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PRELIMINARY ASSESSMENT OF ACCESS BY SPAWNING SALMON TO SIDE SLOUGH HABITAT ABOVE TALKEETNA

BY

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INTRODUCTION

The proposed Susitna hydroelectric project will alter the existing streamflow, sediment and thermal regimes of the river. The project would reduce streamflows at Gold Creek during summer and increase them during winter. Suspended sediment, turbidity and water temperatures are expected to follow similar patterns (Acres American Incorporated 1982). Several anadromous and resident species of fish utilize a variety of riverine and associated tributary habitats to varying degrees throughout various seasons (ADF&G 1981a, 1981b, 1981c). The anticipated changes in the streamflow, thermal, and sediment regimes are expected to affect the quantity and/or quality of fish habitat in the Susitna River throughout the year (Woodward-Clyde Consultants 1982).

Although some mainstem spawning has been documented, the most intensively used spawning areas within the Talkeetna to Devil Canyon reach are located in tributary streams and side sloughs (ADF&G 1981a). Of these, side-slough habitats are most likely to be adversely effected by reduced streamflows during the inmigration and spawning period. Natural flows at the Gold Creek stream gage commonly range from 25,000 to 16,000 cfs during late August and early September. A controlled flow of no less than 12,000 cfs from mid-August to mid-September is proposed by the Alaska Power Authority.

Because of the magnitude of the proposed streamflow reductions during the inmigration and spawning period, the availability, as well as the quality, of existing side-slough spawning habitat is of concern. The purpose of this paper is to present a preliminary analysis of the influence that mainstem discharge has on access to spawning areas in the side sloughs above Talkeetna. The paper has been prepared at the request of the Alaska Power Authority and in cooperation with the Alaska Department of Fish and Game, Su Hydro Aquatic Studies Group.

Much of the discussion and the conclusions presented in the latter portion of this report are based on direct observation by the author and other experienced observers. Corroborative field data to support many of the statements made in this report are, at present, both limited and provisional. Continuing analysis of these and other 1982 data by the Su Hydro Aquatic

Studies Group will provide a more reliable indication of the range of mainstem discharges that are necessary for providing access by adult salmon to the side sloughs. The ADF&G report is scheduled for June 1983. Until the remainder of the 1982 data are analyzed by ADF&G, the statements presented in this paper regarding the streamflows necessary for chum salmon to gain access to the side sloughs must be viewed as the provisional opinion of the author.

Four general categories of fish habitat that exist along the Susitna River between Talkeetna and Devil Canyon are identified, and an introductory description of the physical processes that interact to provide side-slough habitat is presented. Much of the discussion pertaining to slough processes consists of hypotheses and is unsupported at this time, by data or analyses. However, it is believed that further analysis of the data collected during the 1982 field season and data that could be collected during a well focused field program in 1983 will substantiate these hypotheses and provide a basis for quantifying associated relationships. To assist with recognizing the specific focus of this paper, the sequence in which the various topics are addressed is diagrammed in Figure 1.

SUSITNA RIVER FISHERY RESOURCES

The Susitna River basin supports populations of five Pacific salmon species (chinook, sockeye, coho, chum, and pink), one additional anadromous salmonid (Bering cisco), an anadromous osmerid (eulachon), and several resident species (Arctic grayling, rainbow trout, burbot, Dolly Varden, round whitefish, humpback whitefish, longnose sucker, threespine stickleback, Arctic lamprey, and sculpin). Rainbow trout, grayling, Dolly Varden and burbot are the principal resident contributors to the Susitna River sport fishery (Mills 1982). The rainbow, grayling and Dolly Varden fishery is primarily located in clear water tributaries, whereas burbot are generally found in the mainstem Susitna River.

Sockeye and chum salmon originating in the Susitna basin are the most important contributors to the total upper Cook Inlet commercial salmon harvest. Coho and pink salmon are of lesser commercial value. Commercial harvest of chinook has been very limited, because regulations prevent commercial fishing

Fishery Resource

Spatial and Seasonal Distribution
Evaluation Species

General Habitat Categories Talkeetna to Devil Canyon

1. Mainstem
2. Side-channel
3. Side-slough
4. Tributaries

Physical Aspects of Side-Slough Habitat

1. Mainstem Discharge
2. Local Runoff
3. Groundwater Inflow
4. Riverine Ice Processes

Influence on Side-Slough Access

(Focus of Paper)

Figure 1. Schematic Diagram of Information Flow

for chinook salmon until most of the run has entered natal streams. However, chinook salmon are a very important sport fish in the lower Susitna drainage, and are harvested in a local subsistence fishery at Tyonek. Therefore Susitna River chinook stocks might be considered to hold a relative overall rank in the Susitna basin at least equal to pink and coho salmon.

The five species of Pacific salmon that inhabit the Susitna basin utilize a variety of habitats to different degrees during various seasons (Figure 2). Activity is implied by the relative abundance of a particular species/life stage within the respective time periods. Degree of activity (intense or moderate) was determined by the University of Alaska's Arctic Environmental Information and Data Center (AEIDC) from information presented by Woodward-Clyde Consultants (WCC) in Chapter 3 of the draft Exhibit E for the FERC license application report (Acres 1982).

Identification of critical habitat components during each season of the year is a necessary step in assessing impacts and developing a viable mitigation plan. Various species and life stages have different critical requirements and respond differently to habitat alterations. A change in habitat conditions that benefits one species or life stage may adversely affect another; and mitigation plans favoring one species may discriminate against another. Therefore, selection of one or two species (evaluation species) in preference to the many life stages or species that utilize a particular habitat type during any given season is an effective approach for prioritizing seasonal habitat requirements and focusing mitigation efforts.

An evaluation species can be selected after initial baseline studies and impact assessments have identified the dominant species of interest and those habitats that are most vulnerable to potential impacts. For the purposes of this report, species within the Susitna River with high commercial, sport, subsistence, or aesthetic value were given priority. Those species within this category whose habitat is thought to be most jeopardized by anticipated project effects were rated higher than those species whose habitat was not considered as vulnerable (Table 1). Since no rare or endangered species inhabit the Susitna River, it was not necessary to respond to this consideration in the selection and prioritization of the evaulation species.

Figure 2. Provisional Periodicity Chart for Salmon in the Talkeetna to Devil Canyon Segment of the Susitna River (Adapted from AEIDC, 1982).

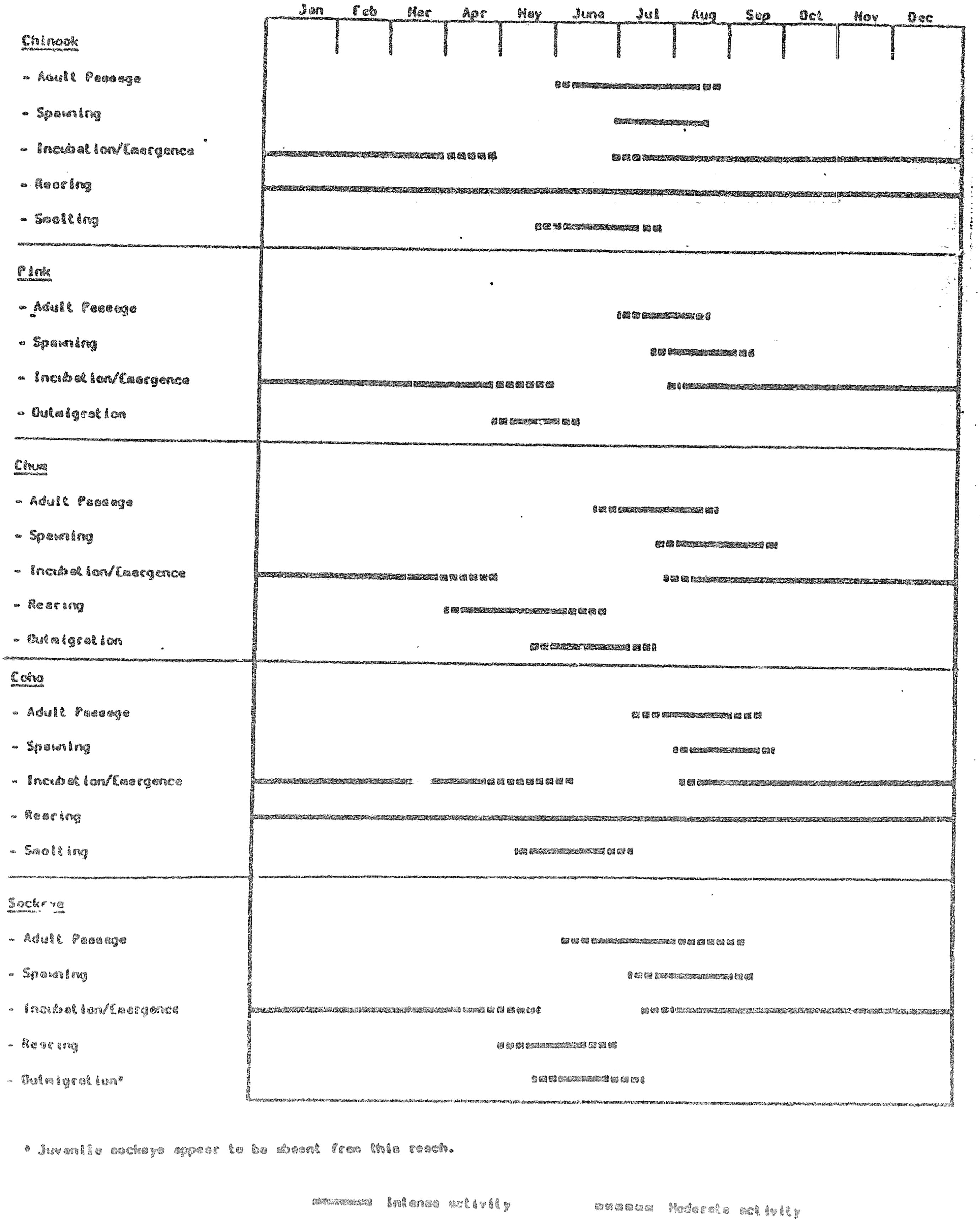


Table 1. Evaluation Species and Life Stages for Side Slough Habitats in the Talkeetna to Devil Canyon Reach.

- <u>Chum Salmon</u>

  . Returning adults;
  . Spawning adults;
  . Incubating embryos and pre-emergent fry;
  . Emergent fry;
  . Outmigrant juveniles.

- <u>Sockeye Salmon</u>

  . Returning adults;
  . Spawning adults;
  . Incubating embryos and pre-emergent fry;
  . Emergent fry;
  . Outmigrant juveniles.

- <u>Chinook Salmon</u>

  . Rearing juveniles.

- <u>Coho Salmon</u>

  . Rearing juveniles.

- <u>Pink Salmon</u>

  . Returning adults;
  . Spawning adults;
  . Incubating embryos and pre-emergent fry;
  . Emergent fry;
  . Outmigrant juveniles.

- <u>Resident Species</u>

  . Limited data base precludes identification of relevant life stage.

Because of differences in habitat location and seasonal habitat requirements, not all salmon species are expected to be equally affected by the proposed project. The greatest changes in flow-dependent habitat characteristics are expected to occur between Talkeetna and Devil Canyon. Of the five species of salmon that inhabit the Talkeetna to Devil Canyon reach, chum and sockeye salmon appear to be the most vulnerable. This is due to their dependence on the slough habitats along the margins of the floodplain for spawning, incubation and early rearing (ADF&G 1981a, 1981b, 1981c, 1982). Of these two species, chum salmon appear to be dominant (ADF&G 1981b). Chinook and coho salmon, while having a greater commercial and sport value than chum salmon, may not be as adversely affected by the project. These species are principally tributary spawners; fry and juveniles rear in clearwater areas such as the mouths of sloughs and tributaries (ADF&G 1981a, 1981b, 1981c, 1982). Postproject conditions in the mainstem (reduced velocity and turbidity) may provide replacement habitat to offset any potential loss to these traditional rearing areas that might occur. While some pink salmon spawn in slough habitats in the reach between Talkeetna and Devil Canyon, the majority of these fish utilize tributary habitats (ADF&G 1981a). Although some adult residents appear to use the side-slough habitats between Devil Canyon and Talkeetna, limited information regarding utilization of side-slough habitat by other life history phases of resident species precludes a meaningful prioritization at this time. The authors' prioritization of evaluation species for side-slough habitat along the Susitna River between Devil Canyon and Talkeetna is provided in Table 1.

GENERAL HABITAT CATEGORIES

Fish habitat in the Talkeetna to Devil Canyon reach of the Susitna can be divided into four general categories: mainstem, side-channel, side-slough, and tributary habitats. Each general habitat category contains a spectrum of physical attributes rather than a specific set of uniform characteristics.

Mainstem habitat consists of those portions of the Susitna River that normally convey streamflow throughout the year. Both single and multiple channel reaches are included in this habitat category. Groundwater and tributary inflow appear to be inconsequential contributors to the overall characteristics of mainstem habitat. Mainstem habitat is typically characterized by high-velocity streamflows and well armored streambeds. Substrates generally consist of boulder and cobble size materials with interstitial spaces filled with a grout-like mixture of small gravels and glacial sands. Suspended sediment concentrations and turbidity are high during summer due to the influence of glacial melt-water. Streamflows recede in early fall, and the mainstem clears appreciably in October before an ice cover forms on the river in late November or December. Seasonal surface water temperatures in the mainstem river appear to be primarily influenced by ambient air temperature and solar radiation. Mainstem surface water temperatures are believed to be a principal determinant of mainstem intragravel water temperatures.

Side-channel habitat consists of those portions of the Susitna River that normally convey streamflow during the open water season but become appreciably dewatered during periods of low flow. Side-channel habitat may exist either in well defined overflow channels, or in poorly defined water courses flowing through partially submerged gravel bars and islands along the margins of the mainstem river. Side-channel streambed elevations are typically lower than the mean monthly water surface elevations during June, July and August. Thus side channels normally convey streamflow throughout the summer. Side-channel habitats are characterized by shallower depths, lower velocities and smaller streambed materials than mainstem habitats. In general, the sediment and thermal regimes of the side channel habitats reflect mainstem conditions. A winter ice cover, similar to that which forms on the mainstem, generally exists in the side channels. The presence or absence of clear water inflows is not considered a critical component in the designation of side-channel habitat. Tributary and groundwater inflow may prevent some side-channel habitats from becoming completely dewatered when mainstem flows recede. Throughout the winters of 1974-75 and 1981-82 groundwater inflow and upwelling retained open leads in some side-channel areas (Barrett 1975a, 1975b, 1975c and Trihey 1982).

Side-slough habitats are found in spring-fed overflow channels along the edge of the floodplain, separated from the mainstem by well-vegetated bars. An exposed alluvial berm often separates the head of the slough from mainstem or side-channel flows. The controlling streambed/streambank elevations at the upstream end of the side sloughs are slightly less than the water surface elevations of the mean monthly flows for June, July, and August. At intermediate and low-flow periods, the side sloughs convey clear water from small tributaries and/or upwelling groundwater (ADF&G 1981c, 1982). These clear water inflows are essential contributors to the existence of this habitat type. The water surface elevation of the river generally causes a backwater to extend well up into the slough from its lower end (ADF&G 1981c, 1982).

Even though a substantial backwater exists, the sloughs function hydraulically very much like small stream systems. Several hundred feet of the slough channel often conveys water independent of mainstem backwater effects.

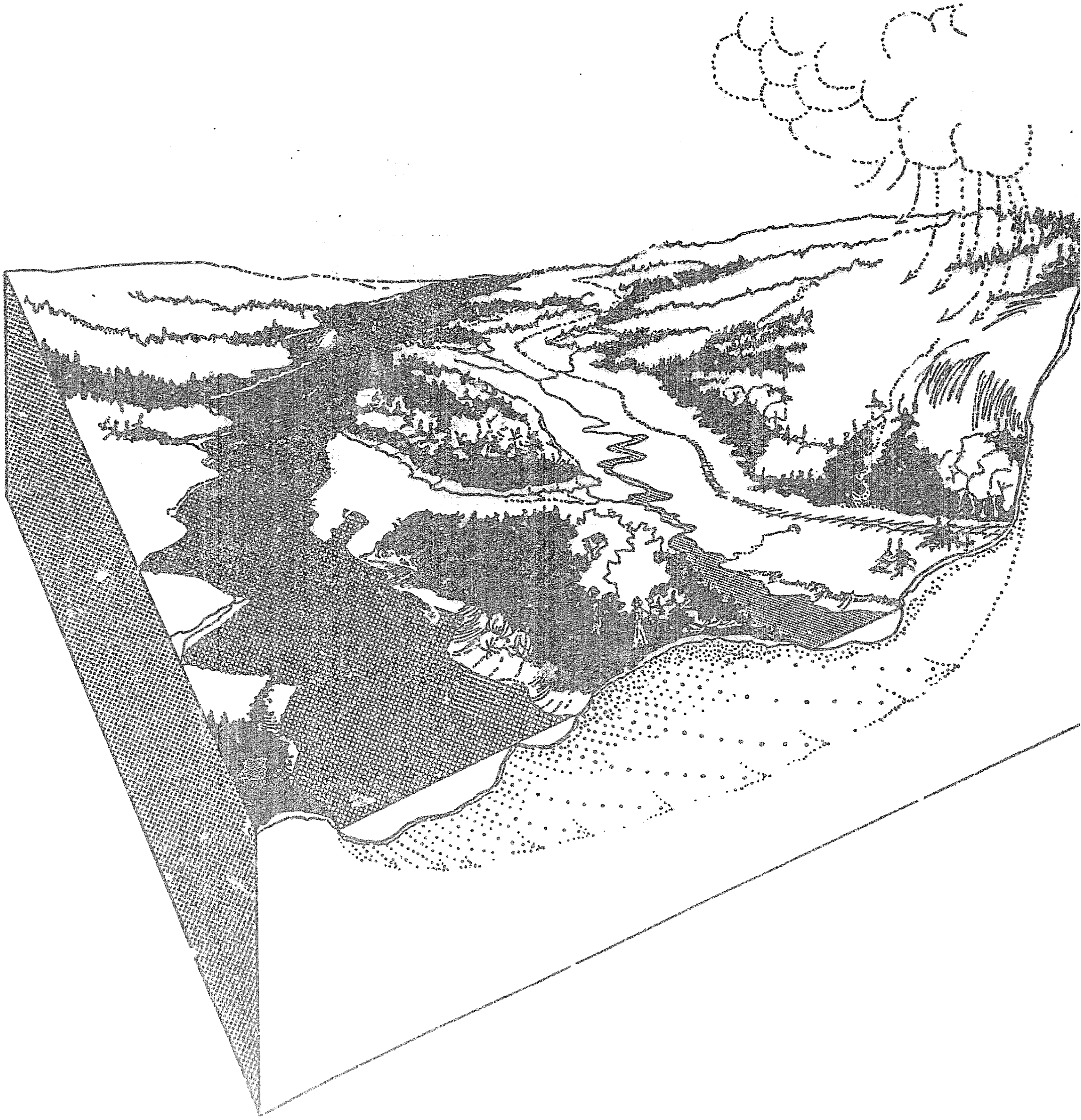
Except when the water surface elevation (discharge) in the mainstem river is sufficient to overtop the upper end of the slough, surface water temperatures in the side sloughs appear to respond independently of mainstem temperatures (ADF&G 1981c, 1982). Surface water temperatures in the side sloughs during summer months are principally a function of air temperature, solar radiation, and the temperature of the local runoff. During winter months surface water temperatures are strongly influenced by upwelling groundwater. The large deposits of alluvium through which the upwelling water flows appear to act as a buffer or thermal reservoir, attenuating summer temperatures and providing very stable winter temperatures. Although some exceptions have been noted, intragravel water temperatures in upwelling areas are generally between 2 and 4°C throughout the year.

Tributary habitat consists of the full complement of hydraulic and morphologic conditions that occur in the tributaries. Their seasonal streamflow, sediment, and thermal regimes reflect the integration of the hydrology, geology and climate of the tributary drainage. The physical attributes of tributary habitat are not dependent on mainstem conditions except at the tributary mouth, where the discharge influences access into the tributary and the clear water tributary habitat extends as a plume into the turbid waters of the mainstem (ADF&G 1981c, 1982).

PHYSICAL ASPECTS OF SIDE-SLOUGH HABITAT

The physical characteristics of side-slough habitat appear to be dependent upon the interaction of four principal factors: discharge of the mainstem Susitna River, surface runoff patterns from the adjacent catchment area, local groundwater inflow, and riverine ice processes. These factors interact to varying degrees during different seasons of the year to provide a unique type of fish habitat along the margins of the Susitna River (Figure 3). Side-slough habitat is utilized predominately by chum and sockeye salmon, although chinook, coho and pink salmon also inhabit the side sloughs at some

Figure 3. Artists sketch of a side-slough and adjacent Susitna River (courtesy of AEIDC).



time during their fresh water life. Resident species are also found in these areas.

Mainstem Discharge

The amount of streamflow in the mainstem Susitna River principally influences side-slough habitat conditions in two ways: 1) intermediate level streamflows cause a backwater effect at the mouth of the slough, which creates a special type of slough habitat and facilitates access by fish into the slough (ADF&G 1981c, 1982); and 2) high flows overtop the upstream end of the slough and provide the dominant flushing action, removing debris and sediments from the slough.

Streambed elevations at the downstream entrance to the side sloughs are generally lower than the stage (water surface elevation) in the adjoining mainstem channel. Thus the stage of the mainstem causes a hydraulic plug, which impedes the flow of clear water from the mouth of the slough and forms a clear backwater zone that may extend several hundred feet upstream into the slough.

As mainstem discharge increases, the depth and size of the backwater zone at the mouth of the slough continues to increase. At some point, the stage in the mainstem river becomes high enough that turbid glacial flow from the mainstem enters the slough at its upstream end. Once overtopped, flow within the sloughs often increase rapidly from less than 10 cfs to more than 500 cfs (ADF&G 1982, R&M Consultants, Inc. 1982). These periodic high flows tend to flush out detrital material and fine sediments, which commonly accumulate in low velocity areas near the mouth of the slough. Occasionally, high flows transport sands and silts into the slough from the mainstem; however, the overall effect of these periodic overtoppings is generally thought to result in a net transport of fines and organic material out of the slough. During spring break up, large short-duration flows pass through the side sloughs. Periodically, breakup flows are apparently of such magnitude that they remove debris and beaver dams, redistribute streambed gravels and, at times, alter the bottom profile or alignment of the slough.

Local Runoff

During those portions of the year when mainstem streamflows are high enough to cause a backwater effect at the mouth of the slough, but not high enough to overtop the slough at its upstream end, the principal sources of streamflow within the slough (slough flow) are from local surface runoff and groundwater upwelling. Summer rainstorms appear to have a major influence on the amount of clear water flow in side sloughs during July and August. In general, local surface runoff is thought to contribute a greater percentage to the clear water flow in the slough during the ice-free period of the year than does groundwater upwelling. However, a subset of side sloughs also exist that depend predominantly on ground water throughout the year (ADF&G 1981c).

Unseasonably dry weather during August of 1982 resulted in the second lowest mean monthly mainstem discharge in 33 years of record at Gold Creek. Average daily streamflows fluctuated between 12,000 and 14,000 cfs for 14 days. The mean monthly flow was 15,270 in comparison to the long term average monthly flow of 22,200 cfs. During this time, groundwater inflow to small tributary streams and upwelling within the side slough itself was the most significant factor in maintaining sloughflow. It is hypothesized that, during a more normal year, local runoff would have provided the greatest source of clear water to the side sloughs.

Groundwater Inflow

Although groundwater upwelling normally contributes a lesser amount of water to the total clearwater flow in the side sloughs than does surface runoff, the upwelling is believed to be essential for attracting adult salmon into those spawning areas that are not likely to freeze during winter. During winter months, groundwater inflow and upwelling provide nearly all of the slough flow. Even the water flowing into the slough from small tributary channels most likely has entered that channel as groundwater. Groundwater inflow also results in stable water surface elevations and a discontinuous ice cover. By mid-winter the mainstem river is frozen over and nearly all tributary flow has ceased. Yet substantial portions of the side sloughs remain ice free. Even if winter air temperatures become cold enough to cause an ice cover to form over the side sloughs, substrates are not expected to freeze. Field work conducted during the winters of 1974-75 and of 1981-82 indicate that surface and intragravel water temperatures in upwelling areas commonly ranged between 2 and 4°C and had a significant influence on retarding the formation of an ice cover and maintaining gravel substrates in an unfrozen condition throughout the winter (Barrett 1975a, 1975b, 1975c and Trihey 1982).

Preliminary investigations indicate that the predominant slope of the groundwater table beneath the flood plain is down valley (Acres American Incorporated 1982). The origin of the water that upwells in the side sloughs is unknown at this time. It may be from a discontinuous local aquifer or it may be from the mainstem river.

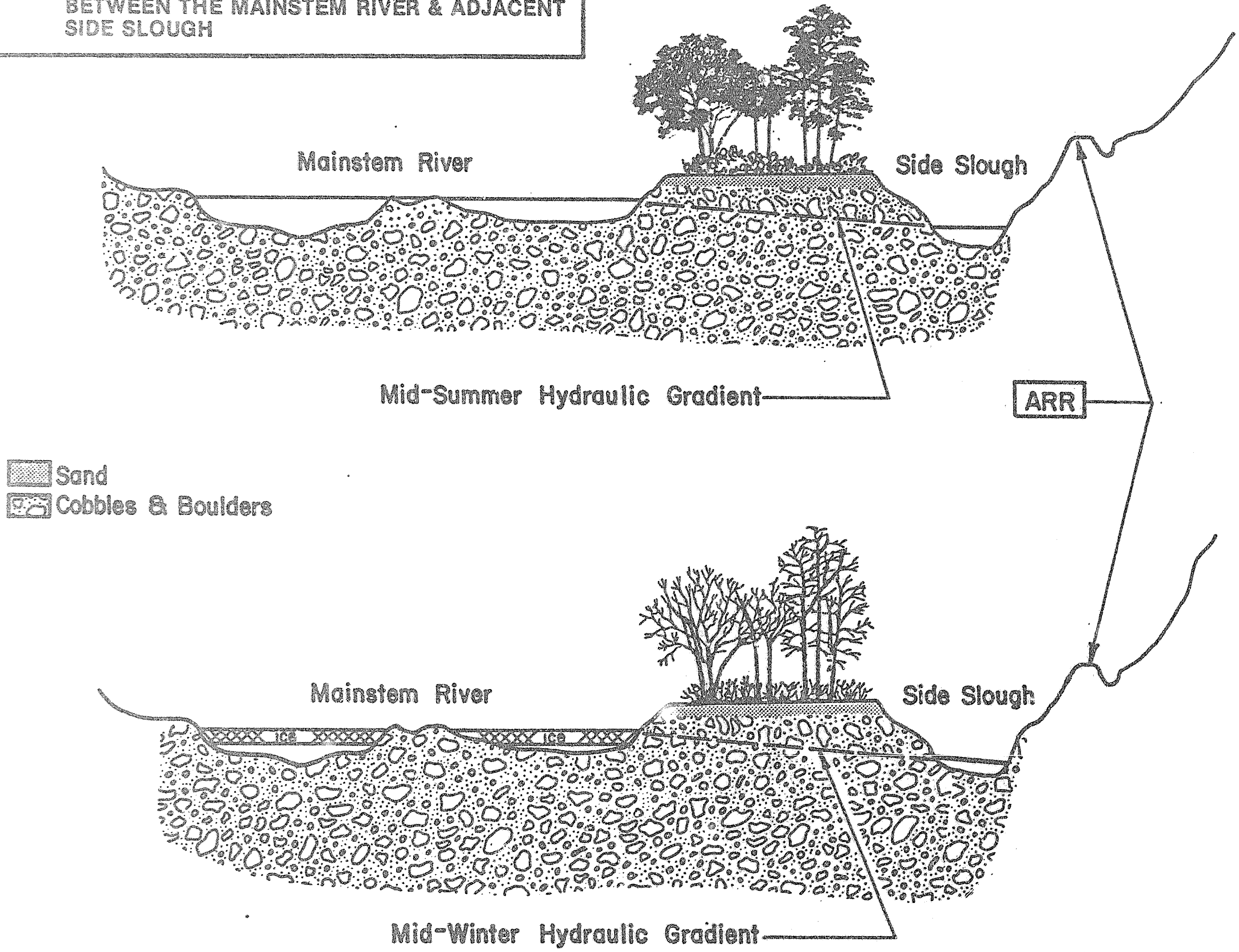
Upwelling water appears to flow from beneath the streambed into the slough in a near vertical direction. Besides preventing substrates from freezing, upwelling is also thought to prevent deposits of silts and sands from suffocating developing embryos that are within the underlying streambed gravels. The general oxygen content and direction of the upwelling flow is also believed to keep the embryos oxygenated during the incubation period. Oxygen being supplied from beneath the streambed should obviate the problems that are normally associated with a deep silt mantle overlying spawning gravels.

Ice Processes

Ice processes in the mainstem river are important in maintaining the character of the slough habitat. Besides reworking substrates and flushing debris and beaver dams from the sloughs that could otherwise be potential barriers to upstream migrants, ice processes are also considered important for maintaining the groundwater upwelling in the side sloughs during winter months.

The increased stage associated with a winter ice cover on the Susitna makes it possible for approximately the same hydraulic head to exist between the mainstem and an adjacent sideslough during periods of low winter flow as that which exists during normal summer flow (Figure 4). The river stage observed during mid-winter 1981-82 associated with the ice cover formation on the Susitna River appeared very similar to the water surface elevation associated

Figure 4. COMPARISON OF CONCEPTUAL MID-SUMMER & MID-WINTER HYDRAULIC GRADIENTS BETWEEN THE MAINSTEM RIVER & ADJACENT SIDE SLOUGH



with summer discharges of 18,000 to 19,000 cfs. The ice formation covered the mainstem and most side channels. When the ice cover was penetrated, the water level generally rose in the auger hole to within a few inches of the ice surface. Thus the midwinter hydraulic grade line of the mainstem is suspected of closely paralleling the surface of the mainstem ice cover.

The alluvial deposits that form gravel bars and islands between the mainstem river and side sloughs are highly permeable - making it possible for water from the river to flow downgradient through the alluvium and into the sloughs. Thus the increased stage associated with an ice cover on the river may provide an important driving mechanism for maintaining the upwelling in the side sloughs throughout the winter.

SIDE-SLOUGH ACCESS

The remainder of this paper addresses only one element of the preceding discussion: the effect of mainstem discharge on chum salmon access into the side sloughs during the spawning season. Slough 9 has been selected as the focal point for this analysis. In general, access for upstream migrants into Slough 9 is somewhat more difficult than an average access condition encountered by adult spawners in the Talkeetna to Devil Canyon reach. Upstream access into Slough 9 is far better than access to Slough 16B or 19; but much more difficult than access into Whiskers Slough or Slough 8A. It is a reasonable index of entrance conditions into Sloughs 20 and 21.

The streambed and water surface profiles that define entrance conditions for Slough 9 on August 24, 1982 are presented in Figure 5. The mainstem discharge at Gold Creek was 12,500 cfs and flow in Slough 9 was 3 cfs. The profiles originate in the Susitna River approximately 1000 feet downstream from the mouth of the slough (R&M cross section 128.4W1) and continue up the slough terminating with the streambed elevation at the upstream entrance to the slough. The profile is 7250 feet in length, and reflects a difference in elevation of approximately 15 feet between the downstream (mouth) and the upstream (head) ends of the slough. The uppermost 2900 feet of Slough 9 has an average streambed gradient of 18.6 ft/mi; whereas the average gradient of the lower 2900 feet of the slough is 5.6 ft/mi. In comparison, the average

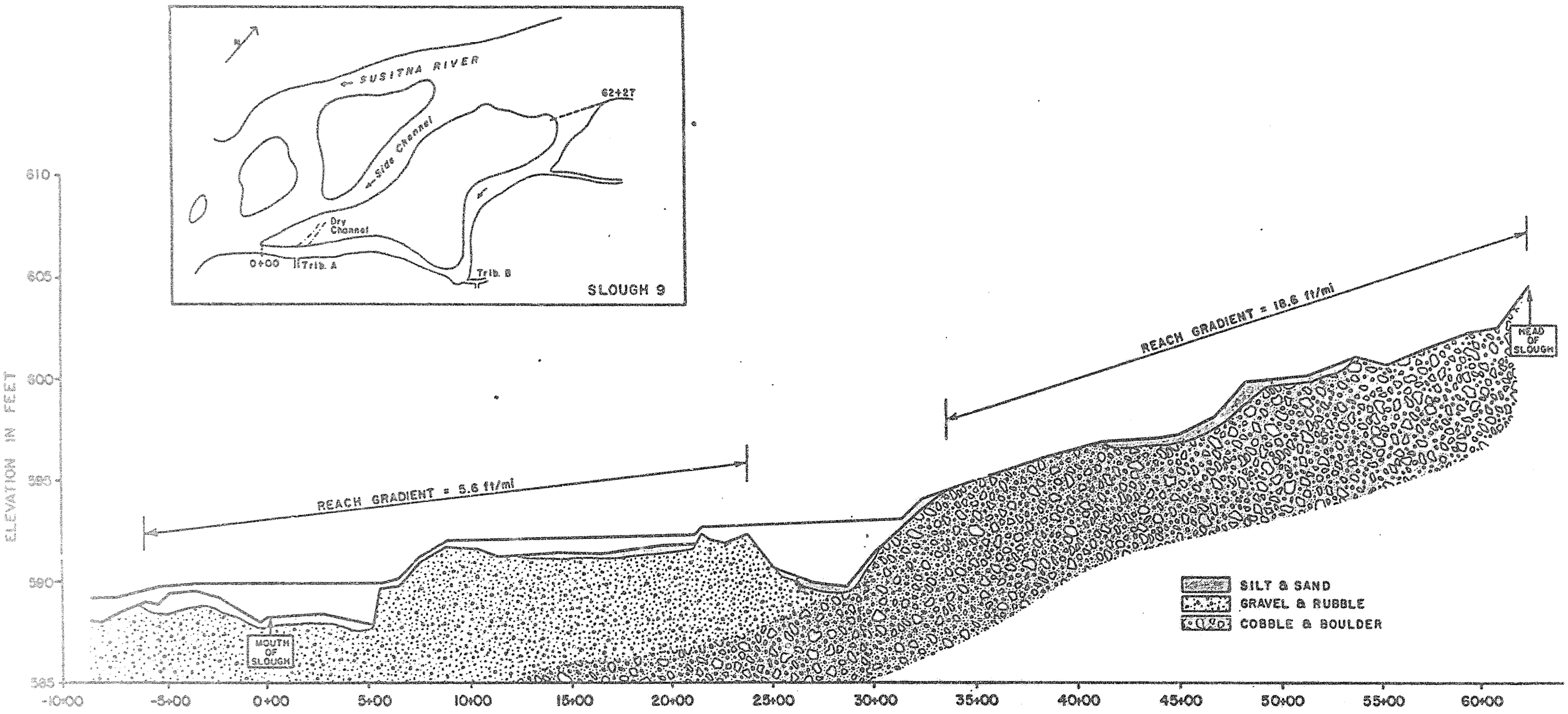


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Figure 5. Slough 9 Streambed & Water Surface Profiles; August 24, 1982.

gradient of the river between the head and the mouth of Slough 9 is 10.9 ft/mi (R&M Consultants, Inc. 1982).

Although high velocities have been identified as blocking the upstream migration of spawning fish in some Alaskan rivers, field observations of entrance conditions at several side sloughs in the Talkeetna to Devil Canyon reach indicate that it is nearly impossible for velocity barriers to exist at these locations. Thus the ease with which adult salmon can enter the side sloughs from the mainstem Susitna is primarily a function of depth.

The depth at the slough mouth is a function of the water surface elevation of the mainstem and the discharge from the slough. Data obtained during the 1981 and 1982 field seasons indicate that the flow from Slough 9 is quite small, unless the mainstem has overtopped the alluvial berm at its upstream end (Table 2). On the basis of these data, 3 cfs was selected as being typical of the mid-summer sloughflow in Slough 9.

A staff gage was installed near the mouth of Slough 9, and numerous gage height readings were recorded through September. The staff gage was installed in the deepest water available within the passage reach to ensure that it would not dewater before the passage reach. As a result, gage height readings are 0.3 feet greater than the controlling depth at the mouth of the slough. Water surface elevations were determined for each staff gage reading and compared to the average daily mainstem discharge at Gold Creek (Table 3). A plot of these data indicates that the relationship between mainstem discharge and the water surface elevation in the mouth of Slough 9 is well defined for the range of streamflows from 11 to 33,000 cfs (Figure 6).

To evaluate the influence of mainstem discharge on fish passage, backwater profiles were determined for the 2200 foot reach near the mouth of Slough 9 for incremental levels of mainstem discharge and a constant sloughflow of 3 cfs (Figure 7). Two potential problem areas exist for adult salmon entering Slough 9, a 125 foot reach approximately 400 feet downstream from the mouth of the slough (passage reach A), and a 280-foot reach from 620 to 900 feet upstream of the mouth (passage reach B). The approximate length and average depth within the two critical passage reaches were determined for each backwater profile (Table 4).

Table 2. A comparison of Slough 9 streamflow measurements with the average daily mainstem discharge at Gold Creek.

Date	Sloughflow (cfs)	Mainstem (cfs)
6/24/81	2.9*	16,600
7/21/81	714.0*	40,800
9/30/81	1.5*	8,000
10/14/81	1.2*	7,290
6/23/82	182.0#	No Record
7/15/82	108.0#	25,600
7/20/82	28.5#	22,900
8/25/82	3.4*	13,400
9/4/82	8.4*	14,400
9/9/82	3.0#	13,400
9/18/82	232.0*	26,800
9/20/82	145.0*	24,000

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* ADF&G 1981c and 1982.
\# R&M Consultants 1982.

Table 3. Comparison of water surface elevations (WSEL) at the entrance to Slough 9 and the average daily mainstem discharge at Gold Creek, 1982.

Date	WSEL* (ft)	Gold Creek Discharge (cfs)	Date	WSEL (ft)	Gold Creek Discharge (cfs)
8/24/82	590.03	12,500	9/05/82	590.16	13,600
8/25/82	590.19	13,400	9/06/82	589.91	12,200
8/26/82	590.24	13,600	9/07/82	589.84	11,700
8/27/82	590.04	12,900	9/16/82	594.09	32,500
8/28/82	589.98	12,400	9/17/82	593.71	32,000
8/29/82	589.91	12,200	9/18/82	592.86	26,800
9/02/82	590.82	16,000	9/19/82	592.37	24,100
9/03/82	590.51	14,600	9/20/82	592.36	24,000
9/04/82	590.42	14,400	9/29/82	589.98	12,400

* ADF&G gages 129.2 W1A and W1B.

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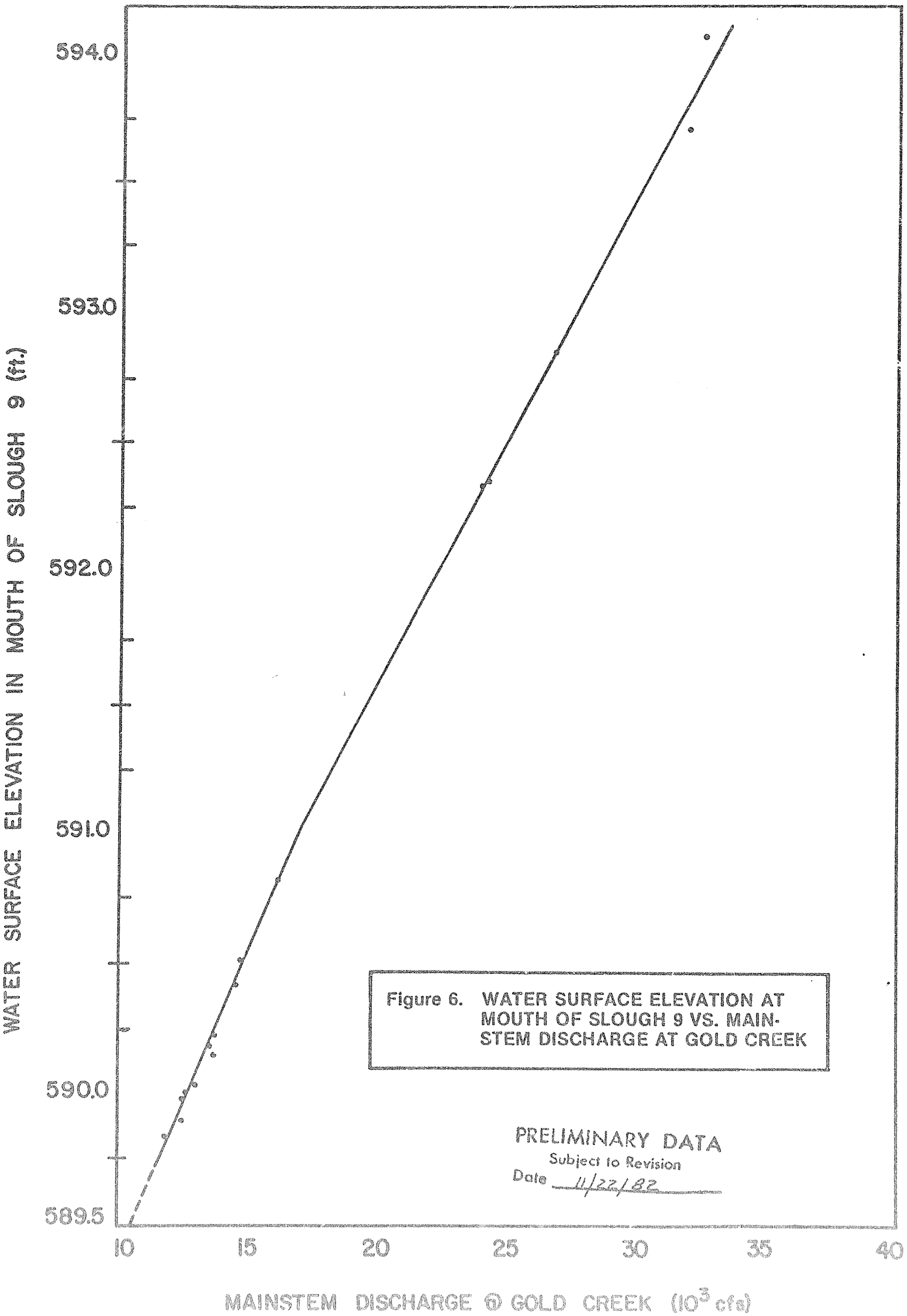


Figure 6. WATER SURFACE ELEVATION AT MOUTH OF SLOUGH 9 VS. MAINSTEM DISCHARGE AT GOLD CREEK

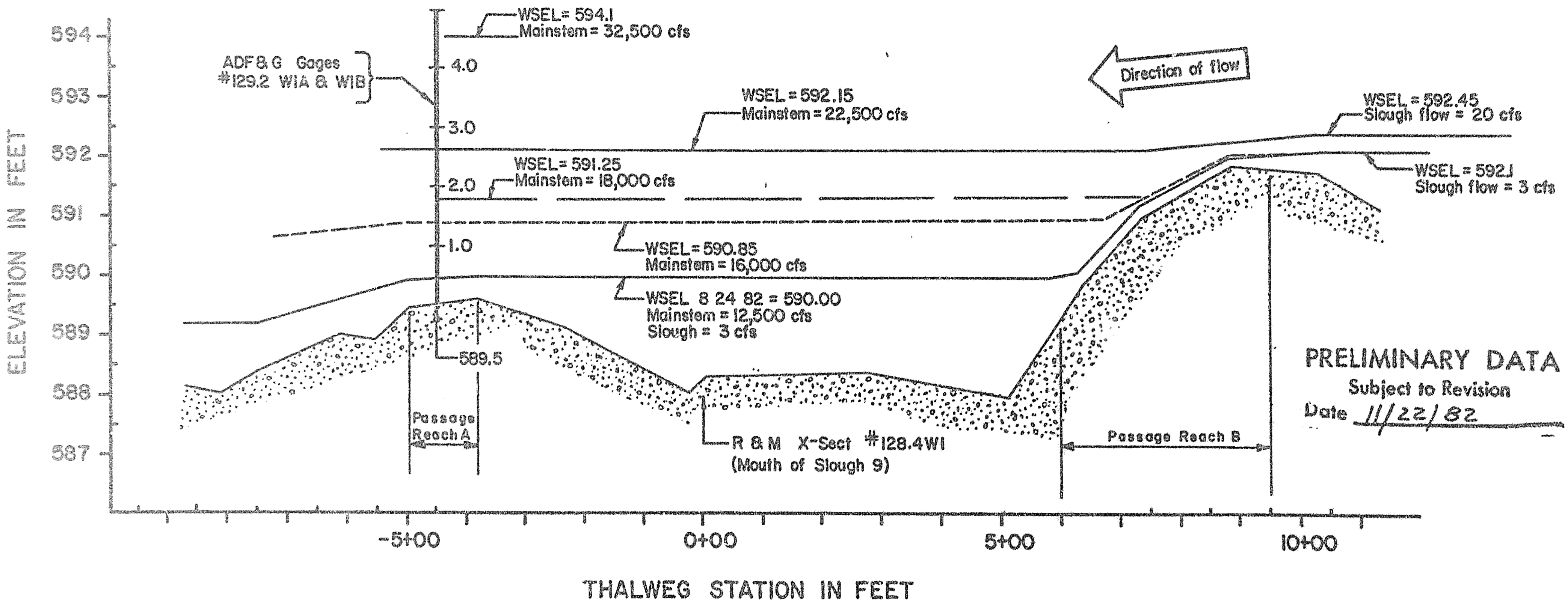


Figure 7. Backwater Profiles at the Entrance to Slough 9 for Selected Mainstem Streamflows at Gold Creek.

Upstream passage into Slough 9 by adult chum salmon would not appear to be restricted when mainstem discharges were 18,000 cfs or higher. Access becomes increasingly more difficult as mainstem discharges decrease. An acute access problem exists at streamflows of 12,000 cfs and less.

These statements are, in part, substantiated by field observations made by the author the morning of August 24, 1982 while conducting a foot survey to assess spawning conditions in the lower 5000 feet of Slough 9. The mainstem discharge was 12,500 cfs and no appreciable backwater zone was present at the entrance to the slough. Several chum salmon were observed grounded in shallow

Table 4. Entrance conditions at the mouth of Slough 9 for various mainstem flows at Gold Creek and sloughflow of 3 cfs.

Mainstem Discharge (cfs)	Slough 9 WSEL (ft)	Passage Reach A		Passage Reach B	
		Average Depth (ft)	Reach Length (ft)	Average Depth (ft)	Reach Length (ft)
10,000	589.50	0.1	125	0.20	280
12,000	589.90	0.4	125	0.20	240
14,000	590.35	0.85	125	0.20	200
16,000	590.85	1.35	125	0.25	140
18,000	591.25	1.75	125	0.30	80
20,000	591.60	2.10	125	0.50	30
22,000	591.90	2.40	125	0.6	10

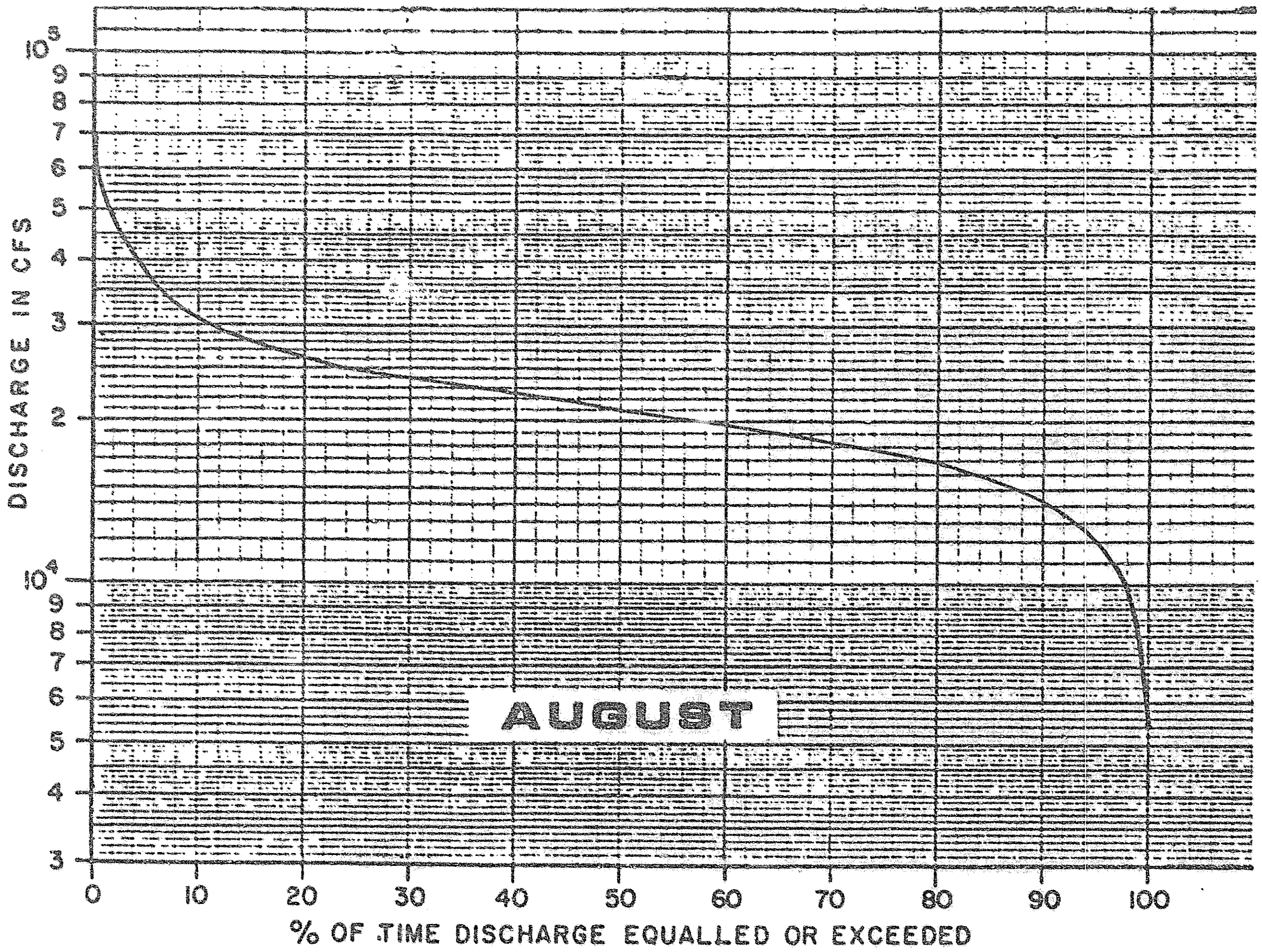
water near the entrance to the slough (passage reach A). Depths were measured at numerous points where the fish were grounded. A few isolated depths of 0.5 feet were measured, but the most representative depth restricting access at the entrance to the slough was 0.2 feet. Approximately 500 feet upstream several chum salmon were actively digging redds along both banks of the slough. Further upstream between station 15+00 and 20+00 (refer Fig. 5) chum salmon were observed actively digging three redds in upwelling areas along the west bank of Slough 9. (A total of twenty fish were counted). No rainfall had occurred and mainstem streamflows had ranged between 12,200 and 13,300 cfs during the five days preceding these observations (USGS 1982). This would tend to indicate that the shallow depths at the downstream entrance to the slough were not a complete blockage for upstream migrants.

The mainstem discharge at Gold Creek fluctuated between 16,000 and 18,000 cfs from August 30 to September 3, the result of rather typical fall rains. Streamflow data are not available for Slough 9 during this period, although it is known that the mainstem discharge of 18,000 cfs did not breach the head of the slough. On September 5 the author conducted another ground survey of spawning conditions in Slough 9. Many more chum salmon were observed in the slough than were observed August 24, and active redds were located as far up the slough as station 37+00. From these observations it can be concluded that a short term rise in mainstem stage in conjunction with an increase in sloughflow can provide conditions that permit adult salmon to reach spawning areas mid-way into the sloughs.

Pre- and Postproject Access

Typical preproject entrance conditions at Slough 9 during the chum salmon inmigration and spawning period were determined from a comparison of streamflow duration curves (Figure 8) and the information summarized in Table 4. Preproject streamflows during August would seldom inhibit passage into Slough 9 by adult spawners. Average daily streamflows equal to or greater than 18,000 cfs have occurred 70% of the time during 33 years of record. Adult passage could be hampered during September since streamflows equal to or greater than 16,000 cfs have only occurred about 25% of the time, and mainstem September flows of 12,000 cfs or greater only occurred 54% of the time. A more refined evaluation of access to the side sloughs during the inmigration and spawning period could be obtained from a flow duration curve specifically developed for the mid-August to mid-September period.

The range of entrance conditions most likely to exist at Slough 9 under postproject flows was determined from a comparison between the proposed average monthly streamflows during August for various project phases (Table 5), and the information summarized in Table 4. It is anticipated that adult spawners will experience considerable difficulty in gaining access to traditional spawning areas in the side sloughs under the proposed filling and operational flows. However, these proposed streamflows may be sufficient to provide some potential for rectifying impacts. Additional information and



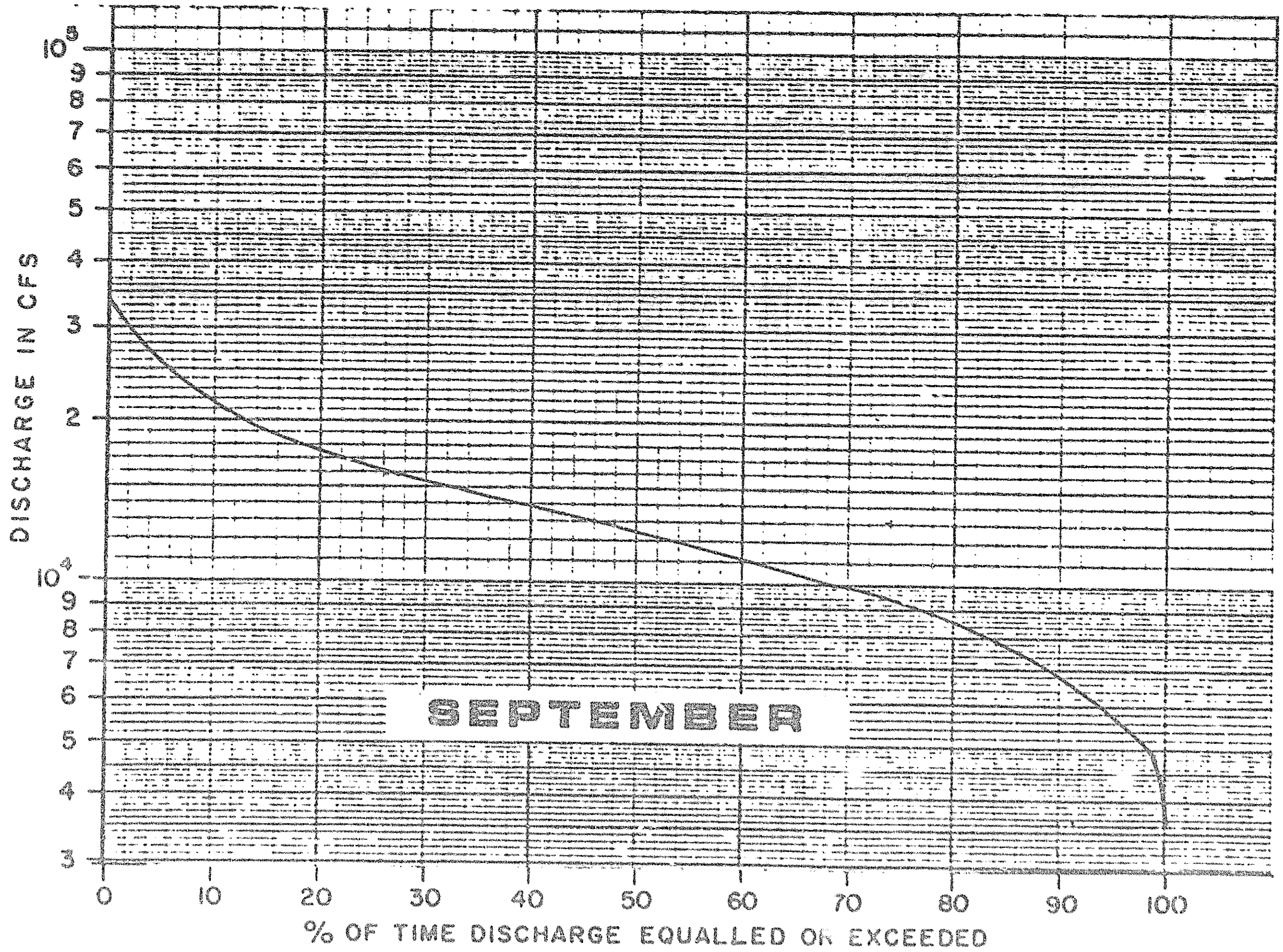


Figure 8. August and September Average Daily Streamflow Duration Curves for the Susitna River at Gold Creek.

analysis will provide a more refined understanding of the daily or weekly fluctuations in mainstem stage and slough discharge that might be expected under various postproject scenarios. This knowledge will be instrumental in better quantifying impacts and evaluating alternative mitigation proposals.

Table 5. Comparison of average monthly pre- and proposed postproject streamflows at Gold Creek.

Month	Streamflow (cfs)			
	Preproject	Filling[a]	Watana[b]	Watana/Devil[c]
January	1500	1000	9700	10600
February	1200	1000	9000	10200
March	1100	1000	8300	9300
April	1400	1000	7700	8100
May	13200	6000	10400	8700
June	27800	6000	11400	9900
July	24400	6480	9200	8400
August	22200	12000[d]	13400[d]	12600[d]
September	13300	9300[d]	9800[d]	10500[d]
October	5800	2000	8000	7800
November	2600	1000	9200	9600
December	1800	1000	16700	11300

[a] Filling streamflows are target minimum values; actual streamflows during filling will typically be greater.

[b] Operation of Watana dam only.

[c] Operation of Watana and Devil Canyon dams.

[d] Includes a controlled flow of no less than 12,000 cfs from mid August to mid September.

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