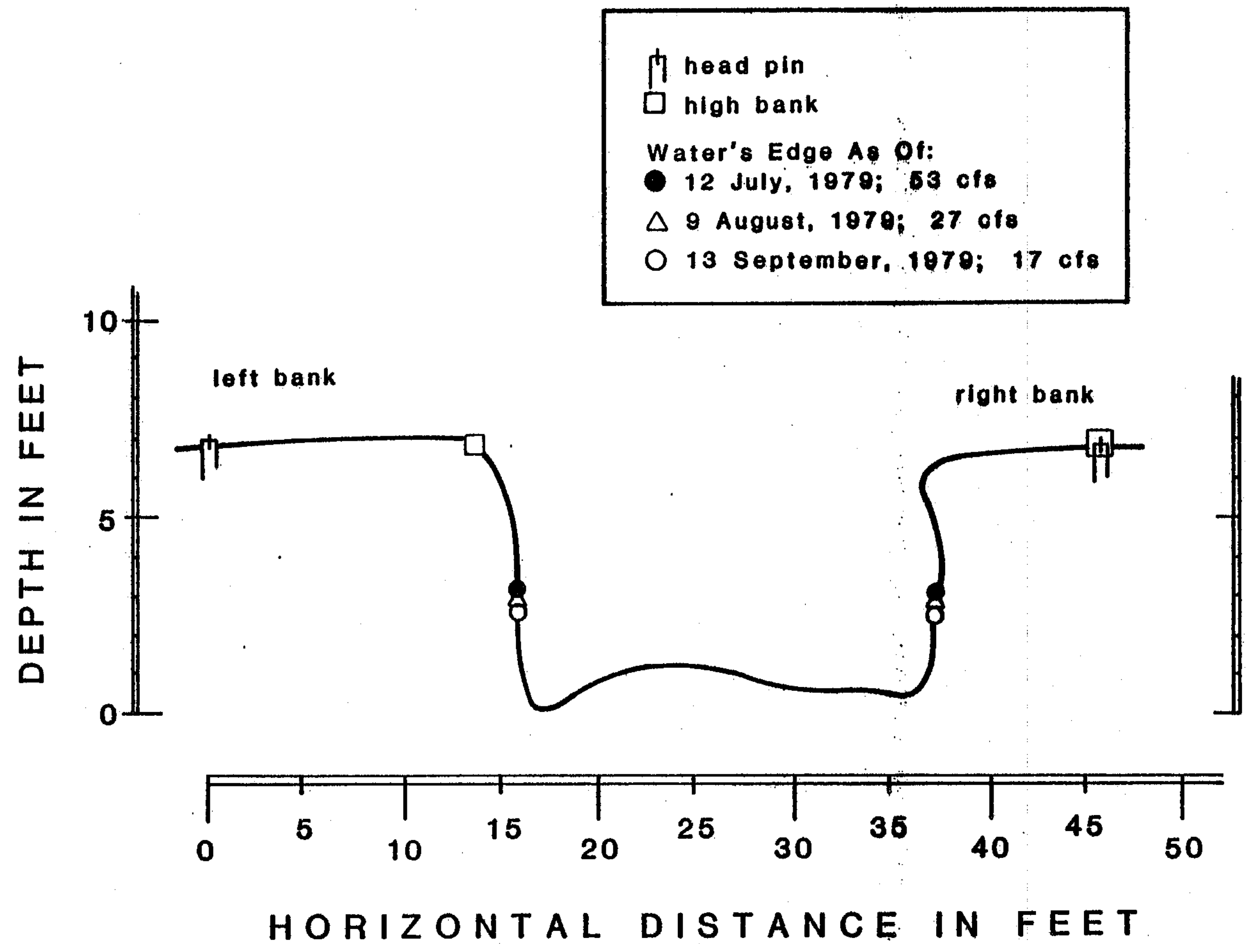
DECEPTION CREEK WATER'S EDGE & HEAD PIN STATIONING MAP

12 July, 1979

Average discharge 57 cfs

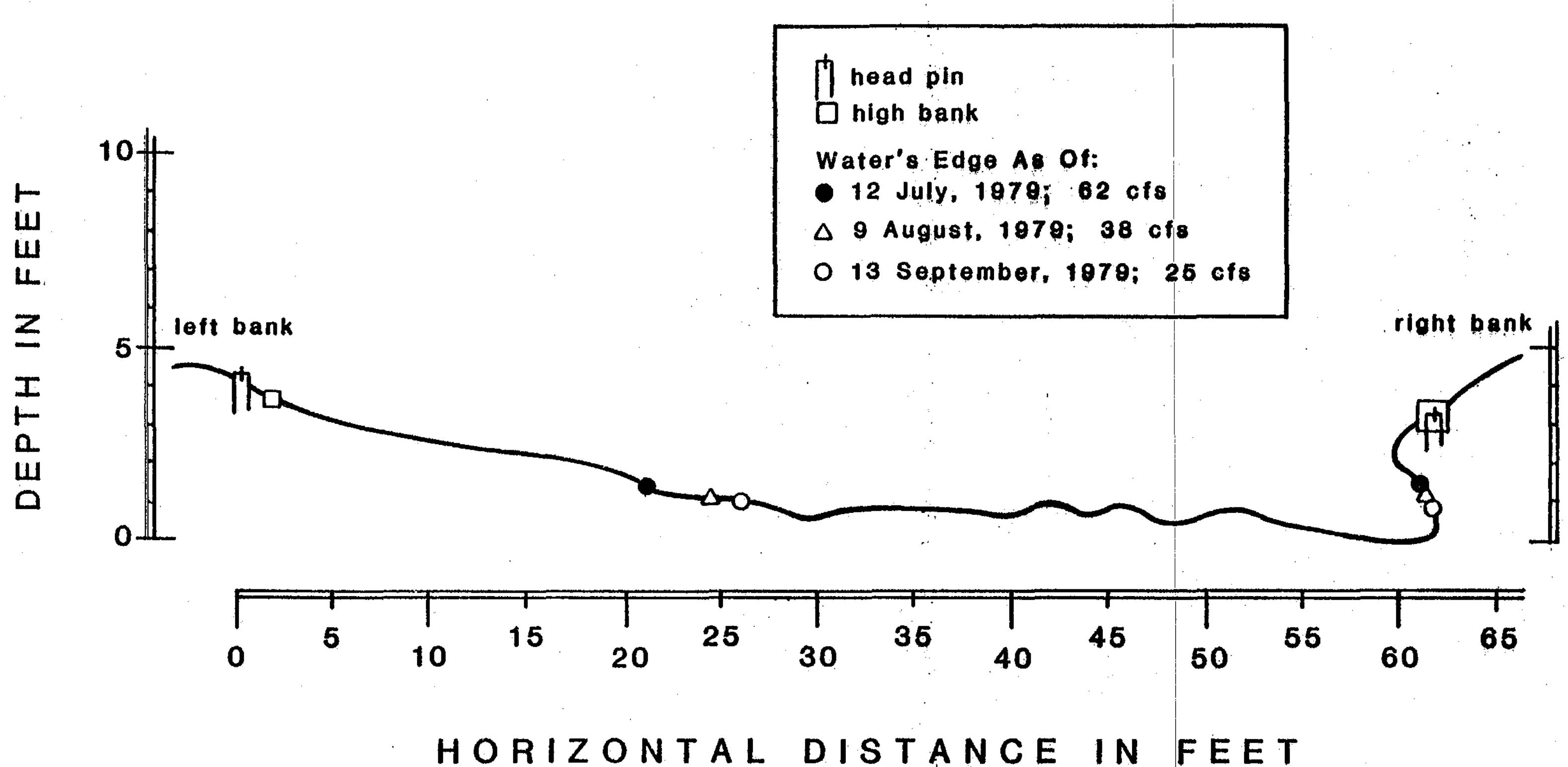
Figure 19

Figure 20



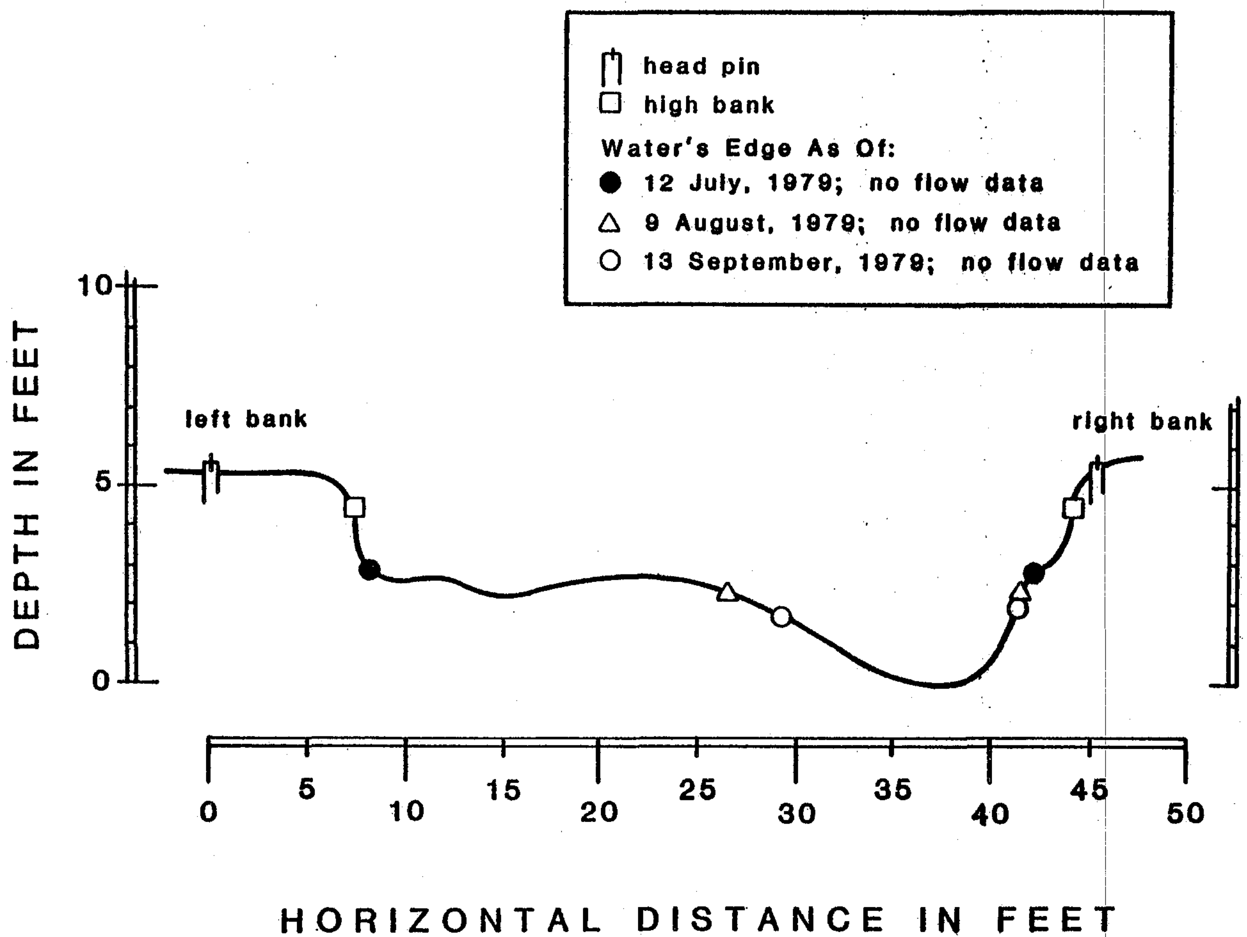
CROSS-SECTIONAL PROFILE OF DECEPTION CREEK REACH, TRANSECT #1.
(1 vertical foot equals 2 horizontal feet)

Figure 21



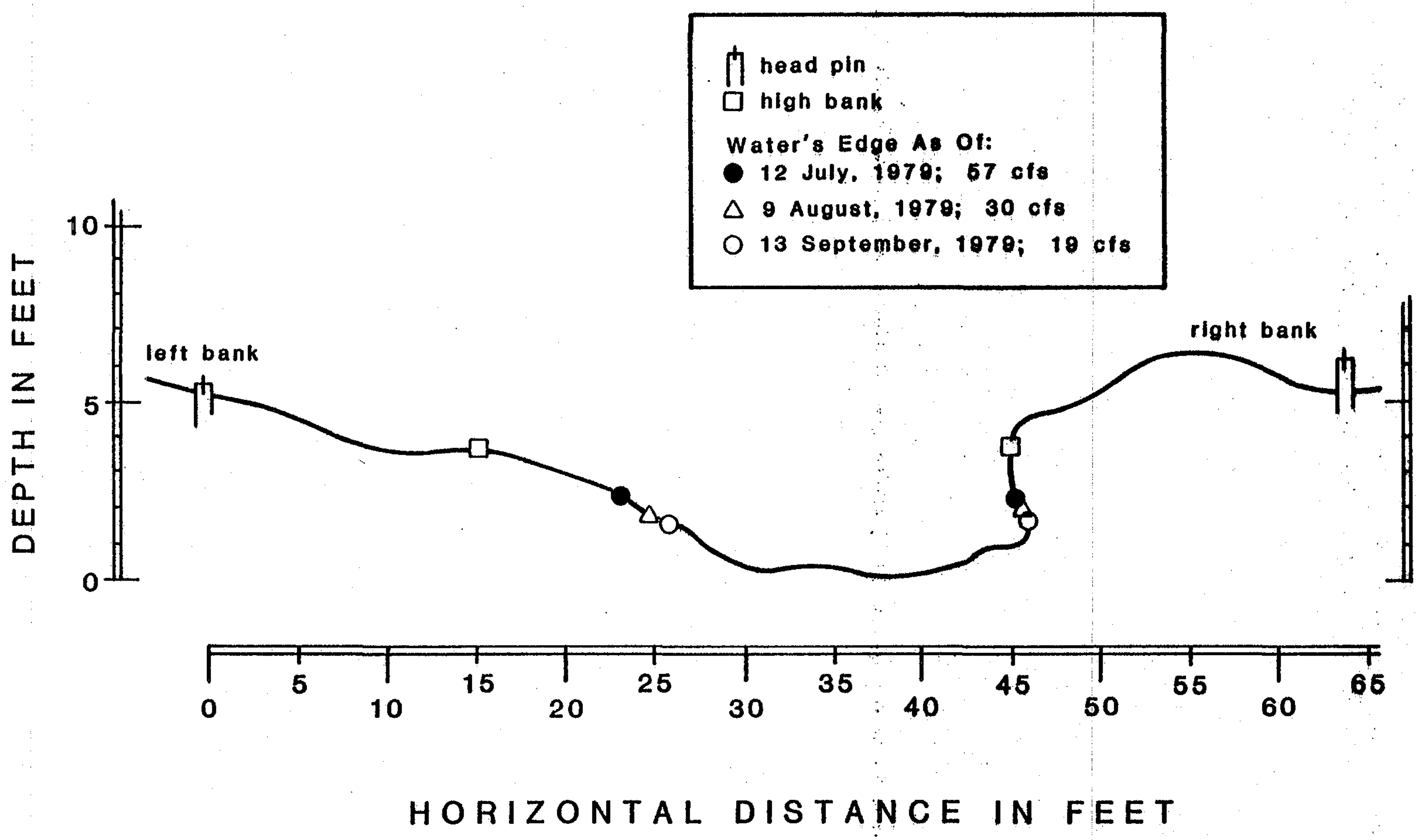
CROSS-SECTIONAL PROFILE OF DECEPTION CREEK REACH, TRANSECT #2.
(1 vertical foot equals 2 horizontal feet)

Figure 22



CROSS-SECTIONAL PROFILE OF DECEPTION CREEK REACH, TRANSECT #3.
(1 vertical foot equals 2 horizontal feet)

Figure 23



CROSS-SECTIONAL PROFILE OF DECEPTION CREEK REACH, TRANSECT #4.
(1 vertical foot equals 2 horizontal feet)

Supplemental Biological, Water Quantity and Quality Study Sites

Peters/Purches Creeks

Three index study areas were established to collect biological and physiochemical data in the upper Willow Creek drainage on Purches Creek and four on Peters Creek (Figure 24; Table 2).* Site descriptions were recorded on stream survey forms (Appendix A). Within these index areas, ten discharge sites (Q) and two water quality sites (W) were established (Figure 24; Table 2).

ADF&G/USGS Sites

Miscellaneous water quantity and quality measurements were collected at seven sites on Willow and Deception Creeks (Figure 25; Table 3).* Site descriptions are summarized in the USGS (1980) publication: Water resources data for Alaska, water year 1979.

Fishery Resources**

Four of the five species of Pacific salmon (chinook, pink, coho, and chum, *Oncorhynchus keta*) are known to occur in Willow and Deception

---

*Refer to Methods section for a description of site selection techniques.

**Additional Willow Creek fishery data are presented in the ADF&G publication: New capital city environmental assessment program - phase I (Watsjold and Engel 1978).

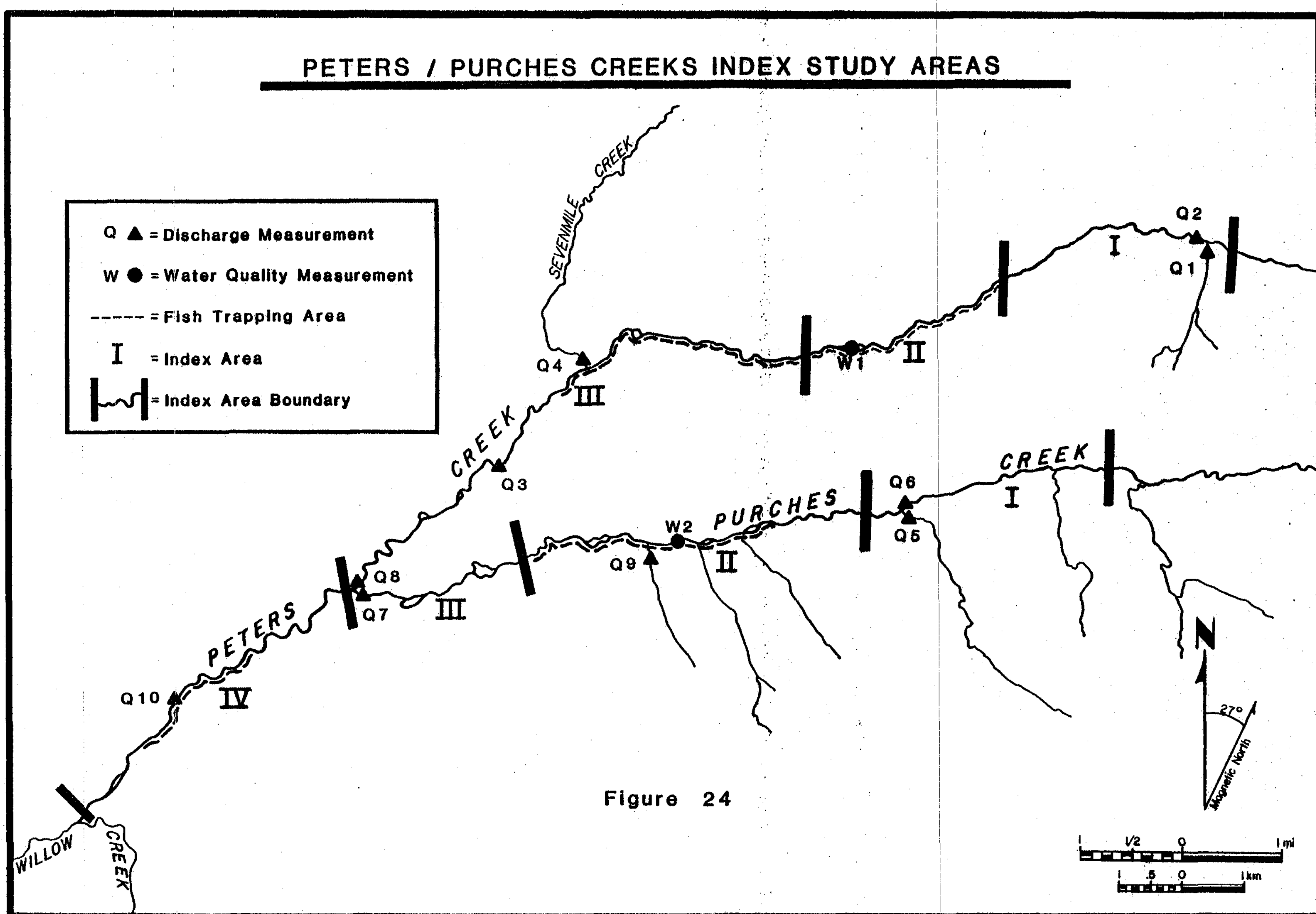

PETERS / PURCHES CREEKS INDEX STUDY AREAS
Q ▲ = Discharge Measurement
W ● = Water Quality Measurement
----- = Fish Trapping Area
I = Index Area
= Index Area Boundary
SEVENMILE CREEK
PETERS CREEK
PURCHES CREEK
WILLOW CREEK
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
Q9
Q10
W1
W2
I
II
III
IV
N
27°
Magnetic North
1/2
0
1 mi
.5
0
1 km

Figure 24

Table 2. Geographic locations for Peters/Purches Creeks Supplemental Study sites (Figure 24).*

PURCHES CREEK INDEX AREA BOUNDARIES

Index Area	ADF&G Geographic Location		
	UPSTREAM		DOWNSTREAM
I	20N01W11CBD	to	20N01W17AAB
II	20N01W17AAB	to	20N02W14BDD
III	20N02W14BDD	to	20N02W16DCD*

PETERS CREEK INDEX AREA BOUNDARIES

Index Area	ADF&G Geographic Location		
	UPSTREAM		DOWNSTREAM
I	21N01W30ACC	to	21N01W34CAC
II	21N01W34CAC	to	20N01W05CBB
III	20N01W05CBB	to	20N02W16DCD**
IV	20N02W16DCD**	to	20N03W36AAD***

PETERS/PURCHES CREEKS DISCHARGE MEASUREMENTS SITES

Site	ADF&G Geographic Location	Site	ADF&G Geographic Location
Q1	21N01W36BDC	Q6	20N01W09CCD
Q2	21N01W36BCA	Q7	20N02W16DCD
Q3	20N02W11CBB	Q8	20N02W16DCA
Q4	20N02W02DAA	Q9	20N02W13DBB
Q5	20N01W16BBA	Q10	20N02W19DDD

PETERS/PURCHES CREEKS WATER QUALITY MEASUREMENT SITES

Site	ADF&G Geographic Location	Site	ADF&G Geographic Location
W1	20N01W05ADD	W2	20N02W13ADA

* Refer to Methods section for a description of the ADF&G Geographic Location system.
** Confluence of Peters Creek and Purches Creek.
*** Confluence of Peters Creek and Willow Creek.

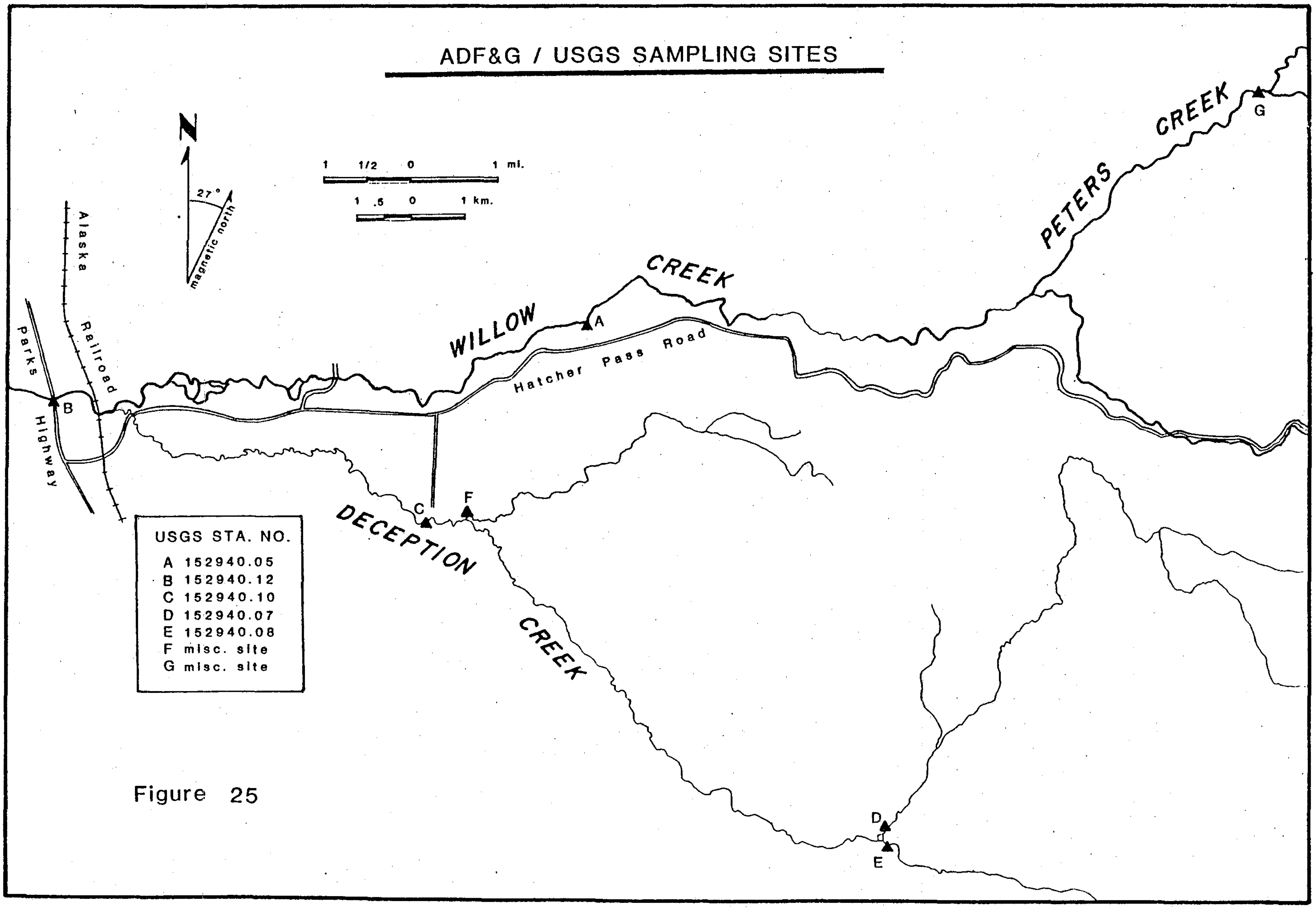

ADF&G / USGS SAMPLING SITES
N
27°
magnetic north
1 1/2 0 1 mi.
1 .5 0 1 km.
Alaska Railroad
Parks Highway
WILLOW CREEK
PETERS CREEK
DECEPTION CREEK
Hatcher Pass Road
A
B
C
D
E
F
G
USGS STA. NO.
A 152940.05
B 152940.12
C 152940.10
D 152940.07
E 152940.08
F misc. site
G misc. site

Figure 25

Table 3. Geographic locations of ADF&G/USGS sampling sites (Figure 25).*

Site	Description	USGS Geographic Location	ADF&G Geographic Location
A	Willow Creek near Willow Gage USGS# 152940.05	NE 1/4 SE 1/4 Sec 31 T 20N R 03W	20N03W31DAA
B	Willow Creek at Parks Hwy, Bridge USGS #152940.12	NE 1/4 SW 1/4 Sec 06 T 19N R 04W	19N04W06ACD
C	Deception Creek near Willow USGS #152940.10	NE 1/4 SW 1/4 Sec 11 T 19N R 04W	19N04W11CA
D	Deception Creek ab.trib.nr. Houston USGS #152940.07	SE 1/4 NW 1/4 Sec 35 T 19N R 03W	19N03W35BDB
E	Deception Creek Trib. nr. Houston USGS #152940.08	SE 1/4 NW 1/4 Sec 35 T 19N R 03W	19N03W35BDC
F	Unnamed Decep. Cr. Trib. nr. Willow USGS misc. site	NE 1/4 SW 1/4 Sec 12 T 19N R 04W	19N04W12CAD
G	Peters Cr. below Purch. Cr. nr. Willow USGS misc. site	SE 1/4 SW 1/4 Sec 16 T 20N R 03W	20N03W16DCB

* Refer to Methods section for a description of the ADF&G Geographic Location system.

Creeks (Figure 26). In addition, adult sockeye salmon (O. nerka) are known to mill at the mouth of Willow Creek. Resident fish species include Dolly Varden (Salvelinus malma), rainbow trout (Salmo gairdneri), Arctic grayling (Thymallus arcticus) (Figure 27), and burbot (Lota lota).

Pink salmon are the most abundant salmon found in Willow and Deception Creeks, with the largest runs occurring during even years. In 1978, Willow Creek had the highest pink salmon sport fishing harvest (19,000) in Alaska (Mills 1980), and a pink salmon escapement estimated at 220,000 (Watsjold and Engel 1978). With the opening of a limited chinook sport fishery in 1979 (chinook fishing had been prohibited since 1972), Willow Creek now provides one of the four roadside fisheries for this species in the Susitna Basin.

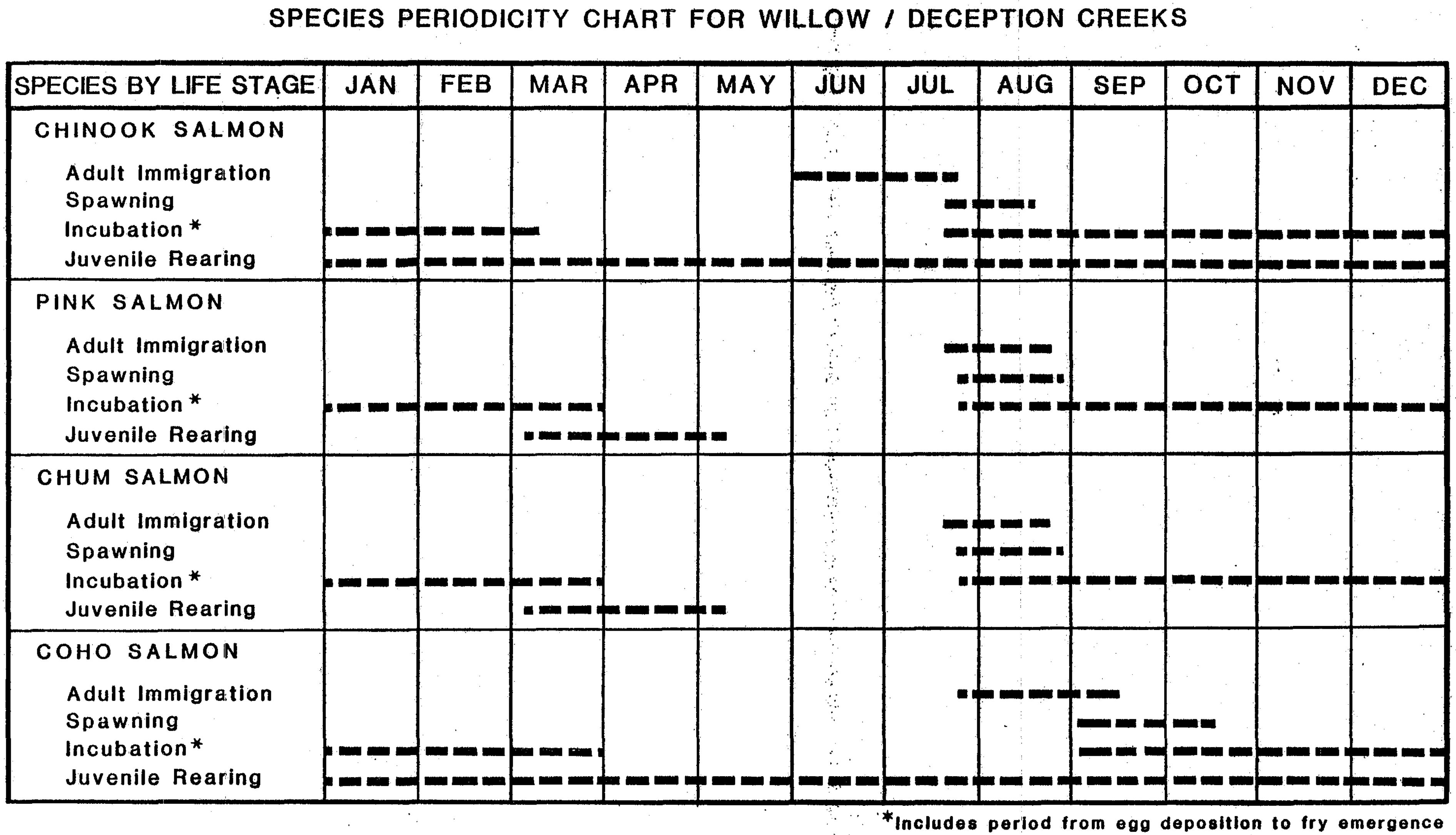
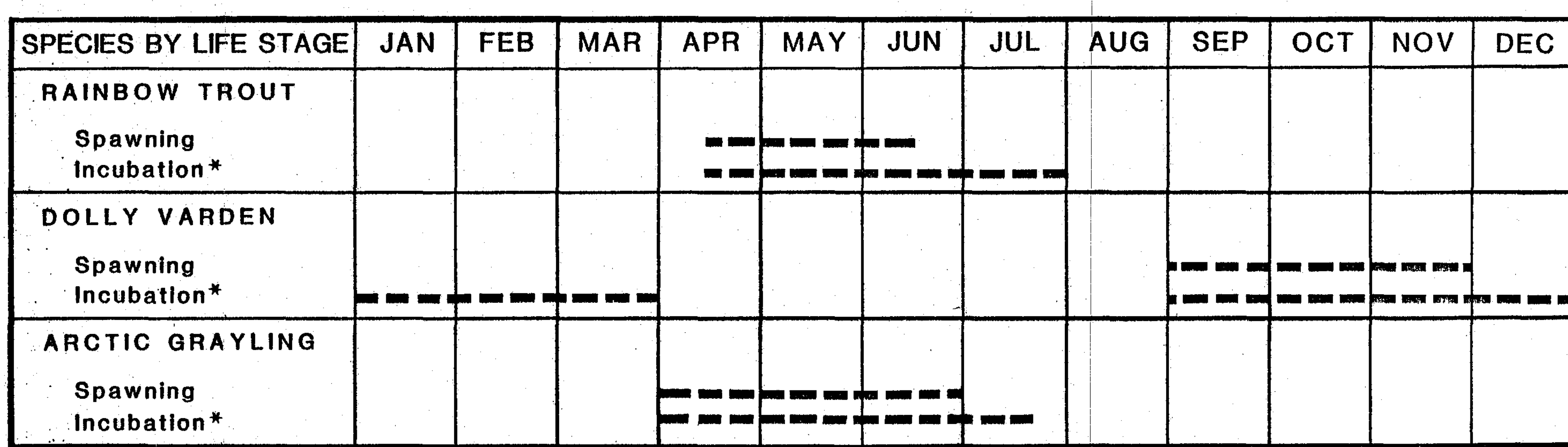


Figure 26. Anadromous fish species.

SPECIES PERIODICITY CHART FOR WILLOW / DECEPTION CREEKS



* Includes period from egg deposition to fry emergence

**Burbot data unavailable

Figure 27. Resident fish species**

MATERIALS

MATERIALS

Project equipment is listed below (Table 4).

Table 4. Equipment used in Instream Flow and Supplemental Studies.

Surveying Equipment	
Leitz B2-A level	Philadelphia rod
K&E AL-3 level	rod level
100 ft fiberglass tape	rebar
Flow Metering Equipment	
Price AA meter	stopwatch
Pygmy meter	tagline
top setting wading rod	18' Monarch boat with 25 hp motor and jet foot
headphones	cantilevered boom and rail flow suspension system on bridge.
beeper box*	
Water Quality Equipment	
YSI** dissolved oxygen meter	thermometer
YSI conductivity meter	Ryan thermograph
Beckman RB-III conductivity meter	Cole-Parmer pH meter
Biological Sampling Equipment	
1/8-inch mesh minnow traps	salmon roe
dip nets	Surber sampler
MS-222	

*Substituted for flow meter headphones.

**Yellow Springs Instrument Company.

METHODS

METHODS

Instream Flow Study*

Geographic Code Locations

In this report, locations of features such as reaches, sampling sites, etc., were specified by a code containing up to fourteen characters (Figure 28). The first three characters identify the Township of the sampling point; the next three, the Range; and, the next two, the section number within the Township. Following these eight characters, one to four letters are used to indicate the location of the sampling point within the 640-acre section. Each letter progressively subdivides the section into fourths, designating them A, B, C, and D in a counter-clockwise direction. The first letter following the section number therefore represents the location of the site within the quarter section (160-acre tract); the next, the quarter-quarter section (40-acre tract); the next, the quarter-quarter-quarter section (10-acre tract); etc. When more than one site is sampled within the same subsection, the number of sites is added at the end of the code. For example, if two samples were collected in Section 21, Township 9 North, Range 20 West, the geographic code would be 09N20W21DAA2. The letters DAA indicate that the samples were collected in the 10-acre NE quarter-quarter-quarter section of the 40-acre NE quarter-quarter section of the 160-acre SE quarter

*Analysis techniques are discussed in the Results section.

section of Section 21. The number 2 following the letters DAA indicates there were two sampling locations in this 10-acre tract.

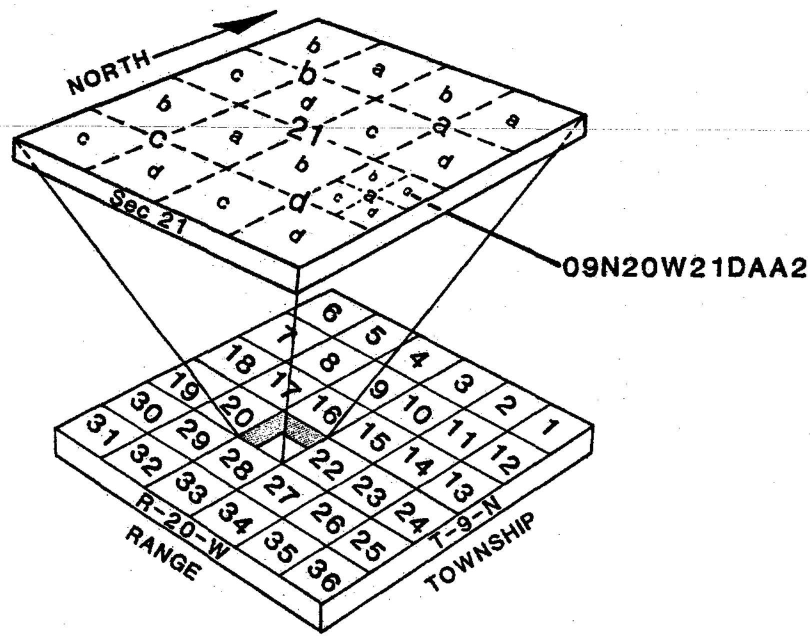


Figure 28. ADF&G geographic location system.

Training

Personnel involved with the field data collection completed the 1-week IFG course: Instream Flow Data Collection Techniques prior to initiating this study. Personnel involved in the computer analysis attended the 1-week IFG course: Instream Flow Computer Analysis Techniques in August 1980.

Reach Selection

Study reaches were selected with the assistance of Larry Engel and Dave Watsjold, ADF&G Palmer Area Sport Fish Biologists. A number of factors were considered in choosing these reaches, including: presence of spawning activity, accessibility, permission from landowners, physical difficulties that could be encountered when surveying and/or obtaining acceptable flow measurements (based on the hydraulic characteristics at the site), the proximity of USGS gaging stations, and the availability of personnel, equipment, and time. As a result, reaches which were selected during this study do not exactly match the IFG's definitions (Bovee and Milhous 1978) for "critical or representative reaches". Thus, they should not be used to represent other reaches within Willow and Deception Creeks without additional investigation.

Transects were selected within each reach according to the procedures outlined in the Montana Department of Fish, Wildlife, and Parks publication: Guidelines for using the Water Surface Profile program to determine instream flow needs for aquatic life (Spence 1975) and the IFG publication: Hydraulic simulation in instream flow studies: theory and techniques (Bovee and Milhous 1978).

Discharge

Three seasonal discharges were measured at transects within each study reach by ADF&G Sport Fish Division Biologists with assistance from USGS, ADF&G Habitat Division, and ADNR personnel. Measurements were timed to correspond to seasonal high, medium, and low flow periods because measurements of these discharges are required for analysis by the IFG-4 computer model (Bovee and Milhous 1978; Bovee 1980a).

Procedures for discharge measurements outlined by Spence (1975), the IFG (Bovee and Milhous 1978), and the USGS (Buchanan and Somer 1973; Smoot and Novak 1977) were followed. When depths and velocities were too large to allow study personnel to wade the stream, measurements were collected from a boat.

Stage

Staff gages were installed at each study reach to monitor stage/discharge relationships. Gages were placed to accomodate both low and high stream flows. Stage readings were recorded on a daily basis unless other study activities prevented an observation. Additional stage readings were recorded immediately before and after discharge measurements to determine if and how much the discharge had fluctuated.

Substrate

Substrate data were collected along discharge measurement transects, each time discharges were measured, to characterize hydraulic roughness. Additional substrate data were collected at point velocity redd sites to identify the physical characteristics of substrate types associated with spawning sites (see Point Specific Spawning Habitat section below).

Substrate was assessed by observing the stream bottom and recording the percentages of predominant substrate groups. The sizes and types of substrate recorded were adapted from the Modified Wentworth Scale and grouped into seven classes (Table 5).

Water Quality

Each time discharges were measured, data on dissolved oxygen (DO), specific conductance, pH, and temperature were collected to determine whether water quality variations corresponded to changes in discharge. Data were collected from each reach with the instruments listed in Table 4 following the procedures established by the respective manufacturers and the USGS (1979).

Surface water temperatures of each reach were continuously monitored by thermographs which were enclosed within minnow traps to protect them from damage. The traps were weighted with stones and attached to staff gages with wire. The thermographs were inspected and calibrated on a weekly basis. Calibration data (time, date, and temperature) were recorded on thermograph charts. Charts were changed every 30 days. New charts were rewound prior to installation to prevent jamming. The "O" ring seal of the thermograph casing was cleaned and greased with a thin layer of silicone grease before resealing to prevent leakage.

Table 5. Equivalence of Modified Wentworth and Willow/Deception Creeks Study substrate scales.

MODIFIED WENTWORTH SCALE		WILLOW/DECEPTION CREEKS SCALE	
Class	Description*	Class	Description*
1	plant detritus		not considered
2	0.0001 - 0.0016	I	mud
3	0.0016 - 0.0024	II	sand
4	0.0024 - 0.079		
5	0.079 - 2.5	III	0.25 - 1.00
		IV	1.00 - 3.00
6	2.5 - 9.8	V	3.00 - 5.00
		VI	5.00 - 10.00
7	greater than 9.8	VII	greater than 10

*Description numbers represent inches.

Point Specific Spawning Habitat Data*

Water velocity, depth, and substrate characteristics, associated with chinook salmon redds, were recorded to characterize spawning habitat conditions in the study area. Visual observation of females actively fanning redd sites proved to be the most reliable means of identifying locations of redds. Because females were occasionally observed fanning false redds, it was necessary to observe females fanning the same site a number of times to verify active redd locations. Redds were located also by noting the presence of Classes III and/or IV substrate, overturned stones, and a characteristic mound deposited downstream of the redds during their construction.

After redd sites were located, point specific data were collected in the vertical plane at the upstream portion of the redds. When water was less than 3 feet deep, an average point velocity was measured at the data collection site by placing the velocity meter at 0.6 of the total depth measured from the surface of the water. When water depth was 3 feet or greater, two velocity readings were obtained, at positions 0.2 and 0.8 of the total depth, and later averaged to calculate the mean velocity. Substrate characteristics were classified and recorded, according to substrate procedures outlined above.

---

*Point specific data characterize the range of streamflow-dependent characteristics which appear to be influencing the suitability of various habitat types for the species and life stages of interest.

Benthic Invertebrates

Aquatic larval insects were collected from the stream bottom substrate using a Surber sampler to characterize the presence of benthic invertebrates. One square-foot of stream bottom was sampled at each study reach on the first two discharge measurement dates. The insects were preserved in isopropyl alcohol and returned to the laboratory where they were enumerated and identified to taxonomic orders.

Supplemental Biological, Water Quantity and Quality Study

Peters/Purches Creeks

Site Selection

Streams were subdivided into reaches (index areas) according to gradient, channel geometry, pool-riffle ratio, substrate, and surrounding terrain characteristics (Watsjold and Engel 1978).

Biological Data

One-eighth-inch mesh minnow traps were baited with one inch diameter pieces of salmon roe which had been autoclaved for 45 minutes at 121°C according to procedures outlined by Wadman (1979). Set traps were checked after 24 ±4 hours. Trap locations were noted, and number and species of fish captured were recorded for each trap. Substrate characteristics were also recorded at trap sites according to substrate procedures discussed above.

Water Quantity and Quality

Discharge, dissolved oxygen, pH, water and air temperature, and specific conductance data were collected with the instruments listed in Table 4 according to procedures discussed above.

ADF&G/USGS Study

Site Selection

Sampling sites were established on major tributaries of Willow and Deception Creeks. Site selections were based on availability of historical data for particular sites (Scully 1978; McCoy 1978), accessibility of sites by helicopter, and practicability of sampling all sites in one day.

Water Quantity

Discharge data were collected with the instruments listed in Table 4 according to procedures discussed above. Flows were not measured when the velocity of the water was too swift and/or the depth of the water was too deep to permit wading. Measurements were timed to correspond with seasonal high, medium, and low flow periods in an attempt to monitor seasonal variability.

Water Quality

Water samples, dissolved oxygen, pH, temperature, and specific conductance data were collected, each time flows were measured, with the instruments listed in Table 4 following procedures discussed above. Water samples were processed for shipping to the USGS laboratory in Denver, Colorado for analysis. Procedures outlined by the USGS (1977) were followed when collecting water samples. The parameters analyzed are listed in Appendix B.

RESULTS

RESULTS

Instream Flow Study

Discharge

Willow Creek flows ranged from 1163 cubic feet per second (cfs) on July 10, 1979 to 205 cfs on September 14, 1979 in the lower reach, from 991 cfs on July 11, 1979 to 175 cfs on September 14, 1979 in the middle reach, and from 917 cfs on July 11, 1979 to 174 cfs on September 14, 1979 in the upper reach (Table 6). Flows were 5 percent higher in the middle reach than in the upper reach and 10 percent higher in the lower reach than in the middle reach. The difference in flow between the middle and lower Willow Creek reaches is higher than that between the upper and middle reaches because of the flow contribution of Deception Creek. Deception Creek flows ranged from 57 cfs on July 12, 1979 to 20 cfs on September 13, 1979. Discharge information recorded at nearby USGS gaging stations is listed in Appendix B.

Stage

Daily stage data collected in Willow Creek indicate that the stage had peaked at all Willow Creek sites in mid-July after which it gradually declined until it increased abruptly in mid-September before falling again (Appendix C, Figures 1-6). Deception Creek stage began to decline in late July and peaked in mid-September before dropping again (Appendix C, Figure 7).

Table 6. Flow (cfs) summary for Willow/Deception Creeks Instream Flow Study reaches, 1979.

SITE	FLOW #1	FLOW #2	FLOW #3
LOWER WILLOW	(07/10/79)	(08/08/79)	(09/14/79)
Transect No. 1	1225	674	201
Transect No. 2	1215	661	212
Transect No. 5	1050	662	202
AVERAGE FLOW	1163	652	205
MIDDLE WILLOW	(07/11/79)	(08/08/79)	(09/14/79)
Transect No. 1	987	623	180
Transect No. 2	1025	620	155
Transect No. 3	929	571	165
Transect No. 4	1021	620	200
AVERAGE FLOW	991	598	175
UPPER WILLOW*	(07/11/79)	(08/08/79)	(09/14/79)
Transect No. 1	493	240	42
Transect No. 2	470	262	45
Transect No. 3	466	234	50
AVERAGE FLOW	476	245	46
Above Forks	918	569	174
DECEPTION CREEK	(07/12/79)	(08/09/79)	(09/13/79)
Transect No. 1	53	27	16
Transect No. 2	62	38	24
Transect No. 3	57	30	19
AVERAGE FLOW	57	32	20

*Upper Willow reach flows represent the south fork of the mainstem of Willow Creek. Therefore, the total discharge for this portion of Willow Creek was measured on the mainstem upstream of the braided section of the creek (Above Forks).

Substrate

Predominant substrate classes ranged from Classes II to VII in Willow Creek and from Classes II to IV in Deception Creek (Table 7).

Table 7. Range of predominant substrate classes observed in the Willow/Deception Creeks Study reaches, 1979.

STUDY REACH	SUBSTRATE CLASS RANGE
Lower Willow Creek	II - VI
Middle Willow Creek	III - VII
Upper Willow Creek	II - VI
Deception Creek	II - IV

Water Quality

Willow and Deception Creek water temperatures, measured on an instaneous basis, ranged from 9.0° to 12.0°C, DO from 8.3 parts per million (ppm) to 11.5 ppm, pH from 7.0 to 7.6, and specific conductance from 30 to 90 µmhos/cm (Table 8). Continuously monitored water temperatures ranged from 2.8° to 15.6°C in Willow Creek and from 3.3° to 14.8°C in Deception Creek (Appendix D).

Point Specific Spawning Habitat Data

The most frequently measured water depth, at 33 chinook salmon redds,

Table 8. Water Quality Summary for Willow/Deception Creeks Instream Flow Study reaches, 1979.

Site	Date	Temp.[1]	D.O.[2]	pH	Cond.[3]
LOWER WILLOW	07/10/79	09.0	10.3	7.4	37
	08/08/79	11.1	08.3	7.1	31
	09/14/79	10.0	10.9	7.1	70
MIDDLE WILLOW	07/11/79	10.0	11.1	7.6	30
	08/08/79	--[4]	--	--	--
	09/14/79	10.5	11.3	7.3	60
UPPER WILLOW	07/11/79	12.0	10.5	7.6	31
	08/08/79	--	--	--	--
	09/14/79	10.0	11.5	7.1	60
DECEPTION	07/12/79	12.0	10.2	7.5	68
	08/09/79	11.5	10.7	7.0	78
	09/13/79	10.0	11.2	7.2	95

1 Temp. = temperature in °C
2 D.O. = dissolved oxygen in mg/l
3 Cond. = specific conductance in µmhos/cm
4 -- = equipment malfunction

was 1.6 feet, with a range of 0.95 to 3.00 feet; most frequently measured average water column velocity was 2.25 feet per second (ft/sec), with a range from 0.28 to 4.75 ft/sec; and most frequently measured substrate was Class III, with a range of II to IV (Table 9).

Because of insufficient resources to collect additional point specific spawning habitat data, point specific chinook and pink salmon spawning habitat data collected in Willow Creek during 1978 by Watsjold and Engel (1978) are included in this report (Tables 10 and 11). The most frequently measured chinook salmon spawning depth measured in Willow Creek in 1978 was 1.65 feet, with a range of 1.0 to 2.2 feet; most frequently measured average water column velocity was 3.16 ft/sec, with a range of 1.51 to 4.75 ft/sec; and most frequently measured substrate was Class IV with a range of III to VI. Pink salmon spawning depth most frequently measured was 1.35 feet, with a range of 0.6 to 2.4 feet; average water column velocity most frequently measured was 2.4 ft/sec, with a range of 1.01 to 4.01 ft/sec; and substrate most frequently measured was Class III, with a range of II to IV.

Suitability Curves

Point specific spawning habitat data outlined above are presented as suitability curves (Figures 29-37).* The curves were derived using

---

*Habitat suitability curves are developed to represent the ranges of depth, velocity, and substrate types commonly occupied by a particular species and life stage. The chinook and pink salmon curves presented in this report are provided as illustrations and are <u>not</u> to be used to develop specific flow regimes for Willow and Deception Creeks. The curves were developed from a small number of observations, and ADF&G biologists should be consulted for further interpretation of these curves.

Table 9. Redd measurements for Chinook Salmon in Willow Creek, August 1979 (Not recommended for application to other watersheds).

Depth (ft.)	Velocity (ft./sec.)	Substrate Classification
1.10	1.920	IV
1.70	2.390	III-IV
0.95	0.279	II
1.30	4.750	III-IV
2.00	5.200	III-IV
1.50	3.210	III
1.60	1.290	III
1.40	2.340	IV
3.00	4.280	III
2.70	2.500	III-IV
2.10	2.800	III
2.20	0.993	III
1.60	0.993	III
1.10	0.837	III-IV
2.00	2.100	III
2.40	2.990	III
2.00	4.750	IV
1.50	2.440	IV
2.20	3.130	III
1.70	3.060	III
1.40	3.280	III-IV
2.00	2.690	III
2.50	3.210	III
2.60	3.280	III
1.80	2.990	III
2.10	1.160	III-IV
2.00	2.200	III-IV
1.60	2.290	III
1.10	2.100	III
1.60	2.100	III
1.50	2.740	III-IV
1.50	1.880	III
1.70	3.800	III

Table 10. Redd measurements for Chinook Salmon in Willow Creek, August 1978. (adapted from Watsjold and Engel 1978).*

Depth (ft.)	Velocity (ft./sec.)	Substrate (in.)	Substrate Classification**
1.7	3.72	2.0-6.0	IV-V
1.3	3.06	2.0-6.0	IV-V
1.0	2.39	1.5-6.0	IV
1.3	3.28	2.0-7.0	IV-V
1.9	1.54	2.0-6.0	IV-V
1.8	1.76	1.5-7.0	IV
1.5	1.76	2.0-7.0	IV-V
1.7	2.44	1.5-7.0	IV
1.4	4.46	1.5-7.0	IV
1.3	3.57	1.5-7.0	IV
2.2	3.21	2.0-7.0	IV-V
1.8	2.61	2.0-6.0	IV-V
2.0	3.50	2.0-5.0	IV
1.4	3.80	2.0-6.0	IV-V
2.1	3.43	3.0-6.0	V
1.4	3.28	1.0-5.0	III-IV
1.4	3.21	3.0-6.0	V
1.0	3.89	3.0-6.0	V
1.3	2.92	2.0-5.0	IV
1.4	2.50	2.0-4.0	IV
1.2	1.51	1.0-4.0	III-IV
1.6	3.43	1.0-6.0	III-IV
1.2	3.80	2.0-6.0	IV-V
2.0	3.37	3.0-7.0	V
1.6	2.29	1.5-4.0	III-IV
1.3	2.55	1.5-4.0	III-IV
1.8	2.99	2.0-5.0	IV
1.8	3.80	1.5-4.0	III-IV
1.8	3.28	2.0-6.0	IV-V
1.6	3.98	1.5-6.0	IV
1.7	2.55	3.0-6.0	V
1.3	1.58	1.5-3.0	III-IV
1.9	2.74	2.0-6.0	IV-V
2.1	2.50	- -	- -
2.0	1.65	3.0-6.0	V
1.9	3.43	3.0-5.0	V
1.7	3.50	2.0-6.0	IV-V
2.1	4.75	2.0-6.0	IV-V
2.0	4.16	- -	- -
2.2	3.56	- -	- -

* Not recommended for application to other watersheds.

** Substrate data collected in 1978 and classified using the method described in this report.

Table 10. Continued.

Depth (ft.)	Velocity (ft./sec.)	Substrate (in.)	Substrate Classification*
2.2	3.28	- -	- -
1.8	4.37	1.5-4.0	III-IV
1.7	4.55	1.5-4.0	IV
1.7	3.80	2.0-6.0	IV-V
1.5	2.29	1.5-3.0	III-IV
1.9	2.92	1.5-4.0	III-IV
1.4	2.99	1.5-3.0	III-IV
1.4	4.16	4.0-6.0	V-VI
1.7	4.07	3.0-5.0	V
1.5	3.89	2.0-5.0	V

* Substrate data collected in 1978 and classified using the method described in this report.

Table 11. Redd measurements for Pink Salmon in Willow Creek, August 1978 (adapted from Watsjold and Engel 1978).*

Depth (ft.)	Velocity (ft./sec.)	Substrate (in.)	Substrate Classification**
1.8	2.10	1.0-1.5	III-IV
1.8	2.29	1.0-2.0	III-IV
2.1	2.10	1.0-2.0	III-IV
1.4	1.01	1.0-2.0	III-IV
2.1	1.17	1.0-2.0	III-IV
2.4	2.20	1.0-2.0	III-IV
1.9	1.51	1.0-1.5	III-IV
2.1	3.28	0.5-2.0	III
2.0	2.55	1.0-2.0	III-IV
0.9	1.92	1.5-2.0	III-IV
1.7	3.28	2.0-3.0	IV
1.8	3.50	2.0-5.0	IV
1.4	1.76	1.0-1.5	III-IV
2.3	2.74	1.5-2.0	III-IV
1.6	2.00	1.0-2.0	III-IV
1.1	2.20	0.5-1.5	III
0.9	1.33	1.0-1.5	III-IV
0.6	1.25	0.5-1.0	III
2.1	2.74	0.5-1.5	III
0.8	2.02	1.0-1.5	III-IV
0.9	3.72	1.5-2.0	III-IV
1.1	1.58	0.5-1.5	III
1.0	2.00	0.5-1.5	III
0.8	3.11	0.5-1.0	III
1.5	2.74	0.5-1.5	III
0.5	1.84	1.0-1.5	III-IV
0.8	2.44	1.0-1.5	III-IV
1.5	3.28	1.5-3.0	III-IV
1.7	3.65	1.0-2.0	III-IV
0.6	1.25	1.0-1.5	III-IV
0.7	1.96	0.5-1.5	III
0.7	2.34	1.0-1.5	III-IV
0.8	1.58	0.5-1.0	III
1.4	2.20	1.0-2.0	III-IV
1.4	2.50	- -	- -
0.7	2.50	1.0-2.0	III-IV
1.7	2.50	1.0-2.0	III-IV
1.5	2.38	1.0-2.0	III-IV
0.7	1.96	0.5-1.5	III
1.5	2.55	1.0-1.5	III-IV

* Not recommended for application to other watersheds.
** Substrate data collected in 1978 and classified using the method described in this report.

Table 11. Continued.

Depth (ft.)	Velocity (ft./sec.)	Substrate (in.)	Substrate Classification*
1.5	2.10	0.50-1.50	III
1.7	2.29	1.00-1.50	III-IV
1.1	1.47	0.50-0.75	II-III
1.7	1.92	0.50-1.00	III
1.8	2.29	0.50-1.50	III
2.0	2.74	1.00-2.00	III-IV
1.8	2.55	0.50-1.00	III
0.6	1.35	0.50-1.00	III
0.9	1.88	0.50-1.00	III
1.5	2.20	1.00-1.50	III-IV
0.7	1.63	f**-0.75	II
1.3	1.96	1.00-2.00	III-IV
1.5	2.99	1.00-2.00	III-IV
1.0	1.28	f**-2.00	II-III
1.2	2.20	1.00-2.00	III-IV
1.3	2.39	1.00-2.00	III-IV
0.8	1.65	0.50-1.50	III
1.3	2.44	1.00-3.00	III-IV
1.1	3.50	1.00-2.00	III-IV
1.6	2.34	1.00-1.50	III-IV
1.4	3.13	1.00-2.00	III-IV
1.2	2.44	0.50-1.50	III
1.7	2.74	0.75-2.00	III
1.5	2.55	0.50-1.50	III
1.3	2.74	1.50-2.00	III-IV
1.4	2.99	1.50-2.00	III-IV
1.1	2.61	0.50-1.50	III
1.1	2.29	1.00-2.00	III-IV
1.3	3.37	1.00-1.50	III-IV
1.1	3.37	1.00-2.00	III-IV
0.9	2.05	1.00-1.50	III-IV
1.7	2.10	f**-1.00	II-III
1.1	1.88	0.25-6.00	III
1.2	2.74	1.00-6.00	III-IV
1.6	2.50	0.50-5.00	III
1.0	2.55	0.50-5.00	III
1.1	2.74	0.50-5.00	III
1.6	2.99	1.00-6.00	III-IV
2.0	4.01	1.00-6.00	III-IV
1.2	2.20	0.50-4.00	III

* Substrate data collected in 1978 and classified using the method described in this report.

f** = fines

Table 11. Continued.

Depth (ft.)	Velocity (ft./sec.)	Substrate (in.)	Substrate Classification*
1.9	2.74	0.50-5.0	III
1.6	3.80	1.00-4.0	III-IV
2.1	2.39	1.00-4.0	III-IV
1.0	3.21	0.75-5.0	III
1.2	2.72	0.50-3.0	III
1.5	2.98	1.00-6.0	III-IV
1.9	3.89	1.00-6.0	III-IV
0.9	2.05	f**-1.0	II-III
1.1	2.05	0.50-3.0	III
1.6	3.13	1.00-6.0	III-IV
1.5	1.84	f**-3.0	II-III
1.3	2.29	0.50-5.0	III
1.5	3.07	1.00-5.0	III-IV
1.6	1.65	0.50-3.0	III
2.4	2.00	0.50-4.0	III
1.7	3.80	0.75-4.0	III
0.9	2.50	0.50-2.5	III
1.5	2.55	0.50-4.0	III
2.3	2.61	0.50-4.0	III
1.2	1.88	0.50-2.5	III
1.8	2.98	0.50-7.0	III
1.0	2.68	0.75-3.0	III
1.6	3.24	0.50-3.0	III
1.0	1.62	0.50-2.5	III
1.2	2.10	0.50-3.0	III
0.6	1.84	0.50-4.0	III
1.3	1.65	0.50-3.0	III
1.4	2.15	0.50-2.5	III
0.9	1.92	0.50-3.0	III
1.5	2.44	0.75-4.0	III
1.7	2.61	1.00-5.0	III-IV
1.5	3.65	0.75-5.0	III
1.0	3.43	0.75-4.0	III
1.0	2.61	0.50-2.5	III

* Substrate data collected in 1978 and classified using the method described in this report.

f** = fines

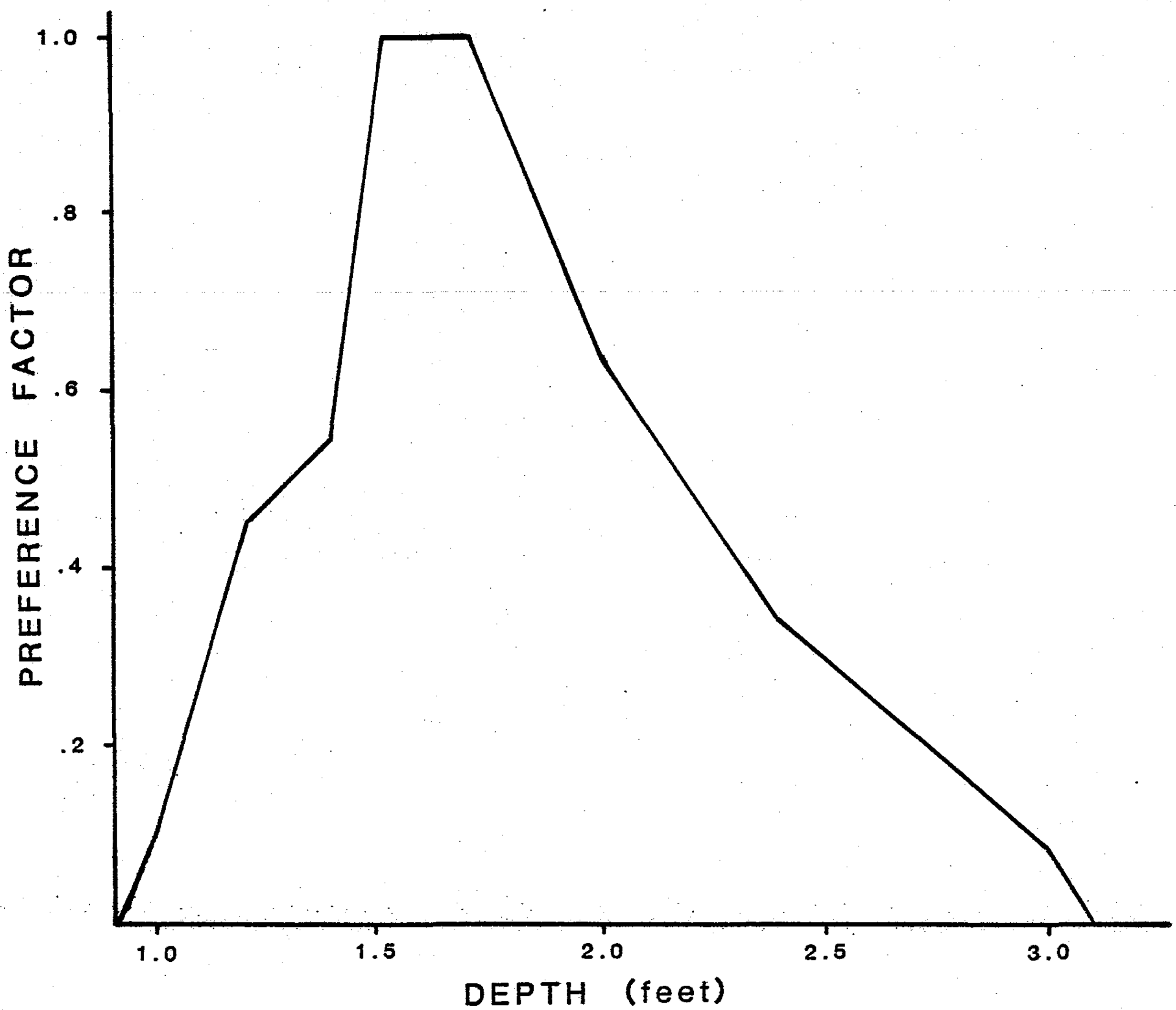


Figure 29. Depth suitability curve for spawning chinook salmon in Willow Creek, Alaska, Summer 1979. Not recommended for application to other watersheds. Consult ADF&G for further interpretation.

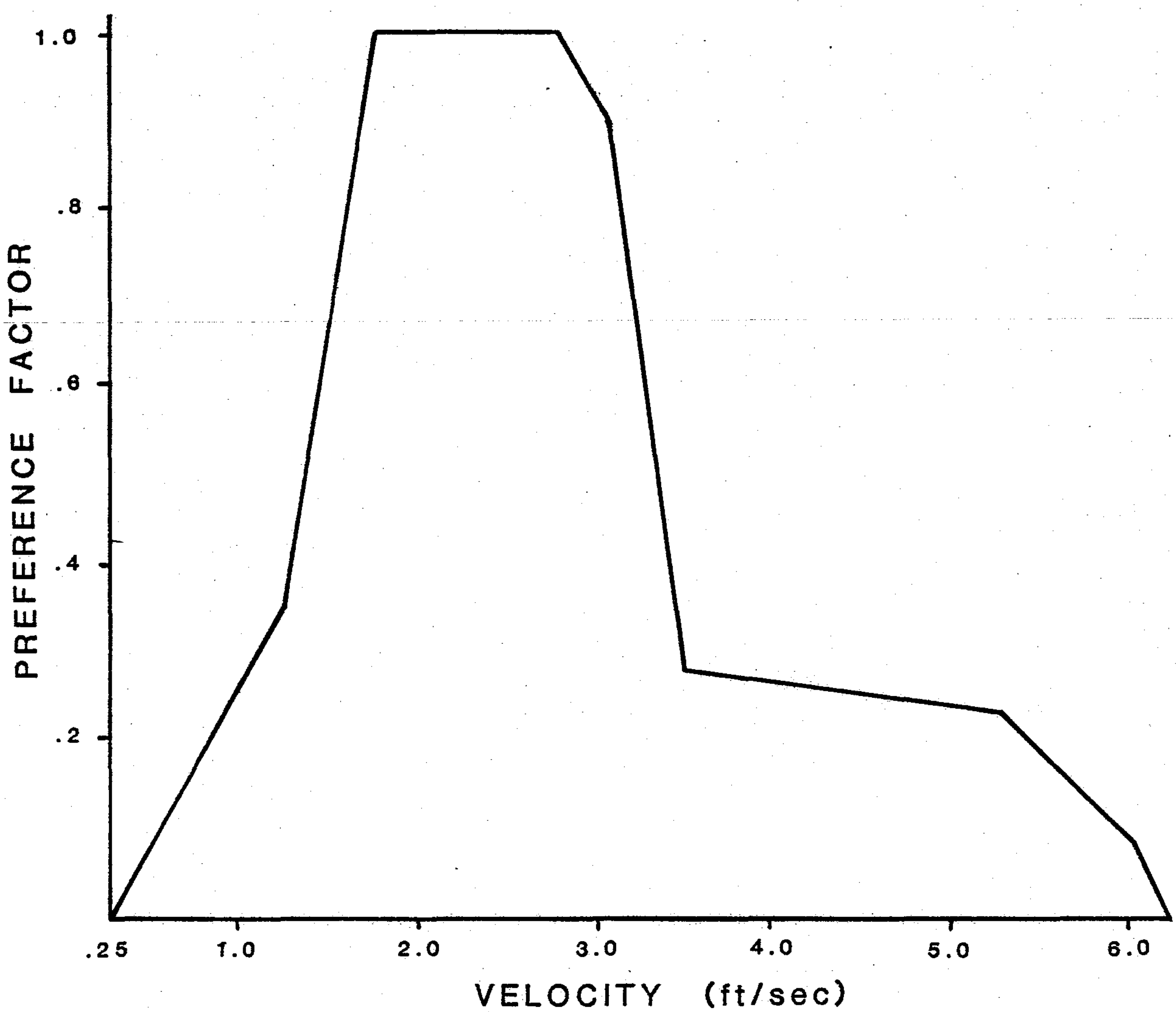


Figure 30. Velocity suitability curve for spawning chinook salmon in Willow Creek, Alaska, Summer 1979. Not recommended for application to other watersheds. Consult ADF&G for further intrepretation.

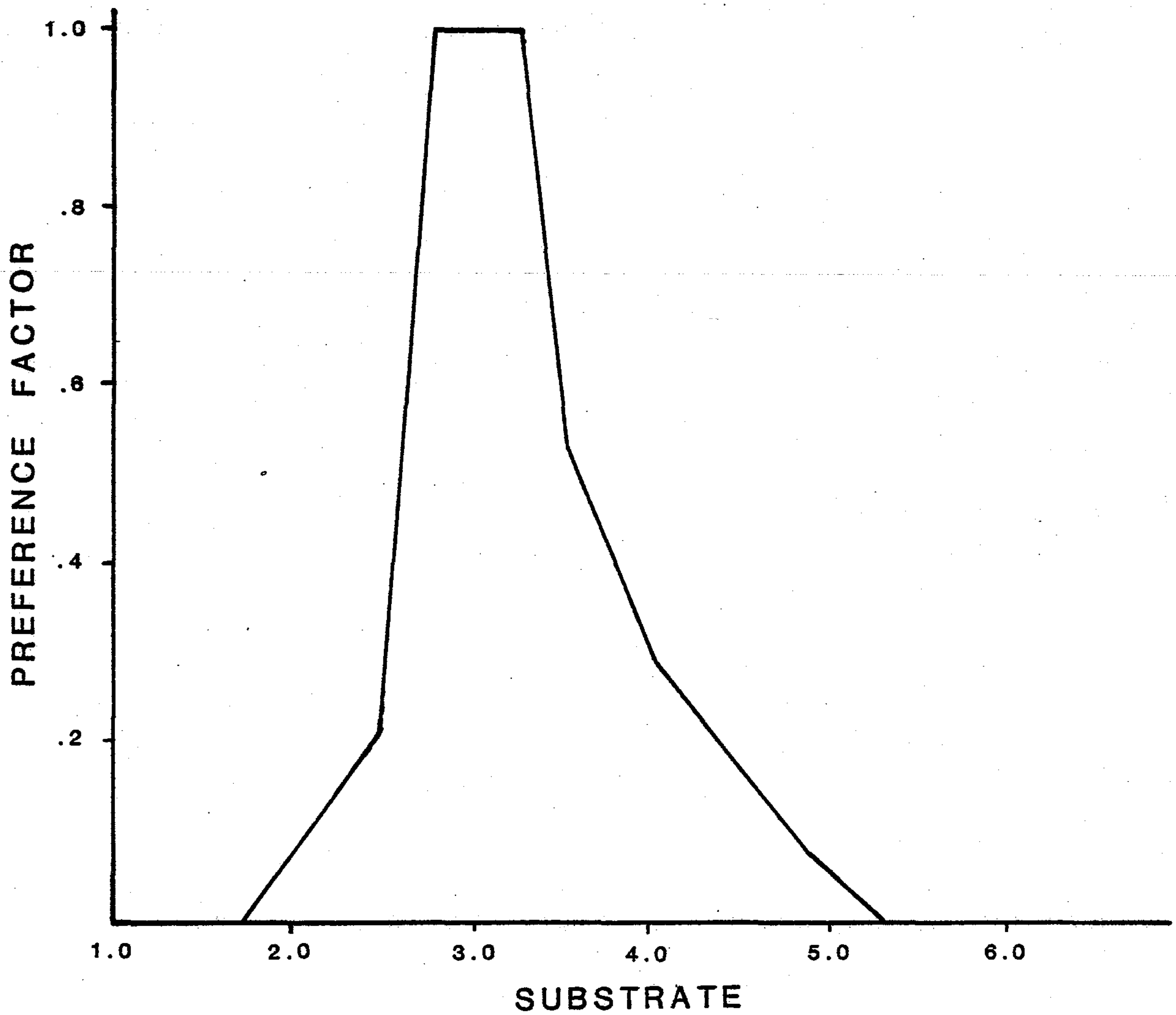


Figure 31. Substrate suitability curve for spawning chinook salmon in Willow Creek, Alaska, Summer 1979. Not recommended for application to other watersheds. Consult ADF&G for further interpretation.

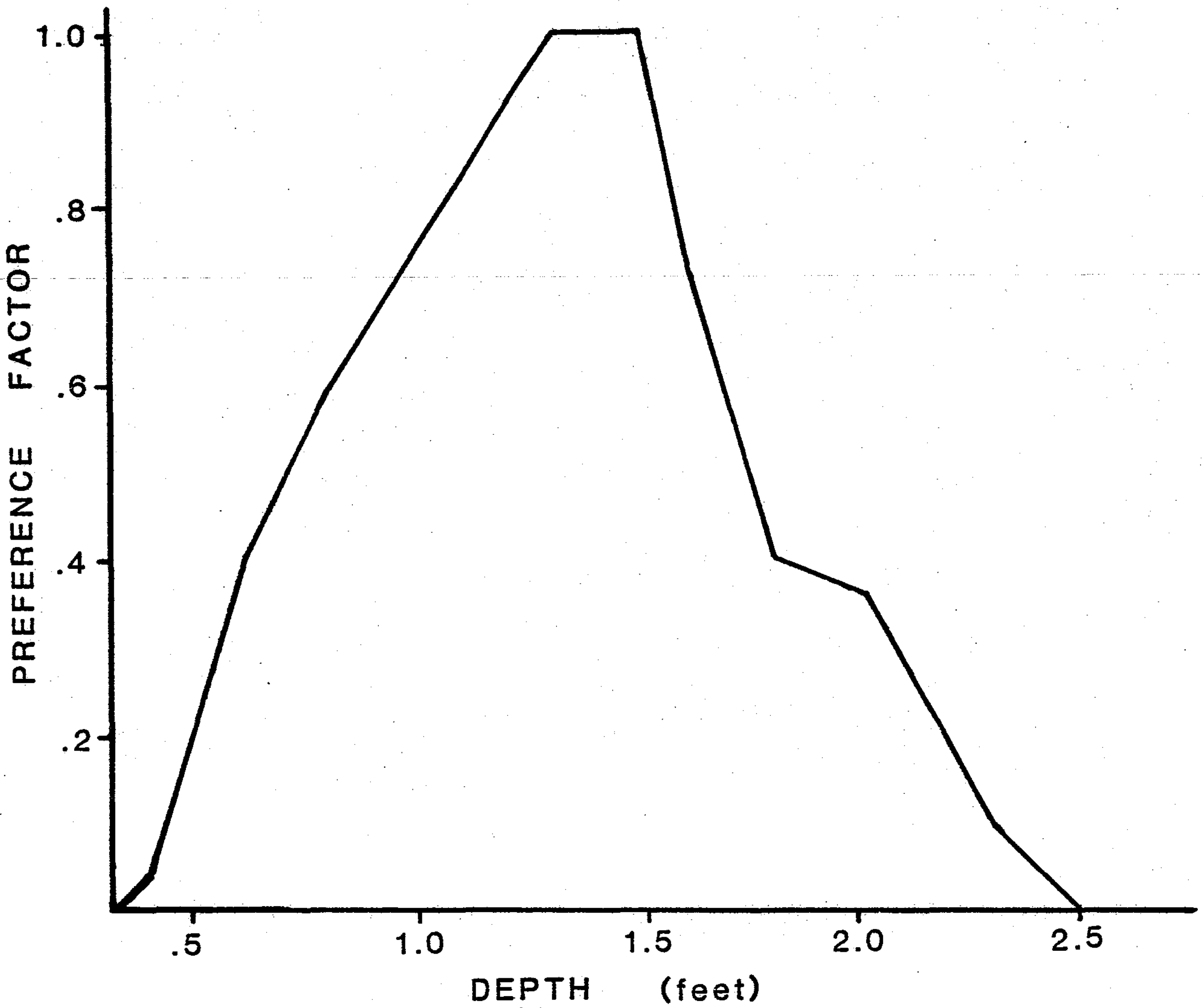


Figure 32. Depth suitability curve for spawning chinook salmon in Willow Creek , Alaska, Summer 1978 (adapted from Watsjold and Engel 1978). Not recommended for application to other watersheds. Consult ADF&G for further interpretation.

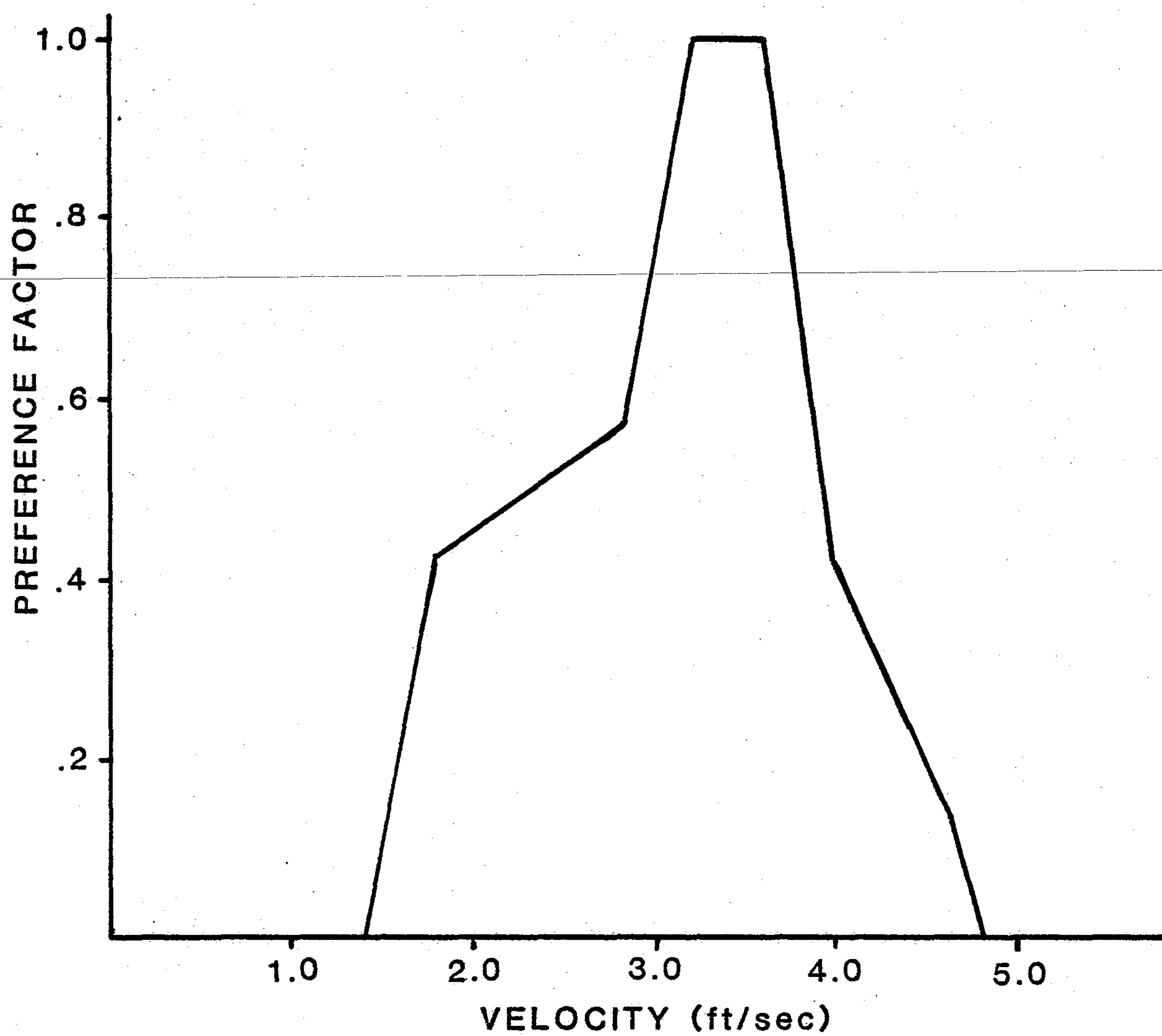


Figure 33. Velocity suitability curve for spawning chinook salmon in Willow Creek, Alaska, Summer 1978 (adapted from Watsjold and Engel 1978). Not recommended for application to other watersheds. Consult ADF&G for further intrepretation.

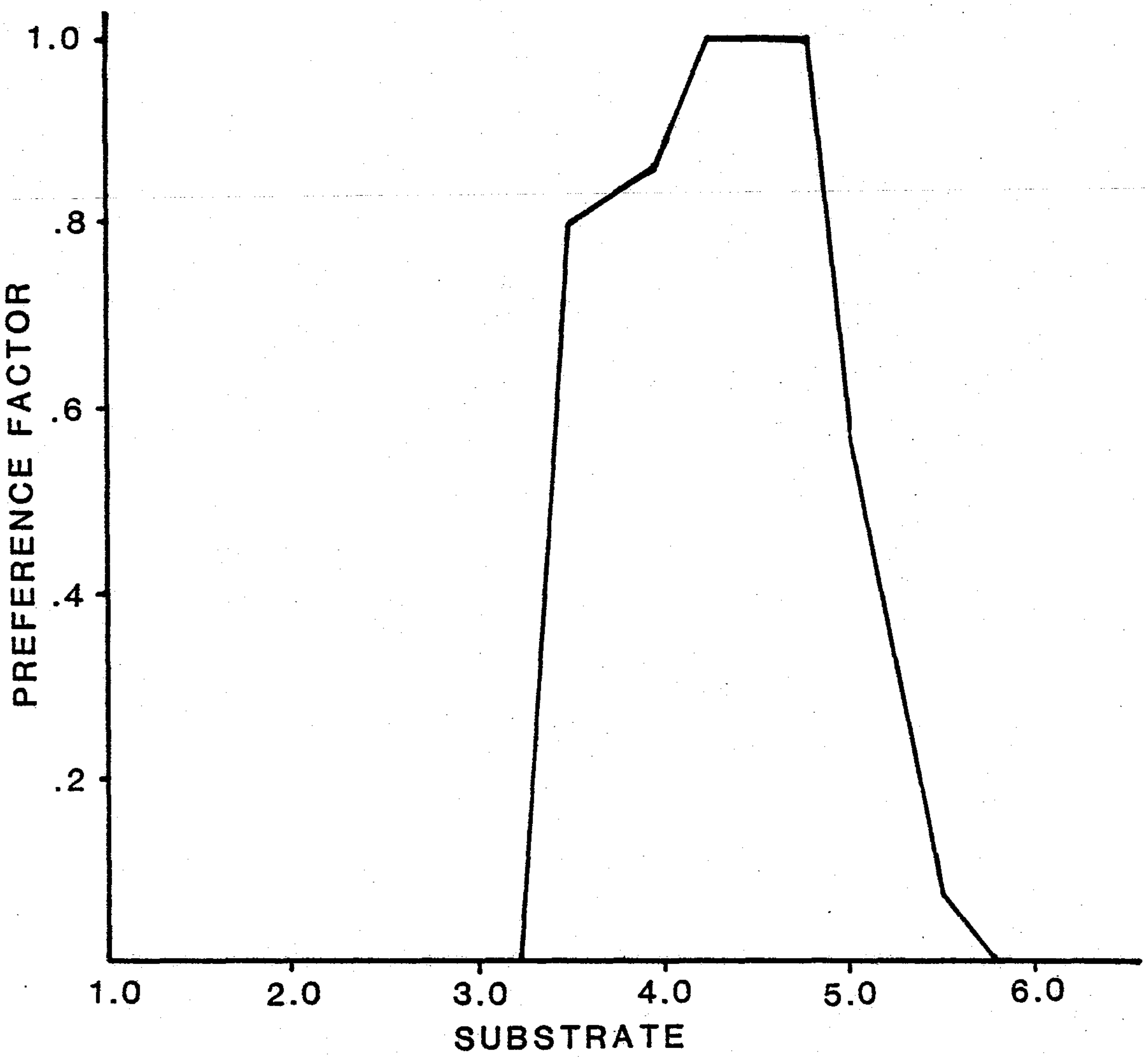


Figure 34. Substrate suitability curve for spawning chinook salmon in Willow Creek, Alaska, Summer 1978 (adapted from Watsjold and Engel 1978). Not recommended for application to other wastersheds. Consult ADF&G for further intrepretation.

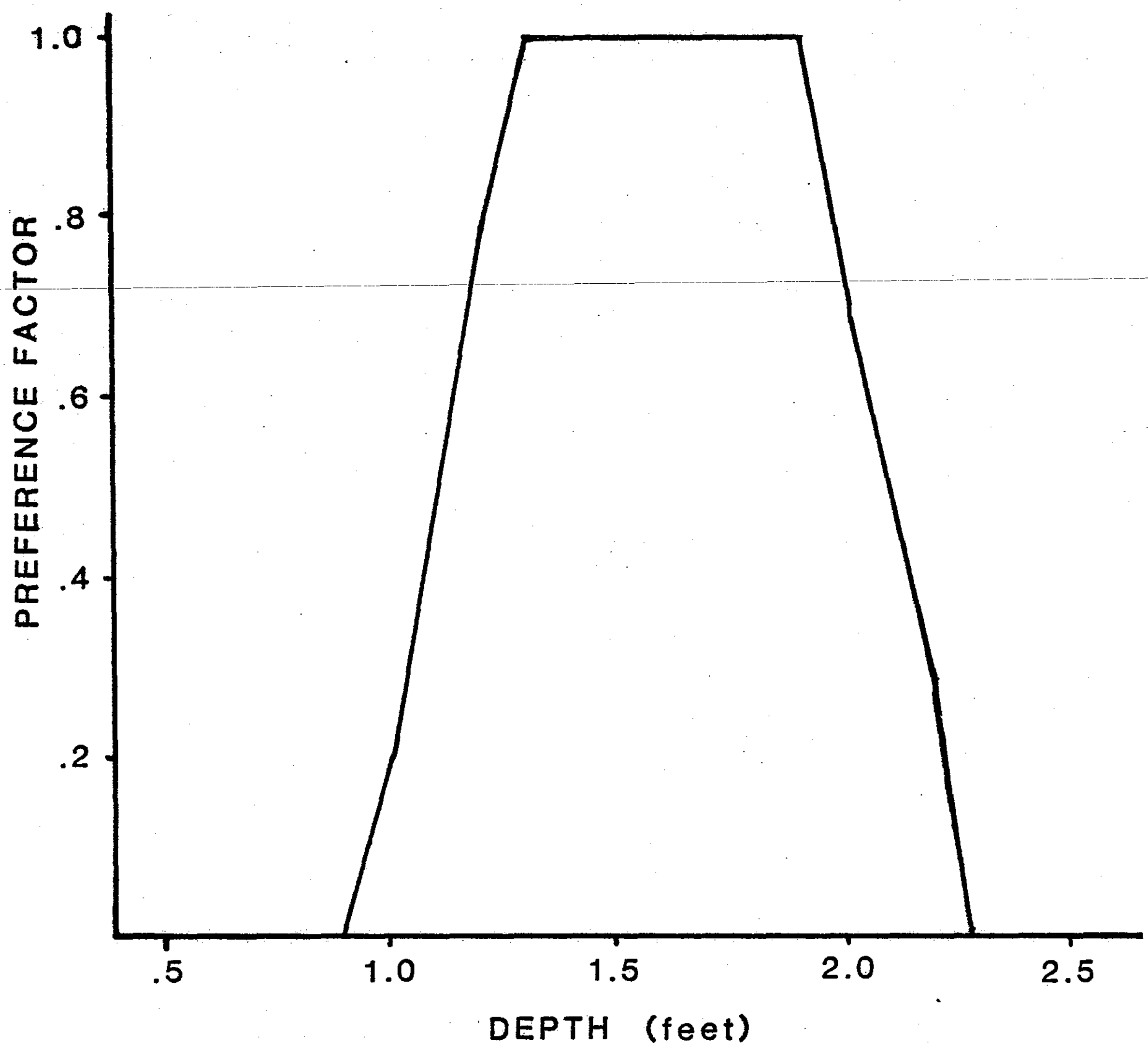


Figure 35. Depth suitability curve for spawning pink salmon in Willow Creek, Alaska, Summer 1978 (adapted from Watsjold and Engel 1978). Not recommended for application to other watersheds. Consult ADF&G for further interpretation.

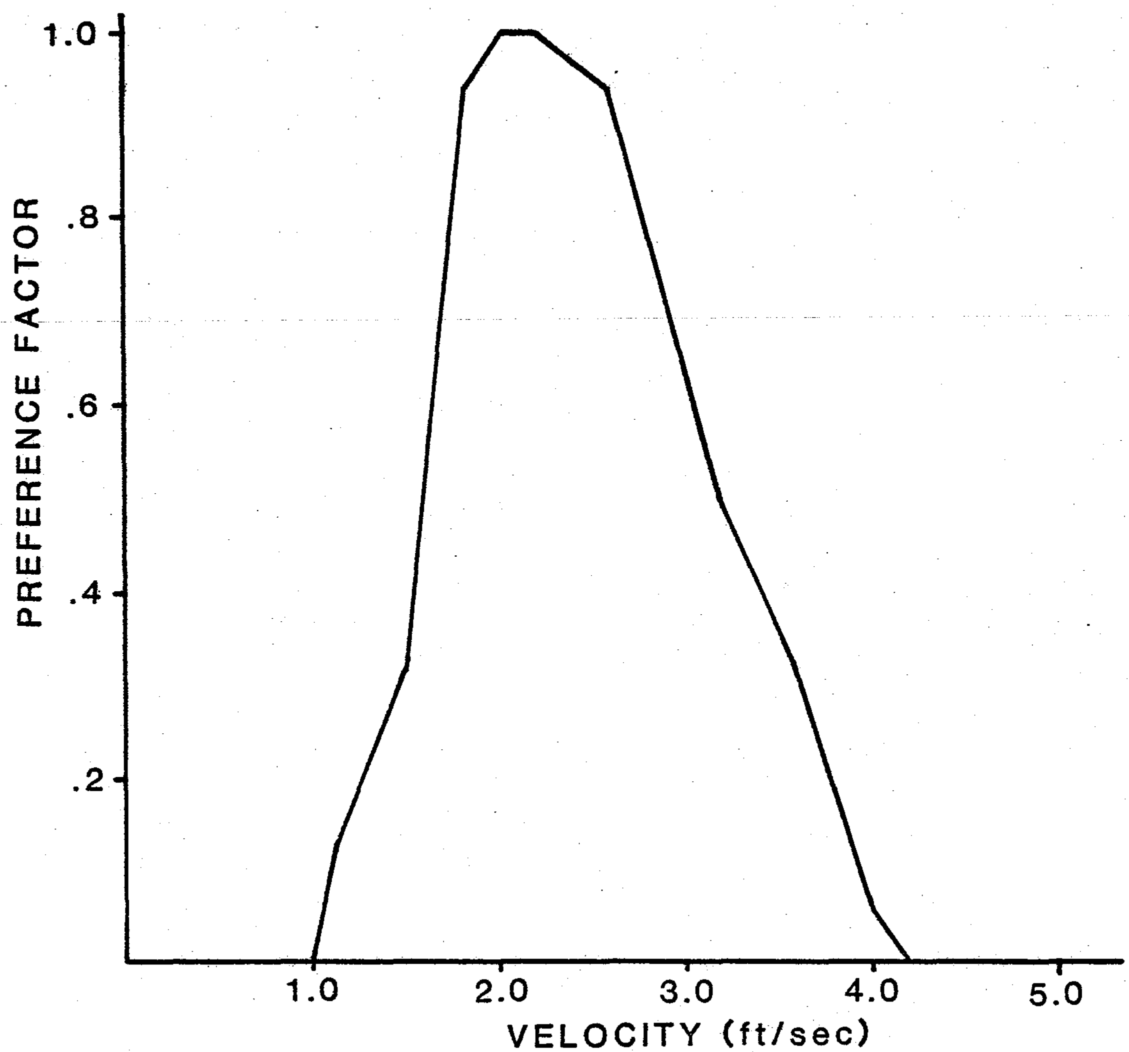


Figure 36. Velocity suitability curve for spawning pink salmon in Willow Creek, Alaska, Summer 1978 (adapted from Watsjold and Engel 1978). Not recommended for application to other watersheds. Consult ADF&G for further intrepretation.

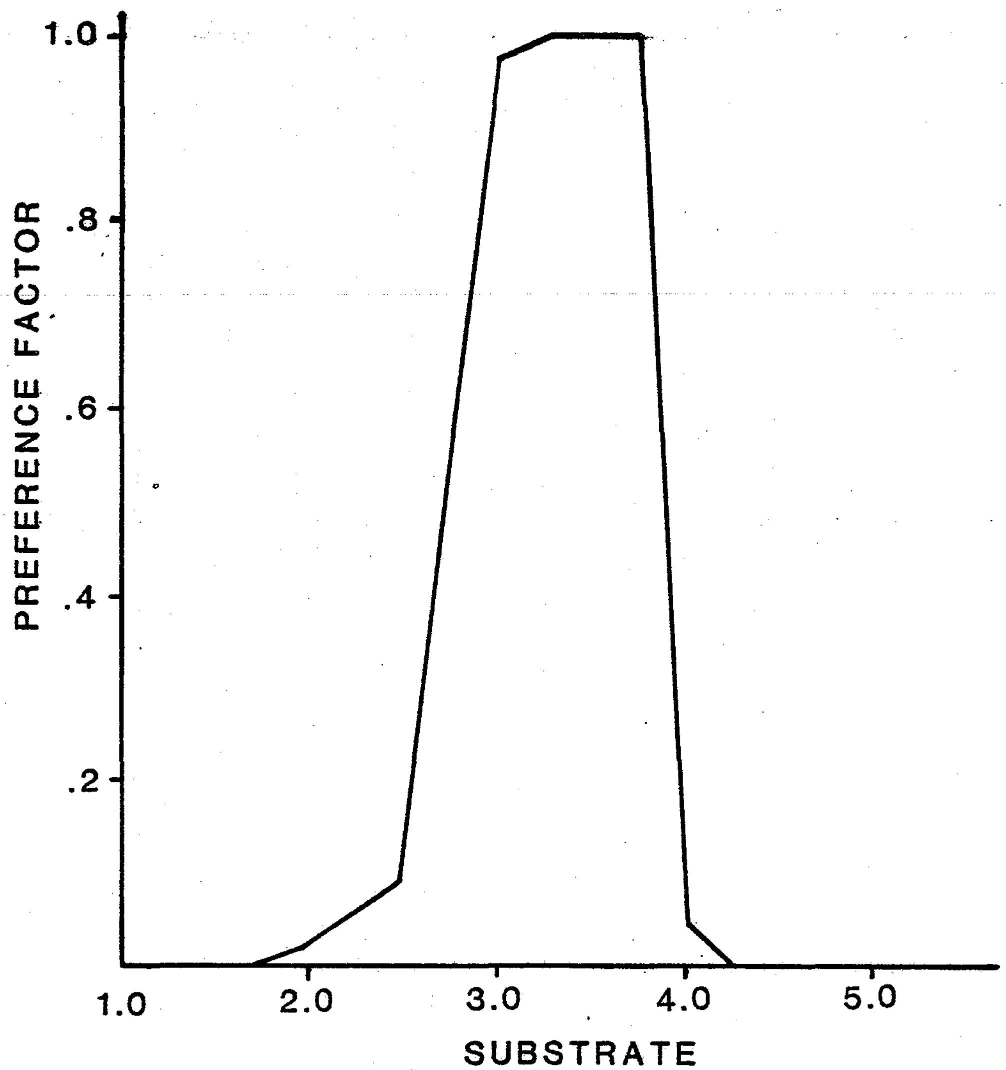


Figure 37. Substrate suitability curve for spawning pink salmon in Willow Creek, Alaska, Summer 1978 (adapted from Watsjold and Engel 1978). Consult ADF&G for further interpretation. Not recommended for application to other watersheds.

frequency analysis. This was accomplished by dividing the range of values obtained for each parameter (i.e., depth, velocity, or substrate), into appropriate equal increments, assigning each data point to the proper increment, and clustering adjacent increments to reduce the variance. The cluster pattern giving the least variance was plotted and the increment containing the greatest number of observations was designated as the optimum condition, receiving a preference value of 1.0. The remaining clustered increments were assigned preference factors by dividing the frequency of each increment by the frequency of the optimum. Detailed instructions for developing these curves are outlined by Bovee and Cochnauer (1977).

Velocity and depth curves were developed without data modifications. Development of substrate curves, however, required some data conversions. Substrate data, were aggregated for use in developing suitability curves. The data collection method used resulted in potentially unlimited combinations of categories for substrate classification (i.e., categories could be based on any percentage of any or all of the seven substrate classes). As a result, one site might include 50 subtrate categories while another might contain 10. By limiting substrate categories which could be used at a particular site to three dominant particle size classes, each of which had to comprise at least 10 percent of the substrate particle sizes present, the number of categories was reduced to 275. The 275 categories were then grouped into 10 categories according to predominant substrate size. After data were organized according to this system, frequency analysis of substrate categories was performed to develop substrate curves. Substrate data, thus grouped, were easily converted to the modified Wentworth classification (Table 5).

Benthic Invertebrates

One-hundred-six individual benthic invertebrates collected from the Willow/Deception Creeks Study reaches were classified to taxonomic order (Table 12). Eleven percent were identified as Trichoptera, 25 percent as Plecoptera, 56 percent as Diptera, 7 percent as Ephemeroptera, and 1 percent as representative of other orders.

Computer Analysis

Financial and time limitations restricted computer analysis of hydraulic data to one reach. The middle Willow Creek reach was selected because it contained both pink and chinook salmon spawning habitat.

Discharge and substrate data were coded and computer analyzed with the IFG-2 and IFG-4 programs* stored on the Boeing Computer Services System. Using the IFG-2 model, encoded data were calibrated to the highest

---

*The IFG-2 program is a modified version of the Water Surface Profile (WSP) computer program designed by the IFG which uses one set of observed stream flow data (depth, velocity, and substrate) to predict hydraulic parameters for a range of desired flow regimes. The hydraulic model is calibrated to reproduce water surface elevations and velocity distributions observed at selected stream flow conditions. Once properly calibrated, the computer program will predict the water surface elevations and respective horizontal velocity distributions at each transect for a range of desired discharges. The IFG-4 hydraulic model, unlike the IFG-2 model, requires at least two and preferably three sets of observed stream flows at each transect to correlate flow versus velocity and stage versus flow. Once calibrated, depths and velocities for flows of interest can be predicted from the established correlations (IFG 1980b).

Table 12. Benthic insects (no/ft.^{2}), classified to order, collected from each of the Willow/Deception Creek Instream Flow Study reaches, 1979.

SITE	TRICHOPTERA	PLECOPTERA	DIPTERA	EPHEMEROPTERA	OTHER
Lower Willow					
07/12	1	02	01	0	0
08/08	1	01	25	0	0
Middle Willow					
07/11	0	01	01	0	0
08/08	1	00	02	0	0
Middle Willow Slough					
07/11	0	01	26	1	0
Upper Willow					
07/11	0	06	03	0	0
08/08	2	00	00	2	2
Deception Creek					
07/12	2	13	02	4	0
08/09	5	02	00	0	0

discharge (991 cfs) following the procedures outlined by the IFG (1980b) and Trihey (1980).* IFG-2 computer output data for the middle reach of Willow Creek are presented in Appendix E. Unstable channel geometry and inability to obtain assistance of a hydraulic engineer prevented analysis by the IFG-4 program which would have required further hydraulic analysis (Newcome 1980).

Once calibrated, the hydraulic model was integrated with six different sets of point specific habitat suitability criteria for chinook and pink salmon to calculate predicted hypothetical Weighted Usable Area (WUA).** WUA values were predicted at six different discharges by each of the following IFG (1980b) methods:

1. Standard Calculation - "This is the calculation of the habitat area with the Joint Preference Factor (JPF) equal to (a x b x c); where a, b, and c, equal preference variables for velocity, depth, and substrate. This technique implies synergistic action; optimum habitat only exists if all variables are optimum".

   a. Standard Calculation With Three Matrices - "This is the Standard Calculation in which depth/velocity, velocity/

---

*This was based on the assumption that streambed elevations measured at this discharge level would be static for all predicted flows.

**The WUA represents the square feet (ft^2) or percentage (%) of wetted surface habitat area predicted to be available per 1000 linear feet of stream reach at a given flow.

substrate, or depth/substrate relationships are displayed in a matrix".

2. Geometric Mean - "This is the calculation of the habitat area with the JPF equal to $(a \times b \times c)^{0.333}$. This technique implies compensation effects; if two of the three variables are in the optimum range, the value of the third variable has little effect unless it is zero".

3. Lowest Limiting Parameter - "This is the calculation of the habitat area with the JPF equal to the variable having the lowest preference factor at a given discharge. In other words, the optimum habitat will be based on the most limiting variable for a given discharge. This implies a limiting factor concept, or that the habitat is no better than its least suitable factor".

The six sources of habitat suitability criteria used in the demonstration WUA analysis are listed below:

A. 1980 depth, velocity, and substrate preliminary data on pink salmon habitat from the Terror Lake Hydroelectric feasibility study, Kodiak Island (AEIDC 1980);

B. 1978 depth, velocity, and substrate data on pink salmon habitat in Willow Creek (Watsjold and Engel 1978);

C. 1979 depth, velocity, and substrate data on chinook salmon habitat in Willow Creek;

D. 1978 depth, velocity, and substrate data on chinook salmon habitat in Willow Creek (Watsjold and Engel 1978);

E. 1978 depth and velocity data on chinook salmon habitat in Willow Creek (Watsjold and Engel 1978), and 1979 substrate data on chinook salmon habitat in Willow Creek; and

F. 1979 depth and velocity data on chinook salmon habitat in Willow Creek; and 1978 substrate data, on chinook salmon habitat in Willow Creek (Watsjold and Engel 1978).

Descriptions of the calculation methods above suggest that the Lowest Limiting Parameter calculation method would generate the most conservative* WUA value for a given discharge. However, results obtained by each of the three methods indicate that the Standard Calculation procedure will generate the most conservative WUA values (Figure 38; Tables 13, 14). This occurs because the suitability values used to compute WUA must always range between 0 and 1.

Results of the above demonstration calculations to predict WUA values indicate that suitablility data collected from one stream system may not necessarily apply to another (Figure 39; Tables 13, 14).** For example,

---

*Conservative WUA values, as defined in this report, represent the lowest predicted WUA values for a given discharge when more than one calculation method is applied.

**It should be noted that suitability data presented in this report were derived from dissimilar samples in terms of the population size sampled and location of the sampling. These factors may also have influenced the results.

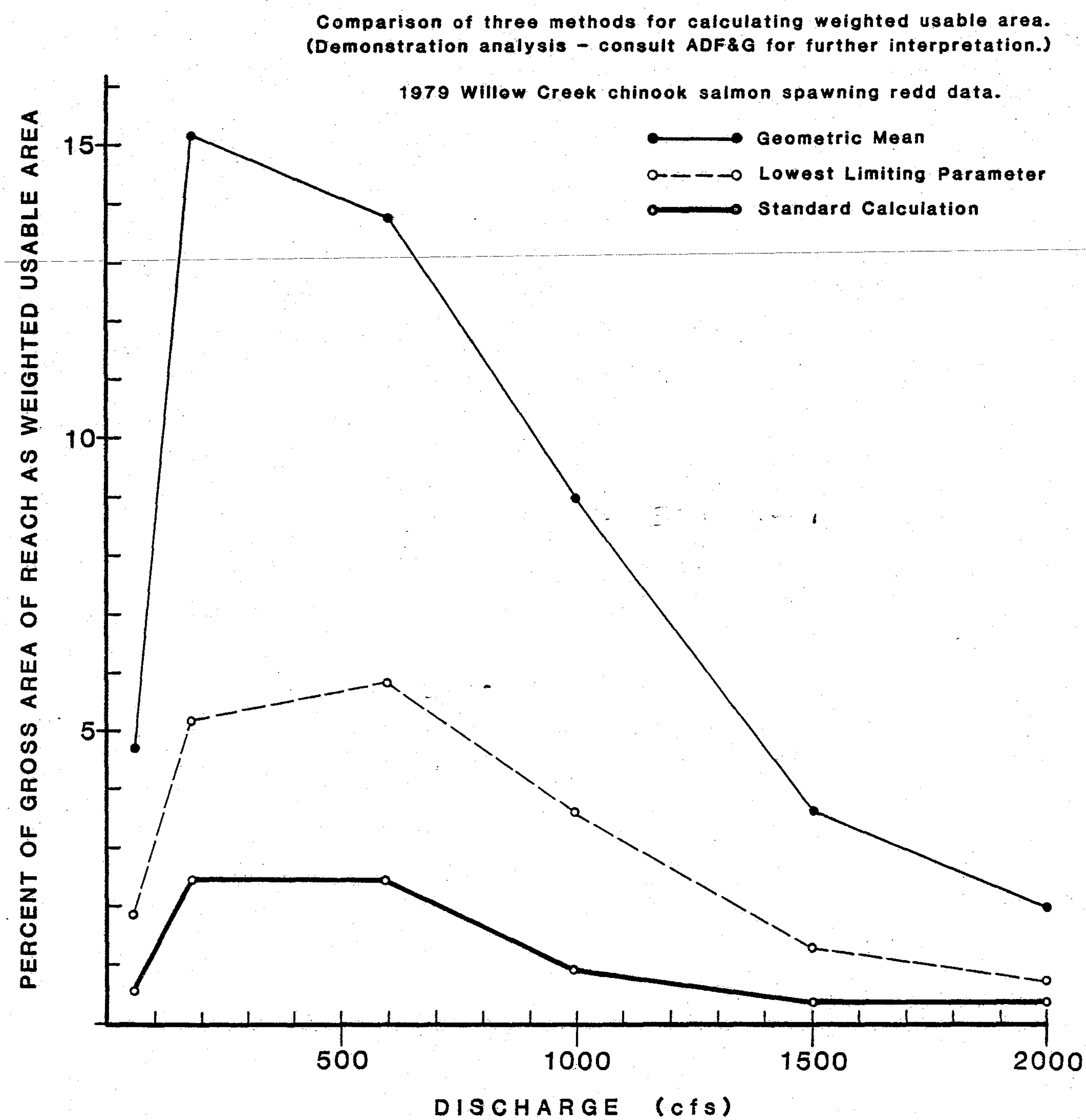

Comparison of three methods for calculating weighted usable area.
(Demonstration analysis - consult ADF&G for further interpretation.)
1979 Willow Creek chinook salmon spawning redd data.
Geometric Mean
Lowest Limiting Parameter
Standard Calculation
PERCENT OF GROSS AREA OF REACH AS WEIGHTED USABLE AREA
15
10
5
500
1000
1500
2000
DISCHARGE (cfs)

Figure 38.

Table 13. Discharge vs. predicted available spawning habitat area (ft^2) per 1000 feet of the Willow Creek Instream Flow Study middle reach (Demonstration analysis - consult ADF&G for further interpretation).

DISCHARGE (cfs)	PINK SALMON A	PINK SALMON B	CHINOOK SALMON C	CHINOOK SALMON D	CHINOOK SALMON E	CHINOOK SALMON F
Standard Calculations						
2000	16051	0000	00463	00416	0042	02876
1500	18273	0041	00538	01371	0117	03839
0991	16132	0026	00897	02500	0234	05674
0598	19586	0995	01941	04423	1411	07677
0175	25361	0329	01552	05930	0751	09284
0050	14315	0005	00255	01203	0112	01811
Geometric Mean						
2000	45640	0000	02933	03853	1072	08044
1500	48735	0435	04999	06501	1633	13534
0991	39540	0508	08916	09633	3447	19737
0598	42264	2210	11093	14997	7612	23430
0175	44018	1401	09726	19015	6923	20612
0050	29093	0127	02315	05750	2013	04792
Lowest Limiting Parameter						
2000	21451	0000	1128	01070	0477	04631
1500	23819	0064	1735	02775	0551	07741
0991	21557	0096	3610	05513	1005	10916
0598	25112	1060	4678	08492	3074	13376
0175	28956	0709	3326	10095	2058	12521
0050	18719	0025	0905	02814	0620	03223

A Pink salmon 1980 Terror Lake depth, velocity, and substrate data (AEIDC 1980).
B Pink salmon 1978 Willow Creek depth, velocity, and substrate data (Watsjold and Engel 1978).
C Chinook salmon 1979 Willow Creek depth, velocity, and substrate data.
D Chinook salmon 1978 Willow Creek depth, velocity, and substrate data (Watsjold and Engel 1978).
E Chinook salmon Willow Creek 1978 depth and velocity data (Watsjold and Engel 1978); 1979 substrate data.
F Chinook salmon Willow Creek 1979 depth and velocity data; 1978 substrate (Watsjold and Engel 1978).

Table 14. Discharge vs. predicted available spawning habitat area (ft^2) as a percentage of the Willow Creek Instream Flow Study middle reach (Demonstration analysis - consult ADF&G for further interpretation).

DISCHARGE (cfs)	PINK SALMON		CHINOOK SALMON			
	A	B	C	D	E	F
			Standard Calculations			
2000	10.73	0.00	00.31	00.28	00.03	01.92
1500	13.13	0.03	00.39	00.99	00.08	02.76
0991	16.18	0.03	00.90	02.51	00.23	05.69
0598	24.27	1.23	02.41	05.48	01.75	09.51
0175	39.52	0.51	02.42	09.24	01.17	14.47
0050	29.01	0.01	00.52	02.44	00.23	03.67
			Geometric Mean			
2000	30.50	0.00	01.96	02.57	00.72	05.38
1500	35.01	0.31	03.59	04.67	01.17	09.72
0991	39.66	0.51	08.94	09.66	03.46	19.80
0598	52.37	2.74	13.75	18.58	09.43	29.03
0175	68.59	2.18	15.15	29.63	10.79	32.11
0050	58.96	0.26	04.69	11.65	04.08	09.71
			Lowest Limiting Parameter			
2000	14.33	0.00	00.75	00.71	00.32	03.09
1500	17.11	0.05	01.25	01.99	00.40	05.56
0991	21.62	0.10	03.62	05.53	01.01	10.95
0598	31.12	1.31	05.80	10.52	03.81	16.57
0175	45.12	1.10	05.18	15.73	03.21	19.51
0050	37.94	0.05	01.83	05.70	01.26	06.53

A Pink salmon 1980 Terror Lake depth, velocity, and substrate data (AEIDC 1980).
B Pink salmon 1978 Willow Creek depth, velocity, and substrate data (Watsjold and Engel 1978).
C Chinook salmon 1979 Willow Creek depth, velocity, and substrate data.
D Chinook salmon 1978 Willow Creek depth, velocity, and substrate data (Watsjold and Engel 1978).
E Chinook salmon Willow Creek 1978 depth and velocity data (Watsjold and Engel 1978); 1979 substrate data.
F Chinook salmon Willow Creek 1979 depth and velocity data; 1978 substrate data (Watsjold and Engel 1978).

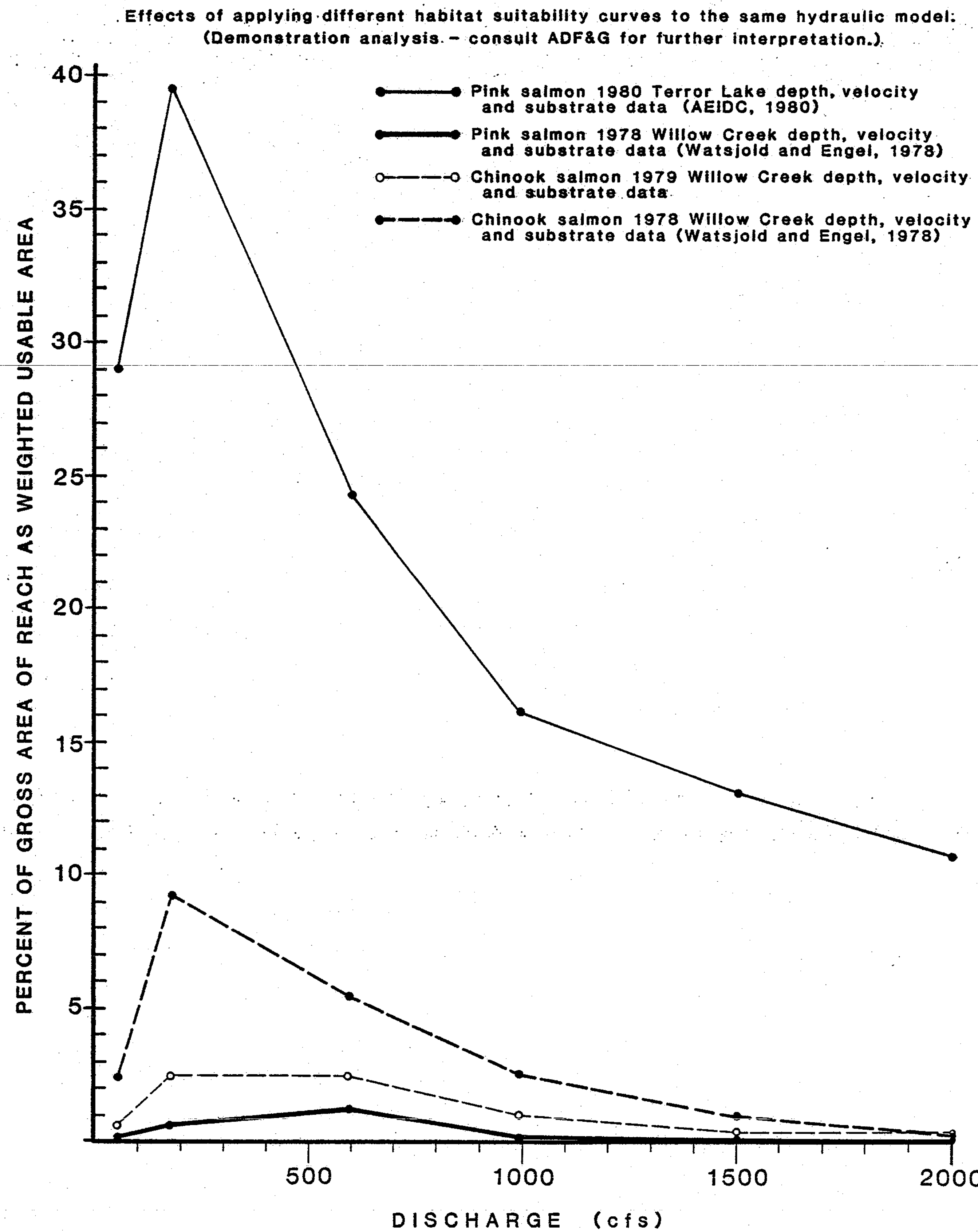

Effects of applying different habitat suitability curves to the same hydraulic model:
(Demonstration analysis - consult ADF&G for further interpretation.)
Pink salmon 1980 Terror Lake depth, velocity and substrate data (AEIDC, 1980)
Pink salmon 1978 Willow Creek depth, velocity and substrate data (Watsjold and Engel, 1978)
Chinook salmon 1979 Willow Creek depth, velocity and substrate data
Chinook salmon 1978 Willow Creek depth, velocity and substrate data (Watsjold and Engel, 1978)
PERCENT OF GROSS AREA OF REACH AS WEIGHTED USABLE AREA
40
35
30
25
20
15
10
5
500
1000
1500
2000
DISCHARGE (cfs)

Figure 39.

using the Standard Calculation, predicted WUA at a discharge of 175 cfs (based on suitability criteria for pink salmon collected from different stream systems) ranged from 329 ft^2 (0.51%) per 1000 feet to 25,361 ft^2 (39.53%) per 1000 feet (Tables 13, 14).

Supplemental Biological, Water Quantity and Quality Study

Peters/Purches Creeks

Biological Data

One hundred twenty four Dolly Varden and 10 slimy sculpin (*Cottus cognatus*) were captured in Peters Creek. Eighty Dolly Varden and 15 slimy sculpin were captured in Purches Creek (Table 15).

Water Quantity

Flows ranged from 1 to 76 cfs on Peters Creek and 8 to 97 cfs on Purches Creek (Table 16).

Substrate

Substrate classes ranged from II to VII in Peters Creek and from III to VII in Purches Creek (Table 17).

Table 15. Fish trapping results, Peters and Purches Creeks, 1979.

Date	Index Area	No. of Traps	No. of Fish DV*	No. of Fish SS*	Catch/Trap DV*	Catch/Trap SS*
08/23	Peters II	20	33	5	1.65	0.25
08/24	Peters III	20	30	4	1.50	0.20
08/26	Purches II	20	35	9	1.75	0.45
08/27	Purches II	20	45	6	2.25	0.30
09/09	Peters IV	20	43	0	2.15	0.00
09/10	Peters IV	20	18	1	0.90	0.50

Table 16. Discharge measurements (Q) in cubic feet per second (cfs) Peters and Purches Creeks, 1979.

Date	Index Area	Map Location No.	Discharge (cfs)
08/23	Peters I	Q1	01
08/23	Peters I	Q2	43
08/24	Peters III	Q3	73
08/24	Peters III	Q4	13
08/26	Purches I	Q5	08
08/26	Purches I	Q6	32
08/27	Purches III	Q7	61
08/27	Peters III	Q8	76
08/27	Purches II	Q9	10
09/10	Purches IV	Q10	97

*DV-Dolly Varden, SS-Slimy Sculpin.

Table 17. Range of predominant substrate classes observed in Peters and Purches Creeks, 1979.

PETERS CREEK INDEX AREA	SUBSTRATE CLASS RANGE	PURCHES CREEK INDEX AREA	SUBSTRATE CLASS RANGE
I	V - VII	I	V - VII
II	IV - VII	II	III - VI
III	III - VI	III	III - VI

Water Quality

Water quality data were not collected because of instrument malfunction.

ADF&G/USGS Sites

Water Quantity and Quality

Water quantity and quality data collected in the spring, summer, and fall of 1979 are presented in Appendix B. Additional water quality data collected in the winter of 1979-80 and spring, summer, and fall 1980 will be included in the USGS publication: Water resources data for Alaska, water year 1980.

DISCUSSION

DISCUSSION

Instream Flow Study

The Willow/Deception Creeks Instream Flow Study constituted an initial "hands-on" experience at collecting and analyzing Alaskan instream flow data for the ADF&G and cooperating agencies, following Incremental Methodology procedures established by the IFG (1980a, b; Bovee 1980a; Bovee and Milhous 1978; Bovee and Cochnauer 1977; Trihey 1980). This demonstration project enabled the participants to develop the capability to perform this type of instream flow field data collection and analysis, identify the limitations of the methodology, develop suggestions for its improvement, and recommend a plan of study for determining instream flow values in Willow and Deception Creeks.*

Hydraulic Data Collection Limitations and Recommendations

Of the six individuals required to collect hydraulic data for this project, only two were actually employed by the ADF&G to perform the study. To compensate, volunteers were recruited from other ADF&G projects and from cooperating agencies. Scheduling necessary to accommodate changes in weather and to insure that one set of data was collected during each period of seasonal high, medium, and low flows often prevented

---

*Additional recommendations and strategies for determining instream flow values are presented in the publications: A synthesis and evaluation of ADF&G fish and wildlife resources information for the Willow and Talkeetna sub-basins (Estes and Lehner-Welch 1980) and Opportunities to protect instream flows in Alaska (White 1981).

the same volunteers from returning to the project. As a result, substitutes had to be recruited, and trained in the field, while collecting data. This proved to be time consuming, and hampered efforts to insure quality control and minimize data gaps and/or errors. Another disadvantage was that a hydraulic engineer, familiar with instream flow investigations, was not assigned to the project. Without this technical input, it was difficult to determine whether site selection and related activities associated with hydraulic data collection were properly executed. These problems can be minimized in future studies if sufficient funding is secured to employ adequate numbers of full-time experienced personnel, including at least one biologist and hydraulic engineer.

As would be expected in a first-time study, problems and complications arose in the data reduction and computer analysis portions of the project. The following check list of procedures for field collection of hydraulic data is recommended to insure that future data will be suitable for analysis (Newcome 1980):

1. All initial cross-section data for each transect should be collected with a rod and level;

2. Sufficient elevation data should be collected between the water's edges and headpins to document the shape of the entire streambed;

3. Headpin elevations should be measured both on the top of each headpin and on the ground beside each headpin to document its-

vertical positioning and permit reinstallation in the event it is removed or disturbed at a later date;

4. Magnetic bearings should be recorded, and/or diagonal distances should be measured, between transects to facilitate scale drawings of the study sites;

5. Stationing should begin downstream (i.e. the downstream-most transect should be 0+00) to facilitate data reduction and coding in preparation for computer analysis with the IFG models;

6. Streambed elevations should be recorded from left bank to right bank looking upstream to facilitate data reduction and coding in preparation for computer analysis with the IFG models;

7. Water surface elevation should be recorded before and after discharge is measured at a transect;

8. Distance from left bank headpin (LBHP) to right bank headpin (RBHP) should be measured at each transect each time velocities are measured. This measurement should be equal to (LBHP to left edge of water) + (top width of stream) + (RBHP to right edge of water) and should not change at different flows;

9. Transects over islands or gravel bars should be "dog-legged" to insure water surface elevations are equal on each side of the island;

10. Level loops should be clearly documented with station, backsight, height of instrument, foresight, and elevations in separate columns. There should be no question as to how each reading or calculation was obtained and the error of closure should be no greater than (0.1 ft) x ($\sqrt{\text{square miles}}$);

11. Crew members should read Appendixes A and B of the IFG field data collection procedures publication No. 5 (Bovee and Milhous 1978) as part of their pre-field training;

12. When unusual measurements or readings are recorded, they should be footnoted with an explanation of the circumstances to insure the data will not be mistaken as being in error;

13. At least one member of the field crew (preferably the leader) should perform all the exercises in the manual: Field data reduction and coding procedures for use with the IFG-2 and IFG-4 hydraulic simulation models (Trihey 1980);

14. Field data should be reconciled and reduced in the field to identify and correct data gaps and/or errors;

15. Half-inch margins should be left on all borders of field forms

to permit photocopying without loss of data resulting from distortion.

Point Specific Habitat Data Collection Limitations and Recommendations

Presently, limited information exists concerning the specific spawning, rearing, incubation, and passage streamflow requirements of culturally and economically important fish. These data are essential for wise land-use planning and development (Estes and Lehner-Welch 1980). Bell (1980), Bovee (1980 b), and Estes and Lehner-Welch (1980) recommend that habitat requirements for a particular life phase of a fish species should be determined by collecting and analyzing comprehensive stream-specific data in addition to reviewing all pertinent literature. Literature review alone is not usually adequate because data and findings cited for one area are not likely to fully or accurately represent another specific location. As a result, it is recommended that point specific data collected for a particular life phase of a particular fish species in a specific geographic location not be applied to another location unless careful analysis is completed to determine if such an application is valid.

Point specific data collection for this study was limited to the spawning phase of chinook salmon.* Developing an understanding of other chinook life phases and the life phases of other fish species in Willow and

---

*Funding, personnel, and time constraints prevented the execution of the pink salmon spawning habitat portion of Objective 3 of the Instream Flow Study and Objective 4, an evaluation of chinook salmon rearing habitat.

Deception Creeks will require a considerable amount of work over all seasons of the year (Watsjold and Engel 1978). It is recommended that future instream flow studies assign at least two individuals to collect point specific field data for species and life phases of interest. It is also suggested that research be performed by a hydraulic engineer and fishery biologist to evaluate the various techniques for collecting point specific data. For example, the topic of whether to measure point specific water velocity at the mean depth of the water column as opposed to the actual depth of the fish should be addressed.

Computer Analysis

Five man-months were expended in familiarizing personnel with methods of IFG computer analysis and in analyzing the hydraulic data. Limitations of and recommendations for improving computer analysis are discussed below:

Limitations

Because of their familiarity with and day to day use of their programs, the IFG has inadvertently underestimated the limitations of user groups who are inexperienced or use the models infrequently. As a result,

1. The IFG computer programs on the Boeing system require more experience than is provided by the IFG computer analysis

course, or require that users have access to a computer programmer familiar with the IFG programs on the Boeing system (Newcome 1980);

2. IFG computer analysis often requires the supplemental input of a hydraulic engineer to insure hydraulic output is valid. When field data are collected incorrectly or from complex field situations and cannot be readily analyzed, a hydraulic engineer is required to modify the data to develop stage, velocity, and depth relationships, calibrate the model, and interpret the output (Newcome 1980);

3. Some of the recommended IFG procedures, as documented in the draft version of the IFG computer manual (IFG 1980b), do not work on the Boeing system. These errors are being corrected as users notify the IFG, but the errors are very frustrating for both novice and experienced users (Newcome 1980; Amos 1981);

4. Although there are less expensive methods for performing some of the analytical computer operations on an interactive* basis, the IFG has not incorporated these procedures into their manuals (e.g. running the programs in the batch** mode at a

*Interactive refers to computer programs which request immediate responses from the user resulting in a "dialogue" between the user and the program.

**Batch refers to computer programs which contain all of the instructions for performing a job and are submitted to the computer to be run at a later time.

lower priority or entering data with the "Editor" (Newcome 1980); and

5. Examples presented in the sections of the IFG computer manual (IFG 1980b), illustrating how to weigh the advantages and disadvantages of various procedures, lack adequate documentation (Newcome 1980).

Recommendations

To minimize these problems,

1. IFG publications should be revised to provide more detailed background information on the resources and training required to collect and analyze data;

2. The IFG computer manual should be revised to include a variety of sample problems with an explanation of the iterative process for solving them. Examples of outputs, interpretations of results, and sample computing sessions should also be provided (Newcome 1980);

3. The IFG should thoroughly test its computer programs and procedures on all computer systems having the IFG software (Newcome 1980);

4. IFG computer courses should be oriented towards use of all

computer systems capable of using the IFG software (Newcome 1980); and

5. The IFG should develop procedures for improving its capability to communicate procedural changes to user groups (Newcome 1980; Amos 1981).

Biological, Water Quantity and Quality Data

Instream flow related data on water chemistry, stage, and supplemental biological conditions do not indicate the presence of any unusual conditions in the study area. Additional analysis of these data are beyond the scope of this study. Therefore, if additional funding can be secured to evaluate the biological, physical, and chemical relationships which are influenced by changes in disharge, it is recommended that:

1. hydrographs illustrating average daily flows as a function of time be developed for the Willow and Deception Creeks study reaches;

2. water temperature and quality data as a function of time be graphically illustrated;

3. graphics developed for (1) and (2) above be combined for the same locations to illustrate the relationships between discharge, water quality, stage, and temperature as a function of time;

4. fish species periodicity charts be combined with data from (3)

above to illustrate the relationships between the time of occurrence of each life history phase of each fish species present, and discharge, water quality, stage, and temperature; and

5. air temperature data be graphed and compared with water quality data from (2) above.

WUA Calculations

The hypothetical WUA calculations for the middle Willow Creek reach presented in this report demonstrate the variability which can result from applying habitat suitability data collected for different stocks of the same fish species at different locations and times to the same sets of hydraulic data. They demonstrate also that the use of a particular calculation procedure will influence the WUA output. This variability illustrates the complexity of data acquisition, analysis, and interpretation, and emphasizes the importance of both understanding how to select and interpret a particular calculation, as well as insuring that habitat suitability data external to the project apply to the system under question.

Supplemental Biological, Water Quantity and Quality Study

Biological, water quantity and quality data collected from the Peters/Purches Creeks and ADF&G/USGS sites do not indicate the presence of any unusual conditions in the study area. Analysis of these data is beyond the scope of this study.

CONCLUSIONS

CONCLUSIONS

Criticisms in this report are intended to be constructive. Overall, the authors believe the Incremental Methodology is the best approach available for determining instream flow requirements when sufficient resources to collect and analyze the required information are on hand. The IFG has done a commendable job in developing this methodology, in light of their present budgetary constraints and the large number of user groups requesting their assistance. Alaska and other states will continue to benefit from the perpetuation of the IFG as a national clearinghouse for state-of-the-art instream flow techniques and as a central information source for all instream flow related studies.

To insure that land-use activities are planned and implemented with minimal degradation to the fish and wildlife resources within the study area, the authors recommend that:

1. a follow-up comprehensive IFG Incremental Methodology instream flow study be conducted over a 2-year period to:

   a) better define and/or identify seasonal life history habitat requirements of selected fish species in Willow and Deception Creeks; and

   b) recommend and file for an instream flow reservation to maintain the existing fishery values; and

2. alternative instream flow data collection and analysis techniques

described by Ott and Tarbox 1977; Fraser 1975; Orsborn and Allman 1976; Stalnaker and Arnette 1976; Smith 1979; Tennant 1975; Orsborn and Watts 1980; and Orsborn 1981 be tested on Willow and Deception Creeks to evaluate their advantages and disadvantages as alternative approaches to the IFG Incremental Methodology approach for determining instream flows.

REFERENCES

REFERENCES

AEIDC. 1980. Pink salmon spawning habitat suitability data. (Draft). Terror Lake Hydroelectric Facility. Instream Flow Studies File. Arctic Environment Information Data Center. Anchorage, Alaska.

Amos, D. 1981. Personal communication. USFWS. Anchorage, Alaska.

Bell, M. 1980. Personal communication. Fishery consultant. Seattle, Washington.

Bovee, K.D. 1980a. A user's guide to the IFG incremental method. (Draft). USFWS. IFG. Ft. Collins, Colorado.

_____. 1980b. Personal communication. IFG. Ft. Collins, Colorado.

_____, and T. Cochnauer. 1977. Development and evaluation of weighted criteria, probability-of-use curves for instream flow assessments: fisheries. Instream Flow Information Paper No. 3. USFWS. Ft. Collins, Colorado.

_____, and R. Milhous. 1978. Hydraulic simulation in instream flow studies: Theory and Techniques. Instream Flow information paper No. 5. Cooperative Instream Flow Service Group. FWS/OBS-78/33. Ft. Collins, Colorado.

Buchanan, T.J., and W.P. Somers. 1973. Discharge measurements at gaging stations. Techniques of Water Resources Investigations of the United States Geological Survey. Book 3. Chapter A 8. Arlington, Virginia.

Estes, C., and D. Lehner-Welch. 1980. A synthesis and evaluation of ADF&G fish and wildlife resources information for the Willow and Talkeetna sub-basins. ADF&G. Habitat Protection Division. Anchorage, Alaska.

Fraser, J.C. 1975. Determining discharges of fluvial resources. FAO. Fisheries Technical Paper No. 143. Rome.

Instream Flow Group (IFG). 1980a. The incremental approach to the study of instream flows. USFWS. W/IFG-80W31. Ft. Collins, Colorado.

_____. 1980b. Users guide to the Physical Habitat Simulation Model (PHABSIM). (Draft). USFWS. IFG. Ft. Collins, Colorado.

McCoy, G.A. 1978. Water resources of the new capital site - a phase I progress report prepared for the Capital Site Planning Commission. USGS. Anchorage, Alaska.

Mills, M.J. 1980. Statewide harvest study: July 1, 1980 - June 30, 1980. ADF&G. Sport Fish Division. Vol. 21. Anchorage.

_____. 1981. Personal communication. ADF&G. Sport Fish Division. Anchorage, Alaska.

Newcome, N. 1980. Personal communication. ADF&G. Sport Fish Division. Anchorage, Alaska.

Orsborn, J.F. 1980. Personal communication. Washington State University. Department of Civil and Environmental Engineering. Pullman, Washington.

_____. 1981 Personal communication. Washington State University. Department of Civil and Environmental Engineering. Pullman, Washington.

_____, and C.H. Allman. 1976. Instream flow needs. Volumes I and II. American Fisheries Society. Bethesda, Maryland.

_____, and F.J. Watts. 1980. Hydraulics and hydrology for fisheries biologists. USFWS Fisheries Academy. Kearneysville, Virginia.

Ott, A., and K. Tarbox. 1977. Instream flow, applicability or existing methodologies for Alaska waters. Prepared for the ADF&G and ADNR. Woodward and Clyde Consultants. Anchorage, Alaska.

Scully, D., L.S. Leveen, and R.S. George. 1978. Surface water records of Cook Inlet Basin, Alaska through September 1975. USGS. Anchorage, Alaska.

Smith, G.L. 1979. Proceedings: Workshop in instream flow habitat criteria and modeling. Colorado Water Resources Research Institute Information Series 40. Colorado State University. Ft. Collins, Colorado.

Smoot, G.F., and C.E. Novak. 1977. Calibration and maintenance of vertical-axis type current meters. Techniques of Water Resources Investigations of the United States Geological Survey. Book 8. Chapter B2. Instrumentation. Arlington, Virginia.

Spence, L.E. 1975. Guidelines for using the Water Surface Profile program to determine instream flow needs for aquatic life. Montana Dept. of Fish, Wildlife, and Parks. Helena, Montana.

Stalnaker, C.B., and J.L. Arnette.. 1976. Methodologies for the determination of stream resource flow requirements: an assessment. USFWS/OBS. and Utah State University. Logan, Utah.

Tennant, D.L. 1975. Instream flow regimes for fish, wildlife, recreation, and related environmental resources. USFWS. Billings, Montana.

Trihey, E.W. 1980. Field data reduction and coding procedures for use with the IFG-2 and IFG-4 hydraulic simulation models. USFWS. IFG. Ft. Collins, Colorado.

REFERENCES-continued

USGS. 1977. National handbook of recommended methods for water-data acquisition. USGS Office of Water Data Coordination. Reston, Virginia.

____. 1979. Cooperative USGS and ADF&G agreement. Anchorage, Alaska.

____. 1980. Water resources data for Alaska. USGS - Data Report AK-79-1. Anchorage, Alaska.

____. 1981. Water resources for Alaska. (Draft). USGS - Data Report AK-80-1. Anchorage, Alaska.

Wadman, R. 1979. Memorandum: Autoclaving salmon roe. ADF&G. Sport Fish Division. Anchorage, Alaska.

Watsjold, D., and L. Engel. 1978. New capital city environmental assessment program - phase I. Source Document 2. Fish and Wildlife Studies. ADF&G. Sport Fish Division. Palmer, Alaska.

White, M.R. 1981. Opportunities to protect instream flows in Alaska. (Draft). USFWS. Office of Biological Services. Washington, D.C.

ACKNOWLEDGEMENTS

ACKNOWLEDGEMENTS

Many individuals representing several state and federal agencies provided support to this project. The authors wish to especially thank T.W. Trent, L.J. Heckart, R. Redick, D.A. Watsjold, L. Engel, M.J. Mills, R. Logan, R. Andrews, J. Clark, C. Yanagawa, D. Lehner-Welch, E. Huttenen, R. Cannon, T.A. Arminski, C. Reidner, A. Bingham (ADF&G); M.L. Harle, S. Mack, and D. Brown (ADNR); R. George, R. Brown, and G. Solin (USGS); D. Amos (USFWS); B. Petrie, APA (former Chief of the ADNR Water Management Section); W. Trihey and J. Baldridge (AEIDC); and J.F. Orsborn (Washington State University, Department of Civil and Environmental Engineering).

Special acknowlegement and appreciation are extended to N. Newcome (ADF&G) who dedicated many hours performing the computer analysis, the USDA Soil Conservation Service, most notably S. Powell, for providing the assistance which made this study possible, and the ADNR for funding a portion of the computer analysis.

APPENDIXES

Appendix A.

STREAM SURVEY FORM

Stream Peters Creek Index Area Peters Cr. I Date 8/22/79

Average Stream Width 30' Average Stream Depth 1

Tributaries Present Blues Creek plus several small seeps (>1cfs) drain marshes

Dams and Obstructions Large boulders were present; w/no beaver dams

Immediate Shore Vegetation: overhanging willow shrubs & moss. Edge of water marked by abrupt drop from shore.

Surrounding Country Open glacial valley w/ hummocks of moss and short 12" shrubs.

Spawning Area Not suitable for salmon because of large substrate size (Class VII)

Discharge 43 cfs Map Location Anchorage 0-7 21N01W36 BCD2

Pools and Shelter

a. Size Pools ranged from 3-7' wide & 2-3' deep.

b. Type Most pools formed in back of large boulders obstructing the flow.

c. Frequency pool/riffle ratio: 1/10 - high stream bed gradient

Bottom Type Large boulders & w/ rocks >10" w/ some sand & gravel

Shade Nearly zero, w/ some given by slightly overhanging brush & large rocks

Chemical Analysis - N/A

pH

Dissolved Oxygen

Temperature

Conductivity

Appendix Appendix C

STREAM SURVEY FORM

Stream Peters Creek Index Area Peter Cr. II Date 8/22-23/79

Average Stream Width 30' Average Stream Depth 1.0'

Tributaries Present two of ≈ 2 cfs plus several small seeps draining marshes

Dams and Obstructions No dams on immediate creek although has some large rocks.

Immediate Shore Steep shore with overhanging willow shrubs & moss & sedges intermixed with gravels & a few sand bars

Surrounding Country Large open valley w/ cottonwood & occasionally stands of spruce. Numerous beaver ponds w/ associated bog areas

Spawning Area Large substrate (>10") w/ numerous boulders reduces the amount of spawning area.

Discharge N/A Map Location

Pools and Shelter

a. Size 3' to stream width in size - 1-3' in depth

b. Type Formed by large boulders in stream / bends in stream

c. Frequency Pool / riffle ratio: 1/6

Bottom Type Large rocks (>10"), & cobbles 3-10", w/ sands & gravels in pools

Shade 25% of the stream was shaded by overhanging limbs & shrubs.

Chemical Analysis

pH 7.75

Dissolved Oxygen 10.75 mg/l

Temperature 9°C

Conductivity 24 umhos/cm

Appendix A.

STREAM SURVEY FORM

Stream Peters Creek Index Area Peters Cr. III Date 8/23/79

Average Stream Width 40 ft. Average Stream Depth 1.5 ft.

Tributaries Present Seven Mile Creek & several small springs & seeps from marshes

Dams and Obstructions Not evident on Peters Creeks other than a few boulders

Immediate Shore Lined by willow shrubs & various sedges & grasses w/ spruce stands. Gravel bars were evident w/ low water.

Surrounding Country Drops out of a glacial valley into a broad spruce valley w/ numerous beaver dams and marshes.

Spawning Area Area suitable for spawning w/ a wide range of substrate and riffle areas

Discharge 76 cfs Map Location Anchorage D-8 20N02W16DCB2

Pools and Shelter

a. Size pools no wider than channel & up to 4 ft. in depth

b. Type Formed by bends in the stream and large rocks & decreased gradients.

c. Frequency pool/riffle ratio 50/50

Bottom Type ≈ 70% cobbles (1-7") 20% sand & 10% 7"+

Shade 20% of stream shaded by overhanging spruce & shrubbery

Chemical Analysis

pH N/A

Dissolved Oxygen

Temperature

Conductivity

Appendix A.

STREAM SURVEY FORM

Stream Peters Creek Index Area IV Date 9/10/79

Average Stream Width 45 feet Average Stream Depth 2 feet

Tributaries Present A few very small (<1 cfs) seeps draining bogs

Dams and Obstructions None on main stream

Immediate Shore Frequent high banks and gravel bars due to meandering of stream.

Surrounding Country Spruce and Cottonwood growing on moderatly hilly terrain

Spawning Area large substrate over much of the area, thus providing little spawning area

Discharge 97.0 cfs Map Location 20N02W19 DDD'

Pools and Shelter

a. Size 20-25 feet wide and 3-4 feet deep

b. Type pools formed at base of riffle or fall, behind large rocks, or at bends.

c. Frequency 20-30% pools

Bottom Type large rocks 7-10" and boulders; some smaller substrate in slower areas and pools.

Shade Very little

Chemical Analysis N/A

pH

Dissolved Oxygen

Temperature

Conductivity

Appendix A.

STREAM SURVEY FORM

Stream Purches Creek **Index Area** Purches Creek I **Date** 8/26/79

Average Stream Width 25 ft. **Average Stream Depth** 1.3 ft.

Tributaries Present Blueberry Creek, numerous small springs & seeps

Dams and Obstructions Large boulders

Immediate Shore Large rocks, dense shrubbery w/moss & sedges

Surrounding Country Wide glacial valley w/very few spruce. Bogs w/blueberry patches & hollies & grasses.

Spawning Area Would not be a very good spawning area because of the large substrate size and obstructing boulders.

Discharge 40 cfs **Map Location** Anchorage D-7 20N01W16BBA2

Pools and Shelter

a. **Size** 5-10 ft in width, 1-3 ft. in depth

b. **Type** Formed by large boulders & at the end of a few riffles

c. **Frequency** pool/riffle ratio 1/10

Bottom Type Mostly large rocks w/some smaller cobble (1-5"), moss, & some sand

Shade 20% by overhanging shrubbery

Chemical Analysis

pH N/A

Dissolved Oxygen

Temperature

Conductivity

Appendix A.

STREAM SURVEY FORM

Stream PURCHES CREEK Index Area III Date 8/27/79

Average Stream Width 40 feet Average Stream Depth 1.5 feet

Tributaries Present no large tribs., several small creeks draining marshes

Dams and Obstructions None

Immediate Shore Some high cut banks (3-4 ft) and some gravel bars otherwise fairly abrupt short banks with short overhanging brush

Surrounding Country Spruce woods and occasional grassy field or blueberry patches, Area fairly flat

Spawning Area Possible spawning area in lower part

Discharge 60 cfs Map Location Anch D-8 20N02W16DCB2

Pools and Shelter

a. Size 10' to stream with 2-3 ft deep

b. Type mostly formed by bends in creek, some behind boulders

c. Frequency ~50 %

Bottom Type Rocks 3-7" with sand & gravel in between

Shade partial shade in wooded areas, these areas comprise about 30 % of stream length

Chemical Analysis N/A

pH

Dissolved Oxygen

Temperature

Conductivity

Appendix A.

STREAM SURVEY FORM

Stream Purches Creek **Index Area** II **Date** 8/26/79

Average Stream Width 30 feet **Average Stream Depth** 1.0 ft

Tributaries Present Many small tributaries, 1 large (10cfs) tributary

Dams and Obstructions None on main stream, some on large tributary

Immediate Shore willow shrubs, occasional firs, velvet willows and sedges & moss & grasses

Surrounding Country Glacial valley with spruce and willow thickets some bogs present

Spawning Area area has suitable depth, substrate & riffles for a spawning area.

Discharge N/A **Map Location**

Pools and Shelter

a. **Size** No wider than the average stream width but are mainly 6-10' in width & 1-2' in depth

b. **Type** formed by bends and large boulders and over hanging banks

c. **Frequency** 40% pool - 60% riffle

Bottom Type mostly cobble 1-7", some larger rocks & boulders present w/ sand

Shade 80% open, some shade from overhanging spruce & debris

Chemical Analysis

N/A

pH

Dissolved Oxygen

Temperature

Conductivity

15294005 WILLOW CREEK NEAR WILLOW

LOCATION.--Lat 61°46'49", long 149°52'44", in NE¼SE¼ sec.31, T.20 N., R.3 W., Matanuska-Susitna Borough, Hydrologic Unit 19050002, on left bank 0.7 mi (1.1 km) downstream from unnamed tributary, 5.7 mi (9.2 km) northeast of Willow, and 6.9 mi (11.1 km) upstream from Deception Creek.

DRAINAGE AREA.--166 mi^2 (430 km^2).

WATER-DISCHARGE RECORDS

PERIOD OF RECORD.--June 1978 to current year.

GAGE.--Water-stage recorder. Altitude of gage is 350 ft (107 m), from topographic map.

REMARKS.--Water-discharge records good except those for Nov. 9 to Apr. 21, which are poor.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 3,720 ft^3/s (105 m^3/s) May 28, 1979, gage height, 7.82 ft (2.384 m); minimum daily, about 50 ft^3/s (1.4 m^3/s) Nov. 22-25, 1978.

EXTREMES FOR CURRENT YEAR.--Maximum discharge, 3,720 ft^3/s (105 m^3/s) May 28, gage height, 7.82 ft (2.384 m); minimum daily, about 50 ft^3/s (1.4 m^3/s) Nov. 22-25.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1978 TO SEPTEMBER 1979
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	214	187	75	90	78	70	70	382	2530	864	800	222
2	260	153	76	90	78	70	66	434	2560	920	779	210
3	235	159	80	90	76	68	66	474	2020	1020	682	197
4	218	182	90	90	76	68	65	484	1760	1080	610	196
5	226	190	100	90	76	68	64	540	1860	1920	570	190
6	233	180	110	90	76	68	64	585	2040	2140	620	185
7	224	168	120	90	76	68	64	626	1540	1710	560	180
8	231	130	130	90	76	68	64	676	1470	1320	560	179
9	226	100	135	85	76	68	64	595	1590	1170	488	176
10	210	85	130	85	76	68	64	506	1740	1100	448	173
11	244	75	130	85	76	66	64	535	1680	1020	421	172
12	291	70	130	85	76	66	64	560	1480	1250	393	170
13	272	65	130	85	76	66	66	642	1320	1170	368	172
14	246	60	130	85	74	66	66	724	1150	1100	374	173
15	216	58	130	80	74	66	66	786	1100	1760	378	167
16	216	56	120	80	74	66	66	848	1080	1530	343	166
17	235	54	120	80	74	68	68	832	1000	1210	337	203
18	374	54	120	80	74	68	72	856	960	1280	327	484
19	283	52	120	80	74	68	80	888	928	1160	300	510
20	255	52	120	80	74	70	90	920	1000	984	294	912
21	239	52	115	80	72	75	110	1020	1020	1070	294	1100
22	231	50	110	80	72	90	113	1110	984	992	267	758
23	185	50	110	80	72	100	116	1140	1040	880	255	676
24	239	50	100	80	72	100	129	1240	1070	840	244	700
25	220	50	100	80	72	100	142	1390	1530	1240	239	570
26	212	54	100	80	70	95	157	1850	1980	1090	233	502
27	203	62	100	80	70	90	160	2310	1410	856	226	461
28	189	70	95	80	70	85	180	2700	1160	758	222	456
29	201	74	95	80	---	82	231	2700	1010	730	228	409
30	196	74	95	78	---	78	294	2180	880	688	255	378
31	179	---	95	78	---	75	---	2160	---	920	233	---
TOTAL	7203	2726	3411	2586	2080	2324	2985	32693	42892	35772	12348	11047
MEAN	232	90.9	110	83.4	74.3	75.0	99.5	1055	1430	1154	398	368
MAX	374	190	135	90	78	100	294	2700	2560	2140	800	1100
MIN	179	50	75	78	70	66	64	382	880	688	222	166
CFSM	1.40	.55	.66	.50	.45	.45	.60	6.36	8.61	6.95	2.40	2.22
IN.	1.61	.61	.76	.58	.47	.52	.67	7.33	9.61	8.02	2.77	2.48
AC-FT	14290	5410	6770	5130	4130	4610	5920	64850	85080	70950	24490	21910

WTR YR 1979 TOTAL 158067 MEAN 433 MAX 2700 MIN 50 CFSM 2.61 IN 35.42 AC-FT 313500

NOTE.--No gage-height record Nov. 16 to Apr. 3.

15294005 WILLOW CREEK NEAR WILLOW--Continued

WATER-QUALITY RECORDS

PERIOD OF RECORD.--Water year 1979.

PERIOD OF DAILY RECORD.--
WATER TEMPERATURES: October 1978, April to September 1979.

INSTRUMENTATION.--Temperature recorder since Oct. 5, 1978

REMARKS.--No record Oct. 10 to Apr. 4 and June 14-21 due to recorder or clock malfunction.

EXTREMES FOR CURRENT YEAR.--
WATER TEMPERATURES: Maximum, 15.5°C July 3; minimum, 0.0°C most days during winter period.

WATER QUALITY DATA, WATER YEAR OCTOBER 1978 TO SEPTEMBER 1979

DATE	TIME	STREAM-FLOW, INSTANTANEOUS (CFS)	SPECIFIC CONDUCTANCE (MICROMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	OXYGEN, DISSOLVED (MG/L)	COLIFORM, TOTAL, IMMED. (COLS. PER 100 ML)	COLIFORM, FECAL, 0.7 UM-MF (COLS./100 ML)	STREPTOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	HARDNESS (MG/L AS CACO3)	HARDNESS, NONCARBONATE (MG/L CACO3)
OCT											
05...	1700	238	75	6.7	5.0	12.6	K6	K6	<1	23	3

DATE	CALCIUM DISSOLVED (MG/L AS CA)	MAGNESIUM, DISSOLVED (MG/L AS MG)	SODIUM, DISSOLVED (MG/L AS NA)	POTASSIUM, DISSOLVED (MG/L AS K)	BICARBONATE (MG/L AS HCO3)	CARBONATE (MG/L AS CO3)	SULFATE DISSOLVED (MG/L AS SO4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L)
OCT											
05...	7.0	1.4	4.4	.7	25	0	2.8	6.9	.0	7.8	44

DATE	NITROGEN, NO2+NO3 TOTAL (MG/L AS N)	NITROGEN, NO2+NO3 DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA TOTAL (MG/L AS N)	NITROGEN, AMMONIA DISSOLVED (MG/L AS N)	NITROGEN, ORGANIC TOTAL (MG/L AS N)	NITROGEN, ORGANIC DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA + ORGANIC TOTAL (MG/L AS N)	NITROGEN, NH4 + ORG. SUSP. TOTAL (MG/L AS N)	NITROGEN, AMMONIA + ORGANIC DIS. (MG/L AS N)	NITROGEN, TOTAL (MG/L AS N)
OCT										
05...	.07	.07	.00	.00	.29	.28	.29	.01	.28	.36

DATE	NITROGEN, DISSOLVED (MG/L AS N)	PHOSPHORUS, TOTAL (MG/L AS P)	PHOSPHORUS, DISSOLVED (MG/L AS P)	BARIUM, TOTAL RECOVERABLE (UG/L AS BA)	CADMIUM TOTAL RECOVERABLE (UG/L AS CD)	CHROMIUM, TOTAL RECOVERABLE (UG/L AS CR)	COPPER, TOTAL RECOVERABLE (UG/L AS CU)	IRON, TOTAL RECOVERABLE (UG/L AS FE)	IRON, SUSPENDED RECOVERABLE (UG/L AS FE)	IRON, DISSOLVED (UG/L AS FE)
OCT										
05...	.35	.00	.00	0	0	0	3	140	40	100

DATE	LEAD, TOTAL RECOVERABLE (UG/L AS PB)	MANGANESE, TOTAL RECOVERABLE (UG/L AS MN)	MANGANESE, SUSPENDED RECOV. (UG/L AS MN)	MANGANESE, DISSOLVED (UG/L AS MN)	MERCURY TOTAL RECOVERABLE (UG/L AS HG)	SELENIUM, TOTAL (UG/L AS SE)	SILVER, TOTAL RECOVERABLE (UG/L AS AG)	ZINC, TOTAL RECOVERABLE (UG/L AS ZN)	SEDIMENT, SUSPENDED (MG/L)	SEDIMENT DISCHARGE, SUSPENDED (T/DAY)
OCT										
05...	2	0	0	0	.0	0	0	10	2	1.3

K NON-IDEAL COLONY COUNT

SOUTH-CENTRAL ALASKA

15294005 WILLOW CREEK NEAR WILLOW--Continued

TEMPERATURE (DEG. C) OF WATER, OCTOBER 1978

DAY	MAX	MIN	DAY	MAX	MIN
6	5.0	4.5	8	5.0	4.5
7	4.5	4.0	9	5.0	4.0

TEMPERATURE (DEG. C) OF WATER, APRIL TO SEPTEMBER 1979

DAY	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN
	APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER	
1	---	---	1.5	.0	8.5	4.0	13.5	7.0	13.5	9.5	10.5	7.0
2	---	---	1.5	.5	7.0	4.0	14.5	8.0	14.5	10.0	10.5	7.0
3	---	---	1.5	.5	7.5	3.0	15.5	8.5	15.0	10.0	10.0	9.0
4	---	---	3.0	1.0	8.0	4.0	15.0	9.0	15.0	9.5	10.0	7.0
5	1.0	.0	2.5	1.0	9.0	4.0	11.5	8.0	13.5	10.5	10.0	7.5
6	.5	.0	3.0	1.0	7.0	5.0	8.0	7.0	12.0	10.5	10.0	7.0
7	1.0	.0	4.5	1.5	7.5	4.5	10.5	7.0	11.5	10.0	10.5	7.5
8	1.5	.5	4.5	1.5	8.5	5.0	10.5	7.0	13.0	10.0	10.5	8.0
9	1.5	.5	3.5	1.5	11.0	4.5	11.5	8.0	12.5	10.0	11.0	7.5
10	1.0	.5	5.0	1.0	9.5	5.0	13.5	7.0	12.0	10.0	11.0	10.0
11	1.5	.0	4.5	2.5	9.5	6.0	13.5	9.0	12.5	10.0	10.5	8.0
12	1.5	.0	5.0	2.0	9.5	4.5	12.5	9.0	13.5	10.5	10.5	9.0
13	1.0	.0	6.5	2.0	7.5	5.5	11.5	8.5	12.5	10.0	10.5	9.0
14	1.0	.0	6.0	2.0	---	---	11.5	8.5	12.0	10.5	10.5	9.5
15	1.0	.0	7.0	2.0	---	---	9.5	8.0	11.0	10.0	10.0	8.5
16	2.0	.0	6.0	2.0	---	---	10.0	8.0	11.0	9.5	9.5	7.5
17	2.0	.5	7.0	2.0	---	---	14.0	8.0	12.5	10.0	9.5	8.5
18	1.5	1.0	6.5	2.0	---	---	12.5	9.0	12.5	10.0	8.5	7.5
19	2.0	.5	6.0	2.5	---	---	12.5	9.0	12.5	11.0	9.0	7.0
20	1.5	.5	7.0	2.0	---	---	13.0	8.5	12.5	10.5	8.0	7.0
21	1.5	.5	7.5	2.5	---	---	13.0	10.0	13.0	8.5	7.5	6.5
22	2.0	.5	7.0	2.5	13.5	6.0	11.5	9.0	14.0	9.5	7.0	6.5
23	2.0	.0	6.0	3.0	13.5	6.5	11.5	8.5	15.0	11.0	7.5	6.0
24	1.5	.0	7.5	3.0	11.0	6.5	11.0	9.5	15.0	11.0	7.5	6.0
25	.5	.0	8.5	3.0	9.5	6.5	11.0	9.5	14.5	11.0	6.5	5.0
26	1.0	.0	9.0	3.0	7.0	5.5	12.0	7.5	14.0	11.0	6.0	4.5
27	2.0	.0	9.0	2.5	7.5	5.5	13.0	8.5	13.5	11.0	6.0	5.0
28	2.0	.0	9.0	3.0	8.5	6.0	13.0	9.0	13.5	11.0	7.0	5.0
29	1.5	.0	6.5	3.0	10.0	6.0	13.0	9.5	11.5	9.0	5.5	3.5
30	2.0	.0	6.5	3.5	12.5	6.0	13.0	10.5	10.5	7.5	6.5	3.5
31	---	---	8.0	3.0	---	---	11.5	9.5	10.5	8.0	---	---
MONTH	2.0	.0	9.0	.0	13.5	3.0	15.5	7.0	15.0	7.5	11.0	3.5
YEAR	15.5	.0										

ANALYSES OF SAMPLES COLLECTED AT WATER-QUALITY PARTIAL-RECORD STATIONS

SOUTH-CENTRAL ALASKA--Continued

*15294012 - WILLOW C AT PARKS HWY NR WILLOW AK

WATER QUALITY DATA, WATER YEAR OCTOBER 1978 TO SEPTEMBER 1979

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS)	PH (UNITS)	TEMPER-ATURE, AIR (DEG C)	TEMPER-ATURE (DEG C)	COLI-FORM, FECAL, 0.7 UM-MF (COLS./100 ML)	STREP-TOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	HARD-NESS (MG/L AS CACO3)	HARD-NESS, NONCAR-BONATE (MG/L CACO3)
JUL										
24...	1850	1040	54	6.4	15.0	11.5	53	K16	20	4

DATE	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	BICAR-BONATE (MG/L AS HCO3)	CAR-BONATE (MG/L AS CO3)	SULFATE DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO2)
JUL										
24...	6.1	1.1	2.8	.4	19	0	1.9	4.0	.0	6.9

DATE	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	NITRO-GEN, AMMONIA TOTAL (MG/L AS N)	NITRO-GEN, ORGANIC TOTAL (MG/L AS N)	NITRO-GEN, AM-MONIA + ORGANIC TOTAL (MG/L AS N)	NITRO-GEN, TOTAL (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)
JUL										
24...	38	33	.11	.13	.01	.12	.13	.24	.01	.01

DATE	ARSENIC TOTAL (UG/L AS AS)	BARIUM, TOTAL RECOV-ERABLE (UG/L AS BA)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, SUS-PENDED RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN)
JUL										
24...	2	0	1	0	62	260	160	100	14	20

DATE	MANGA-NESE, SUS-PENDED RECOV. (UG/L AS MN)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG)	SELE-NIUM, TOTAL (UG/L AS SE)	SILVER, TOTAL RECOV-ERABLE (UG/L AS AG)	ZINC, TOTAL RECOV-ERABLE (UG/L AS ZN)	CYANIDE TOTAL (MG/L AS CN)	SEDI-MENT, SUS-PENDED (MG/L)	SEDI-MENT DIS-CHARGE, SUS-PENDED (T/DAY)
JUL									
24...	0	30	.1	0	0	60	.00	6	17

611946151372600 - CAPPS C NR TYONEK AK

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	SEDI-MENT, SUS-PENDED (MG/L)	SEDI-MENT DIS-CHARGE, SUS-PENDED (T/DAY)
OCT				
16...	1300	31	16	1.3

K NON-IDEAL COLONY COUNT
* LOW-FLOW PARTIAL-RECORD STATION

15294010 DECEPTION CREEK NEAR WILLOW

LOCATION.--Lat 61°44'52", long 149°55'59", in NE¼SE¼ sec.11, T.19 N., R.4 W., Matanuska-Susitna Borough, Hydrologic Unit 19050002, on right bank 0.5 mi (0.8 km) downstream from unnamed tributary, 3.4 mi (5.5 km) east of Willow, and 5.0 mi (8.0 km) upstream from mouth.

DRAINAGE AREA.--48.0 mi^2 (124.3 km^2).

WATER-DISCHARGE RECORDS

PERIOD OF RECORD.--May 1978 to current year.

GAGE.--Water-stage recorder. Altitude of gage is 250 ft (76 m), from topographic map.

REMARKS.--Records good except those for period of no gage-height record, Feb. 9 to Mar. 28, which are poor.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 553 ft^3/s (15.7 m^3/s) May 9, 1979, gage height, 6.22 ft (1.896 m); minimum, 14 ft^3/s (0.40 m^3/s) Sept. 10, 1979, gage height, 3.52 ft (1.073 m).

EXTREMES FOR CURRENT YEAR.--Maximum discharge, 553 ft^3/s (15.7 m^3/s) May 9, gage height, 6.22 ft (1.896 m); minimum, 14 ft^3/s (0.40 m^3/s) Sept. 10, gage height, 3.52 ft (1.073 m).

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1978 TO SEPTEMBER 1979
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	27	34	22	19	17	16	40	360	100	76	76	22
2	62	35	24	19	17	16	41	410	95	62	69	20
3	52	35	27	19	17	16	42	430	90	50	55	19
4	40	33	29	18	17	16	42	450	86	48	48	19
5	38	32	30	18	17	16	42	440	84	129	60	17
6	37	31	31	18	16	16	43	440	80	155	70	16
7	35	30	31	18	16	16	43	450	75	145	55	16
8	40	28	30	18	16	16	44	494	70	95	58	16
9	40	26	30	18	16	16	44	501	68	76	54	15
10	37	24	30	18	16	15	46	359	64	64	48	14
11	56	22	30	18	16	15	48	347	60	53	45	15
12	166	20	29	18	16	15	48	359	58	55	42	15
13	127	19	29	18	16	15	47	361	55	84	40	16
14	107	17	29	17	16	15	47	368	71	78	42	19
15	71	17	28	17	16	15	47	385	56	310	50	19
16	52	16	27	17	16	15	47	354	50	288	45	22
17	54	16	27	17	16	15	48	326	50	199	39	34
18	115	16	26	17	16	15	52	292	46	290	35	63
19	84	15	26	17	16	15	54	274	44	234	32	70
20	64	15	25	17	16	17	58	268	60	145	22	138
21	53	15	24	17	16	20	64	228	67	106	19	244
22	50	15	22	17	16	40	70	215	53	116	26	146
23	48	15	22	17	16	50	78	219	42	102	24	92
24	48	15	21	17	16	52	88	242	36	89	22	116
25	46	15	21	17	16	50	100	203	65	217	20	114
26	44	17	21	17	16	48	120	193	338	191	20	76
27	40	19	20	17	16	46	150	176	285	114	19	62
28	36	20	20	17	16	43	180	167	209	86	19	73
29	39	20	20	17	---	41	230	150	169	70	21	80
30	39	21	20	17	---	40	300	130	108	62	29	63
31	33	---	19	17	---	40	---	110	---	64	26	---
TOTAL	1780	653	790	543	453	781	2303	9701	2733	3853	1230	1651
MEAN	57.4	21.8	25.5	17.5	16.2	25.2	76.8	313	91.1	124	39.7	55.0
MAX	166	35	31	19	17	52	300	501	338	310	76	244
MIN	27	15	19	17	16	15	40	110	36	48	19	14
CFSM	1.20	.45	.53	.37	.34	.53	1.60	6.52	1.90	2.58	.83	1.15
IN.	1.38	.51	.61	.42	.35	.61	1.78	7.52	2.12	2.99	.95	1.28
AC-FT	3530	1300	1570	1080	899	1550	4570	19240	5420	7640	2440	3270

WTR YR 1979 TOTAL 26471 MEAN 72.5 MAX 501 MIN 14 CFSM 1.51 IN 20.51 AC-FT 52510

15294010 DECEPTION CREEK NEAR WILLOW--Continued

WATER-QUALITY RECORDS

PERIOD OF RECORD.--October 1978 to September 1979.

PERIOD OF DAILY RECORD.--
WATER TEMPERATURES: October 1978, May to September 1979.

INSTRUMENTATION.--Temperature recorder since October 1, 1978.

REMARKS.--No record October 23 to May 6 and August 1-8, due to recorder malfunction. Records represent water temperature at sensor within 0.5°C.

EXTREMES FOR CURRENT YEAR.--
WATER TEMPERATURES: Maximum, 17.0°C July 3; minimum, 0.0°C on many days during winter period.

WATER QUALITY DATA, WATER YEAR OCTOBER 1978 TO SEPTEMBER 1979

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS)	PH (UNITS)	TEMPER-ATURE, AIR (DEG C)	TEMPER-ATURE (DEG C)	OXYGEN, DIS-SOLVED (MG/L)	COLI-FORM, TOTAL, IMMED. (COLS. PER 100 ML)	COLI-FORM, FECAL, 0.7 UM-MF (COLS./100 ML)	STREP-TOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	HARD-NESS (MG/L AS CACO3)	HARD-NESS, NONCAR-BONATE (MG/L CACO3)
OCT												
05...	1750	40	125	6.8	--	4.5	12.1	K10	K8	K2	36	3
JUL												
24...	0815	81	85	7.2	14.0	11.0	10.2	--	120	K13	26	0

DATE	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	BICAR-BONATE (MG/L AS HCO3)	CAR-BONATE (MG/L AS CO3)	SULFATE DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO2)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)
OCT												
05...	11	2.1	10	1.0	40	0	2.3	18	.1	11	80	76
JUL												
24...	7.9	1.5	6.5	.7	32	0	5.1	7.2	.0	10	63	55

DATE	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	NITRO-GEN, AMMONIA TOTAL (MG/L AS N)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N)	NITRO-GEN, ORGANIC TOTAL (MG/L AS N)	NITRO-GEN, ORGANIC DIS-SOLVED (MG/L AS N)	NITRO-GEN, AM-MONIA + ORGANIC TOTAL (MG/L AS N)	NITRO-GEN, AM-MONIA + ORGANIC DIS. (MG/L AS N)	NITRO-GEN, TOTAL (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)
OCT												
05...	.05	.09	.00	.03	.27	.27	.27	.30	.32	.01	.01	80
JUL												
24...	.05	.01	.03	--	.28	--	.31	--	.36	.01	.01	--

DATE	ARSENIC TOTAL (UG/L AS AS)	BARIUM, TOTAL RECOV-ERABLE (UG/L AS BA)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, SUS-PENDED RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN)	MANGA-NESE, SUS-PENDED RECOV. (UG/L AS MN)
OCT											
05...	1	0	0	0	3	340	--	210	0	10	--
JUL											
24...	1	0	1	0	13	330	190	190	15	20	0

DATE	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG)	NICKEL, TOTAL RECOV-ERABLE (UG/L AS NI)	SELE-NIUM, TOTAL (UG/L AS SE)	SILVER, TOTAL RECOV-ERABLE (UG/L AS AG)	ZINC, TOTAL RECOV-ERABLE (UG/L AS ZN)	CARBON, ORGANIC DIS-SOLVED (MG/L AS C)	CARBON, ORGANIC SUS-PENDED TOTAL (MG/L AS C)	CYANIDE TOTAL (MG/L AS CN)	SEDI-MENT, SUS-PENDED (MG/L)	SEDI-MENT DIS-CHARGE, SUS-PENDED (T/DAY)
OCT											
05...	10	.0	1	0	0	0	4.7	1.0	--	3	.32
JUL											
24...	20	.1	--	0	0	30	--	--	.00	5	1.1

K NON-IDEAL COLONY COUNT

15294010 DECEPTION CREEK NEAR WILLOW--Continued

TEMPERATURE (DEG. C) OF WATER, OCTOBER 1978

DAY	MAX	MIN	DAY	MAX	MIN	DAY	MAX	MIN
1	4.5	4.0	9	5.0	5.0	16	2.5	1.5
2	5.0	4.5	10	5.0	4.0	17	3.0	2.5
3	5.0	4.0	11	4.5	4.0	18	3.5	3.0
4	4.0	3.5	12	4.0	3.5	19	3.5	3.5
5	4.5	4.0	13	3.5	3.5	20	3.5	2.0
6	5.0	4.0	14	3.5	3.0	21	2.0	2.0
7	5.0	4.5	15	3.0	1.5	22	2.0	1.5
8	5.0	5.0						

TEMPERATURE (DEG. C) OF WATER, MAY TO SEPTEMBER 1979

DAY	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN
	APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER	
1			---	---	10.5	9.5	15.0	10.5	---	---	10.5	8.0
2			---	---	10.5	9.5	16.0	11.0	---	---	10.0	7.5
3			---	---	10.0	8.0	17.0	12.0	---	---	9.5	8.0
4			---	---	11.0	9.5	16.0	13.0	---	---	10.0	7.0
5			---	---	12.0	9.5	14.0	12.5	---	---	10.0	7.0
6			---	---	12.0	10.5	12.5	12.0	---	---	9.5	7.0
7			3.0	1.5	10.5	9.5	13.5	11.0	---	---	9.5	7.0
8			2.0	1.0	11.0	9.5	14.0	11.5	---	---	10.0	7.5
9			2.5	1.5	12.0	9.0	14.5	11.5	14.0	12.0	10.0	7.0
10			3.0	1.5	12.0	10.0	15.5	11.5	13.0	12.0	10.5	9.0
11			3.5	2.0	11.5	10.0	16.0	13.5	13.0	11.5	10.0	8.0
12			3.5	2.0	11.5	9.0	15.5	13.0	14.0	12.0	9.5	8.0
13			4.5	2.0	11.5	9.5	13.5	12.0	13.0	11.5	9.5	8.5
14			5.0	2.0	11.0	8.5	13.5	12.0	13.0	12.0	10.0	9.0
15			6.0	3.0	11.0	9.0	12.0	11.5	12.0	11.5	10.0	9.0
16			5.5	3.0	10.0	9.5	12.0	11.5	12.0	11.0	9.5	8.0
17			5.0	3.0	10.0	9.5	14.0	11.0	13.0	11.0	9.5	9.0
18			5.5	3.5	11.5	9.0	12.5	11.5	12.5	11.0	9.5	9.0
19			6.0	4.0	11.5	10.0	14.0	12.0	12.5	11.0	9.5	8.5
20			6.0	3.5	10.5	10.0	15.0	11.5	12.5	11.0	9.5	9.0
21			7.0	4.0	13.0	9.5	14.0	12.5	12.5	9.5	9.0	8.5
22			7.0	5.0	14.5	10.0	12.5	11.5	12.5	9.5	9.0	8.0
23			7.0	5.5	14.5	11.0	12.5	12.0	13.5	10.0	9.0	8.0
24			7.5	5.5	13.5	11.0	12.5	11.0	13.5	10.0	8.5	8.0
25			9.0	5.5	11.5	10.5	12.0	11.5	13.0	10.0	8.5	7.0
26			9.5	6.5	10.5	10.0	12.5	10.5	13.0	10.0	7.5	6.5
27			10.5	7.0	10.0	9.0	13.0	10.5	12.5	10.0	7.0	7.0
28			11.5	8.0	10.0	9.0	13.5	10.0	12.5	10.5	7.5	7.0
29			11.0	8.5	11.5	9.5	13.0	10.5	11.5	10.0	7.5	5.5
30			10.5	8.5	13.5	9.5	13.0	11.0	11.0	8.5	6.5	5.0
31			10.5	8.0	---	---	12.5	11.0	11.0	9.0	---	---
MONTH			11.5	1.0	14.5	8.0	17.0	10.0	14.0	8.5	10.5	5.0
YEAR	17.0											

Station No.	Station name	Location	Drainage area (mi^2)	Period of record	Measurements Date	Measurements Discharge (ft^3/s)
		South-central Alaska--Continued				
15241570	Ninilchik River tributary 3 near Ninilchik	Lat 60°05'27", long 151°19'44", in SW¼ NW¼ sec.15, T.1 S., R.12 W., Kenai Peninsula Borough, 100 ft downstream from unnamed right bank tributary, and 12 mi east of Ninilchik.	22.7	1978-79	10-11-78	7.7
					11- 8-78	5.3
					1-10-79	5.6
					3-13-79	b2.1
					4-18-79	9.4
					5- 2-79	40
					5-16-79	26
					5-31-79	9.4
					6-14-79	b5.2
					7-19-79	7.8
					8-15-79	5.2
15241590	Ninilchik River tributary 3 at mouth near Ninilchik	Lat 60°03'26", long 151°32'48", in SW¼ SE¼ sec.29, T.1 S., R.13 W., Kenai Peninsula Borough, 300 ft upstream from mouth, and 4.0 mi east of Ninilchik.	56.8	1978-79	10-11-78	33
					11- 8-78	c9.0
					1-11-79	26
					3-14-79	b20
					4-18-79	47
					5- 2-79	164
					5-16-79	74
					5-31-79	41
					6-14-79	b24
					7-19-79	28
					8-15-79	26
15242080	Crooked Creek near Clam Gulch	Lat 60°08'16", long 151°10'30", in SE¼ NW¼ sec.34, T.1 N., R.11 W., Kenai Peninsula Borough, 500 ft downstream from unnamed left bank tributary, and 9.8 mi southeast of Clam Gulch.	21.9	1978-79	10-11-78	25
					11- 8-78	c7.2
					1-10-79	21
					3-13-79	b21
					4-18-79	23
					5- 2-79	45
					5-16-79	26
					5-31-79	23
					6-14-79	b19
					7-19-79	22
					8-15-79	19
#15242100	Crooked Creek near Kasilof	Lat 60°17'50", long 151°16'20", in NE¼ sec.1, T.2 N., R.12 W., Kenai Peninsula Borough, 50 ft downstream from culvert at Old Sterling Highway, 1.8 mi upstream from mouth, and 6.5 mi southeast of Kasilof.	53.8	a1951-52, a1973-77, 1978-79	10- 9-78	80
					11- 7-78	40
					1- 2-79	33
					3-12-79	b30
					4-16-79	96
					4-30-79	155
					5-14-79	81
					5-29-79	51
					6-13-79	b40
					7-18-79	51
					8-14-79	36
*15285000	Wasilla Creek near Palmer	Lat 61°38'47", long 149°11'45", in SW¼ sec.13, T.18 N., R.1 E., Matanuska-Susitna Borough, 60 ft upstream from culvert entrance on Wasilla Fishhook Road and 4.1 mi northeast of Palmer.	16.6	a1954-55, 1971, a1976-77, 1978-79	5- 7-79	96
					5-24-79	49
					5-31-79	50
					7-16-79	72
#15290200	Nancy Lake tributary near Willow	Lat 61°41'17", long 149°57'58", in SE¼SE¼ sec.34, T.19 N., R.4 W., Matanuska-Susitna Borough, 10 ft upstream from culvert at Parks Highway, 0.3 mi upstream from mouth, and 4.5 mi southeast of Willow.	8.00	1978-79	10-17-78	7.6
#15294002	Willow Creek at Hatcher Pass Road near Willow	Lat 61°45'49", long 149°40'54", in NE¼ SW¼ sec.5, T.19 N., R.2 W., Matanuska-Susitna Borough, 0.2 mi downstream from old bridge crossing, 2.5 mi upstream from Peters Creek, and 12 mi east of Willow.	50.1	1978-79	10- 5-78	72
Site D — #15294007	Deception Creek above tributary near Houston	Lat 61°41'48", long 149°46'19", in SE¼ NW¼ sec.35, T.19 N., R.3 W., Matanuska-Susitna Borough, 0.2 mi upstream from unnamed left bank tributary and 4.8 mi northeast of Houston.	17.9	1978-79	10- 5-78	16
					7- 3-79	28
					7-24-79	31

\# See analyses of samples collected at miscellaneous sites.
* Also crest-stage partial-record station.
a Published in miscellaneous measurements table.
b Base flow.
c Water going into ice and channel storage; measurement does not represent basin yield.

Discharge measurements made at low-flow partial-record stations during water year 1979--Continued

Station No.	Station name	Location	Drainage area (mi²)	Period of record	Measurements Date	Measurements Discharge (ft³/s)
		South-central Alaska--Continued				
E — #15294008	Deception Creek tributary near Houston	Lat 61°41'40", long 149"46'21", in SE¼ NW¼ sec.35, T.19 N., R.3 W., Matanuska-Susitna Borough, 0.1 mi upstream from mouth and 4.7 mi northeast of Houston.	8.89	1978-79	10- 5-78 7- 3-79 7-24-79	8.9 10 16
B — #15294012	Willow Creek at Parks Highway near Willow	Lat 61°46'03", long 150°03'48", in SW¼ NE¼ sec.6, T.19 N., R.4 W., Matanuska-Susitna Borough, at bridge at Parks Highway, 0.9 mi downstream from Deception Creek, and 1.7 mi northwest of Willow.	233	1978-79	11-14-78 12-21-78 1-22-79 3-29-79 7-10-79 7-24-79 8- 8-79 9-14-79	c103 b161 b139 164 1,180 1,040 652 b205
*15294025	Moose Creek near Talkeetna	Lat 62°19'00", long 150°26'30", in NE¼ sec.30, T.26 N., R.7 W., Matanuska-Susitna Borough, at bridge on Petersville Road and 10.5 mi west of Talkeetna.	52.3	a1972-75, 1978-79	5- 9-79 8- 1-79	596 34
**15296554	Thumb River near Larsen Bay	Lat 57°21'26", long 153°59'41", in NW¼ SE¼ sec.31, T.32 S., R.29 W., on Kodiak Island, 600 ft upstream from inlet to Karluk Lake and 12.5 mi south of Larsen Bay.	25.3	1979	10-18-78 11-17-78 1-23-79 3-28-79 5-19-79 6-27-79 8- 6-79 9-19-79	327 60 63 85 151 118 31 24
		Yukon Alaska				
15511100	Hopper Creek near Fairbanks	Lat 64°53'33", long 147°24'42", Fairbanks North-Star Borough, in NE¼NE¼ sec.30, T.1 N., R.2 E., at downstream end of culvert on Chena Hot Springs Road, 2.5 mi upstream from mouth, and 9.5 mi northeast of Fairbanks.	2.25	1978-79	8-13-79	b0.0002
15511500	Steele Creek near Fairbanks	Lat 64°53'36", long 147°29'12", in SE¼ sec.23, T.1 N., R.1 E., Fairbanks North-Star Borough, 8 ft upstream from culvert at mi 4.5 on the Chena Hot Springs Highway, and 7.5 mi northeast of Fairbanks.	10.7	ad1967-74, 1976-79	8-13-79	b1.1
15512500	Columbia Creek near Fairbanks	Lat 64°53'29", long 147°32'39", in SW¼ NE¼NE¼E¼ sec.28, T.1 N., R.1 E., Fairbanks North-Star Borough, at downstream end of culvert at mi 2.6 on Chena Hot Springs Road, 1.0 mi upstream from Wigwam Creek and 6.1 mi northeast of Fairbanks.	f3.0	1976-79	8-13-79	b0.10
15514005	Isabella Creek near Fairbanks	Lat 64°53'10", long 147°40'30", in NE¼ NE¼SE¼ sec.26, T.1 N., R.1 W., Fairbanks North-Star Borough, at downstream end of culvert at mi 1.0 on Farmers Loop Road, 2.8 mi upstream from mouth and 3.1 mi north of Fairbanks.	f4.3	1976-79	8-10-79 8-14-79	b0.11 b0.12
15514010	Jusilla Creek near Fairbanks	Lat 64°53'59", long 147°42'59", in NE¼ NW¼SE¼ sec.22, T.1 N., R.1 W., Fairbanks North-Star Borough, at downstream end of culvert at mi 3.4 on Farmers Loop Road, 0.5 mi upstream from Creamers Field and 3.9 mi north of Fairbanks.	f1.6	1976-79	8-10-79 8-14-79	b0.02 b0.008
15514015	Grenac Creek near Fairbanks	Lat 64°53'53", long 147°45'13", in SE¼ NW¼SE¼ sec.21, T.1 N., R.1 W., Fairbanks North-Star Borough, at downstream end of culvert at mi 4.6 on Farmers Loop Road, 1.0 mi upstream from Creamers Field and 3.9 mi north of Fairbanks.	f1.3	a1967-68, 1976-79	8-10-79 8-14-79	b0.05 b0.06

\# See analyses of samples collected at miscellaneous sites.
** Also a continuous-record station for water temperature.
* Also crest-stage partial-record station.
a Published in miscellaneous measurements table.
b Base flow.
c Water going into ice and channel storage; measurement does not represent basin yield.
d Operated as a crest-stage partial-record station.
f Approximately.

SOUTH-CENTRAL ALASKA--Continued

15294002 - WILLOW C AT HATCHER PASS ROAD NR WILLOW AK--Continued

WATER QUALITY DATA, WATER YEAR OCTOBER 1978 TO SEPTEMBER 1979

DATE	PHOSPHORUS, DISSOLVED (MG/L AS P)	ALUMINUM, TOTAL RECOVERABLE (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	BARIUM, TOTAL RECOVERABLE (UG/L AS BA)	CADMIUM TOTAL RECOVERABLE (UG/L AS CD)	CHROMIUM, TOTAL RECOVERABLE (UG/L AS CR)	COPPER, TOTAL RECOVERABLE (UG/L AS CU)	IRON, TOTAL RECOVERABLE (UG/L AS FE)	IRON, DISSOLVED (UG/L AS FE)	LEAD, TOTAL RECOVERABLE (UG/L AS PB)	MANGANESE, TOTAL RECOVERABLE (UG/L AS MN)
OCT											
05...	.00	50	3	0	0	0	3	110	110	1	0

DATE	MANGANESE, DISSOLVED (UG/L AS MN)	MERCURY TOTAL RECOVERABLE (UG/L AS HG)	NICKEL, TOTAL RECOVERABLE (UG/L AS NI)	SELENIUM, TOTAL (UG/L AS SE)	SILVER, TOTAL RECOVERABLE (UG/L AS AG)	ZINC, TOTAL RECOVERABLE (UG/L AS ZN)	CARBON, ORGANIC DISSOLVED (MG/L AS C)	CARBON, ORGANIC SUSPENDED TOTAL (MG/L AS C)	SEDIMENT, SUSPENDED (MG/L)	SEDIMENT DISCHARGE, SUSPENDED (T/DAY)
OCT										
05...	40	.0	1	0	0	0	1.0	.5	1	.19

D

*15294007 - DECEPTION C AB TR NR HOUSTON AK

DATE	TIME	STREAMFLOW, INSTANTANEOUS (CFS)	SPECIFIC CONDUCTANCE (MICROMHOS)	PH (UNITS)	TEMPERATURE, AIR (DEG C)	TEMPERATURE (DEG C)	OXYGEN, DISSOLVED (MG/L)	COLIFORM, TOTAL, IMMED. (COLS. PER 100 ML)	COLIFORM, FECAL, 0.7 UM-MF (COLS./ 100 ML)	STREPTOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	HARDNESS (MG/L AS CACO3)	HARDNESS, NONCARBONATE (MG/L CACO3)
OCT												
05...	0940	16	120	6.9	--	3.5	13.0	K36	K22	K2	34	3
JUL												
24...	1345	31	89	7.4	16.5	12.0	10.3	--	--	K4	25	2

DATE	CALCIUM DISSOLVED (MG/L AS CA)	MAGNESIUM, DISSOLVED (MG/L AS MG)	SODIUM, DISSOLVED (MG/L AS NA)	POTASSIUM, DISSOLVED (MG/L AS K)	BICARBONATE (MG/L AS HCO3)	CARBONATE (MG/L AS CO3)	SULFATE DISSOLVED (MG/L AS SO4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO2)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L)
OCT												
05...	10	2.1	12	1.1	37	0	2.3	22	.0	11	81	79
JUL												
24...	7.5	1.4	7.0	.7	28	0	6.2	8.6	.0	9.9	63	56

DATE	NITROGEN, NO2+NO3 TOTAL (MG/L AS N)	NITROGEN, NO2+NO3 DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA TOTAL (MG/L AS N)	NITROGEN, AMMONIA DISSOLVED (MG/L AS N)	NITROGEN, ORGANIC TOTAL (MG/L AS N)	NITROGEN, ORGANIC DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA + ORGANIC TOTAL (MG/L AS N)	NITROGEN, AMMONIA + ORGANIC DIS. (MG/L AS N)	NITROGEN, TOTAL (MG/L AS N)	PHOSPHORUS, TOTAL (MG/L AS P)	PHOSPHORUS, DISSOLVED (MG/L AS P)	ALUMINUM, TOTAL RECOVERABLE (UG/L AS AL)
OCT												
05...	.04	.06	.00	.00	.20	.20	.20	.20	.24	.01	.00	60
JUL												
24...	.37	.10	.01	--	.20	--	.21	--	.58	.00	.01	--

DATE	ARSENIC TOTAL (UG/L AS AS)	BARIUM, TOTAL RECOVERABLE (UG/L AS BA)	CADMIUM TOTAL RECOVERABLE (UG/L AS CD)	CHROMIUM, TOTAL RECOVERABLE (UG/L AS CR)	COPPER, TOTAL RECOVERABLE (UG/L AS CU)	IRON, TOTAL RECOVERABLE (UG/L AS FE)	IRON, SUSPENDED RECOVERABLE (UG/L AS FE)	IRON, DISSOLVED (UG/L AS FE)	LEAD, TOTAL RECOVERABLE (UG/L AS PB)	MANGANESE, TOTAL RECOVERABLE (UG/L AS MN)	MANGANESE, SUSPENDED RECOV. (UG/L AS MN)
OCT											
05...	1	0	0	0	9	250	--	190	0	0	--
JUL											
24...	0	0	0	10	28	290	120	170	14	10	5

K NON-IDEAL COLONY COUNT
* LOW-FLOW PARTIAL-RECORD STATION

D

SOUTH-CENTRAL ALASKA--Continued

15294007 - DECEPTION C AB TR NR HOUSTON AK--Continued

WATER QUALITY DATA, WATER YEAR OCTOBER 1978 TO SEPTEMBER 1979

DATE	MANGANESE, DISSOLVED (UG/L AS MN)	MERCURY TOTAL RECOVERABLE (UG/L AS HG)	NICKEL, TOTAL RECOVERABLE (UG/L AS NI)	SELENIUM, TOTAL (UG/L AS SE)	SILVER, TOTAL RECOVERABLE (UG/L AS AG)	ZINC, TOTAL RECOVERABLE (UG/L AS ZN)	CARBON, ORGANIC DISSOLVED (MG/L AS C)	CARBON, ORGANIC SUSPENDED TOTAL (MG/L AS C)	CYANIDE TOTAL (MG/L AS CN)	SEDIMENT, SUSPENDED (MG/L)	SEDIMENT DISCHARGE, SUSPENDED (T/DAY)
OCT 05...	0	.0	3	0	0	0	4.2	.3	--	3	.13
JUL 24...	5	.1	--	0	0	30	--	--	.00	3	.25

F

*15294008 - DECEPTION C TR NR HOUSTON AK

DATE	TIME	STREAMFLOW, INSTANTANEOUS (CFS)	SPECIFIC CONDUCTANCE (MICROMHOS)	PH (UNITS)	TEMPERATURE, AIR (DEG C)	TEMPERATURE (DEG C)	OXYGEN, DISSOLVED (MG/L)	COLIFORM, TOTAL, IMMED. (COLS. PER 100 ML)	COLIFORM, FECAL, 0.7 UM-MF (COLS./100 ML)	STREPTOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	HARDNESS (MG/L AS CACO3)	HARDNESS, NONCARBONATE (MG/L CACO3)
OCT 05...	1115	8.9	150	6.6	--	3.0	13.1	K22	K28	K4	37	3
JUL 24...	1430	16	90	6.7	15.0	11.0	--	--	K76	K8	28	3

DATE	CALCIUM DISSOLVED (MG/L AS CA)	MAGNESIUM, DISSOLVED (MG/L AS MG)	SODIUM, DISSOLVED (MG/L AS NA)	POTASSIUM, DISSOLVED (MG/L AS K)	BICARBONATE (MG/L AS HCO3)	CARBONATE (MG/L AS CO3)	SULFATE DISSOLVED (MG/L AS SO4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO2)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L)
OCT 05...	11	2.2	14	1.1	41	0	2.0	24	.0	11	92	86
JUL 24...	8.4	1.6	8.0	.2	30	0	4.9	9.1	.0	11	67	59

DATE	NITROGEN, NO2+NO3 TOTAL (MG/L AS N)	NITROGEN, NO2+NO3 DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA TOTAL (MG/L AS N)	NITROGEN, AMMONIA DISSOLVED (MG/L AS N)	NITROGEN, ORGANIC TOTAL (MG/L AS N)	NITROGEN, ORGANIC DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA + ORGANIC TOTAL (MG/L AS N)	NITROGEN, AMMONIA + ORGANIC DIS. (MG/L AS N)	NITROGEN, TOTAL (MG/L AS N)	PHOSPHORUS, TOTAL (MG/L AS P)	PHOSPHORUS, DISSOLVED (MG/L AS P)	ALUMINUM, TOTAL RECOVERABLE (UG/L AS AL)
OCT 05...	.10	.15	.00	.01	.29	.56	.29	.57	.39	.00	.00	60
JUL 24...	.26	.22	.01	--	.04	--	.05	--	.31	.01	.01	--

DATE	ARSENIC TOTAL (UG/L AS AS)	BARIUM, TOTAL RECOVERABLE (UG/L AS BA)	CADMIUM TOTAL RECOVERABLE (UG/L AS CD)	CHROMIUM, TOTAL RECOVERABLE (UG/L AS CR)	COPPER, TOTAL RECOVERABLE (UG/L AS CU)	IRON, TOTAL RECOVERABLE (UG/L AS FE)	IRON, SUSPENDED RECOVERABLE (UG/L AS FE)	IRON, DISSOLVED (UG/L AS FE)	LEAD, TOTAL RECOVERABLE (UG/L AS PB)	MANGANESE, TOTAL RECOVERABLE (UG/L AS MN)	MANGANESE, SUSPENDED RECOV. (UG/L AS MN)
OCT 05...	1	0	0	0	3	300	--	230	1	50	--
JUL 24...	0	0	0	10	3	360	120	240	11	40	10

DATE	MANGANESE, DISSOLVED (UG/L AS MN)	MERCURY TOTAL RECOVERABLE (UG/L AS HG)	NICKEL, TOTAL RECOVERABLE (UG/L AS NI)	SELENIUM, TOTAL (UG/L AS SE)	SILVER, TOTAL RECOVERABLE (UG/L AS AG)	ZINC, TOTAL RECOVERABLE (UG/L AS ZN)	CARBON, ORGANIC DISSOLVED (MG/L AS C)	CARBON, ORGANIC SUSPENDED TOTAL (MG/L AS C)	CYANIDE TOTAL (MG/L AS CN)	SEDIMENT, SUSPENDED (MG/L)	SEDIMENT DISCHARGE, SUSPENDED (T/DAY)
OCT 05...	40	.0	1	0	0	10	6.1	.7	--	3	.07
JUL 24...	30	.0	--	0	0	20	--	--	.00	7	.38

K NON-IDEAL COLONY COUNT
* LOW-FLOW PARTIAL-RECORD STATION

ANALYSES OF SAMPLES COLLECTED AT MISCELLANEOUS SITES

SOUTH-CENTRAL ALASKA--Continued

614446149551000 - UNNAMED TRIB TO DECEPTION C NR WILLOW AK--Continued

WATER QUALITY DATA, WATER YEAR OCTOBER 1978 TO SEPTEMBER 1979

DATE	POTASSIUM, DISSOLVED (MG/L AS K)	BICARBONATE (MG/L AS HCO3)	CARBONATE (MG/L AS CO3)	SULFATE DISSOLVED (MG/L AS SO4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO2)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L)	NITROGEN, NO2+NO3 TOTAL (MG/L AS N)	NITROGEN, NO2+NO3 DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA TOTAL (MG/L AS N)
JUL 24...	.5	30	0	7.3	5.3	.0	11	70	54	.05	.06	.03

DATE	NITROGEN, ORGANIC TOTAL (MG/L AS N)	NITROGEN, AMMONIA + ORGANIC TOTAL (MG/L AS N)	NITROGEN, TOTAL (MG/L AS N)	PHOSPHORUS, TOTAL (MG/L AS P)	PHOSPHORUS, DISSOLVED (MG/L AS P)	ARSENIC TOTAL (UG/L AS AS)	BARIUM, TOTAL RECOVERABLE (UG/L AS BA)	CADMIUM TOTAL RECOVERABLE (UG/L AS CD)	CHROMIUM, TOTAL RECOVERABLE (UG/L AS CR)	COPPER, TOTAL RECOVERABLE (UG/L AS CU)	IRON, TOTAL RECOVERABLE (UG/L AS FE)	IRON, SUSPENDED RECOVERABLE (UG/L AS FE)
JUL 24...	.34	.37	.42	.02	.02	1	0	1	10	17	690	300

DATE	IRON, DISSOLVED (UG/L AS FE)	LEAD, TOTAL RECOVERABLE (UG/L AS PB)	MANGANESE, TOTAL RECOVERABLE (UG/L AS MN)	MANGANESE, SUSPENDED RECOV. (UG/L AS MN)	MANGANESE, DISSOLVED (UG/L AS MN)	MERCURY TOTAL RECOVERABLE (UG/L AS HG)	SELENIUM, TOTAL (UG/L AS SE)	SILVER, TOTAL RECOVERABLE (UG/L AS AG)	ZINC, TOTAL RECOVERABLE (UG/L AS ZN)	CYANIDE TOTAL (MG/L AS CN)	SEDIMENT, SUSPENDED (MG/L)	SEDIMENT DISCHARGE, SUSPENDED (T/DAY)
JUL 24...	390	9	30	10	20	.0	0	0	0	.00	10	.32

614251149585100 - LILLY C AB HOWLING DOG FARM NR WILLOW AK

DATE	TIME	SPECIFIC CONDUCTANCE (MICROMHOS)	TEMPERATURE (DEG C)	OXYGEN, DISSOLVED (MG/L)	COLIFORM, TOTAL, IMMED. (COLS. PER 100 ML)	COLIFORM, FECAL, 0.7 UM-MF (COLS./100 ML)	STREPTOCOCCI FECAL, KF AGAR (COLS. PER 100 ML)	HARDNESS (MG/L AS CACO3)	HARDNESS, NONCARBONATE (MG/L CACO3)	CALCIUM DISSOLVED (MG/L AS CA)	MAGNESIUM, DISSOLVED (MG/L AS MG)
OCT 17...	1100	60	2.0	12.4	139	83	71	28	6	8.3	1.8

DATE	SODIUM, DISSOLVED (MG/L AS NA)	POTASSIUM, DISSOLVED (MG/L AS K)	BICARBONATE (MG/L AS HCO3)	CARBONATE (MG/L AS CO3)	SULFATE DISSOLVED (MG/L AS SO4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO2)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L)
OCT 17...	1.8	.3	27	0	4.2	1.9	.1	9.0	56	41

DATE	NITROGEN, NO2+NO3 TOTAL (MG/L AS N)	NITROGEN, NO2+NO3 DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA TOTAL (MG/L AS N)	NITROGEN, AMMONIA DISSOLVED (MG/L AS N)	NITROGEN, ORGANIC TOTAL (MG/L AS N)	NITROGEN, ORGANIC DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA + ORGANIC TOTAL (MG/L AS N)	NITROGEN, AMMONIA + ORGANIC DIS. (MG/L AS N)	NITROGEN, TOTAL (MG/L AS N)	PHOSPHORUS, TOTAL (MG/L AS P)
OCT 17...	.07	.07	.02	.01	.53	.43	.55	.44	.62	.01

ANALYSES OF SAMPLES COLLECTED AT MISCELLANEOUS SITES

SOUTH-CENTRAL ALASKA--Continued

614906149385000 - PETERS C BL PURCHES C NR WILLOW AK

WATER QUALITY DATA, WATER YEAR OCTOBER 1978 TO SEPTEMBER 1979

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS)	PH (UNITS)	TEMPER-ATURE, AIR (DEG C)	TEMPER-ATURE (DEG C)	OXYGEN, DIS-SOLVED (MG/L)	COLI-FORM, FECAL, 0.7 UM-MF (COLS./100 ML)	HARD-NESS (MG/L AS CACO3)	HARD-NESS, NONCAR-BONATE (MG/L CACO3)
JUL 24...	1230	465	33	6.7	15.0	8.0	11.5	<1	13	2

DATE	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	BICAR-BONATE (MG/L AS HCO3)	CAR-BONATE (MG/L AS CO3)	SULFATE DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO2)
JUL 24...	4.6	.4	1.0	.4	13	0	4.3	.8	.0	5.2

DATE	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	NITRO-GEN, AMMONIA TOTAL (MG/L AS N)	NITRO-GEN, ORGANIC TOTAL (MG/L AS N)	NITRO-GEN, AM-MONIA + ORGANIC TOTAL (MG/L AS N)	NITRO-GEN, TOTAL (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)
JUL 24...	19	23	.05	.05	.01	.27	.28	.33	.00	.00

DATE	ARSENIC TOTAL (UG/L AS AS)	BARIUM, TOTAL RECOV-ERABLE (UG/L AS BA)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, SUS-PENDED RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN)
JUL 24...	0	0	1	10	3	50	40	10	29	0

DATE	MANGA-NESE, SUS-PENDED RECOV. (UG/L AS MN)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG)	SELE-NIUM, TOTAL (UG/L AS SE)	SILVER, TOTAL RECOV-ERABLE (UG/L AS AG)	ZINC, TOTAL RECOV-ERABLE (UG/L AS ZN)	CYANIDE TOTAL (MG/L AS CN)	SEDI-MENT, SUS-PENDED (MG/L)	SEDI-MENT DIS-CHARGE, SUS-PENDED (T/DAY)
JUL 24...	0	1	.1	0	0	20	.00	4	5.0

614446149551000 - UNNAMED TRIB TO DECEPTION C NR WILLOW AK

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS)	PH (UNITS)	TEMPER-ATURE, AIR (DEG C)	TEMPER-ATURE (DEG C)	COLI-FORM, FECAL, 0.7 UM-MF (COLS./100 ML)	HARD-NESS (MG/L AS CACO3)	HARD-NESS, NONCAR-BONATE (MG/L CACO3)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)
JUL 24...	1550	12	76	6.7	16.0	13.0	94	27	2	8.0	1.7	4.9

Appendix C.

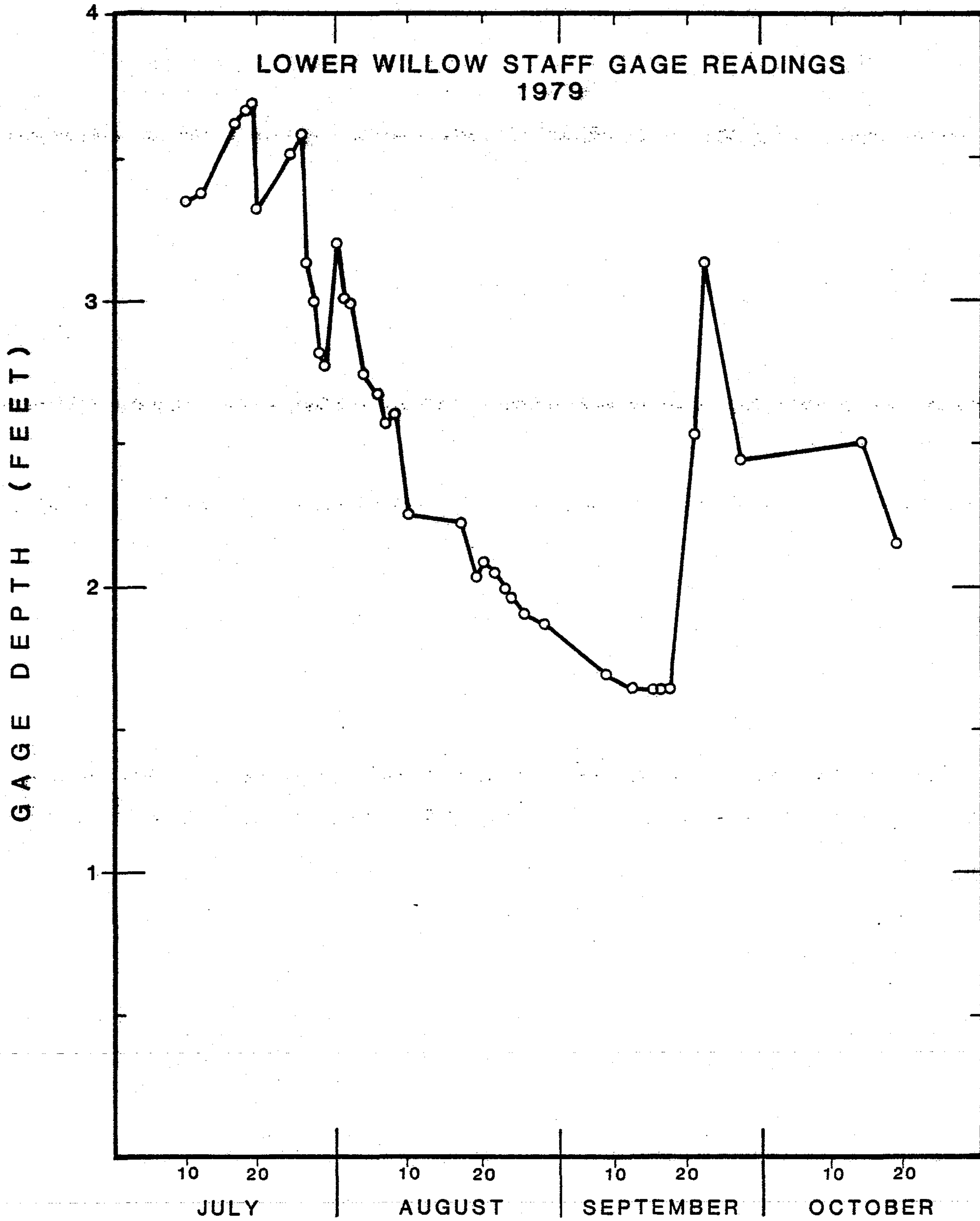


Figure 1

Appendix C.

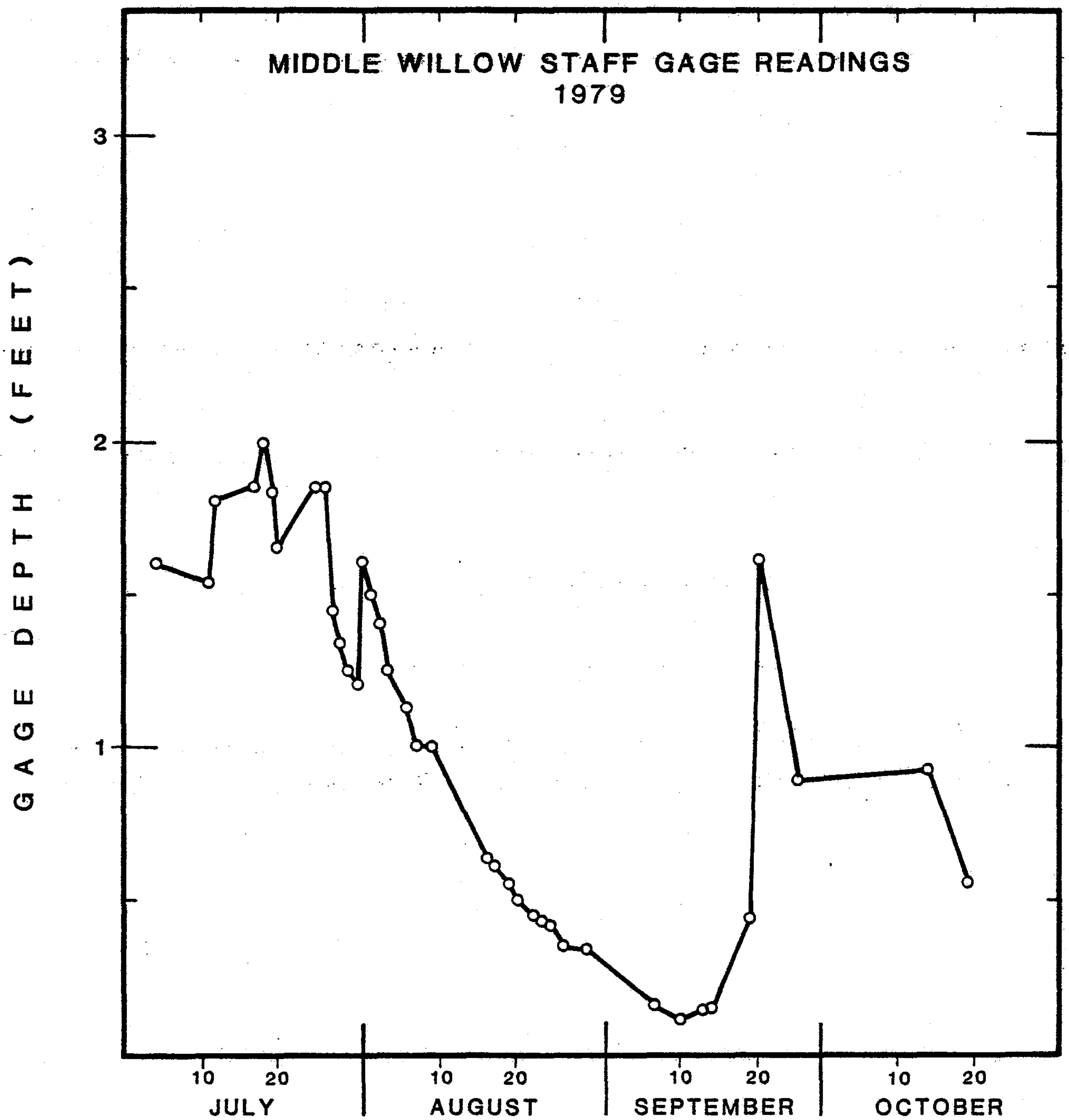


Figure 2

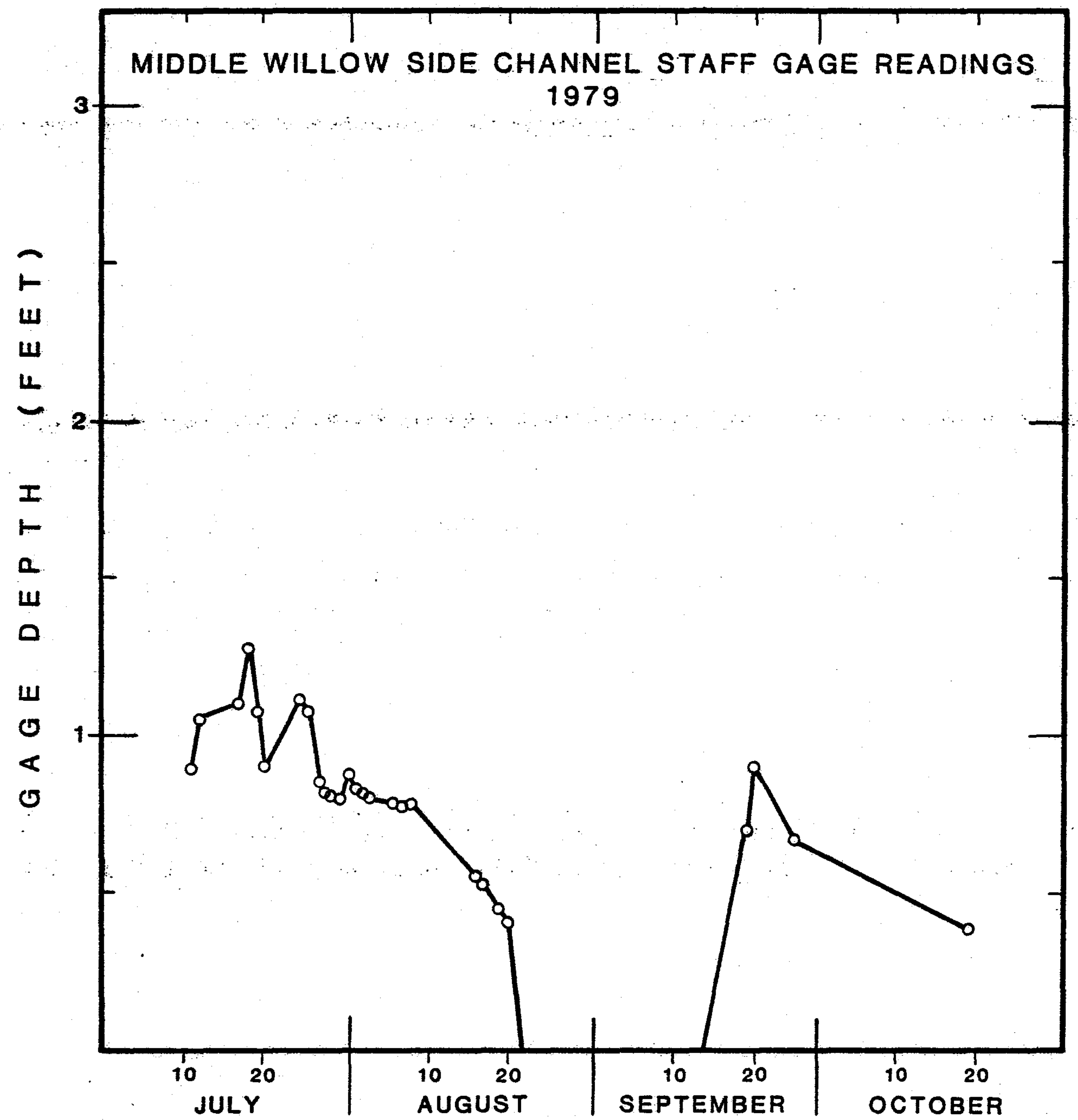

MIDDLE WILLOW SIDE CHANNEL STAFF GAGE READINGS
1979
GAGE DEPTH (FEET)
3
2
1
10
20
10
20
10
20
10
20
JULY
AUGUST
SEPTEMBER
OCTOBER

Figure 3

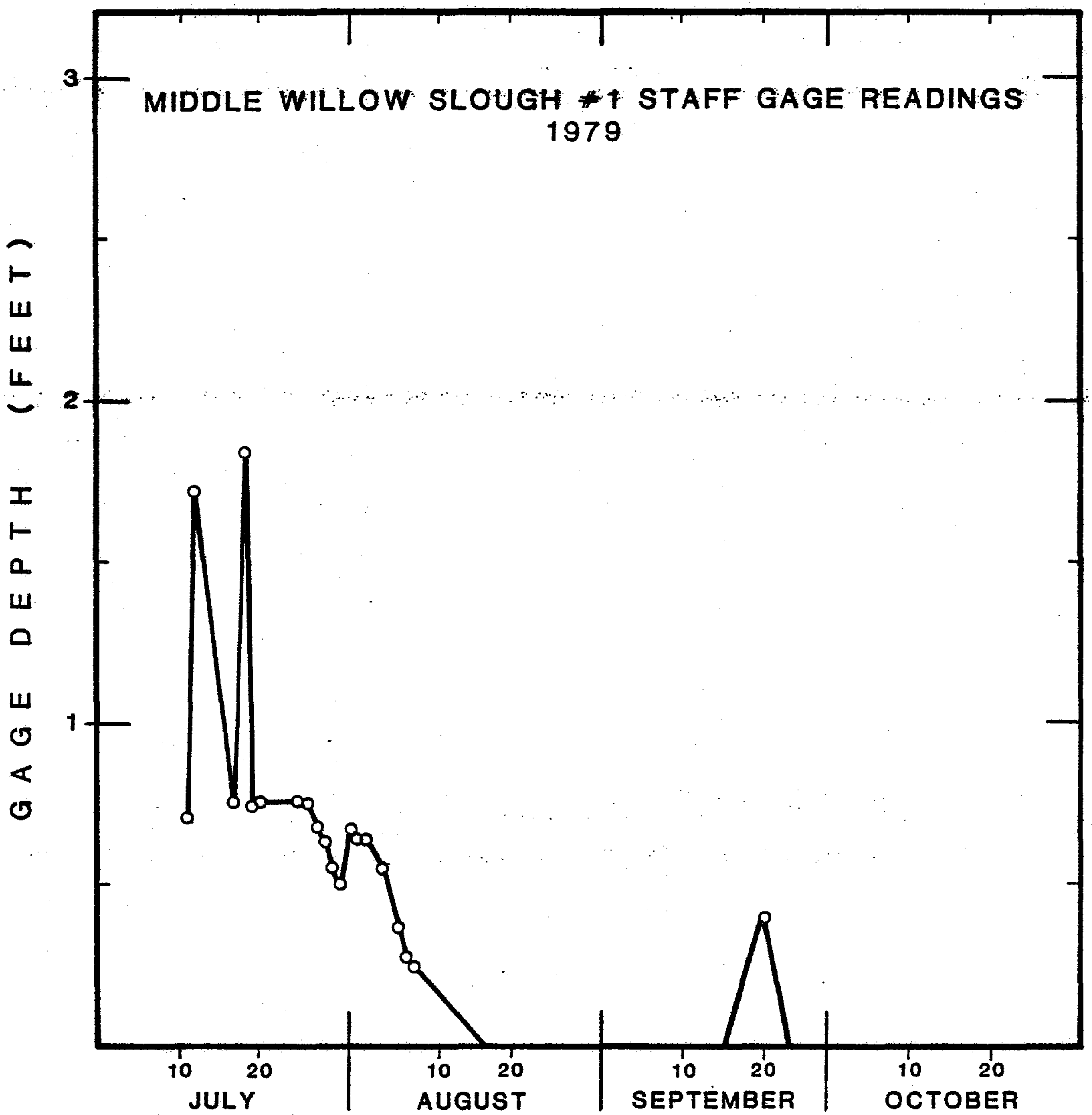

MIDDLE WILLOW SLOUGH #1 STAFF GAGE READINGS
1979
GAGE DEPTH (FEET)
3
2
1
10
20
10
20
10
20
10
20
JULY
AUGUST
SEPTEMBER
OCTOBER

Figure 4

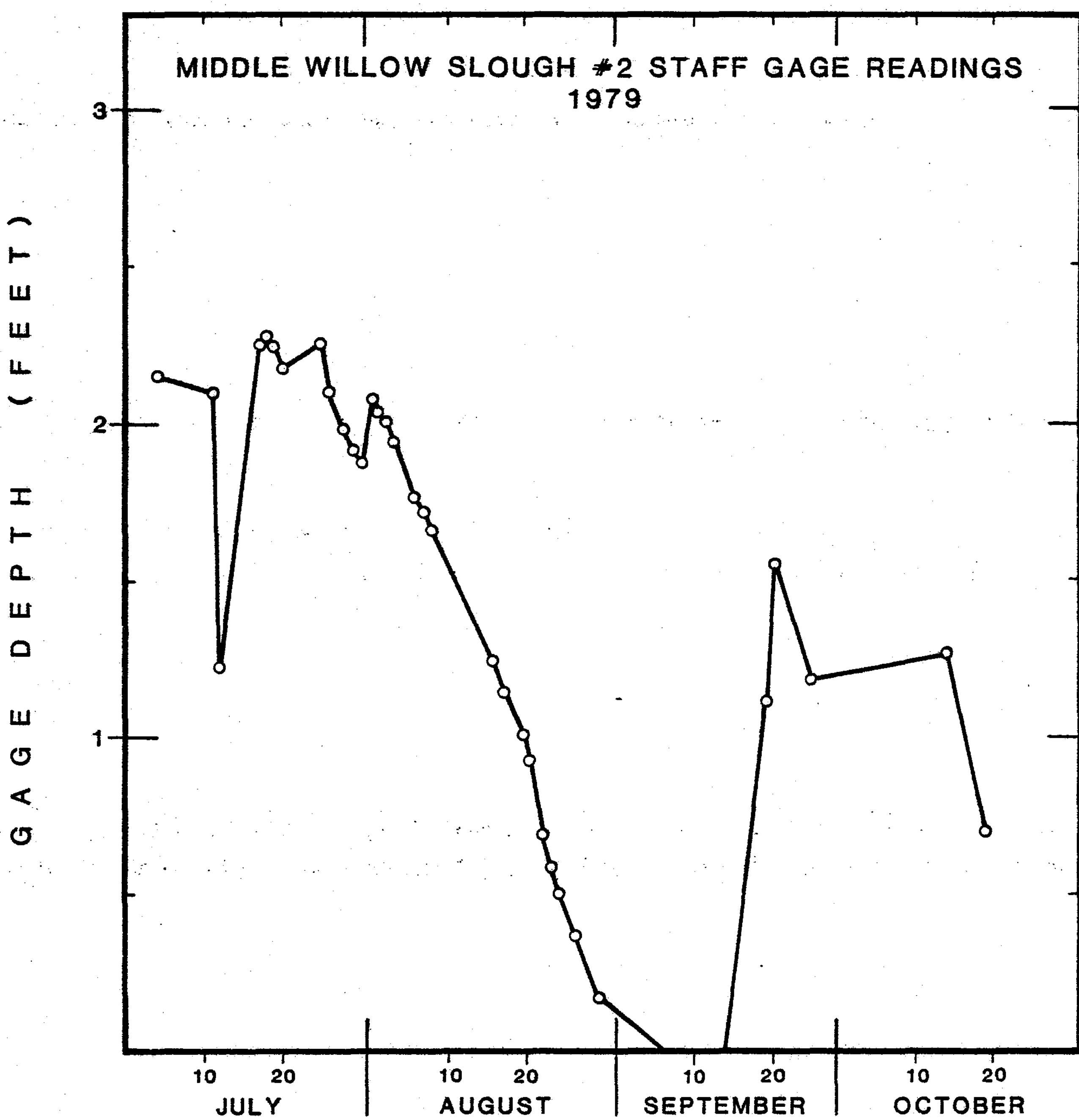

MIDDLE WILLOW SLOUGH #2 STAFF GAGE READINGS
1979
GAGE DEPTH (FEET)
3
2
1
10
20
JULY
10
20
AUGUST
10
20
SEPTEMBER
10
20
OCTOBER

Figure 5

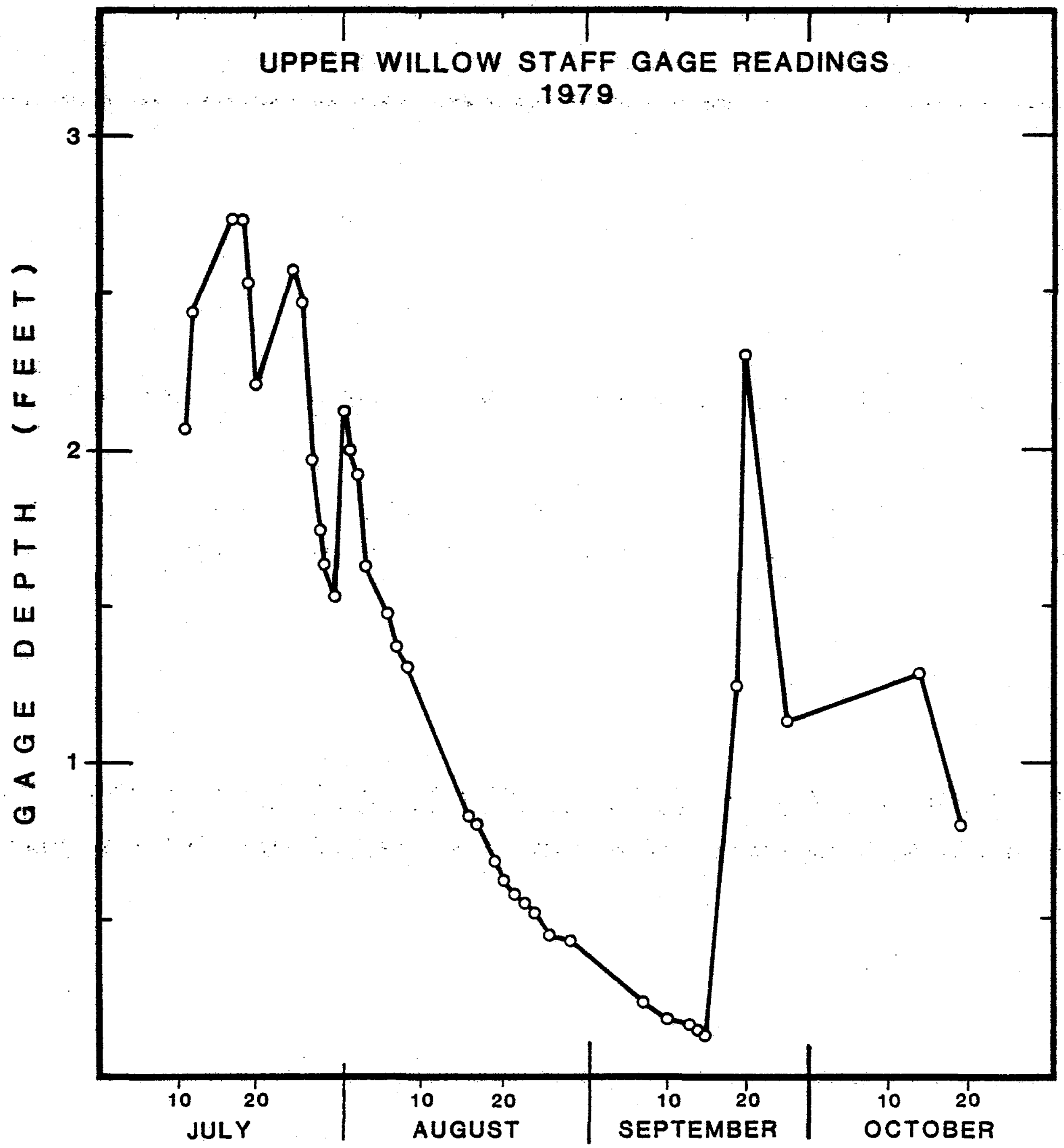

UPPER WILLOW STAFF GAGE READINGS
1979
GAGE DEPTH (FEET)
3
2
1
10
20
10
20
10
20
10
20
JULY
AUGUST
SEPTEMBER
OCTOBER

Figure 6

Appendix C.

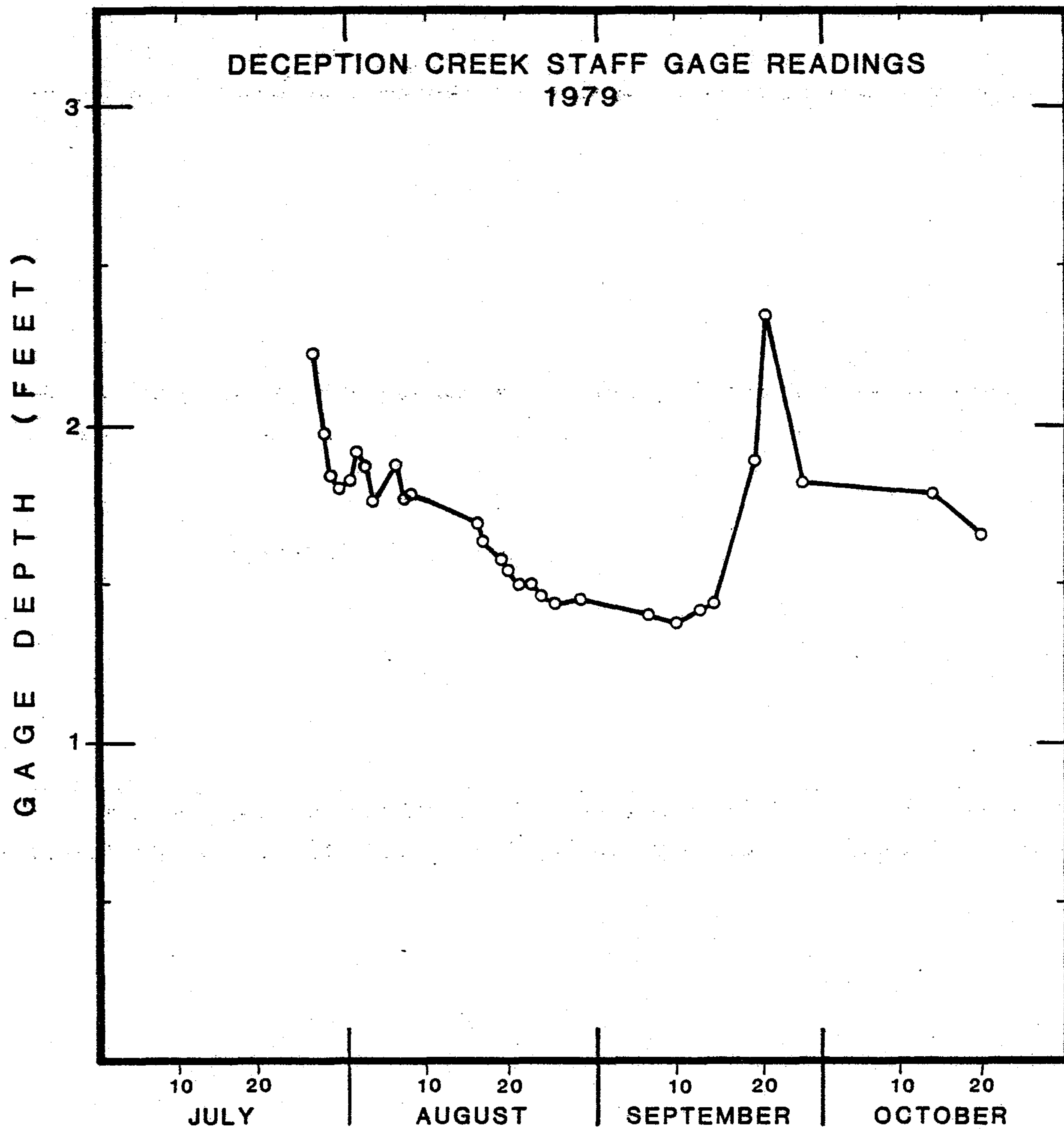


Figure 7

Appendix D.

Table 1. Thermograph data summary for Willow Creek lower reach, 1979.

Date	High	Mean*	Low	Date	High	Mean*	Low
08/03	15.0	14.0	13.0	08/22	13.8	13.0	12.2
08/04	13.4	13.2	13.0	08/23	14.9	14.2	13.5
08/05	13.0	12.8	12.5	08/24	15.4	15.1	14.8
08/06	12.5	12.3	12.0	08/25	15.1	15.0	15.0
08/07	12.2	12.1	12.0	08/26-09/10	equipment malfunction		
08/08	12.2	12.2	12.2	09/11	14.4	13.3	12.2
08/09	12.2	12.1	12.0	09/12	12.8	12.5	12.2
08/10	12.0	12.0	12.0	09/13	12.5	12.5	12.5
08/11	12.5	12.3	12.0	09/14	12.8	12.7	12.5
08/12	12.5	12.5	12.5	09/15	12.8	12.8	12.8
08/13	12.5	12.5	12.5	09/16	12.8	12.3	11.7
08/14	12.5	12.3	12.2	09/17	12.2	12.1	11.9
08/15	12.0	11.9	11.8	09/18	12.2	12.2	12.2
08/16	11.8	11.7	11.5	09/19	12.2	12.0	11.7
08/17	12.3	12.1	11.8	09/20	11.7	11.4	11.1
08/18	12.4	12.2	12.0	09/21	11.1	11.0	10.8
08/19	12.5	11.8	11.0	09/22	11.1	10.9	10.6
08/20	11.5	11.4	11.4	09/23	10.6	10.6	10.6
08/21	12.5	11.8	12.5	09/24**	10.6	10.6	10.6

*Mean temperature (°C) is the average of the daily high and low over a 24 hour period from midnight to midnight.

**Equipment malfunction - 09/25 to 10/12.

Appendix D.

Table 2. Thermograph data summary for Willow Creek middle reach, 1979.

Date	High	Mean*	Low	Date	High	Mean*	Low
07/03	10.5	09.0	07.5	07/28	11.7	11.2	10.7
07/04	08.5	07.8	07.0	07/29	11.7	11.6	11.5
07/05	10.5	09.4	08.3	07/30	11.7	10.7	09.7
07/06	10.5	09.0	07.5	07/31	11.5	11.0	10.5
07/07	11.5	09.8	08.0	08/03	13.5	11.8	10.0
07/08	12.0	10.1	08.3	08/04	12.6	11.6	10.6
07/09	12.0	10.5.	09.0	08/05	12.2	11.6	11.0
07/10	12.0	10.7	09.3	08/06	11.0	10.9	10.8
07/11	10.5	09.7	08.8	08/07	10.8	10.4	10.0
07/12	10.5	09.8	09.0	08/08	12.0	11.0	10.0
07/13	09.5	09.0	08.5	08/09	11.6	11.2	10.8
07/14	10.0	08.8	07.5	08/10	11.0	10.9	10.8
07/15	13.5	11.0	08.5	08/11	11.0	10.8	10.5
07/16	12.5	11.0	09.5	08/12	12.0	11.5	11.0
07/17	12.3	10.9	09.5	08/13	12.0	11.5	11.0
07/18	12.5	11.0	09.5	08/14	11.2	11.0	10.8
07/19	12.5	11.0	10.5	08/15	10.8	10.5	10.2
07/20	10.5	10.0	09.5	08/16	10.2	10.1	10.0
07/21	10.6	10.1	09.5	08/17	11.0	10.5	10.0
07/22	10.6	10.5	10.3	08/18	11.0	10.5	10.0
07/23	10.5	10.0	09.5	08/19	11.2	11.1	11.0
07/24	12.3	09.9	07.5	08/20	11.2	11.1	11.0
07/25	12.0	10.8	09.5	08/21	11.0	10.3	09.5
07/26	12.3	11.4	10.5	08/22	11.8	10.9	10.0

*Mean temperature (°C) is the average of the daily high and low over a 24 hour period from midnight to midnight.

Appendix D.

Table 2. (continued)

Date	High	Mean*	Low	Date	High	Mean*	Low
08/23	12.5	11.9	11.2	09/23	8.5	7.8	7.0
08/24	12.8	12.6	12.4	09/24	8.9	7.7	6.5
08/25	12.8	12.4	12.0	09/25	6.9	6.3	5.7
08/26	12.8	12.4	12.0	09/26	5.7	4.9	4.1
08/27	12.2	11.9	11.6	09/27	5.5	5.4	5.3
08/28	12.2	12.1	12.0	09/28	6.0	5.8	5.5
08/29	14.1	14.0	13.9	09/29	6.0	5.1	4.2
08/30	14.0	12.0	10.0	09/30	5.0	4.6	4.1
08/31	10.0	09.3	08.5	10/01	5.3	5.1	5.0
09/01	09.5	09.3	09.0	10/02	5.1	5.1	5.1
09/02	09.5	08.8	08.1	10/03	5.3	5.3	5.2
09/03	09.0	08.6	08.1	10/04	5.5	5.3	5.1
09/11	10.5	09.8	09.0	10/05	5.8	5.7	5.5
09/12	09.5	09.5	09.5	10/06	5.8	5.5	5.2
09/13	09.8	09.7	09.5	10/07	5.5	5.1	4.8
09/14	09.9	09.9	09.8	10/08	5.0	5.0	5.0
09/15	09.9	09.2	08.5	10/09	6.0	5.6	5.0
09/16	08.8	08.4	08.0	10/10	6.0	5.6	5.2
09/17	09.0	08.9	08.8	10/11	5.8	5.7	5.5
09/18	08.8	08.2	07.5	10/12	5.5	5.0	4.5
09/19	08.3	07.9	07.4				
09/20	08.4	07.4	06.5				
09/21	07.0	06.5	06.0				
09/22	09.0	08.9	08.8				

*Mean temperature (°C) is the average of the daily high and low over a 24 hour period from midnight to midnight.

Appendix D.

Table 3. Thermograph data summary for Willow Creek upper reach, 1979.

Date	High	Mean*	Low	Date	High	Mean*	Low
07/08	09.5	09.4	09.3	08/02	15.6	13.1	10.5
07/09	09.3	08.9	08.5	08/03	14.3	12.2	10.0
07/10	11.5	09.6	07.7	08/04	12.7	11.7	10.6
07/11	12.7	10.9	09.0	08/05	12.0	11.5	11.0
07/12	09.5	09.0	08.5	08/06	11.0	10.9	10.8
07/13	09.0	08.5	08.0	08/07	11.8	11.2	10.5
07/14	09.7	09.1	08.5	08/08	11.5	11.0	10.5
07/15	08.5	08.0	07.5	08/09	11.5	11.0	10.5
07/16	09.5	08.6	07.7	08/10	11.3	10.9	10.5
07/17	11.5	10.0	08.5	08/11	10.7	10.5	10.3
07/18	11.0	10.1	09.3	08/12	12.5	11.5	10.5
07/19	11.7	11.0	10.3	08/13	11.0	10.8	10.5
07/20	11.7	11.3	11.0	08/14	11.5	10.5	10.0
07/21	12.5	10.6	08.7	08/15	10.0	09.9	09.7
07/22	11.5	11.0	10.5	08/16	10.5	10.3	10.0
07/23	09.5	09.3	09.0	08/17	11.0	10.5	10.0
07/24	10.0	09.5	09.0	08/18	11.5	11.0	10.5
07/25	10.5	09.5	08.5	08/19	11.5	11.1	10.7
07/26	11.0	09.5	08.0	08/20	11.5	11.0	10.5
07/27	11.0	09.8	08.5	08/21	10.7	10.6	10.5
07/28	11.5	10.0	08.5	08/22	11.5	10.8	10.0
07/29	11.5	10.2	08.8	08/23	12.7	12.1	11.5
07/30	11.5	11.0	10.5	08/24	12.7	12.4	12.0

*Mean temperature (°C) is the average of the daily high and low over a 24 hour period from midnight to midnight.

Appendix D.

Table 3. (continued)

Date	High	Mean*	Low	Date	High	Mean*	Low
08/25	12.7	12.2	11.7	09/25	6.1	5.0	3.9
08/26	13.0	12.8	11.5	09/26	4.4	4.2	3.9
08/27	11.6	11.3	11.0	09/27	4.4	4.3	4.2
08/28	11.8	11.7	11.6	09/28	5.0	4.7	4.4
08/29	11.6	10.6	09.8	09/29	5.0	4.2	3.3
08/30	09.8	09.2	08.5	09/30	3.9	3.6	3.3
08/31	09.0	08.8	08.5	10/01	4.4	4.2	3.9
09/01	09.3	08.8	08.3	10/02	4.4	4.3	4.2
09/02	08.5	08.5	08.5	10/03	4.7	4.5	4.2
09/03-09/10	equipment malfunction			10/04	5.0	4.5	3.9
09/11	10.5	09.4	08.3	10/05	4.4	4.2	3.9
09/12	08.9	08.8	08.6	10/06	4.4	4.1	3.6
09/13	09.3	09.1	08.9	10/07	4.2	4.1	3.9
09/14	09.3	09.1	08.9	10/08	3.9	3.9	3.9
09/15	08.9	08.4	07.8	10/09	5.0	4.5	3.9
09/16	08.3	08.1	07.8	10/10	5.0	4.2	3.3
09/17	08.3	07.8	07.2	10/11	4.7	4.3	3.9
09/18	07.8	07.5	07.2	10/12	4.4	3.9	3.3
09/19	07.8	07.5	07.2	10/13	4.7	3.7	2.8
09/20	06.7	06.2	05.6				
09/21	06.1	05.9	05.6				
09/22	06.7	06.2	05.6				
09/23	06.7	06.2	05.6				
09/24	06.7	05.9	05.0				

*Mean temperature (°C) is the average of the daily high and low over a 24 hour period from midnight to midnight.

Appendix D.

Table 4. Thermograph data summary for Deception Creek reach, 1979.

Date	High	Mean*	Low	Date	High	Mean*	Low
07/08	11.0	10.5	10.0	08/03	14.8	12.9	11.0
07/09	12.0	11.0	10.0	08/04	13.5	12.0	11.5
07/10	13.1	11.5	10.0	08/05	13.0	12.4	11.8
07/11	14.0	13.2	12.5	08/06	11.8	11.7	11.5
07/12	13.5	12.5	11.5	08/07	11.8	11.5	11.2
07/13	12.0	11.4	10.8	08/08	12.0	11.5	11.0
07/14	12.0	11.5	11.0	08/09	12.1	11.6	11.2
07/15	11.0	10.1	09.2	08/10	12.0	11.6	11.2
07/16	10.5	09.9	09.2	08/11	11.4	11.2	11.0
07/17	14.0	12.2	09.5	08/12	12.4	11.8	11.1
07/18	13.0	11.5	10.0	08/13	12.2	11.6	11.0
07/19	11.5	10.8	10.0	08/14	12.0	11.5	11.1
07/20	12.2	11.1	11.0	08/15	11.1	11.0	11.0
07/21	12.2	12.0	11.8	08/16	11.0	11.0	11.0
07/22	12.0	11.1	11.2	08/17	11.5	10.9	10.4
07/23	11.5	11.2	10.8	08/18	11.4	11.1	10.8
07/24	11.0	10.9	10.8	08/19	11.4	11.2	11.0
07/25	11.2	10.9	10.5	08/20	11.5	11.3	11.0
07/26	11.0	10.2	09.5	08/21	11.5	10.7	09.8
07/27	10.0	10.1	10.2	08/22	11.6	10.6	09.5
07/28	11.5	10.9	10.2	08/23	12.0	11.0	10.0
07/29	12.0	11.5	11.0	08/24	12.0	11.0	10.0
07/30	12.0	11.8	11.5	08/25	12.0	11.0	10.0
07/31	12.2	11.9	11.5	08/26	11.6	10.8	10.0
08/01	11.2	11.1	11.0	08/27	11.8	10.9	10.0
08/02	12.0	11.5	11.0	08/28	12.2	11.1	10.0

*Mean temperature (°C) is the average of the daily high and low over a 24 hour period from midnight to midnight.

Appendix D.

Table 4. (continued)

Date	High	Mean*	Low	Date	High	Mean*	Low
08/29	11.0	10.2	09.4	09/24	06.7	06.6	06.4
08/30	09.4	08.9	08.5	09/25	06.7	06.1	05.6
08/31	09.2	08.8	08.4	09/26	05.6	05.3	05.0
09/01	09.5	08.5	07.5	09/27	05.0	05.0	05.0
09/02	08.8	07.9	07.0	09/28	05.6	05.4	05.3
09/03	08.8	07.9	07.0	09/29	05.6	03.7	03.9
09/04-09/10	equipment malfunction			09/30	03.9	03.6	03.3
09/11	08.9	07.8	06.7	10/01	03.9	03.8	03.6
09/12	07.8	06.2	04.7	10/02	04.2	04.1	03.9
09/13	07.8	07.5	07.2	10/03	04.4	04.3	04.2
09/14	08.3	08.0	07.8	10/04	04.7	04.6	04.4
09/15	08.3	08.3	08.3	10/05	05.0	04.9	04.7
09/16	08.3	07.5	06.7	10/06	05.3	04.6	03.9
09/17	07.8	07.5	07.2	10/07	05.3	04.8	04.2
09/18	07.8	07.8	07.8	10/08	04.2	04.2	04.2
09/19	07.8	07.6	07.5	10/09	04.2	04.1	03.9
09/20	07.8	07.2	06.7	10/10	05.3	04.1	03.9
09/21	07.2	06.7	06.1	10/11	05.0	04.7	04.4
09/22	06.7	06.4	06.1	10/12	05.0	04.1	04.3
09/23	06.7	06.4	06.1				

*Mean temperature (°C) is the average of the daily high and low over a 24 hour period from midnight to midnight.

VOLUME TWO

Appendix E*

Instream Flow Computer Analysis Data

Willow Creek Middle Reach

*Copies of Volume Two are on file at the ADF&G Region II Headquarters of the Habitat and Sport Fish Divisions in Anchorage.