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SUSITNA
HYDROELECTRIC PROJECT

FEDERAL ENERGY REGULATORY COMMISSION
PROJECT No. 7114

SUSITNA HYDROELECTRIC PROJECT
EFFECTS ON NAVIGATION

PREPARED BY

R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS PLANNERS SURVEYORS

UNDER CONTRACT TO

HARZA-EBASCO
SUSITNA JOINT VENTURE

FINAL REPORT

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Alaska Power Authority

Final Report
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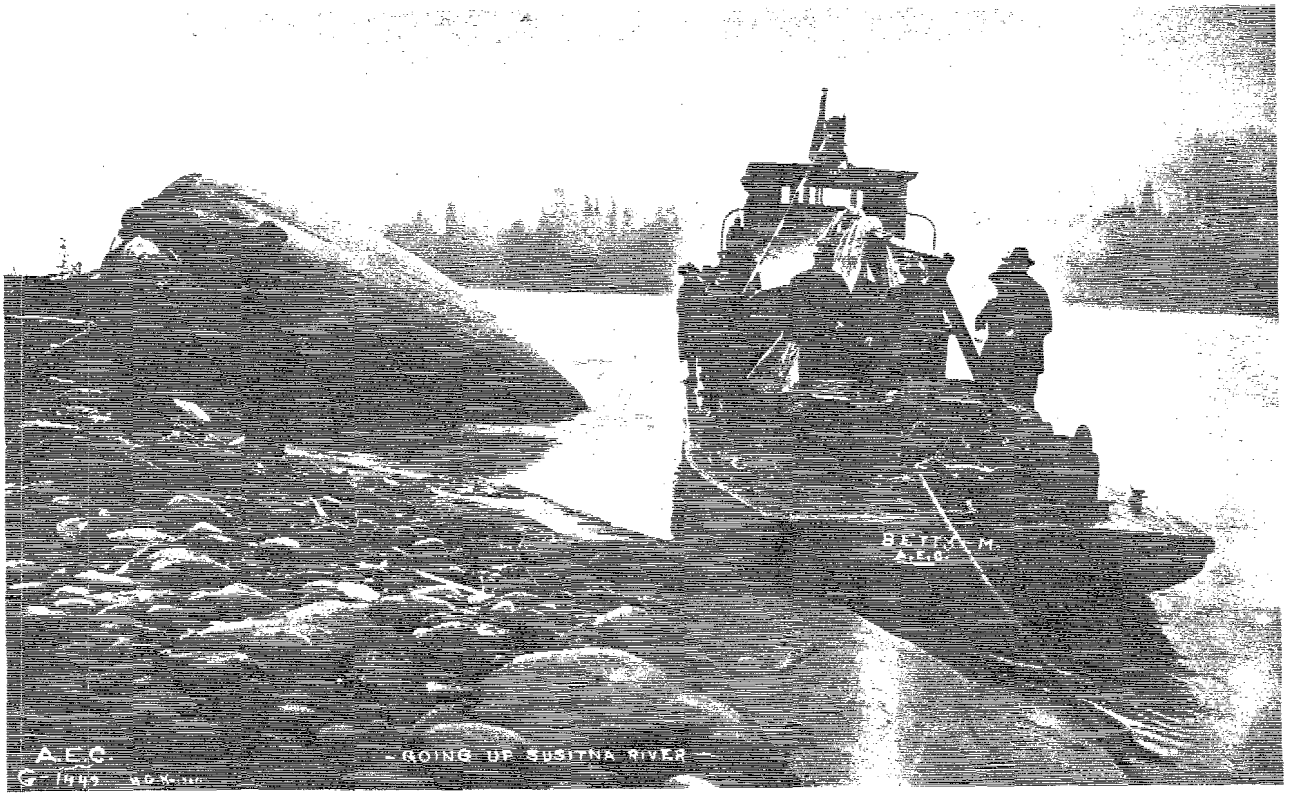

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Cover photo: Going up Susitna River on Riverboat Betty M. August 1919.

Location of photo was near to Gold Creek. Photo courtesy of Alaska Railroad, Collection.

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1.0 SUMMARY

The Susitna River is presently navigable by shallow draft water craft from its mouth at Cook Inlet to the mouth of Devil Canyon, 150 miles upstream. A 12-mile reach through Devil Canyon contains world-class whitewater rapids, navigable only at moderate flows by expert whitewater kayakers. Upstream of Devil Creek, the 150 miles of river are navigable by most types of watercraft, but use is generally limited to hunters boating the segment above Vee Canyon.

Access to the river below Talkeetna is from boat ramps at Willow Creek, Susitna Landing, Sunshine, and Talkeetna, with Susitna Landing the site used the most in 1984. Access to the river above Devil Canyon is limited to the Denali Highway, and through the Lake Louise system and down the Tyone River.

The lower Susitna River is primarily used by sport fishermen, with destinations closely related to the timing and location of salmon runs. The Deshka River and Yentna River are the most common destinations downstream of Talkeetna. Fishermen and guide services use the river between Talkeetna and Devil Canyon, but use is much less than in the downstream reaches.

Operation of the Susitna Hydroelectric Project will alter the flow regime below the projects, decreasing flows in the summer as water is stored to fill the reservoirs, and increasing flows in the winter in order to meet the power demand. Changes in the flow and sediment regime caused by operation of the project are not expected to significantly affect navigation downstream of the projects. The reach from Devil Canyon to the Chulitna River confluence is completely navigable at with-project flows. Downstream of the Chulitna River confluence, a navigable main channel will exist through the open water season, although side channels will not carry as much water during the summer as under natural conditions. In about 10 percent of the years, the project will likely have some effect on navigation

through Alexander Slough during the first half of June. Alternative routes to Alexander Creek exist through Powerline Slough or via Cook Inlet.

Construction of the dams will transform about 87 miles of river from free-flowing reaches into lakes. The whitewater rapids through Devil Canyon will be covered by Devil Canyon Reservoir.

Winter transportation will not be significantly affected. Ice cover downstream of the Yentna River confluence is projected to form at about the same period as under present conditions. The ice cover is expected to progress to Talkeetna 2-5 weeks later when Watana only is operational, and 4-6 weeks later when both Watana and Devil Canyon are operational. The ice cover will progress only to between RM 124 and RM 142 when Watana is operational, and to between RM 123 and RM 137 when both Watana and Devil Canyon are operational. However, the reach above Talkeetna now sees only limited use as a winter transportation route, due to the numerous open leads and to the Alaska Railroad running adjacent to the river. The reservoir ice covers will make winter transportation more feasible in that reach of the river.

2.0 INTRODUCTION

The construction of dams at Watana and Devil Canyon will modify both the natural flow regime and the natural sediment transport regime, thus potentially affecting navigation downstream of the dams. The reservoirs formed by the dams will change a free-flowing reach of river into a flat water reach. This report discusses both past and present uses of the river, including access, destinations, and types of watercraft. Pre-project restrictions to navigation are documented. Following this, with-project changes in flow regime and river morphology and their possible effects on navigation are explored.

This report compiles all available information on navigation on the Susitna River. Much of the information was collected incident to other studies and is as such unpublished. Other data are included in various reports or memos, while some is based on personal recollection of project workers.

3.0 DESCRIPTION OF RIVER

The entire drainage area of the Susitna River is about 19,400 square miles, of which the drainage area above Gold Creek comprises approximately 6,160 square miles. Three glaciers in the Alaska Range feed forks of the Susitna River. These three branches flow southward for about 18 miles (30 km) and then join to form the Susitna River. The river flows an additional 55 miles (90 km) southward through a broad valley, where much of the coarse sediment from the glaciers settles out. The river then flows westward about 96 miles (154 km) through a narrow valley, with constrictions at the Devil Creek and Devil Canyon areas creating violent rapids. Numerous small, steep gradient, clear-water tributaries flow into the Susitna in this reach of the river. Several of these tributaries cascade over waterfalls as they enter the gorge. As the Susitna curves south past Gold Creek, 13 miles (21 km) downstream from the mouth of Devil Canyon, its gradient gradually decreases. The river is joined about 40 miles (64 km) beyond Gold Creek in the vicinity of Talkeetna by two major tributaries, the Chulitna and Talkeetna Rivers. Downstream from this confluence, the Susitna flows south through braided channels for 97 miles (156 km) until it empties into Cook Inlet near Anchorage, approximately 318 miles (512 km) from its source.

The Susitna River is typical of unregulated northern glacial rivers, with high, turbid summer flow and low, clear winter flow. Runoff from snow melt and rainfall in the spring causes a rapid increase in flow in May from the low discharges experienced throughout the winter. Peak annual floods usually occur in June, but significant rainfall flood events may occur at anytime during the summer.

Associated with the higher spring flows is a 100-fold increase in sediment transport which persists throughout the summer. Between May and September, the large suspended sediment concentrations causes the river to be highly turbid. Glacial silt, released by the glaciers when they begin to melt in late spring or when re-entrained from the river banks by high

flows, is responsible for much of the turbidity. The highly turbid water often makes it extremely difficult for boaters to determine channel depths.

Rainfall-related floods often occur in August and early September, but generally these floods are not as severe as the spring (May-June) snowmelt floods.

As the weather begins to cool in the fall, the glacial melt rate decreases, with the flow in the river correspondingly decreasing. Because most of the suspended sediment is contributed by glacial outwash, the river also begins to clear. Freezeup normally begins in October and continues through early December, progressing upstream from one natural lodgement point in the river to the next upstream lodgement point. The river breakup generally begins in late April or early May near the mouth and progresses upstream, with breakup at the damsites occurring in early to mid-May.

3.1 Susitna River Morphology

The Susitna River originates in the glaciers of the southern slopes of the central Alaskan Range, flowing 318 miles (512 km) from Susitna Glacier to the river's mouth at Cook Inlet. Throughout its course, the Susitna River is characterized by several reach types. These are defined and illustrated in Figures 3.1 through 3.4.

3.1.1 Morphological Characteristics Upstream of Devil Canyon

The headwaters of the Susitna River and the major upper basin tributaries are characterized by broad, braided, gravel floodplains downstream of the glaciers with several melt streams exiting from beneath the glaciers before they combine further downstream. The West Fork Susitna River joins the main river about 18 miles (29 km) below Susitna Glacier. Below the West Fork confluence, the Susitna River develops a split-channel configuration with numerous islands

(Figure 3.5). The river is generally constrained by low bluffs for about 55 miles (89 km). The Maclaren River, a significant glacial tributary, and the non-glacial Tyone River, which drains Lake Louise and the swampy lowlands of the southeastern upper basin, both enter the Susitna River from the east.

Below the confluence with the Tyone River, the Susitna River flows west for about 96 miles (154 km) through steep-walled canyons (Figures 3.6 through 3.8) before reaching the mouth of Devil Canyon. River gradients are high, averaging nearly 14 feet per mile (4 m per km) in the 54 mile (87 km) reach upstream of the Watana damsite where the Watana reservoir will be located. From Watana to Devil Creek, the river gradient is approximately 10.4 feet per mile (3.2 m per km). In the 12 mile (19 km) reach between Devil Creek and Devil Canyon, the river gradient averages 31 feet per mile (9.5 m per km).

This 96 mile-long (154 km) reach is primarily a single channel with intermittent islands. Bed material consists mainly of large gravel and cobbles. The mouth of Devil Canyon at RM 149 forms the lower limit of this reach.

3.1.2 Morphological Characteristics Downstream from Devil Canyon

Between Devil Canyon and the mouth at Cook Inlet, the river has been subdivided into nine separate reaches. These reaches are identified in Table 3.1, together with the average slopes and predominant channel patterns.

Through this reach, from RM 149 to RM 144, the Susitna flows predominantly in a single channel confined by valley walls (Figure 3.9). At location where the valley bottom widens, deposition of gravel and cobble has formed mid-channel or side-channel bars. Occasionally, a vegetated island or fragmentary floodplain has formed with elevations

above normal flood levels, and has become vegetated. The presence of cobbles and boulders in the bed material aids in stabilization of the channel geometry.

A broadening of the valley bottom from RM 144 to RM 139 has allowed the river to develop a split channel with intermittent, well-vegetated islands (Figure 3.10). Where the main channel impinges on valley walls or terraces, a cobble armor layer has developed with a top elevation at roughly bankfull flood stage. At RM 144, a periglacial alluvial fan of coarse sediments confines the river to a single channel.

The reach from Rm 139 to RM 129.5 is characterized by a well-defined split channel configuration. Vegetated islands separate the main channel from side channels (Figure 3.11). Side channels occur frequently in the alluvial floodplain and are inundated only at flows above 15,000 to 20,000 cfs. Where the main channel impinges on valley walls or terraces, a cobble armor layer has developed with a top elevation at roughly bankfull flood stage. The main channel bed has been frequently observed to be well armored. Primary tributaries include Indian River, Gold Creek and Fourth of July Creek. Each has formed an alluvial fan extending into the valley bottom, constricting the Susitna to a single channel. Each constriction has established a hydraulic control point that regulates water surface profiles and associated hydraulic parameters at varying discharges.

River patterns from RM 129.5 to RM 119 are similar to those in the previous reach. Prominent characteristics between Sherman and Curry include the main channel flowing against the west valley wall and the east floodplain having several side channels and sloughs (Figure 3.12). The alluvial fan at Curry constricts the Susitna to a single channel and terminates the above patterns. Comparison of 1950 and 1980 aerial photographs reveals occasional local changes in banklines and island morphology (AEIDC, 1984 draft). The west valley wall is generally nonerodible and has occasional bedrock

outcrops. The resistant boundary on one side of the main channel has generally forced a uniform channel configuration with a well armored perimeter. The west valley wall is relatively straight and uniform except at RM 128 and 125.5. At these locations, bedrock outcrops deflect the main channel to the east side of the floodplain.

From RM 119 to RM 104, the river is predominantly a very stable single incised channel with a few islands (Figure 3.13). The channel banks are well armored with cobbles and boulders, as is the bed. Several large boulders occur intermittently along the main channel and are believed to have been transported down the valley during glacial ice movement. They provide minor obstructions to flow and navigation, but do not have a significant impact on channel morphology.

At the confluence of the Susitna, Chulitna and Talkeetna Rivers (Figure 3.14), there is a dramatic change in the Susitna from a split channel to a braided channel. Emergence from the confined mountainous basin into the unconfined lowland basin has enabled the river system to develop laterally. Ample bedload transport and a gradient decrease also assist in establishing the braided pattern.

The glacial tributaries of the Chulitna River are much closer to the confluence than are the Susitna glacial tributaries. As the Chulitna River emerges from an incised canyon 20 miles (32 km) upstream of the confluence, the river transforms into a braided pattern with moderate vegetation growth on the intermediate gravel bars. At about a midpoint between the canyon and the confluence, the Chulitna exhibits a highly braided pattern with no vegetation on intermediate gravel bars, which is evidence of recent lateral instability. This pattern continues beyond the confluence, giving the impression that the Susitna is tributary to the dominant Chulitna River. The split channel Talkeetna River is a tributary to the dominant braided pattern. Terraces generally bound the broad floodplain, but provide

little control over channel morphology. General floodplain instability results from the three-river system striving to balance out the combined flow and sediment regime.

Downstream from the three-river confluence, the Susitna continues its braided pattern, with multiple channels interlaced through a sparsely vegetated floodplain. The channel network consists of the main channel, usually one or two subchannels, and a number of minor channels. The main channel meanders irregularly through the wide gravel floodplain and intermittently flows against the vegetated floodplain (Figure 3.15). It has the ability to easily migrate laterally within the active gravel floodplain, as the main channel is simply reworking the gravel that the system previously deposited. When the main channel flows against vegetated bank lines, erosion is retarded due to the vegetation and/or bank materials that are more resistant to erosion. Flow in the main channel usually persists throughout the entire year.

Subchannels are usually positioned near or against the vegetated floodplain and are generally on the opposite side of the floodplain from the main channel. The subchannels normally bifurcate from the main channel when it crosses over to the opposite side of the floodplain and terminate where the main channel meanders back across the floodplain and intercepts them. The subchannels have smaller geometric dimensions than the main channel, and their thalweg is generally about 5 feet (1.5 m) higher. Their flow regime is dependent on the main channel stage and flow. Flow may or may not persist throughout the year.

Minor channels are relatively shallow, wide channels that traverse the gravel floodplains and complete the interlaced braided pattern. These channels are very unstable and generally short-lived.

The main channel and subchannels are intermittently controlled laterally where they flow against terraces. Since the active floodplain is very wide, the presence of terraces has little significance except for determining the general orientation of the river system. An exception occurs where the terraces constrict the river to a single channel at the Parks Highway bridge. Minor channels react to both of the larger channel's behavior.

Downstream from the Kashwitna River confluence (from RM 61 to RM 42), the Susitna River branches into multiple channels separated by islands with established vegetation. The reach from RM 51 to RM 42 is known as the Delta Islands (Figure 3.16) because it resembles the distributary channel network common with large river deltas. The multiple channels are forced together by terraces just upstream of Kroto Creek (Deshka River) (Figure 3.17). Through this reach, the very broad floodplain and channel network can be divided into three categories:

- Western braided channels;
- Eastern split channels; and
- Intermediate meandering channels.

The western braided channel network is considered to be the main portion of this very complex river system. It appears to constitute the largest flow area and lowest thalweg elevation.

Terraces constrict the floodplain near the Kroto Creek confluence and at Susitna Station. Further downstream, the terraces have little or no influence on the river. The Yentna River (Figure 3.18) joins the Susitna at RM 28 and is a major contributor of flow and sediment.

Downstream from the Delta Islands, the Susitna River gradient decreases as it approaches Cook Inlet. The river tends toward a split channel configuration. There are short reaches where a tendency to

braid emerges. Downstream of RM 20, the river branches out into delta distributary channels.

Tides in Cook Inlet rise above 30 feet (9 m) and therefore control the water surface profile and to some degree the sediment regime of the lower river. A river elevation of 30 feet (9 m) exists near RM 20, which corresponds to the location where the Susitna begins to branch out into its delta channels.

3.2 Flow Regime

Continuous historical streamflow records of various record lengths exist for gaging stations on the Susitna River and its tributaries (Table 3.2). The U.S. Geological Survey gage at Gold Creek has the longest record, as it was established in August 1949. Complete 32 year monthly stremflow data sets for each gaging site were generated through a correlation analysis, whereby missing mean monthly flows were estimated (Acres, 1983). The maximum, mean, and minimum monthly flows for the sites are shown in Table 3.3. Monthly and annual flow duration curves for natural conditions for the Denali, Vee Canyon, Gold Creek, Sunshine, and Susitna Station gaging sites are illustrated in Figures 3.19 and 3.20. Weekly flow duration tables for May through September are shown in Tables 9.1 through 9.3.

4.0 DESCRIPTION OF WATERCRAFT

Both the Lower Susitna River with its numerous braided channels and the middle and upper Susitna River with their frequent sections of rapids create a boating situation in which shallow water is often encountered. As the boaters say "the river gets skinny" or "the bottom gets pretty close to the surface". This, combined with the low visibility due to silty water, dictates the use of a shallow draft craft for most boating situations. The use of this type of craft was verified in a 1984 survey by ADF&G (Howe, 1985). During 1984, boats with drafts of 8.0 inches or less comprised 90% (2,232 boats) of those surveyed at Susitna Landing, 99% (394 boats) at Talkeetna, and 99% (562 boats) at Willow Creek (Table 4.1). In this survey, 89% (2,340 boats) of the boats exiting at Susitna Landing 99% (394 boats), of the boats exiting at Talkeetna and 35% (199 boats) of the boats exiting at Willow Creek were jetboats (Table 4.2). At Willow Creek the remainder of the boats were comprised of 64% airboats (362 boats) and 1% outboard props (5 boats). The type of boat exiting at Willow Creek is often controlled by flow in Willow Creek. For example, 81% (100 boats) of the boats exiting at Willow Creek in September (low flow) were airboats.

Jetboats and airboats are both shallow draft water crafts. A description of both follows.

A jetboat (Figure 4.1) is a planing craft which is propelled by pumping in water through a submerged screen, then passing the water through a turbine and discharging it out a nozzle at a high velocity to provide thrust and steering for the boat. There is no propeller nor any other mechanisms which project below the bottom of the hull. Depending upon the size of these boats, they can successfully navigate waters as shallow as 6-8 inches when they are "on step" (planing). Planing requires fairly high speeds. Water from 16-18 inches deep is required when accelerating to planing speeds and decelerating back to a stop.

An airboat (Figure 4.2) is also a planing craft, but it relies on a large fan to provide propulsion and steering. As is the case with jetboats, no mechanisms project below the hull of the boat. These craft are able to navigate waters as shallow as 4"-6" when they are planing, and can run over gravel bars or up onto land with little problem. Shallow water is not a barrier, although the ease and speed of their travel may be hindered.

These are not the only types of boats to use the Susitna River. As recounted in the Historical Use section of this report, paddle wheel, steamboats, and barges have made use of the river. A small percentage of present day boaters use propeller-driven boats. While lacking the capability of jetboats and airboats to travel in very shallow water, this type of craft is generally more fuel-efficient and can carry a heavier load, both desirable characteristics when supplies must be hauled in by boat. A minimum of 18-24 inches of water are required to operate these boats, and their use is limited to known deep water channels and landing areas with fairly deep water. Self-propelled boats such as canoes, kayaks and rafts are also used on the river.

5.0 ACCESS TO RIVER

Access for boats is limited. The existing access points are described below. Their locations can be found on Figure 5.1.

5.1 Willow Creek

The boat landing at Willow Creek (Figure 5.2) is approximately 7 miles upstream of the creek's confluence with a side channel of the Susitna River, and is located adjacent to the Parks Highway. To reach the Susitna river, boats must travel the 7 miles on a narrow, winding stream, with numerous gravel bars and overhanging trees. The site is heavily used, since it is the access point furthest downstream on the Susitna River, and since Willow Creek is a primary salmon spawning stream. Access is a function of flow in Willow Creek, with jetboats and airboats the typical craft. Access from this site is not affected by change in flow of the Susitna River.

Due to the heavy use and the difficult boating in Willow Creek, the State of Alaska is planning the construction of a road to the mouth of Willow Creek, with a boat ramp on the Susitna River. When this new access is completed, it will likely become the most heavily used access point, due to its accessibility to the large population centers of Anchorage and Wasilla, and to its close proximity to the major sport fish areas of the Deshka River and the Yentna River.

5.2 Susitna Landing (Kashwitna River)

The Susitna Landing access point is located on the Kashwitna River, approximately 200 yards upstream of its confluence with the Susitna River at RM 61 (Figure 5.3). It is currently the most heavily used access point on the lower Susitna River, with about 57% of the boaters surveyed during July-September 1984 using this site (Howe, 1985). Both backwater effects from the Susitna River and flow in the Kashwitna River control the access

to and from this site. Two ramps are located at Susitna Landing. Access to and from the upstream ramp is possible during very low Susitna flows (when backwater effects are less) but is made difficult due to a gravel bar just downstream of the ramp. The bar is difficult to steer around when the boat is at low throttle, as the draft of the boat is deeper and the current is strong. When launching, boaters usually avoid this problem bar by boating upstream on the Kashwitna, then turning and getting the boat "on step" so that boat draft is minimized when passing the bar. The second ramp is downstream of this bar and is not affected by it.

5.3 Sunshine

The Sunshine site (Figure 5.4) has a gravel ramp leading to a single channel reach of the lower Susitna at RM 83.8, providing access even at very low flows. Boaters using this site were not surveyed in 1984. However, the site was observed by R&M hydrologist during several aerial overflights of the lower Susitna during the summer. While the number of boats using the site was not quantified, it appeared that the site was not heavily used, presumably because the most frequent destinations (Yentna River, Deshka River, Talkeetna River, and Portage Creek/Indian River) are more easily accessible from other landings.

5.4 Talkeetna

At Talkeetna, the boat landing is located on the Talkeetna River (Figure 5.5) about 1 mile upstream of its confluence with the Susitna River at RM 97. The site is upstream of any backwater effects from the Susitna, so is not directly affected by flow in the Susitna River.

5.5 Alaska Railroad/Aircraft

Although a boat ramp is not located between Talkeetna and Devil Canyon, boaters using self-propelled craft (canoes, kayaks, and rafts) may use either the Alaska Railroad or small aircraft to reach upstream points. The

small craft may be loaded on the Alaska Railroad at Talkeetna and transported as far upstream as the bridge at Gold Creek at River Mile (RM) 136.5 (Figure 5.6) or to the bridge over Indian River, about 1 mile above its confluence with the Susitna River at RM 138.5. Whitewater kayakers sometimes use helicopters and float planes to reach the river upstream of Devil Canyon. The Devil Creek to Devil Canyon rapids is one of the most outstanding and challenging kayak runs in the world, so difficult that, as of September 27, 1982, only 29 runs (17 successful) had been made through it since the first attempted descent in 1972 (Knik Kanoers and Kayakers, 1983). No reported attempts at rafting the rapids have been found.

5.6 Denali Highway/Lake Louise

The Susitna River from Devil Creek at RM 162 (head of Devil Canyon) to the headwaters is accessible from the Denali Highway at either Denali or at the Maclaren River. Boaters may also reach the upper Susitna by boating through the Lake Louise - Lake Susitna - Lake Tyone system and continuing down the Tyone River.

Historically, the upper Susitna River has never received a large amount of usage due to the barrier to upstream and downstream passage provided by the Devil Canyon rapids. Until the Denali Highway was opened in 1957, the upper reaches of the Susitna River were virtually inaccessible. Since 1957, the primary use of the upper Susitna River from Denali downstream to the confluence with the Oshetna River has been by hunters. Below the Oshetna River is a section of rapids which, while navigable by either an experienced kayaker or jetboater, is not frequently attempted. Even if this section is successfully negotiated, there are no downstream take-outs for jetboaters above Devil Creek, and either a long portage around Devil Canyon or a fly out are required by kayakers.

6.0 DESTINATIONS

6.1 Cook Inlet to Talkeetna

The major use of the Susitna river is by sport fishermen (Howe, 1985). Other uses of the river are often tied into providing services for the fisherman. Therefore, the destinations of almost all boaters are to the areas where fishing is best. In the river below Talkeetna, this is restricted to streams and sloughs which enter the Susitna. The two most productive salmon fishing areas are the Deshka River and tributaries to the Yentna River. These two areas are major destinations of most boaters.

The primary destinations for boaters using the Willow Creek landing were the Deshka River and Willow Creek itself, with some boaters also going to the Yentna River and Little Willow Creek later in the season (Table 6.1). Destinations are closely related to the timing of salmon runs. Figure 6.1 illustrates the migrational timing of the five species of salmon found in the Susitna River. The Deshka River has a major run of king salmon in June, resulting in the overwhelming selection of the Deshka River as the primary destination in June. Later salmon runs are in the Deshka River, Willow Creek, Little Willow Creek, other tributaries to the Susitna, and tributaries to the Yentna River, resulting in a wider diversity of destinations later in the summer. Many of the boats never leave Willow Creek.

A similar pattern was noted for boaters leaving Susitna Landing (Table 6.2). The Deshka River was the primary destination in May and June, with Yentna River, Willow Creek, and Alexander Slough also visited. When later salmon runs reached other tributaries and when the hunting season started in September, the diversity of destinations increased.

The breakdown of major destinations of boaters on the lower Susitna River is further illustrated in Table 6.3, with secondary destinations also included. Table 6.3 also illustrates the destination pattern based on the

major sporting seasons of king salmon fishing, other salmon fishing, and hunting.

6.2 Talkeetna to Devil Canyon

The vast majority of boaters that use the access area at Talkeetna boat up the Talkeetna River (Table 6.4). Middle Susitna River usage has been recently dominated by Susitna River Study teams. Other boaters using the Middle Susitna River are primarily fishermen and guide services, with destinations of Indian River, Portage Creek and Devil Canyon. A recent state land disposal along Indian River and the Susitna River above Indian River may generate increased traffic in this reach of the river.

6.3 Upstream of Devil Canyon

As previously described, little use is made of the river between Devil Canyon and the Oshetna River except for limited whitewater kayaking trips. No specific destinations have been identified along the reach above the Oshetna River, with boaters primarily using the river for access to hunting areas.

7.0 USE OF RIVER

7.1 Historical Use

The historical use of the Susitna River is recounted in the BLM Navigation Study of Southcentral Alaska (Bureau of Land Management, 1983). This report details the use of the river from its first ascent by white men in the spring of 1896, up to the present. The following accounts are excerpted from this report.

The early trips were made in hand-made riverboats, usually by prospectors or government agents. These often took on epic proportions, with some trips exceeding a year in length.

Technical details of the early navigation of this river are best recounted in a letter of October 2, 1898 in which W.G. Jack told of his trip up the Susitna River to Captain Edwin F. Glenn, who was then planning to send a detachment of soldiers up the Susitna River on a topographical survey.

> ". . . . . we used small boats and depended upon rowing and cordelling them. In my best judgment a properly constructed boat drawing not to exceed 2 feet of water can navigate this river (Susitna) from its mouth as far as the forks (Talkeetna), and from that point up the Middle Fork for a distance of about 37 miles, or to Indian Creek [River]. The only obstacle to be overcome in this fork is a sand bar. They may not exist another season, but during this season it confined the current to a very narrow, swift channel. At no stage of water have I found this river with a channel that did not contain sufficient water to float a vessel of the draft above mentioned. The mean fall in this river from the forks to its mouth is about 3 feet to the mile. In the main fork [Middle Fork] the mean fall is about 7 or 8 feet to the mile. The current is about the same as that of the Missouri River, or from 4 to 5 miles per hour, in the main stream, and probably a mile (per hour) more in the fork. The

> difficulty in navigating this stream will be greater in descending than in ascending. The type of boat for this stream must be a flat-bottomed, stern-wheel, with sufficient power to enable it to be checked quickly, especially in descending the river. The principal reason for this, aside from overcoming the current and handling the boat readily, is that the channels change frequently and quickly, and freshets bring down a great amount of driftwood in the shape of large trees, which must be avoided. The changes in the channels are so easily, quickly, and frequently made that the same channel used in going up will not be used in coming down on the same trip. The total navigable distance, according to the above, is 119 miles, which a boat would have to travel at least 130 miles to overcome."

Following these early explorations the belief was formed that the Susitna was navigable for powerboats, at least up to Indian River. This was successfully put to the test in 1907. During the period from 1907-1910 propeller-driven barges made several trips to Indian River (Figure 7.1 and cover). These trips were limited to periods of high water. Their main purpose were to supply miners in the Valdez Creek area and to transport supplies for the building of the Alaska Railroad. Paddle wheel driven steamboats were also used on the river, but their destinations were usually limited to the lower 30 miles of the river (Figure 7.2).

When the Alaska Railroad was completed in the early 1920's, use of the Susitna River as a supply route came to an end. Since then the boating use of the river has been left to sportsmen and homesteaders.

7.2 Summer Use

Present day use was documented during the summer of 1984 by an ADF&G user survey (Howe, 1985) made of boaters exiting the Susitna River at the three main access points of Willow Creek, Susitna Landing, and Talkeetna (Figure 5.1). At all of these sites sporting use, with fishing being the dominant sport, is the primary purpose of the boaters.

Sport fishing was the main activity engaged in by boaters exiting at Willow Creek in 1984 (Tables 7.1 and 7.2). During July and August, 174 boats (78%) and 160 boats (71%), respectively, identified sport fishing as the main activity. Another 27 boats (12%) and 20 boats (9%) identified sport fishing as a secondary activity during the same two months. During September, 29 boats (22%) identified hunting as the main activity, with another 75 boats (58%) identifying it as a secondary acctivity. During July through September, boaters exiting at Willow Creek indicated their main activities as sport fishing (342 boats - 60%), transportation (56 boats - 10%), hunting (32 boats - 6%), and private supply (32 boats - 6%).

Sport fishing was also the main activity identified by boaters exiting at Susitna Landing (Tables 7.3 and 7.4) during May (328 boats - 80%), June (783 boats - 83%), July (252 boats - 58%), and August (215 boats - 61%). Private supply and transportation were also significant activities for each of the summer months. For May through September 1984, boaters exiting at Susitna Landing indicated their main activities as sport fishing (1,585 boats - 60%), private supply (293 boats - 12%), and transportation (228 boats - 10%).

During Juy through September at Talkeetna, boaters indicated that sport fishing was the main activity (156 boats - 39%), but that transportation (59 boats - 15%), the Susitna study (54 boats - 14%), and sightseeing (27 boats - 7%) were also major activities (Tables 7.5 and 7.6). Talkeetna is the most upstream access point to the major study areas in the middle Susitna River, and is also the primary access point for guides taking sightseers to Devil Canyon.

Not surprisingly, the major users of the river where those from the Municipality of Anchorage (Group 2, Chugiak to Girdwood), as seen in Table 7.7. Local residents (Groups 1 and 4) also frequently use the river. Most boaters indicated they planned to use the river many times during the summer (Table 7.8), with over 46% of those surveyed at Susitna Landing planning to use it from 11-20 times.

To help relieve the intense fishing and boating pressure on the Kenai River by Anchorage residents, the State of Alaska is planning to develop increased boat access to the Susitna River. A major component of the State's plan is development of the proposed Willow Creek State Recreation Area. The proposed recreation area is located along Willow Creek, accessible via the Parks Highway to the major population centers of Anchorage, Eagle River, and Wasilla. Facilities proposed for the park include an access road leading from the Parks Highway to the mouth of Willow Creek, development of trails and campgrounds, and construction of a boat launch on the Susitna River just downstream of the mouth of Willow Creek. This new access point will greatly increase the ease and convenience of boating on the lower Susitna River. The development of this recreation area, together with the increasing population of the Anchorage area, indicates increased usage of the lower Susitna River as a recreational resource.

The Susitna River above Portage Creek sees only limited use. The steep gradient, high canyon walls, lack of access and take-out points, and heavy rapids at Vee Canyon and from Devil Creek to Devil Canyon limit recreational use below the Oshetna River primarily to whitewater kayakers. The rapids in the 12-mile reach from Devil Creek to Devil Canyon are considered world-class, and are navigable by a limited number of experts. If this 12-mile reach is not run, the only other ways out of the river are to be flown out, to portage around Devil Canyon, or to portage to Stephen Lake and go down the Talkeetna River.

Above Vee Canyon, the primary use of the river is by hunters during September. Access was very limited until construction of the Denali Highway. Statements by local residents (Cole, 1979) indicated that "95-100 percent of traffic on the river is in the first two weeks of September every year. During that time . . . . there might be 30-35 boats on the river. Most of the hunters are after moose, but there are some caribou and brown bear hunters as well. According to Huttnen, among the boats there are air boats, canoes with props, riverboats with jet units and

props, large inboard jets with 307 Chevrolet engines and others". The river is deep enough above the mouth of the Tyone River to accomodate any conventional craft.

7.3 Winter Uses

The Susitna River sees only limited use as a transportation corridor during the winter, with the primary use in the reach below the Parks Highway Bridge. Frequent open leads often make snowmachine travel hazardous, especially upstream of Talkeetna. The Alaska Railroad parallels the river from Talkeetna to Gold Creek, providing ready access to this reach. The river upstream of Gold Creek is very remote and inaccessible except in the area of the Denali Highway, which is usually not maintained during the winter. The few people who overwinter near Denali occasionally snowmachine along this braided portion of the river.

The areas around Susitna Station and the mouth of the Deshka River see the most frequent use. Several year-round residents live at Susitna Station. The Iditarod Trail also crosses the Susitna River at Susitna Station. The Deshka Silver-King Lodge, at the mouth of the Deshka River, stays open year-round, and is a popular destination for cross-country skiers, who must cross the Susitna River at about RM 42.

8.0 NAVIGATION RESTRICTIONS

8.1 Cook Inlet to Talkeetna

The lower portion of the Susitna River is braided, silty, and constantly changing. A deep main channel exists from Talkeetna to Cook Inlet. In most places this main channel has numerous side channels branching from it. Depth of water in these side channels is dependent on flow rate and channel morphology. Side channels navigable at high flow will sometimes dewater or have long shallow reaches at lower flows. At high flows, several routes are usually available to the boater to reach his destination. At lower flows, boaters may have to take a more circuitious route in order to have sufficient depth to navigate. High flows sometimes increase navigation hazards. During a flood, there are usually a large number of floating trees. Also, many familiar landmarks are covered by water and new channels are opened. The highly turbid water makes it difficult to determine the depth of water in the new channels and along the edges of gravel bars.

The boater's experience on the river and with his type of boat also determine navigation routes. Those who use the river often are familiar with its characteristics under a variety of flow conditions. They also know how their boat reacts, and what its limitations are. These boaters are familiar with the best routes for their particular craft, and may quickly react to varying conditions. Those boaters with less experience on the lower Susitna River often find it confusing at first, due to its broad floodplain and multiple channels. It is quite possible to select a channel which looks good at its entrance, only to find that it may rapidly become shallow with no place left to take the boat. As boaters gain more experience on a particular reach of river, their navigation problems tend to decrease.

At times, even experienced boaters may have navigation problems on the Susitna River. Large flood events tend to cause significant bed material

transport, with major channels sometimes shifting several hundred yards in a few days. Log and debris jams may block previously navigable channels and cause channel shifts. Gravel bars may have moved to new locations. Boaters have no option but to exit as gracefully as possible when they encounter these new conditions.

8.1.1 Cook Inlet (RM 0) to Yentna River Confluence (RM 28)

A deep channel exists from the Yentna River downstream to Cook Inlet. The major destination for boaters in this reach of river is Alexander Creek. During moderate-to-high flows, boaters often travel through Alexander Slough (Figure 8.1), which is actually a major side channel west of the main channel. As flows drop, insufficient flow enters the channel at the upstream end (RM 19) and Alexander Slough generally becomes unnavigable except for airboats. When this occurs, boaters have the options of either going through Powerline Slough at RM 6.5 (Figure 8.2) or else continuing to Cook Inlet and then going up the west channel. Use of Powerline Slough is common for residents of Susitna Station (Hawley, 1984). Examination of aerial photographs indicates that Alexander Slough is navigable by jetboats at Susitna Station flows of 67,800 cfs, but that only airboats could navigate it at Susitna Station flows of 51,400 cfs. Numerous shifting sand bars exist in this side-channel.

8.1.2 Yentna River Confluence (RM 28) to Susitna Landing (RM 61)

This reach of river is the most frequently used on the Susitna River, as it includes the major salmon fishing areas (of Willow Creek, Deshka River , and Yentna River) and the major access points (Willow Creek and Susitna Landing). The reach has multiple channels separated by vegetated islands, and includes the segment known as Delta Islands (RM 51 to RM 42).

Table 8.1 summarizes the navigational problems indicated in the 1984 ADF&G survey (Howe, 1985). The survey indicated only whether navigational problems were encountered, but did not include either the severity of the problem or its location. At Susitna Landing, boaters indicated more problems with debris and high velocities in May and June, with problems with bars becoming more prevalent in late summer when the flows decreased. Boaters at Willow Creek indicated more problems with bars and rocks. It is likely that many of these problems were encountered on Willow Creek itself, as boaters must travel along its narrow, winding course for seven miles before reaching the Susitna River. The types of boats used changed during the summer, with airboats more commonly used late in the summer.

Locations of specific navigation problem areas in this reach were determined from examination of aerial photographs, from discussions with local residents, boaters, and ADF&G study crews, and from observations during aerial overflights and boating trips. Only those problems concerned with either major channels or with access will be discussed. Many channels navigable at high flows may dewater at lower flows.

During low flows at Susitna Landing (mouth of Kashwitna River), boaters may encounter problems reaching the main channel when they attempt to go upstream into the Susitna side channel into which the Kashwitna River empties (Figure 8.3). However, no problems are encountered when entering or leaving the downstream end of this channel. R&M hydrologists observed jet boats on the main channel at RM 60.8 on September 12, 1984 (flow at Sunshine = 22,700 cfs).

Downstream of Susitna Landing, the main channel is located in the braided segment on the west side of the floodplain. The channel can be easily followed, although some problems may be encountered when boaters attempt to take shortcuts through other channels. Three major channels flow through the Delta Islands. Boaters from Susitna

Landing usually travel down the western channel, as it is the shorter and quicker route to the Deshka and Yentna Rivers. Jetboats were observed by R&M hydrologists at RM 52.5, RM 47.5, and RM 43.7 on September 12, 1984, with average daily flow at Sunshine equal to 22,700 cfs. Although the center channel is sometimes used, it is generally narrower and shallower than the other channels. Since Willow Creek flows into the eastern channel, boaters commonly continue down it to the Deshka River and beyond. Boats were observed at the mouths of Willow Creek and Little Willow Creek when flow at Sunshine was 17,800 cfs.

Near RM 51, shifting gravel bars and falling trees create a navigation problem where the river enters the Delta Islands reach. The channel just upstream of the island at RM 51 (Figure 8.4) was navigable for most of 1983 and 1984, but a falling tree blocked it in September 1984, forcing boaters to use a shallow channel just upstream. This channel was navigable at a Sunshine flow of 31,200 cfs by a propeller-driven riverboat which required 18 inches of water (Ellithorpe, 1984).

The Delta Islands are considered to end where the eastern and western channels meet at RM 42.5. A well-defined deep channel exists from this point past the confluence with the Deshka River (RM 40.5) to the confluence with the Yentna River (RM 28). Several jetboats were observed on the main channel along this reach by R&M hydrologists on September 27, 1984, when the average daily flow at Sunshine was 17,800 cfs. Numerous side-channels branch off in this reach, but they do not provide access to any additional fishing areas. Kroto Slough branches off to the southwest as a side-channel at RM 40 (Figure 8.5). Two gravel bars control flow through this channel, one at the head of the side-channel at RM 40, and another at the head of the slough where it branches off from the side-channel and continues to the Yentna River. Kroto Slough provides limited access during high water to a number of remote parcels along its length.

Flow is maintained in its lower reaches by several small tributary streams.

8.1.3 Susitna Landing (RM 61) to Talkeetna (RM 97)

Only a small number of boaters appear to use this reach of river, with the possible exception of during hunting season. No major salmon spawning streams are located on the west side of the river. Several important salmon spawning streams, including Sheep Creek, Goose Creek, Montana Creek, Sunshine Creek, and Birch Creek, join the Susitna River or its side channels along the east bank. The backwater zone at the mouth of Caswell Creek is also an important salmon fishing area. Except for Sheep Creek and Birch Creek, the mouth of each of the above streams can be reached by short walks from roads leading off the Parks Highway, limiting the need to boat to those areas.

Sheep Creek empties into a side-channel at about RM 66 (Figure 8.6). Jetboats were observed up to RM 64.5 on this side-channel at Sunshine flows of 22,700 cfs. It appeared that they could continue to the confluence with Sheep Creek, although navigation past a gravel bar may have been difficult. Airboats would have had no problems.

Birch Creek joins the Susitna side channel at about RM 88.2 (Figure 8.7). Travel down the side-channel past the gravel bars controlling flow may be difficult at low flow, but access is feasible up the lower end of the side channel.

Access can be gained to this reach of the river at Susitna Landing (RM 61), Sunshine (RM 83.8), or Talkeetna (RM 97). As previously mentioned, the Sunshine site does not appear to be frequently used.

Jetboats were observed to be navigating this reach of the river at Sunshine flow of 22,700 cfs. The major navigational problems are in

the braided sections of the river where numerous channels branch off. Jetboats and airboats should not have problems, but riverboats using propellers without a lift could encounter difficulties at low flows.

8.2 Talkeetna (RM 97) to Devil Canyon (RM 150)

Access to this reach is primarily from Talkeetna. For most of the summer, boats leaving the Talkeetna River at RM 97 go upstream along the east side-channel to reach the mainstem of the Susitna River (Figure 8.8). However, this route becomes increasingly difficult at low flows, and boaters sometimes boat downstream to where the channel joins the mainstem at RM 95, then continue up the Susitna River.

Upstream of its confluence with the Chulitna River, the Susitna becomes more channelized with either a single channel or split channel morphology up to Devil Canyon. Numerous side channels exist which are navigable at high water, but which dewater at lower flows. The main channel is navigable by jetboat to Devil Canyon.

Isolated large boulders exist in some portions of the channel (Figure 8.9), but they are easy to navigate around. The only potential navigation problem area was identified by Janke (1982) as a broad shallow reach below Sherman at RM 128, where the main channel crosses the floodplain (Figure 8.10). This area was subsequently surveyed (R&M, 1982c) and a deepwater channel found. This location was later navigated without problem by jetboat at a flow rate of 6,300 cfs (measured at the Gold Creek gage).

Steve Mahay, local guide, has traveled this reach of the Susitna River for nine years and has reported no navigational problems (Mahay, 1984). He did comment that after a flood it is a bit more difficult to read the river due to shifting gravel bars.

8.3 Devil Canyon (RM 150) to Devil Creek (RM 162)

This is the steepest (gradient of 31 feet/mile) and most treacherous reach of the Susitna River, and is navigable only by expert whitewater kayakers at low-to-moderate flows. Access is either by helicopter or by floating down from the Denali Highway. In recent years, this reach has gained a reputation as one of the most difficult whitewater runs in North America. The first successful kayak run was recorded in 1976. Since then, a handful of successful trips have been completed, mostly at flow rates less than 26,000 cfs at Gold Creek. A 22-foot jet boat attempted to run upstream through the canyon in 1982, but was quickly sunk.

8.4 Upstream of Devil Creek

Although steep and swift, the river upstream of Devil Creek is navigable by most types of watercraft. Numerous rapids exist, but they are navigable. The most serious rapid is located at Vee Canyon, where several large standing waves occur. Upstream of Vee Canyon, the river is deep and relatively easy to navigate.

9.0 WITH-PROJECT CHANGES IN FLOW REGIME

Operation of the Susitna Hydroelectric Project will alter the flow regime below the projects, decreasing flows in the summer as water is stored to fill the reservoirs, and increasing flows in the winter in order to meet the power demand. The weekly flow duration values for week 32 (May 6 - May 12) through week 52 (September 23 - September 30) are shown for gaging stations at Gold Creek, Sunshine, and Susitna Station. Three conditions are tabulated; natural; 1996 load with Watana only operating; and 2020 load with both Watana and Devil Canyon operating. The flow duration values are those derived for the Case E-VI flow alternative (Harza-Ebasco, 1984a), which is shown in Table 9.1.

The change in flow regime is most noticable at Gold Creek (Table 9.2). With-project flows are less than natural flows under all conditions from week 35 to week 45, or from late May to mid-August. Maximum flows are sharply reduced, although the tables indicate that relatively high flows may occasionally occur in August and September, when the reservoir is full. With-project flows are occasionally greater than natural flows, as seen for weeks 32-34 (early to mid-May) and weeks 46-52 (mid-August through September). Minimum weekly flow in the middle Susitna River during the open-water water season is 5,990 cfs in mid-May and late September, with flows of 7,990 cfs exceeded from June through August.

Changes in flow are not as significant at Sunshine (Table 9.3) and at Susitna Station (Table 9.4), although patterns similar to those at Gold Creek occur. The Chulitna and Talkeetna Rivers enter the Susitna River upstream of the Sunshine, minimizing the impacts of flow regulation.

Flows exceed 30,000 cfs at Sunshine under most conditions from early June to mid-August. After mid-August, low flows under with-project conditions are usually only slightly less than low flows under natural conditions, and in some cases exceed natural flows.

10.0 WITH-PROJECT CHANGES IN RIVER MORPHOLOGY

Changes in river morphology will vary along the length of the river. Consequently, the expected changes will be described for each reach of river from the reservoirs downstream to Cook Inlet.

10.1 Watana Reservoir

Watana Dam is to be the first project constructed. During construction, little change in river morphology will occur except at the damsite itself, where cofferdams will divert all flow through two tunnels on the north abutment. Tunnel No. 1 will have its inlet above the river bed level and its outlet at the river bed level. Tunnel No. 2 will have both the inlet and outlet below the river bed level. All river flows up to approximately 20,000 cfs can be passed solely through Tunnel No. 2. Because of its lower elevation, Tunnel No. 2 will also pass all sediment loads past the damsite. Consequently, no interruption in sediment load is anticipated, so no changes in downstream river morphology are expected.

Once filling of the reservoir commences, the character of the river immediately upstream of the dam will change from a fast-flowing river with numerous rapids to a still-water reservoir. The reservoir will ultimately extend 54 river miles upstream, terminating 8 miles downstream from the confluence with the Tyone River, and will inundate the major rapids at Vee Canyon. During project operation, the actual upstream extent of the reservoir will depend on the reservoir level.

10.2 Devil Canyon Reservoir

After Watana Dam is constructed, but before Devil Canyon Dam is constructed, the river reach from RM 151 to RM 184 will tend to be shallower and narrower than under natural summer conditions. Velocities will be less than under natural summer flows. In some places, especially in Devil Canyon, more rocks and boulders will be exposed.

When Devil Canyon dam is being built, the most significant impacts will be at the damsite, as the rapids at the upper end of Devil Canyon will be blocked off and approximately 1100 feet of the Susitna River between the upstream and downstream cofferdams will be dewatered.

The major impact on this reach during filling and operation of Devil Canyon Reservoir will be the transformation of this reach from a free-flowing river into a reservoir.

10.3 Devil Canyon to the Chulitna River Confluence

During filling and operation of the Watana and Devil Canyon Reservoirs, the trapping of bedload and suspended sediment by the reservoirs will greatly reduce the sediment being transported by the Susitna River in the reach from Devil Canyon to the Chulitna River confluence. Analyses have indicated that channel degradation will be small in this reach, generally less than 0.3 feet, due to the large bed material. The reduced flood flows will be unable to transport as much or as large of bed material as under natural conditions. The estimated armoring sizes for with-project condition are considerably smaller than those for natural conditions because of the smaller dominant discharge (Harza-Ebasco, 1984b). The Susitna River main channel in this reach will tend to become better defined with a narrower channel (R&M, 1982a). The main channel river pattern will strive for a tighter, better defined meander pattern within the existing banks. A trend toward channel width reduction by encroachment of vegetation will begin. Tributary streams will extend their alluvial fans into the river (R&M, 1982a), with some aggradation expected downstream of the tributary mouths (Harza-Ebasco, 1984b).

Overflow into many of the side-channels will be significantly reduced by regulation of the summer floods. The backwater effects at the mouths of side channels and sloughs will be reduced. These factors will lead to vegetation encroachment in the side channels and sloughs.

The channel cross-section obtained at the potential navigation restriction area at RM 128 is shown on Figure 10.1, together with summer flow levels for natural and with-project conditions. An aerial view of this reach at 7,500 cfs (500-1,500 cfs less than with-project flow conditions) is seen in Figure 8.10.

10.4 Chulitna River Confluence to Cook Inlet

Project effects on sediment transport in this reach will depend primarily on the change in the the bedload transporting capacity of the Susitna River below its confluence with Chulitna and Talkeetna Rivers. Under with-project conditions the reduction in summer flows from the Susitna River will result in a decrease of the total sediment discharge capacity at Sunshine to about 55 percent of that under natural conditions. With 80 percent of the total sediment load coming from the Chulitna and Talkeetna rivers, long-term aggradation can be expected. It is expected that aggradation will start at the mouth of the Chulitna River. Existing delta formation will further develop and extend towards the left bank below the confluence (Harza-Ebasco, 1984b). The aggradation is not expected to be significant downstream of the Sunshine bridge. The estimates of aggradation are being refined, using the IALLUVIAL model developed by the Iowa Institute of Hydraulic Research.

Downstream of the Susitna-Chulitna confluence, the frequency of occurrence of dramatic changes in river morphology will decrease under with-project conditions, resulting in a more stabilized floodplain, decreased number of subchannels, and increased vegetative cover. However, an extreme flood event generated by either the Chulitna River or Talkeetna River could still cause significant morphologic changes. Project impacts on river morphology will decrease further downstream as more tributaries enter the Susitna. By the time the Yentna River enters, project effects on river morphology would be extremely difficult to quantify.

11.0 WITH-PROJECT CHANGES IN THERMAL AND ICE REGIMES

Changes in the thermal and ice regimes downstream of the reservoirs are relevant to navigation primarily in determining the open-water season for boating and the ice-covered period for winter transportation. The periods of most interest are therefore the freeze-up and breakup periods.

Under natural conditions, frazil ice is first generated in the upper reaches of the Susitna River. This portion of the basin is higher, farther north, and in the continental climate zone, resulting in colder temperatures earlier in the winter. Until river water temperatures drop to 0°C throughout the length of the river, the ice melts before reaching Cook Inlet. Ultimately, sufficient ice is being contributed by the Susitna and its tributaries to form an ice bridge near RM 9, usually during a high tide cycle. Formation of the ice bridge blocks the passage of ice to Cook Inlet, and the ice cover progresses upstream as ice is added to the upstream edge. Depending on meteorological conditions, and on the formation of additional ice bridges on the lower Susitna River, the ice cover normally reaches Talkeetna from early November to early December. The ice front progression continues upstream of Talkeetna, but at a slower rate due to the steeper gradient. The ice front reaches Gold Creek sometime between mid-December to mid-January. Ice cover formation between Gold Creek and Devil Canyon is usually by anchor ice dam and border ice growth. Upstream of Devil Canyon, ice cover formation is both by upstream progression from ice bridges and by border ice growth.

Operation of the projects will result in water being released in fall and winter in greater volumes and at higher temperatures than occur under natural conditions. The reservoirs will also trap the ice generated in the upper reaches. Consequently, freeze-up will be delayed by several weeks. Melt-out of the ice cover will occur earlier. The actual timing of these events is dependent on the distance downstream from the reservoirs, meteorological conditions, and the discharge. Estimate of with-project ice-conditions have been made using the ICECAL simulation model

(Harza-Ebasco, 1984). Those results are summarized below. The simulations are for the reach between the Chulitna confluence and Gold Creek only.

Although ice contributions from the Susitna River above Talkeetna will be greatly reduced during the early freeze-up period, the assumption has been made that sufficient ice will be contributed by the Yentna, Chulitna, Talkeetna, and lower Susitna Rivers to form an ice bridge near RM 9 in late October, the same as under natural conditions. Based on this assumption, November 1 was selected as a representative date on which the lower Susitna ice front would reach the Yentna confluence under with-project conditions (Harza-Ebasco, 1984c). The ICECAL model and related computations of tributary frazil ice production were initated on November 1 of each simulation year in order to estimate the time required to form an ice cover on the Susitna River up to the Chulitna confluence. Once the ice cover reached the Chulitna confluence, detailed modelling was conducted of ice cover progression on the Middle Susitna. The reservoir release temperature policy used in the simulations attempted to match the natural stream temperatures incoming to the reservoir.

When Watana is operating alone, the ice front is expected to reach the Chulitna confluence 2 to 5 weeks later than under natural conditions. A gradual spring melt-out above the Chulitna confluence will occur 5 to 7 weeks earlier than the natural mechanical breakup, and will continue downstream of Talkeetna. Maximum upstream extent of the river ice cover during the simulated warm, average, and cold winters is expected to range from RM 124 to RM 142. The maximum total and solid ice thicknesses are expected to be generally similar to those of natural conditions.

When both Watana and Devil Canyon are operating, the ice front is expected to reach the Chulitna confluence 4 to 6 weeks later than under natural conditions. Completion of the spring melt-out above the Chulitna confluence is expected 7 to 8 weeks earlier than the natural breakup, or by early to mid-March. The maximum extent to ice cover would range

between RM 123 and RM 137. The maximum total and solid ice thicknesses are expected to be typically 1 to 2 feet less than those of natural conditions.

12.0 IMPACTS ON OPEN-WATER NAVIGATION

12.1 Watana Reservoir

Since all flow will be diverted through tunnels during construction of Watana Dam, the only effect on navigation will be in the immediate vicinity of the dam and its diversion tunnels. The cofferdams will form an obstacle which will be difficult to circumvent. However, since use of this river reach is limited, the effect is expected to be minimal.

Once impoundment of the reservoir commences, the character of the river immediately upstream from the dam will change from a fast-flowing river with numerous rapids to a still-water reservoir. The reservoir will ultimately extend 54 river miles (87 km) upstream, terminating 8 miles (13 km) downstream from the confluence with the Tyone River, and will inundate the major rapids at Vee Canyon. The reservoir will make possible increased boat traffic to this reach of river by decreasing the navigational hazards through Vee Canyon. Reservoir water craft navigation will extend to November because of the delay in ice cover formation.

12.2 Devil Canyon Reservoir

The reduced summer flows released from Watana Reservoir during its filling and operation could reduce the navigation difficulties between Watana and Devil Canyon during the summer months. However, the lower segment of this reach (from Devil Creek to Devil Canyon) will still consist of whitewater rapids suitable only for expert kayakers.

During construction of Devil Canyon Dam, the reach from Watana Dam to Devil Canyon Dam will be navigable, at flows less than natural conditions. The rapids downstream of Devil Canyon will remain extremely difficult. The whitewater rapids at Devil Canyon will be eliminated because of construction activities.

During filling, the rapids upstream from Devil Canyon will be inundated and whitewater kayaking opportunities will be lost. Since the water surface level of the reservoir may be rising as much as 8 feet (2.4 m) per day during filling, the reservoir will be unsafe for boating. Downstream water levels may be slightly less than normal Watana operation levels, but this will not affect navigation because the change will be confined to the fall and early winter season.

The Devil Canyon reservoir will transform the Devil Canyon rapids into calm water. This will provide recreational opportunities for leisure boaters, but will totally eliminate the world-class whitewater kayaking opportunities.

12.3 Devil Canyon to Chulitna River Confluence

Summer flows downstream of the dam will generally be reduced from natural conditions during operation of either Watana alone or of Watana/Devil Canyon together, except during drought periods in late summer and fall (Table 9.2). Flows will exceed 7,990 cfs from June through early September, after which flows are gradually decreased to 5,990 cfs by the end of September. The only identified navigation problem in this reach, a channel cross-over near RM 128, has been successfully navigated at flows of 6,300 cfs.

Navigation will not be significantly affected in this reach. In fact, several navigational benefits will occur. The navigational hazard of floating trees and debris will be eliminated in most years, due to the elimination or reduction of flood flows. Also, turbidity will significantly decrease, improving visibility.

12.4 Chulitna River Confluence to Yentna River Confluence

Downstream of the Chulitna River confluence, the main channel is completely navigable at flows exceeding approximately 25,000 cfs, especially

for jetboats and airboats. Below 25,000 cfs, specific areas may be difficult to navigate, such as the entrance to the west channel at the head of the Delta Islands (RM 51). The difficulty of navigation will be dependent on the boat draft, on recent changes in channel morphology, and on tree and debris jams. At least one deep water channel should exist from the main access points of Susitna Landing and Willow Creek to the main destinations of the Deshka and Yentna Rivers.

The flow duration data in Table 9.3 indicates that 25,000 cfs will be exceeded 100 percent of the years for week 37 (June 10 - June 16) through week 45 (August 12 - August 18), and at least 90% of the years from week 46 (August 12 - Augut 18) through week 48 (August 26 - September 1). Minor difficulties may exist in this reach during late May to early June and during September. In September, with-project flows will be very similar to those under natural conditions. Any navigational problems experienced during September would also have been experienced under natural conditions.

12.5 Yentna River Confluence to Cook Inlet

The primary destination in this reach is Alexander Creek. During high flows, boaters often use Alexander Slough. At lower flows, numerous sand bars make Alexander Slough difficult to navigate for jetboats, so boaters then either go through Powerline Slough or down the east channel to Cook Inlet, then back up the west channel. The flow rate at which jet-boaters no longer use Alexander Slough has not been precisely defined, but based on the examination of aerial photographs, it is estimated to be about 60,000 cfs at Susitna Station. Under with-project conditions, this flow value is exceeded about 75 percent of the years during week 35 (May 27 - June 2), 90 percent of the years for weeks 36 and 37 (June 3 - June 16), 100 percent of the years from week 38 (June 17 - June 23) to week 46 (August 12 - August 18), and 90 percent of the years for weeks 47 and 48 (August 19 - September 1). During September, flow duration data for natural and with-project conditions are almost identical.

Based on the above flow duration data, the effect of the project on navigation through Alexander Slough will be minimal. For the period June 3 - June 16, it is estimated that navigation problems through Alexander Slough due to project operation would occur about 3 years out of 34, or 10 percent of the years. No problems are anticipated from mid-June through September which would not have occurred under natural conditions. When Alexander Slough is too shallow to navigate, boats may use Powerline Slough.

13.0 IMPACTS ON WINTER TRANSPORTATION

Project effects on winter transportation are expected to be minimal. Much of the existing winter use of the river is downstream of Talkeetna. The ice cover formation in the lower reach of river, where much of the winter transportation occurs, is not expected to be significantly delayed. The ice cover is expected to progress to the Chulitna confluence 2 to 5 weeks later than under natural conditions when only Watana is operating, and 4 to 6 weeks later when both Watana and Devil Canyon are operating. Melt-out will occur several weeks earlier than under natural conditions. This will shorten the winter travel period around Talkeetna. Travel restrictions due to open leads in the ice cover will continue to occur.

Between Talkeetna and Devil Canyon, there will be a delay in ice cover formation, and open water will exist for many miles downstream of the projects. However, travel in this reach is limited at present due to numerous open leads and to the presence of the Alaska Railroad adjacent to much of the river, so the affect on winter transportation patterns will be minimized.

Winter travel in the reservoir areas is expected to improve. Numerous open leads presently occur, and the river flows through a steep canyon. Once the reservoirs are filled, a solid flat ice surface will exist much closer to the top of the canyon. Due to the presence of the project camp, winter travel on this reach of river may significantly increase over existing use patterns.

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TABLES

TABLE 3.1 SUSITNA RIVER REACH DEFINITIONS

River Mile	Average Slope	Predominent Channel Pattern
RM 149 to 144	0.00195	Single channel confined by valley walls. Frequent bedrock control points.
RM 144 to 139	0.00260	Split channel confined by valley wall and terraces.
RM 139 to 129.5	0.00210	Split channel confined occasionally by terraces and valley walls. Main channels, side channels and sloughs occupy valley bottom.
RM 129.5 to 119	0.00173	Split channel with occasional tendency to braid. Main channel frequently flows against west valley wall. Subchannels and sloughs occupy east floodplain.
RM 119 to 104	0.00153	Single channel frequently incised and occasional islands.
RM 104 to 95	0.00147	Transition from split channel to braided. Occasionally bounded by terraces. Braided through the confluence with Chulitna and Talkeetna Rivers.
RM 95 to 61	0.00105	Braided with occasional confinement by terraces.
RM 61 to 42	0.00073	Combined patterns; western floodplain braided, eastern floodplain split channel.
RM 42 to 0	0.00030	Split channel with occasional tendency to braid. Deltaic distributary channels begin forming at about RM 20.

R&M (1982A)

TABLE 3.2 PERIODS OF RECORD FOR GAGING STATIONS

Station Name	USGS Gage Number	Susitna River Mile	Drainage Area (mi^2)	Periods of Record		Agency
				Streamflow (Continuous)[1]	Water Quality[2]	
Susitna River nr. Denali	15291000	290.8	950	5/57-9/66, 11/68-Present	1957-66, 1968-69, 1974-Present (6/30/82)	USGS
Susitna River nr. Cantwell (Vee Canyon)	15291500	223.1	4,140	5/61-9/72, 5/80-Present	1962-72, 1980-Present(7/27/82)	USGS
Susitna River nr. Cantwell (Vee Canyon)	-	223.1	4,140	-	1980-81	R&M Consult.
Susitna River nr. Watana Damsite	-	182.2[3]	5,180	6/80-Present	10/80-12/81	R&M Consult.
Susitna River at Gold Creek	15292000	136.6	6,160	8/49-Present	1949-58, 1962, 1967-68, 1974-Present (9/16/82)	USGS
Susitna River at Gold Creek	-	136.6	6,160	-	1980-Present(10/14/82)	R&M
Susitna River at Sunshine	15292780	83.9	11,100	5/81-Present	1971, 1975, 1977, 1981-Present (10/13/82)	
Susitna River at Susitna Station	15294350	25.8	19,400	10/74-Present	1955, 1970, 1975-Present(10/5/82)	USGS
Maclaren River nr. Paxson	15291200	259.8[4]	280	6/58-Present	1958-61, 1967-68, 1975	USGS
Chulitna River nr. Talkeetna	15292400	98.0[4]	2,570	2/58-9/72, 5/80-Present	1958-59, 1967-72, 1980-Present (6/3/82)	USGS
Talkeetna River nr. Talkeetna	15291500	97.0[4]	2,006	6/64-Present	1954, 1966-Present(10/14/82)	USGS
Skwentna River nr. Skwentna	15294300	28.0[5]	2,250	10/59-Present	1959, 1961, 1967-68, 1974-75, 1980-81	USGS
Yentna River nr. Susitna Station	15294345	28.0[4]	6,180	10/80-Present	1981-Present (8/11/82)	USGS

Notes:

1. All streamflow gage stations are currently active, however, flow data included in this document is through September 1981.
2. "Present" in periods of record indicates station is active as of January 1983. A date after "Present" indicates the most recent data available.
3. Watana continuous water quality monitor was installed at river mile 183.0.
4. River mile at tributary's confluence with Susitna River.
5. River mile at Yentna-Susitna confluence.

Source: USGS and R&M

TABLE 3.3 FILLED STREAMFLOW SUMMARY, SUSITNA RIVER STATIONS

Station		Denali	Cantwell	Watana	Devil Canyon	Gold Creek	Sunshine	Susitna	Maclaren	Chulitna	Talkeetna	Skwentna
Oct	Max	2,165	5,472	6,458	7,518	8,212	18,555	58,640	734	9,314	4,438	7,254
	Mean	1,165	3,149	4,513	5,312	5,757	13,906	31,102	418	5,040	2,720	4,329
	Min	528	1,638	2,403	2,867	3,124	18,593	15,940	249	2,898	1,450	1,929
Nov	Max	878	2,487	3,525	3,955	4,192	9,400	31,590	370	3,277	1,786	4,195
	Mean	500	1,460	2,052	2,383	2,568	6,104	13,361	182	2,083	1,209	1,867
	Min	192	780	1,021	1,146	1,215	3,978	6,606	95	1,236	765	678
Dec	Max	575	1,658	2,259	2,905	3,264	6,137	15,081	246	2,143	1,239	2,871
	Mean	315	951	1,405	1,652	1,793	4,249	8,426	117	1,487	846	1,295
	Min	146	543	709	810	866	2,650	4,279	49	891	515	624
Jan	Max	651	1,694	1,780	2,212	2,452	4,739	12,669	162	1,673	1,001	2,829
	Mean	248	850	1,157	1,352	1,463	3,550	7,971	99	1,288	682	1,068
	Min	85	437	619	687	724	2,218	5,032	44	974	459	600
Feb	Max	422	1,200	1,560	1,836	2,028	4,057	11,532	140	1,414	805	1,821
	Mean	206	706	979	1,147	1,243	3,009	7,117	81	1,092	568	911
	Min	64	426	602	682	723	2,082	4,993	42	820	401	490
Mar	Max	290	1,273	1,560	1,779	1,900	3,898	9,193	121	1,300	743	1,352
	Mean	192	659	898	1,042	1,123	2,683	6,397	74	979	491	826
	Min	42	408	569	664	713	2,013	4,910	36	738	379	522
Apr	Max	415	1,702	1,965	2,405	2,650	5,109	12,030	145	1,600	1,038	2,138
	Mean	231	835	1,113	1,282	1,377	3,257	7,242	86	1,194	573	1,088
	Min	43	465	609	697	745	2,205	5,531	50	700	371	607
May	Max	4,259	13,751	15,973	19,777	21,890	50,302	94,143	2,131	20,025	8,840	22,370
	Mean	2,306	7,473	10,398	12,230	13,277	27,955	61,376	832	9,519	4,150	8,555
	Min	629	1,915	2,857	3,428	3,745	8,645	29,809	208	2,355	1,694	1,635
June	Max	12,210	34,630	42,842	47,816	50,580	110,073	176,219	4,297	40,330	19,045	40,356
	Mean	7,532	17,567	22,913	25,938	27,658	63,810	123,830	2,888	22,892	11,416	18,462
	Min	4,647	9,909	13,233	14,710	15,500	39,311	67,838	1,751	15,587	5,207	10,650
July	Max	12,110	22,790	28,767	32,388	34,450	85,600	181,400	4,649	35,570	15,410	28,620
	Mean	9,688	16,873	20,778	23,101	24,383	64,538	134,130	3,241	27,044	11,118	16,997
	Min	6,756	12,220	14,844	15,651	16,100	45,267	102,121	2,441	20,820	7,080	11,670

TABLE 3.3 FILLED STREAMFLOW SUMMARY, SUSITNA RIVER STATIONS - Continued

Station		Denali	Cantwell	Watana	Devil Canyon	Gold Creek	Sunshine	Susitna	Maclaren	Chulitna	Talkeetna	Skwentna
Yrs. of Record												
Aug	Max	12,010	22,760	31,435	35,270	38,538	84,940	159,600	4,122	33,670	18,033	20,590
	Mean	8,431	14,614	18,431	20,709	21,996	56,642	112,851	2,644	22,732	10,459	13,335
	Min	3,919	6,597	7,772	8,484	8,879	24,656	62,368	974	11,300	3,787	7,471
Sep	Max	6,955	12,910	17,206	19,799	21,240	53,703	104,218	2,439	23,260	10,610	13,371
	Mean	3,334	7,969	10,670	12,276	13,175	32,169	66,790	1,167	11,956	6,084	8,371
	Min	1,194	3,376	4,260	4,796	5,093	14,268	34,085	470	6,424	2,070	3,783
Ann	Max	3,651	7,962	9,833	10,947	11,565	28,226	63,159	1,276	12,114	5,276	10,024
	Mean	2,885	6,184	7,986	9,084	9,703	23,611	48,873	998	9,045	4,226	6,622
	Min	2,127	4,159	4,712	5,352	5,596	14,355	31,428	693	6,078	2,233	4,939

Notes: 1. Based on 32 years of record.

2. Gold Creek data are not filled since 32 years of record are available.

3. Sunshine discharge for WY1980 and Oct-Apr WY1981 were computed from Gold Creek, Talkeetna, and Chulitna discharges for the same period.

Acres (1983)

Table 4.1 Boat draft by exit location, 1984.[a,b]

Exit Location	Month/ Season	Shallow Boats	Shallow %	Medium Boats	Medium %	Deep Boats	Deep %	Total
Susitna Landing	May	203	54	146	39	29	7	378
	Jun	426	48	372	42	90	10	888
	Jul	224	53	147	35	53	12	424
	Aug	189	56	117	35	30	9	336
	Sep	201	46	207	47	33	7	441
	Overall	1,243	50	989	40	235	10	2,467
	Kings	676	50	549	41	128	9	1,353
	Other fish	566	51	439	40	105	9	1,110
Talkeetna	Jul	98	52	89	47	1	1	188
	Aug	88	60	56	39	1	1	145
	Sep	55	87	8	13	0	0	63
	Overall	241	61	153	39	2	1	396
	Other fish	241	61	154	38	3	1	398
Willow Creek	Jul	159	72	62	28	0	0	221
	Aug	181	82	38	17	3	1	222
	Sep	107	86	15	12	2	2	124
	Overall	447	79	115	20	5	1	567
	Other fish	418	80	102	19	5	1	525

[a]Shallow: under 4.1" Medium: 4.1-8.0" Deep: over 8.0"

[b]The numbers presented are estimates.

Howe (1985)

Table 4.2 Boat class by exit location, 1984.[a]

Exit Location	Month/ Season	Air Boat		Canoe		Inboard Jet		Outboard Jet		Outboard Prop		Other		
		Boats	%	Boats	%	Boats	%	Boats	%	Boats	%	Boats	%	Total
Susitna Landing	May	4	1	4	1	153	38	216	53	27	7	0	0	404
	Jun	8	1	6	1	333	36	500	53	78	8	9	1	934
	Jul	7	2	2	1	205	47	191	44	27	6	0	0	432
	Aug	7	2	0	0	150	42	172	49	25	7	0	0	354
	Sep	22	4	2	1	167	33	253	51	56	11	1	0	501
	Overall	48	2	14	1	1,008	38	1,332	51	213	8	10	0	2,625
	Kings	15	1	10	1	532	37	761	53	107	7	9	1	1,434
	Other fish	32	3	4	0	476	39	572	47	105	9	1	2	1,190
Talkeetna	Jul	0	0	0	0	135	72	52	27	1	1	0	0	188
	Aug	0	0	0	0	104	72	39	27	1	1	0	0	144
	Sep	0	0	0	0	45	70	19	30	0	0	0	0	64
	Overall	0	0	0	0	284	72	110	28	2	1	0	0	396
	Other fish	0	0	0	0	284	71	110	28	3	1	0	0	397
Willow Creek	Jul	131	60	1	1	22	10	64	29	0	0	0	0	218
	Aug	131	58	0	0	26	12	66	29	3	1	0	0	226
	Sep	100	81	0	0	0	0	21	17	2	2	0	0	123
	Overall	362	64	1	0	48	8	151	27	5	1	0	0	567
	Other fish	350	62	0	0	48	9	149	26	5	1	0	2	552

[a]The numbers presented are estimates.

Howe (1985)

Table 6.1 First destinations for boaters exiting at Willow Creek, 1984.[a]

First Destination	Jul		Aug		Sep		Overall	
	Boats	%	Boats	%	Boats	%	Boats	%
Alexander Slough	1	0.5	8	3.6	4	3.5	13	2.3
Caswell Creek	0	0	0	0	1	0.8	1	0.2
Deshka River	81	36.7	55	24.8	55	44.2	191	33.7
Flathorn	0	0	0	0	1	0.8	1	0.2
Kroto Slough	0	0	1	0.5	4	3.4	5	0.9
L. Willow Creek	0	0	5	2.3	19	15.2	24	4.2
Portage Creek	0	0	0	0	1	0.8	1	0.2
Sheep Creek	0	0	4	1.8	0	0	4	0.7
Susitna Landing	0	0	1	0.5	0	0	1	0.2
Susitna Station	0	0	2	0.9	1	0.8	3	0.5
Willow Creek	138	62.4	136	61.3	27	21.7	301	53.1
Yentna River	1	0.5	10	4.5	11	8.6	22	3.9
Total	221	100	222	100	124	100	567	100

[a]The numbers presented are estimates.

Howe (1985)

Table 6.2 First destinations for boaters exiting at Susitna Landing, 1984.[a]

First Destination	May		Jun		Jul		Aug		Sep		Overall	
	Boats	%	Boats	%	Boats	%	Boats	%	Boats	%	Boats	%
Alexander Slough	14	3.5	19	2.0	15	3.4	6	1.7	3	0.5	57	2.2
Big Susitna	0	0	0	0	0	0	0	0	19	3.7	19	0.7
Caswell Creek	0	0	4	0.4	3	0.6	1	0.3	12	2.4	20	0.8
Chase	2	0.5	0	0	0	0	0	0	0	0	2	0.1
Chulitna River	0	0	0	0	1	0.2	0	0	0	0	1	0
Cook Inlet	0	0	0	0	0	0	0	0	2	0.4	2	0.1
Delta Islands	0	0	0	0	0	0	0	0	10	2.0	10	0.4
Deshka River	316	79.0	685	74.0	241	55.0	141	40.3	90	17.8	1,473	56.2
Devil Canyon	2	0.5	0	0	0	0	0	0	0	0	2	0.1
Goose Creek	0	0	0	0	0	0	1	0.3	1	0.2	2	0.1
Indian River	0	0	1	0.1	0	0	0	0	0	0	1	0
Kashwitna River	1	0.3	1	0.1	0	0	3	0.9	13	2.6	18	0.7
Kroto Slough	2	0.5	6	0.7	1	0.3	3	0.9	4	0.7	16	0.6
L. Willow Creek	0	0	0	0	2	0.5	2	0.6	3	0.6	7	0.3
Main Susitna	0	0	0	0	1	0.2	0	0	40	7.9	41	1.6
Montana Creek	0	0	0	0	1	0.2	1	0.3	10	2.0	12	0.5
Portage Creek	0	0	0	0	2	0.5	0	0	0	0	2	0.1
Sheep Creek	0	0	0	0	4	1.0	39	11.1	20	4.1	63	2.4
Sunshine	0	0	0	0	1	0.2	0	0	3	0.6	4	0.2
Susitna Landing	0	0	11	1.2	1	0.2	4	1.1	26	5.2	42	1.6
Susitna Station	4	0.9	3	0.3	4	0.9	1	0.3	11	2.1	23	0.9
Talkeetna River	0	0	0	0	0	0	0	0	3	0.6	3	0.1
Trapper Creek	0	0	0	0	0	0	0	0	1	0.2	1	0
Willow Creek	0	0	51	5.5	36	8.2	55	15.7	24	4.7	166	6.3
Yentna River	59	14.9	145	15.7	125	28.7	93	26.6	211	41.7	633	24.2
Total	400	100	926	100	438	100	350	100	506	100	2,620	100

[a]The numbers presented are estimates.

Howe (1985)

Table 6.3 First destinations for boats by exit location for boats engaged in sport fishing, 1984.[a,b]

Month/ Season	First Destination	Susitna Landing				Talkeetna				Willow Creek			
		Main		Secondary		Main		Secondary		Main		Secondary	
		Boats	%	Boats	%	Boats	%	Boats	%	Boats	%	Boats	%
May	Deshka River	290	91	6	27	--	--	--	--	--	--	--	--
	Yentna River	13	4	16	73	--	--	--	--	--	--	--	--
	Alexander Slough	9	3	0	0	--	--	--	--	--	--	--	--
	Others	7	2	0	0	--	--	--	--	--	--	--	--
Jun	Deshka River	628	81	41	51	--	--	--	--	--	--	--	--
	Yentna River	78	10	31	39	--	--	--	--	--	--	--	--
	Alexander Slough	18	2	1	1	--	--	--	--	--	--	--	--
	Willow Creek	45	6	3	4	--	--	--	--	--	--	--	--
	Others	9	1	4	5	--	--	--	--	--	--	--	--
Jul	Deshka River	178	71	33	41	0	0	0	0	53	30	15	60
	Yentna River	28	11	40	50	0	0	0	0	0	0	0	0
	Alexander Slough	4	2	5	6	0	0	0	0	1	1	0	0
	Willow Creek	33	13	0	0	0	0	0	0	120	69	10	40
	Talkeetna River	0	0	0	0	33	100	28	90	0	0	0	0
	Others	9	4	2	3	0	0	3	10	0	0	0	0
Aug	Deshka River	95	44	21	31	0	0	0	0	41	26	4	21
	Yentna River	19	9	40	60	0	0	0	0	2	1	0	0
	Alexander Slough	4	2	1	1	0	0	0	0	1	1	0	0
	Sheep Creek	36	17	3	4	0	0	0	0	4	3	0	0
	Willow Creek	53	25	2	3	0	0	0	0	108	68	15	79
	Talkeetna River	0	0	0	0	83	80	0	0	0	0	0	0
	Birch Creek	0	0	0	0	13	13	0	0	0	0	0	0
	Others	7	3	0	0	8	8	1	100	4	3	0	0

Table 6.3 (Continued)

Month/ Season	First Destination	Susitna Landing				Talkeetna				Willow Creek			
		Main		Secondary		Main		Secondary		Main		Secondary	
		Boats	%	Boats	%	Boats	%	Boats	%	Boats	%	Boat	%
Sep	Deshka River	4	57	7	17	0	0	0	0	1	13	10	50
	Yentna River	0	0	19	46	0	0	0	0	1	13	0	0
	Talkeetna River	0	0	0	0	18	95	0	0	0	0	0	0
	Willow Creek	1	14	1	2	0	0	0	0	6	75	2	10
	Others	2	29	14	34	1	5	1	100	0	0	8	40
King	Deshka River	949	82	50	45	--	--	--	--	--	--	--	--
	Yentna River	102	9	52	47	--	--	--	--	--	--	--	--
	Alexander Slough	27	2	3	3	--	--	--	--	--	--	--	--
	Willow Creek	60	5	3	3	--	--	--	--	--	--	--	--
	Others	16	1	3	3	--	--	--	--	--	--	--	--
Other Fish	Deshka River	245	59	58	33	0	0	0	0	83	25	29	46
	Yentna River	36	9	94	53	0	0	0	0	3	1	0	0
	Alexander Slough	8	2	5	3	0	0	0	0	2	1	0	0
	Sheep Creek	40	10	7	4	0	0	0	0	4	1	0	0
	Talkeetna River	0	0	0	0	134	85	28	85	0	0	0	0
	Birch Creek	0	0	0	0	13	8	0	0	0	0	0	0
	L. Willow Creek	4	1	1	1	0	0	0	0	3	1	7	11
	Willow Creek	72	17	3	2	0	0	0	0	234	71	26	41
	Others	8	2	10	6	10	6	5	15	1	0	1	2

[a]The numbers presented are estimates. Missing data are indicated by --.

[b]'Main' indicates sport fishing was the main activity, 'Yes' indicates secondary involvement in sport fishing.

Howe (1985)

Table 6.4 First destinations for boaters exiting at the Talkeetna boat launch or airstrip, 1984.[a]

First Destination	Jul		Aug		Sep		Overall	
	Boats	%	Boats	%	Boats	%	Boats	%
Birch Creek	6	3.0	18	12.3	2	3.3	26	6.6
Chase	0	0	6	4.0	10	16.8	16	4.1
Chulitna River	7	3.7	0	0	4	6.9	11	2.8
Curry	1	0.7	0	0	1	1.7	2	0.5
Devil Canyon	1	0.7	0	0	0	0	1	0.3
Gold Creek	33	17.4	10	6.9	4	7.1	47	12.0
Indian River	0	0	1	0.9	0	0	1	0.3
Mi 232 AK RR	16	8.6	0	0	4	7.1	20	5.1
Portage Creek	0	0	1	0.9	5	8.7	6	1.5
Sunshine	1	0.7	3	2.0	2	3.5	6	1.5
Talkeetna River	122	64.4	99	69.2	24	39.7	245	62.7
Trapper Creek	0	0	3	1.9	0	0	3	0.8
Whiskers Creek	1	0.7	3	1.9	3	5.2	7	1.8
Total	188	100	144	100	59	100	391	100

[a]The numbers presented are estimates.

Howe (1985)

Table 7.1 Percent of boats by activity and month for boats exiting at Willow Creek, 1984.[a]

Activity	Response[b] Category	July	Aug	Sept	Overall
Sport Fishing	Main	78	71	6	60
	No	10	20	77	29
	Yes	12	9	16	12
Trapping	Main	0	0	0	0
	No	100	100	100	100
	Yes	0	0	0	0
Hunting	Main	0	1	22	6
	No	100	99	33	82
	Yes	0	0	58	13
Commercial Fishing	Main	0	0	0	0
	No	100	100	100	100
	Yes	0	0	0	0
Commercial Supply	Main	0	0	1	0
	No	100	100	99	100
	Yes	0	0	0	0
Private Supply	Main	3	9	3	6
	No	95	90	94	95
	Yes	2	0	3	2
Transportation	Main	8	9	13	10
	No	82	83	84	83
	Yes	9	8	3	8
Camping	Main	0	1	0	1
	No	72	80	35	67
	Yes	28	19	65	32
Sight Seeing	Main	3	2	3	3
	No	88	91	93	90
	Yes	8	7	4	7
Mining	Main	0	0	0	0
	No	100	100	100	100
	Yes	0	0	0	0
Susitna Study	Main	0	1	0	0
	No	100	99	100	100
	Yes	0	0	0	0
Other Activity	Main	7	3	3	5
	No	92	95	95	94
	Yes	1	2	2	2

[a] The numbers presented are estimates.

[b] Respondents indicated whether an activity was the main activity (Main), a secondary activity engaged in (Yes), or an activity they did not participate in (No).

Howe (1985)

Table 7.2 Number of boats by activity and month for boats exiting at Willow Creek, 1984.[a]

Activity	Response[b] Category	July	Aug	Sept	Overall
Sport Fishing	Main	174	160	8	342
	No	23	46	96	165
	Yes	27	20	20	67
Trapping	Main	1	0	0	1
	No	223	224	125	572
	Yes	0	0	0	0
Hunting	Main	1	2	29	32
	No	223	222	26	471
	Yes	0	0	75	75
Commercial Fishing	Main	1	0	0	1
	No	223	224	125	572
	Yes	0	0	0	0
Commercial Supply	Main	1	0	1	2
	No	223	223	124	570
	Yes	0	1	0	1
Private Supply	Main	7	21	4	32
	No	213	202	118	533
	Yes	4	1	4	9
Transportation	Main	19	21	16	56
	No	184	185	104	473
	Yes	21	18	4	43
Camping	Main	1	2	0	3
	No	161	181	44	386
	Yes	62	42	80	184
Sight Seeing	Main	7	5	4	16
	No	198	203	115	516
	Yes	19	16	5	40
Mining	Main	0	0	0	0
	No	224	224	125	573
	Yes	0	0	0	0
Susitna Study	Main	0	2	0	2
	No	224	222	125	571
	Yes	0	0	0	0
Other Activity	Main	15	7	4	26
	No	206	215	119	540
	Yes	3	4	2	9

[a] The numbers presented are estimates.

[b] Respondents indicated whether an activity was the main activity (Main), a secondary activity engaged in (Yes), or an activity they did not participate in (No).

Howe (1985)

Table 7.3 Percent of boats by activity and month, Susitna Landing, 1984.[a]

Activity	Response Category[b]	May	June	July	Aug	Sept	Overall
Sport Fishing	Main	80	83	58	61	1	60
	No	15	8	23	21	90	29
	Yes	5	9	19	19	8	11
Trapping	Main	0	0	0	0	0	0
	No	99	100	100	100	100	100
	Yes	1	0	0	0	0	0
Hunting	Main	4	1	0	0	3	2
	No	96	99	100	99	16	83
	Yes	1	0	0	1	81	16
Commercial Fishing	Main	0	0	0	0	0	0
	No	100	100	100	100	100	100
	Yes	0	0	0	0	0	0
Commercial Supply	Main	1	1	3	1	1	1
	No	99	99	97	99	98	98
	Yes	0	1	0	0	1	0
Private Supply	Main	2	11	19	23	10	12
	No	98	85	76	74	83	83
	Yes	0	5	5	3	7	4
Transportation	Main	10	10	11	9	8	10
	No	89	78	82	83	90	84
	Yes	1	12	7	7	2	6
Camping	Main	0	1	1	1	0	1
	No	66	62	66	72	38	60
	Yes	34	37	33	26	62	39
Sight Seeing	Main	2	1	2	3	1	2
	No	94	90	95	93	97	93
	Yes	4	9	3	4	2	5
Mining	Main	0	0	0	0	0	0
	No	100	99	100	99	100	100
	Yes	0	1	0	1	0	0
Susitna Study	Main	0	0	2	1	1	1
	No	100	99	98	98	98	99
	Yes	0	1	0	0	0	0
Other Activity	Main	5	2	3	3	3	3
	No	93	90	97	96	96	94
	Yes	1	8	0	1	1	3

[a] The numbers presented are estimates.

[b] Respondents indicated whether an activity was the main activity (Main), a secondary activity engaged in (Yes), or an activity they did not participate in (No).

Howe (1985)

Table 7.4 Number of boats by activity and month, Susitna Landing, 1984.[a]

Activity	Response[b] Category	May	June	July	Aug	Sept	Overall
Sport Fishing	Main	328	783	252	215	7	1,585
	No	61	74	102	73	455	765
	Yes	21	83	81	67	41	293
Trapping	Main	0	0	2	0	0	2
	No	406	936	428	354	504	2,628
	Yes	4	0	0	0	0	4
Hunting	Main	15	5	2	1	16	39
	No	393	930	426	351	83	2,183
	Yes	3	0	0	2	412	417
Commercial Fishing	Main	1	0	2	0	0	3
	No	409	659	428	354	503	2,353
	Yes	0	0	0	0	0	0
Commercial Supply	Main	3	4	13	2	5	27
	No	408	651	416	351	496	2,322
	Yes	0	5	1	1	3	10
Private Supply	Main	9	70	81	83	50	293
	No	401	563	327	261	418	1,970
	Yes	0	33	22	10	35	100
Transportation	Main	42	68	46	33	39	228
	No	365	530	354	295	454	1,998
	Yes	4	80	30	26	12	152
Camping	Main	2	6	4	5	0	17
	No	271	584	285	256	193	1,589
	Yes	138	346	141	93	312	1,030
Sight Seeing	Main	8	9	10	12	5	44
	No	388	846	407	329	488	2,458
	Yes	15	81	12	13	11	132
Mining	Main	0	0	0	0	0	0
	No	410	656	430	352	504	2,352
	Yes	0	4	0	2	0	6
Susitna Study	Main	0	3	10	5	6	24
	No	410	654	420	348	496	2,328
	Yes	0	4	0	1	2	7
Other Activity	Main	22	15	11	10	14	72
	No	383	845	417	340	485	2,470
	Yes	6	76	0	4	6	92

[a]The numbers presented are estimates.

[b]Respondents indicated whether an activity was the main activity (Main), a secondary activity engaged in (Yes), or an activity they did not participate in (No).

Howe (1985)

Table 7.5 Percent of boats by activity and month for boats exiting at the Talkeetna boat launch or airstrip, 1984.[a]

Activity	Response[b] Category	July	Aug	Sept	Overall
Sport Fishing	Main	17	72	30	39
	No	66	28	69	53
	Yes	16	1	2	8
Trapping	Main	0	0	0	0
	No	100	100	100	100
	Yes	0	0	0	0
Hunting	Main	0	1	0	0
	No	100	99	69	95
	Yes	0	0	31	5
Commercial Fishing	Main	0	0	0	0
	No	100	100	100	100
	Yes	0	0	0	0
Commercial Supply	Main	0	0	0	0
	No	100	100	100	100
	Yes	0	0	0	0
Private Supply	Main	7	0	2	4
	No	93	98	95	95
	Yes	1	2	3	2
Transportation	Main	16	13	14	15
	No	65	86	86	76
	Yes	19	1	0	9
Camping	Main	1	0	0	0
	No	99	100	100	100
	Yes	0	0	0	0
Sight Seeing	Main	8	1	17	7
	No	84	79	78	81
	Yes	8	21	5	12
Mining	Main	0	0	0	0
	No	100	99	100	100
	Yes	0	1	0	0
Susitna Study	Main	15	14	10	14
	No	84	86	90	86
	Yes	2	0	0	1
Other Activity	Main	0	0	0	0
	No	96	100	100	98
	Yes	4	0	0	2

[a] The numbers presented are estimates.

[b] Respondents indicated whether an activity was the main activity (Main), a secondary activity engaged in (Yes), or an activity they did not participate in (No).

Howe (1985)

Table 7.6 Number of boats by activity and month for boats exiting at the Talkeetna boat launch or airstrip, 1984.[a]

Activity	Response[b] Category	July	Aug	Sept	Overall
Sport Fishing	Main	33	104	19	156
	No	125	40	44	209
	Yes	31	1	1	33
Trapping	Main	0	0	0	0
	No	189	146	64	399
	Yes	0	0	0	0
Hunting	Main	0	1	0	1
	No	189	144	44	377
	Yes	0	0	20	20
Commercial Fishing	Main	0	0	0	0
	No	189	146	64	399
	Yes	0	0	0	0
Commercial Supply	Main	0	0	0	0
	No	189	146	64	399
	Yes	0	0	0	0
Private Supply	Main	13	0	1	14
	No	174	143	60	377
	Yes	1	3	2	6
Transportation	Main	31	19	9	59
	No	122	125	54	301
	Yes	36	1	0	37
Camping	Main	1	0	0	1
	No	187	146	64	397
	Yes	0	0	0	0
Sight Seeing	Main	15	1	11	27
	No	159	115	50	324
	Yes	15	30	3	48
Mining	Main	0	0	0	0
	No	189	144	64	397
	Yes	0	1	0	1
Susitna Study	Main	28	20	6	54
	No	157	126	57	340
	Yes	3	0	0	3
Other Activity	Main	0	0	0	0
	No	181	146	61	388
	Yes	8	0	0	8

[a]The numbers presented are estimates.

[b]Respondents indicated whether an activity was the main activity (Main), a secondary activity engaged in (Yes), or an activity they did not participate in (No).

Howe (1985)

Table 7.7 Number of people for residence groups by exit location, 1984.[a,b]

Interview Location	Month	Residence Groups 1	2	3	4	5	7	8	9	10	11	12	99
Susitna	May	149	261	3	2	0	0	0	15	0	16	0	12
Landing	Jun	226	560	8	8	1	1	0	6	0	26	1	5
	Jul	157	370	5	7	1	0	0	3	0	14	0	3
	Aug	116	311	1	6	0	0	0	8	2	14	1	3
	Sep	146	388	0	8	0	0	1	0	3	5	0	4
	Overall	794	1,890	17	31	2	1	1	32	5	75	2	27
Talkeetna	Jul	2	35	0	10	1	0	0	1	0	5	0	3
	Aug	7	37	0	8	2	0	0	0	0	4	0	0
	Sep	5	42	0	6	0	0	0	2	2	1	0	2
	Overall	14	114	0	24	3	0	0	3	2	10	0	5
Willow	Jul	74	220	0	7	0	0	0	3	0	45	0	0
Creek	Aug	48	231	2	4	0	0	0	0	0	22	0	9
	Sep	23	150	1	0	0	0	0	1	0	3	0	2
	Overall	145	601	3	11	0	0	0	4	0	70	0	11

[a] The numbers presented are sample values.

[b] Groups 1 Montana Creek to Palmer/Wasilla
2 Chugiak to Girdwood
3 Seward, Cooper Landing to Homer
4 Peter's Creek, Talkeetna, Trapper Creek
5 Cantwell to Nenana
6 Glennallen and Paxson
7 Delta Junction, Tok, Valdez, Kodiak
8 Juneau, Ketchikan
9 Fairbanks
10 Missing
11 USA, non-Alaska
12 Non-USA
99 Others

Howe (1985)

Table 7.8 Number of anticipated visits by exit location, 1984.[a]

Exit Location	Month	Under 2		2-5		6-10		11-20		Over 20	
		People	%	People	%	People	%	People	%	People	%
Susitna Landing	May	69	16	66	18	48	11	148	35	93	22
	Jun	117	14	218	36	190	23	297	36	0	0
	Jul	31	6	88	19	130	24	299	55	0	0
	Aug	51	11	105	30	71	16	229	50	0	0
	Sep	58	11	104	23	109	20	278	51	0	0
	Overall	326	12	581	27	548	20	1,251	46	0	0
Talkeetna	Jul	11	22	1	2	5	10	32	65	0	0
	Aug	23	43	10	23	2	4	19	35	0	0
	Sep	17	31	24	80	2	4	11	20	0	0
	Overall	51	32	35	29	9	6	62	39	0	0
Willow Creek	Jul	17	6	31	12	55	19	56	19	134	46
	Aug	26	8	62	25	58	19	78	25	85	28
	Sep	10	6	24	16	15	9	35	20	90	52
	Overall	53	7	117	15	128	16	169	22	309	40

[a]The numbers presented are sample values. Boaters were asked to estimate the number of visits during 1984.

Howe (1985)

Table 8.1 Boats with navigational problems by exit location, 1984.[a]

Exit Location	Month/ Season	Debris			Bars			Rocks			Velocity		
		Total Boats	Boats With Prob	% With Prob	Total Boats	Boats With Prob	% With Prob	Total Boats	Boats With Prob	% With Prob	Total Boats	Boats With Prob	% With Prob
Susitna	May	406	63	16	406	17	4	407	8	2	407	47	12
	Jun	898	149	17	898	83	9	898	103	11	890	16	2
	Jul	427	16	4	429	40	9	427	19	4	427	3	1
	Aug	352	19	5	348	44	13	348	11	3	347	0	0
	Sep	499	12	2	502	96	19	500	54	11	496	4	1
	Overall	2,582	259	10	2,583	280	11	2,580	195	8	2,567	70	3
	Kings	1,400	214	15	1,401	105	7	1,401	114	8	1,393	63	5
	Other fish	1,181	44	4	1,181	174	15	1,178	80	7	1,172	6	1
Talkeetna	Jul	188	1	1	188	13	7	189	27	14	188	13	7
	Aug	146	0	0	146	0	0	146	0	0	146	0	0
	Sep	64	1	2	64	2	3	64	2	3	64	1	2
	Overall	398	2	1	398	15	4	399	29	7	398	14	4
	Other fish	397	2	1	397	15	4	398	29	7	397	14	4
Willow	Jul	224	4	2	223	7	3	223	6	3	224	1	1
	Aug	224	28	12	222	63	28	219	51	23	217	0	0
	Sep	122	7	6	122	20	16	124	17	14	122	2	2
	Overall	570	39	7	567	90	16	566	74	13	563	3	1
	Other fish	555	39	7	552	89	16	551	72	13	548	3	1

[a]The numbers presented are estimates. Since a single boat may have had several different navigational problems during a trip, the sum of boats with problems over all problem groups may not represent the number of unique boats with problems.

Howe (1985)

TABLE 9.1 FLOW CONSTRAINTS FOR ENVIRONMENTAL FLOW REQUIREMENT CASE EVI

Water Week	Gold Creek Flow (cfs) Minimum	Maximum	Water Week	Gold Creek Flow (cfs) Minimum	Maximum
14	2,000	16,000	40	9,000*	35,000
15	2,000	16,000	41	9,000*	35,000
16	2,000	16,000	42	9,000*	35,000
17	2,000	16,000	43	9,000*	35,000
18	2,000	16,000	44	9,000*	35,000
19	2,000	16,000	45	9,000*	35,000
20	2,000	16,000	46	9,000*	35,000
21	2,000	16,000	47	9,000*	35,000
22	2,000	16,000	48	9,000*	35,000
23	2,000	16,000	49	8,000	35,000
24	2,000	16,000	50	7,000	35,000
25	2,000	16,000	51	6,000	35,000
26	2,000	16,000	52	6,000	35,000
27	2,000	16,000	1	6,000	18,000
28	2,000	16,000	2	6,000	17,000
29	2,000	16,000	3	5,000	16,000
30	2,000	16,000	4	4,000	16,000
31	2,000	16,000	5	3,000	16,000
32	4,000	16,000	6	3,000	16,000
33	6,000	16,000	7	3,000	16,000
34	6,000	16,000	8	3,000	16,000
35	6,000	16,000	9	3,000	16,000
36	9,000*	35,000	10	2,000	16,000
37	9,000*	35,000	11	2,000	16,000
38	9,000*	35,000	12	2,000	16,000
39	9,000*	35,000	13	2,000	16,000

* Minimum summer flows are 9,000 cfs except in dry years when the minimum will be 8,000 cfs. A dry year is defined by the one-in-ten year low flow.

H-E (1985)

TABLE 9.2 FLOW DURATION DATA AT GOLD CREEK FOR NATURAL, WATANA ONLY, AND WATANA/DEVIL CANYON, OPEN-WATER SEASON

	Week 32 (May 6 - May 12)			Week 33 (May 13 - May 19)			Week 34 (May 20 - May 26)		
Percent	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load
0	20,400	12,100	12,500	22,000	12,700	12,700	33,900	15,200	14,500
25	11,500	8,220	9,250	18,400	9,580	10,300	23,000	11,800	11,400
50	6,330	7,070	7,650	13,900	8,620	9,080	18,600	10,500	10,100
75	4,340	6,600	6,740	10,800	7,970	7,930	13,500	8,640	8,160
90	2,190	5,760	5,850	4,120	6,830	6,570	6,920	7,310	6,640
100	1,040	4,630	4,680	1,400	5,990	5,990	3,100	6,600	6,160

	Week 35 (May 27 - June 2)			Week 36 (June 3 - June 9)			Week 37 (June 10 - June 16)		
Percent	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load
0	44,300	19,500	16,900	75,100	17,100	14,700	58,800	16,800	13,800
25	29,600	13,000	11,800	30,300	12,700	11,100	34,800	13,200	11,600
50	22,100	12,100	10,900	25,900	11,400	10,300	27,200	11,800	10,300
75	18,500	9,840	9,850	19,800	9,930	8,950	20,600	9,920	9,260
90	14,400	8,320	7,410	16,000	8,730	8,550	16,600	8,950	8,510
100	8,700	7,440	6,600	12,800	8,340	7,990	14,900	8,160	7,990

	Week 38 (June 17 - June 23)			Week 39 (June 24 - June 30)			Week 40 (July 1 - July 7)		
Percent	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load
0	50,300	15,600	13,800	39,600	14,000	12,600	34,200	12,100	11,000
25	35,800	12,900	11,500	30,200	12,200	10,900	27,200	10,800	9,720
50	27,000	11,800	10,300	26,000	11,500	10,400	23,400	9,990	9,130
75	21,200	9,570	8,810	22,000	9,570	8,830	20,600	9,080	9,050
90	16,000	8,640	8,260	17,500	8,560	8,320	18,700	8,920	9,000
100	13,500	7,990	7,990	16,200	7,990	7,990	13,900	7,990	7,990

TABLE 9.2 FLOW DURATION DATA AT GOLD CREEK FOR NATURAL, WATANA ONLY, AND WATANA/DEVIL CANYON, OPEN-WATER SEASON
(Continued)

	Week 41 (July 8 - July 14)			Week 42 (July 15 - July 21)			Week 42 (July 22 - July 28)		
Percent	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load
0	42,100	14,800	12,100	41,200	14,500	13,300	36,700	13,500	12,600
25	26,800	11,000	9,710	27,800	10,900	9,880	27,000	10,700	9,400
50	23,200	9.870	9,020	24,000	9,590	9,020	22,000	9,750	8,950
75	20,600	8,990	8,500	20,300	8,960	8,800	19,600	8,850	8,600
90	18,200	8,300	8,190	17,700	8,260	8,670	17,500	8,250	8,400
100	17,000	7,990	7,990	15,200	7,990	7,990	15,100	7,990	7,990

	Week 44 (July 29 - August 4)			Week 45 (August 5 - August 11)			Week 42 (July 22 - July 28)		
Percent	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load
0	38,700	26,100	12,300	44,800	23,000	11,800	54,900	41,500	26,000
25	28,100	11,900	10,000	25,400	11,100	9,870	23,400	11,100	9,990
50	24,400	10,300	9,120	22,400	10,200	9,080	20,400	9,860	9,090
75	21,700	9,090	8,580	19,900	9,030	8,710	18,612	9,090	8,720
90	19,100	8,620	8,260	18,300	8,480	8,510	15,700	8,740	8,520
100	13,400	7,990	7,990	14,300	7,990	7,990	7,390	7,990	7,990

	Week 47 (August 19 - August 25)			Week 48 (August 20 - September 1)			Week 49 (September 2 - September 8)		
Percent	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load
0	44,200	37,100	37,100	43,200	25,000	25,000	30,100	29,100	29,100
25	22,500	10,800	10,100	22,400	13,500	10,100	18,800	13,500	13,300
50	19,900	9,790	9,320	17,000	10,200	9,360	14,300	10,900	9,970
75	16,300	9,090	8,920	13,500	9,040	8,740	11,500	8,810	8,410
90	14,100	8,690	8,680	9,620	8,520	8,500	8,900	8,260	8,160
100	6,000	7,990	7,990	5,590	7,990	7,990	6,300	7,990	7,990

TABLE 9.2 FLOW DURATION DATA AT GOLD CREEK FOR NATURAL, WATANA ONLY, AND WATANA/DEVIL CANYON, OPEN-WATER SEASON (Continued)

	Week 50 (September 9 - September 15)			Week 51 (September 16 -22)			Week 52 (September 23 - 30)		
Percent	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load
0	29,000	24,500	24,500	26,600	21,900	21,900	25,100	21,900	19,800
25	16,800	14,500	14,100	15,100	12,400	12,000	15,000	11,400	10,400
50	14,000	11,000	10,300	12,200	10,800	10,200	11,500	9,420	9,550
75	10,000	9,080	7,360	8,960	8,730	8,020	7,660	8,620	8,360
90	8,630	7,360	7,140	6,920	7,010	6,230	6,180	6,610	6,250
100	5,510	6,990	6,990	4,720	5,990	5,990	4,530	5,990	5,990

TABLE 9.3 FLOW DURATION DATA AT SUNSHINE FOR NATURAL, WATANA ONLY, AND WATANA/DEVIL CANYON, OPEN-WATER SEASON

	Week 32 (May 6 - May 12)			Week 33 (May 13 - May 19)			Week 34 (May 20 - May 26)		
Percent	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load
0	40,800	31,800	33,100	45,500	43,800	44,600	71,200	54,800	54,500
25	21,400	18,900	19,000	33,000	26,300	27,000	46,700	32,500	30,700
50	13,000	14,200	15,400	29,300	22,600	22,500	36,100	28,000	27,900
75	9,460	11,200	11,300	20,900	17,300	17,400	29,900	25,400	25,000
90	6,330	10,000	10,100	10,200	14,100	13,900	17,300	17,500	17,800
100	3,930	9,010	9,070	5,260	11,100	9,860	10,800	16,100	14,100

	Week 35 (May 27 - June 2)			Week 36 (June 3 - June 9)			Week 37 (June 10 - June 16)		
Percent	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load
0	77,800	53,000	50,500	160,000	99,800	96,300	121,000	82,400	79,800
25	61,100	45,500	43,700	68,000	49,500	48,200	76,400	56,900	54,700
50	48,800	38,200	37,400	54,500	38,700	37,000	61,500	47,200	45,700
75	38,100	30,200	29,100	45,700	35,200	32,200	51,500	39,100	38,600
90	29,200	24,800	23,000	37,500	30,600	29,900	41,000	33,300	32,500
100	23,900	20,700	20,600	28,300	23,800	23,500	37,500	31,200	29,600

	Week 38 (June 17 - June 23)			Week 39 (June 24 - June 30)			Week 40 (July 1 - July 7)		
Percent	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load
0	109,000	77,600	75,500	106,000	77,600	76,200	79,200	57,900	56,700
25	74,100	52,800	51,000	71,100	52,900	51,900	66,000	50,200	49,100
50	63,600	46,400	45,600	63,800	49,200	48,200	60,900	46,500	45,800
75	52,100	40,400	39,800	57,300	44,100	44,000	55,900	44,400	43,200
90	43,100	35,600	35,100	49,200	40,400	39,900	50,200	40,600	40,600
100	39,300	34,600	34,200	46,700	39,200	38,800	45,400	37,500	36,600

TABLE 9.3 FLOW DURATION DATA AT SUNSHINE FOR NATURAL, WATANA ONLY, AND WATANA/DEVIL CANYON, OPEN-WATER SEASON
(Continued)

	Week 41 (July 8 - July 14)			Week 42 (July 15 - July 21)			Week 43 (July 22 - July 28)		
Percent	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load
0	116,000	88,500	85,600	97,300	78,400	77,100	90,600	68,600	67,100
25	72,900	55,500	54,200	73,800	56,200	55,100	71,600	55,200	53,800
50	60,900	49,000	49,100	64,400	49,600	49,800	62,900	49,400	49,200
75	56,100	44,200	43,200	57,700	45,400	44,600	53,800	44,000	42,400
90	52,300	42,000	41,300	48,600	39,100	39,100	48,800	38,700	38,500
100	45,800	37,800	37,800	42,000	35,800	35,800	41,000	33,800	33,800

	Week 44 (July 29 - August 4)			Week 45 (August 5 - August 11)			Week 46 (August 12 - August 18)		
Percent	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load
0	94,300	73,000	75,600	111,000	78,500	75,600	134,000	121,000	96,000
25	73,000	56,400	51,700	65,700	53,900	51,700	63,600	52,200	52,600
50	61,400	47,700	48,200	59,300	46,800	45,700	52,900	44,800	43,900
75	58,200	44,200	44,100	53,200	43,000	42,500	47,100	38,700	38,500
90	50,400	40,700	39,600	49,700	37,900	37,600	42,000	35,100	34,100
100	38,200	32,800	32,800	38,700	32,500	32,500	20,100	20,700	20,700

	Week 47 (August 19 - August 25)			Week 48 (August 26 - September 1)			Week 49 (September 2 - September 8)		
Percent	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load
0	111,000	84,000	82,900	87,700	63,100	61,000	60,100	60,100	60,100
25	58,900	49,000	48,600	52,100	41,500	40,000	45,600	40,800	39,000
50	51,100	43,200	42,000	43,200	35,900	35,800	35,800	33,000	32,500
75	43,500	36,100	35,900	35,900	32,600	31,900	31,500	28,800	28,300
90	38,400	31,300	29,200	30,100	28,700	28,300	25,500	23,800	22,700
100	16,400	18,300	18,300	16,300	18,700	18,700	18,100	19,800	19,800

TABLE 9.3 FLOW DURATION DATA AT SUNSHINE FOR NATURAL, WATANA ONLY, AND WATANA/DEVIL CANYON, OPEN-WATER SEASON (Continued)

	Week 50 (September 9 - September 15)			Week 51 (September 16 -22)			Week 52 (September 23 - 30)		
Percent	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load
0	56,600	52,400	52,400	76,200	60,800	58,000	79,100	69,200	67,100
25	42,600	39,500	36,400	35,200	33,700	31,800	35,800	31,300	27,800
50	33,900	31,400	30,900	29,100	27,300	26,700	26,700	23,800	23,700
75	27,600	25,900	25,800	23,100	22,600	22,300	23,000	21,000	19,700
90	22,400	22,000	21,900	19,200	19,500	18,200	15,800	15,000	15,300
100	15,400	16,900	16,900	13,000	14,200	14,200	12,500	12,100	11,800

TABLE 9.4 FLOW DURATION DATA AT SUSITNA STATION FOR NATURAL, WATANA ONLY, AND WATANA/DEVIL CANYON, OPEN-WATER SEASON

	Week 32 (May 6 - May 12)			Week 33 (May 13 - May 19)			Week 34 (May 20 - May 26)		
Percent	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load
0	98,200	94,600	94,700	93,000	86,900	85,600	98,600	86,500	84,600
25	61,900	58,600	60,100	73,400	62,300	65,900	81,700	70,000	69,800
50	42,600	32,500	34,400	59,000	55,000	55,400	73,500	62,600	62,500
75	19,100	21,400	21,800	52,100	45,600	46,400	63,500	56,500	54,900
90	14,800	16,200	15,700	34,700	37,500	36,200	51,900	51,700	52,800
100	10,200	11,100	12,400	30,100	24,700	26,000	44,500	33,600	34,300

	Week 35 (May 27 - June 2)			Week 36 (June 3 - June 9)			Week 37 (June 10 - June 16)		
Percent	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load
0	129,000	116,000	113,000	158,000	135,000	133,000	173,000	149,000	147,000
25	108,000	94,300	87,900	117,000	105,000	104,000	118,000	102,000	101,000
50	85,700	74,400	74,000	104,000	88,400	89,600	108,000	86,300	85,200
75	69,000	59,900	59,200	91,400	76,600	74,500	87,900	73,200	72,700
90	59,400	52,200	49,600	75,200	60,700	62,700	72,200	64,000	61,700
100	46,000	29,700	28,400	63,900	49,500	47,400	63,400	42,800	40,600

	Week 38 (June 17 - June 23)			Week 39 (June 24 - June 30)			Week 40 (July 1 - July 7)		
Percent	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load
0	172,000	147,000	146,000	182,000	154,000	153,000	162,000	146,000	146,000
25	129,000	108,000	106,000	134,000	116,000	117,000	134,000	120,000	119,000
50	112,000	95,200	94,900	123,000	108,000	109,000	119,000	106,000	105,000
75	101,000	89,000	87,700	114,000	103,000	102,000	106,000	93,700	92,500
90	84,200	71,700	71,500	104,000	91,500	91,300	98,600	90,300	88,400
100	75,900	61,600	60,300	96,300	79,600	78,500	92,600	82,300	81,500

TABLE 9.4 FLOW DURATION DATA AT SUSITNA STATION FOR NATURAL, WATANA ONLY, AND WATANA/DEVIL CANYON, OPEN-WATER SEASON
(Continued)

	Week 41 (July 8 - July 14)			Week 42 (July 15 - July 21)			Week 43 (July 22 - July 28)		
Percent	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load
0	190,000	169,000	168,000	191,000	169,000	168,000	181,000	163,000	163,000
25	150,000	130,800	130,000	110,000	130,000	129,000	144,000	123,000	124,000
50	124,000	111,184	113,000	126,000	111,000	112,000	119,000	103,000	103,000
75	112,000	99,700	98,900	117,000	100,000	102,000	104,000	92,400	92,200
90	104,000	90,800	90,600	96,000	83,700	82,100	93,300	83,800	82,300
100	91,100	79,200	79,100	86,900	79,500	79,500	84,700	76,500	74,900

	Week 44 (July 29 - August 4)			Week 45 (August 5 - August 11)			Week 46 (August 12 - August 18)		
Percent	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load
0	199,000	179,000	176,000	177,000	162,000	160,000	207,000	178,000	183,000
25	134,000	120,000	119,000	136,000	121,000	121,000	131,000	117,000	117,000
50	122,000	104,000	104,000	120,000	109,000	107,000	111,000	96,700	97,600
75	109,000	96,000	94,400	109,000	97,500	97,300	100,000	90,700	90,100
90	99,700	85,200	85,100	101,000	90,500	89,500	82,200	78,700	77,700
100	91,000	82,300	82,300	96,800	87,100	87,100	75,300	66,200	64,900

	Week 47 (August 19 - August 25)			Week 48 (August 26 - September 1)			Week 49 (September 2 - September 8)		
Percent	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load
0	135,000	134,000	134,000	116,000	116,000	116,000	101,000	97,600	97,600
25	110,000	106,000	106,000	91,300	84,900	84,700	78,400	77,000	76,400
50	100,000	89,200	88,400	84,600	72,800	72,500	69,900	65,200	64,500
75	89,400	77,900	77,900	70,400	66,600	65,200	59,600	56,000	53,600
90	80,900	75,100	75,100	65,900	60,800	58,400	46,800	46,800	44,200
100	55,300	57,300	57,300	53,600	56,000	55,800	42,300	42,600	42,600

TABLE 9.4 FLOW DURATION DATA AT SUSITNA STATION FOR NATURAL, WATANA ONLY, AND WATANA/DEVIL CANYON, OPEN-WATER SEASON
(Continued)

	Week 50 (September 9 - September 15)			Week 51 (September 16 -22)			Week 52 (September 23 - 30)		
Percent	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load	Natural Conditions	1996 Load	2020 Load
0	102,000	97,700	95,700	175,000	159,000	156,000	116,000	103,000	101,000
25	84,100	77,800	80,400	89,500	84,400	81,900	91,900	78,900	80,100
50	67,500	65,100	63,900	64,800	62,700	61,000	61,900	53,800	51,500
75	55,300	51,100	50,800	51,000	51,300	50,300	46,000	38,600	39,900
90	40,000	40,800	40,800	39,200	39,000	38,000	36,600	34,800	32,600
100	38,300	38,300	38,300	34,700	35,600	35,600	28,400	24,900	24,900

FIGURES

RIVER MILE 103.2

SINGLE CHANNEL:

- STABLE
- NON-ERODIBLE BANKS; CONTROLLED BY VALLEY WALLS, BEDROCK OR ARMOR LAYER CONSISTING OF GRAVEL/COBBLES.
- CHANNEL MAY BE EITHER STRAIGHT OR MEANDERING; IN STRAIGHT CHANNELS, THALWEG OFTEN MEANDERS ACROSS CHANNEL.
- OCCASIONAL FRAGMENTARY ALLUVIAL DEPOSITS IN FLOODPLAIN.

Single-Channel River Pattern

Source: R&M (1982A)

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Figure 3.1

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RIVER MILE 124.4

SPLIT CHANNEL:

- MAIN CHANNEL BEHAVES SIMILAR TO SINGLE CHANNEL AT LOW FLOW.
- SIDE CHANNELS PROVIDE FLOOD RELIEF AT HIGH FLOWS (GREATER THAN 20,000 CFS).
- ISLANDS WELL ESTABLISHED WITH VEGETATION.
- GRAVEL/COBBLE BED MATERIAL.
- MEAN ANNUAL FLOOD CORRELATES WITH BANKFULL FLOW.
- CHANNELS ARE MODERATELY STABLE.

Split-Channel River Pattern

Source: R&M (1982A)

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Figure 3.2

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CHULITNA RIVER NEAR CONFLUENCE WITH SUSITNA RIVER

BRAIDED CHANNEL:

- FLOODPLAIN IS VERY WIDE AND SHALLOW EVEN AT FLOOD FLOW.
- MULTIPLE AND INTERLACING CHANNELS IN UNVEGETATED GRAVEL FLOODPLAIN
- MOVE LARGE QUANTITIES OF BED MATERIAL DURING FLOWS GREATER THAN BANKFULL
- RESULTS FROM COMBINATION OF HIGH RATES OF BEDLOAD TRANSPORT, LOW CHANNEL STABILITY, HIGH SEDIMENT SUPPLY, HIGH GRADIENTS AND LOW UPSTREAM FLOW REGULATION.

Braided-Channel River Pattern

Source: R&M (1982A)

DELTA ISLANDS

MULTI-CHANNEL (DELTA ISLANDS):

- VERY BROAD FLOODPLAIN WITH LITTLE LATERAL CONTROL.
- MULTIPLE CHANNELS CONSIST OF A MIX OF BRAIDED, SPLIT CHANNEL AND SINGLE CHANNELS WITHIN FLOODPLAIN.
- RELATIVELY UNSTABLE, SUBJECT TO MAJOR LOCAL CHANGES DURING SINGLE FLOOD EVENTS.
- LARGE AMOUNT OF FINE SUSPENDED SEDIMENT HELPS STABILIZE BANKS; DENSE VEGETATION EFFECTIVE IN TRAPPING SEDIMENT.
- BED MATERIAL CONSISTS OF GRAVEL/SAND WITH POCKETS OF SILT.

Multi-Channel River Pattern

Source: R&M (1982A)

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Figure 3.4

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Figure 3.5 Split channelmorphology below west fork Susitna confluence.

Figure 3.6 Vee Canyon.

Figure 3.7 Susitna River near Watana Damsite.

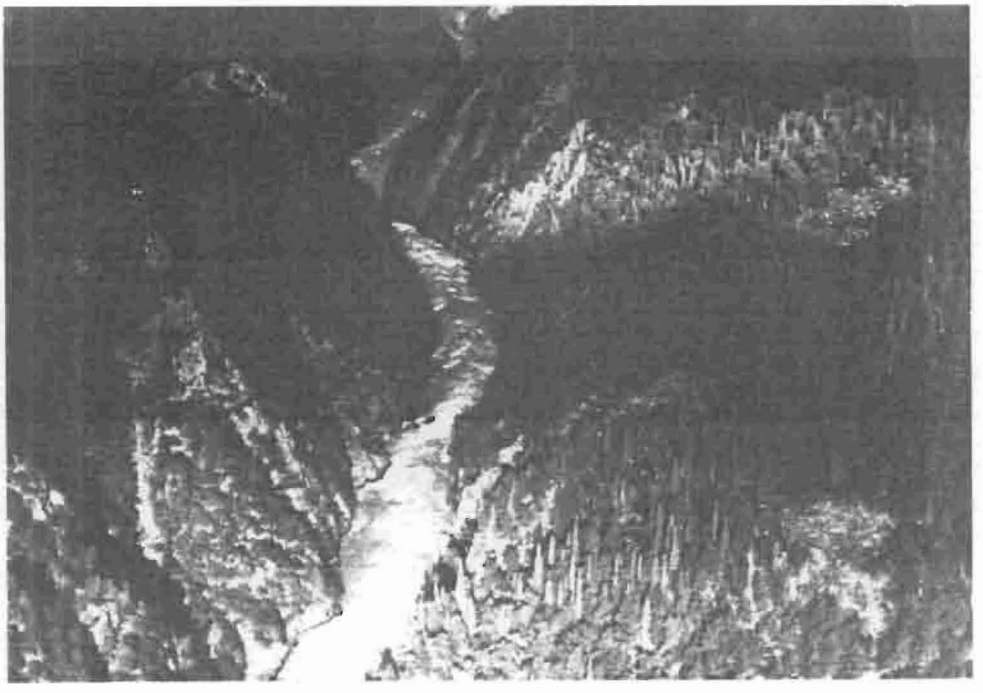

Figure 3.8 Rapids at Devil Canyon.

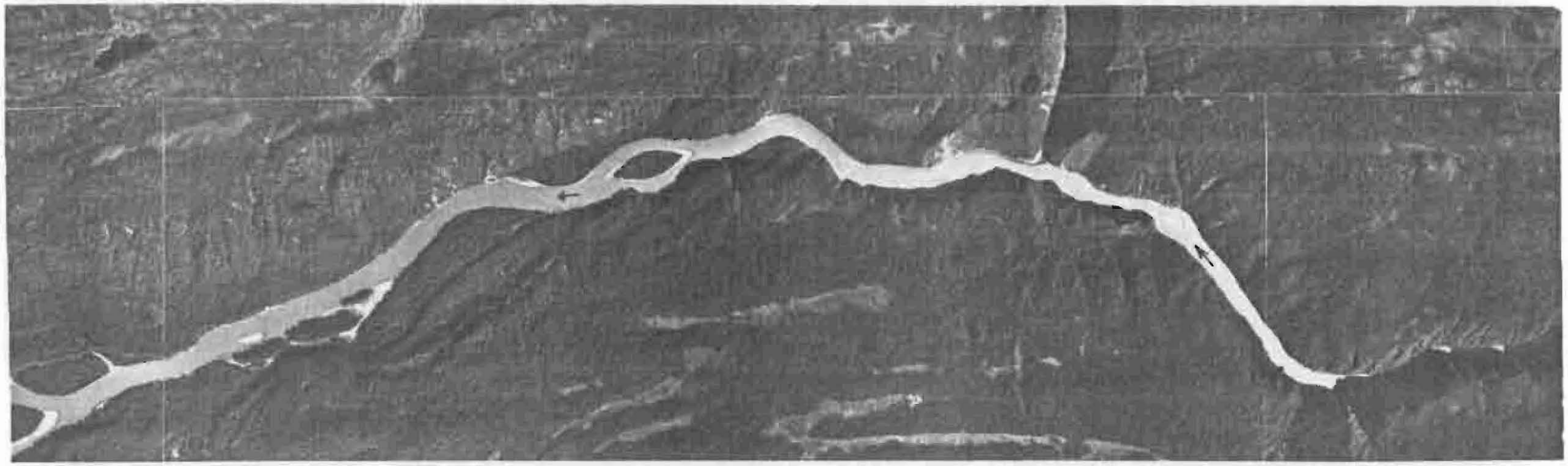

Figure 3.9 Single channel morphology, Susitna River, RM 150 to RM 144.
Flow at Gold Creek = 18,000 cfs. August 24, 1980.

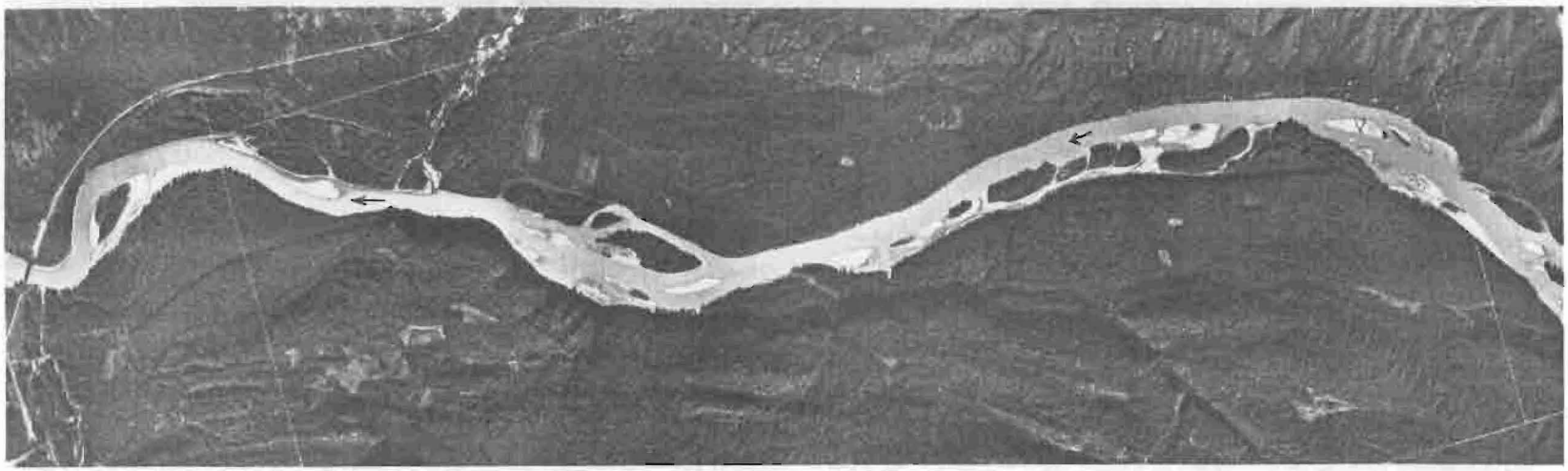

Figure 3.10 Split-channel morphology, Susitna River, RM 144 to RM 137
Flow at Gold Creek = 18,000 cfs. August 24, 1980

Scale 1" = 4000'

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Figures 3.9 and 3.10

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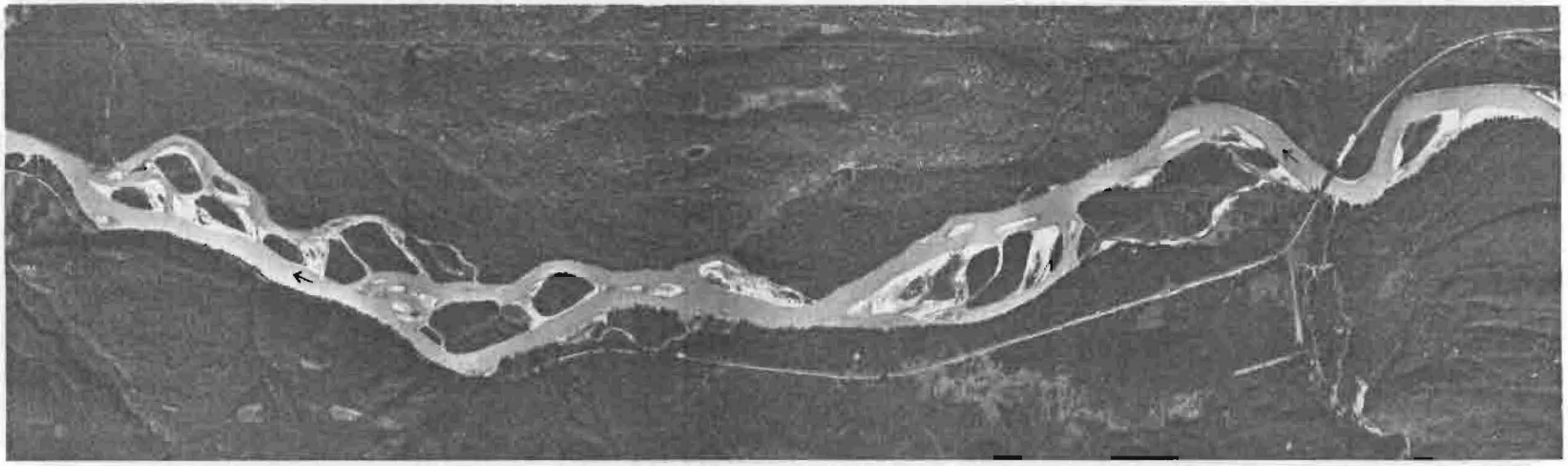

Figure 3.11 Split-channel morphology, Susitna River, RM 137 to RM 131.
Flow at Gold Creek = 18,000 cfs. August 24, 1980

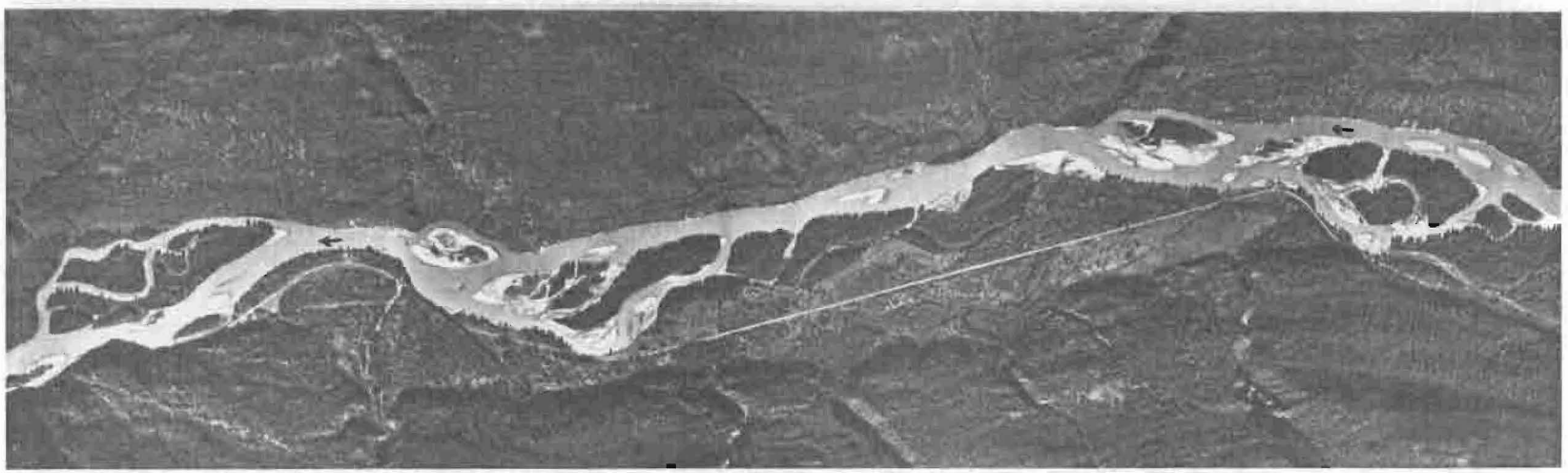

Figure 3.12 Side channels and sloughs along Susitna River, RM 126 to RM 119.
Flow at Gold Creek = 18,000 cfs. August 24, 1980

Scale 1" = 4000'

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Figures 3.11 and 3.12

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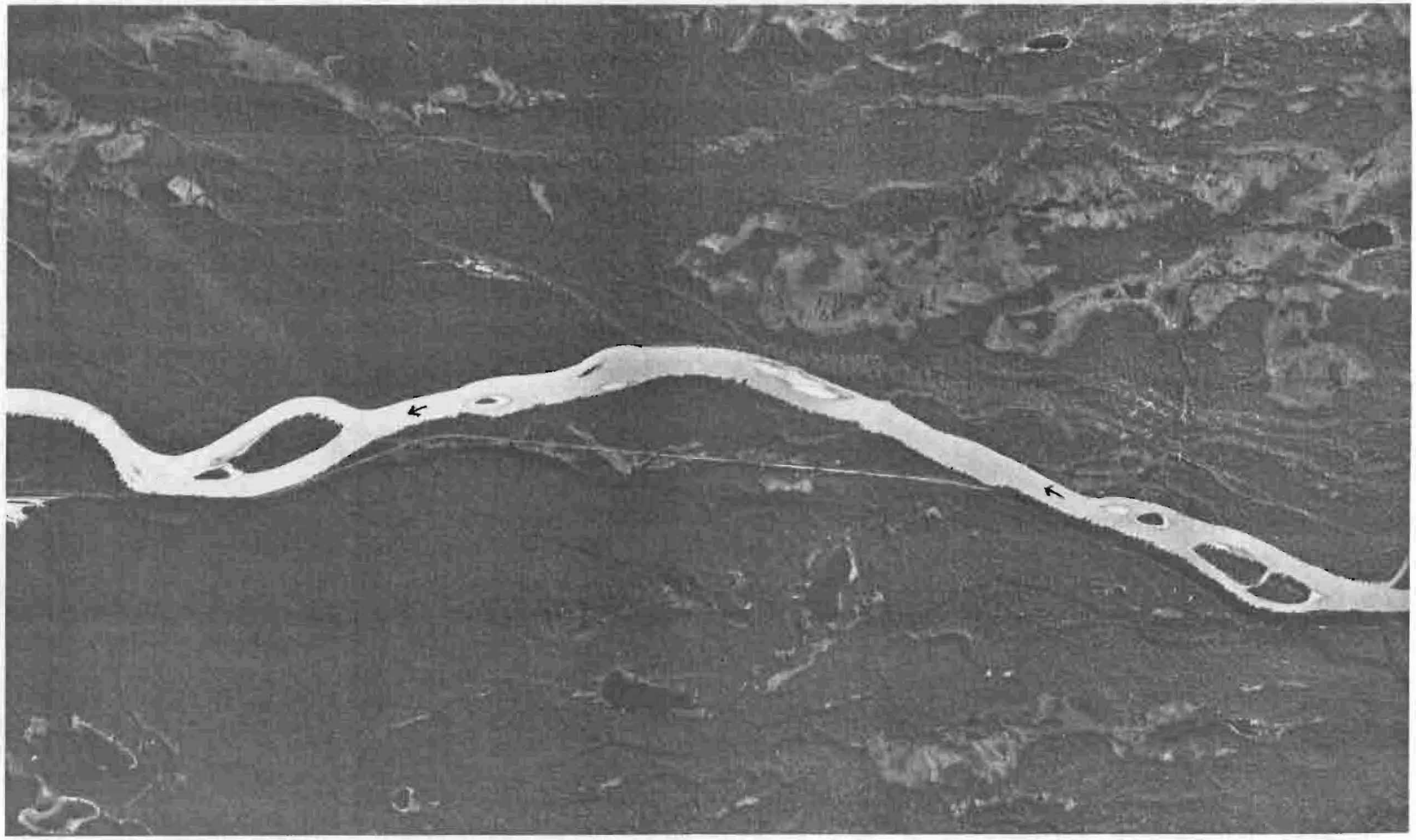

Single channel morphology, Susitna River, RM 110 to RM 104.
Flow at Gold Creed = 18,000 cfs. August 24, 1980.

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Figure 3.13

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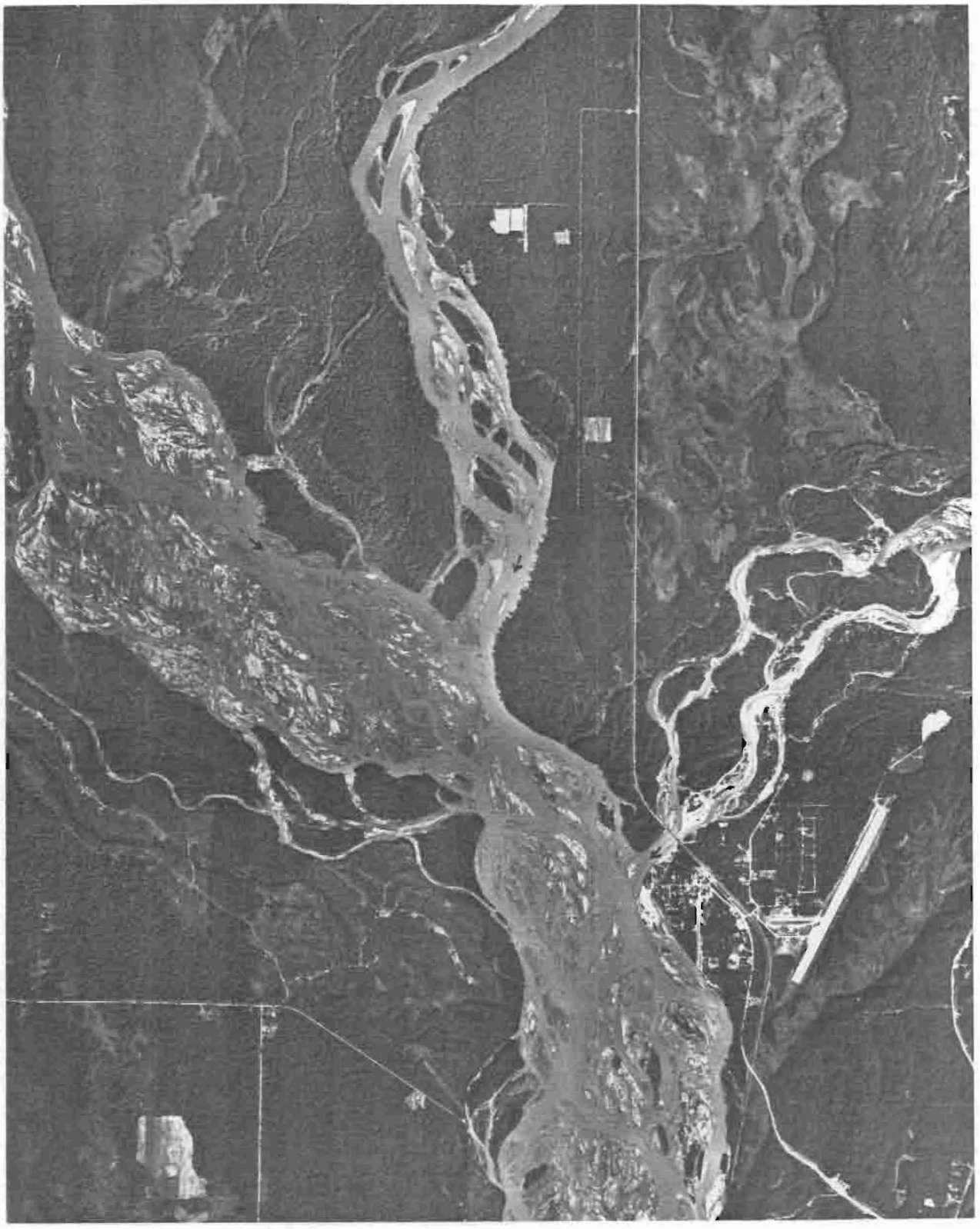

Confluence of Susitna, Chulitna, and Talkeetna Rivers, RM 102 to RM 95. Flow at Sunshine approximately 39,400 cfs. August 29, 1980

Scale 1" = 4000'

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Figure 3.14

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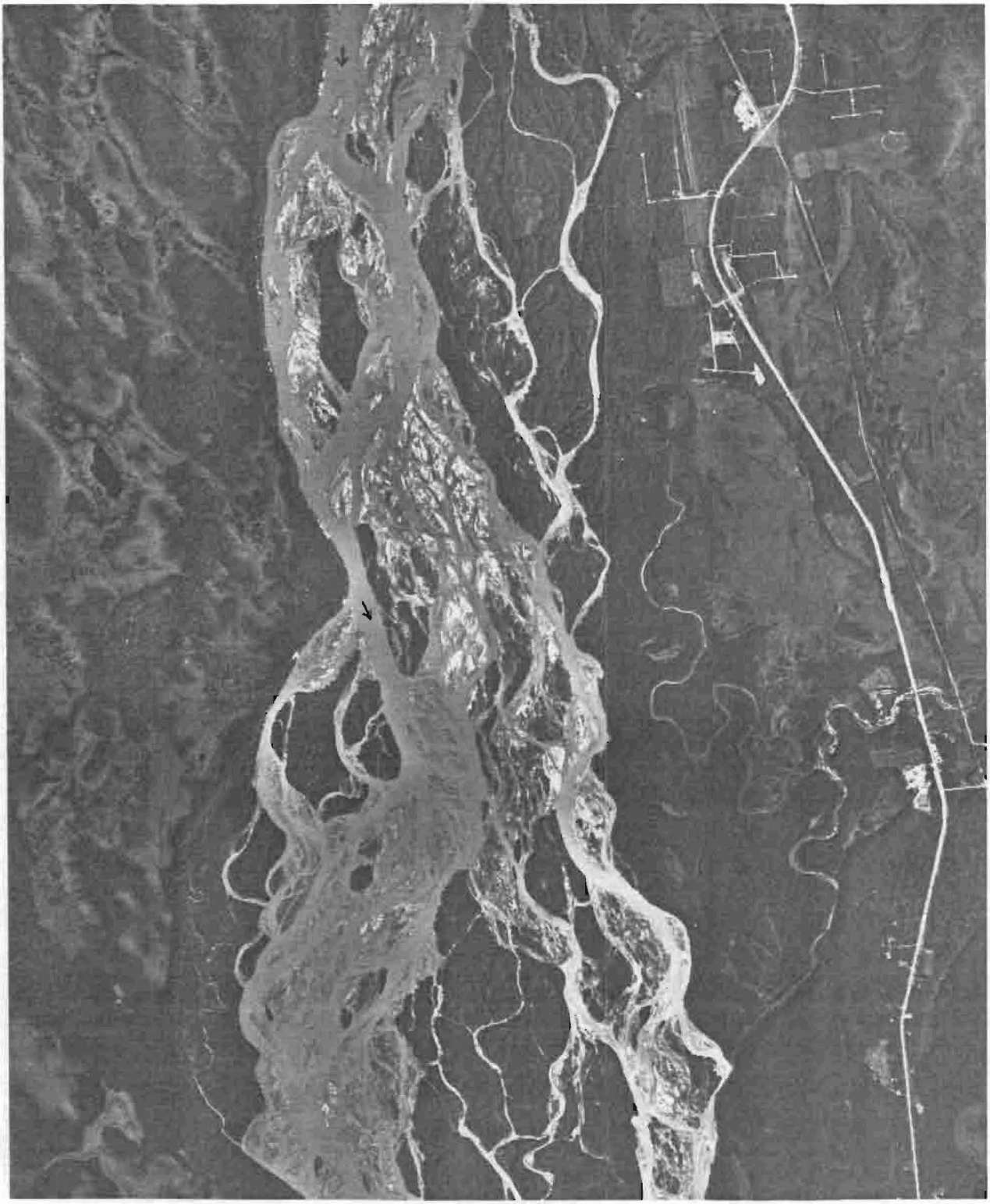

Braided river morphology downstream of Talkeetna RM 72 to RM 65.
Flow at Sunshine approximately 39,400 cfs. August 24, 1980
Scale 1" = 4000'

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Figure 3.15

PREPARED FOR:
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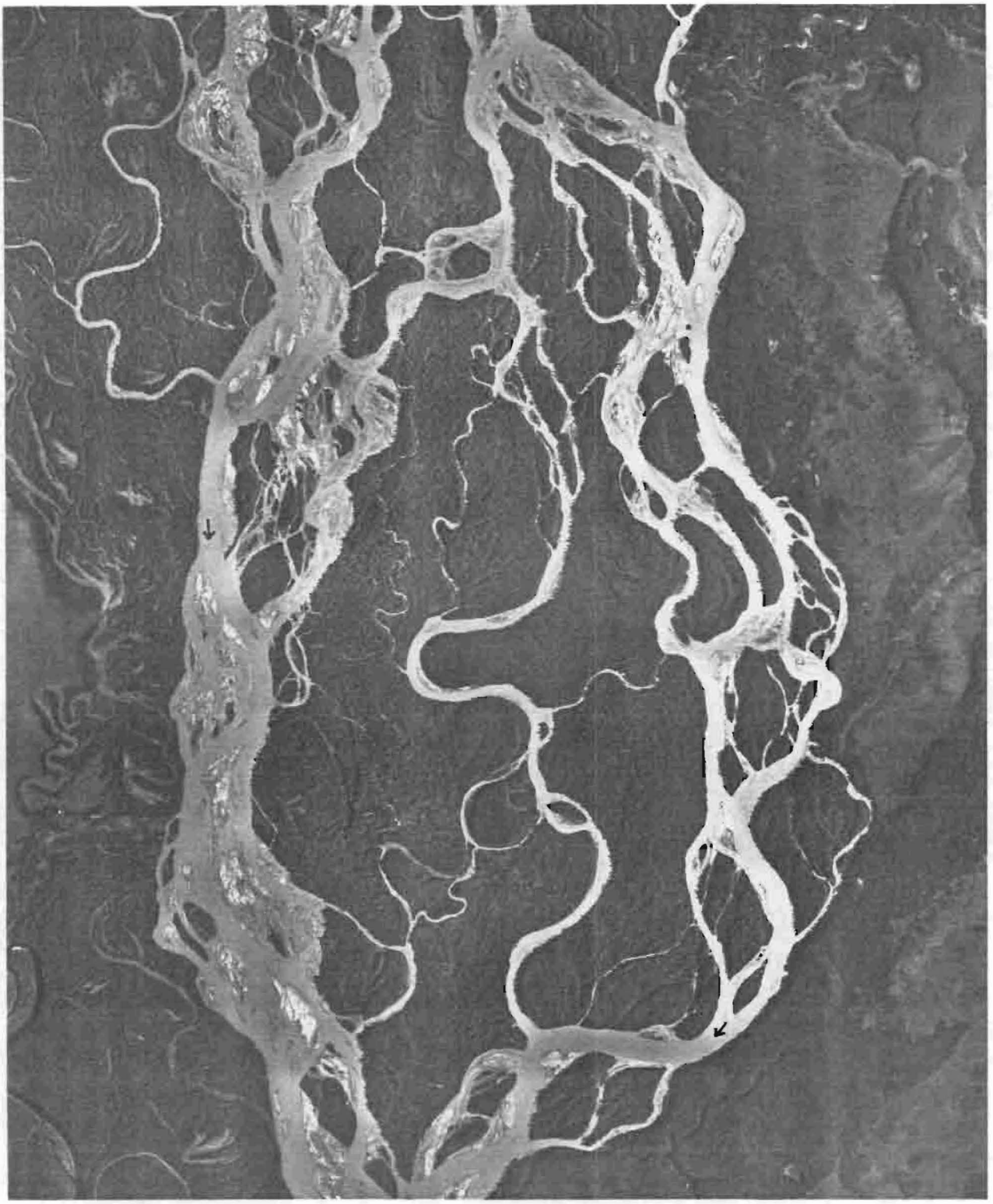
SUSITNA JOINT VENTURE



Delta Islands, RM 50 to RM 43.
Flow at Sunshine approximately 39,400 cfs. August 24, 1980
Scale 1" = 4000'

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Figure 3.16

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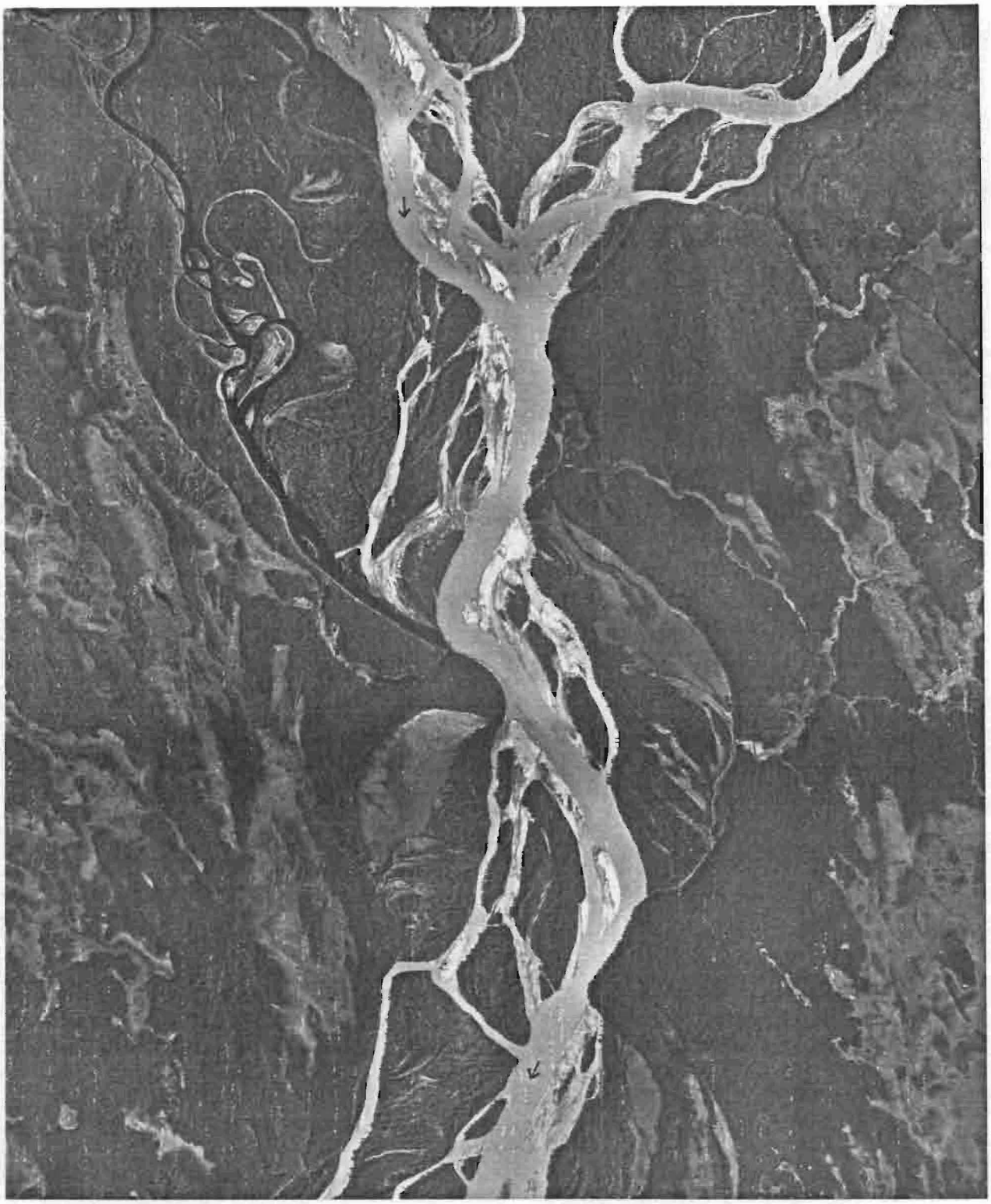
SUSITNA JOINT VENTURE



Deshka River Confluence
Flow at Sunshine approximately 39,400 cfs. August 24, 1980
Scale 1" = 4000'

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Figure 3.17

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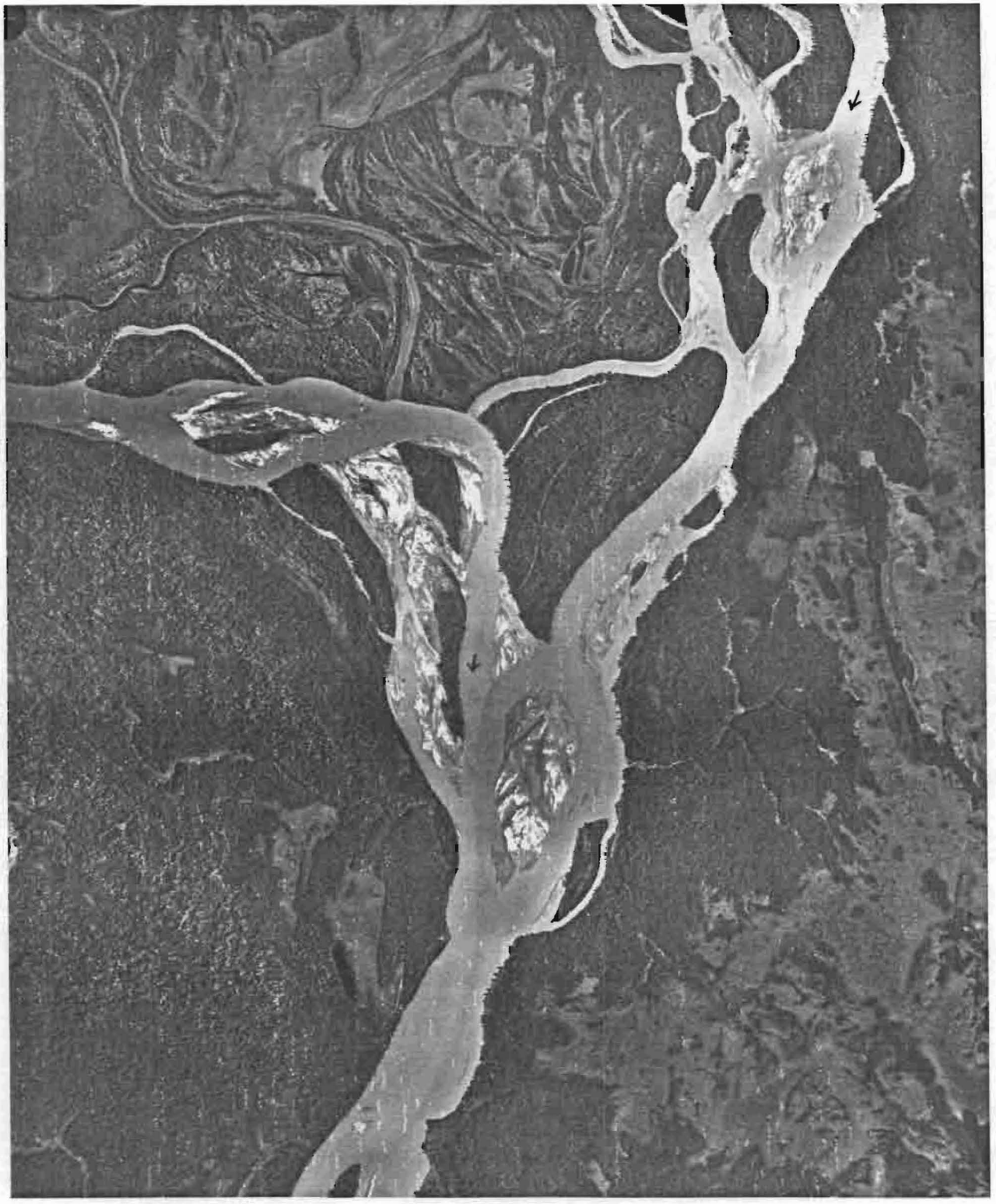
SUSITNA JOINT VENTURE



Yentna River Confluence
Flow at Sunshine approximately 39,400 cfs. August 24, 1980
Scale 1" = 4000'

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Figure 3.18

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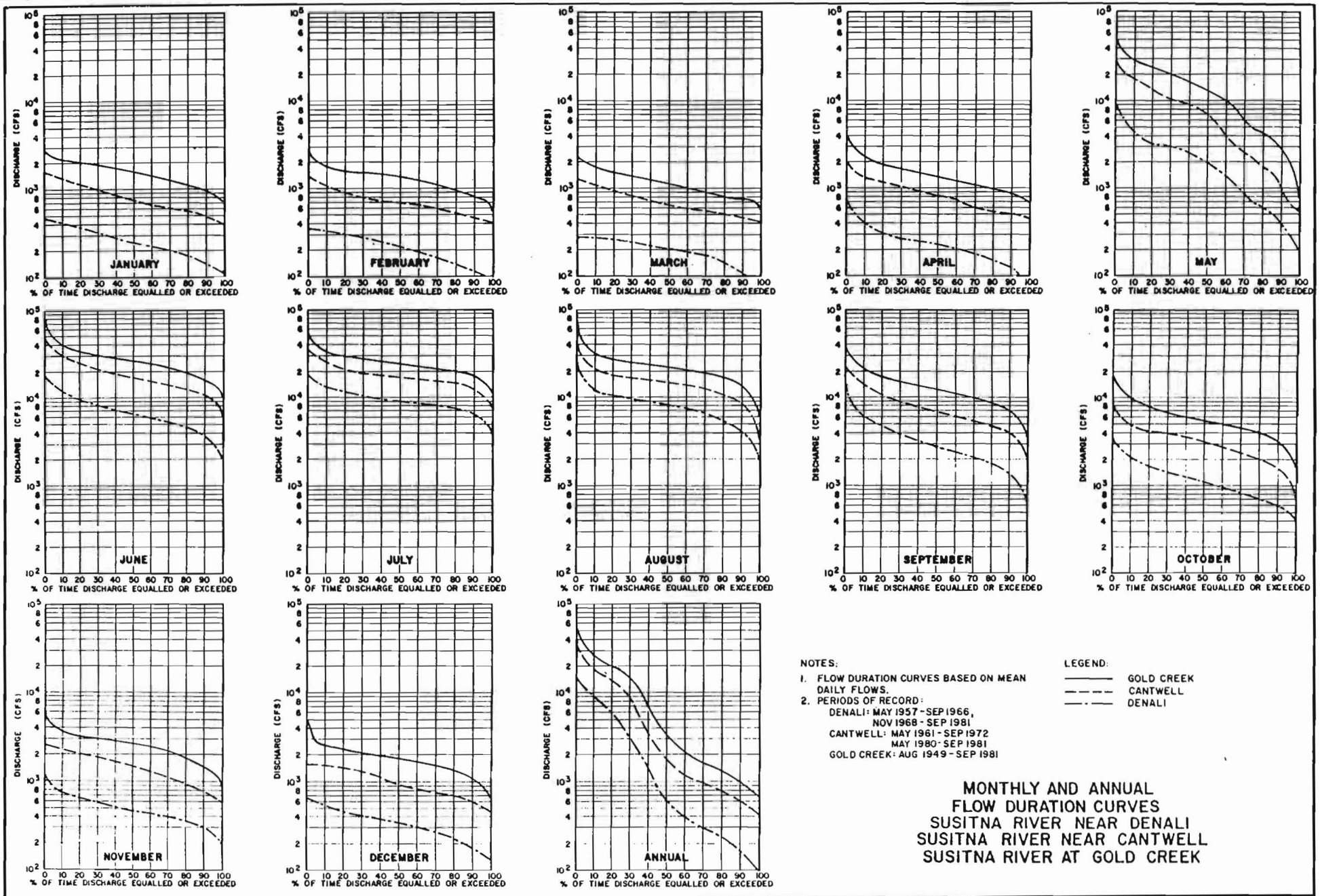

NOTES:

1. FLOW DURATION CURVES BASED ON MEAN DAILY FLOWS.
2. PERIODS OF RECORD:
   DENALI: MAY 1957 - SEP 1966,
   NOV 1968 - SEP 1981
   CANTWELL: MAY 1961 - SEP 1972
   MAY 1980 - SEP 1981
   GOLD CREEK: AUG 1949 - SEP 1981

LEGEND:

——— GOLD CREEK
– – – – CANTWELL
—·—·— DENALI

MONTHLY AND ANNUAL FLOW DURATION CURVES SUSITNA RIVER NEAR DENALI SUSITNA RIVER NEAR CANTWELL SUSITNA RIVER AT GOLD CREEK

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Figure 3.19

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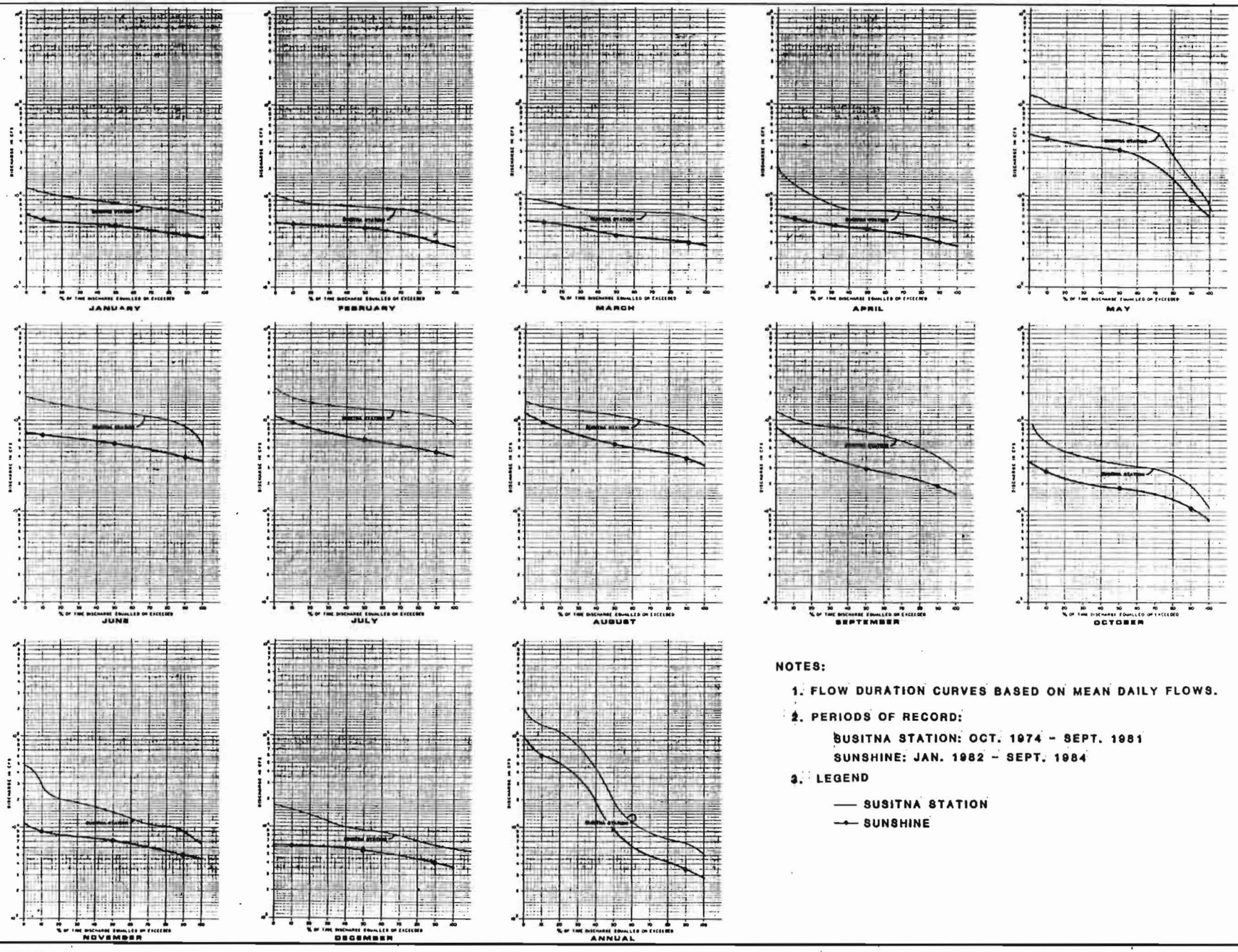
SUSITNA JOINT VENTURE



NOTES:

1. FLOW DURATION CURVES BASED ON MEAN DAILY FLOWS.
2. PERIODS OF RECORD:
   SUSITNA STATION: OCT. 1974 - SEPT. 1981
   SUNSHINE: JAN. 1982 - SEPT. 1984
3. LEGEND
   — SUSITNA STATION
   —•— SUNSHINE

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Figure 3.20 Monthly and annual flow duration curves
Susitna River at Susitna Station
Susitna River at Sunshine

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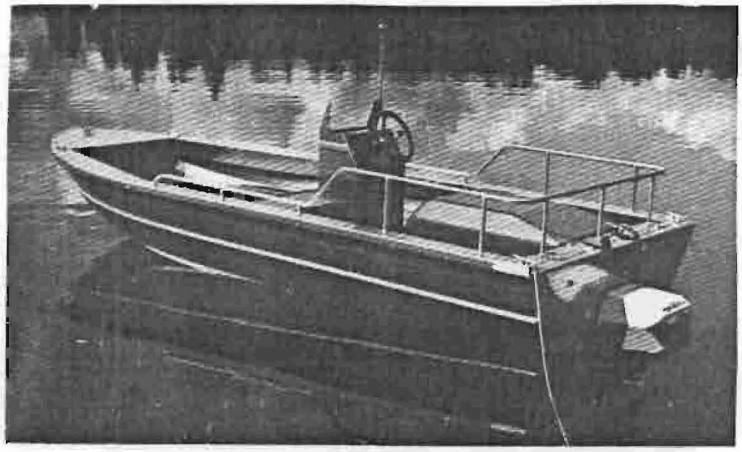
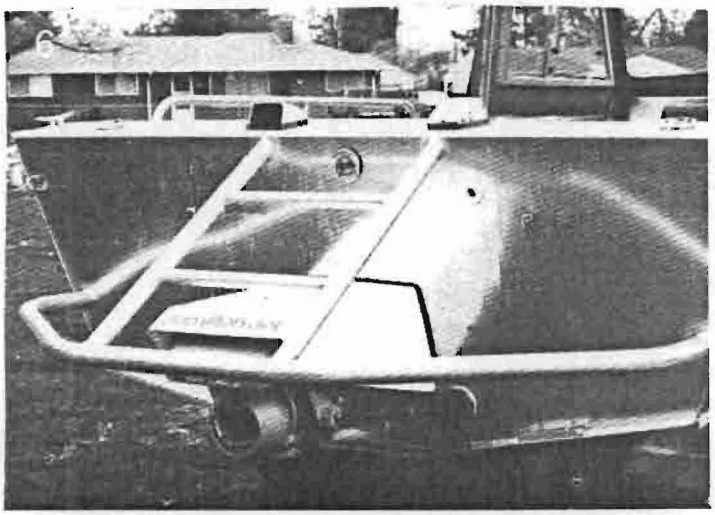


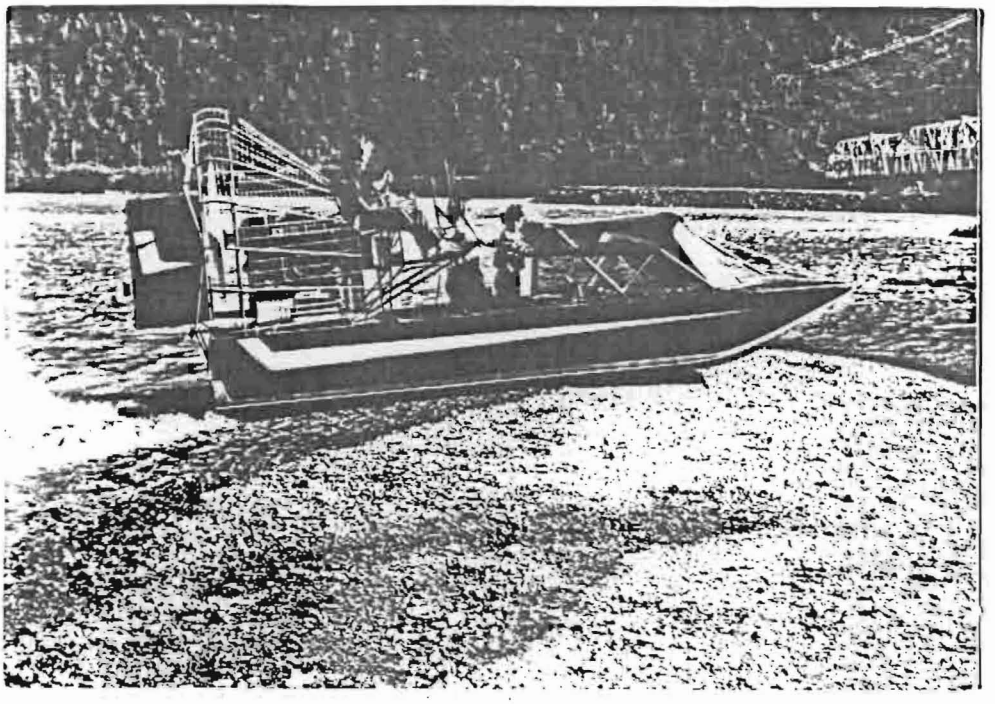
INBOARD ENGINE
JETBOAT



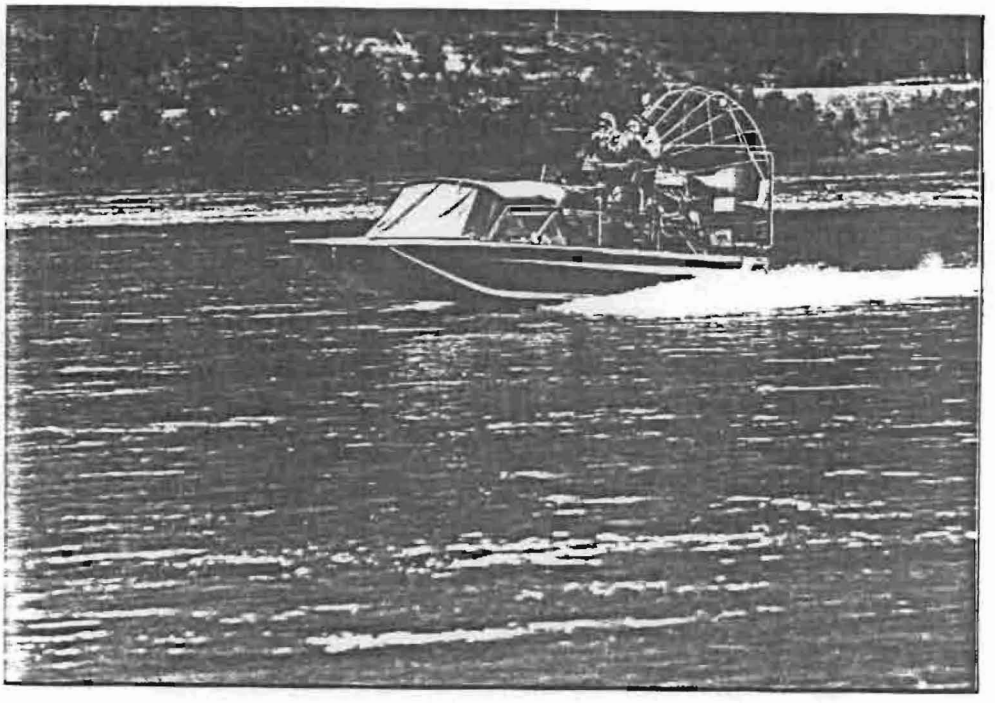
INBOARD ENGINE
JET UNIT DETAIL

OUTBOARD
ENGINE
JETBOAT

PREPARED BY: R&M CONSULTANTS, INC. ENGINEERS GEOLOGISTS HYDROLOGISTS SURVEYORS	JETBOATS FIGURE 4.1	PREPARED FOR: HARZA-EBASCO SUSITNA JOINT VENTURE



AIRBOAT TRAVEL OVER GRAVEL BARS PRESENTS NO PROBLEM



PLANING AIRBOAT (DRAFT IS APPROX. 4 inches)

PHOTOS COURTESY OF MAC'S AIRBOATS, ANCHORAGE

PREPARED BY:		PREPARED FOR:
R&M CONSULTANTS, INC. ENGINEERS GEOLOGISTS HYDROLOGISTS SURVEYORS	AIRBOATS FIGURE 4.2	HARZA-EBASCO SUSITNA JOINT VENTURE

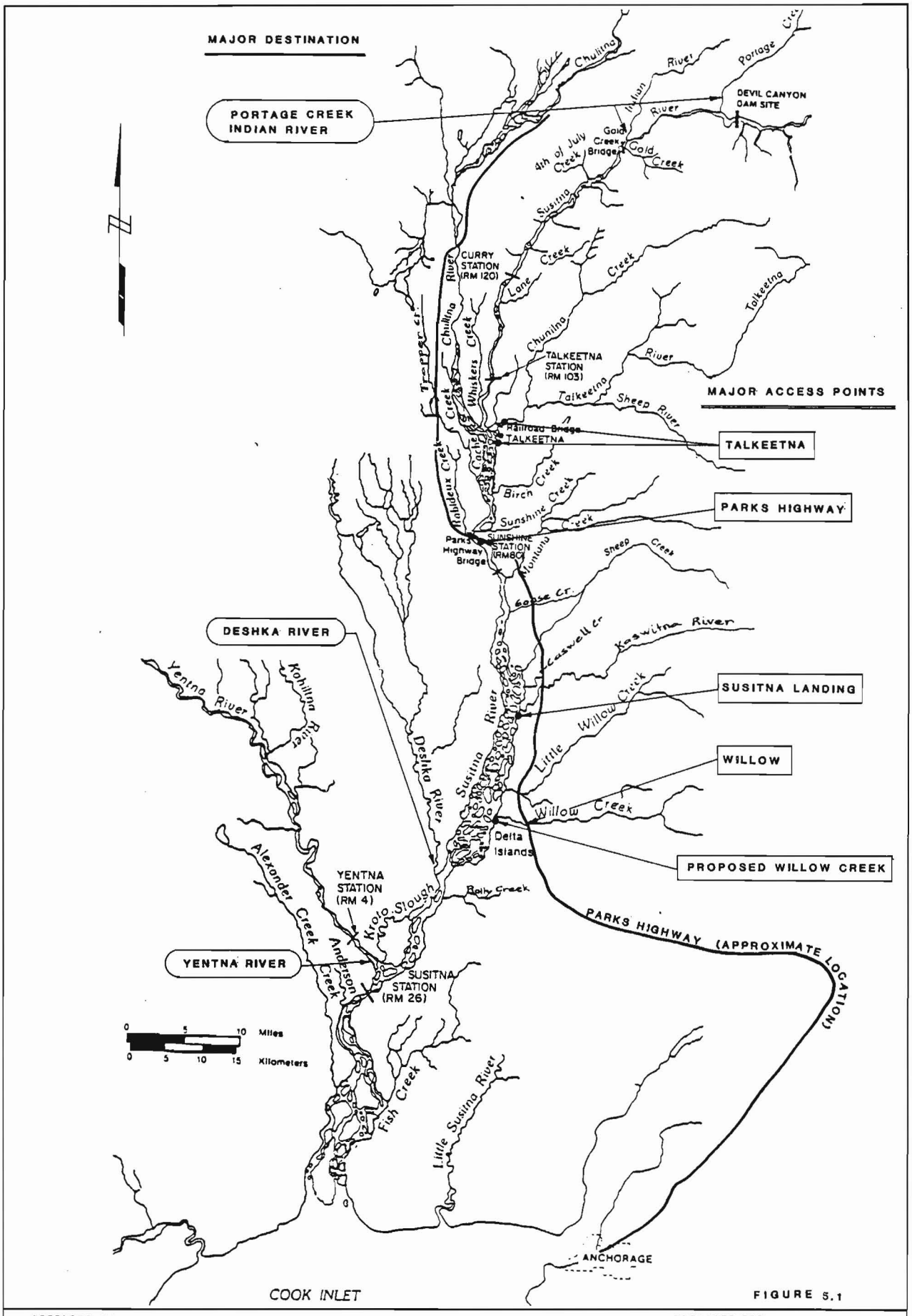


FIGURE 5.1

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LOCATION MAP OF BOATING ACCESS POINTS AND MAJOR DESTINATIONS

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SUSITNA JOINT VENTURE

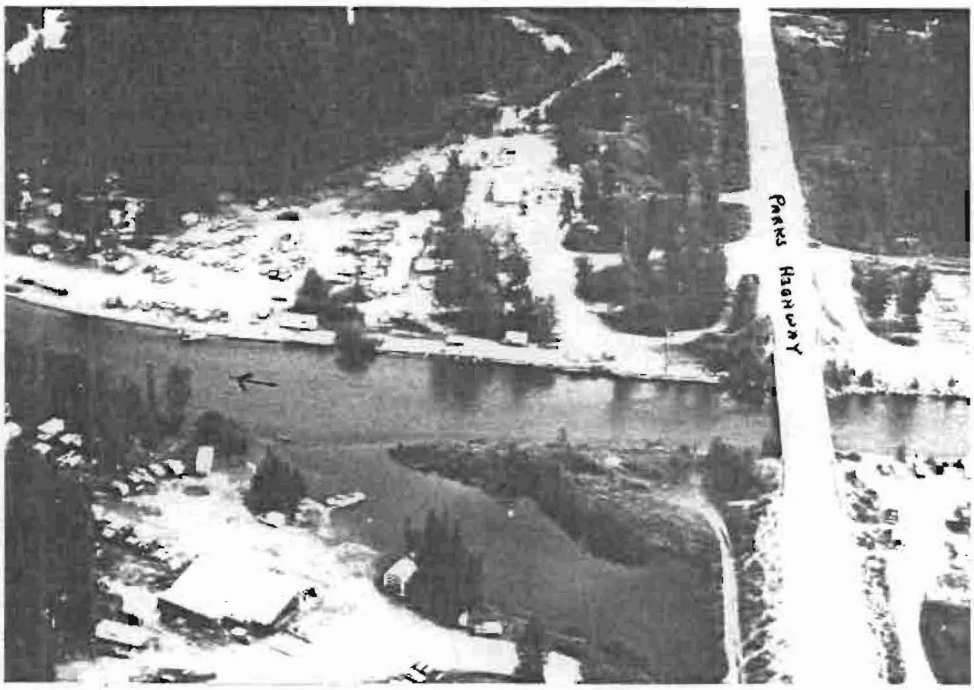

Figure 5.2 Willow Creek boat landing.

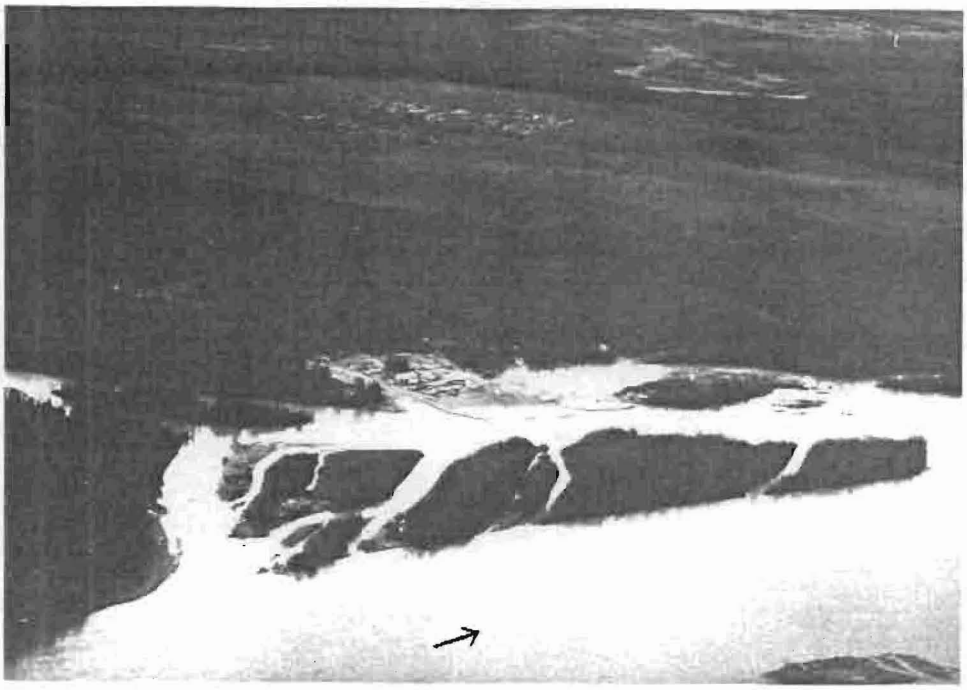

Figure 5.3 Susitna landing.

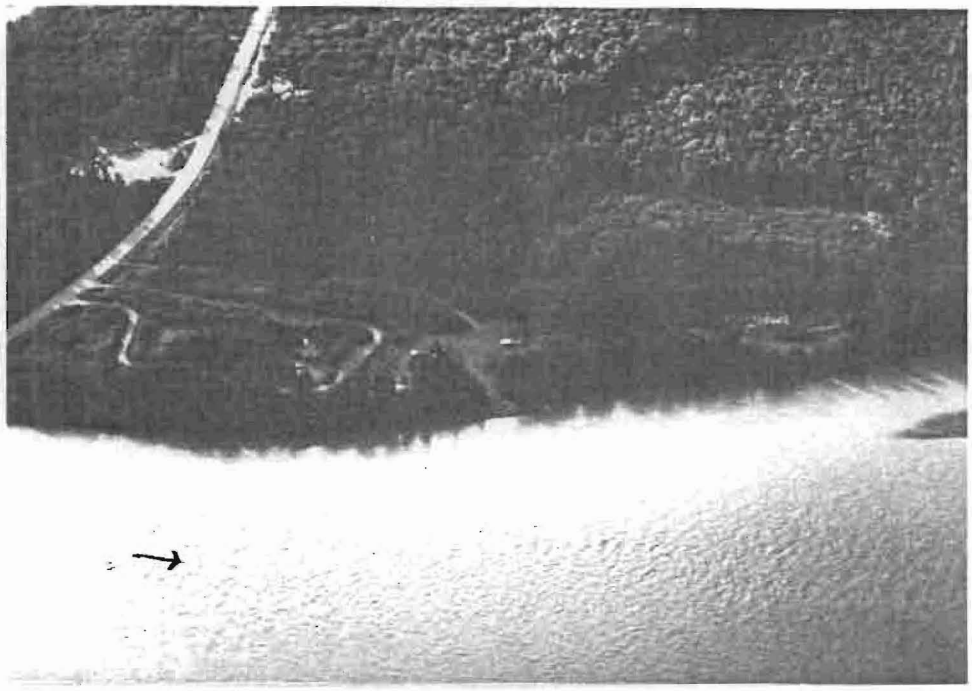

Figure 5.4 Sunshine boat landing

Figure 5.5 Talkeetna boat landing

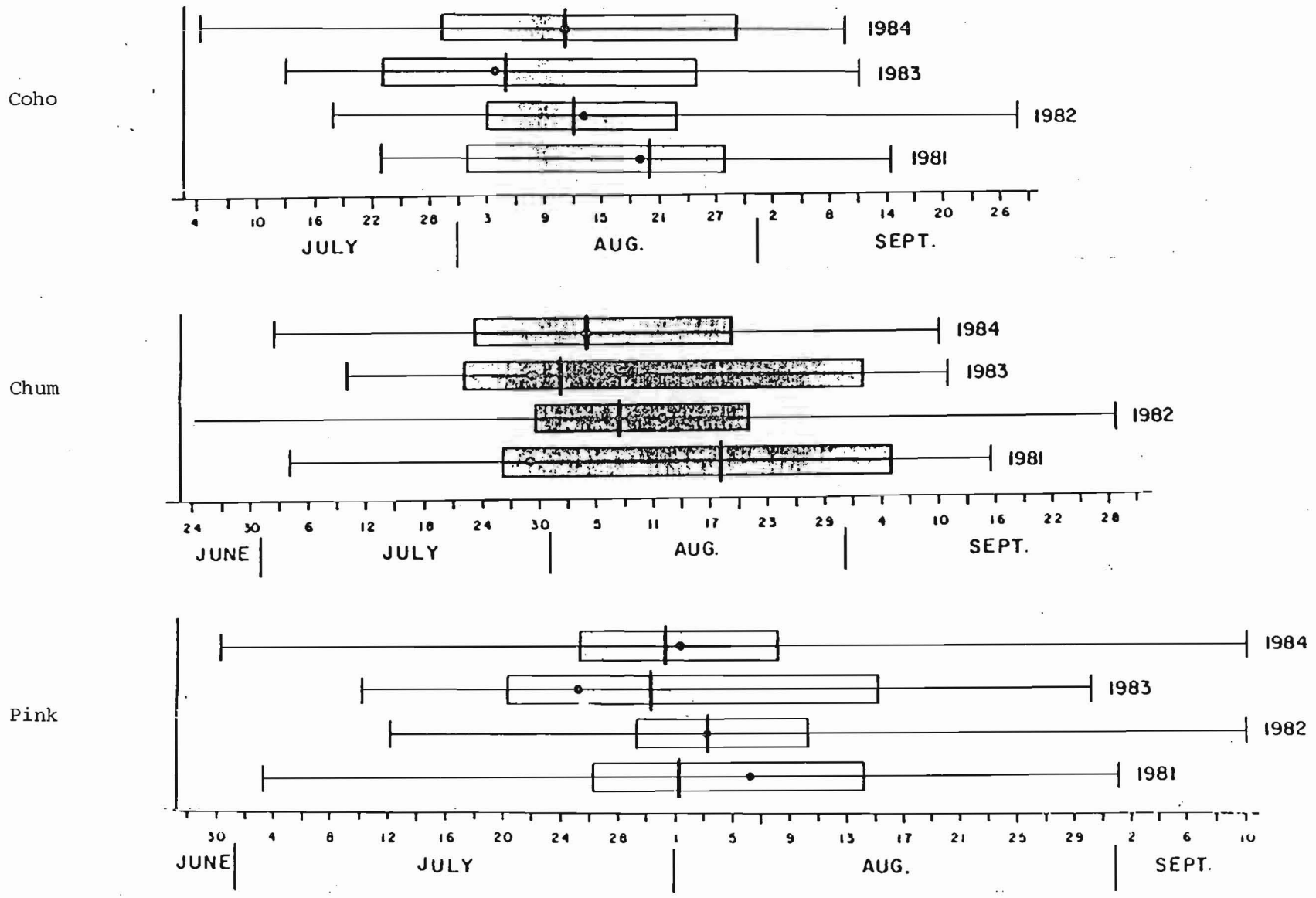

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Figure 6.1 Migrational timing of Salmon based on Fishwheel catch per unit effort Modified from ADF&G (1985B)

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SUSITNA JOINT VENTURE

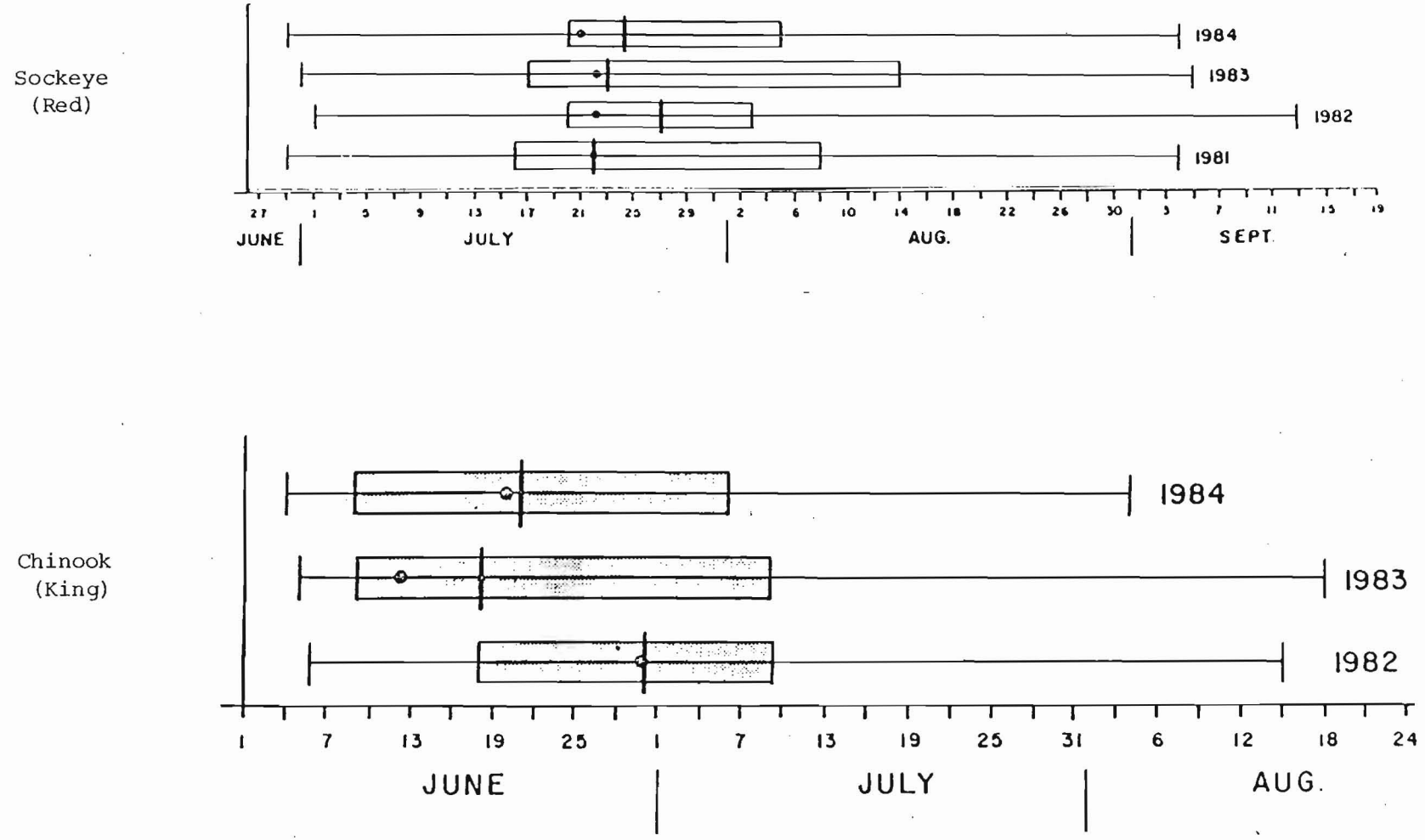

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Figure 6.1 (cont.) Migrational timing of salmon based on Fishwheel catch per unit effort
Modified from ADF&G (1985B)

PREPARED FOR:
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SUSITNA JOINT VENTURE

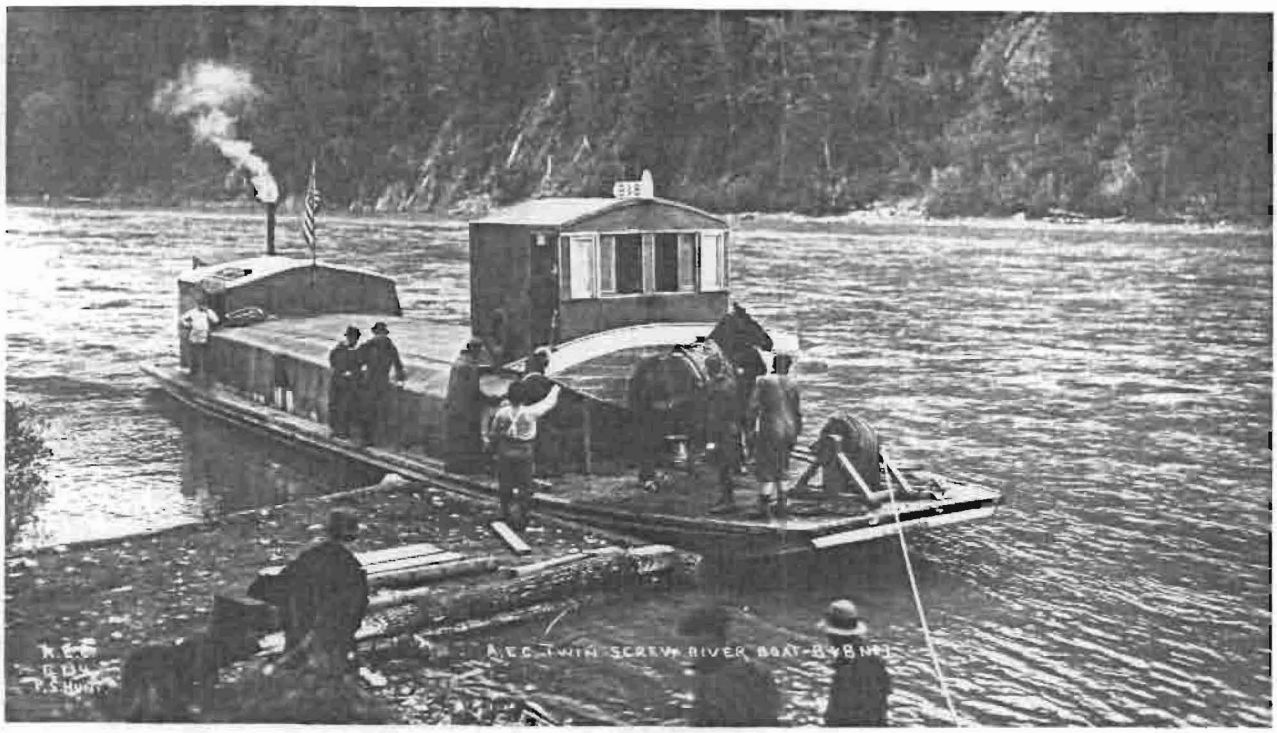


Figure 7.1 Alaska Engineering Commission twin screw riverboat on middle Susitna River, 1919

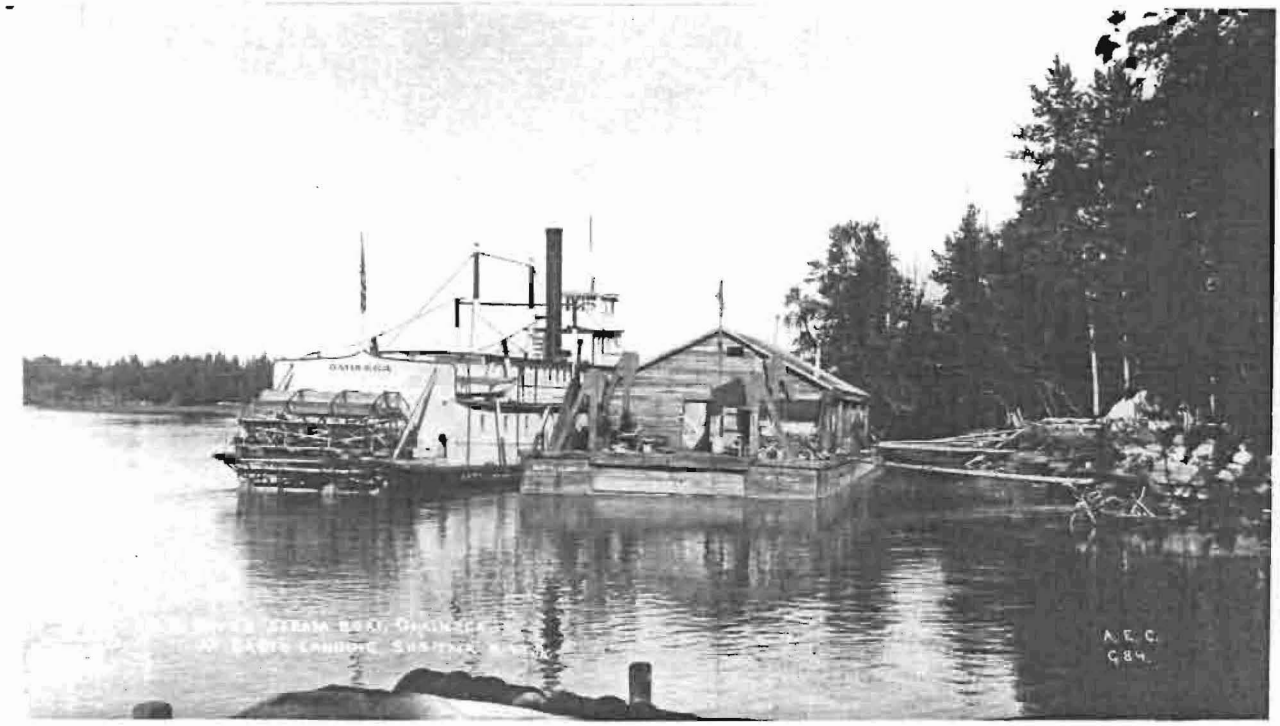
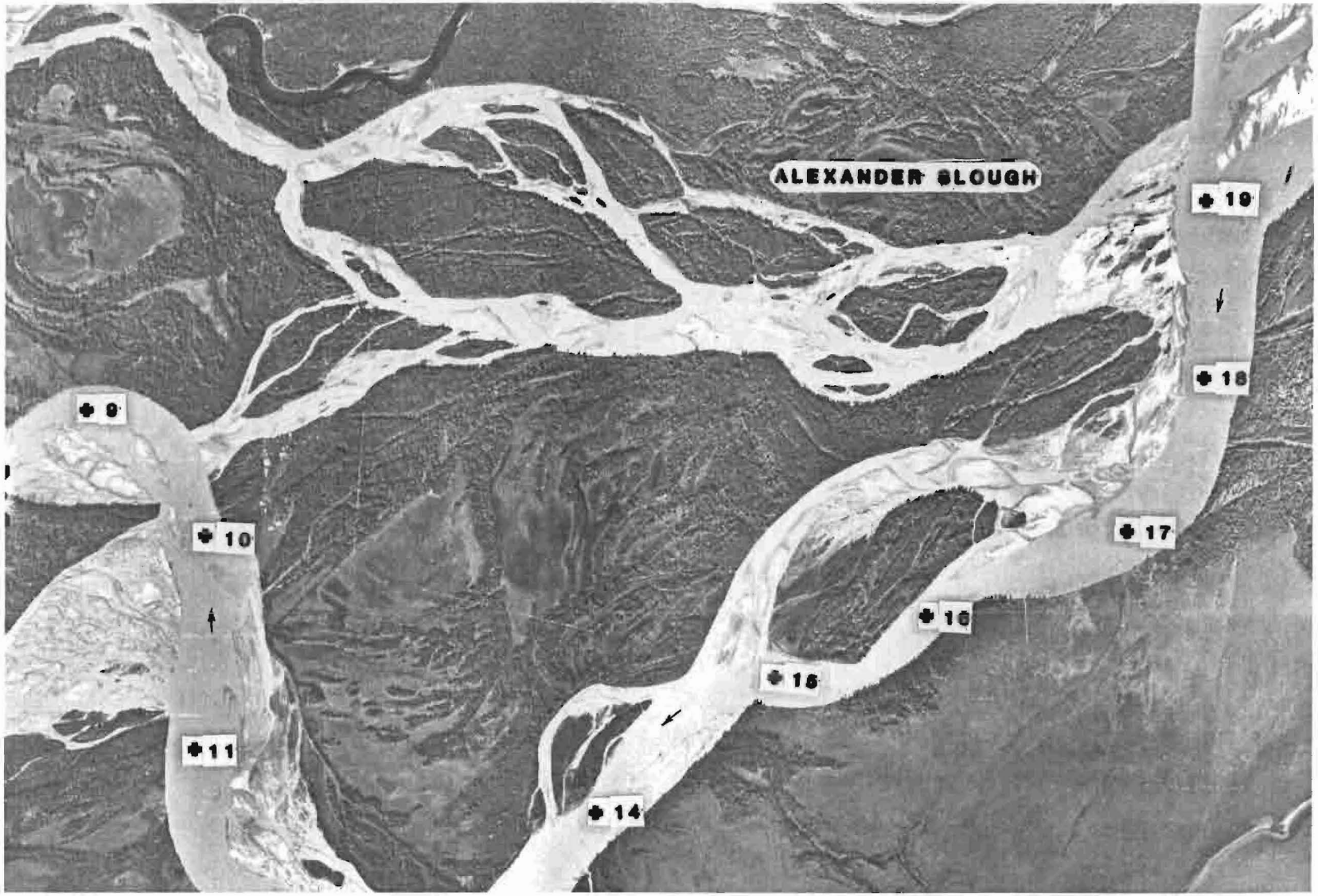


Figure 7.2 U.S. River Steamboat, Omineca at Kroto Landing, 1917. Photos courtesy of Alaska Railroad Collection.



Flow at Susitna Station = 119,000 cfs. August 24, 1980

Scale 1" = 4000'

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Figure 8.1 Head of Alexander Slough

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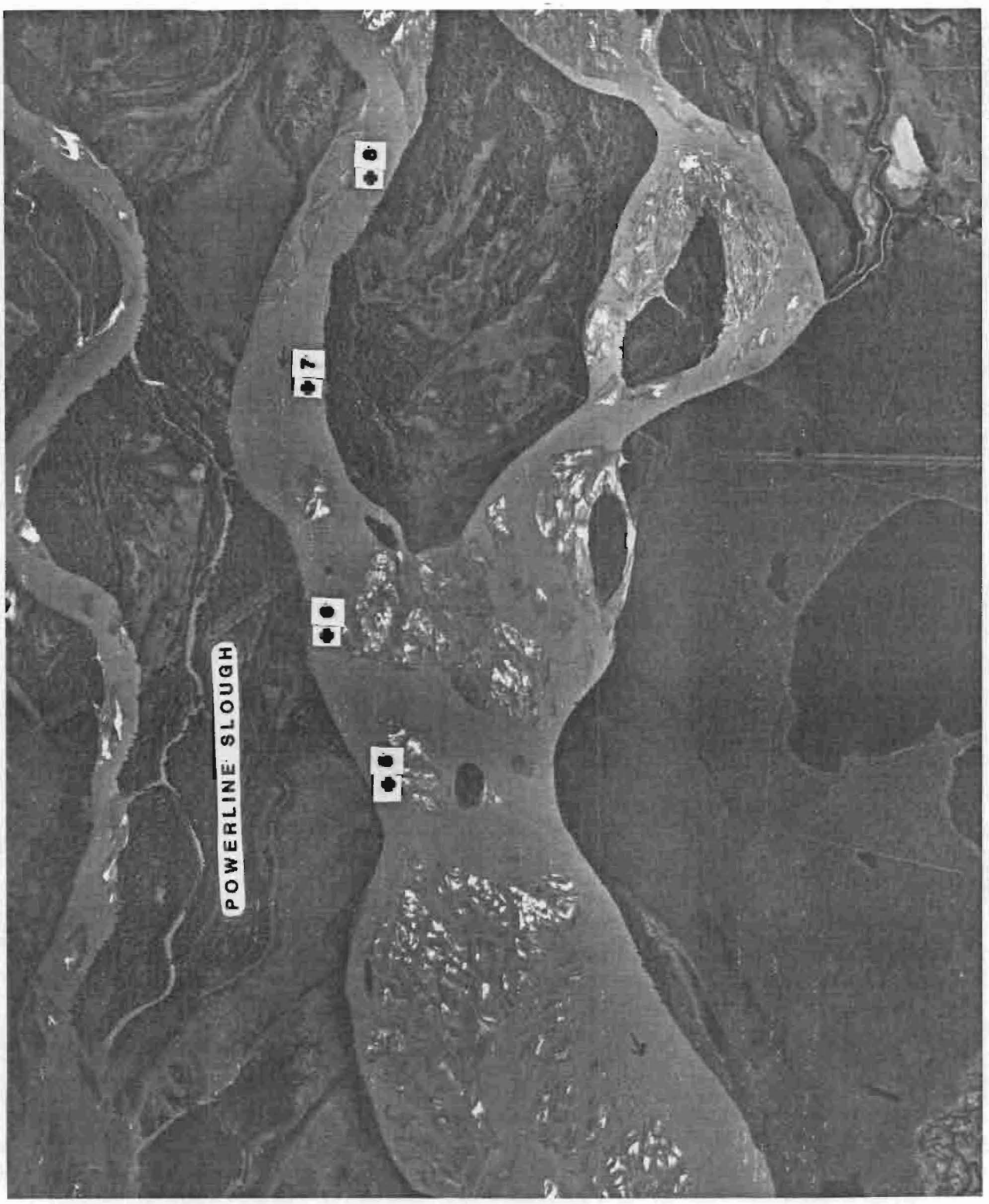

Powerline Slough
Flow at Susitna Station = 119,000 cfs. August 24, 1980
Scale 1" = 4000'

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Figure 8.2

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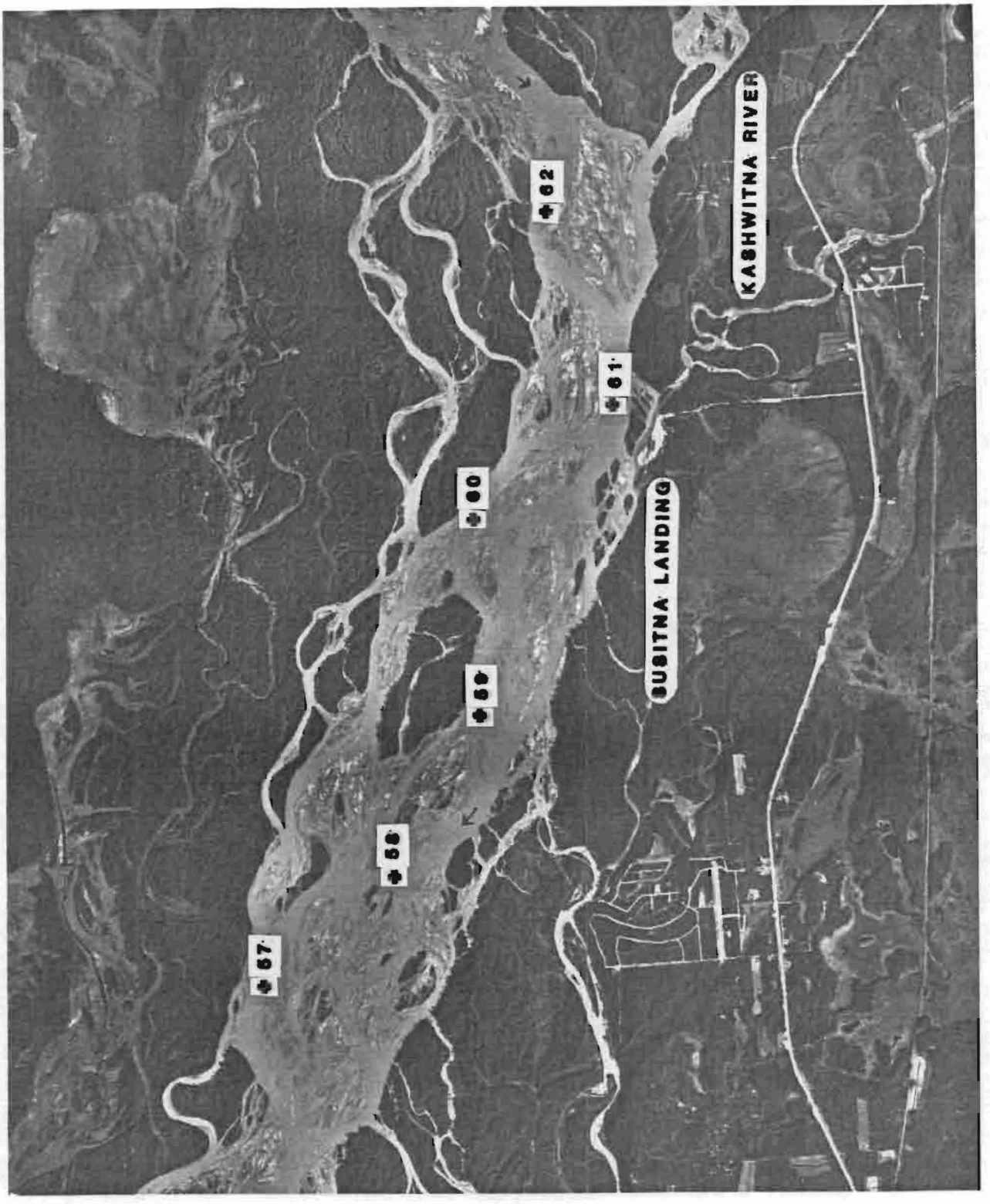

Side channel at Susitna Landing
Flow at Sunshine approximately 39,400 cfs. August 24, 1980
Scale 1" = 4000'

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Figure 8.3

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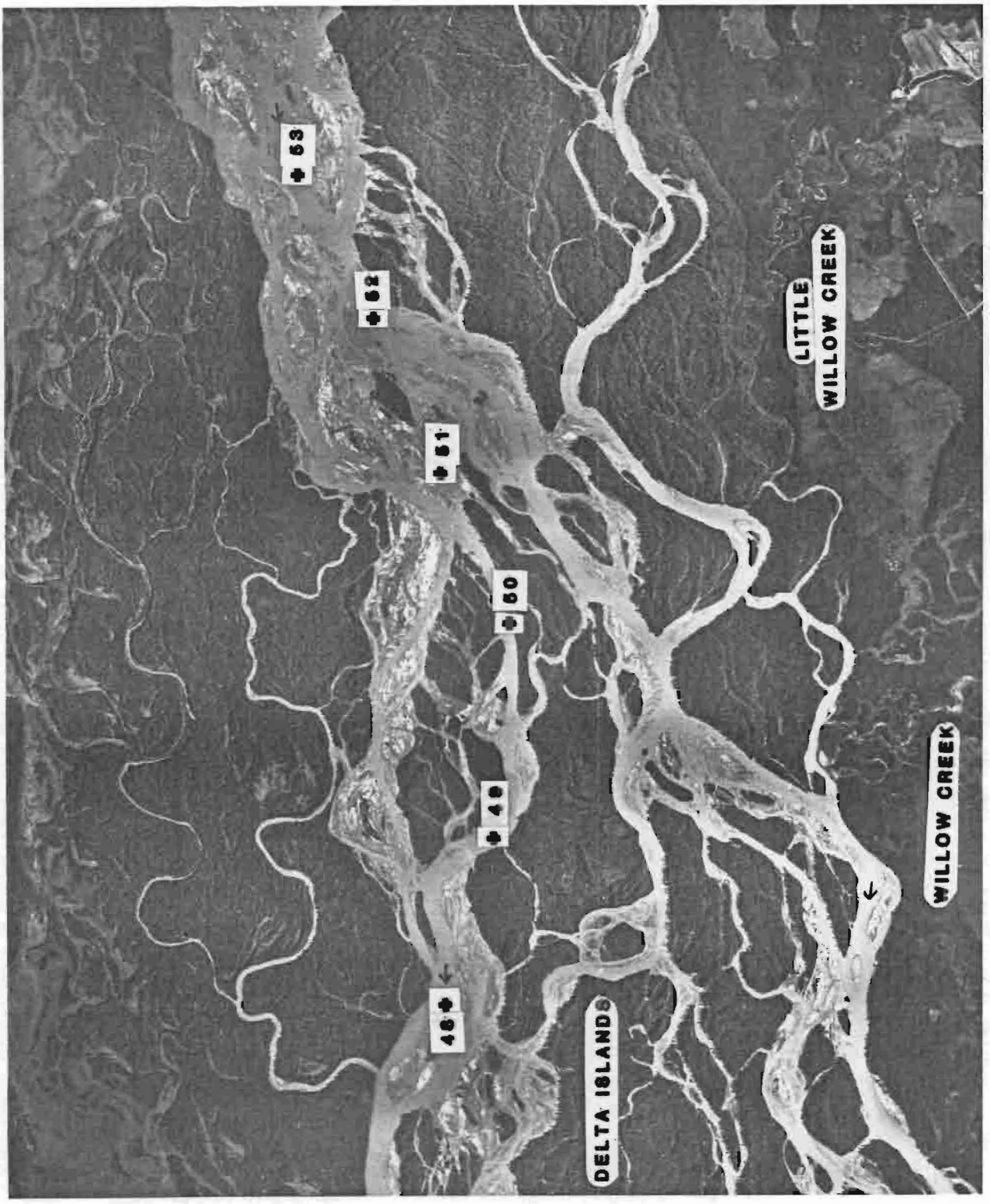

Upper end of Delta Islands
Flow at Sunshine approximately 39,400 cfs. August 24, 1980
Scale 1" = 4000'

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Figure 8.4

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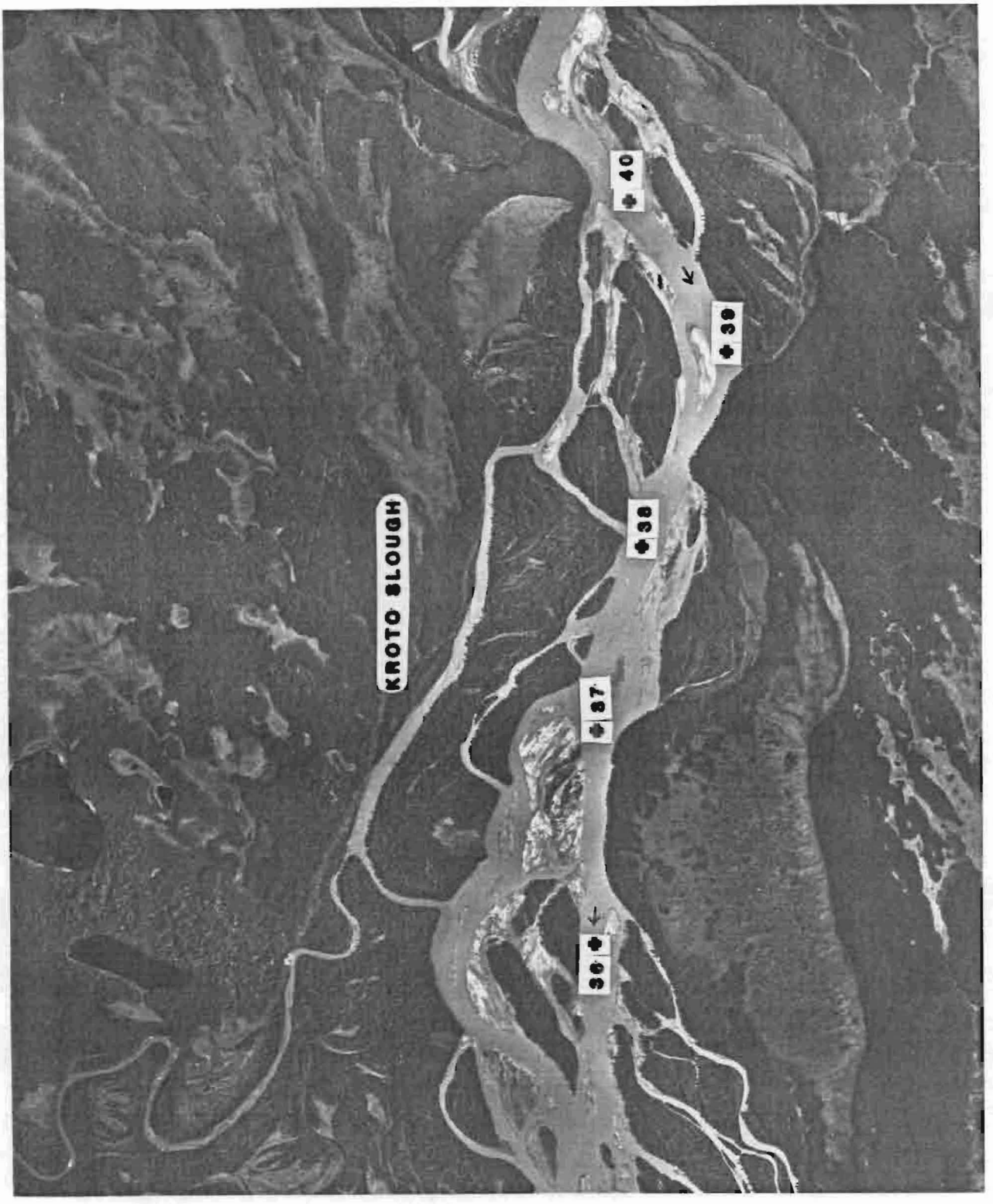

Head of Kroto Slough
Flow at Sunshine approximately 39,400 cfs. August 24, 1980
Scale 1" = 4000'

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Figure 8.5

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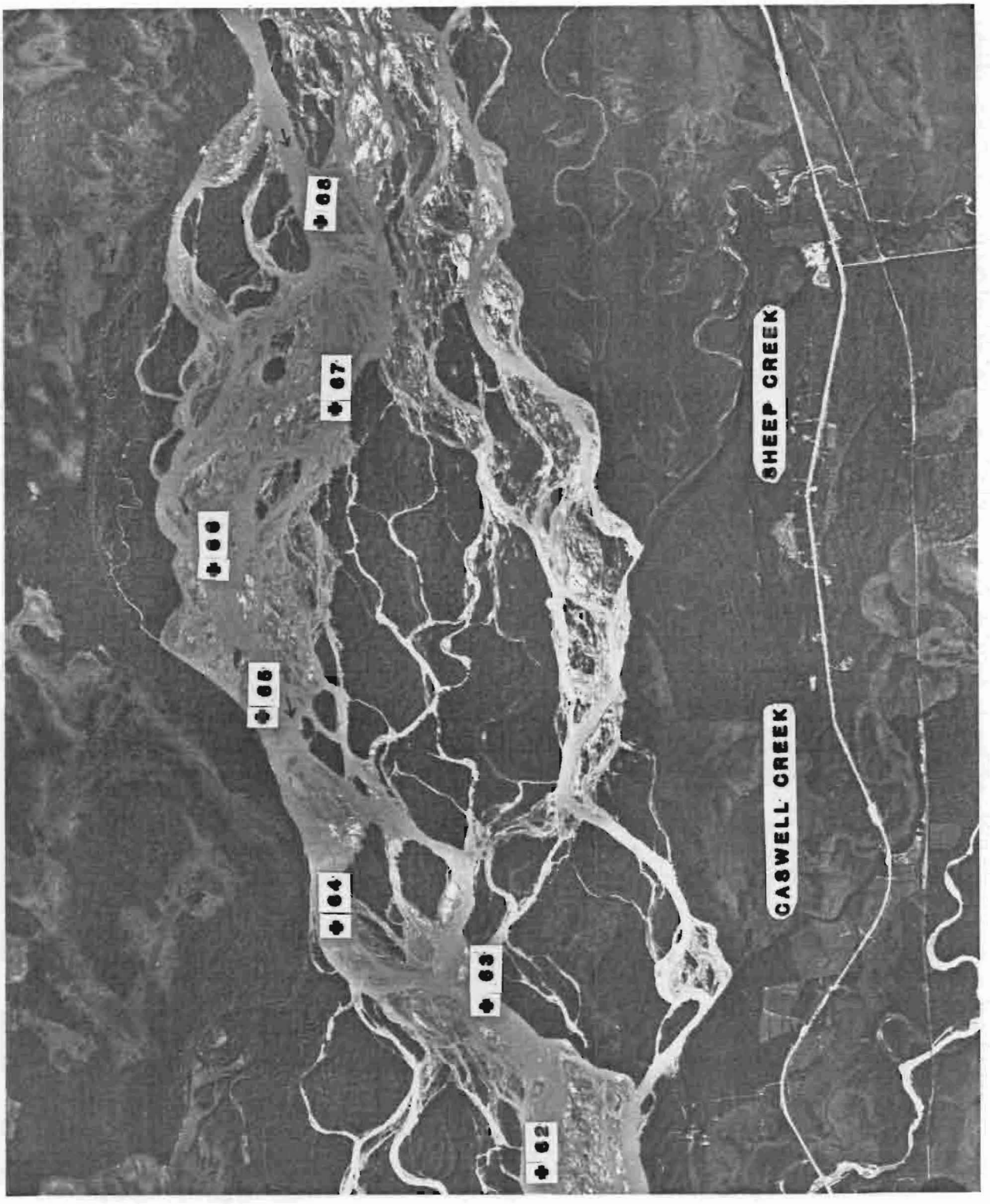

Confluence with Sheep Creek
Flow at Sunshine approximately 39,400 cfs. August 24, 1980
Scale 1" = 4000'

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Figure 8.6

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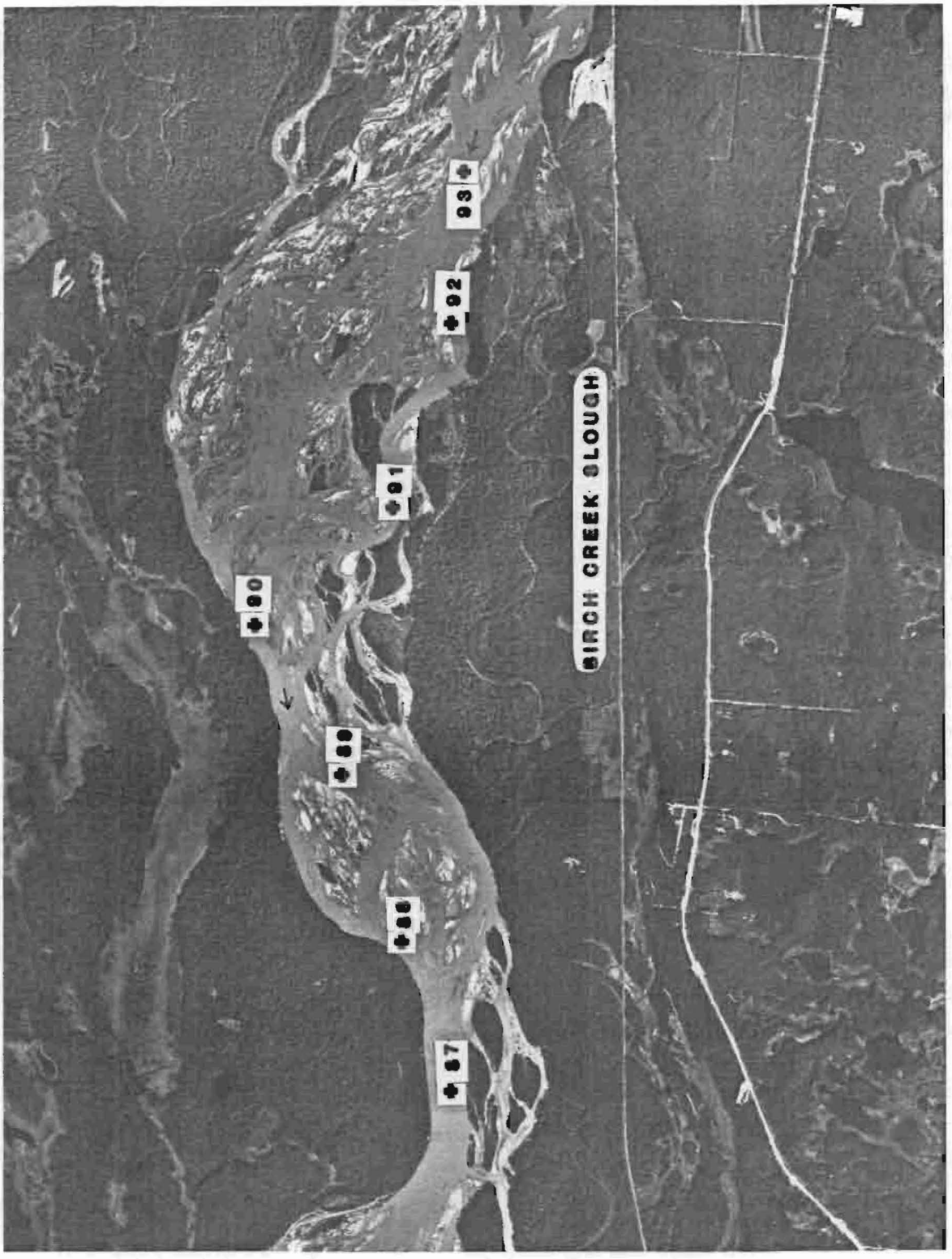
SUSITNA JOINT VENTURE



Confluence with Birch Creek Slough
Flow at Sunshine approximately 39,400 cfs. August 24, 1980
Scale 1" = 4000'

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Figure 8.7

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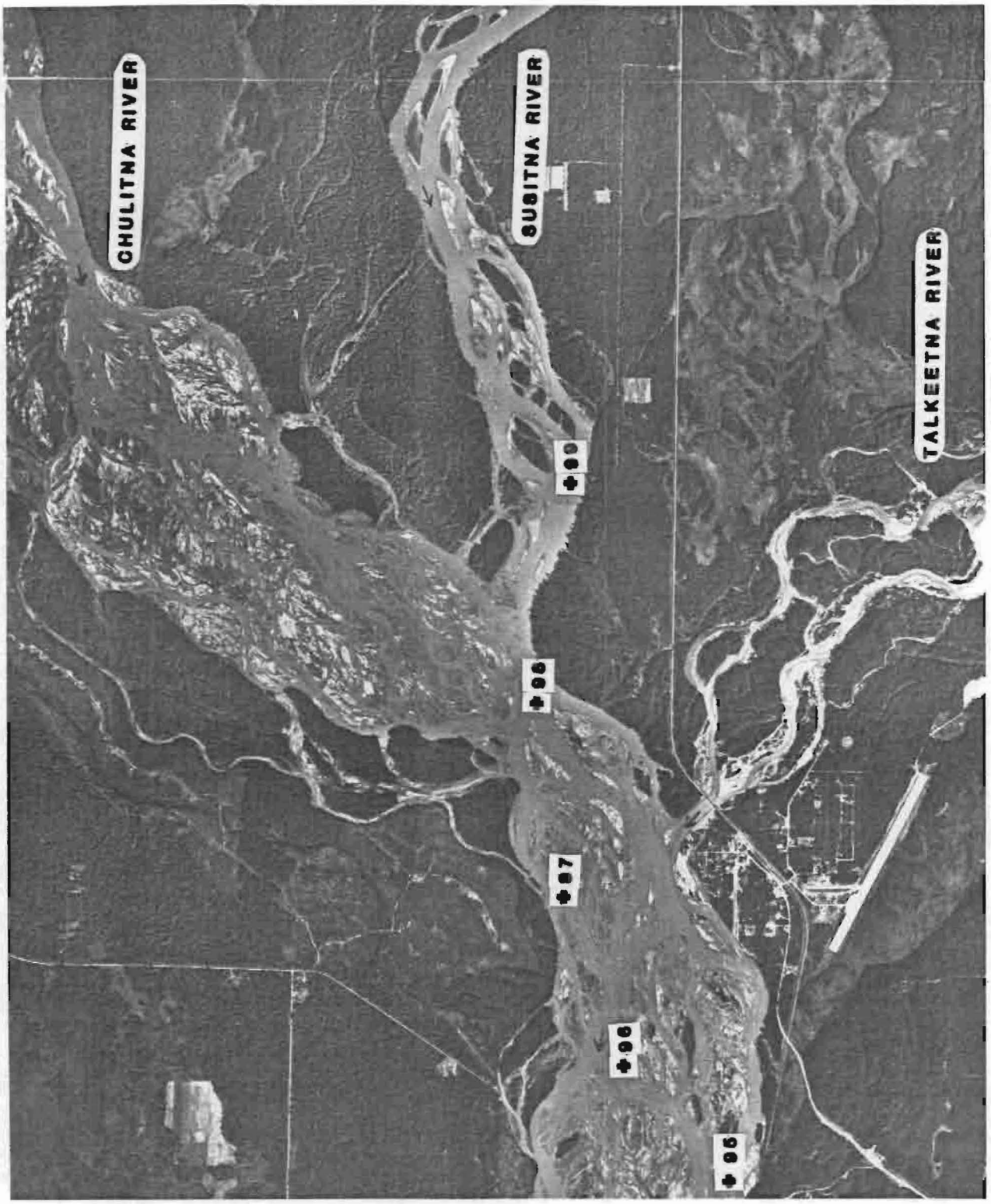

Confluence of Susitna, Talkeetna, and Chulitna Rivers
Flow at Sunshine approximately 39,400 cfs. August 24, 1980
Scale 1" = 4000'

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Figure 8.8

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Boulder strewn reach at RM 112 to RM 113
Flow at Gold Creek = 7,400 cfs. October 4, 1984

Scale 1" = 4000'

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Figure 8.9

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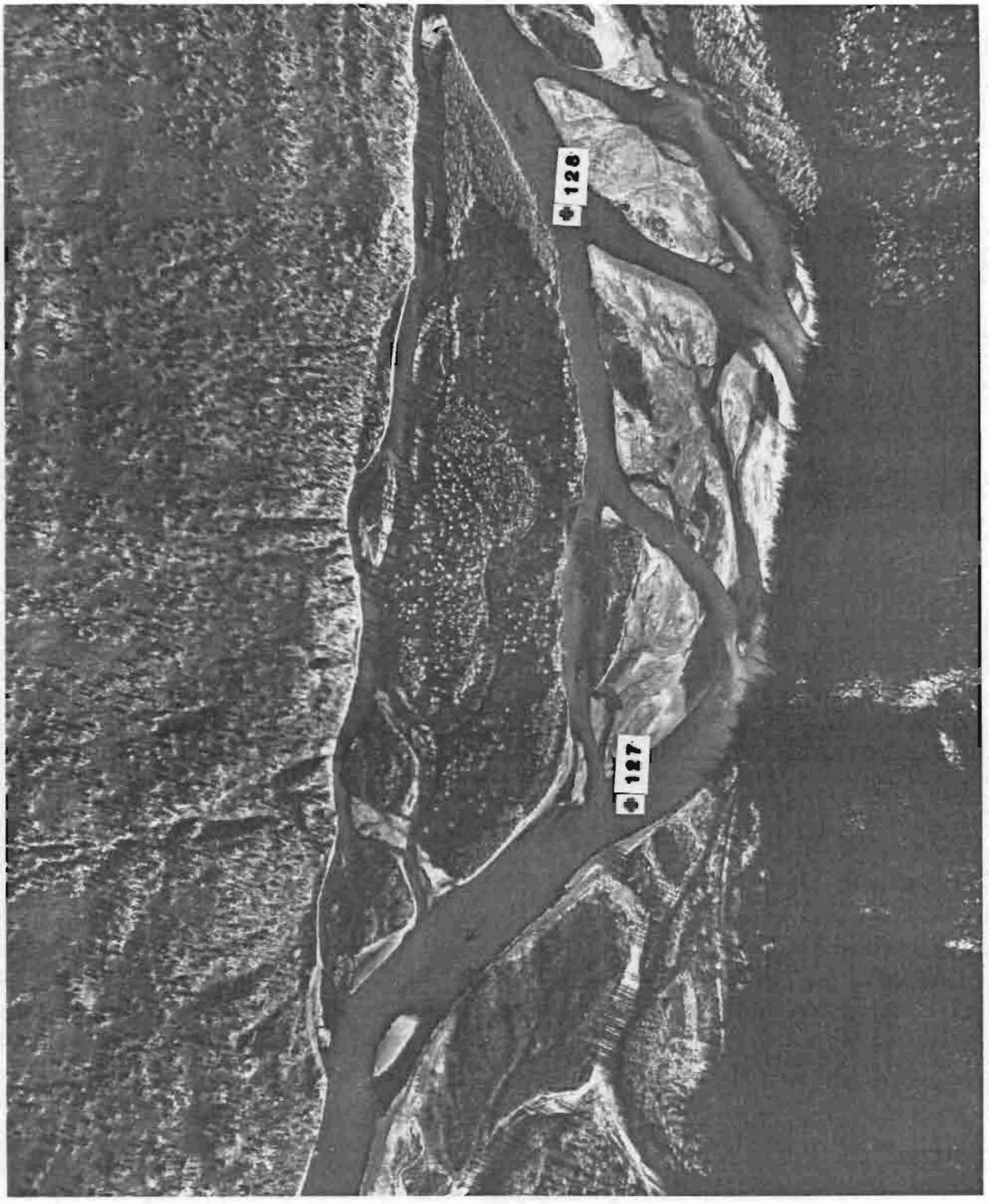

Main channel crossing floodplain at RM 128.
Flow at Gold Creek = 7,400 cfs. October 4, 1984

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Figure 8.10

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SUSITNA JOINT VENTURE

SUSITNA HYDROGRAPHIC SURVEYS

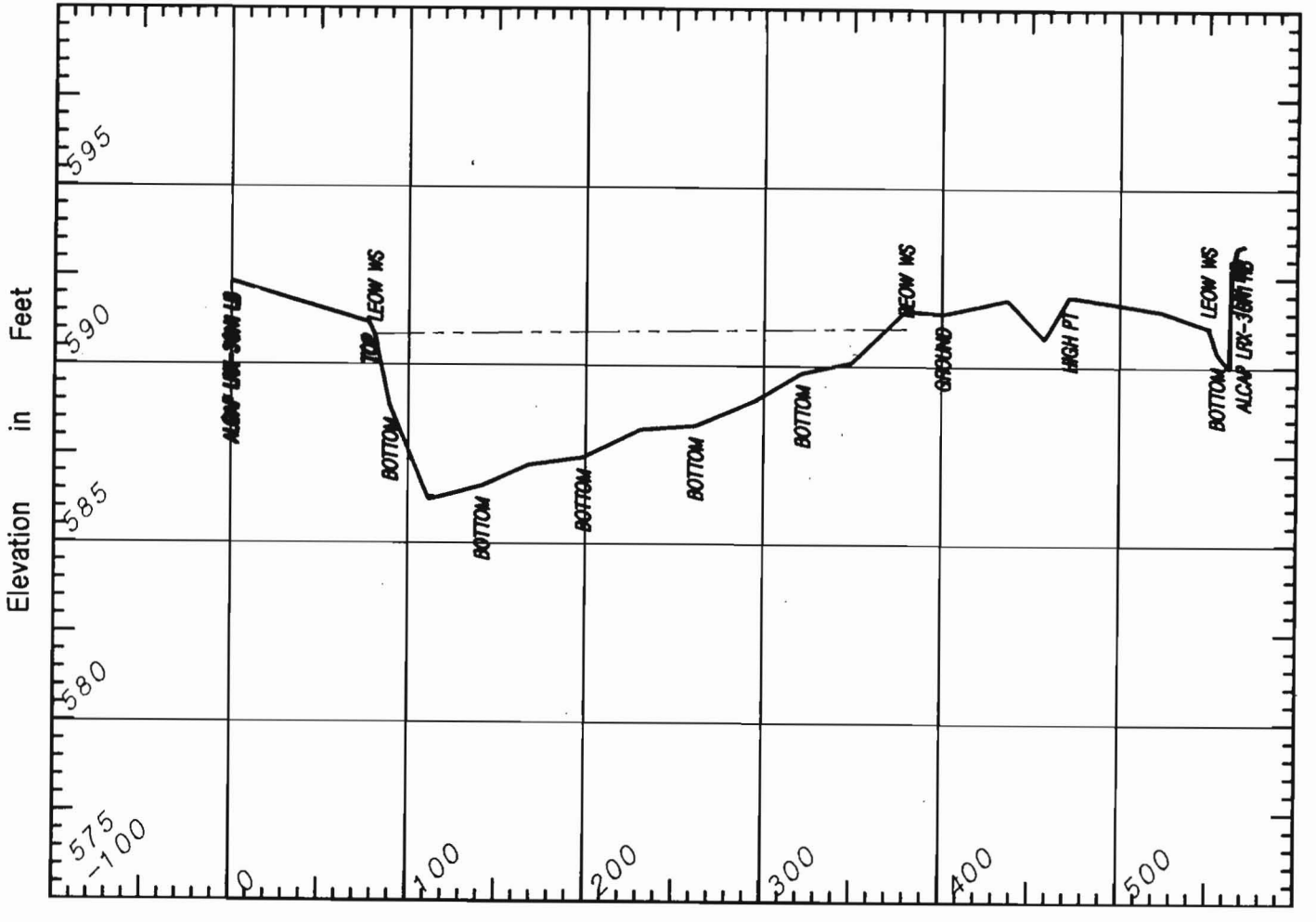

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Figure 10.1 Channel cross-section, RM 128.2

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