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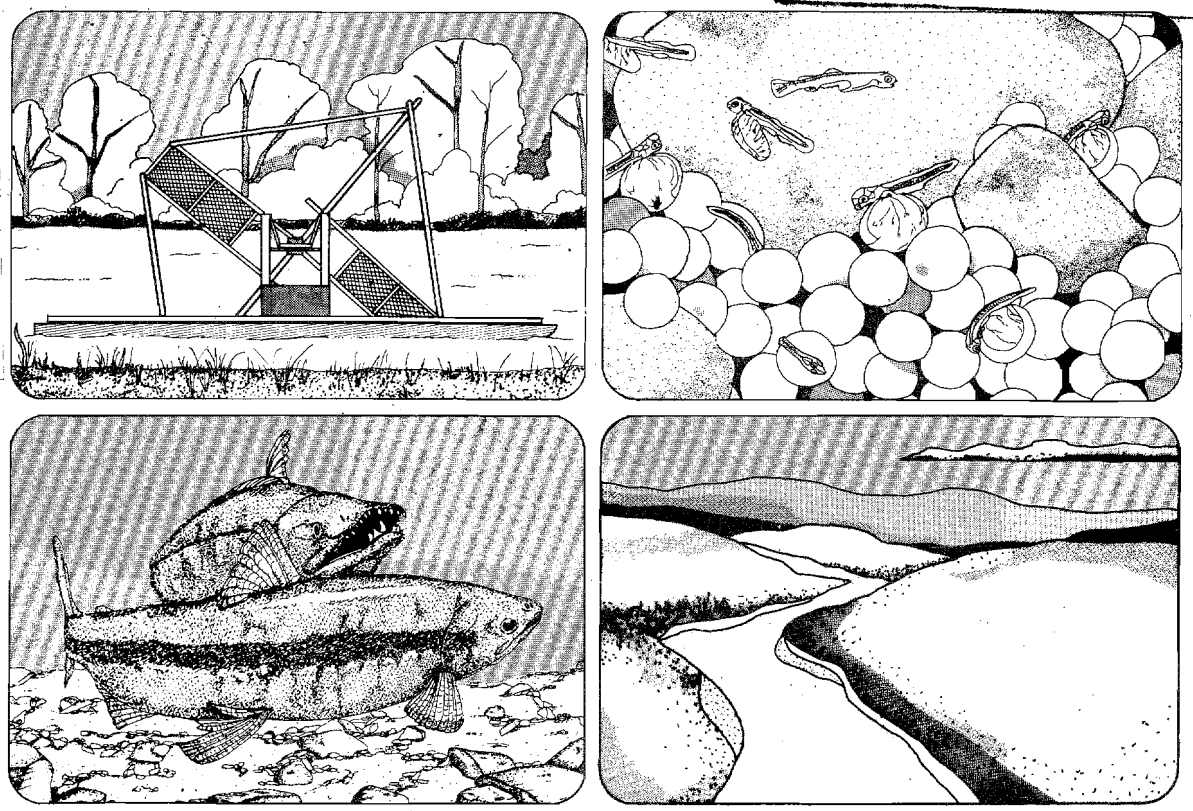

REPORT NO. 3

AQUATIC HABITAT AND INSTREAM FLOW INVESTIGATIONS (MAY-OCTOBER 1983)

Chapter 8: Evaluations of Chum Salmon Spawning Habitat in Selected Tributary Mouth Habitats of the Middle Susitna River

ALASKA DEPARTMENT OF FISH AND GAME
SUSITNA HYDRO AQUATIC STUDIES REPORT SERIES

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Chapter 8: Evaluations of Chum Salmon Spawning Habitat in Selected Tributary Mouth Habitats of the Middle Susitna River

Edited by:

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PREFACE

This report is one of a series of reports prepared for the Alaska Power Authority (APA) by the Alaska Department of Fish and Game (ADF&G) to provide information to be used in evaluating the feasibility of the proposed Susitna Hydroelectric Project. The ADF&G Susitna Hydro Aquatic Studies program was initiated in November 1980. The five year study program was divided into three study sections: Adult Anadromous Fish Studies (AA), Resident and Juvenile Anadromous Studies (RJ), and Aquatic Habitat and Instream Flow Studies (AH). Reports prepared by the ADF&G prior to 1983 on this subject are available from the APA.

The information in this report summarizes the findings of the 1983 open water field season investigations. Beginning with the 1983 reports, all reports were sequentially numbered as part of the Alaska Department of Fish and Game Susitna Hydro Aquatic Studies Report Series.

TITLES IN THE 1983 SERIES

Report Number	Title	Publication Date
1	Adult Anadromous Fish Investigations: May - October 1983	April 1984
2	Resident and Juvenile Anadromous Fish Investigations: May - October 1983	July 1984
3	Aquatic Habitat and Instream Flow Investigations: May - October 1983	1984
4	Access and Transmission Corridor Aquatic Investigations: May - October 1983	1984

This report, "Aquatic Habitat and Instream Flow Investigations" is divided into two parts. Part I, the "Hydrologic and Water Quality Investigations", is a compilation of the physical and chemical data collected by th ADF&G Su Hydro Aquatic Studies team during 1983. These data are arranged by individual variables and geographic location for ease of access to user agencies. The combined data set represents the available physical habitat of the study area within the Cook Inlet to Oshetna River reach of the Susitna River. Part II, the "Adult Anadromous Fish Habitat Investigations", describes the subset of available habitat compiled in Part 1 that is utilized by adult anadromous fish studied in the middle and lower Susitna River (Cook Inlet to Devil Canyon) study area. The studies primarily emphasize the utilization of side slough and side channel habitats of the middle reach of the Susitna River for spawning (Figure A). It represents the first stage of development for an instream flow relationships analysis report which will be prepared by E.W. Trihey and Associates.

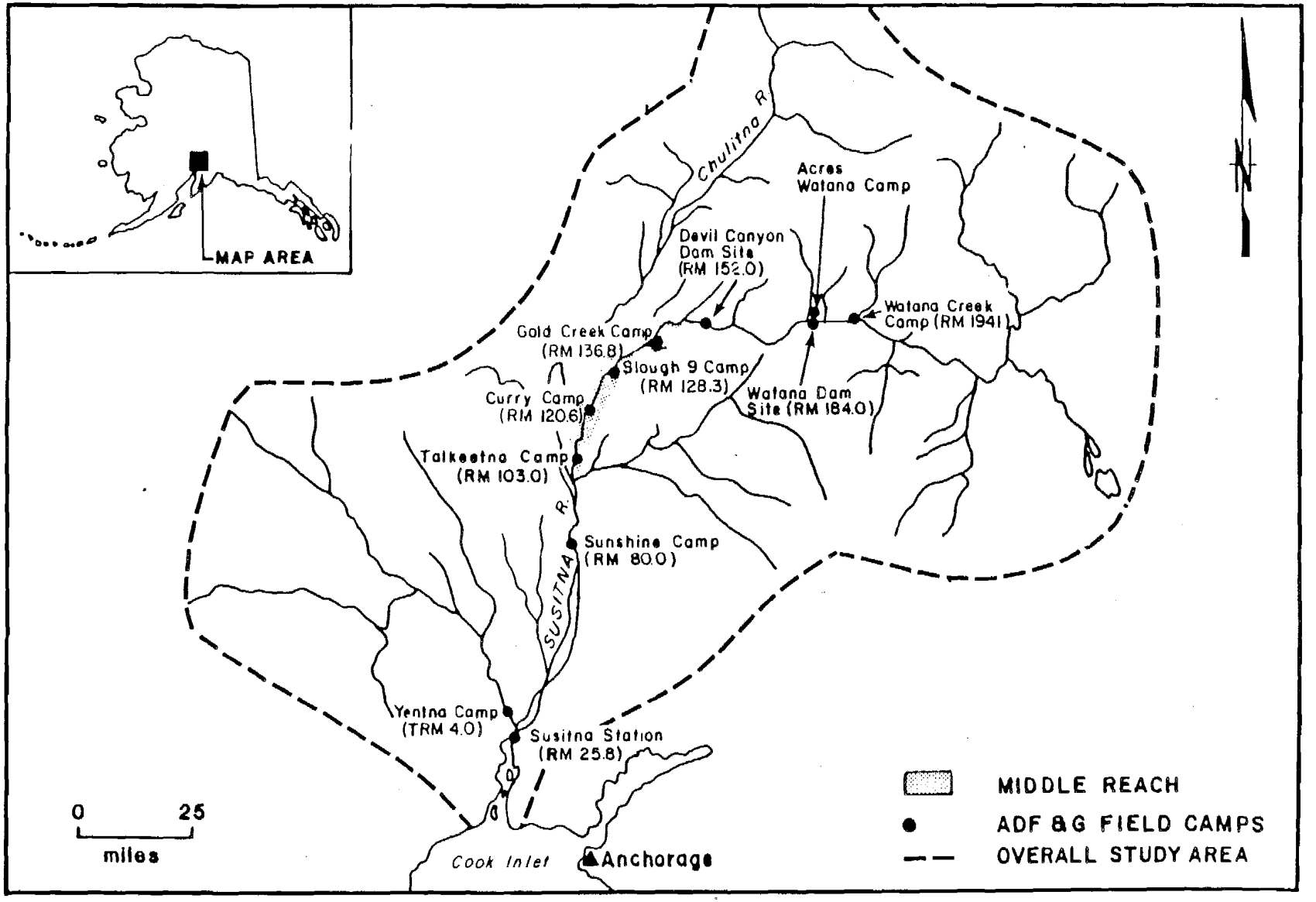

Figure A. Susitna River drainage basin.

CONTENTS OF REPORT NO. 3

Part One

Part Two

Questions concerning this and prior reports should be directed to:

Alaska Power Authority
334 W. 5th Avenue
Anchorage, Alaska 99501
Telephone (907) 276-0001

EVALUATIONS OF CHUM SALMON-SPAWNING HABITAT IN SELECTED TRIBUTARY-MOUTH HABITATS OF THE MIDDLE SUSITNA RIVER

1984 Report No. 3, Chapter 8

By: Gene Sandone, Doug Vincent-Lang, and Andrew Hoffmann

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Susitna Hydro Aquatic Studies
2207 Spenard Road
Anchorage, Alaska 99503

ABSTRACT

Two tributary mouths (Lane Creek and Fourth of July Creek) located in the middle reach of the Susitna River were evaluated to determine the influence that mainstem discharge has on the quantity and quality of chum salmon spawning habitat. During the 1983 field season, chum salmon were observed spawning in the clearwater plume of Fourth of July Creek, but not within the Lane Creek mouth area. At each study site, the location and surface area of available and usable chum salmon spawning habitat was determined. Available habitat surface area was positively correlated to changes in mainstem discharge at both tributary mouth study sites, whereas usable chum salmon spawning habitat increased with increasing mainstem discharge only at the Fourth of July Creek mouth area. The surface area of usable chum salmon spawning habitat within the Lane Creek mouth decreased as mainstem discharge increased. This difference in usable surface area responses is likely related to the different type of confluence area of each site. Lane Creek flows directly into the mainstem while Fourth of July Creek empties into a side channel. Spawning activity could not be observed beyond the clearwater plume at the Fourth of July mouth area due to high mainstem turbidities. Because of this, the importance of the clearwater plume in determining the area of usable chum salmon spawning habitat at tributary mouth habitats could not be ascertained. If it is subsequently determined that chum salmon spawning does take place in the clearwater plume area of tributary mouths, the frequency distribution of spawning depths and velocities reported herein is likely biased towards shallower and slower waters.

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1.0 INTRODUCTION

This chapter presents an evaluation of chum salmon spawning habitat within the confluence area of two tributaries (Lane and Fourth of July Creeks), henceforward referred to as tributary mouth habitat, located in the middle reach of the Susitna River. Tributary mouth areas of the Talkeetna of Devil Canyon reach of the Susitna River provide spawning habitat for chum salmon (Barrett et al. 1981) and rearing habitat for various resident and anadromous fish species (Schmidt et al. 1984). Previous analyses of these areas, however, are lacking because of a higher priority placed on research of other habitat types and sampling difficulties associated with these habitats. As a result, very little quantitative information has been compiled for tributary mouth areas.

The objectives of this investigation were to:

1. Develop specific spawning habitat criteria for chum salmon tributary mouth spawners;

2. Locate and quantify the amount of wetted surface area (available habitat) within the tributary mouth study areas for selected mainstem discharges;

3. Monitor and record hydraulic and other physical conditions which appear to influence the selection of spawning sites (redds) by chum salmon within tributary mouth areas; and,

4. Locate and quantify that portion of the wetted surface area (available habitat) which represents potential chum salmon spawning habitat (usable habitat) within the tributary mouth study areas for selected mainstem discharges.

A similar evaluation of salmon spawning habitat in side slough and side channel habitats is presented in Chapter 7. The purpose of the slough and side channel investigations has been to predict the availability of chum and sockeye salmon spawning habitat in these habitats as a function of flow variations. The slough and side channel studies have relied on the use of computer simulation through mathematical models to achieve their purpose. The computer models used in these investigations, however, could not be applied in this study because tributary mouth habitats do not have a fixed boundary and thus are not amenable to modelling using the incremental flow methodology. Consequently, the evaluation of tributary mouth habitat used in this study was designed to describe, evaluate, and quantify the presence of physical conditions as a function of observed mainstem discharges and tributary flows. Study results in this chapter address three categories of habitat found in tributary mouth areas: available habitat (wetted surface area), usable and unusable salmon spawning habitat, and salmon spawning utilized habitat.

The results of this investigation should not be used unilaterally as a predictive tool. Instead, they should only be used to describe the baseline physical conditions present within the selected tributary mouth areas for the observed combinations of mainstem discharges and tributary flows.

2.0 METHODS

2.1 Site Selection

Tributary mouth habitat investigations were conducted at Lane Creek (RM 113.6) and Fourth of July Creek (RM 131.1). These tributary mouths (Figure 8-1) were selected on the basis of their historical importance as chum salmon spawning areas and their representativeness of other tributary mouth habitats found in the Talkeetna to Devil Canyon reach of the Susitna River. Approximately 30 tributaries enter the middle reach of the Susitna River. Table 8-1 summarizes relative spawner utilization at 14 of the major tributary mouth areas surveyed in the middle reach during the 1981-1983 period. Also indicated in Table 8-1 is the type of confluence zone noted for the larger tributaries. Lane Creek empties into the main channel of the Susitna River; whereas, Fourth of July Creek enters a side channel. The type of confluence zone has important consequences, as will be discussed later, in regard to the available and usable salmon spawning habitat present within tributary months.

For the purposes of this investigation, the tributary mouth area extends from the uppermost point in the tributary influenced by mainstem discharge effects, laterally to the juncture of the tributary plume and the mainstem river. Every combination of Susitna River discharge and tributary flow potentially affects the boundary where the free-flowing tributary habitat ends and the tributary mouth habitat area begins. For

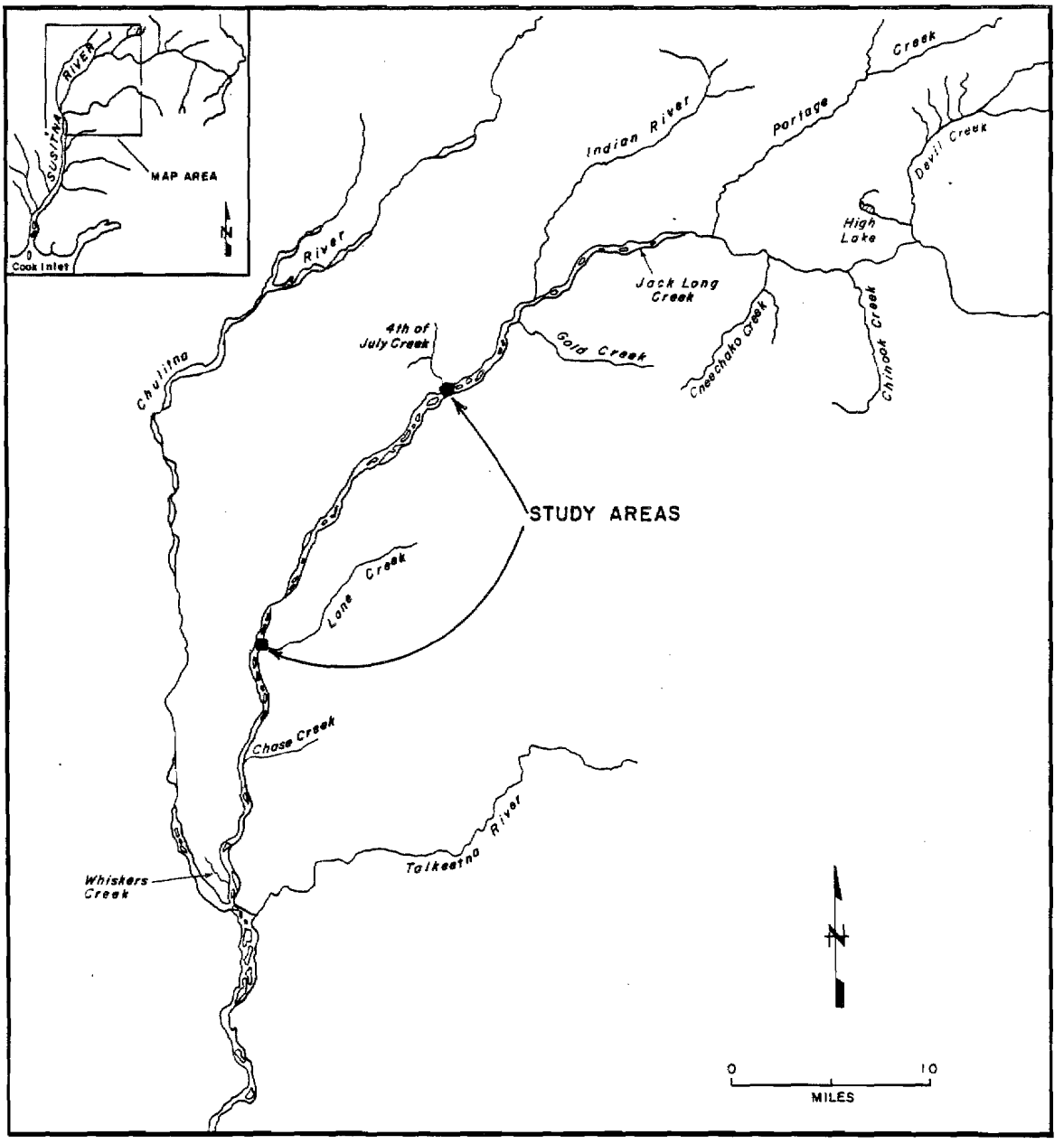


Figure 8-1. Locations of the Lane Creek and Fourth of July Creek tributary mouth study areas.

Table 8-1. Major Susitna River tributaries between the Chulitna River (RM 98.3) and Devil Canyon (RM 152.0) and their relative chum salmon spawner utilization and their type of confluence habitat.

Tributary	River Mile	Relative Chum Salmon Spawner Utilization [1]	Confluence Habitat
Whiskers Creek	101.4	+	slough
Chase Creek	106.9	+	mainstem
Slash Creek	111.2	+	side channel
Gash Creek	111.6	+	side channel
Lane Creek	113.6	++	mainstem
Lower McKenzie Creek	116.2	+	mainstem
McKenzie Creek	116.7	+	mainstem
Little Portage Creek	117.7	0	side channel
Deadhorse Creek	121.0	0	mainstem
Fifth of July	123.7	0	mainstem
Skull Creek	124.7	+	side channel
Sherman Creek	130.8	+	mainstem
Fourth of July Creek	131.0	+++	side channel
Gold Creek	136.7	+	mainstem
Indian River	138.6	+++	mainstem
Jack Long Creek	144.5	++	mainstem
Portage Creek	148.9	+++	mainstem

1/ +++ high utilization
++ moderate utilization
+ low utilization
0 no utilization

this reason, designation of this boundary line is important for delineating and differentiating between spawner utilization within tributary, tributary mouth, and mainstem habitats.

The tributary mouth study area boundaries (upstream and downstream) were initially established to include the area at and below the actual tributary/mainstem confluence (Figures 8-2 and 8-3). The mainstem portion of the study area was later expanded (based on consultation with a hydraulic engineer) to better describe the overall hydraulics within the original study area. This included adding two transects at both study areas in the mainstem above the confluence and adding a downstream transect at the Lane Creek study area.

Transects were established to represent reaches having uniform hydraulic conditions and related characteristics. Transects within the mainstem and tributary portions of the study areas were located perpendicular to the discharge or flow, respectively.

Additional transects were added at both study areas after the first sampling period had been completed at each study area. Therefore, the size of the study areas at both study sites increased after the first sampling period. For this reason, comparisons of habitat area measurements are only valid for the area within the boundaries of the originally sampled transects for all mainstem discharges sampled.

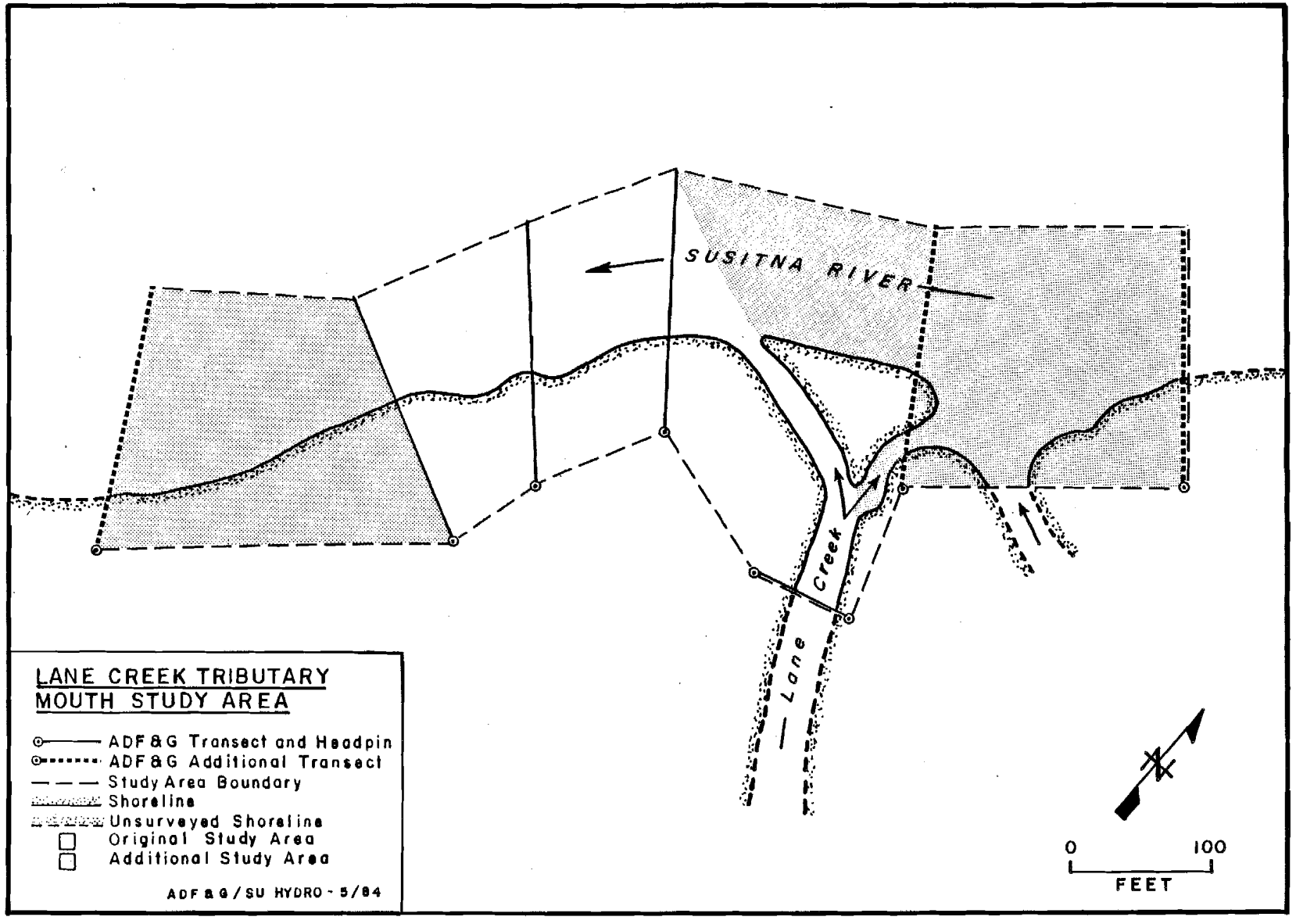


Figure 8-2. Lane Creek tributary mouth study area boundaries.

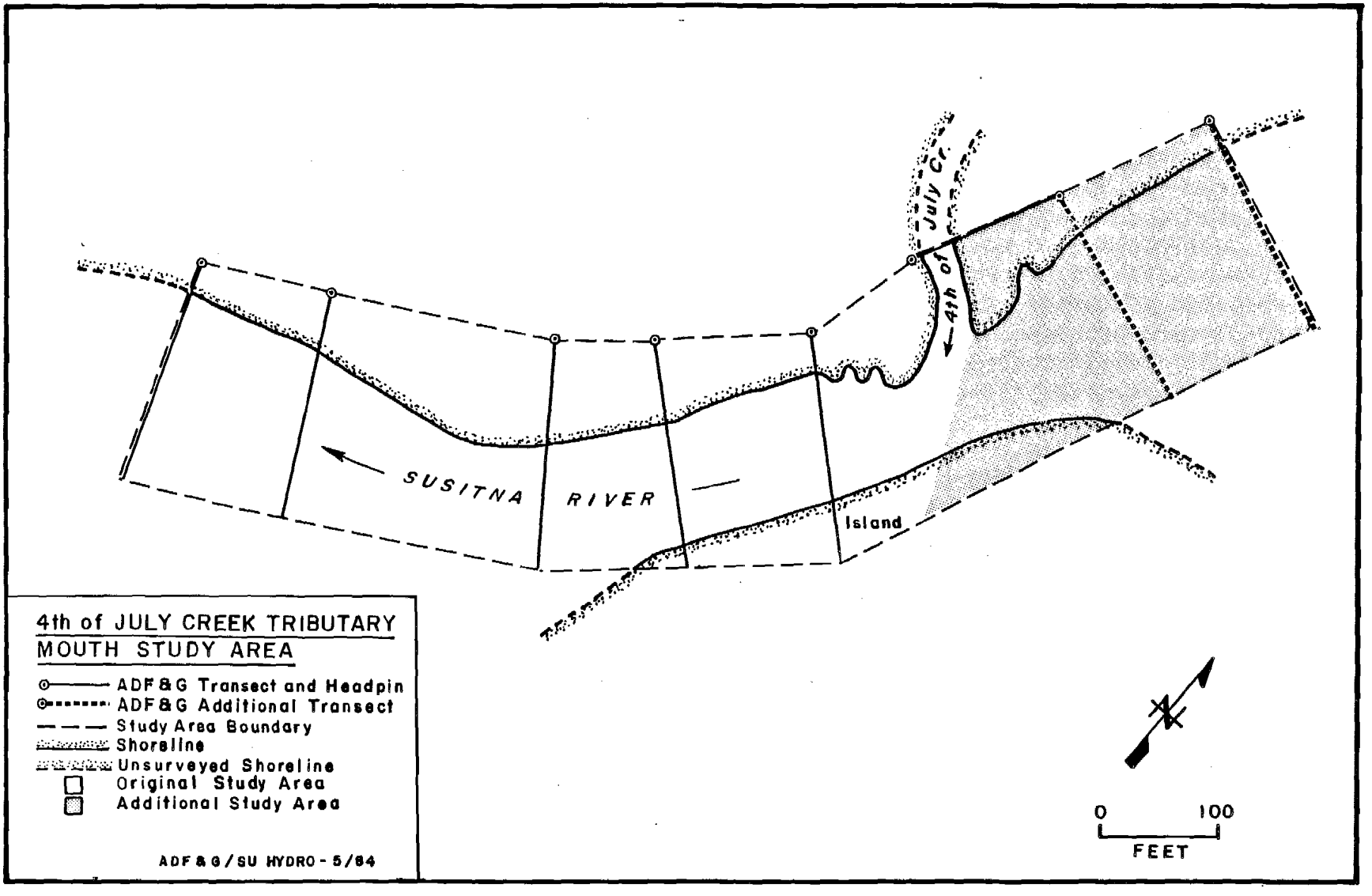


Figure 8-3. Fourth of July Creek tributary mouth study area boundaries.

The clearwater tributary mouth plume was within the confines of the original boundaries at each study site during the first sampling period at the 23,000 cfs and 24,000 cfs discharge levels. The clearwater plume, however, was not contained within the original or expanded boundaries of either study areas at mainstem sampling discharge levels of 16,000, 12,000 and 8,000 cfs. The boundaries of the tributary mouth study areas, however, did contain the major portion of the clearwater plume at each study area during these discharges. Spawning activity was observed beyond the boundary of the Fourth of July Creek tributary mouth study area at mainstem discharges ranging from 21,000 to 26,500 cfs; however, this activity was minimal and therefore should not significantly affect the results of this investigation.

In summary, both study areas may be considered representative of the entire tributary/mainstem confluence area at each study site. Additionally, it appears that these study sites are generally representative of the major tributary mouth habitats in the middle reach of the Susitna River.

2.2 Available Habitat

Available habitat is defined in this chapter as the wetted surface area within the study area boundaries at each combination of mainstem discharge and tributary flow sampled. In order to determine the amount, location, and type of available habitat present within the study area for each discharge/flow combination sampled, the wetted surface area of hydraulic and substrate conditions evaluated were delineated on maps.

Base maps were developed from survey data which included transects. Surveys were referenced to project datum. Streambed elevations along established transects were obtained during low Susitna River discharge conditions (below 8,000 cfs). One foot contours were added to the maps as determined from survey data.

The clearwater plume of the tributary was defined for each sampled Susitna River discharge by measuring the distance from the headpin of each transect to the water's edge and then to the interface of the clear and turbid waters. The downstream extent of the clearwater plume within the study area was also noted. Study area transects and shoreline and clearwater plumes were defined on study area base maps at each combination of mainstem discharge and tributary flow measured.

Hydraulic data (water depths and mean column velocities) were collected at verticals along transects when Susitna River discharges at Gold Creek (USGS gaging station 15292000) were in the ranges of 8,000, 12,000, 16,000, and 20,000 cfs from a boat or by wading. These data were plotted along study area transects on parameter specific maps. Water velocity and depth isopleths (increments of 1.0 ft/sec and 1.0 ft, respectively) were drawn between identical readings on study transects on each parameter specific map. If the actual isoplethic value was not observed, the value was interpolated. Quantification of areas characterized by an incremental velocity or depth was achieved by digitizing the water surface area associated with each specific increment.

Large substrate size and relatively high water velocities precluded the visual detection of upwelling groundwater below the water surface at both study areas at all sampled mainstem discharges and tributary flows. However, a limited number of temperature differences between surface and intragravel waters observed at active chum redds indicate possible upwelling groundwater venting within the Fourth of July Creek tributary mouth study area. Because of the limited amount and tentative nature of these data, areas of potential upwelling were only depicted on spawning area maps.

Substrate composition was determined along transects by visual observation during the low, clear, autumn flows of the Susitna River (18,000 cfs). Turbidity levels associated with higher open water mainstem discharges prohibited evaluation earlier in the season. Substrate composition was assumed to be static throughout the sampling period. Accordingly, a single substrate composition map delineating substrate data observed along study area transects was constructed for each study area.

2.3 Usable Salmon Spawning Habitat

Usable salmon spawning habitat is defined in this chapter as the portion of available habitat area where an acceptable range of water velocities, depths, and substrate conditions exist for supporting chum salmon spawning. Earlier investigations by the ADF&G have not focused on chum salmon spawning requirements at tributary mouth habitat areas. Because

of this, overall usable ranges of water velocities, water depths, and substrate conditions for chum salmon spawning were derived from data collected in this study as modified using literature information (Hale 1981) and the suitability criteria presented in Chapter 7. The resulting ranges of hydraulically related habitat parameters considered to be acceptable for chum salmon spawning in tributary mouths for this study were determined to be:

Parameter	Range
Water velocity	0.0-4.5 ft/sec.
Water depth	0.2-4.0 ft
Substrate	Small gravel - boulders

The ranges of usable depths, velocities, and substrates used in this chapter are generally similar to the ranges of suitable depths, velocities, and substrates used in the evaluation of chum salmon spawning in sloughs and side channels of the middle reach of the Susitna River (see Chapter 7) with certain exceptions. The range of usable depths in this study was only extended to a maximum depth of 4.0 ft; whereas, in the slough and side channel study it was extended out to a maximum depth of 8.0 ft. The reason for this discrepancy is that the range of usable depths in this study was determined prior to the final determination of the range of suitable depths in the slough and side channel study. The range of usable depths in this study should likely be extended, as was done in the slough and side channel study, to the maximum expected depth in the tributary mouth habitats, as depth alone would not likely limit spawning in this range (see Chapter 7). Time

constraints did not allow the recalculation of usable habitat using the extended depth range. The difference, however, is expected to be small as larger depths would likely be associated with higher, less usable, velocities.

Usable substrates in this study ranged from small gravels to boulder while in the slough and side channel study suitable substrates ranged from small gravels to cobbles. The range of usable substrates was extended to include boulders in this study as, based on discussions with field personnel, there was a strong likelihood of sampling bias towards larger substrate classes. For this reason, it was determined that areas characterized as having boulder substrates actually had smaller more usable substrates and would thus be usable spawning substrates.

Usable habitat areas were determined by first outlining on each parameter-specific map the areas where the observed values were within the acceptable range. The three maps (water velocity, water depth, and substrate composition) constructed for a particular combination of mainstem discharge and tributary flow were than overlaid. The resulting surface area where the observed values of all three variables were within acceptable ranges was defined as usable chum salmon spawning habitat. These areas were quantified by digitizing. The location of usable habitat within each study area was also delineated on a final habitat map for each mainstem/tributary discharge.

The two dimensional mapping technique described above has been applied elsewhere as a means of quantifying spawning habitat at fixed discharges

(Collings 1972, 1974). Referred to as the Washington Method, the technique is usually applied to several discharges in order to develop a response curve of spawnable area as a function of discharge. The study design implemented in this investigation is conceptually similar to the Washington Method.

2.4 Habitat Utilized by Spawning Chum Salmon

Utilized habitat is defined in this chapter as that portion of usable habitat actually used for spawning by chum salmon. Spawning chum salmon were observed only within the tributary mouth of Fourth of July Creek in late August at mainstem discharges ranging from 21,000 to 26,000 cfs. Utilization data were gathered at observed spawning sites (redds) within this tributary mouth according to methods outlined in Chapter 7. It could not be determined if salmon were actually spawning beyond the plume of Fourth of July Creek because the turbid water of the mainstem prevented visual observations. Utilization data collected within the tributary clearwater plume were used in defining usable habitat as described in Section 2.3.

Preference curves, as defined in Chapter 7, could not be developed since the available habitat within the tributary clearwater plume was not determined at the time of collection of the utilization data. That is, the combinations of mainstem discharges and tributary flows at which available habitat data were collected differed from flows which existed when utilization data collected.

3.0 RESULTS

General summaries of the tributary mouth habitat analyses conducted at the tributary mouths of Lane Creek and Fourth of July Creek are presented in Tables 8-2 and 8-3 and Figure 8-4, and Tables 8-4 and 8-5 and Figure 8-5, respectively. Comparisons of results presented for mainstem discharges of 23,000 and 24,000 cfs with other sampled discharges should not be attempted due to unavailable transect data when these discharges were sampled. Results from these abbreviated sampled areas are presented in tables and figures but are not discussed in the text. Morphometric and substrate maps of the Lane Creek and Fourth of July Creek tributary mouth study areas are presented in Figures 8-6 and 8-7 and Figures 8-8 and 8-9, respectively.

3.1 Available Habitat

The wetted surface area of available habitat at both tributary mouth study areas was positively correlated to the mainstem discharge at Gold Creek (Figures 8-10 and 8-11). There were no correlations, however, between area of available habitat and tributary flow (Figures 8-12 and 8-13). It should be noted that these relationships are only valid for the observed combinations of tributary flow and mainstem discharge.

Fluctuations in percent area of available habitat were much more dramatic at the Fourth of July Creek tributary mouth study area than at the Lane Creek tributary mouth study area (Figure 8-14). Area of available habitat at the Lane Creek tributary mouth study area ranged

Table 8-2. Lane Creek tributary mouth study area habitat analysis, 1983.

Date	Discharge (cfs)		Surface Area (ft^2)					
	Susitna River	Lane Creek	Sampled Area	Available Habitat	Usable Habitat	Clearwater Plume	Usable Habitat of Clearwater Plume	Total Unusable Habitat
831007	9,240	39	160,500	96,500	79,100	25,400	22,450	17,400
830912	11,600	21	160,500	101,600	45,900	13,100	12,600	55,700
830908	13,700	28	160,500	107,000	35,900	13,000	11,300	71,140
830625	23,000	20	41,200[a]	35,200	9,850	0[b]	0[b]	25,350

[a] Sample area reduced because of unavailable transect data.

[b] Clearwater plume surface area occurs outside of the sampled area. Total surface area of the clearwater plume is 850 square feet. Usable habitat area of the clearwater plume outside of the sample area is 840 square feet.

Table 8-3. Analysis of the total unusable available habitat in the Lane Creek mouth study area.

Date	Total Unusable Habitat	Unusable Habitat [surface area (ft^2)] Depth	Velocity	Substrate	Combination [description]
831007	17,400	1,800 (+)[c] 2,410 (-)[d]	9,890	3,400	100 [depth (-) and velocity]
830912	55,700	47,110 (+) 1,970 (-)	41,150	3,550	38,000 [depth (+) and velocity] 80 [depth (-) and velocity]
830908	71,140	60,975 (+) 1,970 (-)	58,835	3,770	54,280 [depth (+) and velocity] 80 [depth (+) and velocity] 50 [depth (+) and substrate]
830625	25,350[e]	21,210 (+) 570 (-)	20,590	3,820	250 [depth (-) and substrate] 20,590 [depth (+) and velocity]

[c] (+) indicates habitat unusable due to deep water depths (4.0 ft.)

[d] (-) indicates habitat unusable due to shallow water depths (0.2 ft.)

[e] sampled area reduced because of unavailable transect data

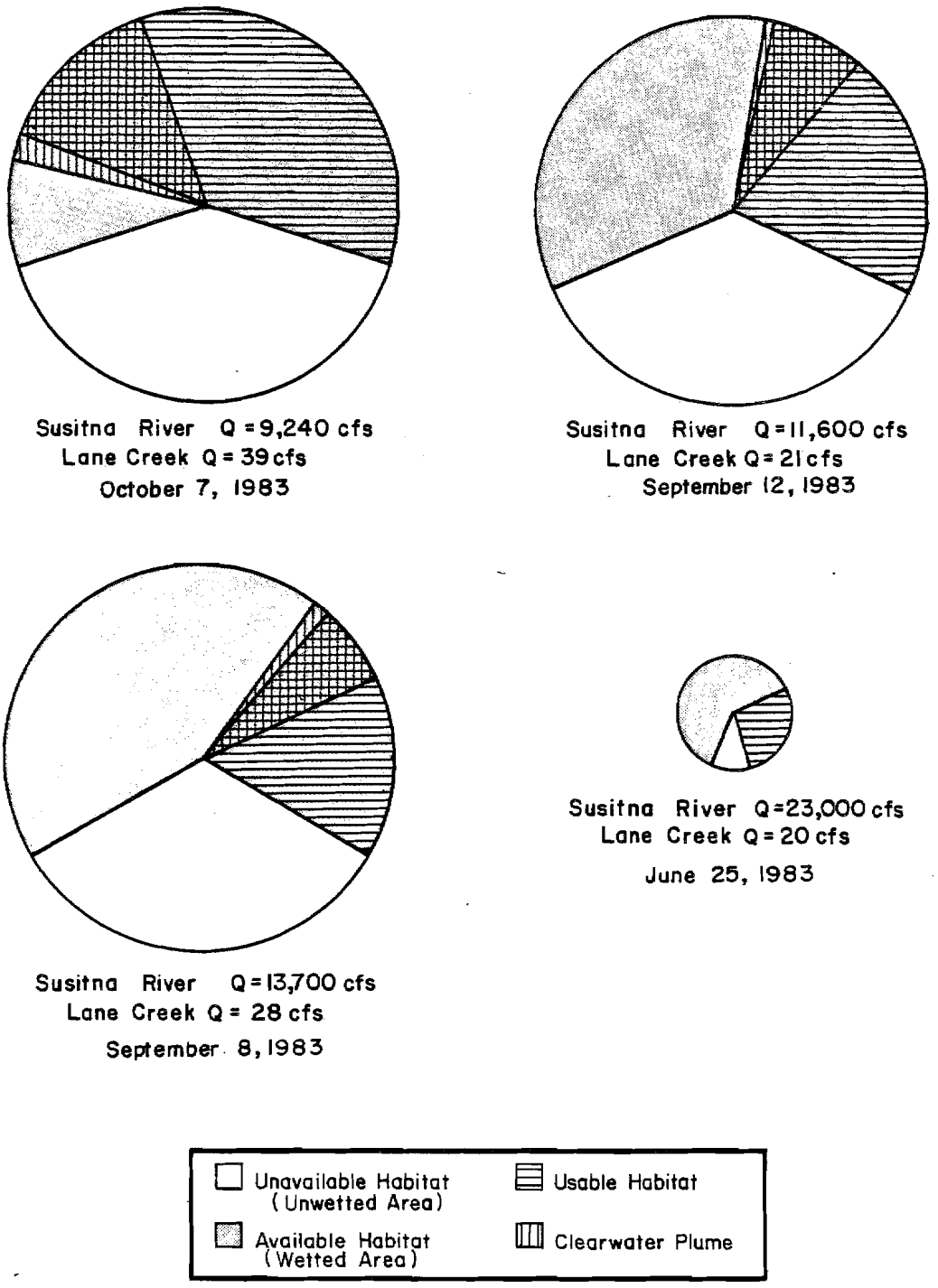


Figure 8-4. Proportional area pie charts of the sampled area, clearwater plume, and available and usable salmon spawning habitats of the Lane Creek tributary mouth study area (RM 113.6) at the four sampled mainstem discharges (USGS gaging station, 15292000), 1983. (Note: sampled area at the sampled mainstem discharge of 23,000 cfs was reduced by 74% because of unavailable transect data).

Table 8-4. Fourth of July Creek tributary mouth habitat analysis, 1983.

Date	Discharge (cfs)		Surface Area (ft^2)					
	Susitna River	Fourth Of July Creek	Sampled Area	Available Habitat	Usable Habitat	Clearwater Plume	Usable Habitat of Clearwater Plume	Total Unusable Habitat
831008	8,040	55	199,600	80,700	66,670	45,500	37,800	14,000
830912	11,600	33	199,600	119,100	106,140	46,200	40,800	13,040
830907	14,800	63	199,600	131,400	120,600	42,800	40,000	10,800
830624	24,000	11	143,900[a]	117,200	105,030	3,100[b]	2,600[b]	12,230

[a] Sampled area reduced because of unavailable transect data.

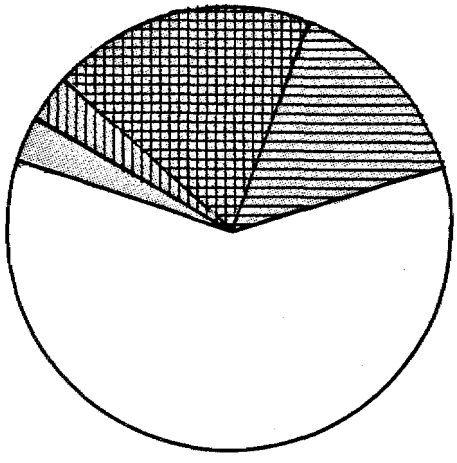
[b] Clearwater plume and substrate area are not affected by reduction in sampled area.

Table 8-5. Analysis of the total unusable available habitat in the Fourth of July Creek tributary mouth study area.

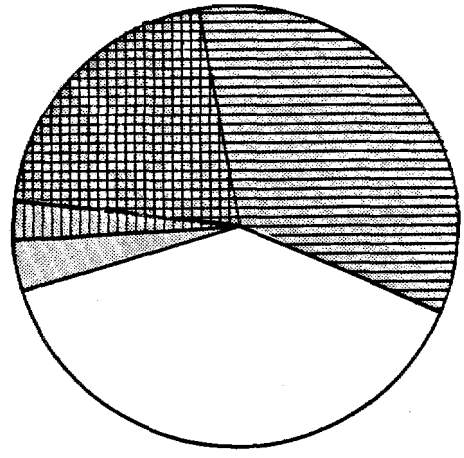
Date	Unusable Habitat [surface area (ft^2)]				
	Total Unusable Habitat	Depth (+ or -)	Velocity (+)	Substrate	Combination [description]
830810	14,000	8,040 (-)[a]	0	6,180	220 [depth (-) or substrate]
831209	13,040	5,960 (-)	0	7,080	0
830709	10,800	3,720 (-)	0	7,080	0
832406	12,230[b]	4,570 (-)	6,160	1,500	0

[a] (-) indicates habitat unusable due to shallow water depth (0.2 ft.)

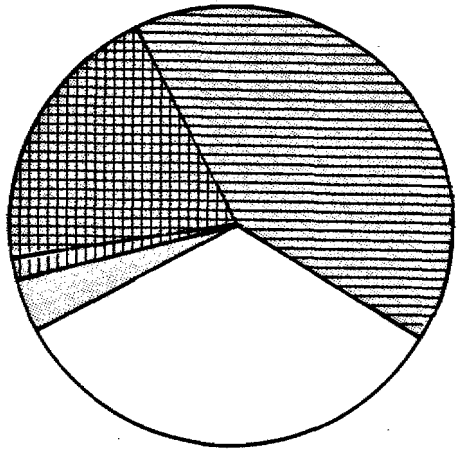
[b] sampled area reduced because of unavailable transect data



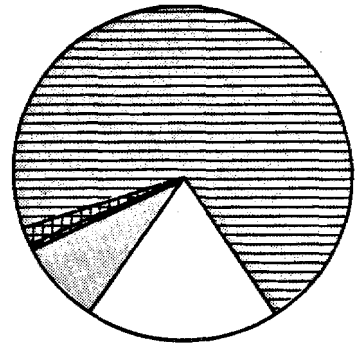
Susitna River Q=8,040 cfs
Fourth of July Cr. Q=55 cfs
October 8, 1983



Susitna River Q=11,600 cfs
Fourth of July Cr. Q=33 cfs
September 12, 1983



Susitna River Q=14,800 cfs
Fourth of July Cr. Q=63 cfs
September 7, 1983



Susitna River Q=24,000 cfs
Fourth of July Cr. Q=11 cfs
June 24, 1983

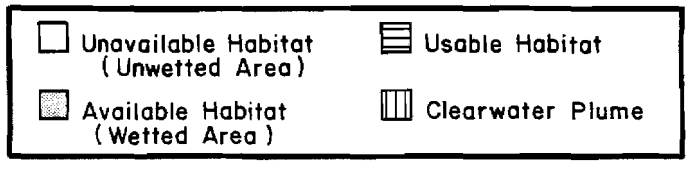


Figure 8-5. Proportional area pie charts of the sampled area, clearwater plume, and available and usable salmon spawning habitats of the Fourth of July tributary mouth study area (RM 131.2) at the four sampled mainstem discharges (USGS gaging station, 15292000), 1983. (Note: sampled area at the sampled mainstem discharge of 24,000 cfs was reduced by 28% because of unavailable transect data).

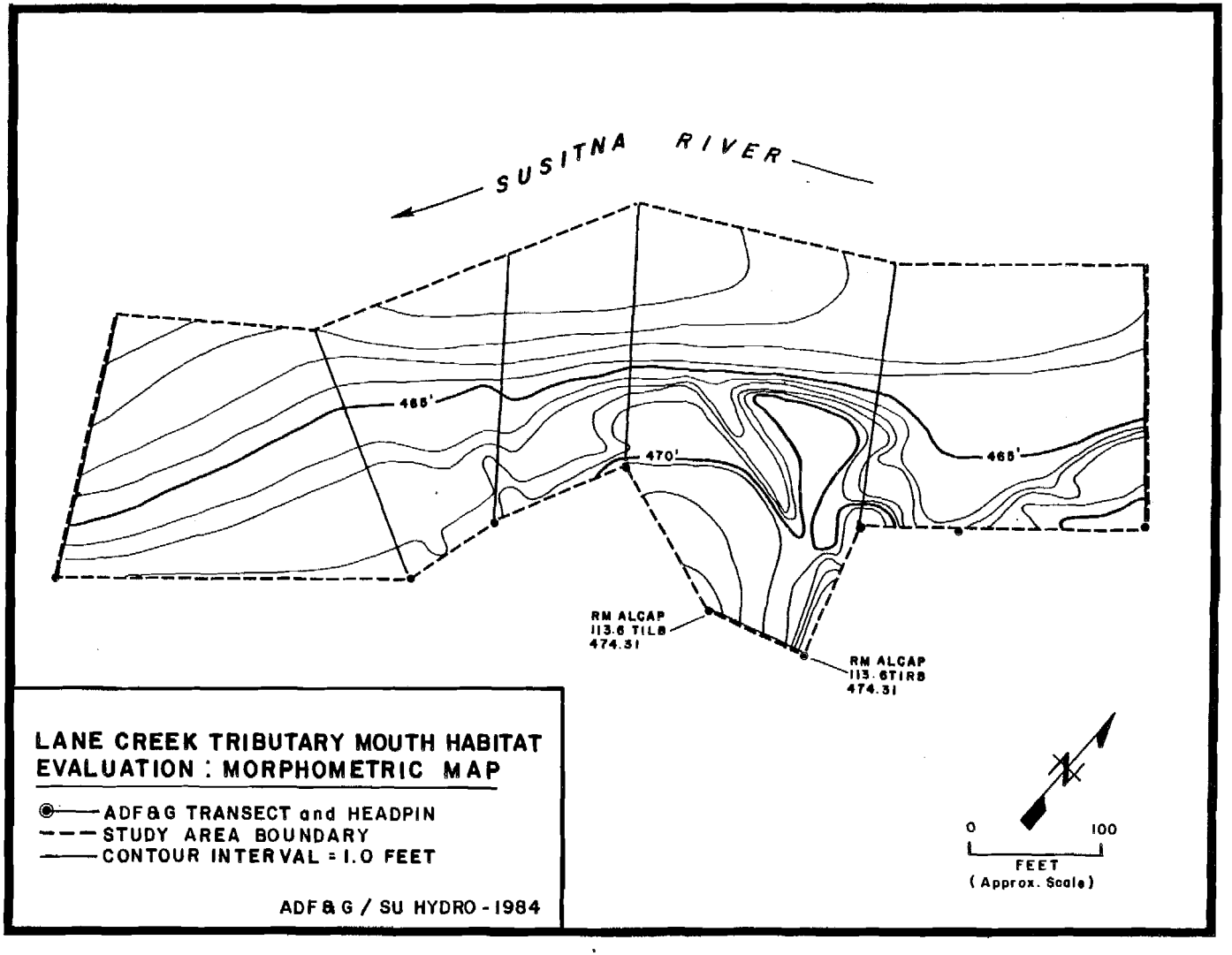


Figure 8-6. Morphometric map of the Lane Creek tributary mouth study area (RM 113.6), 1983.

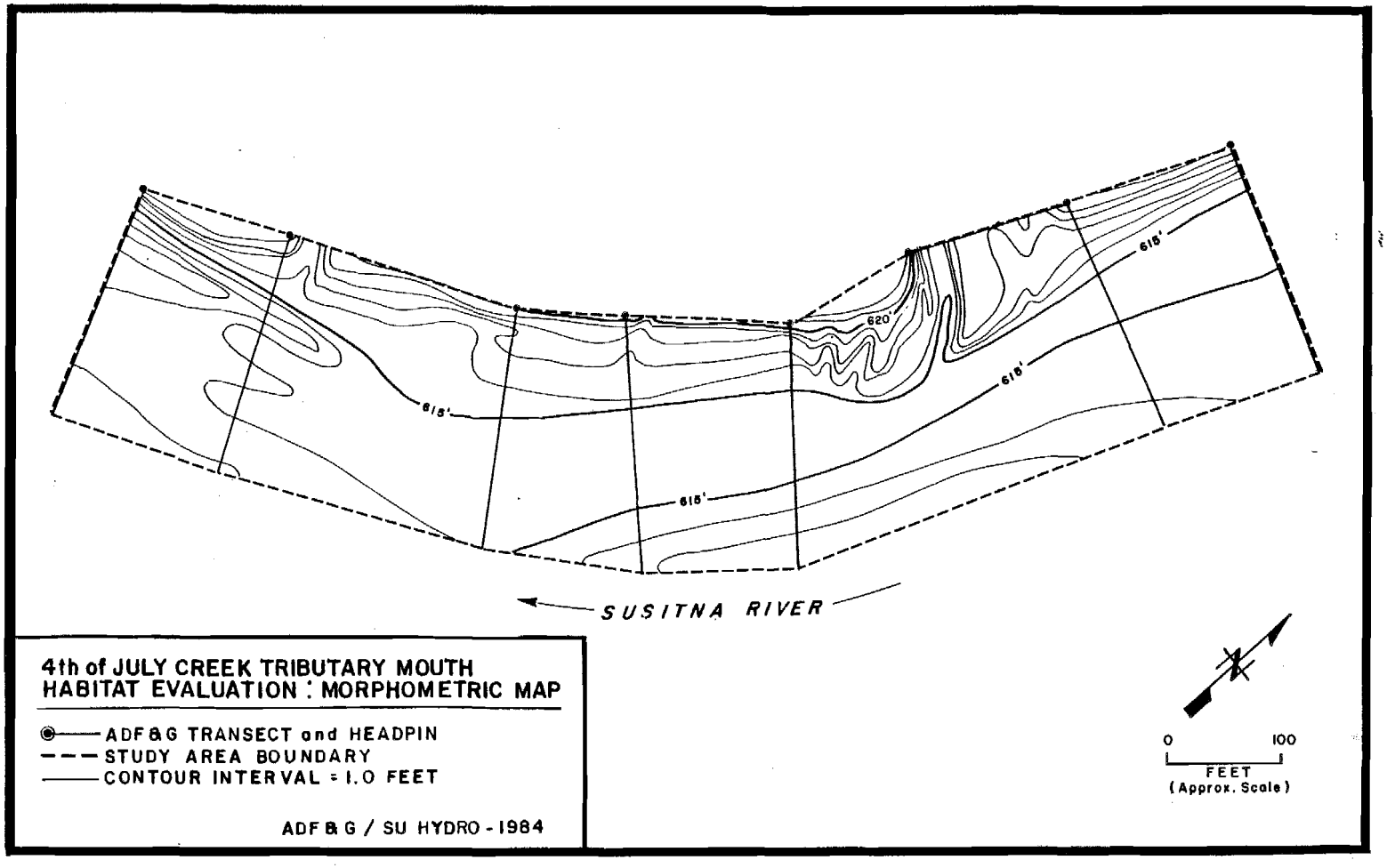


Figure 8-7. Morphometric map of the Fourth of July Creek tributary mouth study area (RM 131.2), 1983.

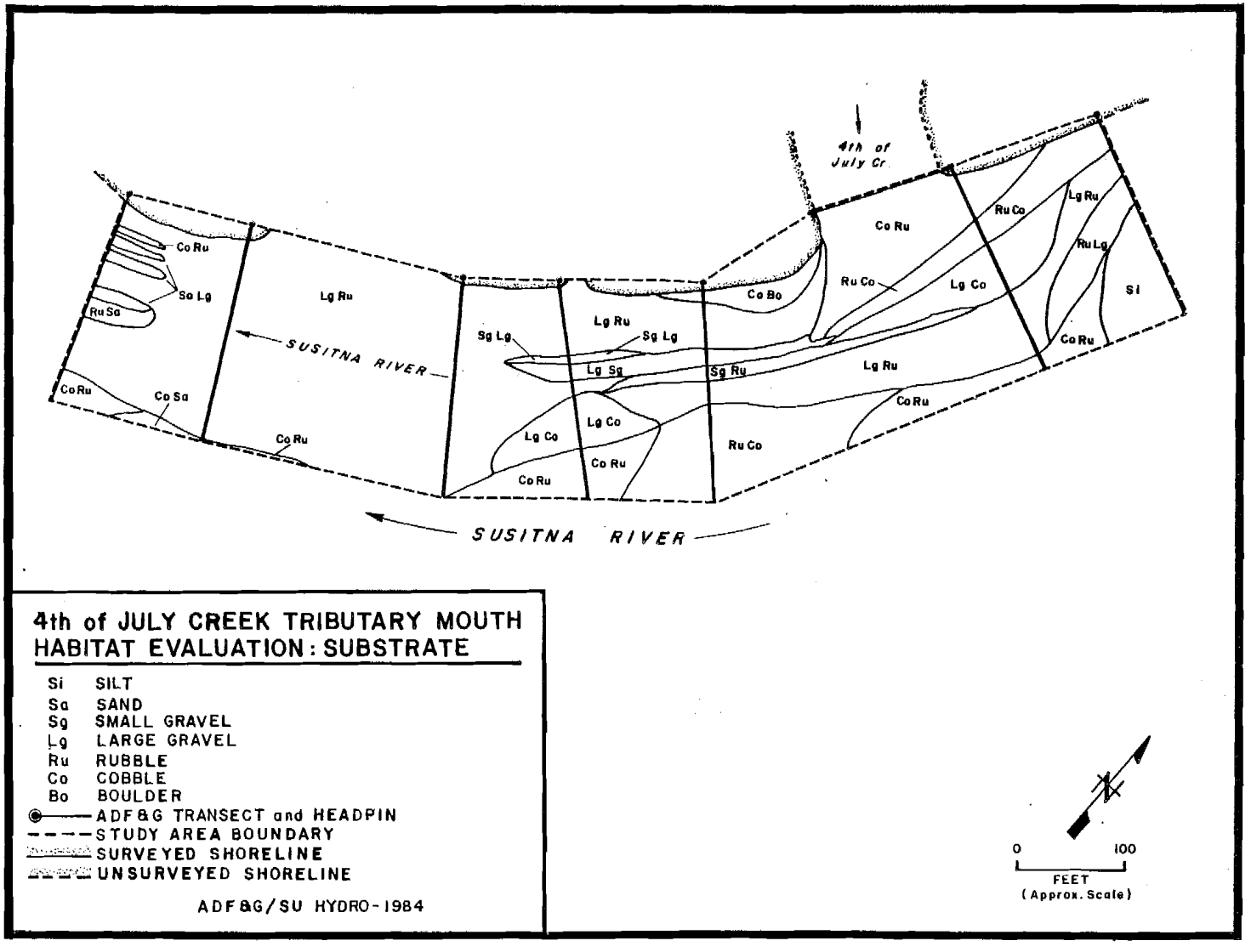


Figure 8-8. Substrate map of the Lane Creek tributary mouth study area (RM 131.6), 1983.

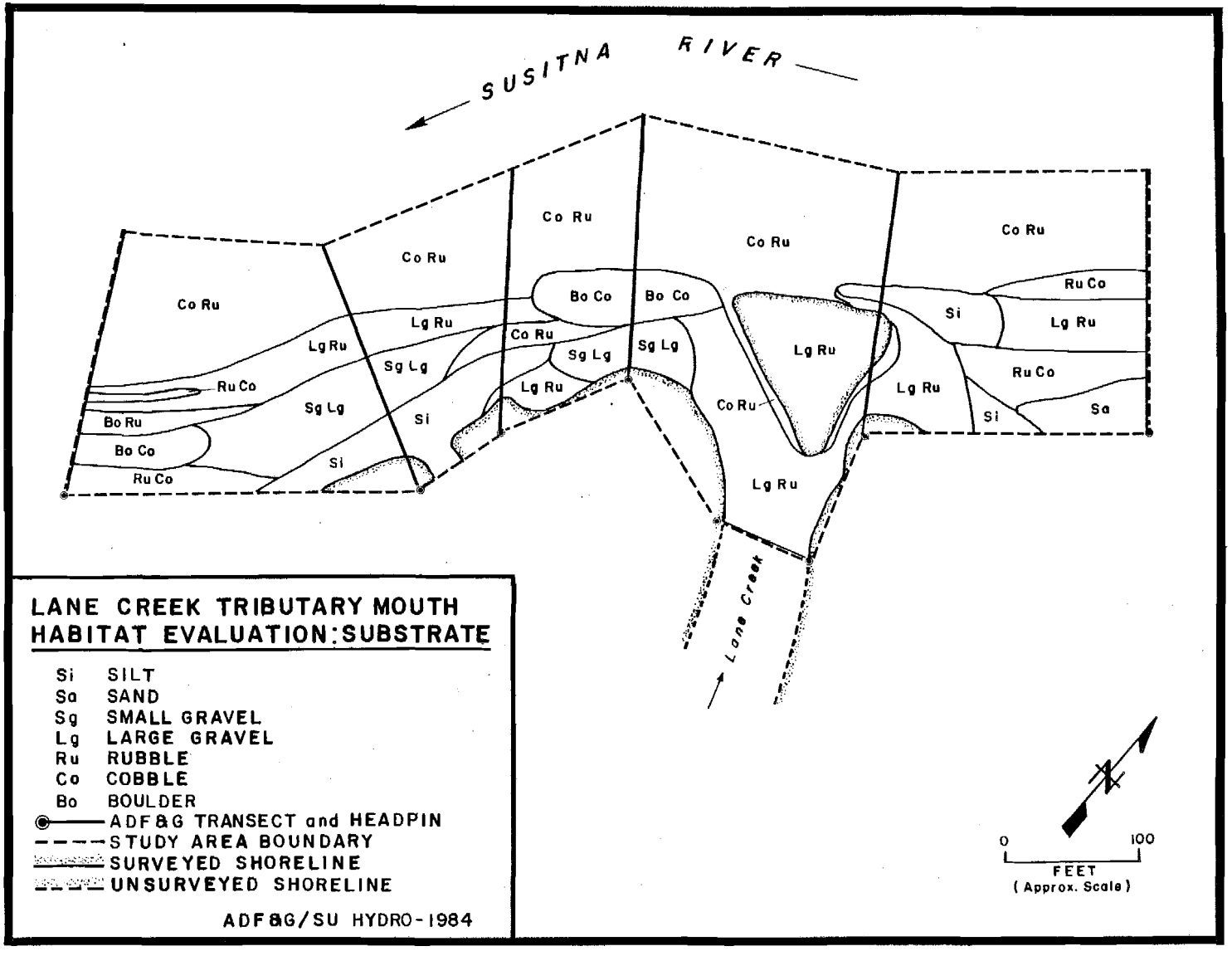


Figure 8-9. Substrate map of the Fourth of July tributary mouth study area (RM 131.2), 1983.

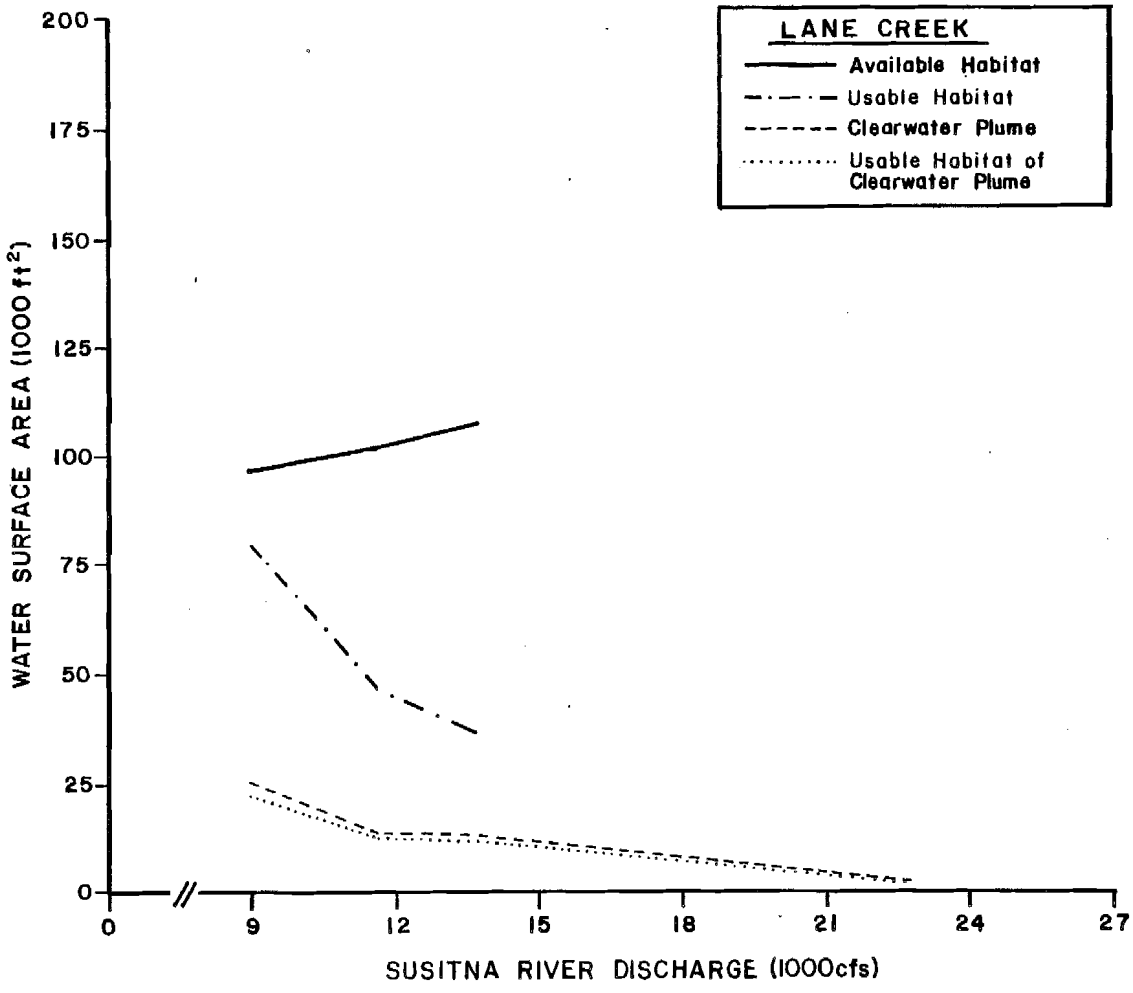


Figure 8-10. Habitat and clearwater plume areas (expressed as surface water area) at the Lane Creek tributary mouth study area (RM 113.6) versus Susitna River discharge (USGS gaging station, 15292000) 1983. (Note: total available and usable salmon spawning habitat area data were unavailable at the sampled 23,000 cfs mainstem discharge).

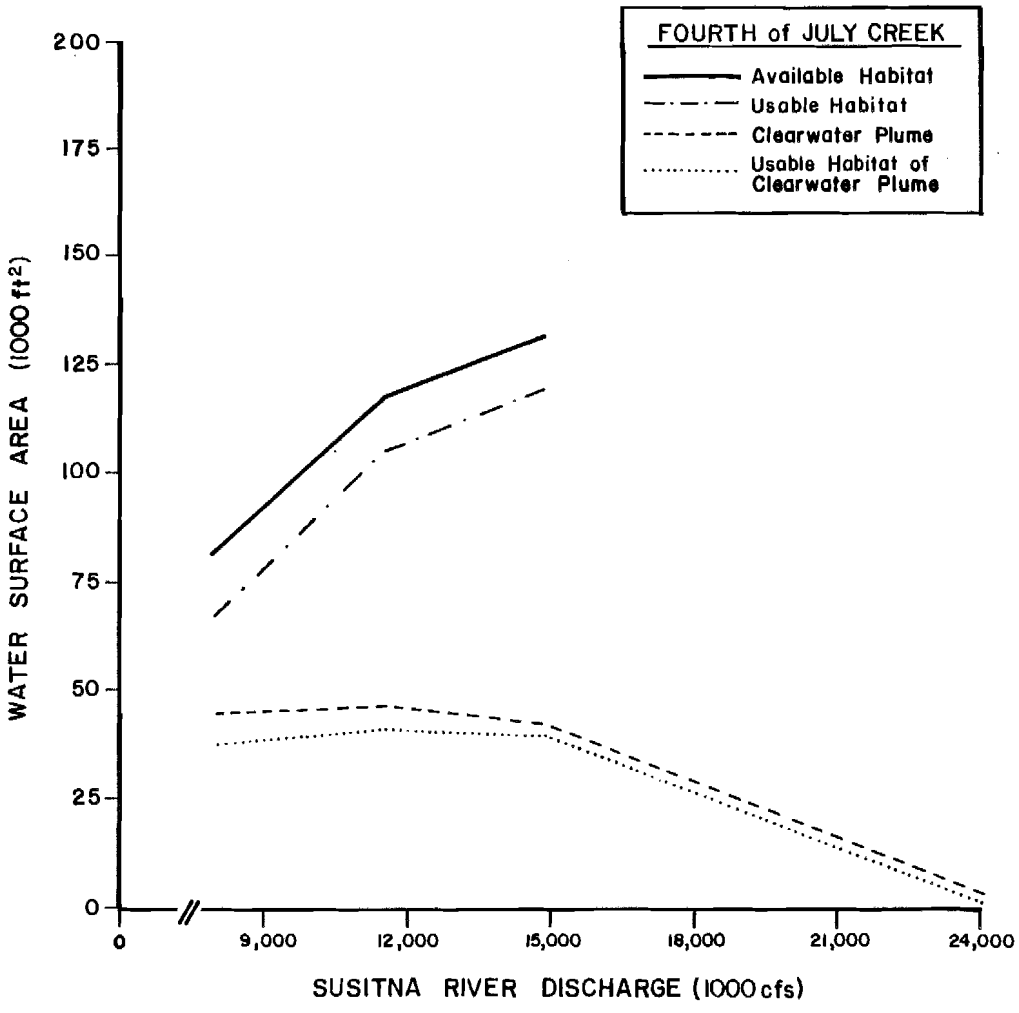


Figure 8-11. Habitat and clearwater plume areas (expressed as surface water area) at the Fourth of July Creek tributary mouth study area (RM 131.2) versus Susitna River discharge (USGS gaging station 15292000), 1983. (Note: total available and usable salmon spawning habitat area data were unavailable at the sampled 24,000 cfs mainstem discharge).

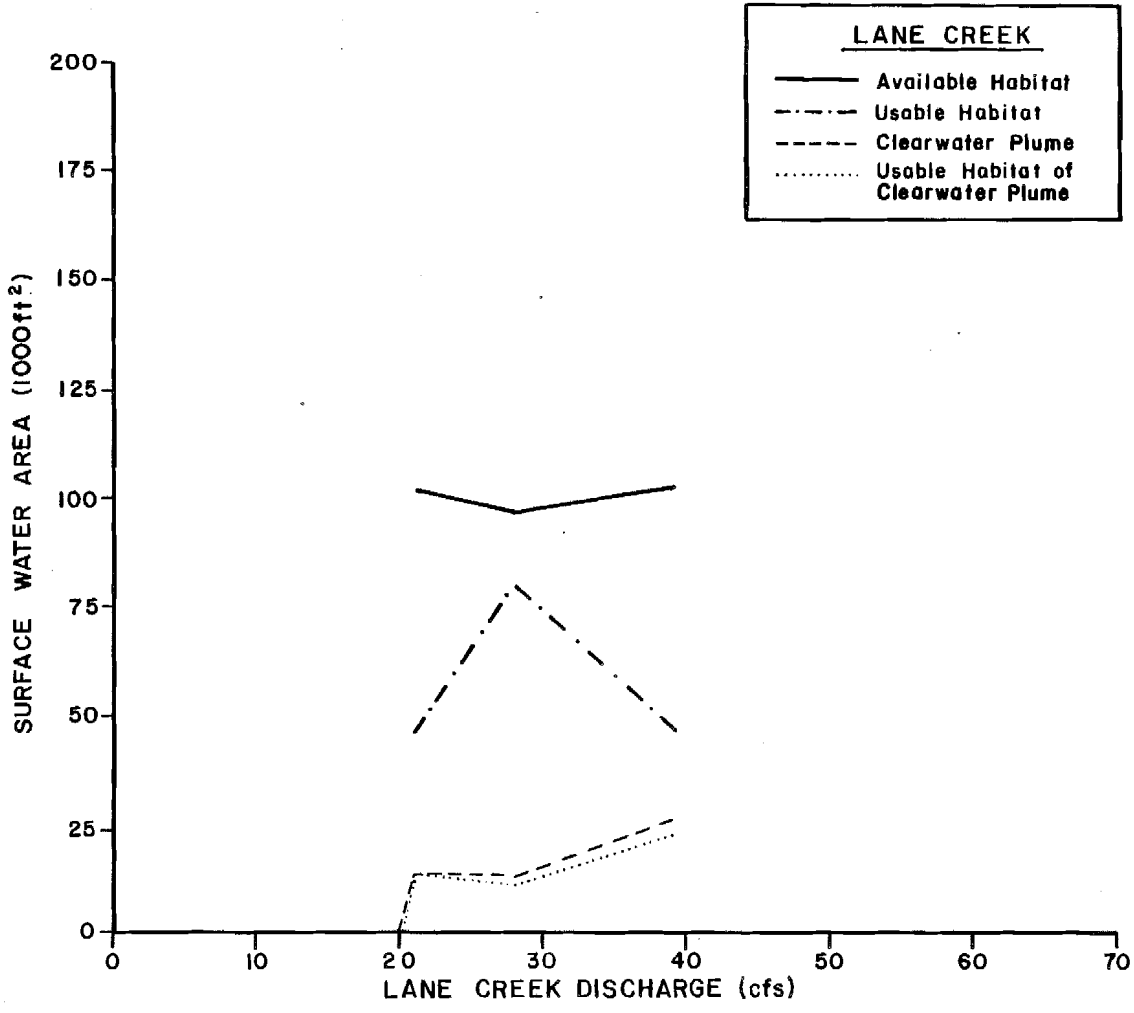


Figure 8-12. Habitat and clearwater plume areas (expressed as surface water area) at the Lane Creek tributary mouth study area (RM 113.6) versus Lane Creek flow, 1983 (Note: total available and usable salmon spawning habitat area data were unavailable at the 20 cfs tributary flow).

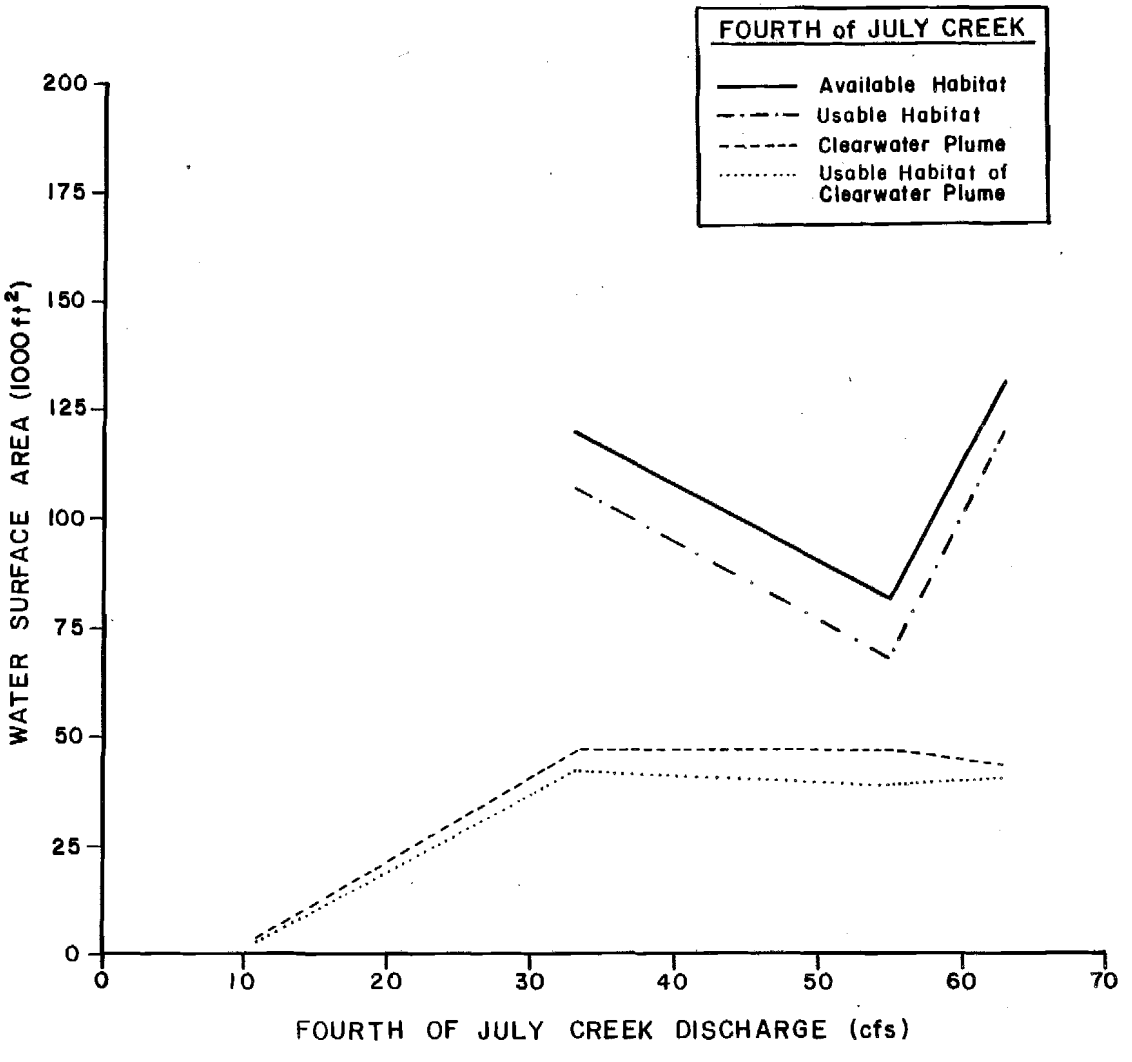


Figure 8-13. Habitat and clearwater plume areas (expressed as surface water area) at the Fourth of July tributary mouth study area (RM 131.2) versus Fourth of July Creek flow, 1983. (Note: total available and usable salmon spawning habitat area data were unavailable at the 11 cfs tributary flow).

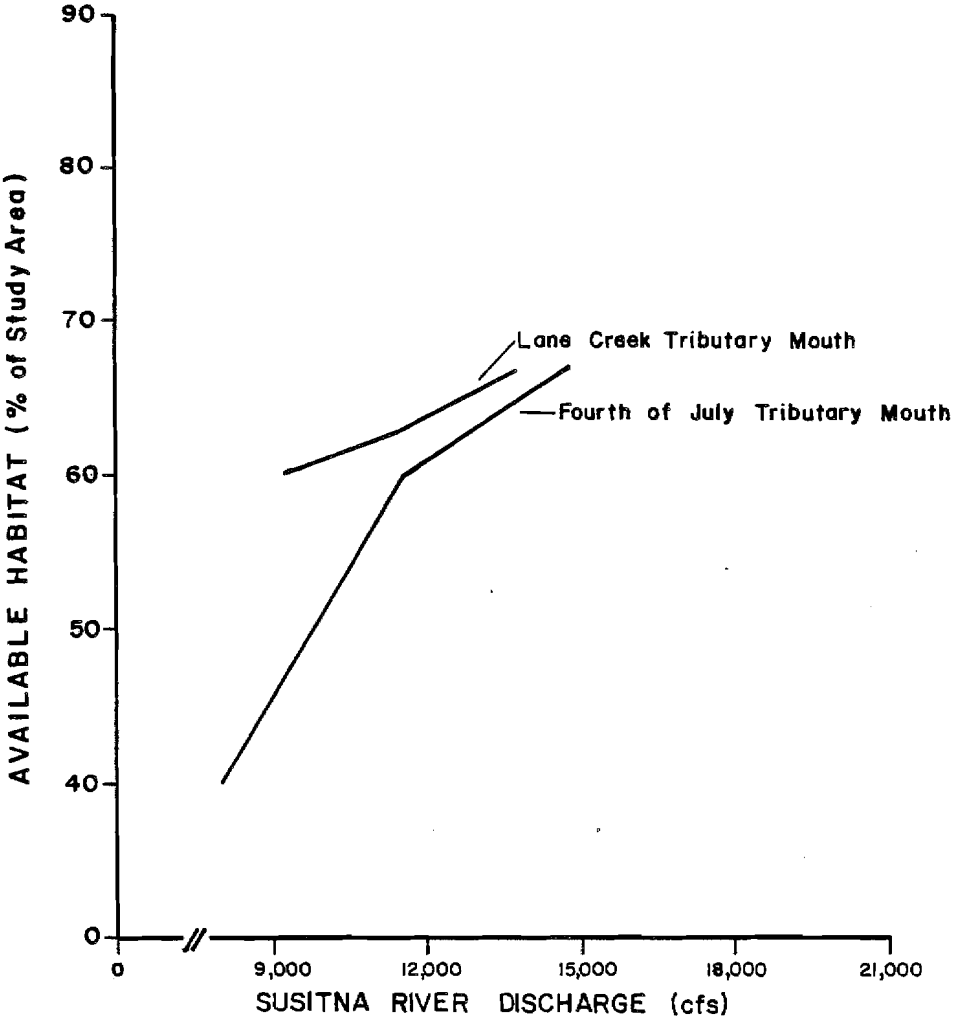


Figure 8-14. Available habitat versus Susitna River discharge (USGS gaging station, 15292000) for the Lane Creek and Fourth of July Creek tributary mouth study areas, 1983. (Note: data unavailable for the 23,000 and 24,000 cfs sampled Susitna River discharges, respectively).

from a low of 60% of the study area at a mainstem discharge of 9,240 cfs to 67% at 13,700 cfs. The area of available habitat within the Fourth of July Creek tributary mouth study area, however, ranged from 40% to 66% of the study area for the same mainstem discharges.

Frequency distributions of the available habitat areas associated with incremental velocities and depths of the Lane Creek tributary mouth study area were generally skewed toward deeper and faster waters (Tables 8-6 and 8-7, Figure 8-15); whereas, at the Fourth of July Creek tributary mouth, velocities and depths were skewed toward shallower and slower waters (Tables 8-8 and 8-9, Figure 8-16).

3.2 Usable Habitat

Mainstem discharge at the time of sampling was positively correlated with area of usable chum salmon spawning habitat at the Fourth of July Creek tributary mouth study area (Figure 8-11), but negatively correlated with Lane Creek tributary mouth usable chum salmon spawning habitat (Figure 8-10). There were no correlations between water surface areas of usable chum salmon spawning habitat and respective tributary flows (Figures 8-12 and 8-13). Locations of areas associated with usable chum salmon spawning habitat at the Lane Creek and Fourth of July Creek tributary mouth study areas at each combination of mainstem discharge and tributary flow sampled are delineated in Figures 8-17 through 8-24.

Usable chum salmon spawning habitat at the Lane Creek tributary mouth study area was limited mainly by unacceptably high water velocities and

Table 8-6. Lane Creek tributary mouth water surface area (ft^2) associated with increments of observed velocities at four Susitna River discharges (USGS gaging station 15292000), 1983. The percentage of the total available habitat represented by each increment is indicated in parenthesis.

Date	Discharge (cfs)		Water Velocity Increments (ft/sec)											Total Available
	Susitna River	Lane Creek	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	9.1-10.0	(10.0)	Habitat
831007	9240	39	17100	16200	14990	7060	37880	3250						96500
			(18)	(17)	(16)	(7)	(39)	(3)						(100)
830912	11600	21	10950	15490	16720	8330	26760	23340						101600
			(11)	(15)	(16)	(8)	(26)	(23)						(100)
830908	13700	28	11180	9720	12520	9310	11950	26580	25300	470				107000
			(10)	(9)	(12)	(9)	(11)	(25)	(24)	(1)				(100)
830625	23000	20	10840	2060	300	290	300	290	2280	2100	2260	1400	13110	35200[1]
			(31)	(6)	(1)	(1)	(1)	(1)	(6)	(6)	(6)	(4)	(37)	(100)

1 - Total water surface area sampled reduced due to unavailable data (see text for explanation).

Table 8-7. Lane Creek tributary mouth water surface area (ft^2) associated with increments of observed water depths at four Susitna River discharges (USGS Gold Creek gaging station), 1983. The percentage of the total available habitat represented by each increment is indicated in parenthesis.

Date	Discharge (cfs)		Water Depth Increments (ft)							Total Available Habitat
	Susitna River	Lane Creek	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	
831007	9240	39	14050 (15)	19100 (20)	23650 (25)	38440 (40)	1250 (1)			96500 (100)
830912	11600	21	10940 (11)	20290 (20)	11550 (11)	11850 (12)	29650 (29)	17300 (17)		101600 (100)
830908	13700	28	11420 (11)	16200 (15)	9580 (9)	9360 (9)	23470 (22)	31820 (30)	5180 (5)	107000 (100)
830625	23000	20	3790 (11)	6340 (18)	2190 (6)	2140 (6)	2808 (8)	5232 (15)	12733 (36)	35200[1] (100)

1 - Total water surface area sampled reduced due to unavailable data (see text for explanation).

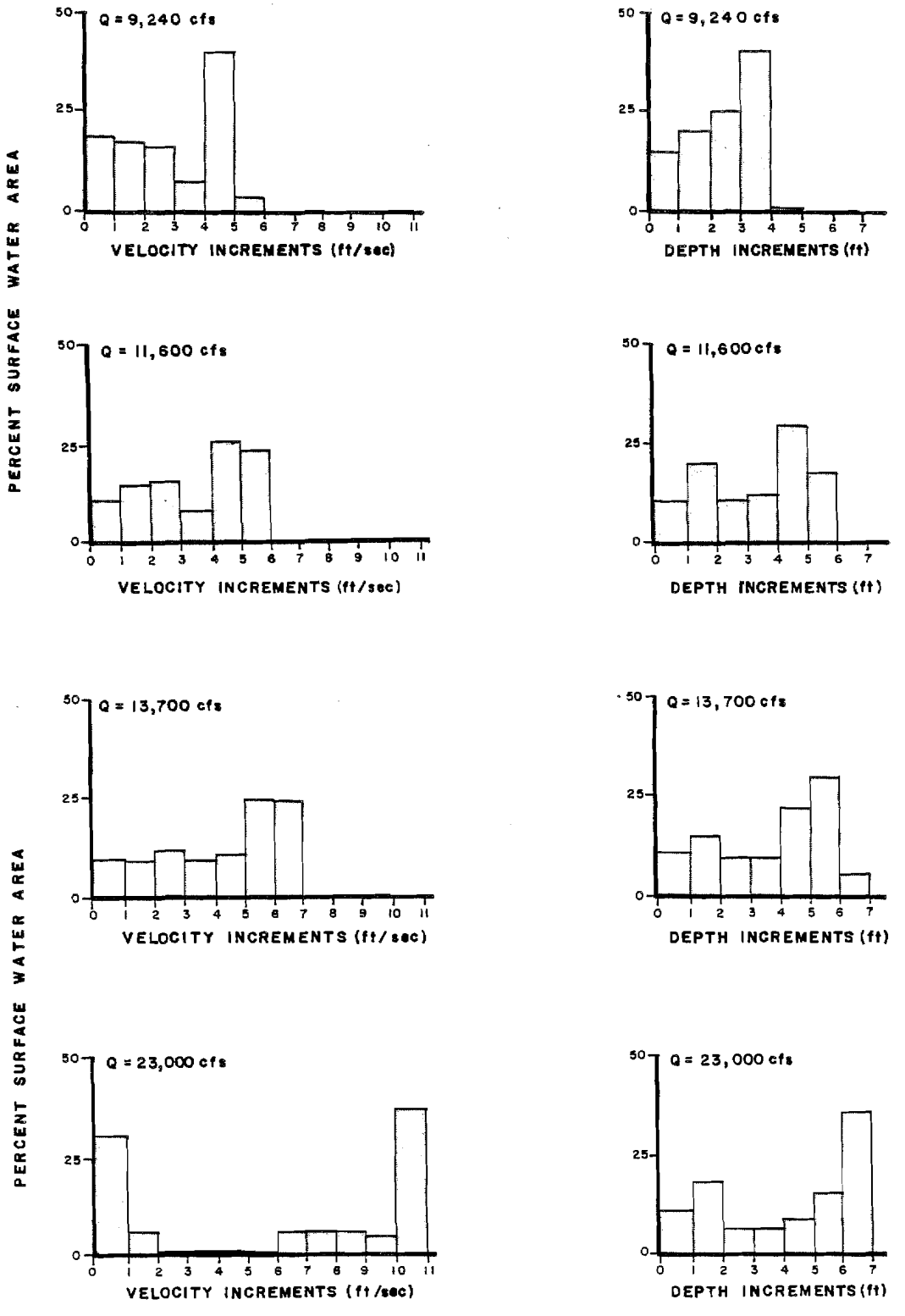


Figure 8-15. Frequency distributions of observed water velocities and depths at the Lane Creek tributary mouth study area (RM 113.6) at the four Susitna River discharges sampled, 1983.

Table 8-8. Fourth of July tributary mouth water surface area associated with increments of observed water velocities at four Susitna River discharges (Gold Creek USGS gaging station), 1983. The percentage of the total available habitat represented by each increment is indicated in parenthesis.

Date	Discharge (cfs)		Water Velocity Increments (ft.sec)						Total Available Habitat
	Susitna River	Fourth of July Creek	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	
830810	8040	55	61080 (76)	16510 (20)	2820 (3)	280 (1)	20 (1)		80700 (100)
830912	11600	33	61600 (52)	35580 (30)	21910 (18)				119100 (100)
830907	14800	63	58230 (43)	41820 (32)	26560 (20)	3760 (3)	1030 (1)		131400 (100)
830624	24000	11	39220 (33)	32120 (27)	22340 (19)	16250 (14)	5020 (4)	2250 (2)	17200 (100)

Table 8-9. Fourth of July tributary mouth water surface area associated with increments of observed water depths at four Susitna River discharges (Gold Creek USGS gaging station), 1983. The percentage of the total available habitat represented by each increment is indicated in parenthesis.

Date	Discharge (cfs)		Water Depth Increments (ft)					Total Available Habitat
	Susitna River	Fourth of July Creek	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	
830810	8040	55	49780 (62)	30496 (38)	440 (1)			80700 (100)
830912	11600	33	55540 (47)	51570 (43)	12000 (10)			119100 (100)
830907	14800	63	38790 (30)	68490 (52)	23950 (18)	160 (1)		131400 (100)
830624	24000	11	30050 (26)	20950 (18)	34990 (30)	30640 (26)	520 (1)	17200 (100)

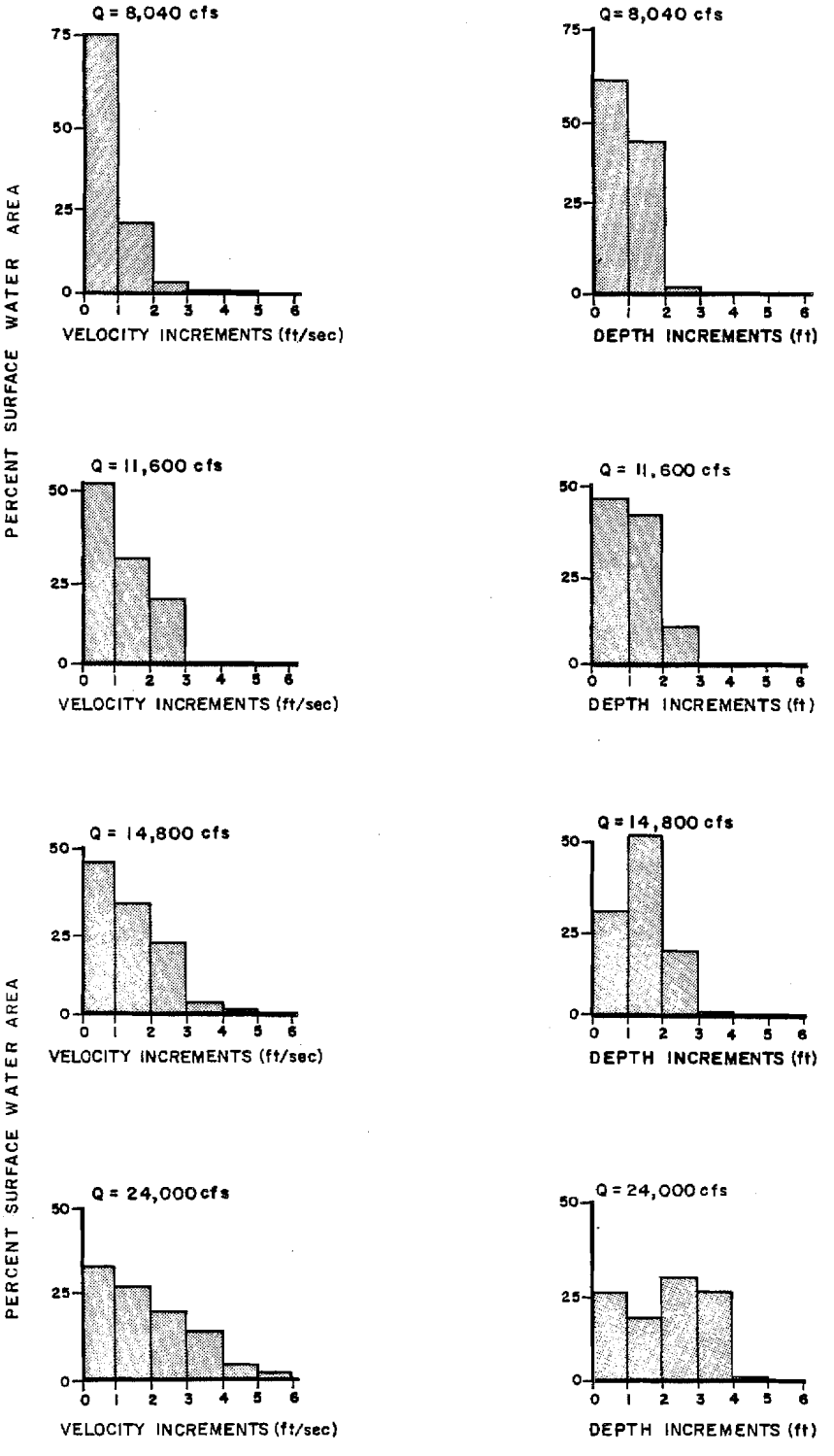


Figure 8-16. Frequency distributions of observed water velocities and depths at the Fourth of July tributary mouth study area (RM 132.0) at the four Susitna River discharges sampled, 1983.

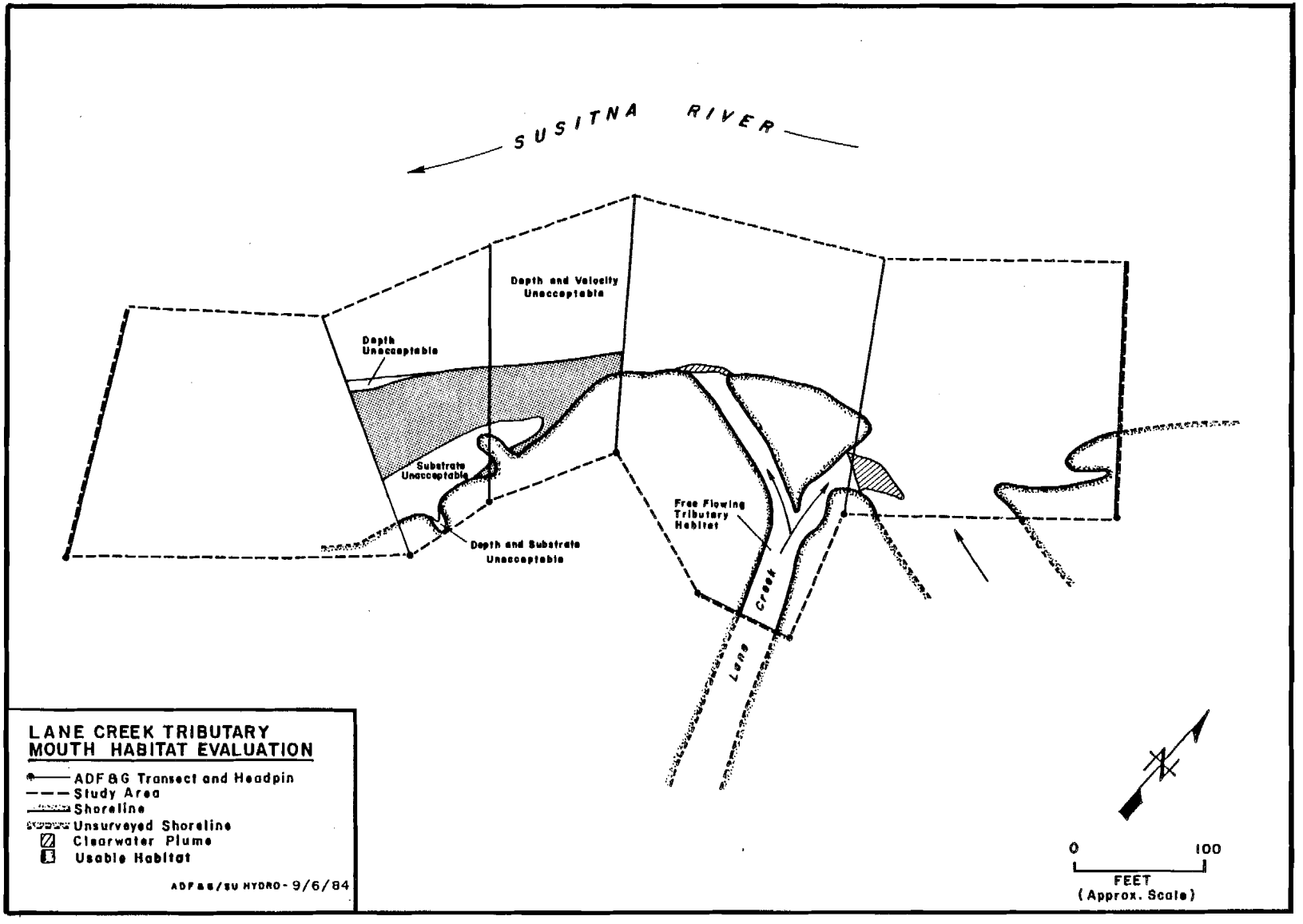


Figure 8-17. Habitat evaluation of the Lane Creek tributary mouth study area (RM 113.6) at a combination of a Susitna River discharge of 23,000 cfs (USGS gaging station 15292000) and a Lane Creek flow of 20 cfs, 1983. (Note: sample area reduced due to unavailable transect data).

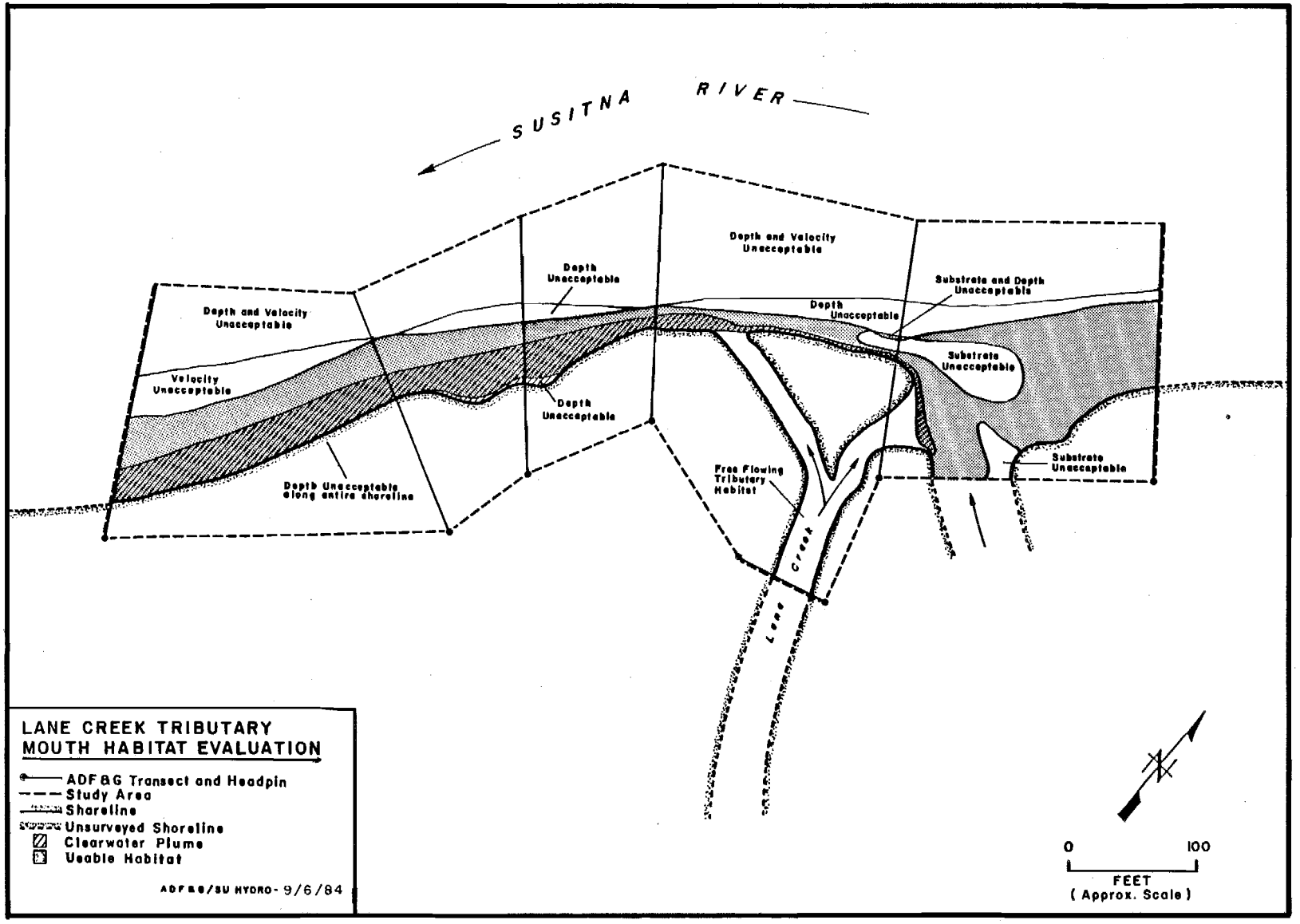


Figure 8-18. Habitat evaluation of the Lane Creek tributary mouth study area (RM 113.6) at a combination of a Susitna River discharge of 16,000 cfs (USGS gaging station 15292000) and a Lane Creek flow of 21 cfs, 1983.

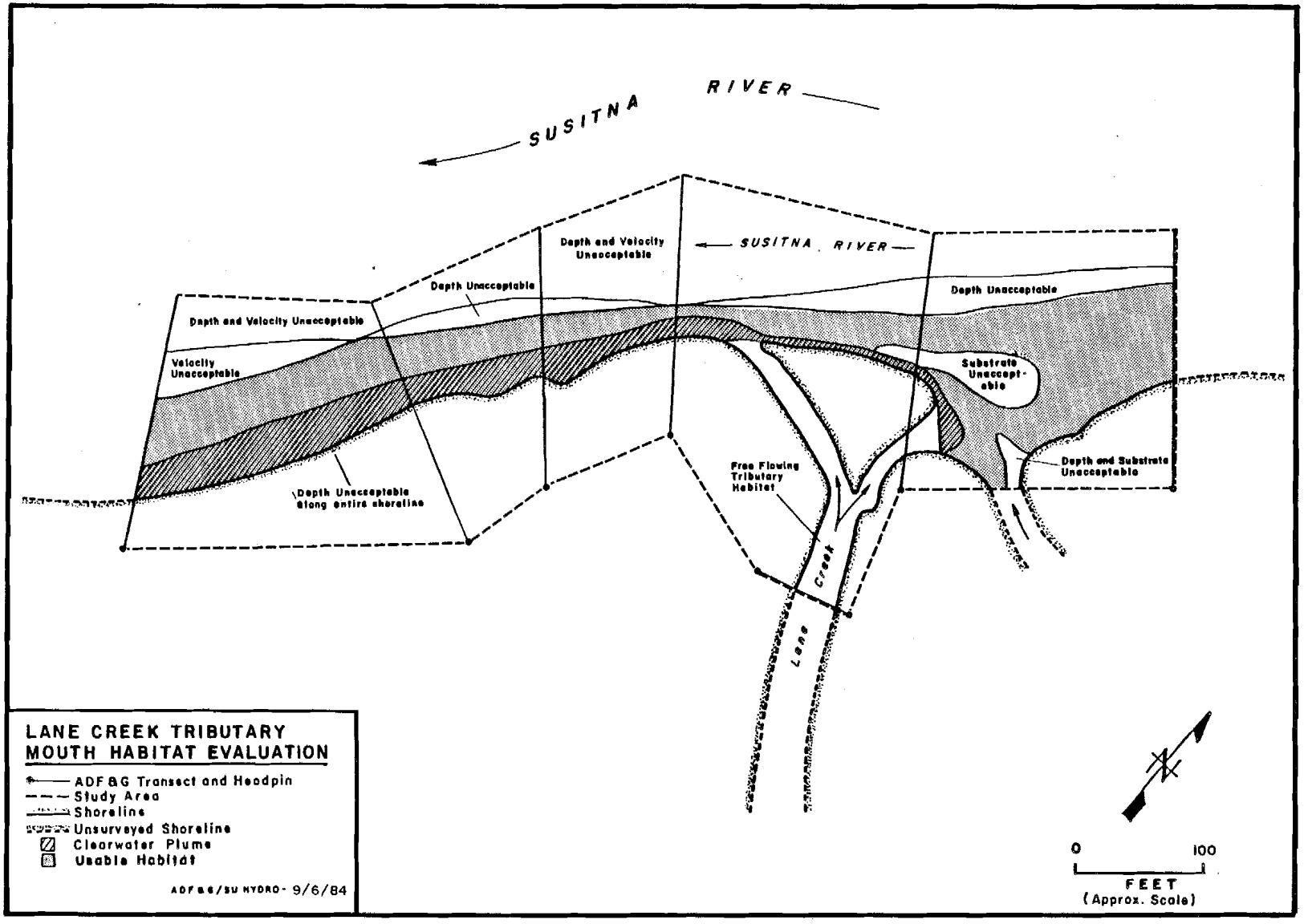


Figure 8-19. Habitat evaluation of the Lane Creek tributary mouth study area (RM 113.6) at a combination of a Susitna River discharge of 13,700 cfs (USGS gaging station 15292000) and a Lane Creek flow of 28 cfs, 1983.

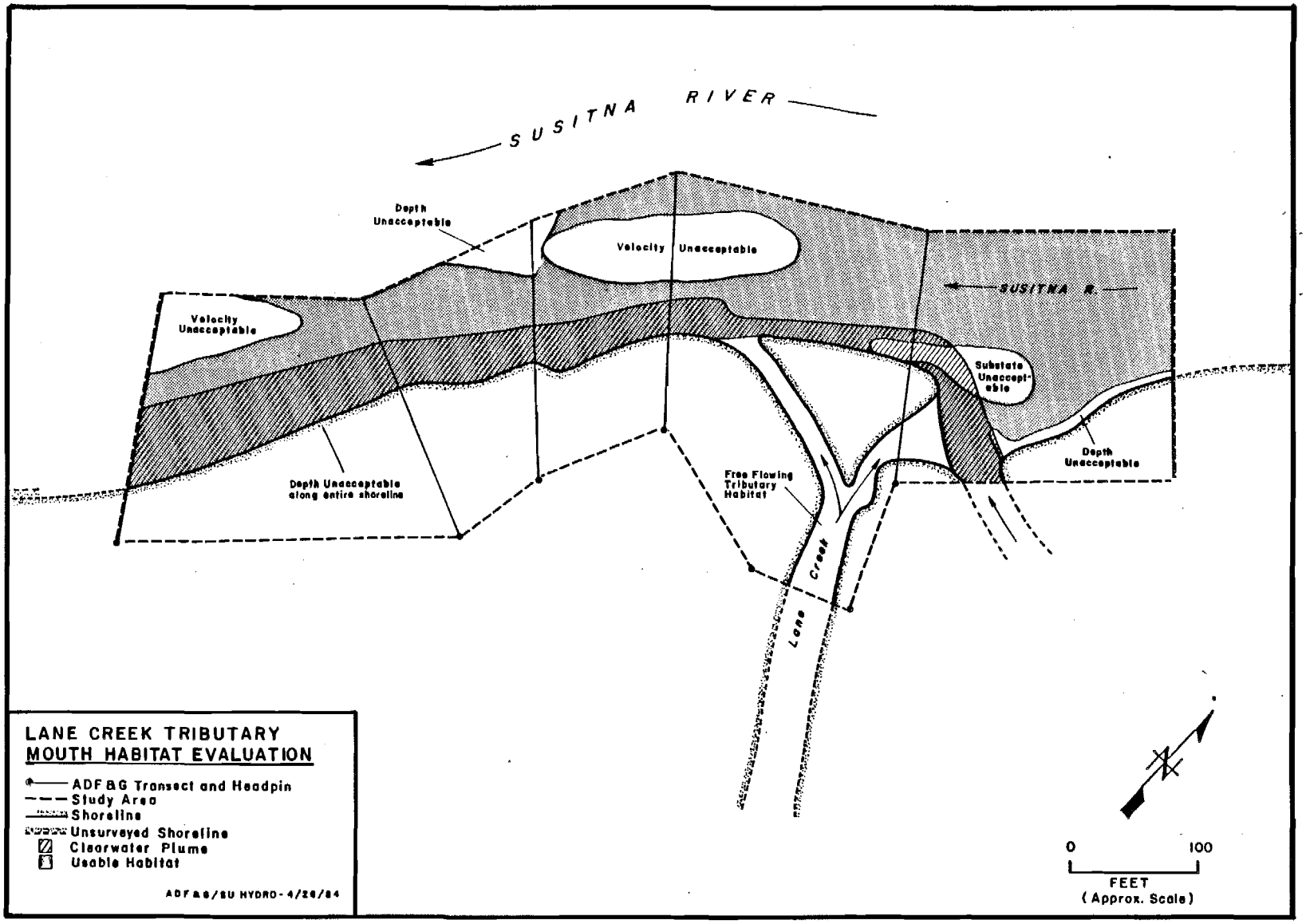


Figure 8-20. Habitat evaluation of the Lane Creek tributary mouth study area (RM 113.6) at a combination of a Susitna River discharge of 9,240 cfs (USGS gaging station 15292000) and a Lane Creek flow of 39 cfs, 1983.

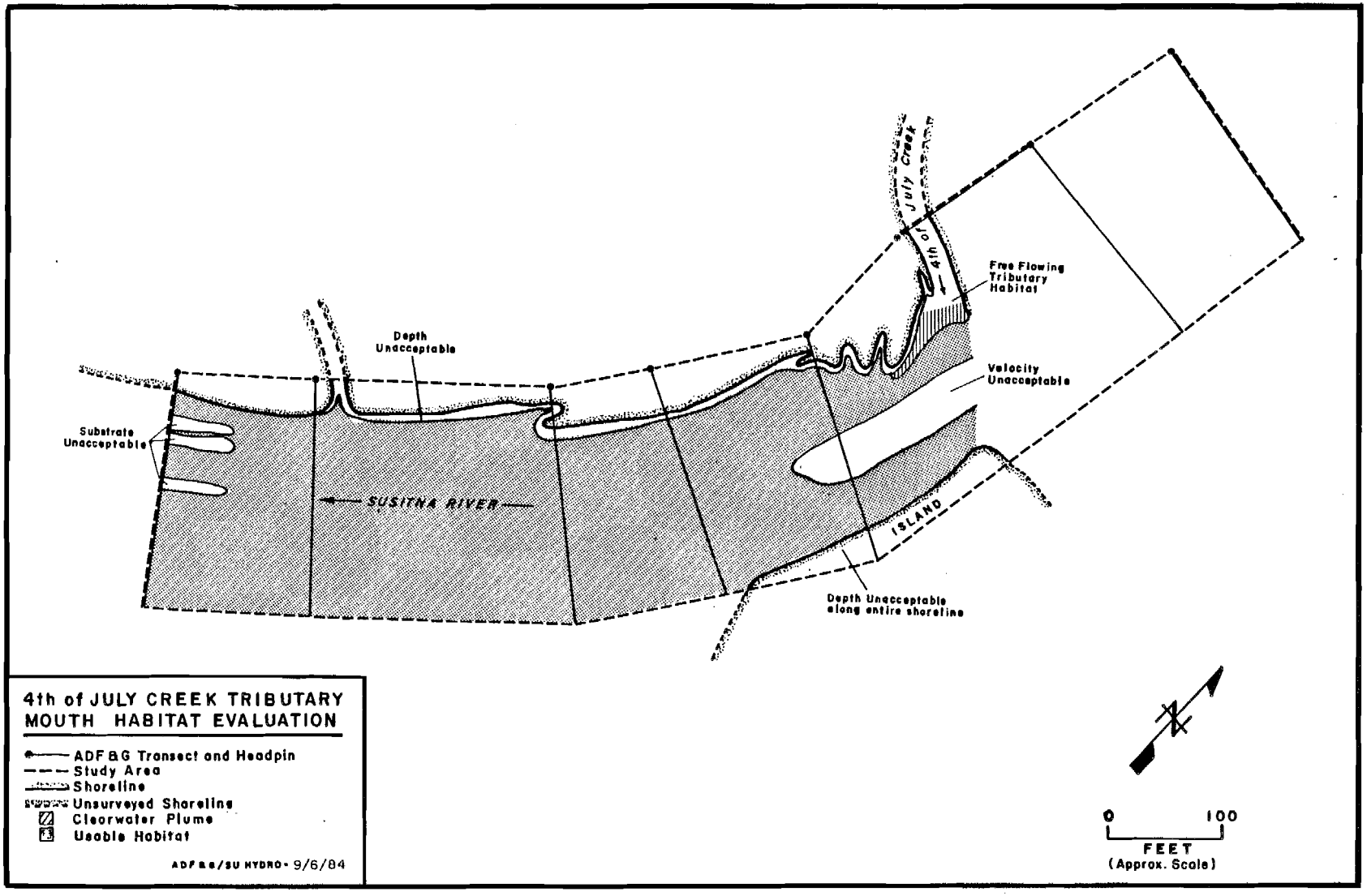


Figure 8-21. Habitat evaluation of the Fourth of July Creek tributary mouth study area (RM 131.2) at a combination of a Susitna River discharge of 24,000 cfs (USGS gaging station 15292000) and a Fourth of July Creek flow of 11 cfs, 1983.

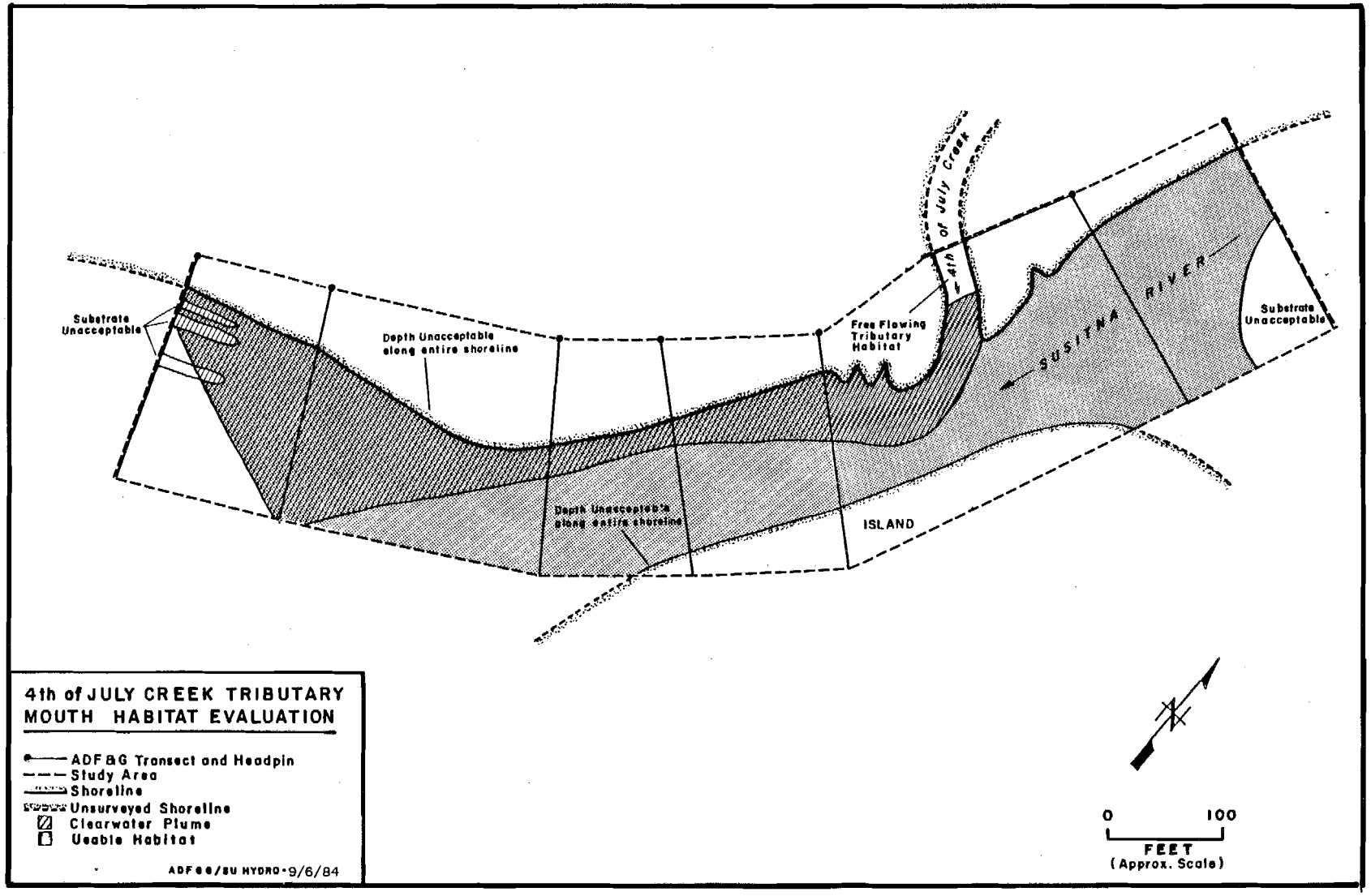


Figure 8-22. Habitat evaluation of the Fourth of July Creek tributary mouth study area (RM 131.2) at a combination of a Susitna River discharge of 14,800 cfs (USGS gaging station 15292000) and a Fourth of July Creek discharge of 63 cfs, 1983.

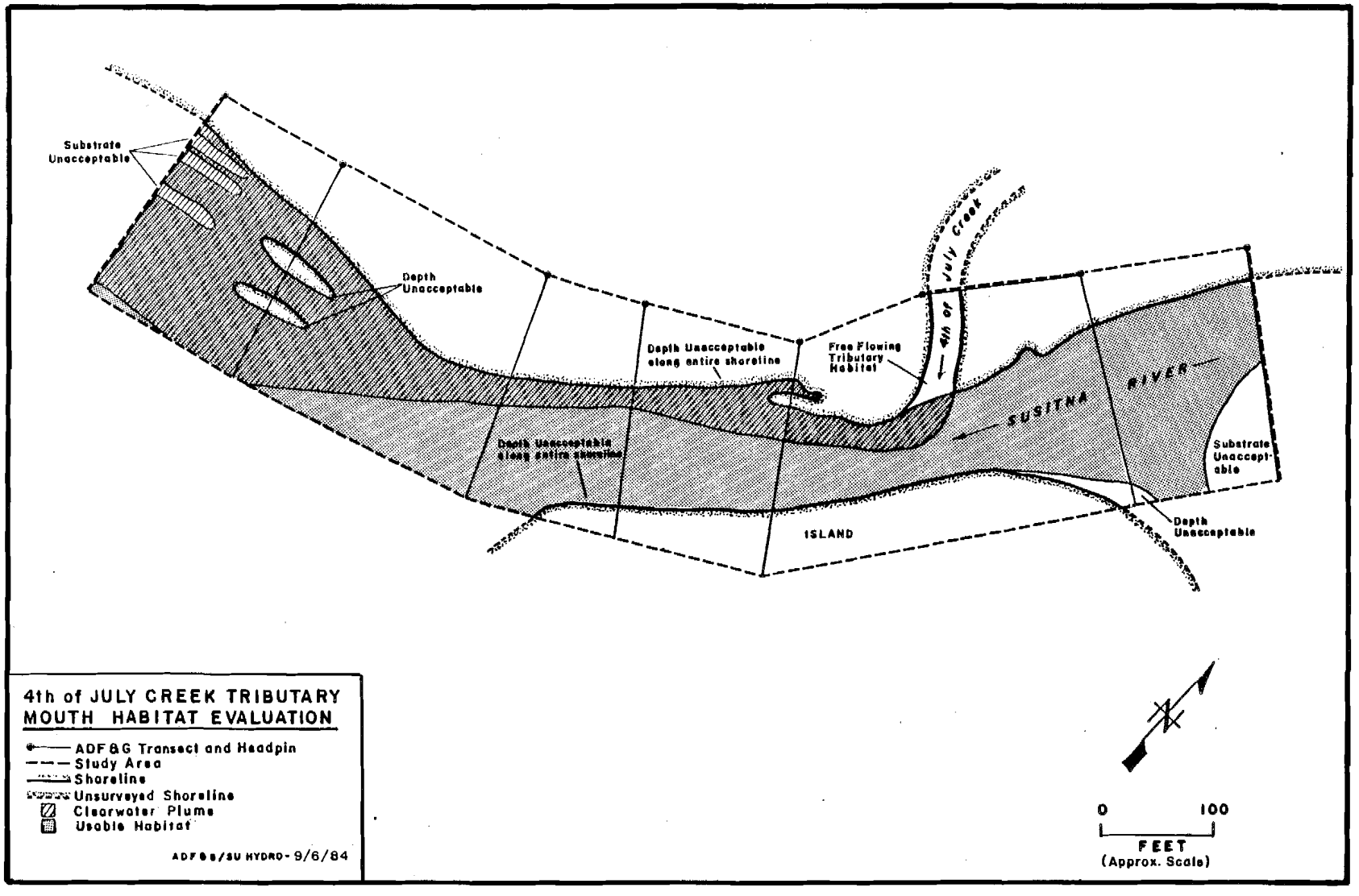


Figure 8-23. Habitat evaluation of the Fourth of July Creek tributary mouth study area (RM 131.2) at a combination of a Susitna River discharge of 11,600 cfs (USGS gaging station 15292000) and a Fourth of July Creek discharge of 33 cfs, 1983.

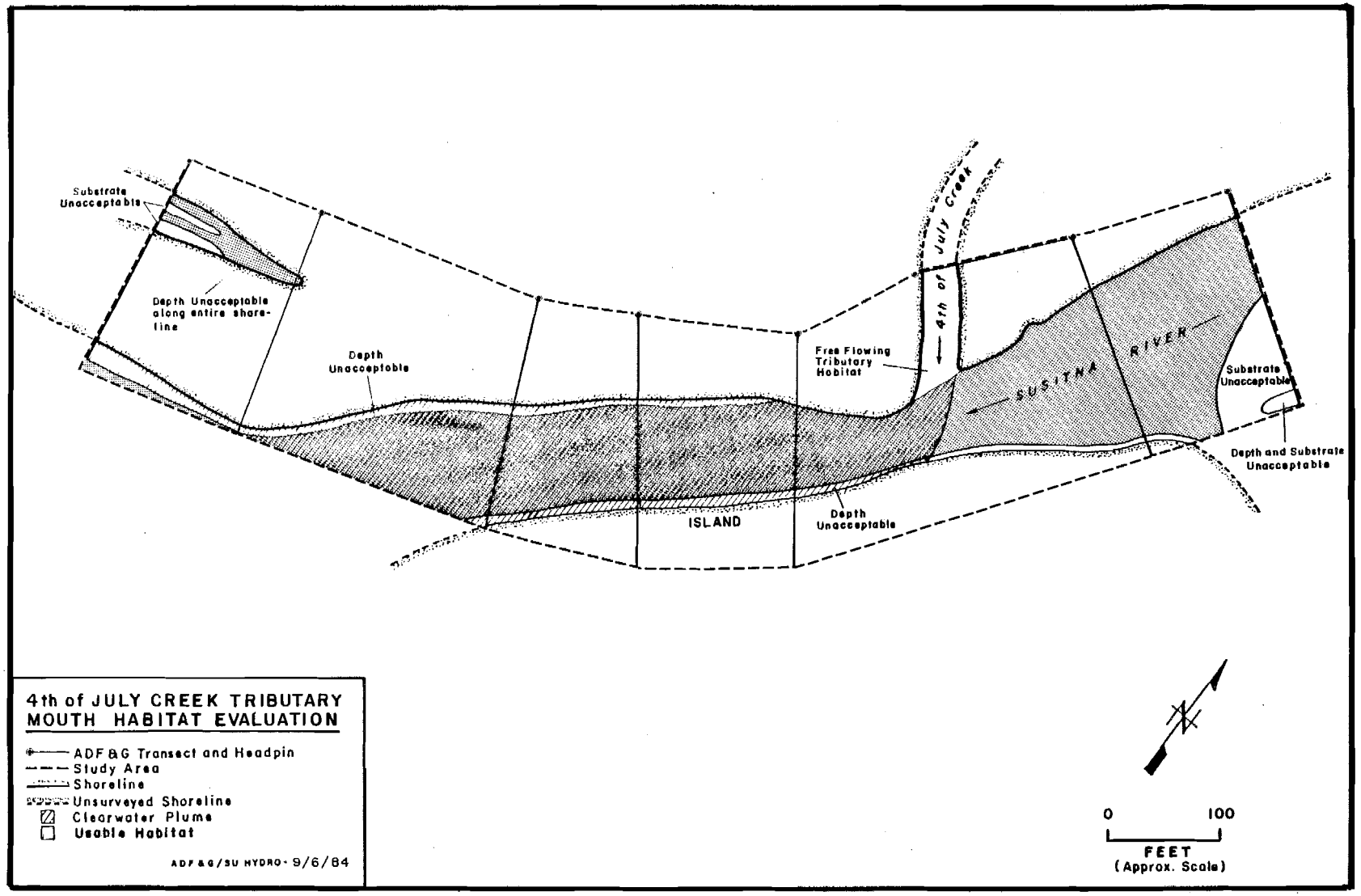


Figure 8-24. Habitat evaluation of the Fourth of July Creek tributary mouth study area (RM 131.2) at a combination of a Susitna River discharge of 8,040 cfs (USGS gaging station 15292000) and a Fourth of July Creek discharge of 55 cfs, 1983.

deep water depths. As Susitna River discharge increased, the surface area of usable chum salmon spawning habitat within the study area decreased (Tables 8-2 and 8-3, Figure 8-25). Usable chum salmon spawning habitat area at the Fourth of July Creek mouth study area was limited by high water velocities (but not by deep water depths) only at the 24,000 cfs mainstem discharges. Shallow water near the shore was the main restriction on this type of habitat. Since the upper limit of acceptable ranges of water velocities and water depths was not a major factor restricting usable chum salmon spawning habitat at the Fourth of July Creek tributary mouth study area, usable area of chum salmon spawning habitat tended to increase as available habitat increased. (Tables 8-4 and 8-5, Figure 25).

Overall, substrate composition had minimal influence on the usability of the available habitat by spawning chum salmon at both study sites because substrate composition was generally within the acceptable range.

The surface area of a tributary clearwater plume is obviously dependent upon tributary flow but is also affected by Susitna River discharge. Increasing Susitna River discharge had a dampening effect on the surface area of the tributary clearwater plume at the Lane Creek tributary mouth study area (Figure 8-4). At Lane Creek flows from 21 to 28 cfs there was a slight decrease in clearwater plume surface area (Figure 8-12). This decrease in clearwater plume surface area can be attributed to the dampening effect of a corresponding 2,100 cfs increase in mainstem discharge. With the exception of the above incident, all other

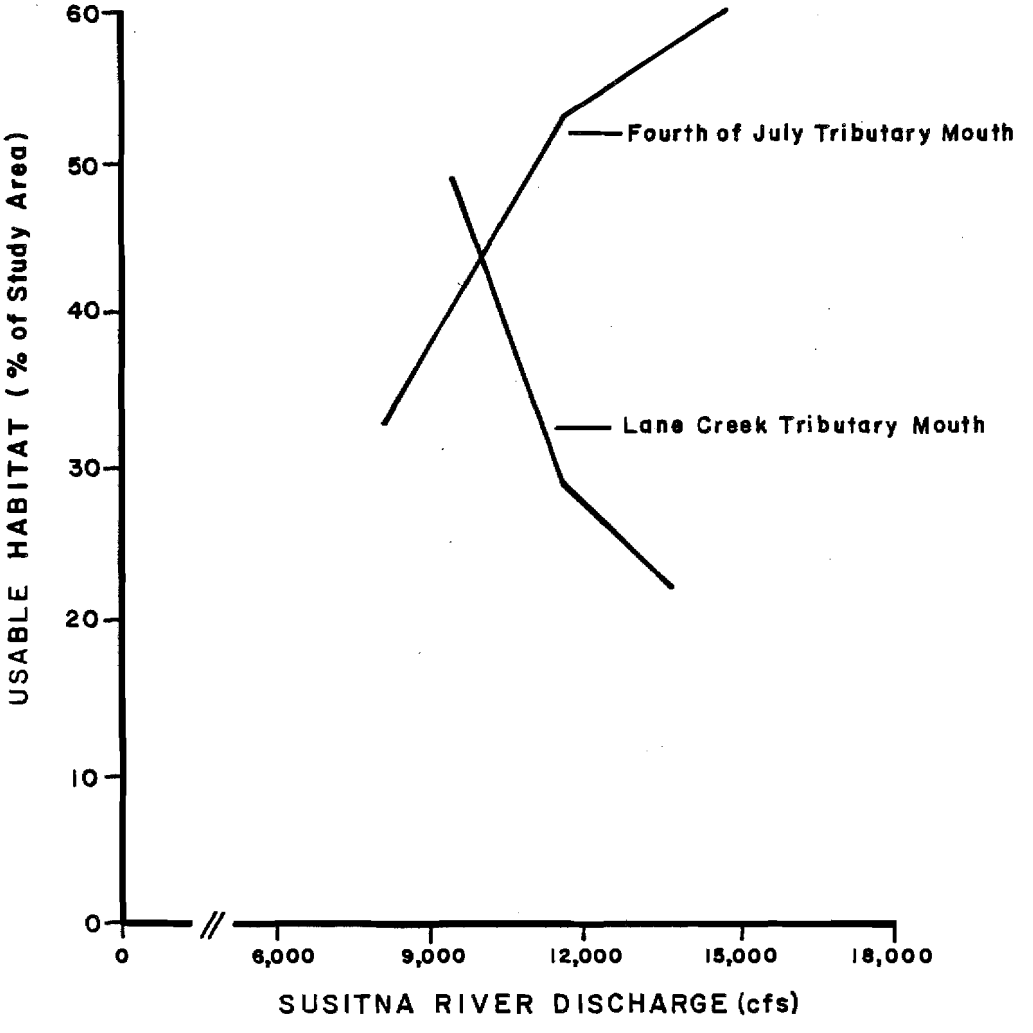


Figure 8-25. Usable habitat at the Lane Creek and Fourth of July Creek study areas versus Susitna River discharge (USGS gaging station 15292000).

increases in Lane Creek flows sampled were accompanied by a decrease in Susitna River discharge.

In both study areas, the area of the usable chum salmon spawning habitat portion of the tributary clearwater plume increased as the size of the plume increased (Figure 8-4, 8-5, 8-10 and 8-11). The area of usable chum salmon spawning habitat of the clearwater plume responded to fluctuations in mainstem discharge in the same manner as the tributary clearwater plume did.

2.4 Utilized Habitat

Spawning utilization data were collected at 28 active chum salmon redds (Table 8-10) and 5 active pink salmon redds* (Table 8-11) within the Fourth of July Creek tributary mouth study area. No spawning salmon were observed within the study site of the tributary mouth of Lane Creek. All data were collected when the daily mean Susitna River discharge at Gold Creek were between 21,000 and 26,000 cfs. A map of the Fourth of July Creek study area depicting chum salmon spawning areas, possible upwelling areas, and shoreline at mainstem discharges of 24,000 and 8,040 cfs is presented in Figure 8-26. A large portion of the depicted spawning areas was dewatered before the final transect habitat data were collected on October 8, 1983.

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* These data are incidental and not discussed in this report.

Table 8-10. Salmon spawning habitat utilization data collected at the mouth of Fourth of July Creek August 17-28, 1983.

Date	Mainstem[a] Q (cfs)	Observ. #	Depth (ft)	Velocity (ft/sec)	Substrate[b]	Temperature (°C) Intra-gravel	Temperature (°C) Surface
8-17	22,700	01	1.00	0.60	LG/RU	10.6	11.6
		02	1.70	0.75	CO/RU	11.5	11.6
		03	1.60	0.70	LG/RU	11.2	11.6
		04	2.20	0.60	LG/RU	10.2	11.6
		05	2.00	0.60	LG/RU	10.8	11.7
		06	2.30	0.60	LG/RU	10.7	11.6
		07	2.00	0.10	CO/RU	11.0	11.8
		08	1.00	0.25	SG/LG	11.3	11.9
		09	1.00	0.25	RU/LG	11.3	11.9
		10	1.70	0.20	RU/LG	11.2	11.8
8-18	21,000	12	2.10	1.35	RU/CO	11.8	12.2
		13	1.50	0.10	SG/SA	10.4	12.0
		14	1.70	2.10	LG/SG	7.5	12.3
		15	1.90	4.50	RU/CO	8.1	12.3
8-22	21,600	16	2.20	1.30	RU/LG	9.7	11.2
		17	2.00	1.00	RU/LG	11.1	11.3
		18	1.80	1.40	LG/SA	11.0	11.3
		19	2.00	1.80	RU/LG	9.3	11.3
		20	1.30	2.20	RU/LG	9.8	11.2
		21	0.90	2.00	RU/LG	11.4	11.3
		22	1.20	3.10	RU/LG	11.3	11.3
		23	1.70	2.00	RU/CO	11.4	11.3
8-28	26,600	24	0.70	0.40	---	9.5	10.7
		25	1.70	2.50	---	9.4	10.7
		26	0.90	0.80	---	9.0	10.6
		27	0.70	0.75	---	8.7	10.6
		28	0.60	1.20	---	10.1	10.7
		29	1.10	0.10	---	5.7	10.8

[a] Discharge measured at USGS Gold Creek Station.
[b] Substrate Code: SG = Small gravel, LG = large gravel, RU = rubble, Co = cobble, BO = boulder

Table 8-11. Pink salmon spawning habitat utilization data collected at the mouth of Fourth of July Creek; August 17-28, 1983.

Date	Mainstem[a] Q (cfs)	Observ. #	Depth (ft)	Velocity (ft/sec)	Substrate[b]	Temperature (°c) Intra-gravel	Temperature (°c) Surface
8-17	22,700	01	1.80	0.35	LG/RU	11.2	11.9
		02	0.70	0.20	LG/RU	11.1	11.8
8-18	21,000	03	0.50	0.35	SG/LG	12.0	12.3
		04	0.30	0.65	LG/RU	12.4	12.3
		05	0.70	4.30	RU/LG	12.8	12.4

[a] Discharge measured at USGS Gold Creek station.

[b] Substrate Code: SG = small gravel, LG = large gravel, RU = rubble

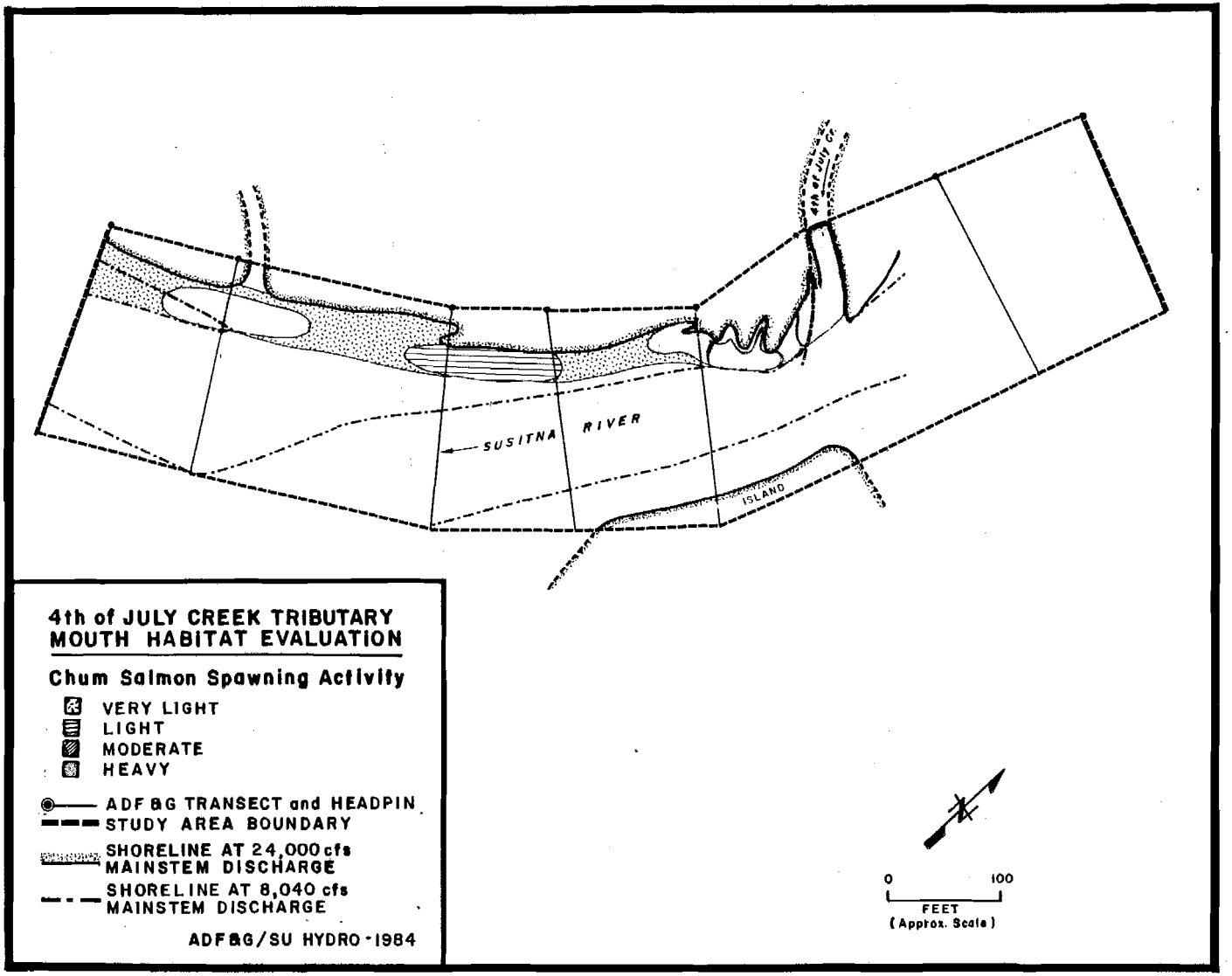

Figure 8-26. Chum salmon spawning areas at the Fourth of July tributary mouth study area (RM 131.2) and shoreline boundaries at the 24,000 and 8,040 cfs Susitna River discharges (USGS gaging station 1529000), 1983.

A scatter plot of water depths versus water velocities measured at active chum salmon redds within the Fourth of July Creek tributary mouth study area is presented in Figure 8-27. It can be inferred from the scatter plot that velocities and depths measured at chum salmon redds appear to be independently related within the range of hydraulic conditions sampled. Velocity and depth frequency distributions of chum spawner utilization data indicate that chum salmon most often select redd sites in relatively slow (0.1-1.0 ft/sec), shallow (1.1 to 2.0 feet) water (Figure 8-28).

A scatter plot of intragravel versus surface water temperatures (Figure 8-29) suggests that chum salmon redds were generally located within areas of groundwater upwelling. Virtually all intragravel temperatures were less than corresponding surface temperatures as is typical of of upwelling areas located within tributaries (see Chapter 3). These data corroborate evidence indicating that chum salmon spawning in areas of upwelling (see Chapter 7).

From the foregoing analysis, it appears that physical habitat conditions (water depth, water velocity, and substrate) govern chum salmon redd site selection within the Fourth of July Creek tributary mouth. This observation also likely holds true for other non-studied tributary mouth areas in the middle river reach.

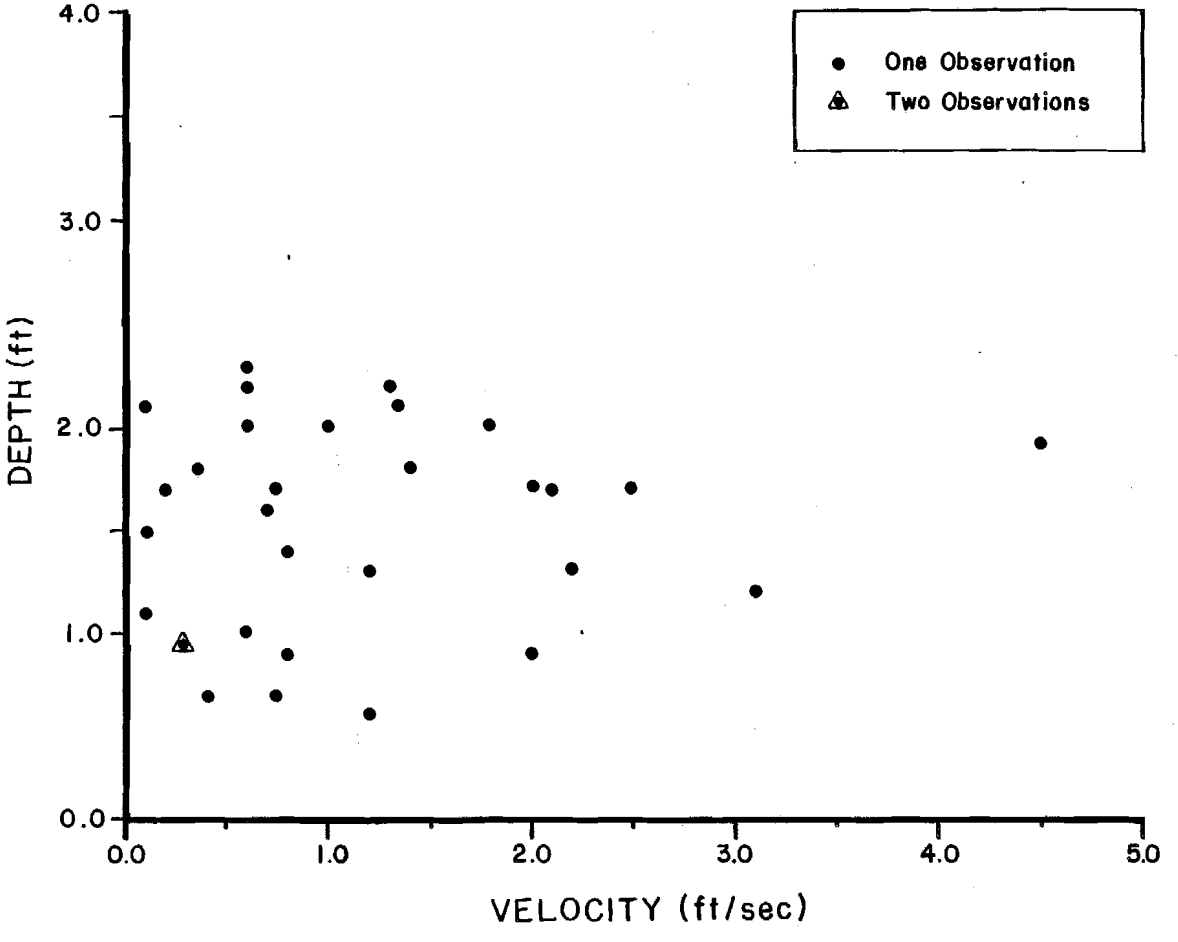

Figure 8-27. Scatter plot of water velocity versus water depths observed at active chum salmon redds at the Fourth of July Creek tributary mouth study area, 1983.

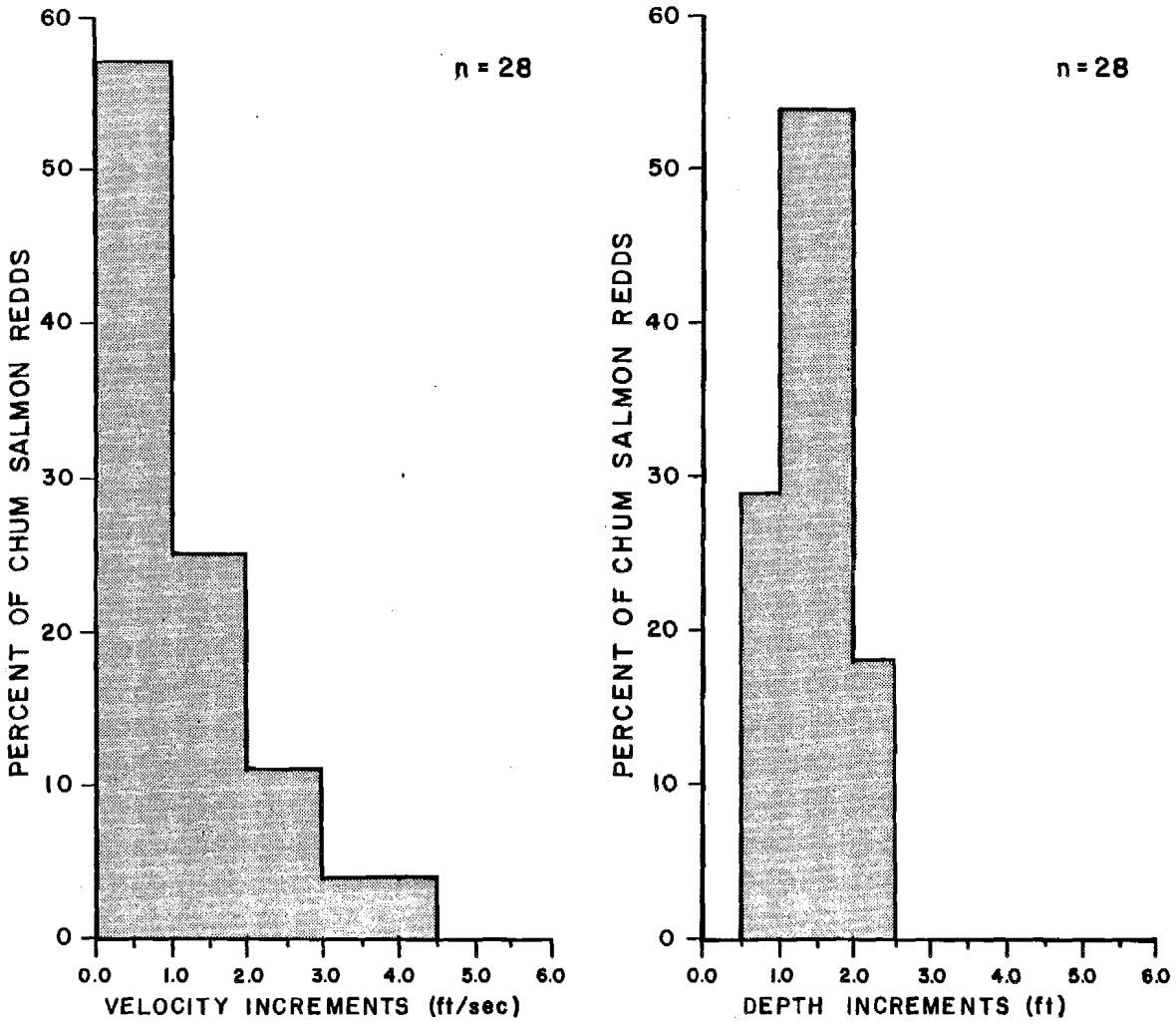

Figure 8-28. Frequency distribution of velocity and depth increments observed at active chum salmon redds at the Fourth of July tributary mouth study area (RM 131.2), 1983.

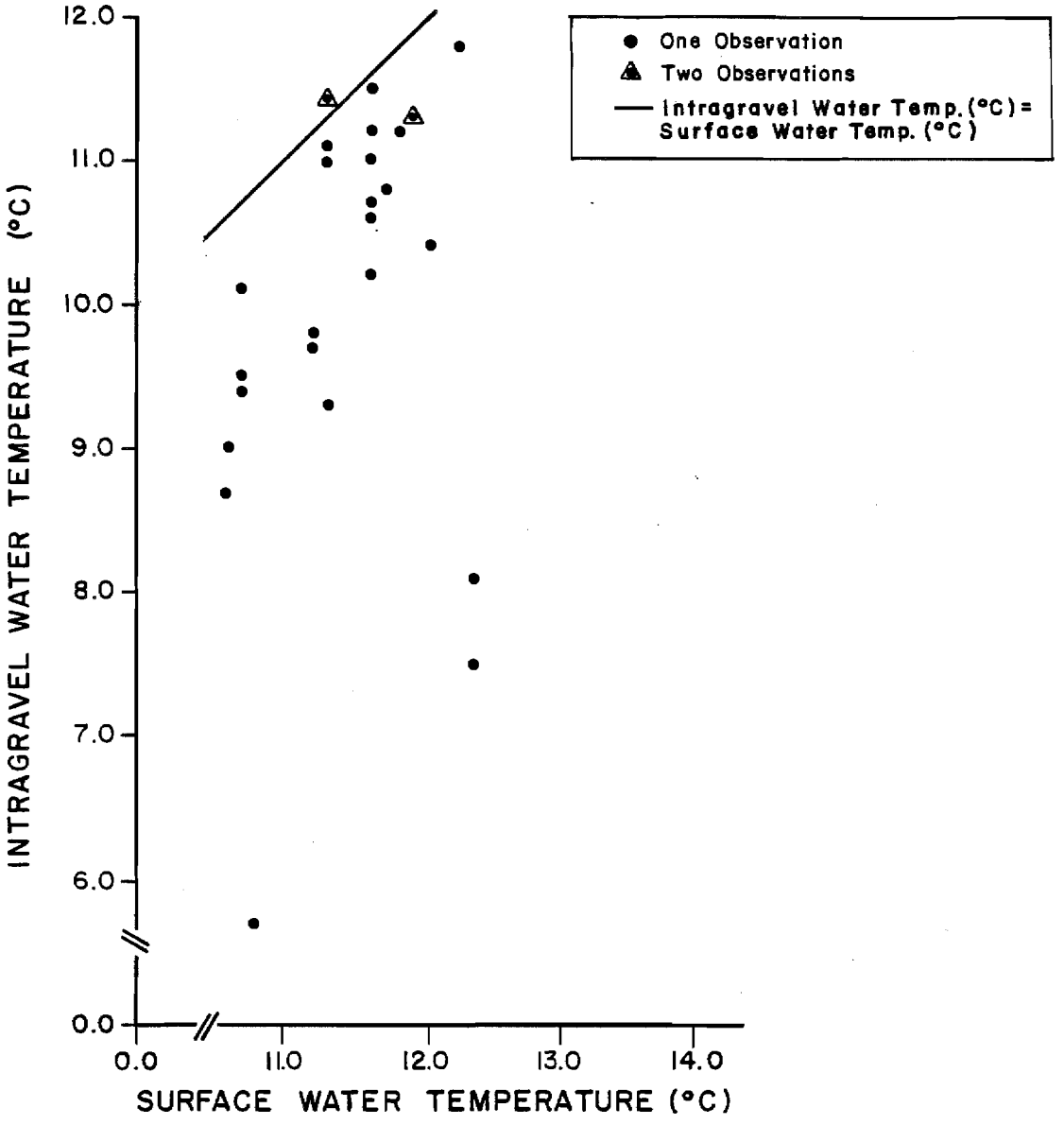

Figure 8-29. Surface water versus intragravel water temperatures observed at active chum salmon redds at the Fourth of July Creek tributary mouth study area, 1983.

4.0 DISCUSSION

4.1 Tributary Mouth Chum Salmon Spawning Habitat

Fluctuations in Susitna River discharge affect the Lane Creek tributary mouth area differently than they do the Fourth of July Creek tributary mouth area. As mainstem discharge increases, the amount of available habitat remains nearly constant at the Lane Creek study area, while at the Fourth of July Creek study area available habitat increased dramatically. The large reduction in the usable chum salmon spawning habitat at the Lane Creek tributary mouth study area (from 49% to 22% of the study area) between Susitna River discharges of 9,240 cfs and 13,700 cfs did not occur at the Fourth of July Creek study area. In fact, for a similar range of mainstem discharges, the usable habitat at the Fourth of July Creek study area almost doubled (from 33% to 60% of the study area). Such differences in available and usable habitats between study areas and the manner in which they respond to changes in mainstem discharge can be best ascribed to basic differences in the nature of each of the tributary/mainstem confluence areas.

Lane Creek empties into a mainstem channel of the Susitna River. Mainstem channels are characterized by relatively high water velocities, deep waters depths, and wide channels (ADF&G 1983b). The confluence zone of this type of tributary mouth is usually open; that is, the opposite river bank is located far beyond the influence of the tributary on the mainstem. Water velocities and depths increase from shore without reaching a maximum within the tributary mouth study area. The

distribution of water velocities and depths within the study area is therefore skewed toward deeper and faster waters. The generally steep lateral gradient and the openness of the area accounts for the small incremental increases observed in available habitat associated with increases in mainstem discharge. As water velocities and depths increase, the surface area of unusable salmon spawning habitat increases, severely limiting and confining usable spawning habitat area.

In contrast to Lane Creek, Fourth of July Creek empties into a side channel of the Susitna River. The tributary mouth area associated with this confluence reflects the influence of the adjoining side channel. Side channels are characterized by relatively lower velocities, shallower depths, and more constricted channels than adjacent mainstem channels (ADF&G 1983b). The tributary mouth area is usually confined by the narrower dimensions of the side channel. Study area water velocities and depths increase from shore, reach a maximum, and decrease as the opposite bank is approached, and are therefore skewed toward shallower, slower waters. The relatively shallow nature of the side channel accounts for the comparatively large increases in available and usable habitats observed with corresponding increases in mainstem discharge. Similar interactions between tributary mouths and receiving waters can be expected to occur in side slough habitats of the middle Susitna River. In this case, however, the boundaries of the tributary mouth are difficult to detect due to imperceptible differences in water clarity between the two bodies of water.

The number of chum salmon utilization measurements (28 redds) collected at the Fourth of July Creek tributary mouth study area was insufficient to determine whether chum salmon spawning in the tributary mouth areas select different hydraulic conditions than chum salmon spawning in sloughs or side channels. Fish were not observed spawning at the Lane Creek site and thus no utilization data were collected at this site. At the Fourth of July Creek tributary mouth area, chum salmon were observed spawning in water depths which range from 0.6 to 2.3 feet. These depths are within the range of depths (0.16-3.9 ft) reported for chum salmon spawning in the sloughs and side channels of the Susitna River (0.3-2.9 ft) (ADF&G 1983a and Chapter 7) and as reported in a literature review by Hale (1981).

Chum salmon redd velocities observed at the Fourth of July Creek tributary mouth study area ranged from 0.1-4.5 ft/sec. All but one of these 28 measured velocities (4.5 ft/sec) were within the combined ranges of observed velocities of chum salmon spawning reported by Hale (1981) in his literature review. The range of velocities observed at the Fourth of July Creek tributary mouth study area also compares favorably with the range of velocities utilized by spawning chum salmon in sloughs and side channels in the middle river reach (0.0-4.5 ft/sec) (ADF&G 1983a and Chapter 7).

Predominant substrate types observed at chum salmon redds in the Fourth of July Creek tributary mouth study area ranged from small gravel to cobble. This range is similar to the range of substrate types reported for chum salmon spawning by Hale (1981) (sand to bedrock covered with small boulders) and in sloughs and side channels (sand to cobble) of the

Susitna River (ADF&G 1983a; Chapter 7). Substrate type appeared to have negligible influence in determining the limits of usable chum salmon spawning habitat at the Fourth of July tributary mouth study area.

Although limited, the collection of utilization data at the Fourth of July Creek tributary mouth area serves an important function, since this type of habitat is generally characterized by a wide range of hydraulic conditions. Based on the limited data available, it appears that physical habitat attributes, particularly water depth and velocity, may be the limiting factors for chum salmon spawning in tributary mouth areas.

4.2 Limitations of the Data

One drawback of this study is the limited precision of the hydraulic data analyses. Computer simulation of tributary mouth areas was not possible. For this reason, a less precise method of delineating isopleths and digitizing areas between isopleths was devised. This procedure is time consuming and likely subject to greater error than computer simulation. With isopleth increments of 1.0, it is difficult to accurately estimate the fractional area within an increment which may be necessary to define subcategories of usable spawning habitat area. Smaller isopleth increments could be used, but the measurement error associated with digitizing increases disproportionately as increment size decreases.

A second limitation was lack of utilization data from tributary mouth areas located outside of the clearwater plume. Visual observations of

spawning salmon beyond the clearwater plume is hindered by high turbidity associated with mainstem water. For this reason, delineation of the utilized portion beyond the plume is impossible. If it could be assumed that spawning chum salmon limit their utilization to areas within the plume, usable habitat would basically be a function of plume size.

The importance of the clearwater plume is also complicated by the distribution of upwelling water within the plume area. Spawning chum salmon have been associated with areas of upwelling groundwater (Kogl 1965, Francisco 1977, Wilson et al. 1981, ADF&G 1983b). It is likely that tributary water flowing through the interstitial spaces of the unconsolidated alluvium at the mouth of the Fourth of July Creek is a stimulus for chum salmon spawning. Although the seeping water is associated with the tributary, it may be less variable and provide a more specific area to the spawners than the plume itself. During times of low tributary discharge and limited clearwater plume surface area, spawning may take place in turbid water areas downstream of the tributary/mainstem confluence. Although the plume is absent in these areas, spawning may be stimulated by the detection of the seeping waters from within the gravels by the spawning chum salmon. Since seepage probably occurs only on the same side of the channel as the tributary, it follows that spawning would only occur there. Although not definitive, surface water disturbances caused by spawning salmon were observed in the shallow waters of the clearwater plume but were not noted in the shallow waters near the opposite bank. This may indicate

that chum salmon spawning was restricted to the tributary side of the channel.

A majority of the spawning areas observed at the Fourth of July Creek tributary mouth area at a mainstem discharge of at least 21,000 cfs were dewatered at 8,040 cfs discharge. At winter mainstem discharges which approach 1,000 cfs (USGS 1975), additional spawning areas may also become dewatered. Salmon embryos in these dewatered areas must rely on upwelling or seeping intragravel waters to survive. If the embryos freeze and die in these areas, the observed spawning may be incidental, but if the embryos are viable, this type of habitat may be extremely important to chum salmon spawning at the Fourth of July Creek tributary mouth.

Finally, the actual tributary mouth study area boundaries affected the description of habitat conditions within the total tributary mouth area because the study area did not include the total mouth habitat at all sampled tributary/mainstem discharges. However, the tributary mouth area studied was considered to be representative of the total mouth habitat. This is especially true at the Lane Creek tributary mouth area since the clearwater plume was contained within the width of the study area at all mainstem/tributary discharges. Physical conditions varied little along the of the Lane Creek clearwater plume. At the Fourth of July Creek tributary mouth area, however, physical conditions changed radically as mainstem discharge decreased. During the final sampling session on October 8, Fourth of July Creek discharge was relatively high (55 cfs), whereas discharge in the adjoining the side channel was

extremely low (10-70 cfs). Under these circumstances, the clearwater plume of the tributary extended along the entire side channel downstream to its confluence with the mainstem. Because of the very low discharge of the Susitna River during this time, large areas of river bed within the tributary mouth study areas were exposed. The entire length of some transects were dewatered because the watered side channel below the tributary confluence migrated laterally in a downstream direction out of the study area. (When the transects were established at a mainstem discharge of 24,000, the exposure of this large portion of riverbed was not anticipated). During these conditions, it appeared that the total wetted surface area of the side channel, including portions within and beyond the study areas, became usable chum salmon spawning habitat. For this reason, the percentage of usable chum salmon spawning habitat in the Fourth of July Creek study area would most likely increase if the study area were enlarged. No similar appreciable increase in usable chum salmon spawning habitat would occur at the Lane Creek study area if the entire plume area were sampled.

Future investigations might consider usable chum salmon spawning habitat within the tributary mouth habitats at sites where tributaries enter side channels and sloughs. It would also be useful to collect additional data to better characterize the response of tributary mouth habitat at higher mainstem discharge levels. The trends evidenced by the analysis performed in this study may not hold at higher discharges. Available and usable chum salmon spawning habitat within tributary mouth areas may be influenced less by variations in tributary discharge than by changes in mainstem Susitna River discharges at higher discharge levels.

5.0 GLOSSARY

Available Habitat - The wetted portion of the study area.

Clearwater Plume - The extension of the clearwater of a tributary into the turbid mainstem at and below the confluence. due to the different densities of the mainstem and tributary waters, these two water bodies do not readily mix, causing a well-defined clearwater extension of the tributary along the river bank below the actual confluence. The size of the plume is a function of tributary flow and mainstem discharge.

Digitizing - A plainmetric procedure used to determine surface area.

Discharge - Water volume passing a fixed point per unit time; specifically refers to mainstem habitat.

Flow - Water volume passing a fixed point per unit time. Refers to slough, side channel, and tributary habitats.

IFG-2 model - A computer model based on theory used to simulate hydraulic conditions (depth and velocity) within a study site. The model is calibrated using one set of hydraulic measurements. It is also referred to as the WSP model.

GLOSSARY (continued)

IFG-4 model - A computer model based on empirical data used to simulate hydraulic conditions (depth and velocity) within a study site. The model is calibrated using a minimum of two or preferably three or more sets of hydraulic measurements.

Isopleth - A line connecting points on a map that have equal values with regard to certain variables (depth, velocity, elevation, etc.)

Project Datum - the project datum refers to true mean sea level.

Usable Habitat - That portion of available habitat which provides the hydraulic and substrate conditions deemed necessary to support successful chum salmon spawning.

Utilization Data - Hydraulic and physical data collected at active salmon redds. These include water depths, mean column water velocity, substrate size, and surface and intragravel water temperatures.

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8.0 LITERATURE CITED

ADF&G. 1981. Aquatic habitat and instream flow project. Phase I Final Draft. Subtask 7.10. Prepared for Acres American, Incorporated, by the Alaska Department of Fish and Game/Su Hydro. Anchorage, Alaska.

ADF&G. 1982. Aquatic studies program. Phase II Final Draft. Subtask 7.10. Prepared for Acres American, Incorporated, by the Alaska Department of Fish and Game/Su Hydro. Anchorage, Alaska.

ADF&G. 1983a. Susitna Hydro Aquatic Studies Phase II basic data report. Volume 4. Aquatic habitat and instream flow studies, 1982. Alaska Department of Fish & Game Susitna Hydro Aquatic Studies. Anchorage, Alaska.

_____. 1983b. Susitna Hydro Aquatic Studies Phase II report. Synopses of the 1982 Aquatic Studies and analyses of fish and habitat relationships (2 volumes and appendices). Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Anchorage, Alaska.

_____. 1984. Susitna Hydro Aquatic Studies, May 1983 - June 1984, Procedures Manual. Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Anchorage, Alaska.

_____. 1984. Susitna Hydro Aquatic Studies Report Series, Report No. 3. A Aquatic Habitat and Instream Flow investigation, May through October, 1983. (eds. C. Estes and D. Vincent-Lang). (In Press).

Collings, M.R. 1972. A methodology for determing instream flow requirements for fish. pp. 72-86. In Proc., Instream Flow Methodology Workshop. Washington State Department of Ecology, Olympic, Washington. 130 pp and Appendix.

_____. 1974. Generalization of spawning and rearing discharges for several Pacific salmon species in western Washington. U.S. Geological Survey Open File Report. 39 pp.

Francisco, K. 1977. Second interim report of the Commercial Fish-Technical Evaluation Study. Joint State/Federal Fish and Wildlife Advisory Team. Special Report No. 9. Anchorage, Alaska, 46 pp.

Hale, S.S. 1981. Freshwater habitat relationships: chum salmon (Onchorhynchus keta). Alaska Department of Fish and Game, Habitat Division, Resource Assessment Branch. Anchorage, Alaska.

LITERATURE CITED (continued)

Kogle, D.R. 1973. Evaluation of the effects of flows on trout stream ecology. Dept. Engineering Research, Pacific Gas and Electric Co., Emeryville, California. 97 pp.

Milhous, R.T., D.L. Wegner, and T. Waddle. 1981. User's guide to the physical habitat simulation system. Cooperative Instream Flow Service Group, U.S. Fish and Wildlife Service. Instream Flow Information Paper No. 11. Report FWS/OBS 81/43. 1 Vol. Washington D.C.

Schmidt, D.S., S.S. Hale, P. Suchanek and D.L. Crawford, editors. 1984 (in preparation). Resident and juvenile anadromous fish investigations (May-October 1983). Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Report No. 2. Prepared for Alaska Power Authority. Anchorage, Alaska.

U.S. Geological Survey. 1975. Surface water research of Cook Inlet Basin, Alaska through September 1975. U.S. Department of the Interior, Geological Survey 78-498. Anchorage, Alaska.

_____. 1983. Provisional Susitna River discharge data for the 1983 water year ending September 1983. Anchorage, Alaska

_____. 1984. Provisional Susitna River discharge data for the 1983 water year ending September 1983. Anchorage, Alaska.

LITERATURE CITED (continued)

Wilson, W.J., E.W. Trihey, J.E. Baldridge, C.D. Evans, J.G. Thiele and D.E. Trudgen. 1981. An assessment of environmental effects of construction and operation of the proposed Terror Lake hydroelectric facility, Kodiak, Alaska. Instream Flow Studies final report. Arctic Environmental Information and Data Center. Univ. of Alaska. 419 pp.