SUSITNA
HYDROELECTRIC PROJECT

FEDERAL ENERGY REGULATORY COMMISSION
PROJECT No. 7114

1983-1984

SUSITNA RIVER ICE STUDY

R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS PLANNERS SURVEYORS

UNDER CONTRACT TO

ZA-EBASCO
NA JOINT VENTURE

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Report by
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R&M Consultants, Inc.

Under Contract to
Harza-Ebasco Susitna Joint Venture

Prepared for
Alaska Power Authority

Final Report
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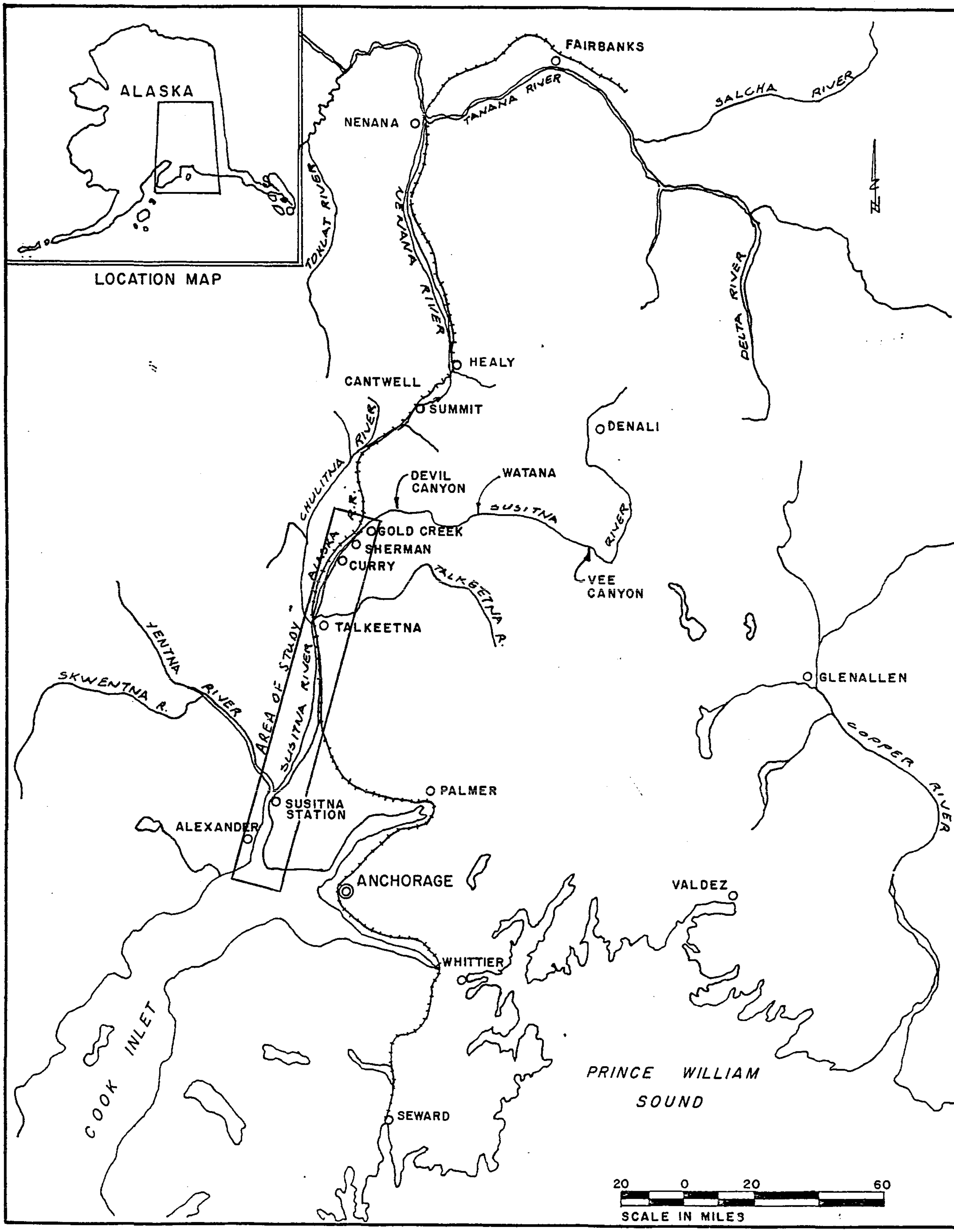
1.0 INTRODUCTION

Previous ice studies (1980-81, 1981-82, 1982-83) emphasized the middle river (Talkeetna to Devil Canyon) since ice in this reach will probably be most affected by hydroelectric project operations. The 1983-84 Susitna River ice studies focused on ice processes and related environmental impacts during freeze-up and breakup on the river downstream from the Chulitna confluence at river mile (RM) 98.5. The tributaries entering the Susitna below RM 98.5 and the change in channel configuration are expected to dampen out project influence on ice in the lower river. Mathematical model simulations of ice cover development on the middle river reach have assumed the arrival of an ice front at RM 98.5, based on an estimate of the time required to fill the lower river and initiate the progression up the middle reach. In order to more accurately define a freeze-up schedule for the lower river, the processes influencing this reach must be known. In addition, further justification for a lower river analysis stemmed from the need to address the environmental impacts. The many side channels between Talkeetna and Cook Inlet may support unidentified fishery habitats that could potentially be impacted by winter flow modification during proposed project operation. This report presents the findings of the 1983-1984 ice study beginning with a brief description of the lower river morphology and the significant tributaries entering the system, and continuing with a discussion on meteorology and river ice processes. It has been assumed that readers are familiar with the previously published ice reports (R&M 1980, 1981, 1982) and therefore many of the fundamental concepts have been only briefly described or are omitted entirely. It is suggested that the 1982-1983 Susitna River Ice Study (R&M, 1984) be reviewed prior to this report. Figure 1.1 illustrates the portion of the Susitna River basin under study.



SUSITNA HYDROELECTRIC PROJECT LOCATION MAP

FIGURE 1.1

2.0 SUMMARY OF 1983-1984 LOWER RIVER ICE PROCESSES

In 1983 frazil ice on the Susitna River was first observed near Gold Creek on September 26, following a four day period of mean daily air temperatures near -10°C at the Denali weather station. The volume of flowing slush fluctuated considerably during the first two weeks in October reflecting variations in air temperatures. Most of this slush ice melted, absorbing heat from the river water which gradually cooled to near 0°C by mid-October. After October 15 a relatively constant flow of slush ice was observed passing Gold Creek. Most of this continued downstream to the river reach influenced by Cook Inlet tidal cycles.

High tides create a backwater effect extending many miles up the Susitna River. This had significant consequences on several hydraulic parameters on the lower 13 miles of river in October, 1983. Water levels rose, cross sectional area increased and water velocity decreased causing the slush ice to accumulate. Ice concentration quickly covered 100% of the surface area and when sufficiently cold air temperatures and slow water velocity was encountered, the unconsolidated slush ice froze in place forming an ice bridge. The constant discharge of slush ice continued accumulating at the upstream edge of the ice bridge and an ice cover began to progress upstream. Where the channel gradient and water velocities were low, advancement occurred rapidly with ice floes abutting one another and remaining on the water surface. When the ice front encountered higher water velocities, crushing and consolidation caused the ice cover to thicken. The thicker ice cover displaced more water, extending the backwater area upstream until the high velocity section was drowned and progression continued.

The rate of ice cover progression is primarily dependent on air temperature, flow rate and channel morphology. Air temperature controls the volume of frazil generated as well as the ice cover stability. The lower 98 miles required over 40 days to freeze-up in 1983, compared to approximately 14 days in 1982. This is attributed to the number of freezing degree-days accumulated during freeze-up. The total number of freezing degree-days at Talkeetna in October 1983, amounted to 56 compared to the 1982 total of 172.

A slow progression rate generally results in lower levels of staging and thinner ice at any given cross section. The discharge and initial water level are less when the ice cover forms later in the year relative to a year when the progression rate is high. In 1982 a high progression rate froze over the lower river by the end of October, when river discharges were much higher than those of November 1983.

The Yentna River contributed approximately the same volume of slush ice as the Susitna, significantly affecting the rate of freeze-up below the confluence with the Susitna. The remaining tributaries, however, had less influence, with the Chulitna and Talkeetna Rivers generating an estimated 15-20% of the combined total volume below the confluences with the Susitna.

Many of the dewatered side channels adjacent to the Susitna mainstem on the lower river were flooded during freeze-up in 1983, some temporarily while the ice front advanced past the upstream entrances and others for the duration of the winter. Slush ice was observed to enter only a few side channels but in insufficient quantities to develop an ice cover. A myriad of side channels and sloughs precluded a comprehensive impact analyses during freeze-up and further studies will focus on specific habitats identified during the 1984 summer field programs.

Deterioration of the ice cover on some reaches of the lower river began immediately after the initial progression. Extensive leads eroded through the cover, exposing open water between thick layers of ice stranded on the banks. Cold air temperatures from December through March appeared to dominate all other factors controlling ice stability and the destruction processes were stalled. The leads began to close again by lateral growth of border ice and accumulation of frazil at the downstream end. Increasing daily duration of exposure to solar radiation begins to have a marked effect in April. Existing leads lengthened as the floating ice cover eroded from underneath, either by heat gained from friction (from the flowing water) or mechanical removal. When the snow had melted from the ice surface, solar radiation bearing directly on the ice surface caused the familiar candling process. This gradual melting seemed to characterize "breakup" on the lower river. Fragmenting of the ice, which is a more typical process on the middle river, occurred only when stages increased sufficiently to exert a critical lifting force. The broad flood plain relative to the area occupied by channels on the lower river prevented a rapid increase in stage with rising discharges. When ice jams did occur, such as when ice debris from the middle river accumulated against a solid cover on the lower river, then water spilled over onto the flood plain and bypassed the congested main channel. Although erosion and damage to vegetation has been observed during breakup, these were isolated incidents and considered insignificant compared to damage incurred during summer floods.

Further studies on the lower river will consider development of the ice bridge near Cook Inlet, ice volume determinations for the Yentna River, and impacts to fisheries habitats during freeze-up. Issues concerning with-project effects on the ice regime include location and timing of ice bridge formation, volume of ice required to freeze-up the lower river, and expected maximum stage levels.

During winter project operations, ice generation on the Susitna River will be delayed, since reservoir releases will cause fall stream temperatures to be higher than natural. This relatively warm water will have to cool to 0°C before frazil ice can be generated. The length of river required to cool the water is dependent upon air temperature, and the 0°C condition may not occur below the project until November. Present observed conditions appear to require high ice concentrations to form the ice bridge in October. The Yentna River in combination with the lower Susitna must produce enough ice to achieve the critical concentration required for bridging. This volume should therefore be quantified so that a with-project freeze-up schedule can be defined.

Although an ice bridge has been observed in previous years at the Chulitna confluence, middle river ice cover progression probably will not begin until the lower river is frozen over. When frazil generation begins, a specific volume will be required to cover the lower river. This volume can be estimated based on ice thickness and wetted surface area.

A third consideration is potential impacts to side channels under with-project conditions. Winter flows will be higher than present flows, so staging and ice thicknesses will increase accordingly. Quantifying natural conditions will assist in analyzing impacts to fisheries habitats. These are some of the issues emphasized in the proposed 1984-1985 ice study and will be required to adequately assess project influences on the lower river ice regime.

3.0 LOWER RIVER MORPHOLOGY

The Susitna River downstream of the Chulitna confluence runs for about 98 miles to Cook Inlet. This reach will be referred to here as the lower river to differentiate it from the upper river which runs from the headwaters in the Alaska Range to Devil Canyon, and the middle river which continues from Devil Canyon to the Chulitna confluence.

The lower river has been further subdivided into five reaches, each with distinct characteristics (see Appendix B for river mile delineation). Segment 1 runs from RM 98.5 at the Chulitna confluence to RM 78 near the confluence of Montana Creek. Segment 2 continues from RM 78 to RM 51, which is approximately the upstream end of the Delta Islands. Segment 3 runs through the Delta Islands to RM 42.5, with Segment 4 continuing to the Yentna River confluence at RM 27. Segment 5 contains essentially the remainder of the reach to Cook Inlet. The exact river mouth is difficult to define because the extreme tidal range in Cook Inlet creates a back-water estuary. For this report RM 9 marks the downstream edge of Segment 5. These 5 river segments represent an attempt to separate the lower river reach into areas which show morphologic similarities based on aerial reconnaissance and analysis of aerial photography. With further study, these similarities may prove to be associated with aquatic habitat types and hydraulic characteristics. This may lead to defining open water flow conditions and ice processes unique to each segment.

The following discussion presents brief descriptions of each river segment including pertinent data (Table 3.1) based on photo interpretation and field observations.

Segment 1 - River M.ie 98.5 to River Mile 78

The river through this reach has multiple braided channels with more channels appearing at higher flows (Figure 3.1). The main channel or thalweg meanders through a wide floodplain often more than 5,000 feet wide. The floodplain consists mostly of gravel bars and some partially vegetated islands. Several complex side channel systems exist but these are generally flooded only at flows exceeding 13,000 cfs at Sunshine and are side sloughs at lower discharges. These side channels are separated from the mainstem by large heavily vegetated islands, and may occur along either the left or right bank. Birch, Sunshine, Rabideux and Whitefish Sloughs are the most extensive and significant side channel systems along this reach.

Six major tributaries enter this reach including the Chulitna and Talkeetna Rivers. Lesser contributions are added by Trapper, Birch, Sunshine and Rabideux Creeks.

The average gradient is about 5 ft/mi. Surface velocities have been measured in excess of 5 ft/sec prior to freeze-up at flows less than 10,000 cfs (USGS at Sunshine). The gradient is less steep at the upper end of the reach with the slope and water velocities increasing near the Parks Highway bridge. The river width is highly variable with a maximum width at RM 92.0 of 7,000 feet and a minimum of 1,000 feet at the Parks Highway bridge, which is also the only place on this segment where the flow is confined to one channel for the entire flow range.

Segment 2 - River Mile 78 to River Mile 51

This reach is characterized by extensive side channel complexes along the entire reach. These consist of a network of interconnecting channels which are normally flooded only at high flows or during the elevated stages induced by an ice cover. Many of the outermost channels in the complexes are fed by one or more tributaries which keep water flowing in a small portion of the side channel regardless of the mainstem flow. Six significant tributaries enter this reach, although only Montana Creek enters the Susitna mainstem directly. Goose Creek, Sheep Creek, Kashwitna River, 197 Mile Creek and Caswell Creek enter side channels which are isolated from the mainstem except at high water stages.

The gradient through this reach starts out at 6 ft/mi and decreases near the Delta Islands for an average of 5.6 ft/mi. This segment has the steepest slope on the lower river and subsequently the highest velocities. Due to shoving or the compression of the ice cover during freezeup, this reach also has the thickest ice cover. The mainstem (excluding the side channel complexes) appears similar to the main channel in Segment 1 with a broad expanse of gravel and sand bars exposed at low flows when the mainstem is generally confined to a single channel (Figure 3.2). The maximum width of the flood plain is 6,000 feet and the minimum is 1,000 feet. The majority of the gravel bars are devoid of vegetation. High summer flows generally inundate the gravel bars, with debris carried along by the flow often piling up on the islands as log jams. At high flows, the water breaches the entrances to side channels and spills into these systems. The side channels seem to function primarily as overflow channels, diverting water away from the mainstem during floods.

Segment 3 - River Mile 51 to River Mile 42.5 (Delta Islands)

This reach runs through an intricate system of islands. The mainstem at some high flows becomes diffused and is difficult to differentiate from side channels. Only at the low flows prior to freeze-up can the thalweg be defined. Even then it is split into two channels flowing along the extreme left and right banks, respectively. The majority of the side channels are dewatered at these low flows. The maximum channel width is 4,500 feet at RM 51, with the narrowest portion of 700 feet at RM 42.5. RM 42.5 also marks the joining or convergence of the two main channels emerging from the Delta Islands and the end of this segment. Field investigations documented groundwater seeps entering several of the side channels, providing these with a separate source of water isolated from the mainstem. The groundwater seeps are probably related to the mainstem stage since the contribution of flow by groundwater in the side channel seems to diminish with lower water levels in the mainstem.

Two tributaries enter this reach along the east bank. Little Willow Creek and Willow Creek initially flow into a side channel which then enters the east mainstem at RM 52 about 1,000 feet downstream of the Willow Creek confluence.

The river gradient reduces substantially from 5.6 ft/mi in Segment 2 to 2.9 ft/mi in Segment 3. This may provide an explanation for the complex morphology of this reach. The lower gradient results in reduced water velocities which could result in less degradation and perhaps some aggradation causing the channels to meander and intertwine.

Segment 4 - River Mile 42.5 - River Mile 27

This reach is similar to Segment 2 with a well defined mainstem and numerous side channels along both the left and right banks. The Deshka River, at RM 40.6, is the only major tributary entering this segment.

Kroto Slough represents one of the major side channel complexes in this segment. The upstream entrance is located about one-half mile below the confluence of the Deshka River. Although this side channel has several branches which connect with the Susitna mainstem, one channel continues on separately to the Yentna River. This side channel system dewaters at flows less than 13,000 cfs (USGS at Sunshine); however, when the mainstem is ice covered the stage increases enough to flood the channel, so for the major portion of the year this side channel flows with Susitna and Deshka River waters.

An interesting feature is that the Deshka River water does not mix immediately with the Susitna flow. At low Susitna flows, a relatively clear water plume exists along the right bank for several hundred yards below the confluence; this low turbidity water enters Kroto Slough. This side channel receives water with a lower sediment load than would be expected if the Deshka water was more thoroughly mixed with the Susitna.

The gradient through this reach continues to decrease with respect to preceding segments. The gradient average of 2.6 ft/mi is also reflected in the lower surface water velocities. Velocities from 3 to 4 ft/sec have been measured when Sunshine flow is 10,000 cfs. Channel widths range from a maximum of 5,500 feet at RM 32.2 to the narrow section of 800 feet at RM 38.5. The side channels through this reach are strictly overflow channels at high water and at flows below 13,000 cfs (USGS at Sunshine) are generally dewatered.

Numerous relic channels to the west of the mainstem along Segment 4 suggest a flow history quite different from the present regime. These ancient channels are now mostly vegetated but are easily discernible from the air and on photographs. The meandering nature of these channels suggests that, historically, the river gradient was probably less than today. These channels are now swamplands with few stands of large trees and entirely bypassed by the present, straighter course of the river.

Segment 5 - River Mile 27 to River Mile 9

This reach begins at the Yentna Confluence and extends to RM 9 near Cook Inlet and represents an area of transition from a river system to an estuary. The extreme tidal range in Cook Inlet is over 25 feet, creating a long backwater zone. The exact longitudinal range has yet to be determined but has been observed up to RM 12. The Yentna River contributes approximately 40 percent of the annual flow measured at Susitna Station (RM 25.9) by the USGS. However, this is not consistent at all flow ranges. The proportion may vary greatly depending on storm system movement and the glacier mass wasting characteristics of each system. The Yentna discharge approximates the flow on the Susitna measured at Sunshine during low flow periods but often does not respond simultaneously to the same hydrograph peaks.

A dominating feature of this segment is Alexander Slough or the Susitna west channel. This represents a major side channel at most open water flows but dewaters just prior to freeze-up. When mainstem water enters this side channel the flow essentially becomes isolated and does not re-enter the mainstem except at flood stages. Then an interconnecting channel at RM 9.7 floods. At low flows, such as prior to freeze-up, the side channels are generally dewatered and the mainstem is confined to one channel, although encompassing many exposed sand bars.

The slope through this reach was determined from USGS topographic contours and is about 1.5 ft/mi, with average surface velocities of 2 to 3 ft/sec.

Other tributaries entering this reach include Alexander Creek and Fish Creek. Alexander Creek enters Alexander Slough and continues out to Cook Inlet without joining the mainstem. Fish Creek drains the swamplands adjacent to, and east of, the Susitna east channel and enters the mainstem at RM 1. As can be expected, the gradient is so low here that flow from this tributary is greatly restricted by backwater created by mainstem stages.

TABLE 3.1

LOWER SUSITNA RIVER MAINSTEM DATA
for FREEZE-UP 1983

Segment	1	2	3
River Mile	98.5 to 78	78 to 51	51 to 42.5
Avg. Gradient (ft/mi)	5.0	5.6	2.9
Flood Plain Widths(1)(2): Max. (RM)	7000 (92.0)	6000 (73)	4500 (51)
Min. (RM)	1000 (83.8)	1000 (75.8)	700 (43.5)
Entering Tributaries	Chulitna R. Talkeetna R. Trapper Cr. Birch Cr. Sunshine Cr. Rabideux Cr.	Montana Cr. Goose Cr. Sheep Cr. Caswell Cr. Kashwitna R. 197 Mile Cr.	Little Willow Cr. Willow Cr.
Approx. Freeze-up Staging (ft.)	4.6	5.1	2.8
Avg. Ice Thicknesses (ft.)	6.3	6.8	4.0
Approx. Surface Velocity (ft/s)	5	5	4
Approx. Freeze-up Date	12/8	11/16	11/6
Approx. Ice Volume (cu ft)(3)	7.0×10^8	10×10^8	2×10^8
Locations of Major Open Leads After Progression (Mainstem Only)	98.5 - 97 95.5 - 93 86 - 85 84 - 78	74 - 72.5 71.5 - 70.5 67 - 61.5	0
Ice Bridges (location)	0	0	0

(1) Widths do not include major side channel complexes or sloughs.

(2) Locations are referenced to the river mile (RM) number.

(3) Ice volume was estimated by multiplying the average ice thickness by the open water surface area at 13,900 cfs. Open water surface area for each segment was digitized from aerial photography.

TABLE 3.1 - (cont')

LOWER SUSITNA RIVER MAINSTEM DATA SHEET
for FREEZE-UP 1983

Segment	4	5
River Mile	42.5 to 28.5	28.5 to 9
Avg. Gradient (ft/mi)	2.6	1.5
Flood Plain Widths(1)(2): Max. (RM)	5500 (32.2)	7000 (0)
Min. (RM)	800 (38.5)	800 (15.8)
Entering Tributaries	Deshka R.	Yentna R. Alexander Cr. Fish Cr.
Avg. Freeze-up Staging (ft.)	3.5	2.5
Avg. Ice Thicknesses (ft.)	5.5	4.0
Approx. Surface Velocity (ft/s)	3-4	2-3
Approx. Freeze-up Date	11/4	10/31
Approx. Ice Volume (cu.ft.)(3)	4×10^8	2×10^8
Locations of Major Open Leads After Progression (Mainstem Only)	0	8 - 0
Ice Bridges (location)	0	1 (RM 9)

(1) Widths do not include major side channel complexes or sloughs.

(2) Locations are referenced to the river mile (RM) number.

(3) Ice volume was estimated by multiplying the average ice thickness by the open water surface area at 13,900 cfs. Open water surface area for each segment was digitized from aerial photography.

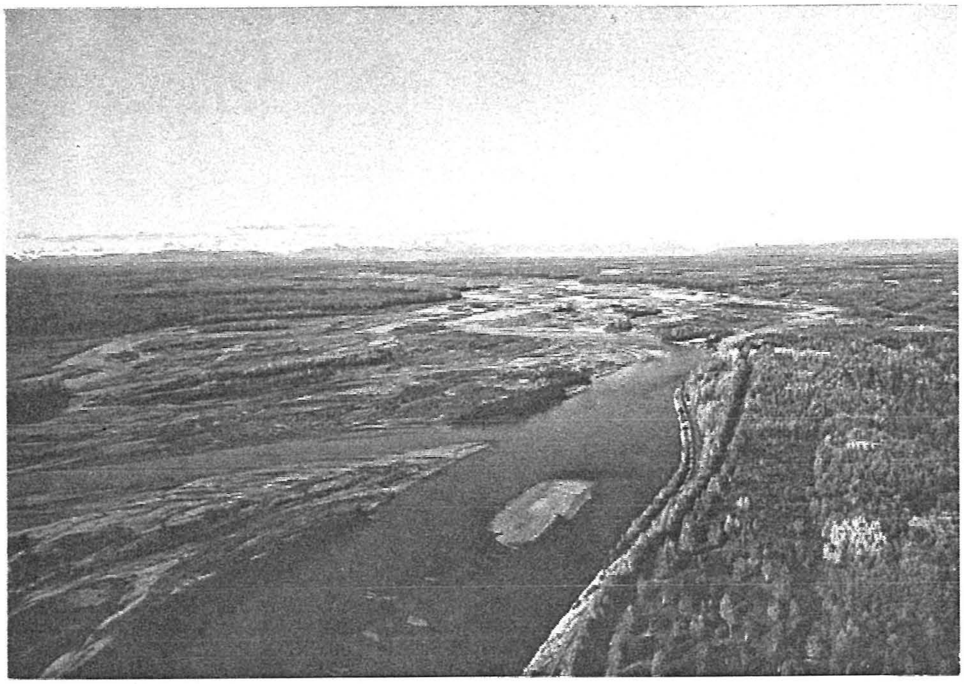


FIGURE 3.1
September 17, 1983. Susitna River looking upstream from RM 94. Talkeetna River confluence is at middle right. Note the broad floodplain relative to the river channels.

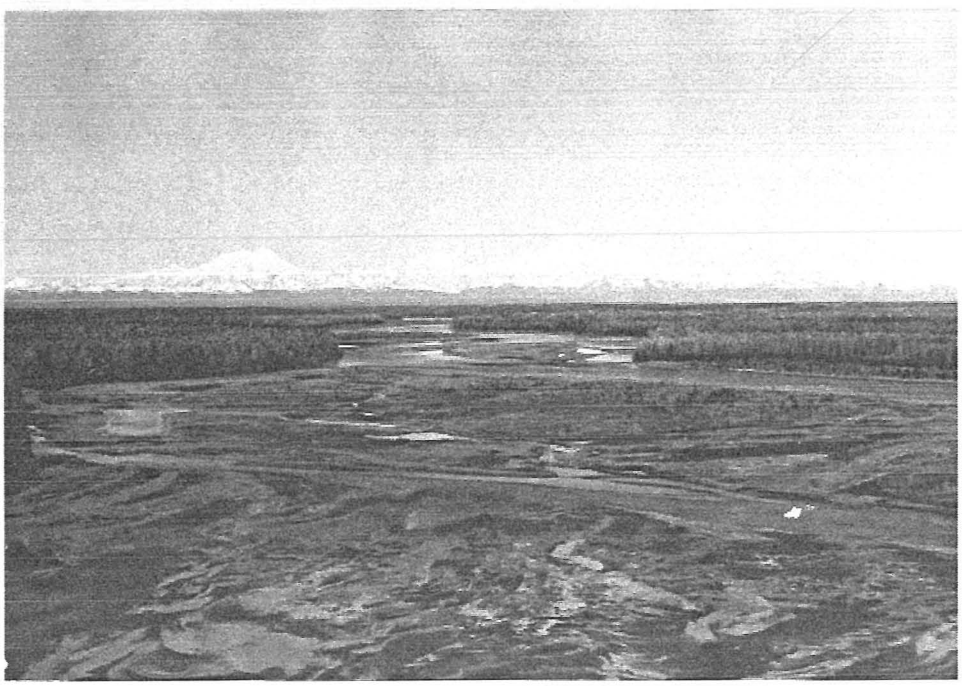


FIGURE 3.2
October 4, 1983. Susitna River looking upstream from RM 78. Secondary channels are dewatering and a major portion of the flow is restricted to one channel.

4.0 LOWER RIVER TRIBUTARIES

The following are the most significant tributaries to the lower river with respect to water volume and sediment load contributions:

Chulitna River	Caswell Creek
Talkeetna River	Kashwitna River
Trapper Creek	197 Mile Creek
Birch Creek	Little Willow Creek
Sunshine Creek	Willow Creek
Rabideux Creek	Deshka River (Kroto Creek)
Montana Creek	Yentna River
Goose Creek	Alexander Creek (west channel)
Sheep Creek	Fish Creek (east channel)

The morphology and what is presently known about the flow characteristics of each tributary will be described:

Chulitna River

Despite the vast differences in drainage areas the water volume contributed by the Chulitna closely approximates the total volume of the Susitna measured at Gold Creek(USGS). The Chulitna (Talkeetna Station) drains an area of 2,570 square miles and the Susitna (Gold Creek) drains an area of 6,160 square miles.

Aggradation influences the flow distribution at the confluence of the Chulitna and Susitna Rivers. The morphology of this area appears to be constantly changing (Figure 4.1 and 4.2). For the past 3 years the Chulitna flow was evenly distributed between two major channels at the confluence. During the 1983 river freeze-up it became apparent that the channel configuration had changed considerably. The west channel dewatered during the second week in November when the Chulitna discharge was between 3000-3500 cfs (USGS at

Chulitna) and the Susitna approximately 3000 cfs (USGS at Gold Creek). The east channel contained more water than in previous years. The higher flows in the east channel may have prevented the formation of the ice bridge at RM 98.5 in 1983. Other significant morphological changes that may be attributed to sediment aggradation include a shift in Susitna flow from the east bank to the west at the three rivers confluence. In previous years the Susitna flowed close to the east bank and merged with the Talkeetna River at RM 97. In 1983 this east channel dewatered at approximately 5,000 cfs (USGS at Gold Creek), due in part to aggradation, but also possibly due to degradation of the west channel, which now carries a major portion of the Susitna and Chulitna flow.

U.S. Geological Survey discharge data on the Chulitna River are reported in the Water Resources Data annual report.

Talkeetna River

This river joins the Susitna at the town of Talkeetna (Figure 4.2). At Susitna flows in excess of 5,000 cfs (USGS at Gold Greek), the Talkeetna flow joins a portion of the Susitna at RM 97. At these flows the Susitna stage is high enough to flood several channels along the east bank between the Chulitna River confluence at RM 98.5 and RM 97. At Susitna flows less than 5,000 cfs these east channels are dry and the mainstem of the Susitna runs to the opposite west bank. The Talkeetna confluence under these conditions shifts downstream 2 miles to RM 95. This is significant during the freeze-up process. In previous years, when the Susitna east channel threshold elevation was lower, the slush ice from the Susitna would accumulate between RM 97 and RM 98 and form an ice bridge. This ice bridge would not, however, initiate an upstream ice progression.

When the Susitna joins the Talkeetna River at RM 97 at high flows, the resulting backwater inundates the alluvial fan at the mouth of the

Talkeetna. The higher stage and increased cross-sectional area reduces the Talkeetna water velocity and dissipates the flow energy over a broad area. During freeze-up, when Susitna flows decrease to less than 5,000 cfs (USGS at Gold Creek) and the east channels have dewatered, the Talkeetna flows unrestricted over the alluvium, maintaining the velocity that is natural to the prevailing channel gradient. Under these conditions the flow energy is concentrated and the unconsolidated gravels rapidly degrade, leaving an entrenched channel. The same situation occurs at the Chulitna confluence but is less obvious because of the extremely broad flood plain.

The U.S. Geological Survey maintains a gaging station on the Talkeetna and reports the data in the Water Resources Data annual report. The National Weather Service - River Forecast Center also monitors the water level at the Alaska Railroad bridge during the open water season.

Trapper Creek

No discharge records have been located for this stream, however the flow contribution is estimated to be small. It joins the Susitna from the northwest near RM 90. The actual confluence may vary depending on mainstem Susitna water levels. At low flows the confluence is at RM 90, while at high flows the confluence may shift to RM 91.

Birch Creek

Birch Creek joins Birch Slough about 4000 feet above the Susitna confluence (Figure 4.3). Birch Slough is a side channel of the Susitna at high mainstem flows. It runs from the head entrance at RM 93.2 on a meandering course along the Susitna east bank. When the slough entrance is dewatered (at approximately 14,000 cfs, Sunshine gage), groundwater seeps provide enough water so that beaver ponds in the slough remain flooded. The combined flow from the slough and creek enter the Susitna mainstem near RM 88.

Discharge measurements have been conducted on this stream, which joins a slough before entering the Susitna mainstem at RM 88. The Alaska Department of Fish and Game (ADF&G) monitored flows during the 1982 open water season and obtained four discharge measurements. R&M Consultants determined flow rates in September and October of 1983 at four specific mainstem discharges and documented the backwater effect at the mainstem confluence. Flows generally range from 36 to 120 cfs. The Susitna creates a significant backwater area during high flows at the slough/river confluence, but this has not been observed to affect the reach upstream of the slough/creek confluence.

Sunshine Creek

This tributary joins a large side channel complex about 1.5 miles upstream of the Susitna confluence at RM 84 (Figure 4.4). The side channel dewaters at low flows prior to mainstem freeze-up. At this time the creek provides the only flow through the lower portion of the channel. ADF&G obtained four discharge measurements in 1982 0.7 miles above the mouth. Flows ranged from 32 to 104 cfs. At high mainstem flows the side channel is flooded and creates an extensive backwater, affecting at least the first 0.7 miles of the creek.

Rabideux Creek

This creek enters the mainstem directly at RM 83.1. Early attempts to measure the flow resulted in first defining the extensive backwater zone influencing the mouth. In order to develop a rating curve, the ADF&G had to conduct measurements 1.7 miles upstream from the confluence. Flow measurements ranged from 129 to 223 cfs during the summer of 1982, while winter flows are estimated to be less than 5 cfs.

Montana Creek

This tributary enters the Susitna directly at RM 76.9. Mainstem velocities prevent significant sediment deposits from accumulating beyond a well defined bank line. At low mainstem stages this stream yields high velocity flows, which degrade a well developed alluvial fan (Figure 4.5). The fan area was not observed to flood during high Susitna flows. The only documented flooding of this fan was during ice cover progression on the Susitna mainstem adjacent to the confluence.

The USGS maintained a crest stage recorder on Montana Creek from 1963-1972, in 1978 and in 1981. Miscellaneous measurements were made by R&M Consultants in 1983. The National Weather Service has maintained a partial stage record since 1973.

Goose Creek

A complex system of distributaries uniquely characterizes the confluence of this creek (Figure 4.6). Originating as a single channel from the east, the flow encounters a gravel deposit near the confluence. This unconsolidated deposit distributes the flow between two channels. One channel is directed north and enters a side channel designated as Goose Creek Slough. The second channel continues westward and splits again into three separate channels, one of which enters the Susitna mainstem directly at RM 73. The other two diverge to the south and flow for about three-quarters of a mile before joining a side channel. Several minor channels also exit the gravel deposit and flow south. The side channel into which these distributaries flow is flooded only at mainstem discharges in excess of approximately 13,000 cfs (USGS Sunshine). At lower flows Goose

Creek provides the majority of the water flowing through the side channel.

The USGS maintained a crest stage recorder on this creek from 1963-1971.

Sheep Creek

This is a stream with no record of discharge measurements. It enters a side channel complex near RM 67. This side channel joins the mainstem near the confluence of the Kashwitna River at RM 62.5. At low Susitna flows, the side channel dewaters so that Sheep Creek provides the only flowing water. The mouth of Sheep Creek is effected only by flows from the side channel and the subsequent backwater zone is controlled by the water level in the side channel.

At high mainstem flows the head entrance of the side channel is flooded and the resultant water level increase controls the extent of the backwater up Sheep Creek. The mainstem, therefore, indirectly influences the backwater zone. Morphological changes at the side channel entrance, such as aggradation or degradation of the threshold elevation, controls the exact Susitna discharge effecting Sheep Creek. In 1983, the backwater zone was observed to extend upstream to near the confluence with Sheep Slough at Sunshine flows of about 60,000 cfs.

Kashwitna River

The Kashwitna confluence also varies with Susitna water levels (Figure 4.7). During the summer the Susitna mainstem spills over numerous, laterally oriented side channels and joins the tributary at about RM 61. Prior to freeze-up these short side channels dewater which shifts the confluence down to RM 60. Discharge records have not been found for this stream. Staging during the ice cover progression creates a backwater area near RM 60 but in 1983 did not significantly influence the flow regime. During the open water season a boat launching facility operates on the Kashwitna adjacent to RM 61. This ramp area requires routine dredging to ensure adequate water depth for motorized vessels.

197 Mile Creek

The designation stems from the Alaska Railroad milepost at the bridge crossing this stream. This slow-moving creek with little discharge mainly drains surrounding swampland and muskegs. The water is heavily loaded with organic material and chemical by-products from decomposing vegetation. It enters a side channel complex near RM 60 which joins Little Willow and Willow Creek before entering the Susitna mainstem at RM 50 in the Delta Islands area. The entrance to this side channel dewaters at mainstem flows less than 13,000 cfs (USGS at Sunshine), however, groundwater seeps and the tributaries provide a steady stream along the eastern-most channel within the complex. This creek is not considered navigable but the side channel may be negotiable by some boats at mainstem flows over 30,000 cfs (USGS at Sunshine). R&M Consultants measured a discharge of 14 cfs on September 7, 1983.

Little Willow Creek

This clearwater stream enters the side channel mentioned above close to the downstream end between one-half and one mile above the confluence with the mainstem at RM 50 (Figure 4.8). The stream is navigable for only about one mile above the confluence with the side channel, and only during high flows. A low flow partial record was obtained by the USGS in 1978.

Willow Creek

Willow Creek is a relatively fast moving stream capable of transporting enough sediment to produce an alluvial deposit at the confluence with a Susitna side channel (Figure 4.9). The flow from this creek joins the east channel mainstem at about RM 50. This stream has been gaged by the U.S. Geological Survey since 1978, with additional miscellaneous measurements at various sites. The mean monthly flow range during water year 1982 ranged from 37 cfs to 1281 cfs. Jetboats and airboats run regularly between the mainstem and the Parks Highway Bridge boat ramp.

Deshka River

This river enters the Susitna mainstem directly at RM 40.6 (Figure 4.10). The water is relatively deep, clear and slow moving. No appreciable alluvial deposits accumulate at the confluence. The stream has continuous flow records from the U.S. Geological Survey since 1978. In water year 1982 mean monthly flows ranged from 177 cfs to 2,561 cfs. This navigable river is a popular sport fishing area during the open water season.

Yentna River

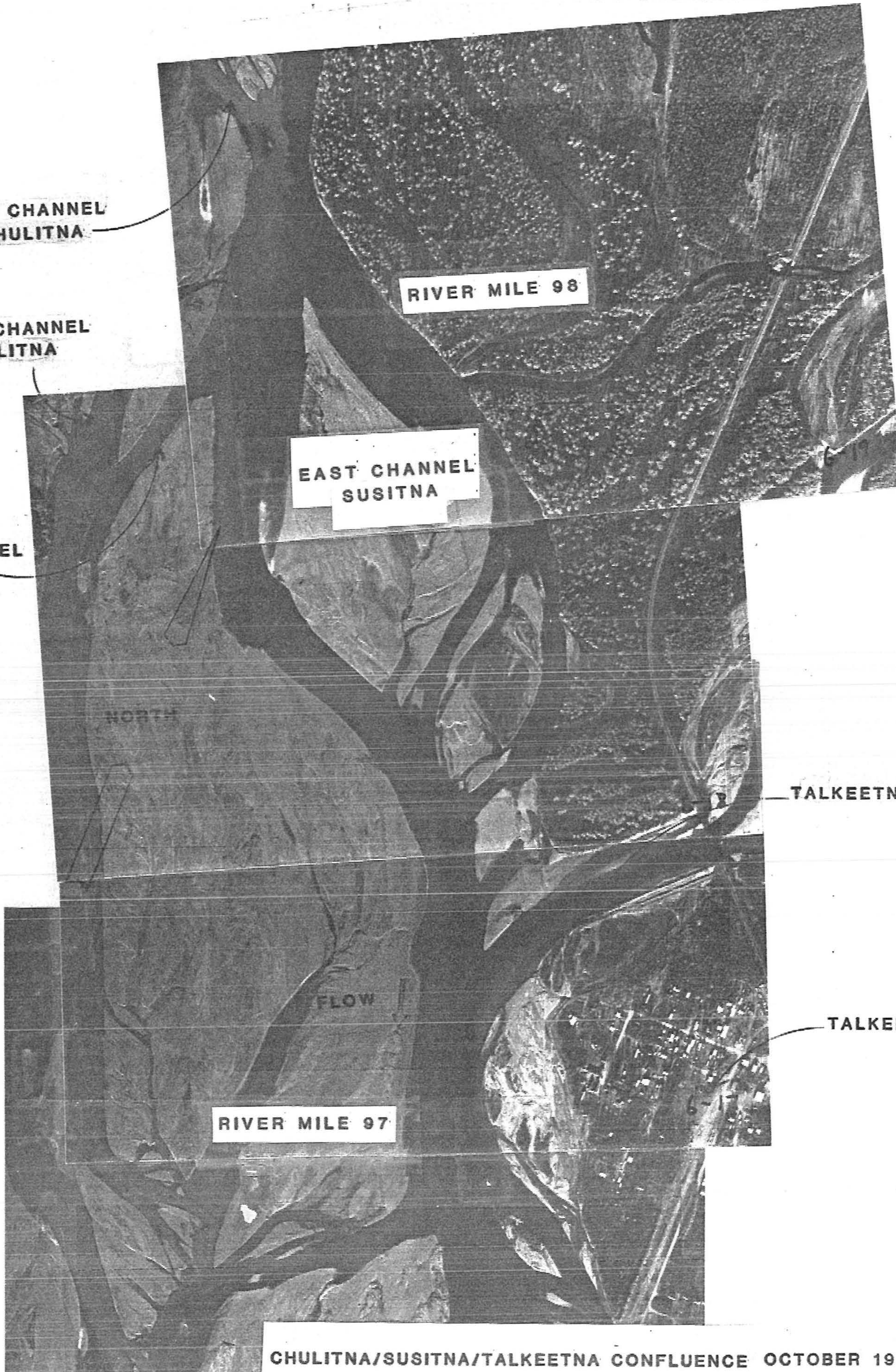
This major tributary enters the Susitna system at RM 28, contributing approximately an equal volume of water to that measured on the Susitna at Sunshine or about 40 percent of the total volume measured at Susitna Station (Figure 4.11). The sediment load appears to be substantial. Being glacial in origin, the particles are small enough to remain entrained and are not deposited in substantial quantities where the two river systems meet. Since October 1980, the USGS has monitored the discharge about 14 miles above the confluence. In 1982 flows ranged from a high daily discharge of 105,000 cfs to a minimum daily flow of 2,000 cfs.

Alexander Creek

This slow clearwater stream enters the west channel of the Susitna near the community of Alexander. The sediment load is probably low throughout the year. The creek is navigable at high flows by jetboat and at low flows by airboat. When the west channel entrance dewaters at RM 19 the only flow in this large channel is from Alexander Creek. The channel then continues to Cook Inlet without joining the eastern main Susitna channel.

Fish Creek

This is a very slow moving stream draining muskeg and swamplands to the east of the river near the estuary. The stream mouth is effected only by high Susitna mainstem flows when the side channel at RM 10 floods. An extensive backwater area has been documented to extend several hundred feet up this creek, which further attests to its low velocity and discharge. Summer residents on Flathorn Lake use this tributary to access the mainstem Susitna and continuing to Alexander Creek. Mainstem ice cover progression does not flood the side channel, and therefore has no influence on the creek.

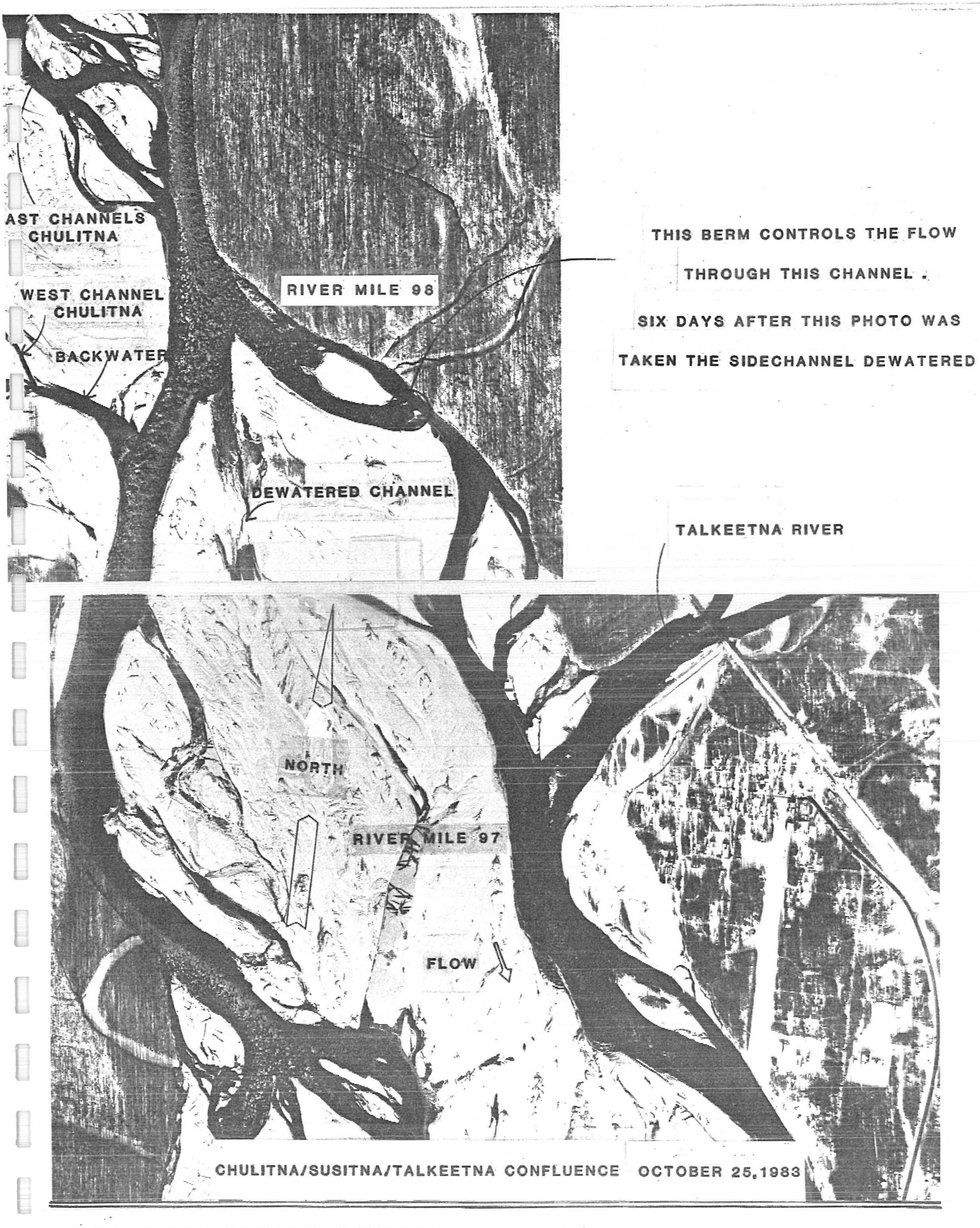


CHULITNA/SUSITNA/TALKEETNA CONFLUENCE OCTOBER 19 1981

FIGURE 4.1

R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS PLANNERS SURVEYORS

HARZA-EBASCO
SUSITNA JOINT VENTURE



CHULITNA/SUSITNA/TALKEETNA CONFLUENCE OCTOBER 25,1983

R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS PLANNERS SURVEYORS

FIGURE 4.2

HARZA-EBASCO
SUSITNA JOINT VENTURE

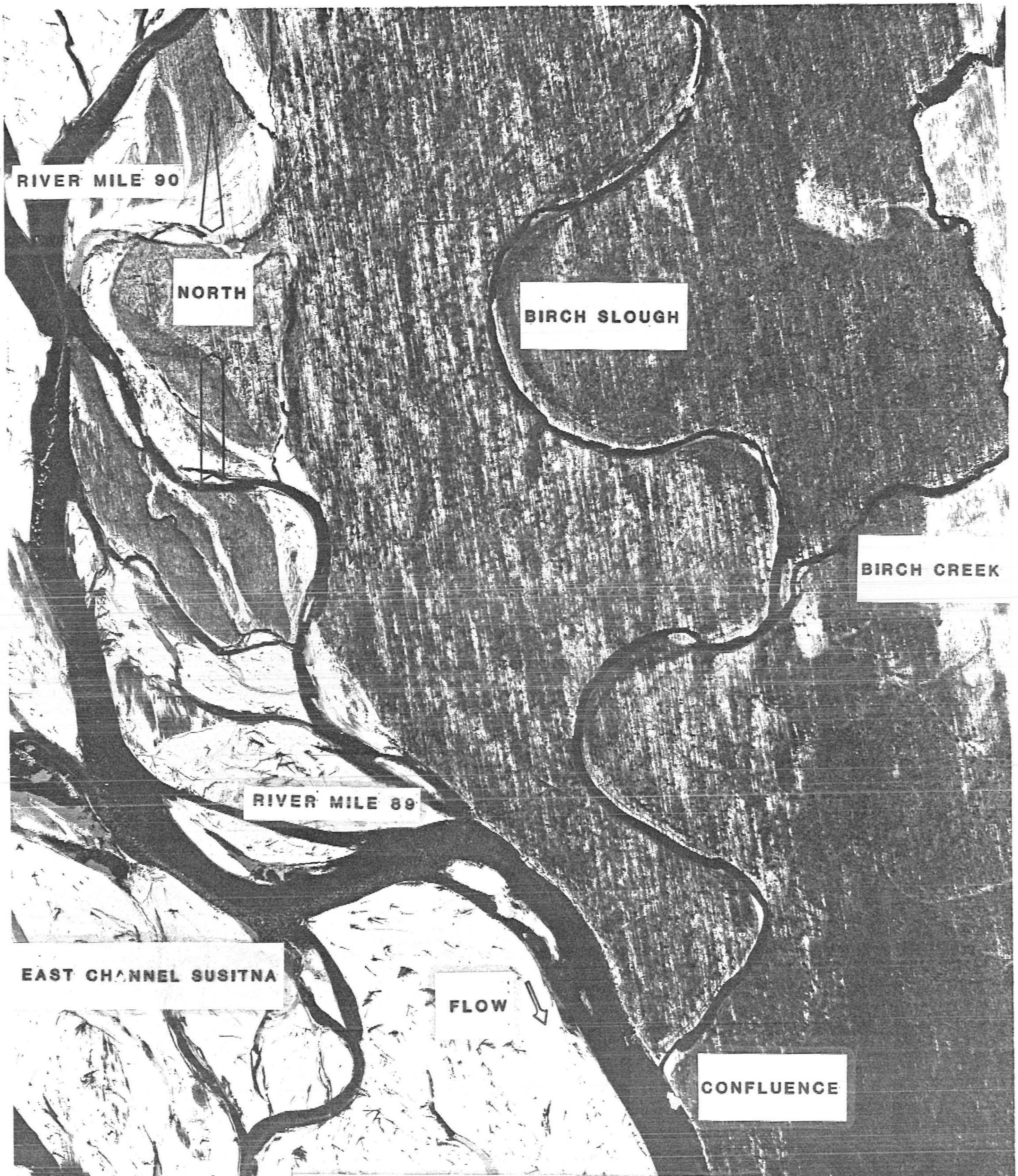
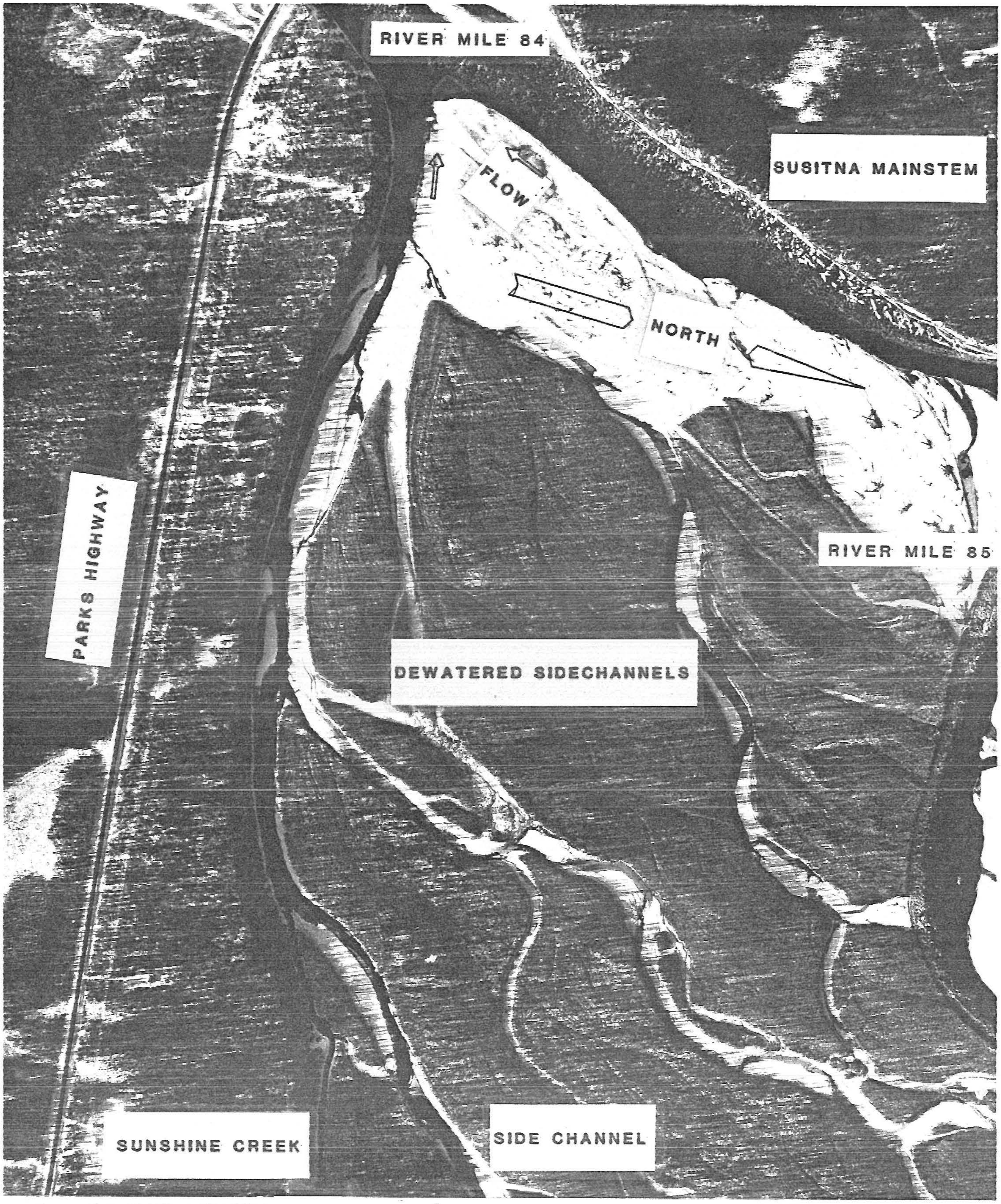

RIVER MILE 90
NORTH
BIRCH SLOUGH
BIRCH CREEK
RIVER MILE 89
EAST CHANNEL SUSITNA
FLOW
CONFLUENCE
BIRCH CREEK CONFLUENCE
OCTOBER 25,1983

FIGURE 4.3



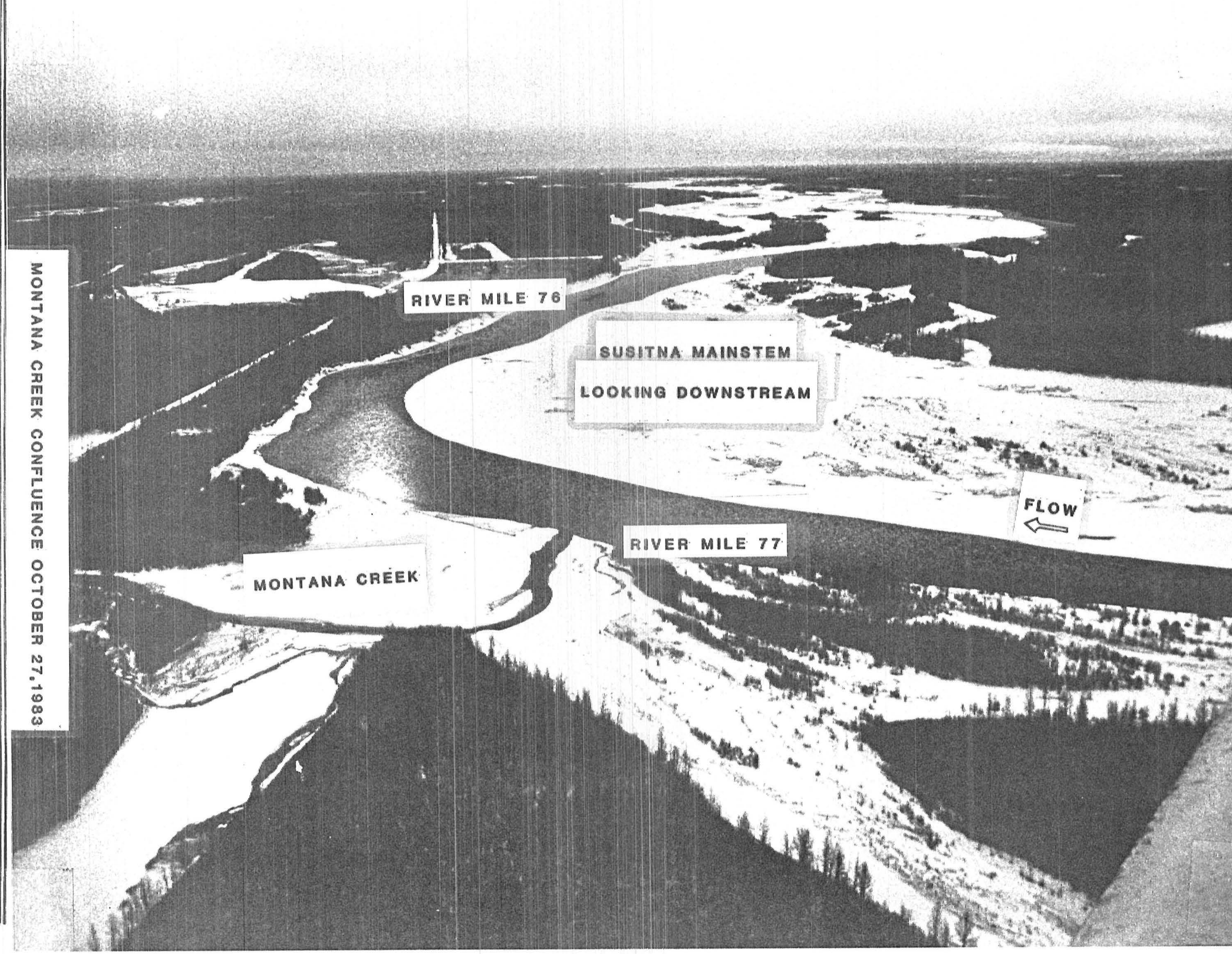
SUNSHINE CREEK CONFLUENCE OCTOBER 25,1983

R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS PLANNERS SURVEYORS

FIGURE 4.4

HARZA-EBASCO
SUSITNA JOINT VENTURE

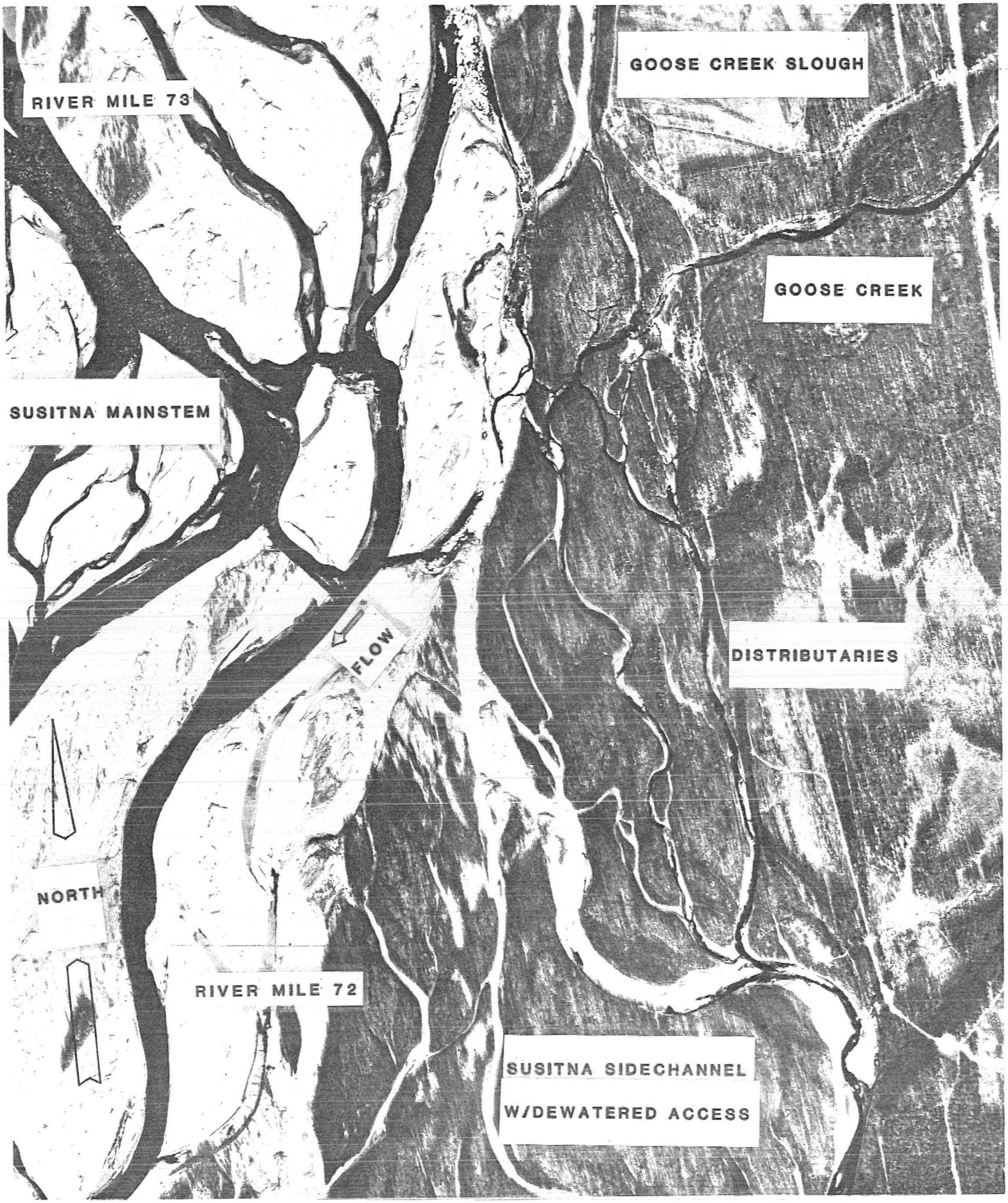
R&M
R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS PLANNERS SURVEYORS



MONTANA CREEK CONFLUENCE OCTOBER 27,1983

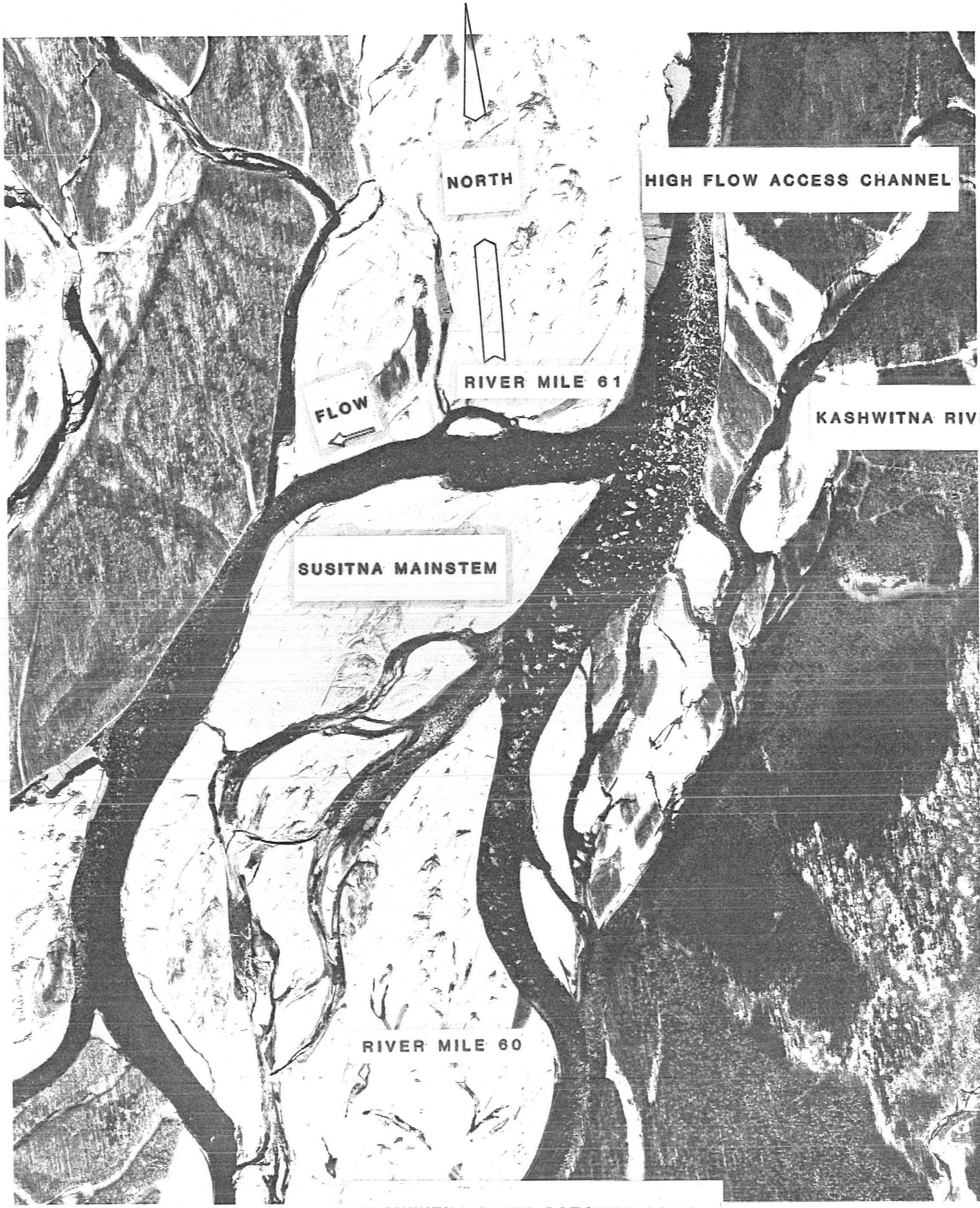
FIGURE 4.5

HARZA-EBASCO
SUSITNA JOINT VENTURE



GOOSE CREEK CONFLUENCE OCTOBER 25,1983

FIGURE 4.6

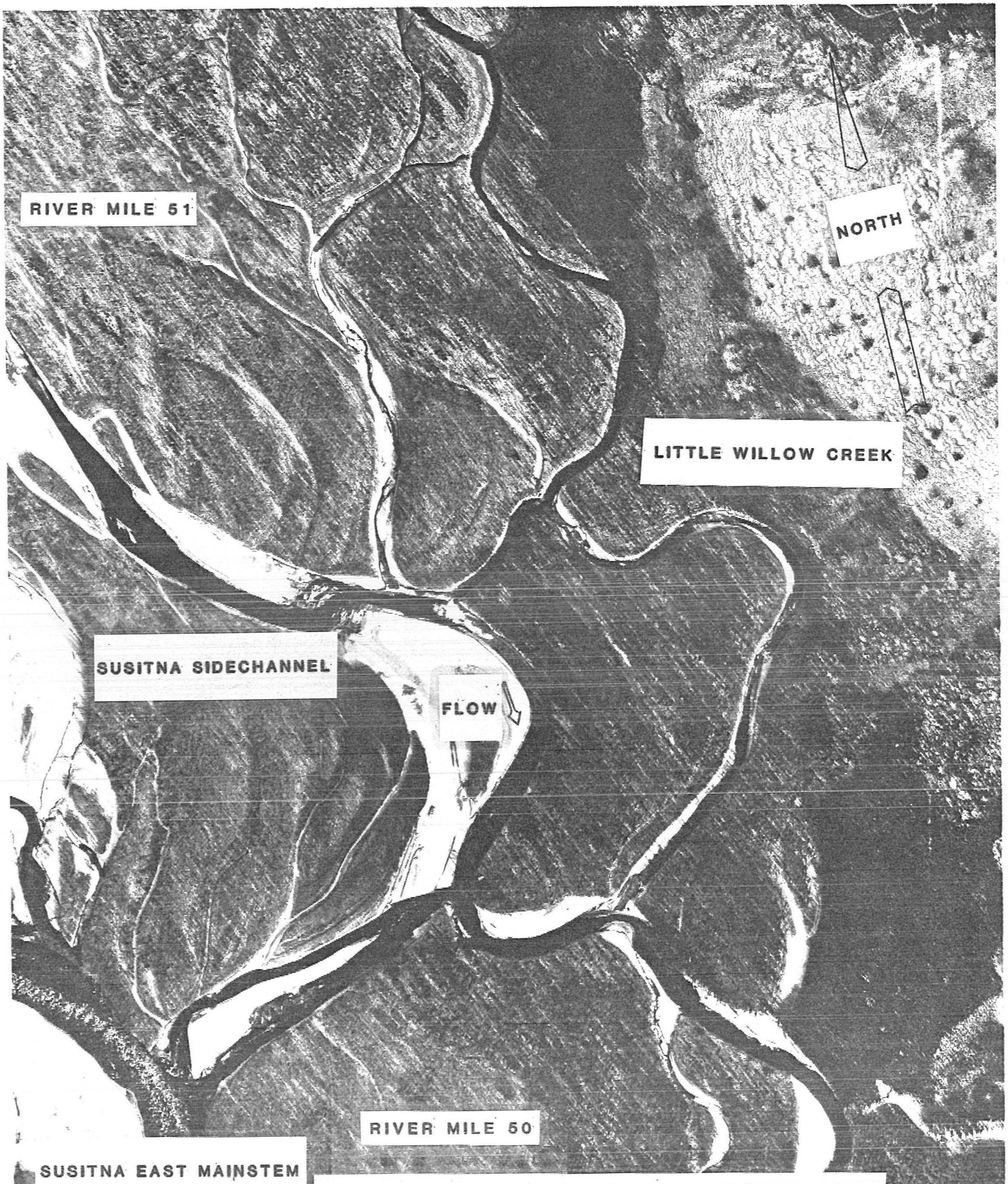


KASHWITNA RIVER OCTOBER 25,1983

R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS PLANNERS SURVEYORS

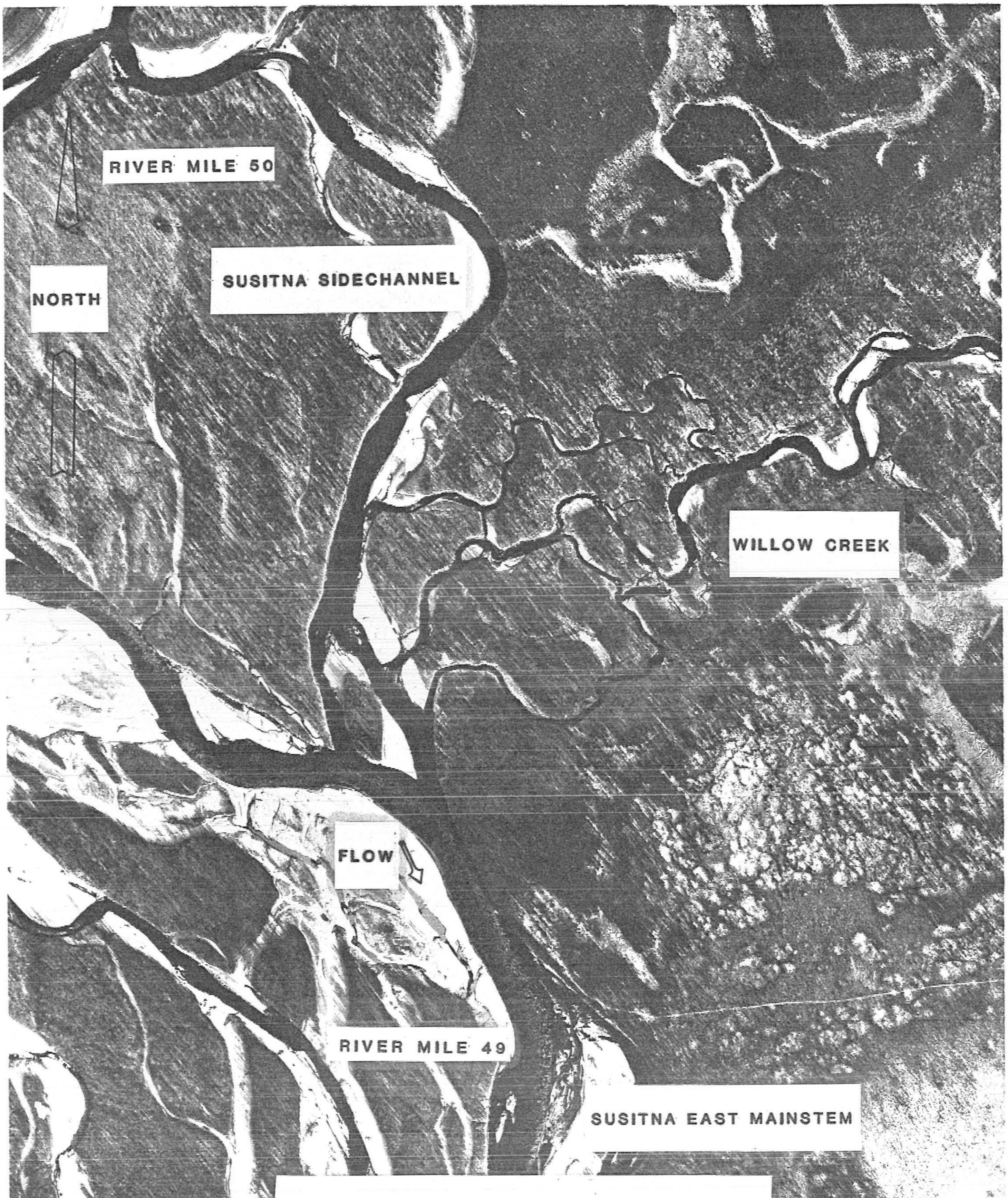
FIGURE 4.7

HARZA-EBASCO
SUSITNA JOINT VENTURE



LITTLE WILLOW CREEK CONFLUENCE OCTOBER 25,1983

FIGURE 4.8



WILLOW CREEK CONFLUENCE OCTOBER 25,1983

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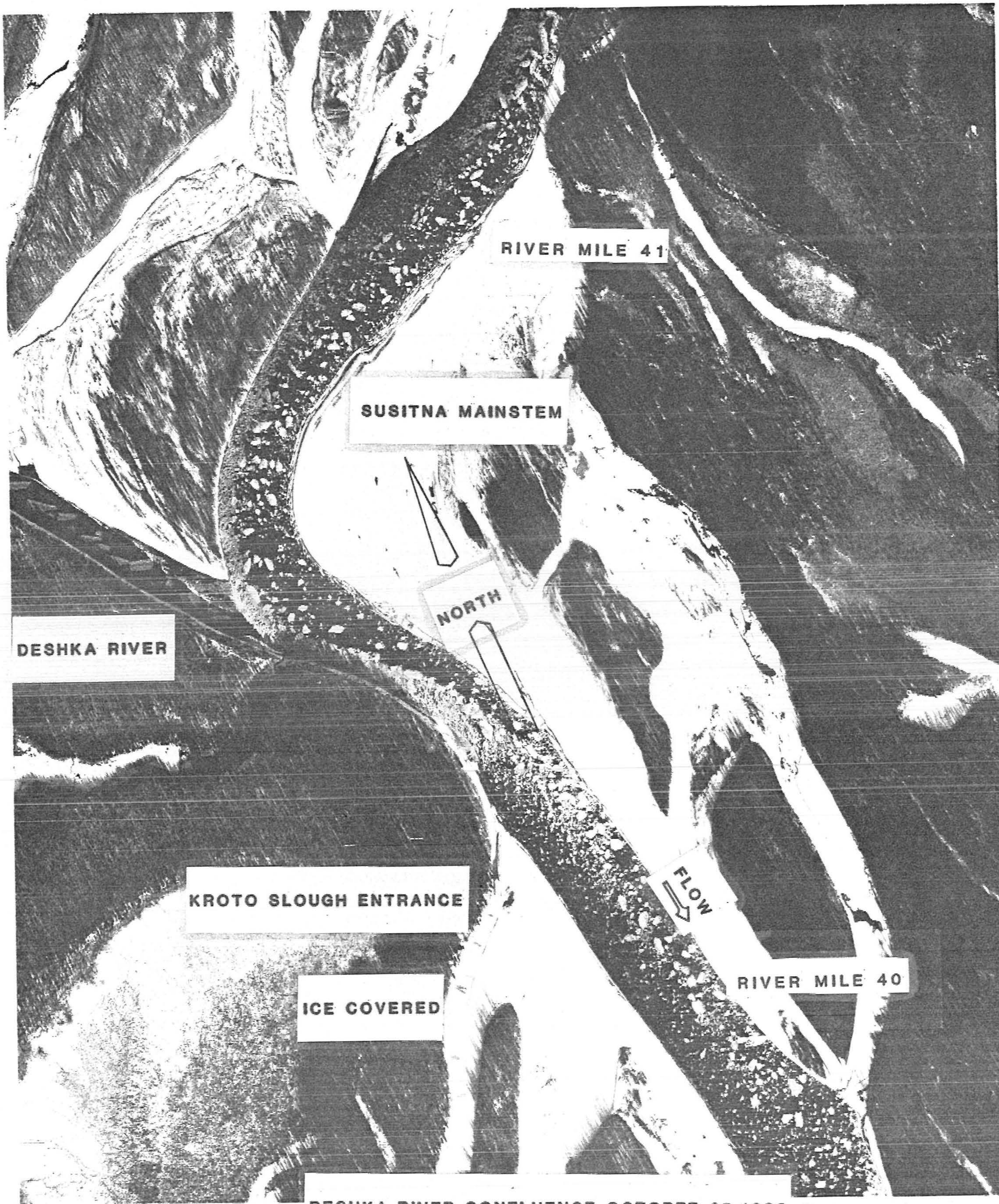
FIGURE 4.9

HARZA-EBASCO
SUSITNA JOINT VENTURE



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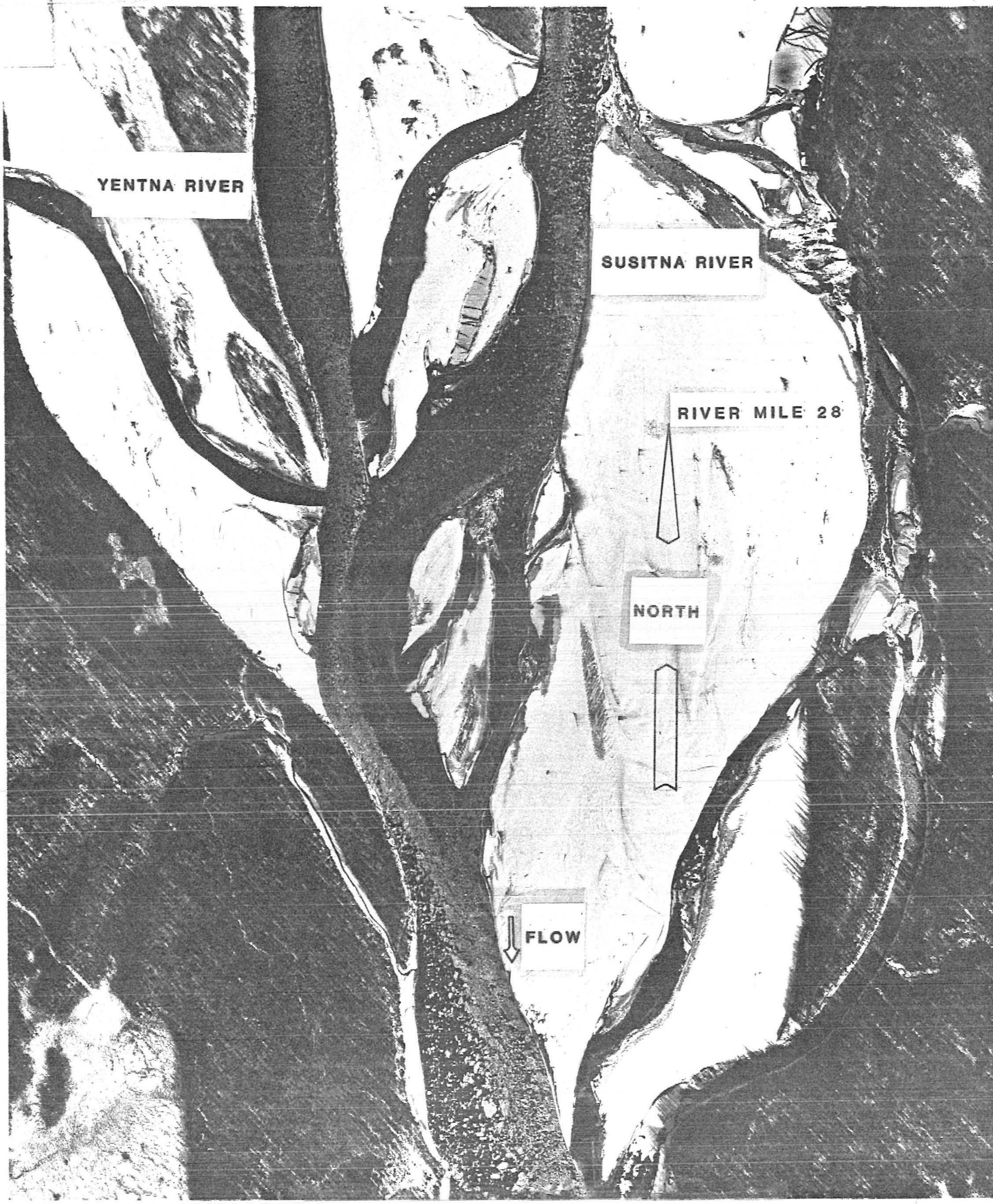
ENGINEERS GEOLOGISTS PLANNERS SURVEYORS

FIGURE 4.10

HARZA-EBASCO
SUSITNA JOINT VENTURE



YENTNA RIVER CONFLUENCE OCTOBER 25,1983

R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS PLANNERS SURVEYORS

FIGURE 4.11

HARZA-EBASCO
SUSITNA JOINT VENTURE

5.0 SUSITNA RIVER BASIN METEOROLOGY

The variable climatic conditions throughout the Susitna River basin significantly affect the gross volume of frazil ice generation, longevity of the floating slush, and rate of ice cover development (Figure 5.1). The dominating parameters governing these variables are air temperature and solar radiation. Beginning in late September and early October frazil ice forms during the night on the upper river near Denali. In 1983, the temperature of the water at this time was still slightly above 0°C. When solar radiation is eliminated and air temperatures are cold (i.e. -5°C), the boundary layer or water surface can be supercooled and frazil crystals form. This supercooled layer is probably too thin to define by a temperature gradient. The only real evidence that it existed is the presence of fine-grained slush ice floating on the surface. Frazil generation stops soon after the sun rises, and solar radiation may actually begin to melt the surface slush ice even when air temperatures are slightly under 0°C. Several authors have observed similar processes (Michel 1971, Newbury 1969).

During the four years of observation, frazil ice has been observed to form in the upper river reach near Denali in September. This frazil floats to the surface and flows downstream at nearly the same velocity as the water. The reach between Denali and Vee Canyon is generally oriented north/south and the low surrounding topography allows a long interval of solar exposure. The net frazil ice volume generated in this area is thus substantially less than the following reach from Vee Canyon to Devil Canyon. In this reach, the river flows west through canyons often over 1,000 feet deep. The steep cliffs on the south bank significantly shade the water surface from the sun. From October through March, when the sun angle is low, little heat is gained from direct short wave radiation. This turbulent reach probably loses more heat and subsequently generates more frazil on any given day during freeze-up than either the area upstream of Vee Canyon or downstream of Gold Creek.

The upper Susitna River basin, north and east of Talkeetna, was relatively cold during September 1983 compared to average historical data (Figure 5.2). September 23rd marked the first day of daily mean air temperatures below freezing at the Denali weather station. On September 25th and 26th, the minimum temperature dropped down to -12.7°C and -17.1°C respectively. These temperatures were sufficiently low for substantial frazil ice generation. On September 26th, this slush ice was observed at Gold Creek by ADF&G field crews and local residents. This cold period was temporary however, and by the last day of the month the mean daily air temperature at Denali was again above 0°C and all traces of ice on the river had disappeared (Figure 5.3). Based on mean daily air temperatures, the total number of freezing degree-days ranged from 49 at the Denali weather station to 6 at Talkeetna. The average historical number of freezing degree-days (FDD) for September was only 17 at Denali and 0 at Talkeetna. The warming trend at the end of September continued during the following months so that the river freeze-up process was considerably slower than that documented in 1982.

The mean monthly air temperatures during October at Talkeetna, Devil Canyon and Watana were colder than normal but the number of accumulated freezing degree-days at all the Susitna Basin weather stations were less than the historical average (Tables 5.1, 5.2, 5.3 and 5.4). This was primarily because of the widely fluctuating mean daily air temperatures and because freezing degree-days (-°C) does not take into consideration the thawing degree-days (+°C) in the statistical accumulation. Mean daily air temperatures at Denali (Table 5.5) were consistently below freezing with the exception of four days. The slush ice volume estimates from Gold Creek show a steady flow of ice after October 14 (Figure 5.4 and 5.5). Ice volumes remained high until October 29, followed by a sharp reduction until November 1. A possible explanation for the low ice volumes observed at Gold Creek on the 30th and 31st of October is the development of an ice bridge in Devil Canyon and the temporary upstream progression from that point. In 1982, ice bridges had been observed to develop rapidly given a sufficient incoming ice volume. When an ice bridge develops in the Devil Canyon area, the ice volume reaching Gold Creek is significantly reduced.

The difference between mean monthly air temperatures and the historical means were even greater during November, with air temperatures above normal. The number of freezing degree-days accumulated in November at Talkeetna was 36 degree-days below the historical average. The last three days of the month were particularly warm with mean daily air temperatures above 0°C. This was reflected by the low volume of slush ice passing Gold Creek.

Ice volumes at Gold Creek stayed low for the first six days in December while air temperatures gradually declined. The maximum ice discharge for the month of December occurred on the 12th. Ice discharges remained low for the remainder of December even though air temperatures were generally below -10°C. This was a consequence of the gradual freezing over of the upper river. Ice bridges were observed near Watana Creek and Kosina Creek. These essentially prevented most of the slush from continuing downstream. The elimination of this frazil generating zone sharply reduced the volume of ice observed at Gold Creek. When the upstream open water area is reduced, less heat exchange takes place and, subsequently, there is a reduction in frazil generation. With less frazil being formed, the entire freeze-up process slows as shown by the rate of leading edge progression on Figure 6.11, in Section 6.

January air temperatures fluctuated considerably, reaching a mean of 0°C on the 12th and 13th and a low of -29°C on the 25th. Ice volumes were low throughout the period of record for the month. Freeze-up at Gold Creek occurred on January 14th but the leading edge did not progress far past this point, as the slush ice produced upstream was minimal, and most ice seemed to be carried underneath the existing cover.

For additional information on the meteorology program for the Susitna Project see the Processed Climatic Data Reports (R&M 1982b, 1983b). The weather conditions related to ice processes were discussed with more detail in the 1983 Ice Studies report and will not be repeated here.

TABLE 5.1

TALKEETNA
SUMMARY OF AIR TEMPERATURES AND
FREEZING DEGREE-DAYS

	SEPTEMBER				OCTOBER			
	Min. °C	Max. °C	Mean °C	FDD* °C	Min. °C	Max. °C	Mean °C	FDD* °C
1.	5.5	14.4	10.0	0	3.9	8.9	6.4	0
2.	2.8	15.6	9.2	0	3.3	11.1	7.2	0
3.	2.8	15.6	9.2	0	1.1	8.9	5.0	0
4.	1.7	13.3	7.5	0	-3.3	9.4	3.1	0
5.	-1.7	14.4	6.4	0	-1.1	5.0	2.0	0
6.	-3.9	15.0	5.6	0	-5.0	5.0	0.0	0
7.	-2.8	15.6	6.4	0	-8.3	2.8	-2.8	2.8
8.	5.6	13.9	9.8	0	-8.3	1.7	-3.3	3.3
9.	5.6	13.9	9.8	0	-2.8	-1.1	-2.0	2.0
10.	1.1	15.6	8.4	0	-1.1	2.8	0.9	0
11.	0.6	16.7	8.7	0	-1.1	6.7	2.8	0
12.	5.0	15.6	10.3	0	0.0	6.1	3.1	0
13.	4.4	13.3	8.9	0	-3.9	4.4	0.3	0
14.	3.3	7.8	5.6	0	-6.7	3.9	-1.4	1.4
15.	-1.1	11.7	5.3	0	-1.1	3.9	1.4	0
16.	-2.8	15.6	6.4	0	-2.8	2.8	-0.4	.4
17.	-3.3	13.3	5.0	0	-1.1	6.1	2.5	0
18.	-2.8	12.2	4.7	0	-3.9	8.9	-1.5	1.5
19.	2.8	12.2	7.5	0	-2.8	3.3	0.3	0
20.	4.4	9.4	6.9	0	-5.0	0.6	-2.2	2.2
21.	6.7	12.2	9.5	0	0.0	6.7	3.4	0
22.	2.2	11.7	10.0	0	-7.8	3.3	-2.3	2.3
23.	-2.2	5.0	1.4	0	-10.0	1.7	-4.2	4.2
24.	-5.6	0.6	-2.5	2.5	-12.2	1.1	-5.6	5.6
25.	-4.4	2.8	-0.8	.8	-15.6	-1.7	-8.7	8.7
26.	-8.3	5.6	-1.4	1.4	-10.0	-3.9	-7.0	7.0
27.	-7.2	4.4	-1.4	1.4	-6.1	3.9	-1.1	1.1
28.	-0.6	2.8	1.1	0	-6.1	3.9	-1.1	1.1
29.	2.8	5.6	4.2	0	-8.3	-0.6	-4.5	4.5
30.	5.0	10.6	7.8	0	-6.7	-0.6	-3.7	3.7
31.					-6.7	-1.7	-4.2	4.2
Mean Monthly Air Temp.			6.0				-0.6	
Monthly Total				6.1				56.0
Average Historical Monthly Total				0				72
Accumulated				6.1				62.1
Average Historical Accumulated				0				72

*Freezing Degree-Days

TABLE 5.1
(cont')

	NOVEMBER				DECEMBER			
	Min. °C	Max. °C	Mean °C	FDD* °C	Min. °C	Max. °C	Mean °C	FDD* °C
1.	-6.7	0.6	-3.1	3.1	-2.2	3.3	0.6	0
2.	-5.0	3.3	-0.9	0.9	-8.9	-1.1	-5.0	5.0
3.	-9.4	3.9	-2.8	2.8	-4.4	-2.2	-3.3	3.3
4.	-12.8	-3.9	-8.4	8.4	-4.4	-2.8	-3.6	3.6
5.	-16.7	-5.6	-11.2	11.2	-2.8	-0.6	-1.7	1.7
6.	-20.0	-5.6	-12.8	12.8	-10.0	0.0	-5.0	5.0
7.	-6.1	-1.7	-3.9	3.9	-15.0	-7.2	-11.1	11.1
8.	-3.8	2.8	-0.5	0.5	-20.0	-13.9	-17.0	17.0
9.	-6.1	2.2	-2.0	2.0	-20.6	-11.7	-16.2	16.2
10.	-2.2	1.7	-0.3	0.3	-12.2	-6.7	-9.5	9.5
11.	-8.3	2.8	-2.8	2.8	-7.8	4.4	-6.1	6.1
12.	-8.3	-1.1	-4.7	4.7	-14.4	-5.6	-10.0	10.0
13.	-17.8	-3.9	-10.9	10.9	-14.4	-6.1	-10.3	10.3
14.	-17.8	-3.9	-10.9	10.9	-23.9	-13.3	-18.6	18.6
15.	-7.2	0.0	-3.6	3.6	-25.6	-14.4	-20.0	20.0
16.	-8.3	-2.2	-5.3	5.3	-20.0	-10.6	-15.3	15.3
17.	-11.7	-3.9	-7.8	7.8	-11.1	-6.7	8.9	8.9
18.	-11.1	-4.4	-7.8	7.8	-14.4	-5.0	-9.7	9.7
19.	-20.0	11.1	-15.6	15.6	-15.5	-4.4	-10.0	10.0
20.	-18.3	-2.8	-10.6	10.6	-5.0	-1.1	-3.1	3.1
21.	-2.8	0.6	-1.1	1.1	-5.0	0.0	-2.5	2.5
22.	-1.1	1.7	0.3	0	-19.4	-2.2	-10.8	10.8
23.	-5.0	-0.6	-2.8	2.8	-22.2	-17.8	-20.0	20.0
24.	-15.6	-4.4	-10.0	10.0	-22.8	5.6	-8.6	8.6
25.	-16.7	4.4	-10.6	10.6	1.7	7.2	4.5	0
26.	-4.4	-2.2	-3.3	3.3	-15.0	5.0	-5.0	5.0
27.	-4.4	0.6	-1.9	1.9	-18.9	-12.8	-15.9	15.9
28.	0.0	2.8	1.4	0	-22.2	-18.3	-20.3	20.3
29.	-3.3	3.9	0.3	0	-25.0	-20.0	-22.5	22.5
30.	-6.7	2.8	2.0	0	-26.1	-12.8	-19.5	19.5
31.					-12.8	-6.1	-9.5	9.5
Mean Monthly Air Temp.			-5.1				-10.1	
Monthly Total				155.6				318.7
Average Historical Monthly Total				191				407
Accumulated				217.7				536.4
Average Historical Accumulated				263				670

*Freezing Degree-Days

TABLE 5.2

SHERMAN
SUMMARY OF AIR TEMPERATURES AND
FREEZING DEGREE-DAYS

	SEPTEMBER				OCTOBER			
	Min. °C	Max. °C	Mean °C	FDD* °C	Min. °C	Max. °C	Mean °C	FDD* °C
1.	5.8	12.4	9.1	0	2.4	7.9	5.2	0
2.	-0.9	15.3	7.2	0	-0.3	10.3	5.0	0
3.	-1.5	16.5	7.5	0	-3.2	7.9	2.4	0
4.	-2.3	13.1	5.4	0	-6.7	9.1	1.2	0
5.	-3.6	14.2	5.3	0	-1.1	3.6	1.3	0
6.	-4.3	15.0	5.4	0	-7.9	5.2	-1.4	1.4
7.	-3.7	14.7	5.5	0	-11.7	0.9	-5.4	5.4
8.	3.8	12.8	8.3	0	-13.4	1.0	-6.2	6.2
9.	4.7	14.6	9.7	0	-3.4	-1.3	-2.4	2.4
10.	0.9	15.0	8.0	0	-1.2	1.0	-0.1	0.1
11.	1.0	15.5	8.3	0	0.5	7.4	4.0	0
12.	3.3	14.8	9.1	0	0.5	4.5	2.5	0
13.	1.5	12.9	7.2	0	-4.2	3.5	-0.4	0.4
14.	0.1	7.5	3.8	0	-8.0	3.0	-2.5	2.5
15.	-3.2	11.9	4.1	0	-3.7	3.4	-0.2	0.2
16.	-4.8	15.7	5.5	0	-4.6	3.1	-0.8	0.8
17.	-5.1	12.8	3.9	0	-4.4	7.2	1.4	0
18.	-4.8	13.5	4.4	0	-1.3	6.5	2.6	0
19.	-3.0	12.0	4.5	0	-6.7	0.2	-3.3	3.3
20.	5.0	8.8	6.9	0	-6.7	0.1	-3.3	3.3
21.	5.9	12.2	9.1	0	-2.9	3.8	0.5	0
22.	0.3	9.8	5.1	0	-7.2	5.4	-0.9	0.9
23.	-2.6	3.4	0.4	0	-11.7	3.4	-4.2	4.2
24.	-3.4	-0.6	-2.0	2.0	-12.1	1.5	-5.3	5.3
25.	-9.2	3.7	-2.8	2.8	-13.2	-0.2	-6.7	6.7
26.	-11.6	3.9	-3.9	3.9	-11.4	1.7	-4.9	4.9
27.	-11.1	3.6	-3.8	3.8	-9.3	2.6	-3.4	3.4
28.	-0.9	1.8	0.5	0	-2.7	2.0	-0.4	0.4
29.	0.2	3.4	1.8	0	-9.0	-2.0	-5.5	5.5
30.	2.3	10.2	6.3	0	-7.0	0.1	-3.5	3.5
31.					-6.2	-1.9	-4.1	4.1
Mean Monthly Air Temp.			4.7				-1.3	
Monthly Total				12.5				64.9
Average Historical Monthly Total				0				189
Accumulated				12.5				77.4
Average Historical Accumulated				0				189

*Freezing Degree-Days

TABLE 5.2
(cont')

	NOVEMBER Min. °C	Max. °C	Mean °C	FDD* °C	DECEMBER Min. °C	Max. °C	Mean °C	FDD* °C
1.	-9.5	-0.6	-5.0	5.0	-3.1	2.2	-0.4	0.4
2.	-7.0	4.2	-1.4	1.4	-8.5	-2.9	-5.7	5.7
3.	-9.4	3.5	-3.0	3.0	-6.5	-3.4	-5.0	5.0
4.	-10.5	-1.8	-6.2	6.2	-8.8	-2.8	-5.8	5.8
5.	-14.3	-1.4	-7.8	7.8	-3.8	-2.4	-3.1	3.1
6.	-17.3	-8.4	-12.8	12.8	-10.7	-1.5	-6.1	6.1
7.	-10.3	-1.6	-6.0	6.0	-15.6	-10.7	-13.2	13.2
8.	-3.6	2.7	-0.4	0.4	-20.6	-11.4	-16.0	16.0
9.	-3.2	4.3	0.6	0	-22.9	-12.9	-17.9	17.9
10.	-3.1	2.9	-0.1	0.1	-14.5	-6.1	-10.3	10.3
11.	-9.1	0.9	-4.1	4.1	-9.5	-4.5	-7.0	7.0
12.	-7.5	-1.4	-4.4	4.4	-16.1	-7.2	-11.7	11.7
13.	-15.4	-6.3	-10.8	10.8	-14.3	-5.5	-9.9	9.9
14.	-17.8	-7.3	-12.6	12.6	-21.2	-16.0	-18.6	18.6
15.	-13.9	0.3	-6.8	6.8	-25.7	-18.4	-22.1	22.1
16.	-10.6	-2.2	-6.4	6.4	-17.7	-12.5	-15.1	15.1
17.	-15.4	-6.9	-11.2	11.2	-12.6	-8.5	-10.6	10.6
18.	-17.6	-6.5	-12.0	12.0	-17.8	-7.7	-12.8	12.8
19.	-21.2	-15.0	-18.1	18.1	-17.5	-6.8	-12.2	12.2
20.	-20.6	-2.4	-11.5	11.5	-7.1	-3.3	-5.2	5.2
21.	-2.0	3.4	0.7	0	-5.8	-2.2	-4.0	4.0
22.	-4.5	0.1	-2.2	2.2	-19.8	-4.3	-12.1	12.1
23.	-9.9	-3.4	-6.6	6.6	-21.3	-16.5	-18.9	18.9
24.	-19.6	-7.4	-13.5	13.5	-19.5	-9.4	-14.5	14.5
25.	-17.5	-6.7	-12.1	12.1	-10.0	0.6	-4.7	4.7
26.	-9.3	-4.4	-6.8	6.8	-17.0	7.7	-12.4	12.4
27.	-8.8	-2.5	-5.7	5.7	-22.2	13.3	-17.8	17.8
28.	-4.1	2.6	-0.8	0.8	-23.9	-20.7	-22.3	22.3
29.	-3.4	4.0	0.3	0	-26.0	-21.7	-23.9	23.9
30.	-7.0	3.4	-1.8	1.8	-27.3	-16.7	-22.0	22.0
31.					-16.3	-10.2	-13.3	13.3
Mean Monthly Air Temp.			-6.3				-12.1	
Monthly Total				191				374.6
Average Historical Monthly Total				301				274
Accumulated				268.4				643.0
Average Historical Accumulated				490				764

*Freezing Degree-Days

TABLE 5.3

DEVIL CANYON
SUMMARY OF AIR TEMPERATURES AND FREEZING DEGREE-DAYS

	SEPTEMBER				OCTOBER			
	Min. °C	Max. °C	Mean °C	FDD* °C	Min. °C	Max. °C	Mean °C	FDD* °C
1.	5.6	10.2	7.9	0	0.2	5.8	3.0	0
2.	1.0	12.1	6.6	0	0.2	7.7	4.0	0
3.	0.6	13.0	6.8	0	-3.0	4.4	0.7	0
4.	-1.1	8.9	3.9	0	-4.1	6.6	1.3	0
5.	-3.0	11.6	4.3	0	-1.6	2.2	0.3	0
6.	-2.1	11.4	4.7	0	-8.3	2.2	-3.1	3.1
7.	-10.5	11.1	0.3	0	-10.9	-2.3	-6.6	6.6
8.	3.8	9.6	6.7	0	-13.2	-0.8	-7.0	7.0
9.	3.5	11.8	7.7	0	-5.2	-2.4	-3.8	3.8
10.	3.7	11.7	7.7	0	-2.8	1.0	-0.9	0.9
11.	3.2	13.0	8.1	0	0.1	7.7	3.9	0
12.	3.7	11.5	7.6	0	-0.2	3.8	1.8	0
13.	2.7	11.0	6.9	0	-5.6	1.5	-2.1	2.1
14.	2.6	6.4	4.5	0	-10.0	-0.5	-5.3	5.3
15.	-1.6	8.9	3.7	0	-7.0	0.8	-3.1	3.1
16.	-3.0	12.5	4.8	0	-8.9	0.4	-4.3	4.3
17.	-2.6	10.0	3.7	0	-5.1	5.1	0.0	0
18.	-8.4	11.3	1.5	0	-1.1	3.4	1.2	0
19.	-0.2	9.4	4.6	0	-3.5	-0.7	-2.1	2.1
20.	3.6	8.7	6.2	0	-3.5	-0.5	-2.0	2.0
21.	5.7	11.3	8.5	0	-2.0	4.3	1.2	0
22.	-0.9	7.3	3.2	0	-3.5	3.7	0.1	0
23.	-5.8	-0.1	-3.0	3.0	-8.7	0.9	-3.9	3.9
24.	-9.3	6.4	-1.5	1.5	-10.9	-1.6	-6.3	6.3
25.	-6.7	-0.8	-3.8	3.8	-12.5	-3.3	-7.9	7.9
26.	-8.9	0.0	-4.5	4.5	-9.2	-1.6	-5.4	5.4
27.	-9.0	0.6	-4.2	4.2	-28.4	-0.2	-14.3	14.3
28.	-2.8	2.1	-0.4	0.4	-4.0	0.1	-2.0	2.0
29.	0.1	3.7	1.9	0	-10.0	-2.0	-6.0	6.0
30.	2.4	7.3	4.9	0	-5.2	-1.4	-3.3	3.3
31.					-8.2	-3.5	-5.9	5.9
Mean Monthly Air Temp.			3.6				-2.5	
Monthly Total				17.4				95.3
Average Historical Monthly Total				5				95
Accumulated				17.4				112.7
Average Historical Accumulated				5				100

*Freezing Degree-Days

TABLE 5.3
(cont')

	NOVEMBER				DECEMBER			
	Min. °C	Max. °C	Mean °C	FDD* °C	Min. °C	Max. °C	Mean °C	FDD* °C
1.	-10.7	0.2	-5.2	5.2	-2.6	2.1	-0.2	0.2
2.	-5.3	1.8	-1.8	1.8	-5.5	0.7	-5.1	5.1
3.	-10.3	0.4	-5.0	5.0	-6.7	3.4	-5.0	5.0
4.	-9.8	0.8	-4.5	4.5	-6.7	-4.7	-5.7	5.7
5.	-9.5	-3.0	-6.2	6.2	-5.5	-2.5	-4.0	4.0
6.	-12.3	-6.7	-9.5	9.5	-8.4	-2.1	-5.3	5.3
7.	-7.5	-2.9	-5.2	5.2	-7.0	-3.8	-5.4	5.4
8.	-3.0	1.3	-0.8	0.8	-10.6	-2.9	-6.8	6.8
9.	-5.3	2.2	-1.6	1.6	-13.6	-2.6	-8.1	8.1
10.	-5.4	0.2	-2.6	2.6	-16.3	-8.8	-12.6	12.6
11.	-6.7	0.7	-3.0	3.0	-11.8	-7.1	-9.5	9.5
12.	-7.2	-4.5	-5.8	5.8	-14.3	-8.9	-11.6	11.6
13.	-13.3	-5.7	-9.5	9.5	-11.8	-8.5	-10.2	10.2
14.	-12.8	-8.4	-10.6	10.6	-22.2	-18.3	-20.3	20.3
15.	-13.3	-0.1	-6.7	6.7	-26.7	-23.3	-25.0	25.0
16.	-12.0	-3.4	-7.7	7.7	-21.1	-17.2	-19.2	19.2
17.	-14.5	-8.3	-11.4	11.4	-15.0	-5.6	-10.3	10.3
18.	-16.0	-8.6	-12.3	12.3	-14.4	-6.7	-10.6	10.6
19.	-17.3	-12.4	-14.8	14.8	-16.7	-7.8	-12.3	12.3
20.	-16.6	-4.6	-10.6	10.6	-8.0	-3.8	-5.9	5.9
21.	-4.4	1.9	-1.2	1.2	-6.4	-2.9	-4.7	4.7
22.	-6.8	0.2	-3.3	3.3	-15.6	-11.1	-13.4	13.4
23.	-7.9	-4.6	-6.2	6.2	-22.2	-17.8	-20.0	20.0
24.	-13.5	-5.6	-9.6	9.6	-20.0	-9.4	-14.7	14.7
25.	-10.2	-9.0	-9.6	9.6	-14.4	1.3	-6.6	6.6
26.	-9.4	-5.5	-7.4	7.4	-11.9	-8.2	-10.1	10.1
27.	-9.2	-3.2	-6.2	6.2	-15.3	-8.2	-11.8	11.8
28.	-4.5	0.9	-1.8	1.8	-23.3	-21.1	-22.2	22.2
29.	-1.4	3.5	1.0	0	-28.9	-19.4	-24.2	24.2
30.	-1.3	2.8	0.8	0	-26.7	-16.7	-21.7	21.7
31.					-24.4	-12.2	-18.3	18.3
Mean Monthly Air Temp.			-5.9				-11.6	
Monthly Total				180				360.8
Average Historical Monthly Total				222				391
Accumulated				292.8				653.6
Average Historical Accumulated				322				713

*Freezing Degree-Days

TABLE 5.4

WATANA
SUMMARY OF AIR TEMPERATURES AND FREEZING DEGREE-DAYS

	SEPTEMBER				OCTOBER			
	Min. °C	Max. °C	Mean °C	FDD* °C	Min. °C	Max. °C	Mean °C	FDD* °C
1.			1.6*	0			-0.9*	0.9
2.			1.1*	0			-0.3*	0.3
3.	1.4	6.1	3.8	0			-1.9*	1.9
4.	4.4	10.0	7.2	0			-3.2*	3.2
5.			-0.9*	0.9			-3.9*	3.9
6.			-1.4*	1.4			-5.3*	5.3
7.	2.3	8.3	5.3	0			-7.2*	7.2
8.	3.2	3.4	3.3	0			-7.6*	7.6
9.	3.6	8.8	6.2	0			-6.7*	6.7
10.	4.2	11.0	7.6	0			-4.7*	4.7
11.	1.6	11.1	6.4	0			-3.4*	3.4
12.	2.6	11.2	6.9	0			-3.2*	3.2
13.	1.2	8.3	4.8	0			-5.1*	5.1
14.	0.1	5.2	2.7	0			-6.3*	6.3
15.	0.1	7.6	3.9	0			-4.3*	4.3
16.	-3.2	10.7	3.8	0			-5.6*	5.6
17.	-4.7	10.0	2.7	0	-0.8	0.9	0.1	0
18.	-6.7	8.6	1.0	0	-5.1	0.5	-2.3	2.3
19.	1.6	7.2	4.4	0	-6.3	-2.7	-4.5	4.5
20.	2.7	8.5	5.6	0	-5.2	-2.7	-4.0	4.0
21.	4.5	8.3	6.4	0	-3.2	1.8	-0.7	0.7
22.			1.6*	0	-4.6	-0.1	-2.4	2.4
23.			-4.3*	4.3	-7.1	-1.9	-4.5	4.5
24.			-7.0*	7.0	-10.5	-2.4	-6.5	6.5
25.			-5.9*	5.9	-9.4	-6.7	-8.1	8.1
26.			-6.3*	6.3	-9.1	-4.6	-6.9	6.9
27.			-6.3*	6.3	-11.8	-2.7	-7.3	7.3
28.			-4.5*	4.5	-8.3	-2.9	-5.6	5.6
29.			-2.4*	2.4	-9.6	-1.3	-5.5	5.5
30.			0.1*	0	-6.0	-2.3	-4.2	4.2
31.					-11.9	-3.6	-7.8	7.8
Mean Monthly Air Temp.			-0.31				-4.5	
Monthly Total				39.0				139.9
Average Historical Monthly Total				13				127
Accumulated				39.0				178.9
Average Historical Accumulated				13				140

* Estimated values from linear correlation with the Talkeetna Weather Station.
** Freezing Degree-Days

TABLE 5.4
(cont')

	NOVEMBER Min. °C	Max. °C	Mean °C	FDD* °C	DECEMBER Min. °C	Max. °C	Mean °C	FDD* °C
1.	-13.4	-2.3	-7.9	7.9	-4.2	0.3	-2.0	2.0
2.	-10.2	-1.8	-6.0	6.0	-6.3	-2.4	-4.4	4.4
3.	-10.6	-1.8	-6.2	6.2	-10.6	-6.1	-8.4	8.4
4.	-11.9	-3.3	-7.6	7.6	-8.6	-7.0	-7.8	7.8
5.	-12.0	-5.1	-8.6	8.6	-7.9	-3.9	-5.9	5.9
6.	-14.8	-7.7	-11.3	11.3	-6.4	-4.2	-5.3	5.3
7.	-11.6	-6.8	-9.2	9.2	-8.7	-5.1	-6.9	6.9
8.	-7.0	-0.2	-3.6	3.6	-14.5	-8.6	-11.6	11.6
9.	-8.4	-1.0	-4.7	4.7	-20.2	-13.6	-16.9	16.9
10.	-8.4	-4.1	-6.3	6.3	-19.2	-13.7	-16.5	16.5
11.	-9.9	-2.5	-6.2	6.2	-15.2	-10.3	-12.8	12.8
12.	-12.3	-6.8	-9.6	9.6	-15.2	-10.4	-12.8	12.8
13.	-15.6	-7.1	-11.4	11.4	-14.7	-12.6	-13.7	13.7
14.	-15.1	-9.2	-12.2	12.2	-22.7	-15.3	-19.0	10.0
15.	-15.2	-6.6	-11.4	11.4	-24.3	-17.2	-20.8	20.8
16.	-15.0	-8.6	-11.8	11.8	-21.9	-18.4	-20.2	20.2
17.	-15.9	-7.8	-11.9	11.9	-19.7	-15.0	-17.4	17.4
18.	-18.1	-10.2	-14.2	14.2	-16.7	-9.2	-13.0	13.0
19.	-18.0	-10.1	-14.1	14.1	-14.0	-8.0	-11.0	11.0
20.	-18.5	-6.7	-12.6	12.6	-10.2	-6.3	-8.3	8.3
21.	-6.2	0.9	-2.7	2.7	-13.0	-5.5	-9.3	9.3
22.	-9.1	-0.8	-5.0	5.0	-16.9	-12.6	-14.8	14.8
23.	-10.6	-6.4	-8.5	8.5	-17.2	-13.5	-15.4	15.4
24.	-14.5	-7.5	-11.0	11.0	-17.7	-1.7	-9.7	9.7
25.	-14.5	-11.0	-12.8	12.8	-13.9	-3.6	-8.8	8.8
26.	-11.7	-7.5	-9.6	9.6	-13.4	-6.2	-9.8	9.8
27.	-9.6	-5.1	-7.4	7.4	-18.1	-7.9	-13.0	13.0
28.	-6.8	0.8	-3.0	3.0	-22.7	-17.1	-19.9	19.9
29.	-1.6	1.8	0.1	0	-22.7	20.0	-21.4	21.4
30.	-2.5	0.5	-1.0	1.0	-26.7	-21.4	-24.1	24.1
31.					-22.2	-10.9	-16.6	16.6
Mean Monthly Air Temp.			-8.3				-13.4	
Monthly Total				247.8				397.5
Average Historical Monthly Total				279				468
Accumulated				426.7				824.2
Average Historical Accumulated				419				887

*Freezing Degree-Days

TABLE 5.5

DENALI
SUMMARY OF AIR TEMPERATURES AND
FREEZING DEGREE-DAYS

	SEPTEMBER				OCTOBER			
	Min. °C	Max. °C	Mean °C	FDD* °C	Min. °C	Max. °C	Mean °C	FDD* °C
1.					0.1	4.1	2.1	0
2.	-0.1	7.4	3.7	0	-1.0	4.8	1.9	0
3.	-0.6	9.4	4.4	0	-5.3	0.3	-2.5	2.5
4.	0.4	5.3	2.9	0	-8.4	1.1	-3.7	3.7
5.	-1.5	5.4	2.0	0	-5.4	0.1	-2.7	2.7
6.	-0.9	6.6	2.9	0	-8.8	-2.0	-5.4	5.4
7.	-0.9	8.0	3.6	0	-16.5	-5.1	-10.8	10.8
8.	1.1	7.6	4.4	0	-18.9	-6.6	-12.8	12.8
9.	2.6	9.3	6.0	0	-9.0	-2.5	-5.8	5.8
10.	0.1	10.0	5.1	0	-2.3	6.0	1.9	0
11.	-2.5	10.3	3.9	0	0.4	4.9	2.7	0
12.	2.4	10.1	6.3	0	-1.8	2.5	0.4	0
13.	0.1	8.0	4.1	0	-4.6	-0.3	-2.5	2.5
14.	0.6	7.4	4.0	0	-9.5	-1.2	-5.4	5.4
15.	-2.5	6.0	1.8	0	-13.6	-1.0	-7.3	7.3
16.	-2.0	8.0	3.0	0	-16.0	-3.6	-9.8	9.8
17.	-4.5	9.4	2.5	0	-8.5	0.1	-4.2	4.2
18.	-5.2	7.9	1.4	0	-6.3	0.1	-3.1	3.1
19.	0.1	6.8	3.5	0	-10.5	6.3	-2.1	2.1
20.	0.7	9.3	5.0	0	-10.7	-2.0	-6.4	6.4
21.	3.3	7.3	5.3	0	-6.9	1.7	-2.6	2.6
22.	-4.4	5.2	0.4	0	-8.6	-0.8	-4.7	4.7
23.	-8.2	-4.8	-6.5	6.5	-12.0	-0.5	-6.3	6.3
24.	-10.0	-7.6	-8.8	8.8	-14.7	-4.3	-9.5	9.5
25.	-12.7	-5.0	-8.9	8.9	-12.0	-9.6	-10.8	10.8
26.	-17.1	-5.5	-11.3	11.3	-13.7	-3.7	-8.7	8.7
27.	-15.7	-3.7	-9.7	9.7	-9.6	-1.7	-5.7	5.7
28.	-4.8	0.7	-2.1	2.1	-9.4	-1.5	-5.5	5.5
29.	-4.8	0.7	-2.1	2.1	-10.8	-2.5	-6.7	6.7
30.	3.3	7.3	5.3	0	-6.1	-2.5	-4.3	4.3
31.					-12.7	-1.3	-7.0	7.0
Mean Monthly Air Temp.			0.7				-4.8	
Monthly Total				49.4				156
Average Historical Monthly Total				17				192
Accumulated				49.4				205.7
Average Historical Accumulated				17				209

*Freezing Degree-Days

TABLE 5.5
(cont')

	NOVEMBER				DECEMBER			
	Min. °C	Max. °C	Mean °C	FDD* °C	Min. °C	Max. °C	Mean °C	FDD* °C
1.	-13.0	-6.0	-9.5	9.5	-4.9	-0.8	-2.9	2.9
2.	-12.7	-2.4	-7.6	7.6	-7.5	-2.0	-4.8	4.8
3.	-19.4	-7.5	-13.5	13.5	-11.7	-3.1	-7.4	7.4
4.	-20.5	-11.7	-16.1	16.1	-10.8	-6.2	-8.5	8.5
5.	-17.2	-9.5	-13.4	13.4	-9.3	-5.4	-7.4	7.4
6.	-20.8	-13.4	-17.1	17.1	-7.0	-6.5	-6.8	6.8
7.	-14.9	-6.6	-10.8	10.8	-7.1	-5.3	-6.2	6.2
8.	-11.9	-2.1	-7.0	7.0	-12.6	-5.4	-9.0	9.0
9.	-14.4	-3.8	-9.1	9.1	-14.0	-12.5	-13.3	13.3
10.	-16.8	-6.8	-11.8	11.8	-17.2	-14.4	-15.8	15.8
11.	-15.7	-8.1	-11.9	11.9	-16.6	-16.6	-16.6	16.6
12.	-16.0	-8.2	-12.1	12.1			-16.1*	16.1
13.	-20.5	-12.0	-16.3	16.3			-17.1*	17.1
14.	-20.8	-15.9	-18.4	18.4			-23.1*	23.1
15.	-24.3	-16.8	-20.6	20.6			-25.1*	25.1
16.	-19.4	-9.4	-14.4	14.4			-24.4*	24.4
17.	-21.9	-17.8	-19.9	19.9			-21.3*	21.3
18.	-21.2	-14.7	-18.0	18.0			-16.3*	16.3
19.	-22.0	-7.8	-14.9	14.9			-14.1*	14.1
20.	-16.9	-3.5	-10.2	10.2			-11.1*	11.1
21.	-2.8	2.6	-0.1	0.1			-12.2*	12.2
22.	-11.6	-1.1	-6.4	6.4			-18.4*	18.4
23.	-16.0	-5.0	-10.5	10.5			-19.0*	19.0
24.	-21.8	-8.5	-15.2	15.2			-12.6*	12.6
25.	-17.7	-12.1	-14.9	14.9			-11.6*	11.6
26.	-18.3	-11.8	-15.1	15.1			-12.7*	12.7
27.	-16.1	-7.6	-11.9	11.9			-16.3*	16.3
28.	-10.6	4.2	-3.2	3.2			-24.1*	24.1
29.	-2.1	5.0	1.5	0			-25.8*	25.8
30.	-5.3	0.9	-2.2	2.2			-28.8*	28.8
31.							-20.4*	20.4
Mean Monthly Air Temp.			-11.7				-15.1	
Monthly Total				352.1				469.2
Average Historical Monthly Total				376				627
Accumulated				557.8				1027.0
Average Historical Accumulated				585				1212

* Estimated values from linear correlation with Watana Weather Station.
** Freezing Degree-Days

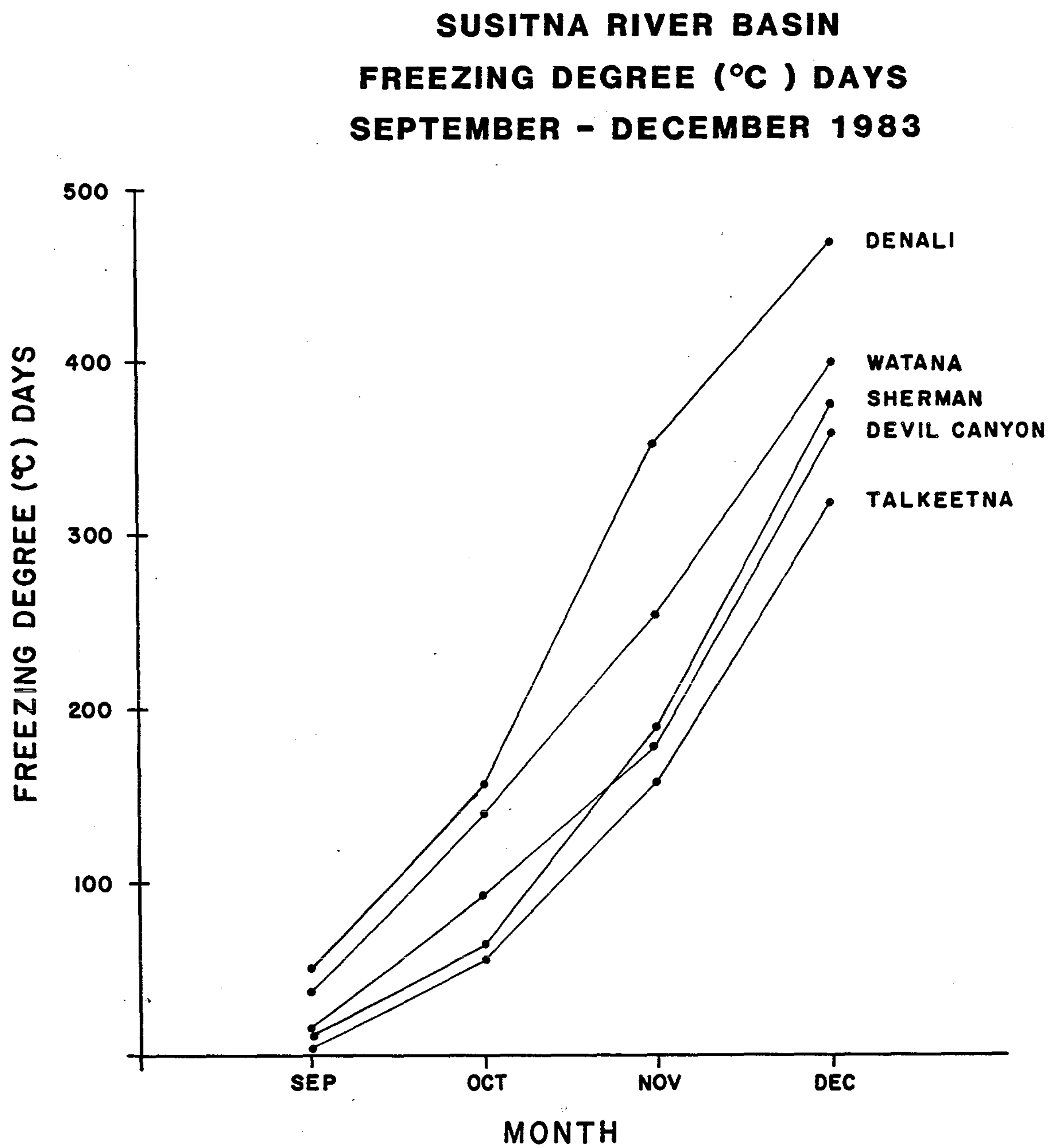


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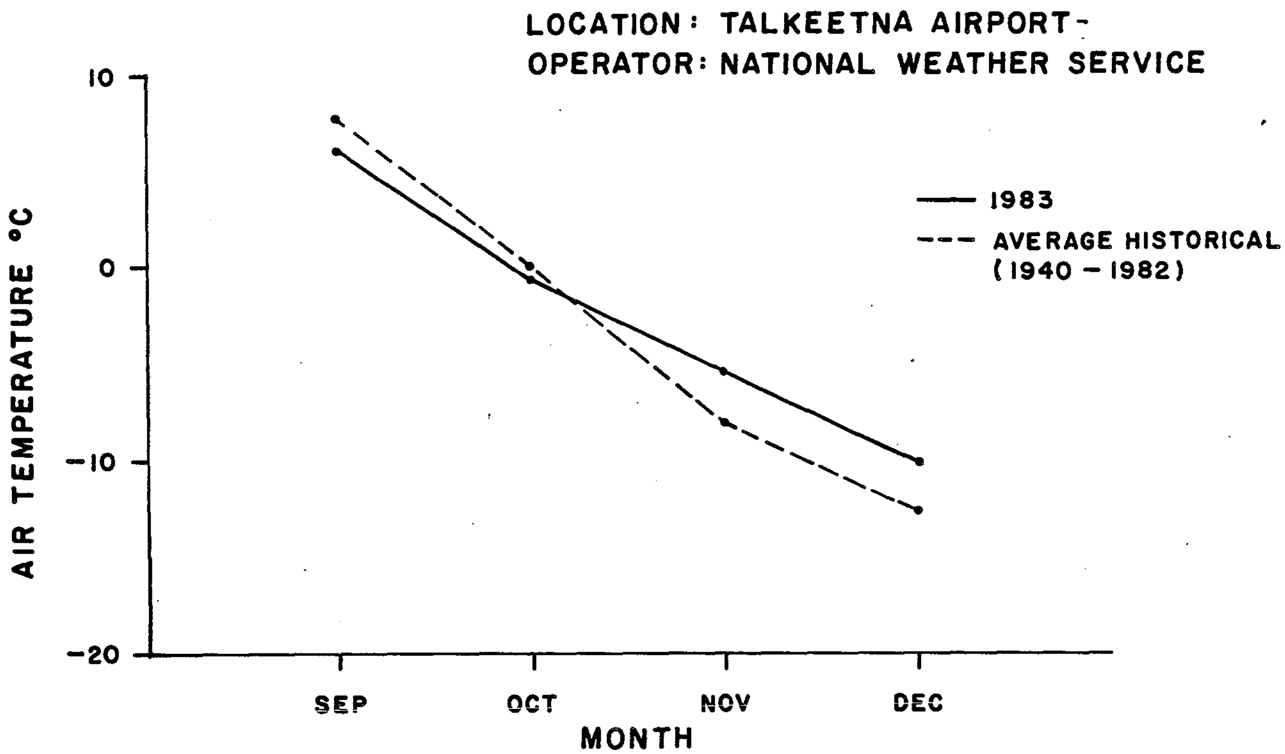
FIGURE 5.1

HARZA-EBASCO
SUSITNA JOINT VENTURE

SUSITNA RIVER BASIN
MEAN MONTHLY AIR TEMPERATURES
1983 and HISTORICAL



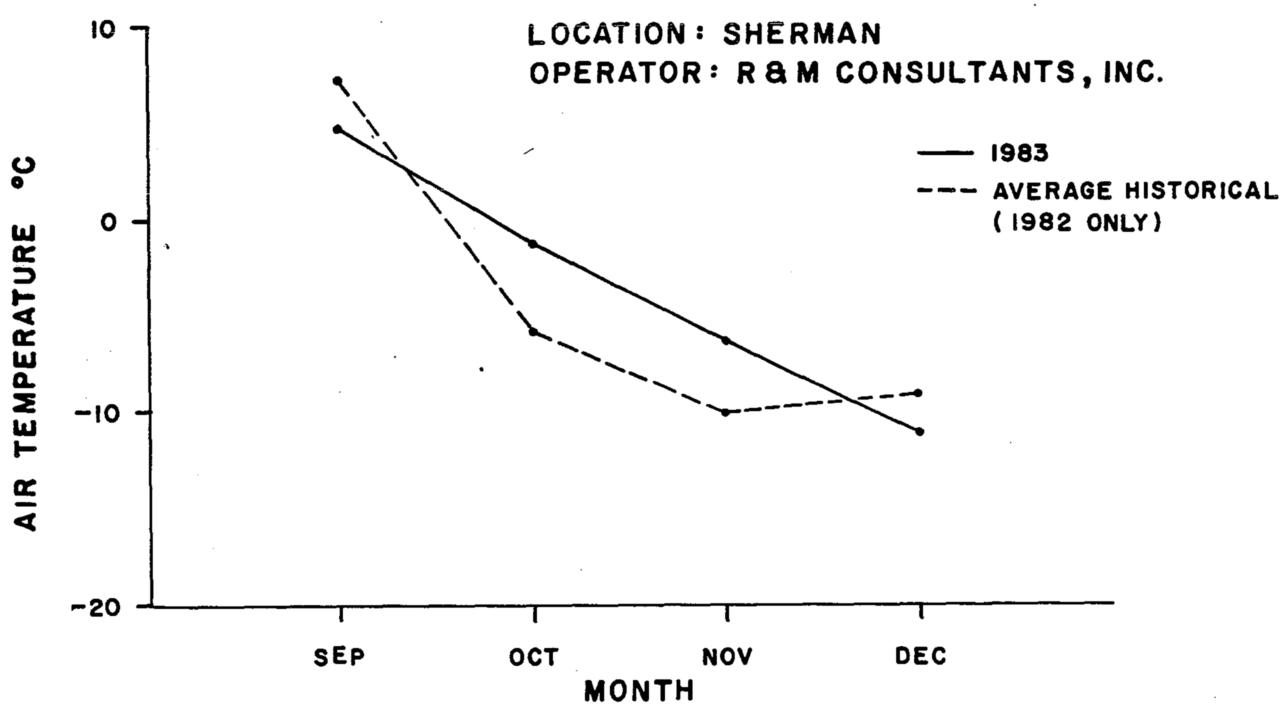
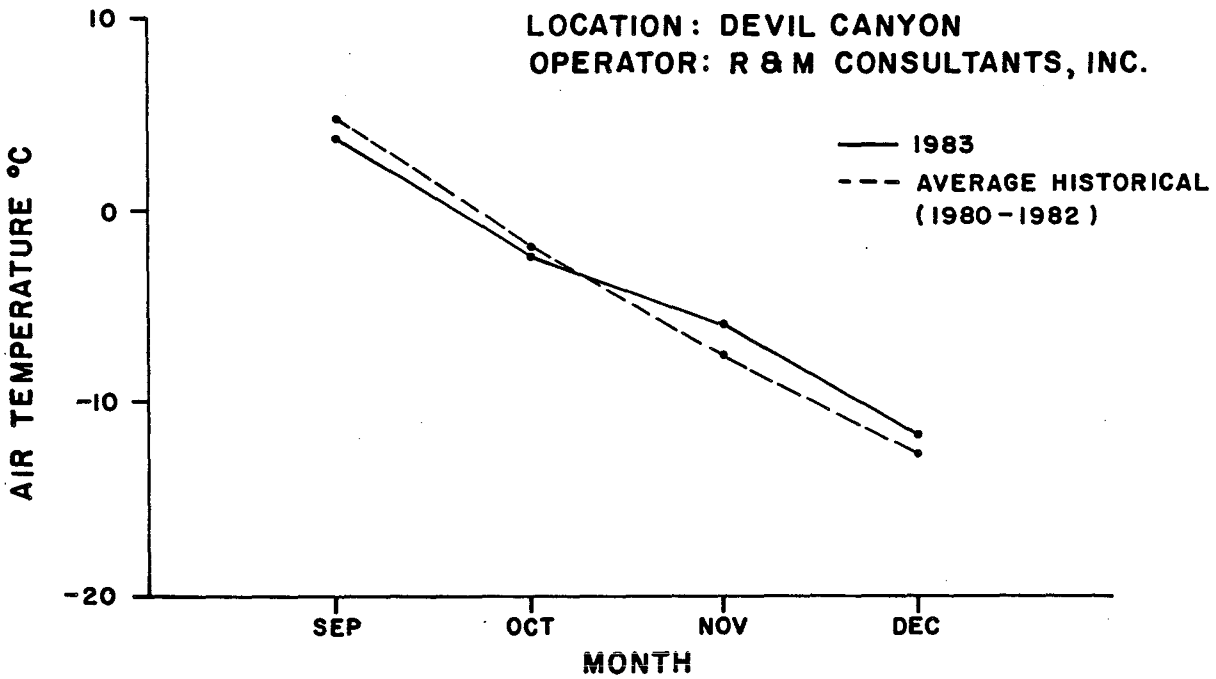
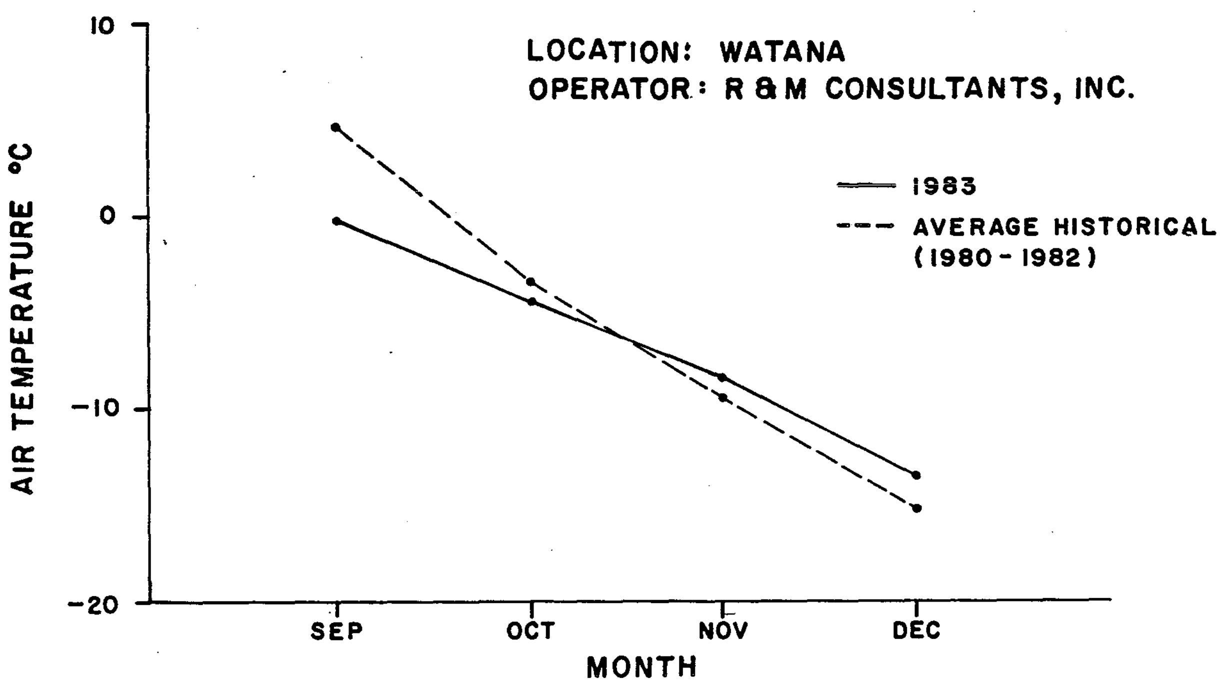


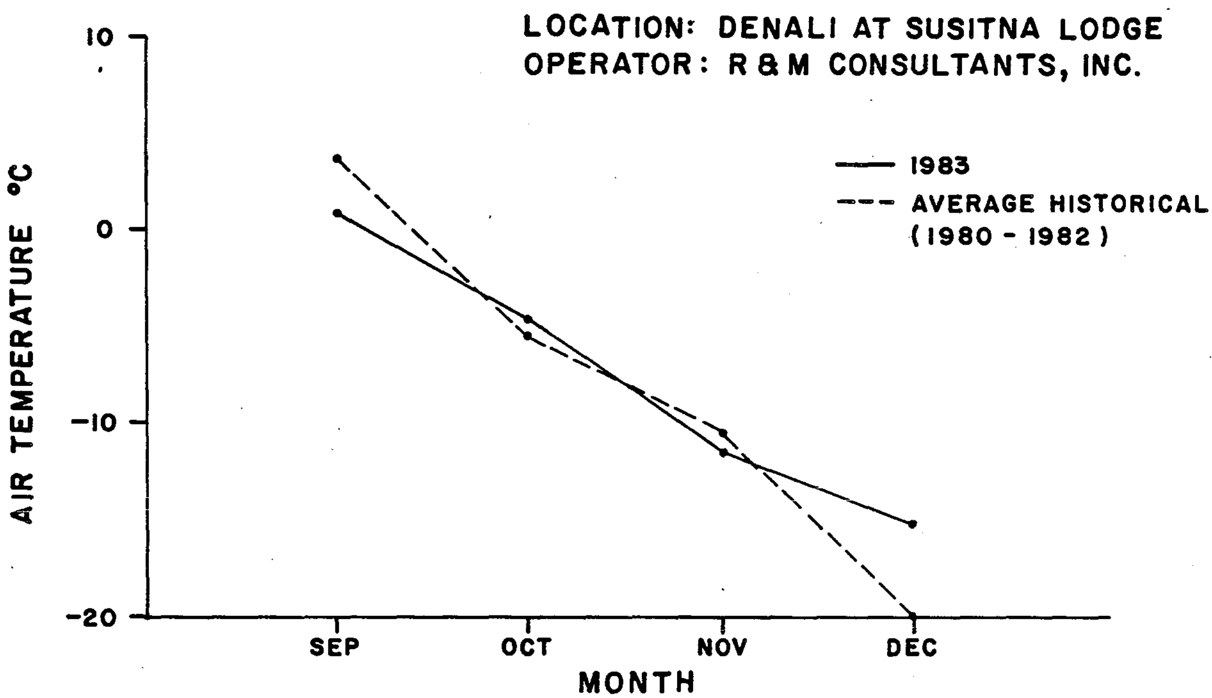
FIGURE 5.2

SUSITNA RIVER BASIN
MEAN MONTHLY AIR TEMPERATURES
1983 and HISTORICAL





SUSITNA RIVER BASIN
MEAN MONTHLY AIR TEMPERATURES
1983 and HISTORICAL



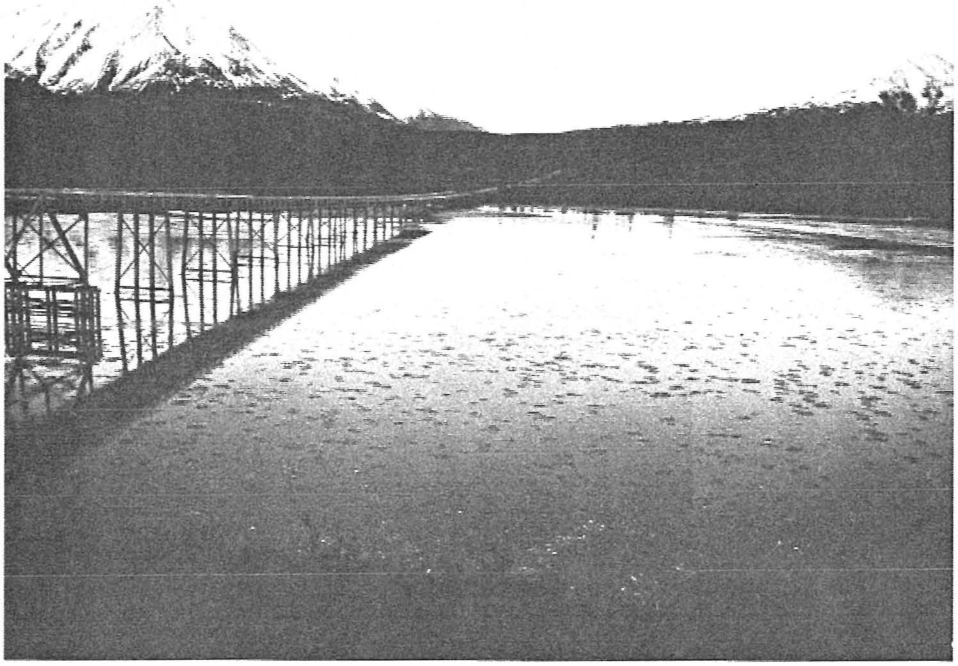


FIGURE 5.3
October 5, 1983. Slush ice usually begins flowing at the Denali Highway bridge and upper river area in September. Because of the initial long southern exposure this ice usually melts before entering the middle river. Flow is left to right.

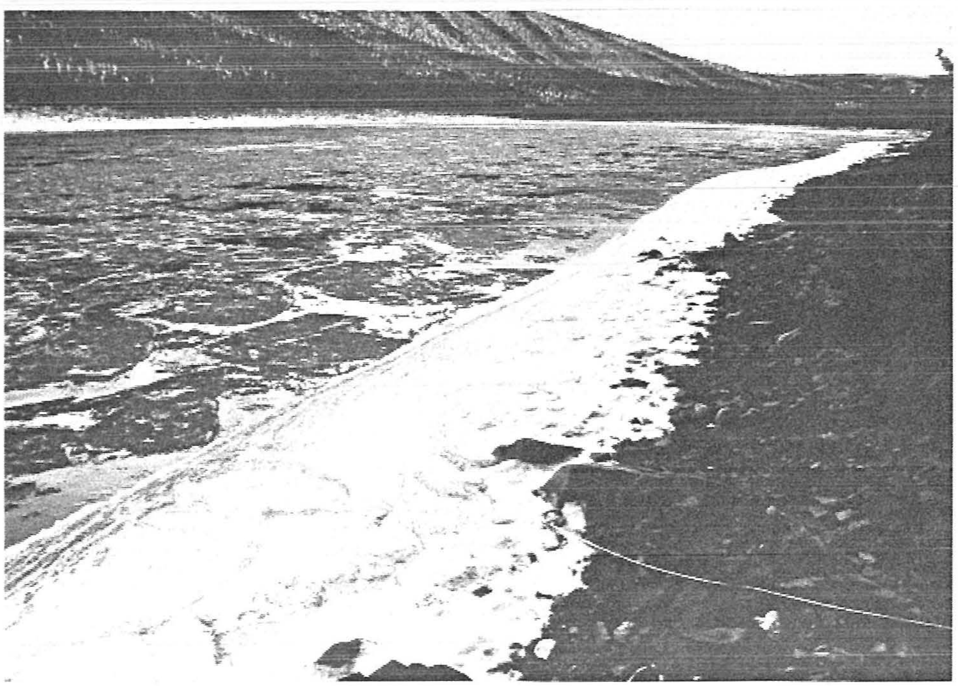


FIGURE 5.4
October 17, 1983. Low air temperatures and minimal solar radiation influence the water surface in the upper river canyons. These factors together with high turbulence generates large volumes of frazil slush in October. This is near the mouth of Jay Creek, looking downstream.

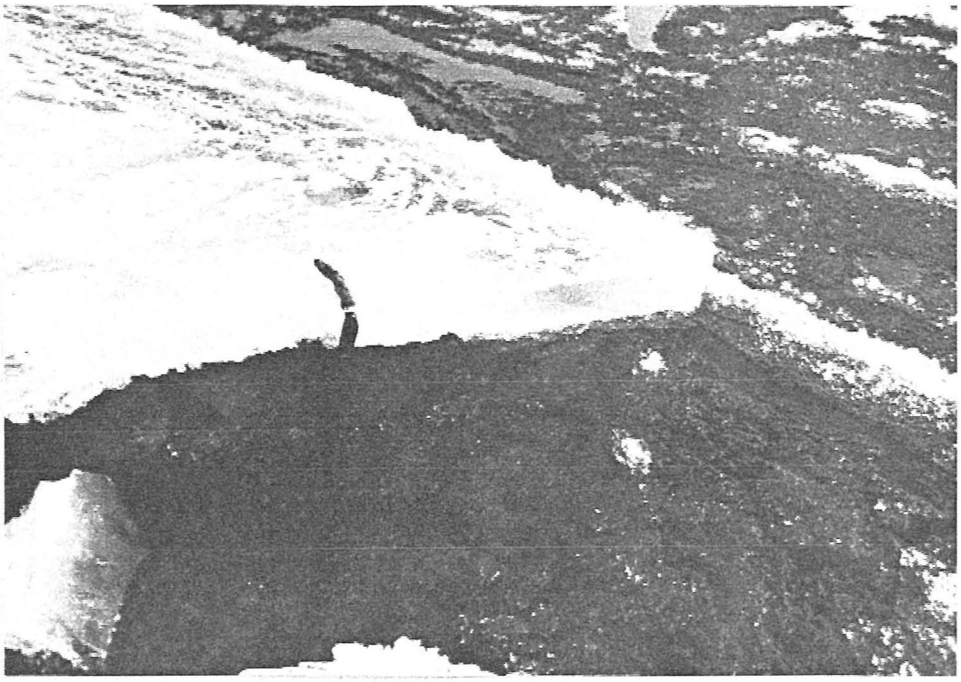


FIGURE 5.5
October 17, 1983. Slush ice that drifts into low velocity areas such as flow margins and eddies freezes into border ice. Note penknife for scale. Border ice was broken and removed. The void immediately filled with slush ice, as can be seen, and a shear zone developed at the contact with flowing slush. Flow is left to right.

6.0 LOWER RIVER ICE REGIME

6.1 Freeze-up

On the morning of October 26, 1983 an ice bridge formed at RM 9. This initiated a continuous ice cover progression upstream. Large volumes of frazil ice had not been carried into the lower Susitna prior to October 23 as mean daily air temperatures at Talkeetna remained relatively warm. The majority of the frazil ice generated between Watana and Denali probably melted enroute to the lower basin (Figure 6.1). On October 17, slush ice flowed through the middle and lower river depositing along flow margins where it quickly froze into border ice (Figure 6.2). Side channels that were beginning to dewater also collected slush ice when the rafts grounded in the shallows (Figure 6.3). From October 23 until October 26 slush ice floes were estimated to cover 60% of the open water surface area on the Yentna River and about 40% on the Susitna. This interval was marked by Talkeetna minimum daily air temperatures less than or equal to 0°C, which was sufficiently cold to maintain high ice concentrations down to RM 9.

Below the Yentna River confluence the Susitna water velocity decreases as the channel gradient drops from about 3 ft/mi to 1.5 ft/mi. This was evident on October 25 by constantly increasing ice floe concentrations on the water surface (Figure 6.4). The estimated concentration below the Yentna confluence increased from 60-70% areal coverage at Susitna Station to 90% at RM 15 and 100% at RM 9 (Figure 6.5).

The tidal fluctuations in Cook Inlet have a significant influence on the water velocity and stage. The principal factor that governs when the moving ice cover stops to form an ice bridge may be a high tide cycle. Tidal fluctuations in Cook Inlet are often over 25 feet. A high tide can cause a backwater effect to extend at least 13 miles upstream. This backwater effect alters normal stream flow by elevating the water level and reducing velocity. Quantification of the effect of tides on velocity and ice movement may be required for future attempts to forecast a lower river freeze-up schedule.

A critical force acting on the moving ice cover is friction against the banks or border ice along the bank. The frictional shear between the bank and slush ice floes decreases the ice velocity by exceeding the shear force exerted by the flowing water. When these counteracting forces are equal then the slush ice movement stops (Figure 6.6). The meander at RM 9 forces the ice floes to contact the outside bank. At a high tide the resulting backwater further reduces the water velocity and with high ice concentrations and cold air temperatures bridging is likely to occur. Cold air temperatures are necessary to quickly freeze the ice in place. Upstream ice cover progression by accumulating ice floes can begin as soon as the slush ice velocity slows (Figure 6.7). The higher upstream velocity of incoming slush causes a greater volume of slush to accumulate against the upstream edge than can be expelled from the downstream end. Therefore, with a low channel gradient and slow water velocity the ice cover "advances" upstream by juxtaposing. This process refers to ice accumulating on the water surface simply by contact with other floes. Juxtaposing continues until higher water velocities are encountered and ice floes contacting a fixed cover are crushed or become entrained and swept under the leading edge (Figure 6.8).

Ice displaces water according to Archimedes principle. A fixed ice cover also imparts a frictional resistance to flowing water. Together these two processes cause an increase in water level (Figure 6.9 and 6.10). The increase in water level, called staging, is required to slow water velocities to such a point that ice floes are not swept beneath the leading edge of the ice cover. The maximum staging in segment 5 was about 2-3 feet with ice thickness averaging 3 feet in 1983. This ice thickness refers to the total of solid surface ice (frozen slush) and the underlying loose slush. Air temperature controls the thickness of the solid ice fraction simply by continually freezing additional slush ice. If the underlying slush ice is removed by erosion then growth of the solid surface ice layer slows significantly.

The first 19 miles of segment 5 has lower water velocities than the reach near Susitna Station at RM 23. The velocities in the upper reach prevented ice cover progression by simple juxtaposition and mechanical thickening, or compression, of the cover occurred for approximately the last five miles up to RM 27. This process of thickening has been observed to occur after the slush ice cover is in place. The frictional shear between high velocity water and the fixed ice creates an unstable condition, which can cause a portion of the ice cover to shift. This sudden movement upsets the stability of adjacent ice and in seconds the entire local cover is moving downstream and consolidating. A chain reaction of this type has been observed to affect over 2,000 feet of ice cover. Compression of unconsolidated slush ice during this move causes the total thickness to increase. The ice cover may also be shoved laterally, creating parallel ridges along the banks as the slush contacts the channel bottom. Several of the ice compression phases were timed to last more than 8 minutes, which brought the leading edge downstream about one-half mile and increased the stage about one foot.

Aerial observations noted that the Yentna River often contributed about 50-60% of the total estimated ice volume below the confluence in 1983. On November 1, the ice front had passed the confluence and split, one leading edge going up the Susitna River and another going up the Yentna River. One day later the ice front on the Yentna was 7 miles upstream while the leading edge on the Susitna was 3 miles above the confluence (Table 6.2 and Figure 6.11). The faster progression rate on the Yentna River was due to its morphological characteristics. The Yenta is generally narrower, shallower and has fewer channels compared to the Susitna in Segment 4. The slower water velocities also permitted less ice thicknesses and therefore less ice volume to develop a stable cover.

Prior to the freeze-up of segment 5, Alexander Slough had dewatered when decreasing mainstem flows dropped below the critical level to overtop the entrance. This side channel was dry from approximately September 17 until October 27 (Figure 6.12). On October 27 the leading edge was located at RM 15, just 4 miles downstream from the side channel entrance. The staging effect by the ice cover was sufficient to flood the channel (Figure 6.13). The flowing water removed much of the snow in the side channel but also inundated the snow cover along the flow margins (Figure 6.14). This quickly froze solid, producing a stranded ice cover over the banks. The flowing open water in Alexander Slough required more than four additional weeks to freeze, primarily because the stage had not increased enough over the entrance to allow passage of slush ice. The slush ice rafts were approximately 2-3 feet thick. Unless the stage increased by that value above the bottom elevation of the channel entrance the floes could not drift into the side channel. The estimated depth of water over the channel entrance at maximum stage was about 1 foot so the ice rafts merely grounded a short distance from the main channel. No slush ice cover progression was, therefore, observed in Alexander Slough but rather a gradual closure of the open water by laterally growing border ice.

On November 1, 1983 the leading edge was at RM 31.5 having progressed more than 16 miles in five days. By November 4 the ice front had passed the confluence of the Deshka River at RM 40.5. The maximum stage increase measured at the entrance to Kroto Slough (RM 40.1) was 3.9 feet (Table 6.1). This was sufficient to overtop the slough with a flow depth of 1.5 feet at the entrance but no ice floes could enter due to thicknesses of about 2 feet. The elevated mainstem stage also affected the Deshka River by creating a backwater zone which extended about 2 miles upstream. The surface water velocities on the Deshka were reduced enough to allow Susitna ice floes to be pushed up the Deshka for about 100 feet. Slush ice drifting down the Deshka river encountered this barrier to flow and an upstream advance by accumulating ice was initiated. The Deshka has low water velocities and the slush ice advanced by juxtaposing, quickly freezing into an ice cover. This developing cover was not tracked further than 2 miles.

On November 5 the ice cover progression entered segment 3 (Delta Islands). The leading edge split, and ice fronts advanced separately up the east and west channels. The east channel ice cover progressed more slowly, possibly due to the influence of Little Willow Creek and Willow Creek, which may have diluted the ice concentration. At RM 50 on the east channel the combined flows from these tributaries enter the Susitna via a short side channel. The advancing ice cover caused stage increases high enough to inundate the snow cover over the Willow Creek gravel fan (Figure 6.15). This saturated snow then froze into an ice cover; however, the water course from Willow Creek was not altered. The measured stage increased about 3 feet during the ice front advance. Slush ice from the Susitna did not encroach on the creek confluence. The stage increase measured at the entrance of a side channel near RM 48 on the west channel was about 2.5 feet. This channel was flooded but no slush ice entered. The Susitna ice cover progressed through the Delta Islands and converged near RM 51, then continued to proceed upstream into segment 2.

Segment 2 contains more secondary channels within a broad gravel and sand floodplain than either segments 4 or 5. The primary or main channel is relatively shallow at freeze-up and when the water level rises a wide area is generally flooded. The ice floes remain contained within the main channel, since water depth is not sufficient to float them laterally out of the thalweg. As the ice cover proceeded through Segment 2 in 1983 a large portion of the flood plain was inundated. The saturated snow eventually froze solid, creating an ice cover but without the hummocked appearance of the main channel slush ice cover.

Most of the side channel complexes through segment 2 were flooded during ice cover progression. Existing ice over isolated pools was immediately broken up and washed down the side channel when the staged mainstem overtopped the channel entrances. Mainstem slush ice was observed to accompany the surge through the side channel at RM 60. The slush ice and ice debris occasionally accumulated in small jams a short distance below the side channel entrances but usually were carried back out to the mainstem.. A maximum mainstem stage increase of 3 feet was measured near the mouth of Kashwitna River (RM 60) on November 11 (Figure 6.16 and 6.17).

On November 9 the leading edge was at RM 66, but the new ice cover remained unstable due to warm air temperatures that prevented the slush from freezing. This was apparent by the quickly deteriorating ice cover below the leading edge. An open lead had formed from RM 62 to RM 65.

The leading edge continued to advance at an average rate of 2 miles per day even though the channel gradient gradually increases beyond RM 66 and more ice was required to produce a sufficiently stable cover. The effects of mainstem staging were not evident to a significant degree at the mouths of either Sheep Creek or Goose Creek. Sheep Creek drains into a side channel that extends from RM 62 to RM 67 (Figure 6.18). Through this reach the mainstem is along the west bank and since the side channel complex is on the east bank, it was therefore not affected by backwater or overtopping. Goose Creek enters a side channel that runs from RM 69 to RM 72 (Figure 6.20). This side channel was also not flooded or affected by backwater when the mainstem water level staged (Figure 6.21). The stage at these tributary mouths did increase slightly due to another phenomenon related to mainstem stage. The approximate 0.4 foot increase in water level in the pool below the Goose Creek mouth (Figure 6.25) was possibly due to a general increase in the local ground water table which may be associated with staging on the mainstem. This is similar to water level fluctuations in ground water wells adjacent to the mainstem at Slough 9 during freeze-up (Figure 6.22). This increase at Goose Creek and Sheep Creek occurred concurrently with the ice cover advance on the mainstem opposite these tributaries.

The mouth of Montana Creek (Figure 6.23) was significantly influenced by the staging process. The existing channel had steadily degraded since the mainstem water level receded. The absence of an extensive backwater area resulted in higher tributary velocities at the mouth and subsequently more downcutting than during high mainstem flows. Montana Creek had therefore become entrenched in the alluvial fan. Heavy anchor ice deposits had accumulated on the substrate and a large ice dam had developed about 200 yards above the confluence by November 10. When the ice front approached RM 73, 2 miles downstream of the confluence, the mainstem stage adjacent to Montana Creek increased by 1 foot and created a backwater zone that flooded the tributary channel and ice dam. A maximum stage increase of 7.1 feet was measured on November 18, and most of the confluence area was inundated (Figure 6.24). The snow cover was flooded and subsequently formed ice. An additional 2 feet of staging would have been required to completely overtop the alluvial fan. The backwater zone extended upstream beyond the Parks Highway bridge and was evident by fractured border ice and flooded snow at Montana Creek Lodge.

Ice thicknesses were measured adjacent to the Montana Creek confluence (RM 77) in late January (Table 6.3). The total thickness averaged 6.8 feet with a minimum of 1.3 feet and a maximum of 7.0 feet. The channel gradient is relatively steep in this area and the ice cover remained unstable. After the initial progression through this reach, an open lead appeared from RM 71 to RM 85. This lead eventually began to freeze over when entrained frazil ice floated and accumulated at the lower end and along the sides. This secondary progression stalled near RM 81 in February 1984 and open water remained up to RM 85 for the entire winter.

The initial ice cover advance near the Parks Highway Bridge characterized the progression process through this reach. The ice front reached RM 82.5 on November 18. By late afternoon on November 19 the leading edge was stalled at RM 84.5. The water velocity of 3.5 ft/sec caused all incoming ice to be subducted under the leading edge. Finally the mass of upstream ice and friction against flowing water upset this configuration and the cover compressed, simultaneously shoving the ice laterally and consolidating the slush downstream (Figure 6.25). The compression lasted about five minutes. Afterwards the leading edge was located at RM 84 and the stage at the USGS gage at Sunshine had risen 1 foot. The increased stage reduced the water velocity at the ice front to 2.3 ft/sec and ice floes were once again accumulating against the leading edge. This sequence was repeated at least four times at RM 84 with a total stage increase of 6.5 feet.

On November 19 the stage was rising at entrances to Sunshine Slough (Figure 6.26). The slough and side channels were eventually overtopped and flooded. Again, no slush ice entered this system due to an insufficient depth at the entrance. These channels subsequently required an additional 8-12 weeks to freeze over and many leads were noted in this area all winter.

The unusually warm air temperatures at the end of November resulted in an unstable ice cover. This instability occurred because the saturated slush was not freezing quickly enough to strengthen the ice cover. As described earlier, the shearing forces imparted by the flowing water often cause a complete collapse of the cover and carry away much of the ice. This condition prevented the ice cover from advancing beyond RM 95 for ten days. On November 26 the leading edge was observed at RM 95.5 but on November 28 this cover had collapsed down to RM 92.5 and remained there until December 6. Rapid upstream advances of the ice cover generally occur only with consistently cold air temperatures, which not only generate frazil ice but also stabilizes the existing ice cover.

The side channels leading to the entrance of Birch Creek Slough were flooded but the stage did not increase enough to overtop the slough entrance. The maximum increase was 3.1 feet near the entrance to Birch Creek Slough. An additional foot would have been necessary for overtopping (Figures 6.27 and 6.28).

The temporary arrival of the leading edge at RM 95.5 initiated a separate ice progression up the Talkeetna River. This progression on the Talkeetna was so late, however, that the majority of the river had already frozen over with anchor ice and border ice, significantly reducing the volume of frazil being generated. By mid-December the ice cover had reached a position about 300 yards upstream of the railroad bridge and essentially remained there for the rest of the winter.

By December 9 the Susitna River ice front had advanced upstream into the middle reach above Talkeetna. The ice cover on the lower river remained unstable and was marked by many extensive open water areas, either in mainstem leads or in flooded side channels. The Chulitna River, like the Talkeetna, had frozen over by lateral ice growth at the headwaters and was by this time generating so little ice that no upstream accumulation occurred. The confluence area of the Chulitna did not freeze over until late March, 1984, due to anchor ice and lateral growth of surface ice.

Trapper Creek was not affected by Susitna mainstem freeze-up. The water level in the mainstem controls the location of the confluence. At prefreeze-up stages Trapper Creek did not merge with the Susitna until RM 90. No slush ice floes drifted up this creek and flow remained unrestricted by ice. With the exception of some backwater, Birch Creek and Sunshine Creek were also unaffected by the ice advance (Figure 6.29 and 6.30). The flow in Rabideux Creek was low (discharge estimated less than 10 cfs) and the staging reached 7 feet over the open water level (Figure 6.31). This caused the mouth to flood and the backwater extended a considerable distance upstream. Slush ice floes did enter the backwater area mostly because the confluence is on the outside of the mainstem bend. The momentum of the floes traveling down the mainstem propelled the floes into Rabideux Creek. When the stage receded the floes were stranded in the confluence area (Figure 6.32). These ice blocks were strewn about randomly and did not restrict flow from the creek.

Most of the side channels below Talkeetna were flooded to some extent, often only saturating the snow cover (Figure 6.33). Several side channels, such as Sunshine Slough and Kroto Slough, remained flooded all winter. The maximum staging levels seem to be temporary and water levels along the entire lower river receded once the leading edge had moved upstream several miles. This may be due to ice cover erosion or seepage of water into the underlying gravels. Staging only effects mainstem water levels, creating a hydrostatic imbalance between surface water and groundwater. The sands and gravels of the lower river are extremely permeable. High surface waters gradually seep into the sand until an equilibrium water level is reached. This is evident by increasing water levels in side channel ponds and decreasing water levels in the mainstem for several days after an ice cover has formed (Figure 6.34).

A reduction in mainstem stage may cause the ice cover to sag and eventually collapse (Figure 6.35). A thinning of the ice cover by erosion has also been measured over high velocity cells along a cross section. Ice thickness measurements along the banks usually reveal thicknesses representative of the original ice cover at the time of progression. Thin covers have been located over fast flowing water either at mid-channel or along either bank. This is indicative of areas where water velocity (friction) is high enough to mechanically or thermally erode the underside of the ice cover. Figure 6.36 illustrates the general freeze-up sequence for the lower Susitna River.

6.2 Breakup

The 1984 lower river breakup was not marked by any unusual or dramatic events. The processes observed in the spring of 1983 were essentially repeated. There seems to be no definite starting date for breakup or, in fact, any well defined interval between freeze-up and breakup.

As previously described, open water leads developed immediately in some areas where water velocities were high enough to erode the underside of the ice (Figure 6.37). Slush ice thicknesses of 4 to 5 feet were generally required during the initial progression to adequately stabilize the ice cover. The top surface of this layer quickly froze solid, being in contact with the air. This layer gradually thickened, as a function of freezing degree-days. Solid ice thicknesses by the end of January averaged 2 feet. The remaining slush ice layer under the solid fraction is subjected to mechanical or thermal erosion imparted by the contacting flow. The slush ice is generally loosely packed and when in contact with velocities exceeding approximately 2 ft/sec simply washes away. The contact surface between flowing water and solid ice may also melt from heat generated by friction. This appears to be a slower process, however, than the mechanical erosion, which has been observed to remove an ice cover within hours after the initial formation. The following river reaches seem to be particularly susceptible to open lead development, where an ice cover cannot remain stable for any period of time unless cold air temperatures override all other influences:

Below RM 9 (tidal influence)
RM 62 to RM 66
RM 70.5 to RM 74
RM 78 to RM 86
RM 93 to RM 95
RM 96.5 to RM 98.5

The reach from RM 96.5 to RM 98.5 opened within 24 hours after ice cover progression from November 27 to December 8, 1983 to a width of about 100 feet at LRX-3 (RM 98.5). The open water surface area gradually diminished through the winter but was not observed to close in 1984. Reach 5 also opened shortly after the initial cover developed in mid-November 1983. A secondary accumulation progressed upstream though the lead but never achieved a complete closure. The remaining reaches eventually froze over by late January 1984 (Figure 6.38). An ice cover that forms over open leads, by nature will be less thick that the initial cover. For this reason these areas will be the first to open up again with warmer air temperatures. This is the pattern observed on the lower river over the past three years. By early April 1984 the reaches listed above were again ice free over a portion of the cross section.

The first indications of "breakup" on the lower river are the increased flows from the tributaries. Increased solar radiation and air temperatures melt the snow and deteriorates the ice. Ice on the tributaries is rapidly removed from the lower elevations, with open water at the mouths being the general condition by mid-April 1984. The major streams such as the Talkeetna River, Montana Creek, Willow Creek and Deshka River erode the Susitna mainstem ice cover for a considerable distance downstream from the confluence. The distance varies at each tributary and is dependent on tributary flow volume, velocity and mainstem ice conditions. All the open leads,

whether at tributary mouths or at high velocity reaches, constantly enlarged as the ice gradually melted in 1984.
Increased flows are not reflected by dramatic increases in stage on the lower river as they are on the middle river (Figure 6.46). Therefore, a more gradual breakup of the ice cover takes place on the lower river without the fracturing and subsequent buildup of ice fragments into jams, which is characteristic on the river above Talkeetna (R&M 1983). A majority of the ice cover is initially stranded on the channel banks. Even when it appears that the river is open, as evidenced by the water in long continuous open leads, the ice on the banks remains until water levels increase enough to provide bouyancy and carry it downstream. This occurs first from the upstream portion of the lower river reach.

The 1983 freeze-up initiated with flows at the Sunshine gage of about 13,000 cfs. The leading edge of the ice cover arrived at Talkeetna with the discharge at Sunshine approximately 5,000 cfs. The majority of the ice cover in the downstream reaches of the lower river, formed at higher stages, is subsequently no long floating prior to breakup. Discharge generally begins to increase in late March from the Sunshine base flow of about 3,000 cfs. The corresponding stage increase consequently breaks up the ice cover over the upper reaches of the lower river first, since this ice developed at lower freeze-up flows. If the ice is still structurally competent during the discharge increase then large ice sheets will break free from the shorefast ice. These remain intact and drift downstream until they contact solid ice or become lodged across the channel. In the latter case a new barrier is created, which may cause ice debris to accumulate into an ice jam. This was observed at RM 79 in 1984. This ice jam remained on the surface and no significant backwater occurred. The ice floes causing the blockage weakened after three days and dislodged. All the accumulated ice debris rushed downstream about 1 mile before contacting a solid ice cover. Here a new ice jam formed, which also remained on the surface with no substantial increase in stage.

Historically, ice jams have been documented between RM 77 and RM 96 but rarely do they cause much flooding since the broad flood plain adjacent to the ice choked channel has a large flow capacity.

The lower river is usually ice free by May 6. At this time the middle river usually has several very large ice jams and the upper river ice may still be intact. When the upper river ice finally disintegrates and moves downstream, it takes out the remaining middle river jams and the ice moves unrestricted through the lower river.

TABLE 6.1

RELATIVE STAGE LEVELS OF
SELECTED TRIBUTARIES ON THE
LOWER SUSITNA RIVER DURING FREEZE-UP 1983*

Date	Leading Edge Location River Mile	Alexander Slough ft	Yentna River ft	Deshka River ft	Delta Islands ft	Willow Creek ft
10/21	-	0.0	0.0		0.0	
10/27	15.0	1.0				
11/1	31.5	2.5	3.0	0.0	0.0	0.0
11/4	42.0			3.9		
11/7	57.0				2.5	3.1
Total Staging in feet		2.5	3.0	3.9	2.5	3.1

Date	Leading Edge Location River Mile	Kashwitna River ft	Sheep Creek ft	Goose Creek ft	Montana Creek ft	Rabideux Creek ft
11/1	31.5	0.0	0.0	0.0		
11/9	66.0				0.0	0.0
11/15	77.0	3.1	0.3	0.4	2.5	
11/16	78.5				7.0	
11/18	82.5				7.1	1.0
11/21	89.0					6.9
11/25	91.0					1.6
Total Staging in feet		3.1	0.3	0.4	7.1	6.9

Date	Leading Edge Location	Birch Slough ft	Chulitna Confluence ft
11/18	82.5	0.0	0.0
11/26	95.5	3.1	
12/22			3.7
Total Staging in feet		3.1	3.7

* Initial values arbitrarily set at zero.

TABLE 6.2

SUSITNA RIVER ICE COVER
LEADING EDGE LOCATIONS DURING
1983 FREEZE-UP

Cook Inlet = River Mile (RM) 0.0

Date		Leading Edge Location
October	26	Initial Ice Bridge at RM 9.0
	27	RM 15.0
November	1	RM 31.5
	4	RM 42.0
	7	RM 57.0
	9	RM 66.0
	15	RM 77.0
	16	RM 78.5
	17	RM 79.5
	18	RM 82.5
	19	RM 84.5
	21	RM 89.0
	25	RM 91.0
	26	RM 95.5
December	8	RM 98.5
	13	RM 108
	22	RM 116.2
		New Ice Bridge at RM 120.7
		Second Leading Edge at RM 127
	28	RM 129.5
January	5	RM 130.2
		New Ice Bridge at RM 135.7
		Third Leading Edge at RM 136.3
	27	RM 137

TABLE 6.3

SUSITNA RIVER
1984 ICE THICKNESSES
(Feet)

Location	Distance From Left Bank	Water Depth	Water Velocity	Solid Ice	Slush Ice	Total Thickness
River Mile 9.1						
(near Alexander)	360	11.4	-	2.0	0	2.0
	540	17.0	-	2.0	0	2.0
Date: January 23	740	34.0	-	1.6	0	1.6
Total Width = 840 ft.						
Average Thickness = 1.9 ft.						
River Mile 25.9						
(Susitna Station)	300	13+	-	2.0	4.0	6.0
	500	13+	-	2.5	3.5	6.0
Date: January 24	700	13+	-	2.3	3.7	6.0
Total Width = 1000 ft.						
Average Thickness = 6.0 ft.						
River Mile 37.2						
(near Deshka River)	200	13+	-	2.2	0.9	3.1
	500	13+	-	2.1	0.9	3.0
Date: January 24	600	13+	-	2.5	3.5	6.0
Total Width = 1000 ft.						
Average Thickness = 4.0 ft.						
River Mile 46.5						
(West Channel through						
Delta Islands)	200	13+	-	1.7	0	1.7*
	300	11.0	-	2.5	2.5	5.0
Date: January 24	400	10.0	-	2.5	3.5	6.0
Total Width = 600 ft.						
Average Thickness = 5.5 ft.						
River Mile 45.1						
(East Channel through						
Delta Islands)	100	10	-	2.5	0	2.5
	200	10	-	2.3	0	2.3
Date: January 24						
Total Width = 300 ft.						
Average Thickness = 2.4 ft.						

* These values were not included in the average ice thickness. Site evaluations were used to determine the probable representative ice thickness at the time of ice cover progression.

TABLE 6.3
(cont')

SUSITNA RIVER
1984 ICE THICKNESSES (Cont.)
(Feet)

Location	Distance From Left Bank	Water Depth	Water Velocity	Solid Ice	Slush Ice	Total Thickness
River Mile 61.2						
(near Kashwitna River)	200	13+	-	2.9	5.1	7.0
	400	10.0	-	2.7	5.3	8.0
Date: January 24	600	10.0	-	3.0	4.0	7.0
Total Width = 700 ft.						
Average Thickness = 7.3 ft.						
River Mile 68.5						
(near Sheep Creek)	200	13+	-	2.8	5.2	8.0
	400	13+	-	2.0	3.0	5.0
Date: January 24	600	7.0	-	1.7	5.3	7.0
Total Width = 800 ft.						
Average Thickness = 6.7 ft.						
River Mile 77.0						
(at Montana Creek)	200	7.0	-	2.0	5.0	7.0
	400	6.0	-	2.3	3.7	6.0
Date: January 24	600	13+	-	1.3	0	1.3*
Total Width = 700 ft.						
Average Thickness = 6.5 ft.						
River Mile 92.6						
(near Birch Slough)	200	13+	-	2.3	0	2.3
	400	10.0	2.5 ft/s	1.8	0	1.8
Date: January 24	600	4.4	-	2.3	0	2.3
Total Width = 700 ft.						
Average Thickness = 2.1 ft.						
River Mile 98.6						
(Chulitna Confluence)			OPEN LEAD			
	88	6.2	4.4 ft/s	1.5	4.7	6.0
Date: January 26						
Total Width = 300 ft.						
Average Thickness = 6.0 ft.						

* These values were not included in the average ice thickness. Site evaluations were used to determine the probable representative ice thickness at the time of ice cover progression.

TABLE 6.3
(cont')

SUSITNA RIVER
1984 ICE THICKNESSES (Cont.)
(Feet)

Location	Distance From Left Bank	Water Depth	Water Velocity	Solid Ice	Slush Ice	Total Thickness
River Mile 103.3						
(LRX-9)	313	9.0	-	2.0	7.0	9.0
	439	12.0	1.9 ft/s	1.5	5.0	6.5
Date: January 26	558	10.6	-	2.0	7.0	9.0
Total Width = 600 ft.						
Average Thickness 8.2 ft.						
River Mile 113.0						
(LRX-18)	238	6.6	1.6 ft/s	2.0	0	2.0*
	341	7.6	-	2.5	5.1	7.6
Date: January 26	467	6.0	-	2.3	3.5	5.8
Total Width = 500 ft.						
Average Thickness = 6.9 ft.						
River Mile 120.6						
(LRX-24)	278	12.2	-	2.8	9.4	12.2
	373	11.7	-	2.0	6.6	8.6
Date: January 26	441	8.0	2.3ft/s	1.5	0	1.5*
Total Width = 500 ft.						
Average Thickness = 10.4 ft.						
River Mile 123.4						
(LRX-27)	284	11.5	-	1.8	8.9	10.7
	368	12.2	-	1.8	8.7	10.5
Date: January 26	461	5.0	4 ft/s	2.4	0	2.4*
Total Width = 500 ft.						
Average Thickness = 10.6 ft.						
River Mile 126.2						
(LRX-29)	252	4.5	-	2.3	1.7	4.0
	381	6.5	-	1.8	4.7	6.5
Date: January 26	513	8.0	4.5 ft/s	1.8	0	1.8*
Total Width = 575 ft.						
Average Thickness = 5.3 ft.						

* These values were not included in the average ice thickness. Site evaluations were used to determine the probable representative ice thickness at the time of ice cover progression.

TABLE 6.3
(cont')

SUSITNA RIVER
1984 ICE THICKNESSES (Cont.)
(Feet)

Location	Distance From Left Bank	Water Depth	Water Velocity	Solid Ice	Slush Ice	Total Thickness
River Mile 128.5						
(near LRX-31)	369	4.8	-	1.8	0	1.8*
	469	6.6	-	1.6	3.6	5.2
Date: January 27	569	7.0	4.5 ft/s	1.0	0	1.0*
Total Width = 600 ft.						
Average Thickness = 5.2 ft.						
River Mile 136.6						
(LRX-45)	96	6.0	5 ft/s	1.1	0	1.1
	188	9.5	-	0.9	3.1	4.0
Date: January 27	287	7.1	-	1.0	0.5	1.5
Total Width = 350 ft.						
Average Thickness = 2.2 ft.						

* These values were not included in the average ice thickness. Site evaluations were used to determine the probable representative ice thickness at the time of ice cover progression.

FIGURE 6.1
October 18, 1983. The ice generated in the upper river canyon floats through the middle river reach where much of it melts. This area is exposed to more solar radiation because of the north/south river orientation and lack of topographic shading. This is the Chulitna confluence, with the Susitna on the right. Flow is left to right.

FIGURE 6.2
October 17, 1983. Border ice begins to develop on the middle river. This is near the Chulitna confluence, flow is right to left.

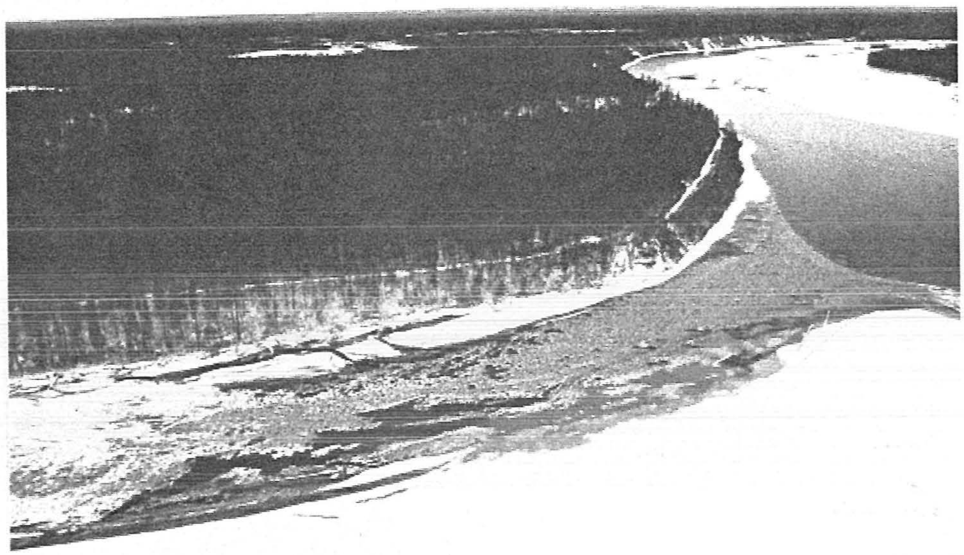
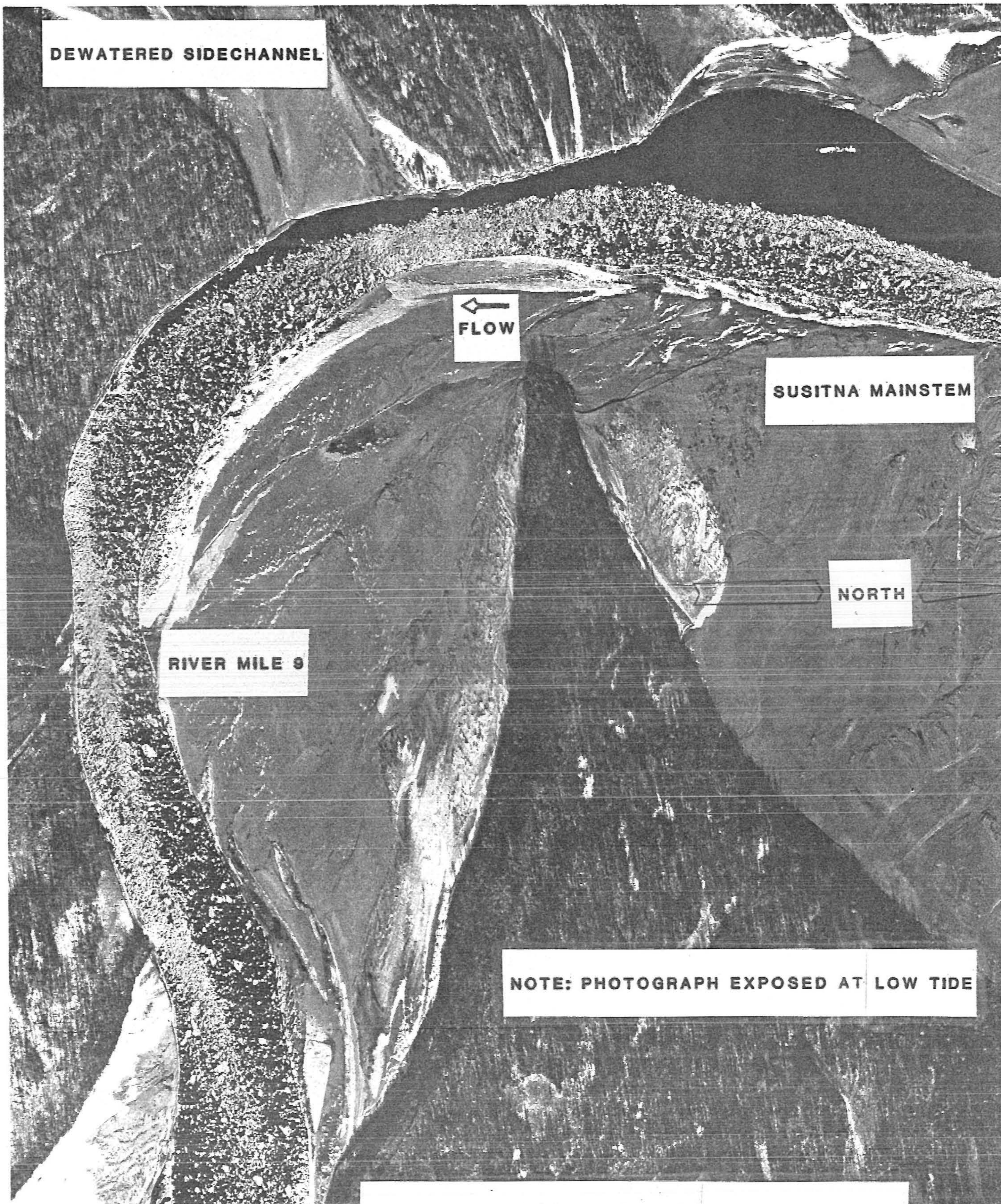


FIGURE 6.3
October 21, 1983. When the water level in the secondary channels recedes, then slush ice becomes grounded on the bottom and the channel quickly fills with ice. This photo views upstream at the entrance to a side channel near Whitefish Slough, RM 81.



SUSITNA RIVER AT RIVER MILE 9 OCTOBER 25,1983

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FIGURE 6.4

HARZA-EBASCO
SUSITNA JOINT VENTURE

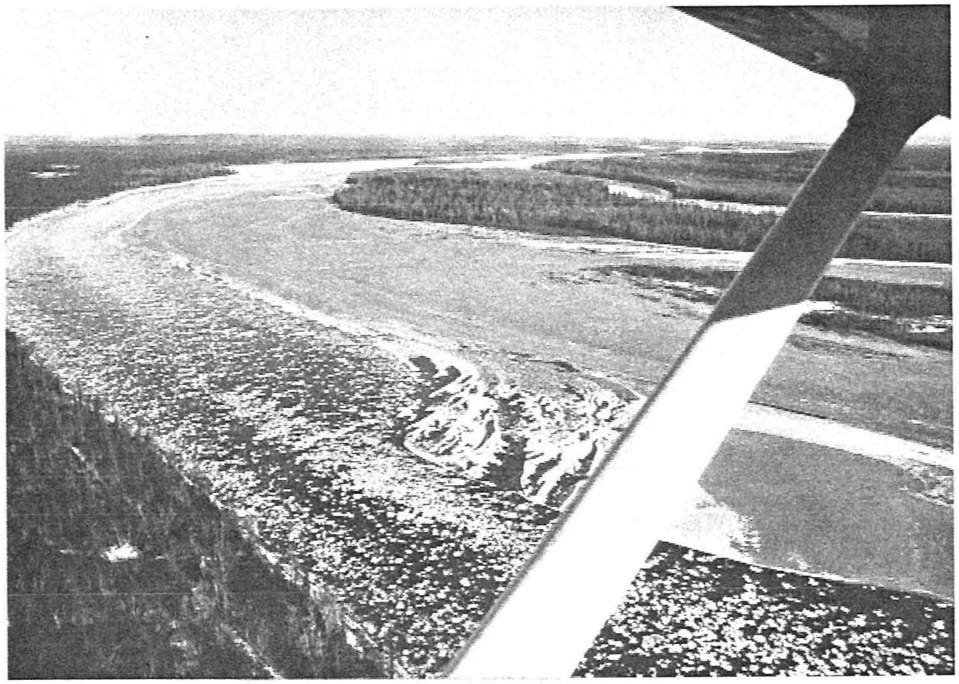

FIGURE 6.5
October 25, 1983. When high volumes of ice are generated and lower river air temperatures remain below 0°C, slush reaches the river mouth where water velocities are significantly controlled by Cook Inlet tidal fluctuations. This is looking downstream from river mile 18.

FIGURE 6.6
October 28, 1983. High tides occurred during this time in October. The slush ice velocity slowed to the point that friction along the bank and within the ice pack exceeded the friction imparted by the slow moving water, and the flowing slush stopped moving. Looking upstream at river mile 9 ice bridge.

FIGURE 6.7
October 27, 1983. When the flowing slush ice cover slows and finally stops, incoming slush rafts accumulates along the upstream "edge" of the cover. This view is looking downstream at RM 11.

JUXTAPOSING

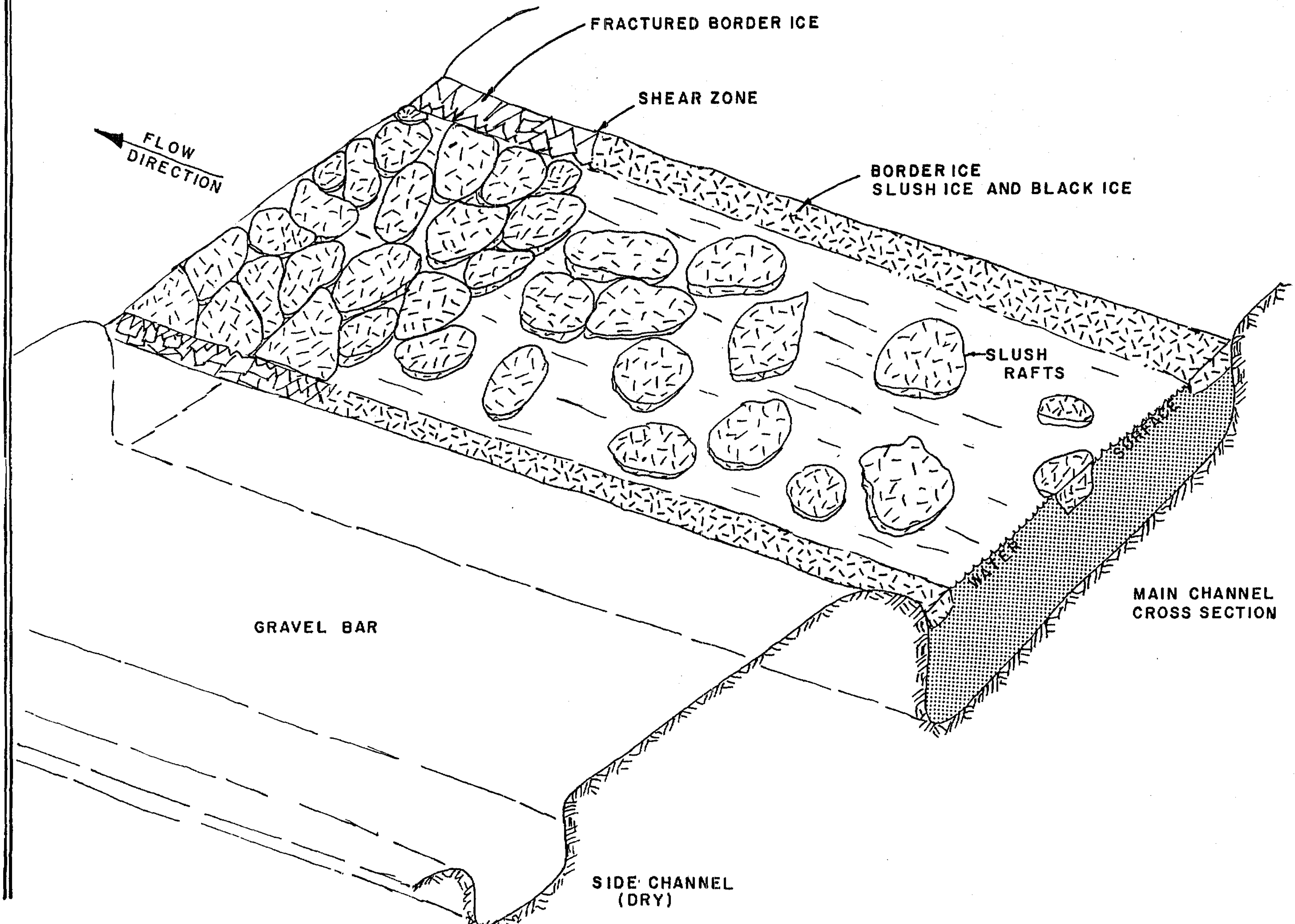

FIGURE 6.8

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HARZA-EBASCO
SUSITNA JOINT VENTURE

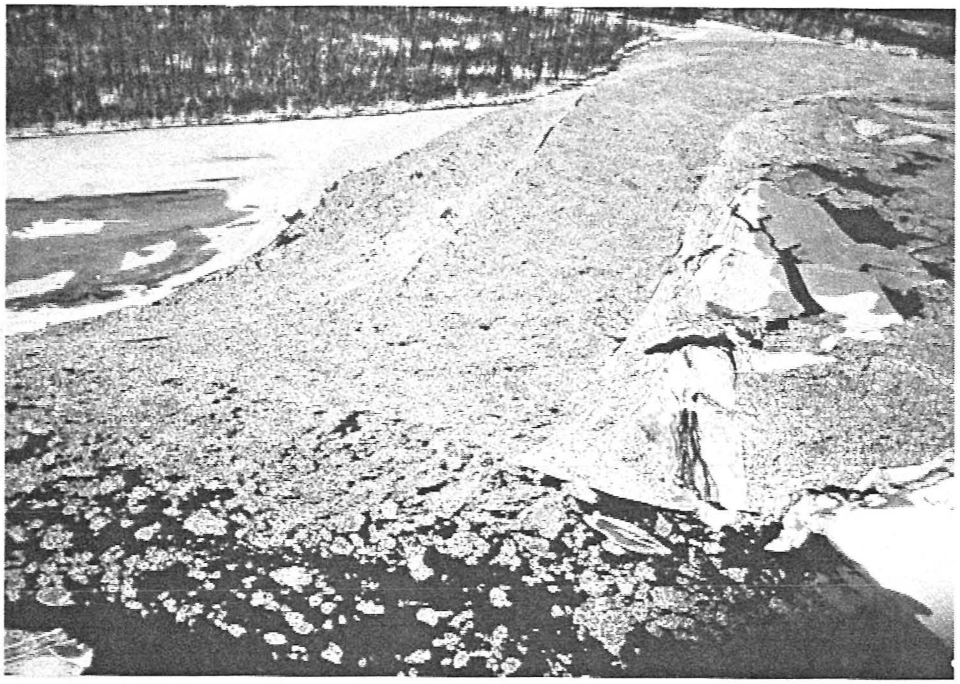
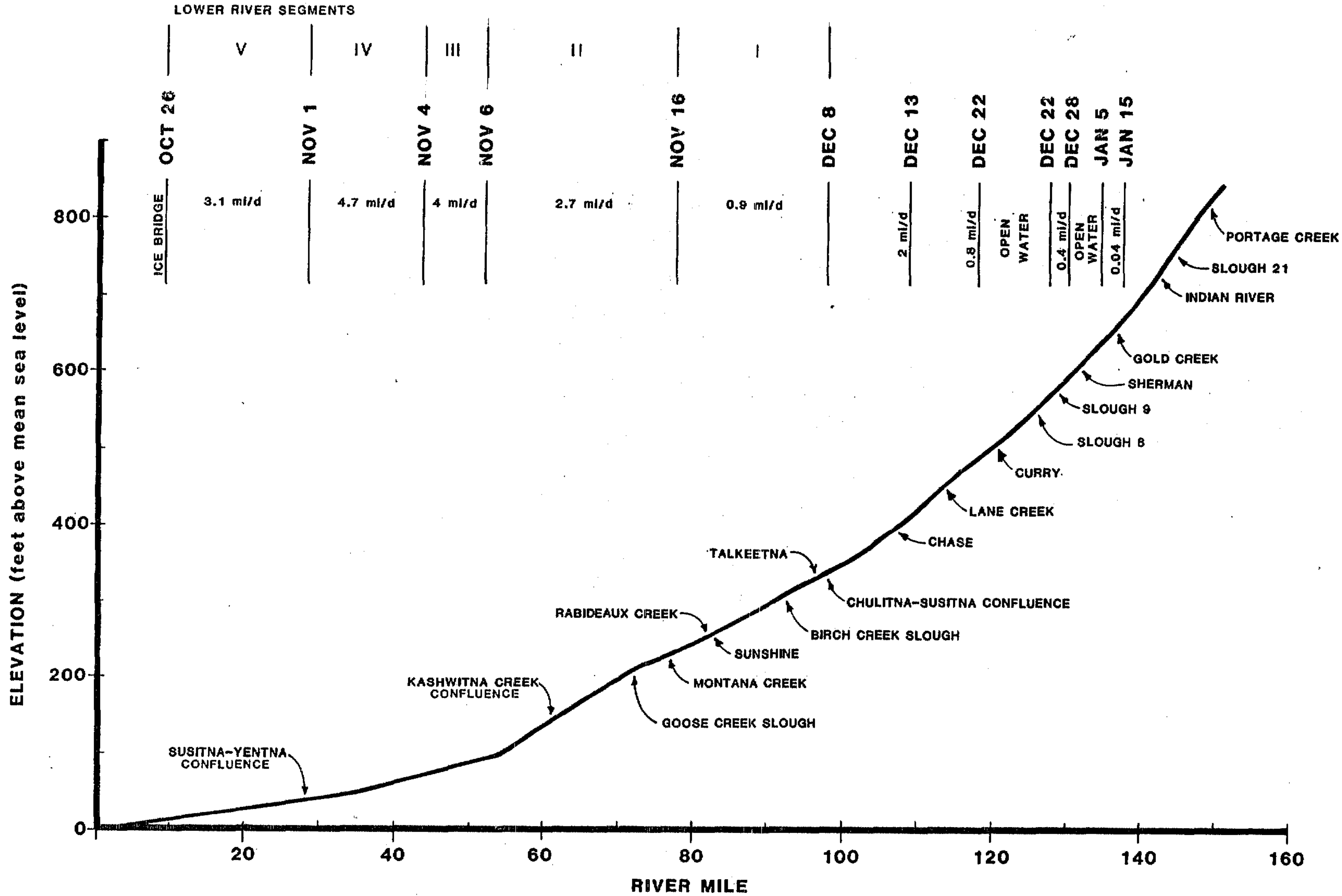


FIGURE 6.9
November 1, 1983. The ice cover lengthens or progresses upstream as slush accumulates along the "leading edge". Water level rises due to displacement by ice and resistance to flow. This is near river mile 31, flow is left to right.

FIGURE 6.10
November 1, 1983. The leading edge at RM 31. Note the increased stage indicated by the flooded snow and dark patches adjacent to the mainstem. This view looks downstream.



SUSITNA RIVER ICE LEADING EDGE PROGRESSION RATES (miles/day) RELATIVE TO THE THALWEG PROFILE FROM RIVER MILE 0 (Cook Inlet) TO RIVER MILE 155 (DEVIL CANYON)

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FIGURE 6.11

HARZA-EBASCO
SUSITNA JOINT VENTURE

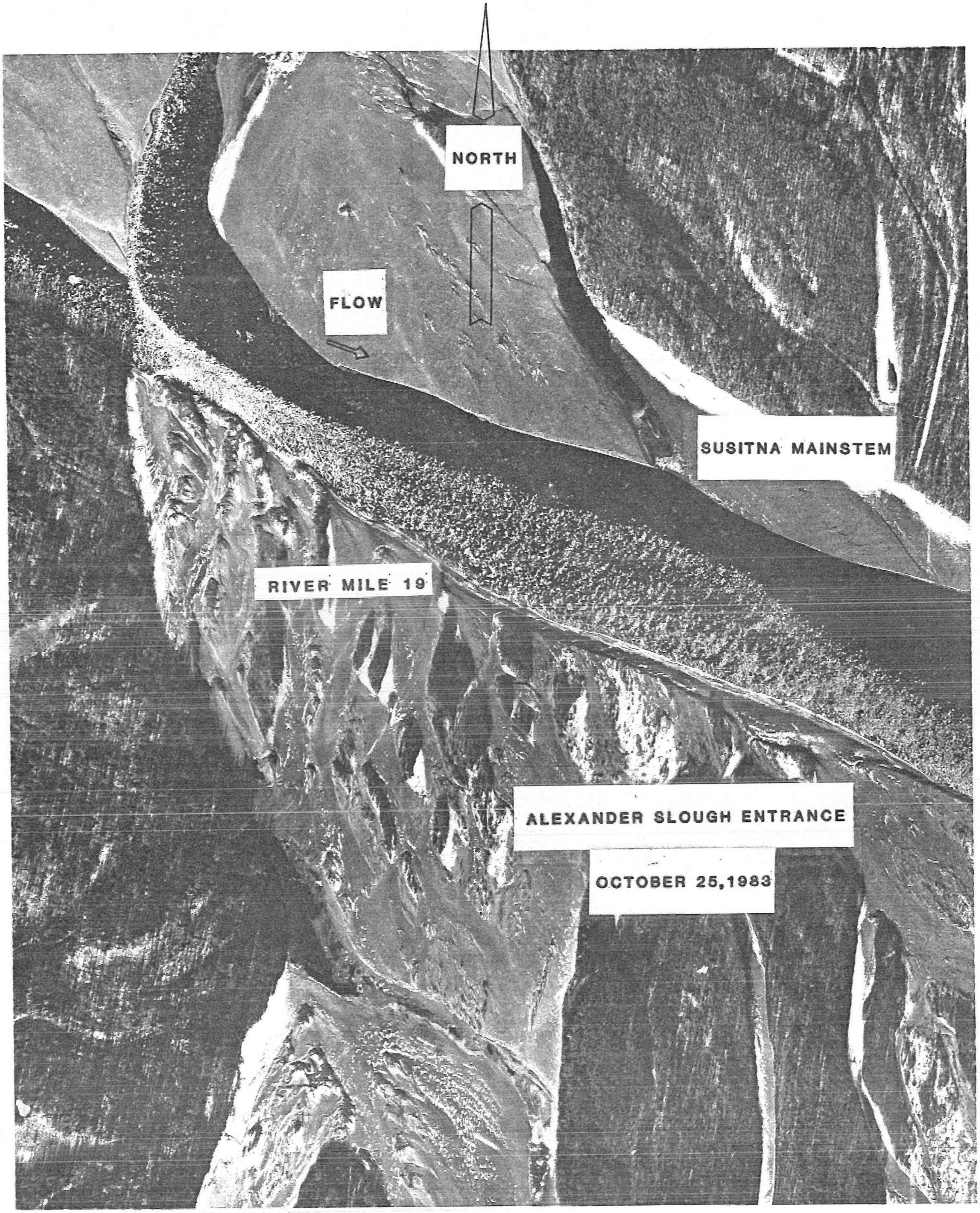

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FIGURE 6.12

HARZA-EBASCO
SUSITNA JOINT VENTURE

FIGURE 6.13
November 1, 1983. Most of the lower river side channels, such as Alexander Slough, are flooded when the main channel stages but few are deep enough to allow passage of slush rafts, which generally require two to three feet of water depth.

FIGURE 6.14
November 1, 1983. This shows a flooded side channel and the slush ice rafts restricted to the mainstem. Flooded snow is visible as a dark band along the periphery. The dark track through the flooded snow was made while walking to the ice cover.

FIGURE 6.15
November 1, 1983. Mouth of Willow Creek. Mainstem ice cover progression caused a backwater area at the confluence. Stage increased and water overtopped the alluvial fan but flow was not rerouted. Flow is right to left.

FIGURE 6.16
October 4, 1983. Mouth of Kashwitna River before freeze-up. Flow is from left to right. The Susitna mainstem is in the foreground.

FIGURE 6.17
November 1, 1983. Mouth of Kashwitna River just prior to Susitna freeze-up. Lateral access channels have dewatered. Mainstem freeze-up has little effect on Kashwitna flow. This tributary freezes over primarily by border ice growth.

FIGURE 6.18
October 4, 1983. Mouth of Sheep Creek. This creek enters a side channel, which remains flooded all winter but little slush ice enters from the mainstem. Flow is generally left to right.

FIGURE 6.19
November 1, 1983. Mouth of Sheep Creek. Mainstem freeze-up does not significantly effect this area. Water level on staff gage rose about 0.5 feet. An ice cover has started to form at the mouth by accumulating slush from Sheep Creek. View is looking downstream at confluence with the side channel.

FIGURE 6.20
October 21, 1983. Mouth of Goose Creek. A side channel from the mainstem comes in on the left. This side channel eventually dewaters and did not overtop during freeze-up in 1983. Goose Creek provided most of the flow in the channel.

FIGURE 6.21
November 1, 1983. Mouth of Goose Creek. Looking downstream at the confluence with the dewatered side channel. Water level at the staff gage rose 0.45 feet during mainstem freeze-up.

GROUNDWATER SENSITIVITY TO MAINSTEM STAGE

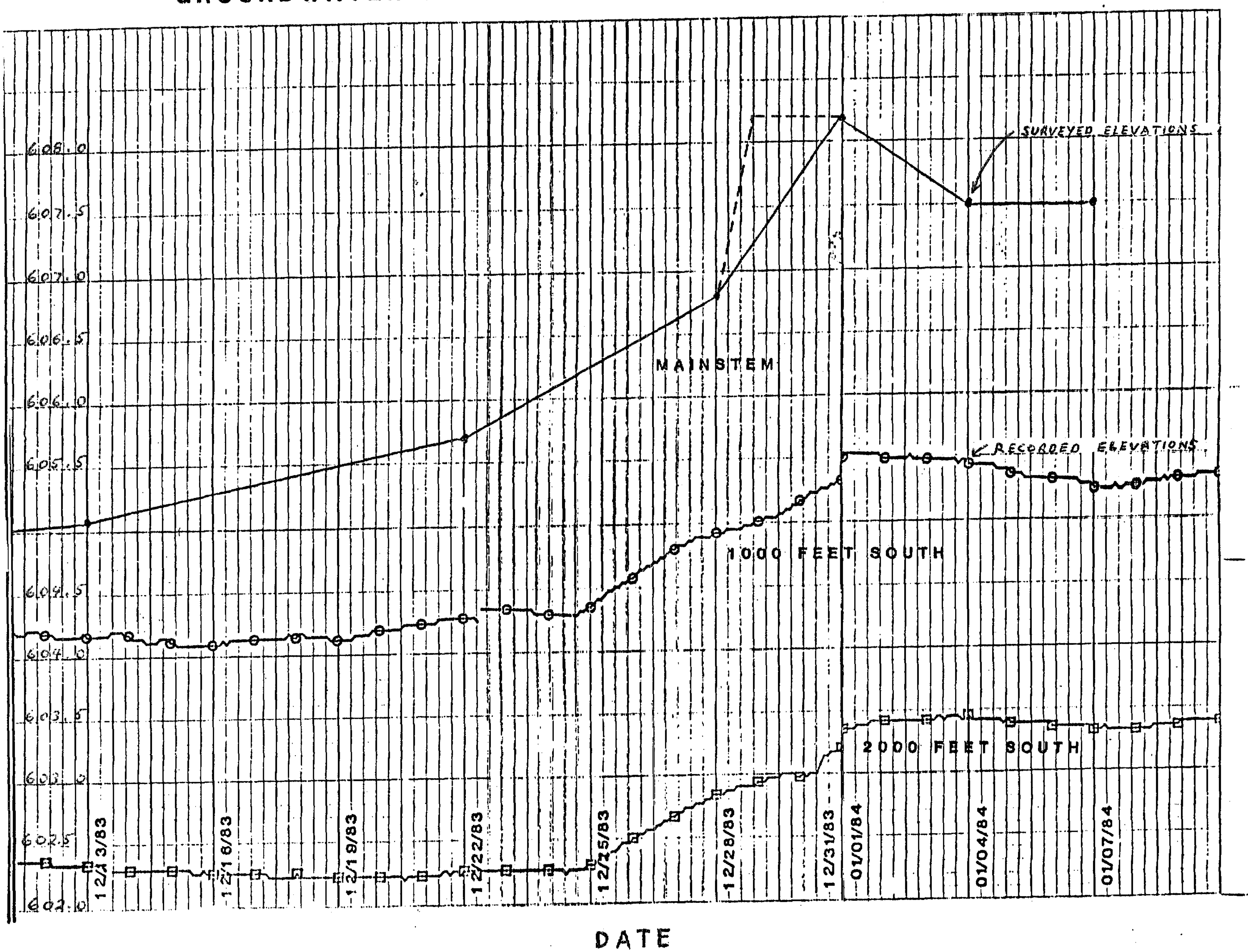

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FIGURE 6.22

HARZA-EBASCO
SUSITNA JOINT VENTURE

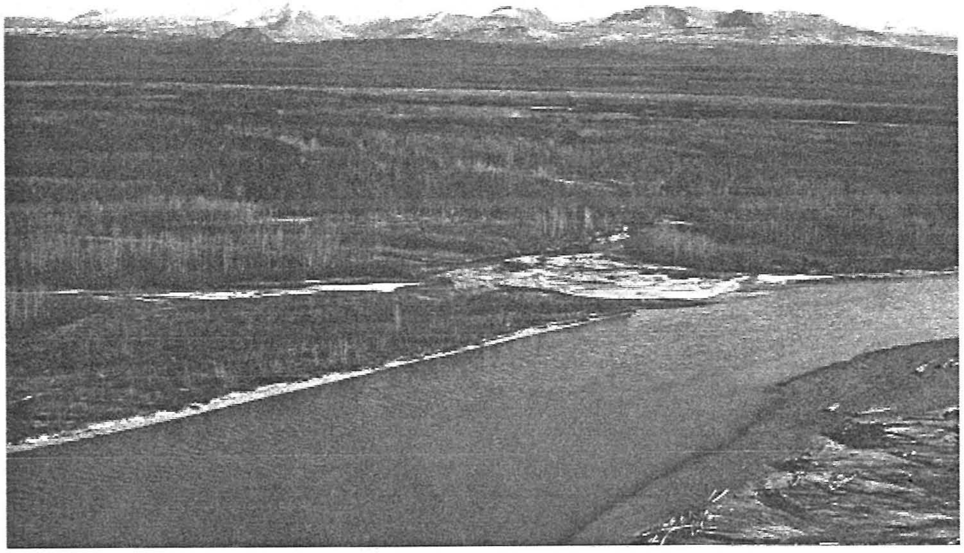

FIGURE 6.23
October 4, 1983. Mouth of Montana Creek. Flow is from left to right. This tributary flows directly into the mainstem and is significantly affected by staging during freeze-up.

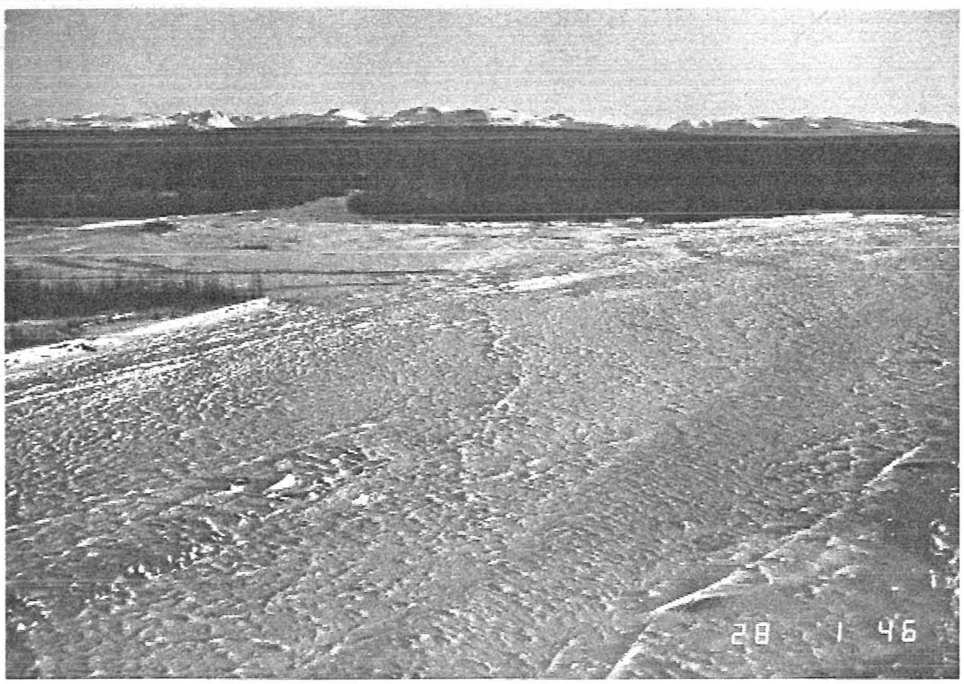

FIGURE 6.24
December 28, 1983. Mouth of Montana Creek. The water level has risen seven feet and flooded the alluvial fan. Backwater extended up Montana Creek beyond the Parks Highway bridge. Some flow was rerouted through a small channel along the left bank.

FIGURE 6.25
November 24, 1983. Parks Highway bridge at Sunshine. The increase in water level caused the border ice to fragment and be shoved onto the left bank. The ice cover has eroded away to form an open lead between the second and third piling. Flow is right to left.

FIGURE 6.26
October 21, 1983. Entrance to Sunshine side channel. This area dewaters prior to freeze-up. The ice cover causes overtopping and the side channel remains flooded for the duration of the winter. Flow is right to left.

FIGURE 6.27
September 17, 1983. Head of Birch Slough. Susitna side channel is in the foreground, and slough is dewatered. Flow is from left to right.

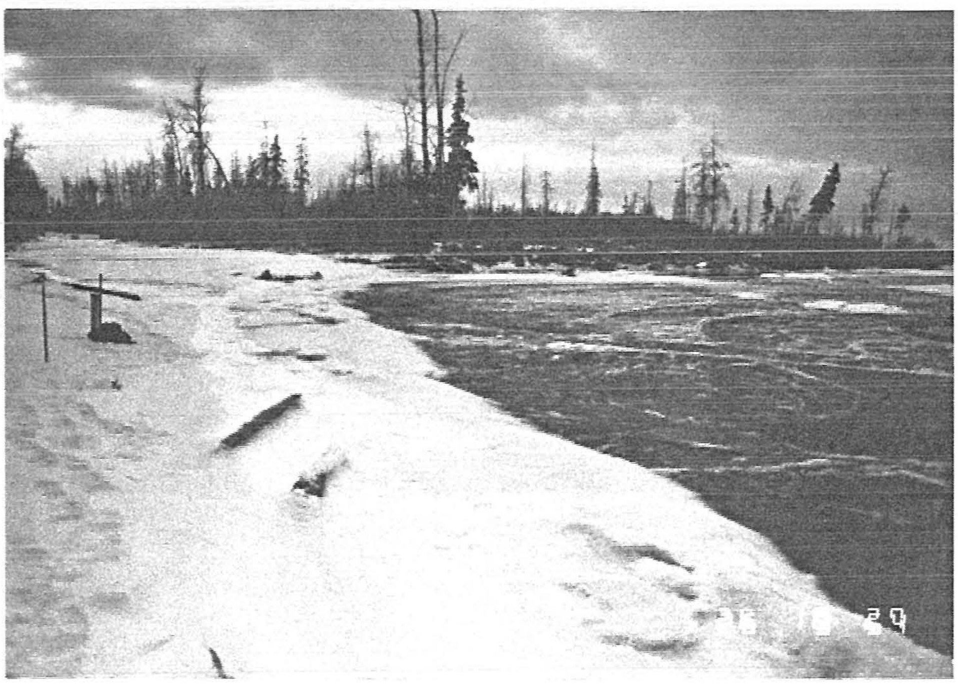

FIGURE 6.28
November 26, 1983. Head entrance to Birch Slough. Side channel is flooded and packed with slush ice but no water entered the slough.

FIGURE 6.29
September 17, 1983. Mouth of Birch Creek. Susitna mainstem is in the foreground, flow is from left to right.

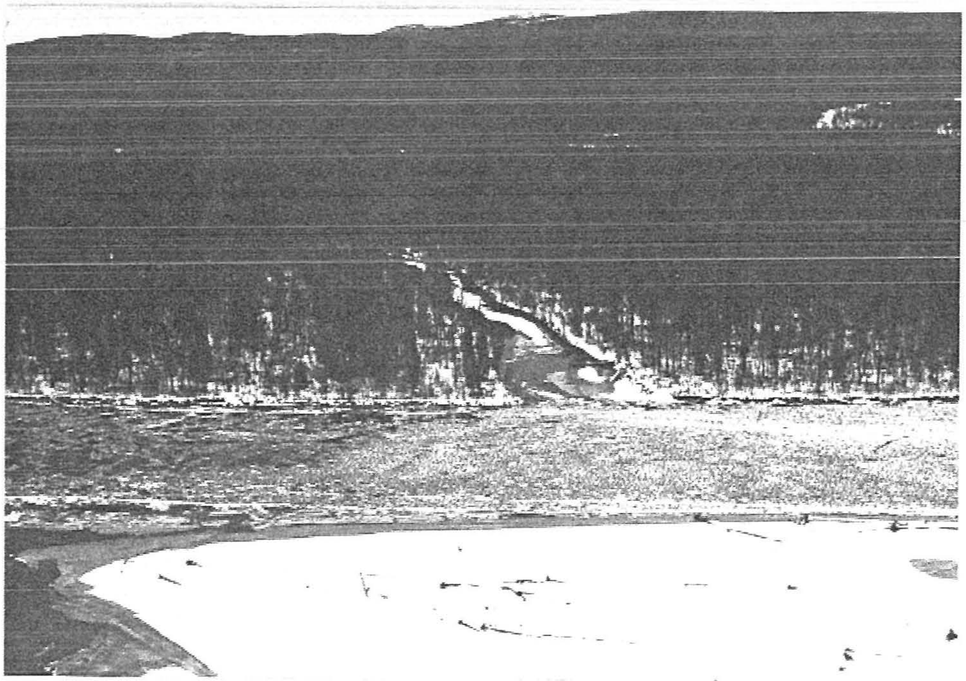

FIGURE 6.30
November 21, 1983. Mouth of Birch Creek. Leading edge is adjacent to the confluence on the mainstem. Stage has increased and flooded the creek mouth but no slush ice entered the backwater area.

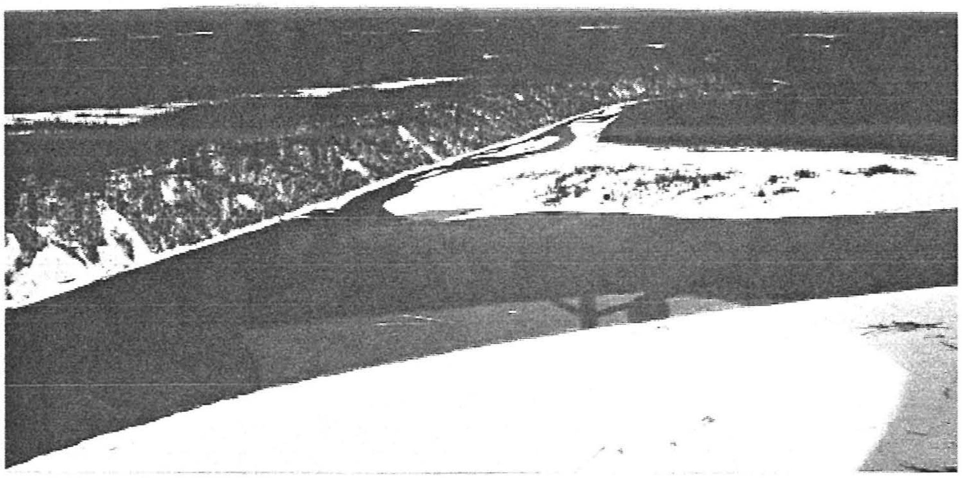

FIGURE 6.31
October 21, 1983. Mouth of Rabideux Creek. This area is influenced all year by backwater from high mainstem stages. Flow is from right to left. Flow from Rabideux Creek was not rerouted during freeze-up.

FIGURE 6.32
November 23, 1983. Mouth of Rabideux Creek. Staging caused water levels to increase over 6.5 feet. The resulting backwater was deep enough to allow slush rafts to drift into the confluence area. The water eventually receded and left the ice floes stranded.

FIGURE 6.33
November 27, 1983. Near the Talkeetna River confluence. Leading edge has started advancing again after actually receding during the previous seven days. Note flooded snow and extent of flooded area. View is looking downstream from river mile 96.

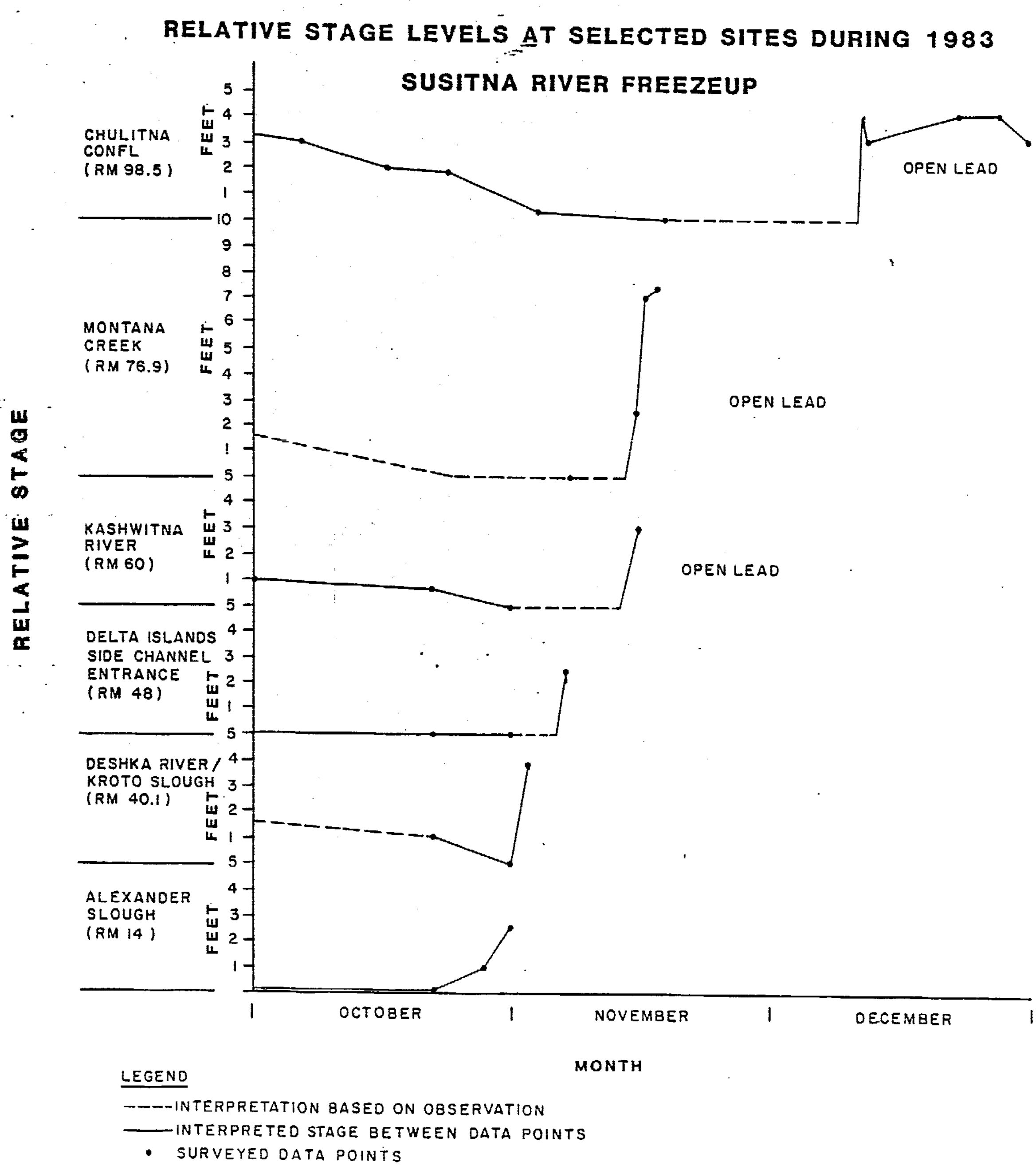
RELATIVE STAGE LEVELS AT SELECTED SITES DURING 1983
SUSITNA RIVER FREEZEUP
RELATIVE STAGE
FEET
CHULITNA CONFL (RM 98.5)
MONTANA CREEK (RM 76.9)
KASHWITNA RIVER (RM 60)
DELTA ISLANDS SIDE CHANNEL ENTRANCE (RM 48)
DESHKA RIVER/ KROTO SLOUGH (RM 40.1)
ALEXANDER SLOUGH (RM 14)
OPEN LEAD
OCTOBER
NOVEMBER
DECEMBER
MONTH
LEGEND
-----INTERPRETATION BASED ON OBSERVATION
——INTERPRETED STAGE BETWEEN DATA POINTS
• SURVEYED DATA POINTS

FIGURE 6.34

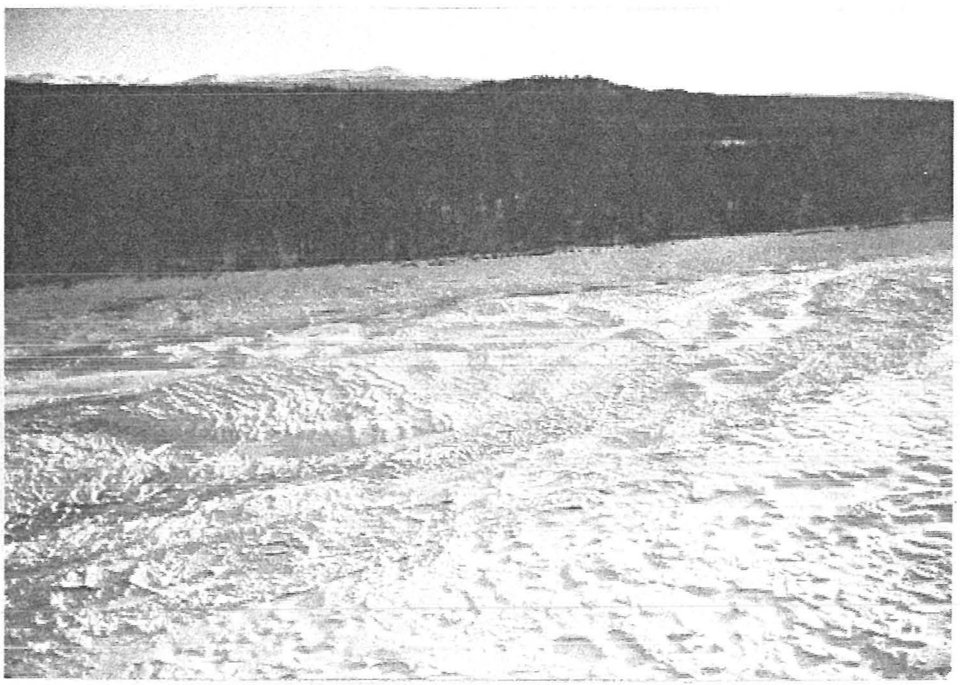

FIGURE 6.35
December 28, 1983. Near LRX-9. This ice cover is deteriorating as evidenced by the sagging cover over the flowing water. A lead will eventually open up in the sagged portion of the section. Flow is left to right.

LOWER RIVER TYPICAL CROSS SECTION

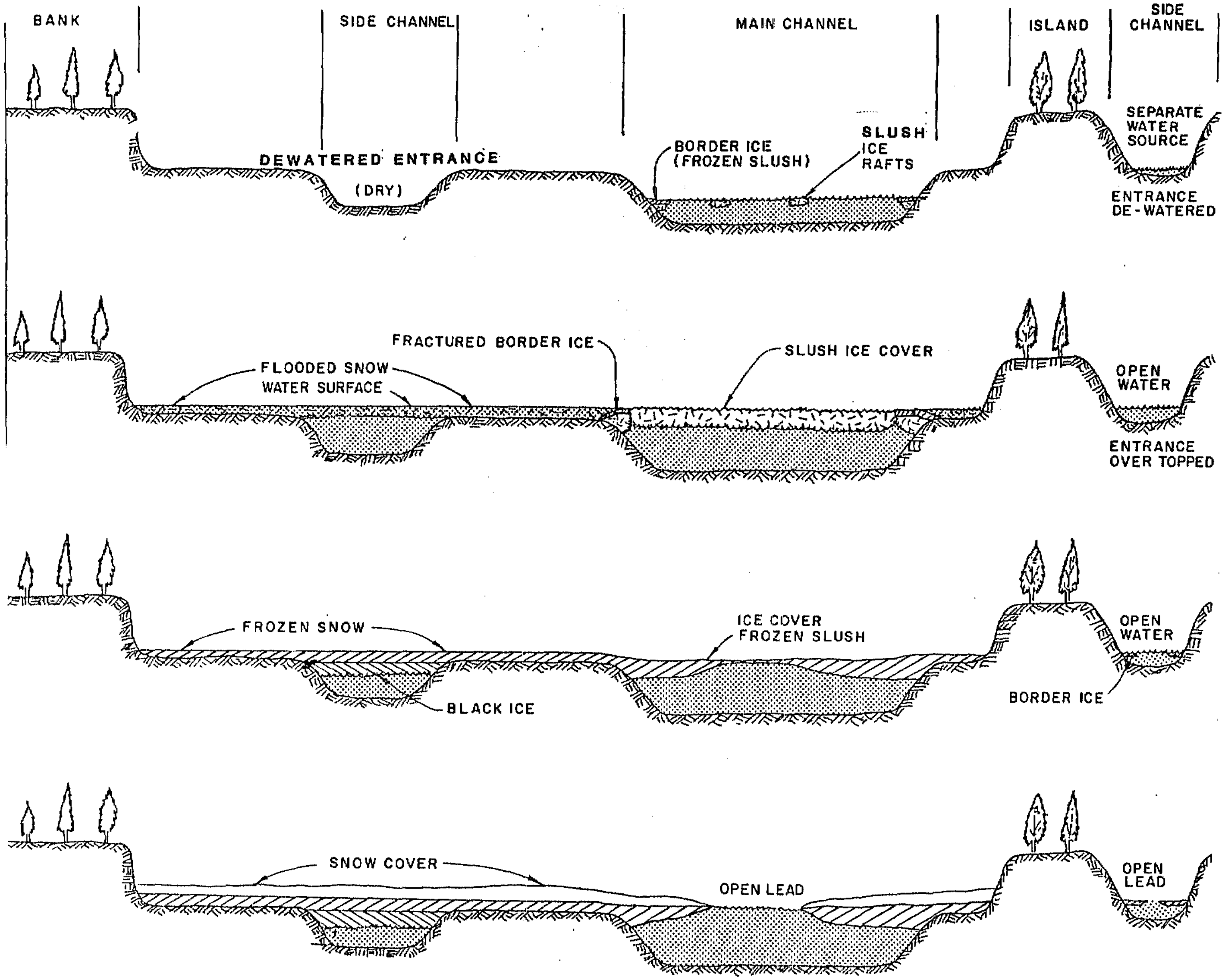

FIGURE 6.36

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HARZA-EBASCO
SUSITNA JOINT VENTURE

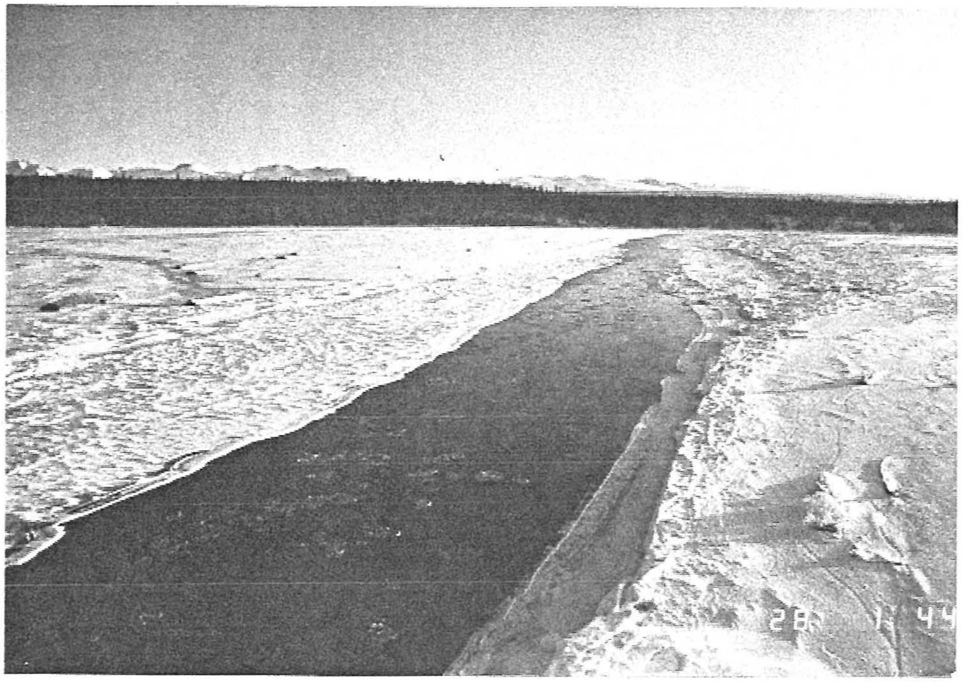


FIGURE 6.37
December 28, 1983. Open lead downstream of Sunshine near RM 80. Stage increased about six feet during progression and receded when this lead opened up. View is looking downstream.

FIGURE 6.38
December 28, 1983. Secondary leading edge progressing upstream through an open lead. The progression rate is slow and the entire length of this open lead did not freeze over. View is looking downstream.

7.0 MIDDLE RIVER ICE STUDY

As indicated earlier in this report, the scope of work for fiscal year 1983 ice study emphasized documentation of lower river ice processes. Quantification of middle river ice processes was also required for ongoing computer simulations of with-project ice cover development. Water surface elevations were surveyed at the following cross section:

Cross Section #	RM #
2.2	98.2
2.3	98.4
3	98.6
9	103.3
near 10.3	106.2
18	113.0
24	120.5
27	123.3
29	126.1
near 31	128.7
near 35	130.9
40	134.2
45	136.5

Water levels were measured during the open water hydrograph recession and during the freeze-up of the middle river reach (Table 1). Continuous stage readings were recorded with a Datapod at LRX-3 (Table 2) and daily measurements were obtained with a wire weight at LRX-45 near Gold Creek (Table 3). The remaining locations were measured periodically with a level and survey rod.

Daily observation were made at the Gold Creek bridge monitoring the following parameters:

Minimum and maximum daily air temperatures
Water temperature (mercury hand held thermometer)
Water level (wire weight reading)
Shore ice width and thickness
Water velocity (surface maximum)
Depth of snow
Ice concentration (percent of water surface covered)

Porosity of the frazil slush was periodically measured throughout freeze-up (Table 7.4). This parameter was required for computations of ice discharge (Table 7.5). Frazil samples were collected at Watana, Gold Creek, and LRX-3 at the Chulitna confluence. The procedure was as follows:

1. A wire mesh container with dimensions of 1 cubic foot was carried out to a water depth of about 2 feet. Usually a slush ice raft was intercepted which quickly filled the container.

2. The water was allowed to drain from the slush. A majority of the water drained out immediately but several minutes were required until only drops issued from the container.

3. An Ohaus 100-pound capacity portable scale was used at the site to weigh the container and then the container with ice.

4. The weight of frazil divided by the density of solid ice is the percent of ice in the container, the remaining fraction is the void space or air.

The results of these measurements were remarkably consistent however, they do not generally agree with published values for frazil ice porosity. Average porosity of Susitna River ice was 0.32, compared to the accepted value range of 0.4 to 0.6. The low porosity of the samples taken on the Susitna may be related to the age of the frazil. In fact, the ice samples collected were composed of course (approximate diameter 3/8 to 1/4 inch), compacted granules of ice which hardly resemble frazil (Figure 7.1). The ice grains were compacted so that each grain contacted another and only the interstices contained water. Further compaction did not seem possible without deforming the grains. The accepted values for porosity of frazil are probably based on newly formed ice crystals and not the metamorphosed granules experienced on the Susitna. These observations are significant when computing ice discharge. The ice volume is a necessary parameter for determining ice cover progression rates. Ice discharge or the volume of ice is computed based on surface velocity, channel width, slush thickness, surface ice concentration and porosity. Preliminary computations resulted in extreme values of ice volumes, This was probably due to the use of a surface velocity which was a measured maximum and not an average cross sectional velocity. The values for ice volume shown on Table 7.5 should be used for relative daily comparison only, and may not represent the actual ice discharge at Gold Creek. Further studies and data acquisition will help to refine these computations for more representative values.

Water temperatures were monitored at Denali, Jay Creek and Watana during September and October 1983 in order to track the cooling process down to 0°C. See Table 6.

On December 9, 1983, the leading edge of the progressing ice cover entered the middle river reach at RM 98.6. The freeze-up processes were documented once per week until the leading edge reached Gold Creek. Water surface elevations were surveyed above and below the leading edge. However, the exact ice front became difficult to define by mid-December.

On December 22, a second leading edge was observed at RM 124, just upstream of Curry. The river downstream between RM 120 and RM 118 was still open and the leading edge was stalled. Heavy anchor ice deposits were observed within the open lead. This anchor ice had noticeably raised the water level and flooded the surrounding shore ice and snow. The second leading edge apparently was initiated by a channel closure at RM 120.7. Since the closure was not witnessed the processes leading up to this event can only be interpreted from the existing ice structure.

The side channel below Curry which runs from RM 119.2 to 120.5 conveys a large volume of the ice flowing down the Susitna, see sheet 11, Appendix B. The sharp river bend at RM 121 forces the water and ice against the west bank adjacent to cross section 24. The momentum of the flowing ice keeps the floes against this right bank and subsequently carries most of the slush into the side channel. The proximity of the leading edge near the side channel mouth had raised the water surface elevation and reduced the water velocity. The side channel therefore quickly became ice choked and no longer capable of conveying all the slush ice. The ice backed up in the side channel and was prevented from diverting into the mainstem by the velocity distribution and a gravel bar located at RM 120.3. A new leading edge was subsequently started and moved past Curry (LRX-24) probably on December 21, 1983.

The open water below Curry on the mainstem eventually froze over by border ice growth. Two anchor ice dams were observed in the lead, at RM 120 and RM 119.6. This created some backwater ponding which facilitated faster lateral growth of border ice (Figure 7.2).

By January 5, 1984 the second leading edge was located at Sherman near RM 130 and since very little slush ice was flowing in the open water, the ice cover progression was relatively slow (Figure 7.3). By this time the river above Devil Canyon had essentially frozen over and stopped generating substantial volumes of frazil. The remaining open water through Devil Canyon and on down to the leading edge appeared to produce relatively low volumes of slush. The frazil generated, however, was "active" meaning it would adhere to any object that the crystals contacted. The anchor ice dams mentioned previously, had also developed at RM 130.5, 132.5, 134, 134.8 and 135.5. The anchor ice accumulated on the bottom rocks to depths of 1 to 2 feet. This subsequently raises the water level and causes a backwater zone. Water levels may rise enough to fracture border ice. Figure 7.4 shows the results of this process at RM 135.6 in 1983. A third leading edge began but progressed only about 1 mile before becoming an indefinite zone of accumulation. The open water area between RM 130 and RM 135.6 eventually closed by border ice extension.

TABLE 7.1
SUSITNA RIVER Between the
CHULITNA CONFLUENCE (RM 98.5) and
GOLD CREEK (RM 136.5)
Water Surface Elevations in Feet (MSL)

Location		Date of Survey 10/6	10/17	10/21	11/4	11/18
LRX-45 Gold Creek	RM 136.5	683.59	683.35	683.06	681.84	681.24
LRX-40	RM 134.2			657.21		654.24
Near LRX-35	RM 130.9					614.92
Near LRX-31	RM 128.7					592.86
LRX-29	RM 126.1			569.44		567.55
LRX-27	RM 123.3					541.11
LRX-24	RM 120.5			520.93		520.05
LRX-18	RM 113.0			460.18		457.74
Near LRX-10.3	RM 106.2*			2.25		
LRX-9	RM 103.3			377.52		375.67
LRX-3	RM 98.6	342.55	341.51	341.30	339.65	339.40
LRX-2.3	RM 98.4	341.24			339.23	
LRX-2.2	RM 98.2	340.86			339.36	
Location of Leading Edge		No Cover	No Cover	No Cover	RM 42.0	RM 82.5
Discharge, cfs (USGS Gold Creek)			8800	7800	6900	392800

* Surveyed from Arbitrary Reference Datum of 10 feet.

TABLE 7.1 (cont.)
SUSITNA RIVER Between the
CHULITNA CONFLUENCE (RM 98.5) and
GOLD CREEK (RM 136.5)
Water Surface Elevations in Feet (MSL)

Location		Date of Survey 12/13	12/22	12/28	1/5	1/27
LRX-45 Gold Creek	RM 136.5	681.59	681.96	682.73	683.49	684.64
LRX-40	RM 134.2		653.86	654.55	655.23	657.58
Near LRX-35	RM 130.9			617.55	617.05	618.16
Near LRX-31	RM 128.7		593.95	596.54	595.58	594.99
LRX-29	RM 126.1	573.49	573.53	572.59	571.53	571.08
LRX-27	RM 123.3		545.31		544.35	544.43
LRX-24	RM 120.5	520.82	522.26		523.58	523.89
LRX-18	RM 113.0	461.87			461.36	461.13
Near LRX-10.3	RM 106.2*	7.65				
LRX-9	RM 103.3	383.57	381.32			381.41
LRX-3	RM 98.6	342.80	343.07	343.00		341.34
LRX-2.3	RM 98.4					
LRX-2.2	RM 98.2					
Location of Leading Edge		RM 108	RM 116.2 RM 127.0	RM 129.5	RM 130.2 RM 136.3	RM 130.2 RM 136.8

Discharge, cfs (USGS Gold Creek) 3400 BACKWATER

* Surveyed from Arbitrary Reference Datum of 10 feet.

TABLE 7.2
CHULITNA CONFLUENCE STAGE DATA
Recorded at LRX-3, Left Bank

Date	Mean Daily Water Surface Elevation Feet (MSL)	Date	Mean Daily Water Surface Elevation Feet (MSL)
November 1983		December 1983	
1	-	1	339.50
2	-	2	339.40
3	-	3	339.37
4	-	4	339.50
5	-	5	339.50
6	-	6	339.50
7	-	7	339.37
8	-	8	339.17
9	-	9	341.47
10	-	10	342.67
11	-	11	342.83
12	339.57	12	342.83
13	339.50	13	342.80
14	339.57	14	343.03
15	339.40	15	342.53
16	339.57	16	342.37
17	339.53	17	342.43
18	339.37	18	342.53
19	339.43	19	342.67
20	339.37	20	342.63
21	339.53	21	343.00
22	340.10	22	-
23	339.87	23	-
24	340.03	24	-
25	339.37	25	-
26	339.50	26	-
27	339.57	27	-
28	339.50	28	-
29	339.53	29	-
30	339.47	30	-
		31	-

A maximum stage of 344.63 feet was reached at 1530 on December 9, 1983 coincident with the leading edge of ice cover passing this cross section.

TABLE 7.3
GOLD CREEK WIRE WEIGHT READINGS (FEET)
with corresponding values in USGS
Datum (feet), Mean Sea Level (feet) and Discharge (cf/sec)

Date October, 1983	WW	USGS	MSL	Q
1	60.10	8.47	684.79	13600
2	59.95	8.32	684.64	12800
3	59.65	8.02	684.34	11600
4	59.38	7.75	684.07	10800
5	59.10	7.47	683.79	9600
6	58.90	7.27	683.59	8800
7	-	-	-	-
8	57.90	6.27	682.59	5750
9	58.30	6.67	682.99	6900
10	58.85	7.22	683.54	8400
11	59.05	7.42	683.74	9200
12	59.45	7.82	684.14	10800
13	59.75	8.12	684.44	12000
14	59.55	7.92	684.24	11200
15	59.15	7.52	683.84	9600
16	58.82	7.19	683.51	8400
17	58.61	6.98	683.30	7800
18	58.48	6.85	683.17	7500
19	58.64	7.01	683.33	7800
20	58.44	6.81	683.13	7200
21	58.37	6.74	683.06	6900
22	58.25	6.62	682.94	6600
23	58.17	6.54	682.86	6300
24	57.97	6.34	682.66	5750
25	57.60	5.97	682.29	5000
26	57.63	6.00	682.32	5000
27	57.64	6.01	682.33	5000
28	57.55	5.92	682.24	4750
29	57.61	5.98	682.30	5000
30	57.73	6.10	682.42	5250
31	57.84	6.21	682.53	5500

TABLE 7.3 (cont.)
GOLD CREEK WIRE WEIGHT READINGS (FEET)
with corresponding values in USGS
Datum (feet), Mean Sea Level (feet) and Discharge (cf/sec)

Date	WW	USGS	MSL	Q
November, 1983				
1	57.63	6.00	682.32	5000
2	57.58	5.95	682.27	5000
3	57.40	5.77	682.09	4500
4	57.15	5.52	681.84	3900
5	57.20	5.57	681.89	4000
6	57.05	5.42	681.74	3700
7	56.80	5.17	681.49	3300
8	56.70	5.07	681.39	3100
9	56.83	5.20	681.52	3300
10	56.70	5.07	681.39	3100
11	56.75	5.12	681.44	3100
12	56.70	5.07	681.39	3100
13	56.65	5.02	681.34	3000
14	56.65	5.02	681.34	3000
15	56.77	5.14	681.46	3100
16	56.60	4.97	681.29	3000
17	56.67	4.94	681.26	2800
18	56.57	4.94	681.26	2800
19	-	-	-	-
20	-	-	-	-
21	-	-	-	-
22	56.85	5.22	681.54	3300
23	56.94	5.31	681.63	3400
24	56.75	5.12	681.44	3100
25	56.79	5.19	681.51	3300
26	56.85	5.22	681.54	3300
27	57.50	5.87	682.19	4800
28	56.95	5.32	681.64	3400
29	56.94	5.31	681.63	3400
30	56.95	5.32	681.64	3400

TABLE 7.3 (cont.)
GOLD CREEK WIRE WEIGHT READINGS (FEET)
with corresponding values in USGS
Datum (feet), Mean Sea Level (feet) and Discharge (cf/sec)

Date	WW	USGS	MSL	Q
December, 1983				
1	56.92	5.29	681.61	3500
2	56.96	5.33	681.65	3550
3	56.72	5.09	681.41	3100
4	56.92	5.29	681.61	3400
5	56.93	5.30	681.62	3400
6	57.07	5.44	681.76	3750
7	57.04	5.41	681.73	3700
8	56.97	5.34	681.66	3550
9	56.90	5.27	681.59	3400
10	56.95	5.32	681.64	3400
11	56.97	5.34	681.66	3450
12	56.92	5.29	681.61	3400
13	56.90	5.27	681.59	3400
14	56.88	5.25	681.57	3350
15	56.90	5.27	681.59	3400
16	57.01	5.38	681.70	3600
17	57.13	5.50	681.82	*
18	57.22	5.59	681.91	*
19	57.30	5.67	681.99	*
20	57.45	5.82	682.14	*
21	57.52	5.89	682.21	*
22	57.27	5.64	681.96	*
23	57.50	5.87	682.19	*
24	57.60	5.97	682.29	*
25	57.65	6.02	682.34	*
26	57.87	6.24	682.56	*
27	57.85	6.22	682.54	*
28	57.82	6.19	682.71	*
29	58.04	6.41	682.93	*
30	58.15	6.52	683.04	*
31	58.33	6.70	683.22	*

* Backwater effect from ice bridge at LRX-43 and advancing ice cover.

TABLE 7.3 (cont')
GOLD CREEK WIRE WEIGHT READINGS (FEET)
with corresponding values in USGS
Datum (feet), Mean Sea Level (feet) and Discharge (cf/sec)

Date	WW	USGS	MSL	Q
January, 1984				
1	-	-	-	-
2	58.52	6.89	683.41	*
3	58.45	6.82	683.34	*
4	58.51	6.88	683.40	*
5	58.63	7.00	683.52	*
6	55.60	7.02	683.54	*
7	55.83	7.25	683.77	*
8	55.97	7.39	683.91	*
9	56.20	7.62	684.14	*
10	56.32	7.74	684.26	*
11	56.25	7.67	684.19	*
12	56.27	7.69	684.21	*
13	56.30	7.72	684.24	*
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				

* Backwater effect from ice bridge at LRX-43 and advancing ice cover.

TABLE 7.4
SUSITNA RIVER
FRAZIL ICE WEIGHTS
For Determining Porosity

<u>Location</u>

Chulitna Confluence

October 17

Sample Size 1 cubic foot

Weight $\frac{\text{36.9 pounds of frazil}}{\text{57.3 pounds solid ice}}$ = 0.64

November 15

Weight $\frac{\text{39.5 pounds of frazil}}{\text{57.3 pounds solid ice}}$ = 0.69

Gold Creek

October 17

Sample Size 1 cubic foot

Weight $\frac{\text{39.0 pounds of frazil}}{\text{57.3 pounds solid ice}}$ = 0.68

November 18

Weight $\frac{\text{39.5 pounds of frazil}}{\text{57.3 pounds solid ice}}$ = 0.69

January 5

Weight $\frac{\text{38.8 pounds of frazil}}{\text{57.3 pounds solid ice}}$ = 0.67

Watana

October 17

Sample Size 1 cubic foot

Weight $\frac{\text{39.3 pounds of frazil}}{\text{57.3 pounds solid ice}}$ = 0.69

AVERAGE = 0.68

POROSITY= 1 - 0.68 = 0.32

TABLE 7.5
SUSITNA RIVER at GOLD CREEK
ICE DISCHARGE COMPUTATIONS

$$Q_i = C_i V_s B_1 t_s (1- E_s)$$

Date	Ice Concentration C_i (%)	Surface Velocity V_s (ft/s)	Channel Width B_1 (ft)	Slush Thickness t_s(ft	Porosity E_s	Ice Discharge* Q_i(ft³/S)
October 1983						
1	0	5.0	347.76	-	0.31	0.0
2	0	5.0	347.76	-	0.31	0.0
3	0	5.0	347.76	-	0.31	0.0
4	0	5.0	347.76	-	0.31	0.0
5	0	5.0	347.76	-	0.31	0.0
6	0	5.0	347.76	-	0.31	0.0
7	30	5.0	347.76	1.5	0.31	539.9
8	50	5.0	347.76	1.5	0.31	899.8
9	50	5.0	347.76	1.5	0.31	899.8
10	35	5.0	347.76	1.5	0.31	629.9
11	25	5.9	324.80	1.5	0.31	495.9
12	0	5.9	324.80	-	0.31	0.0
13	0	5.0	324.80	-	0.31	0.0
14	0	5.0	324.80	-	0.31	0.0
15	5	5.0	324.80	1.5	0.31	84.0
16	30	5.0	324.80	1.5	0.31	504.3
17	35	5.0	324.80	1.5	0.31	588.3
18	25	5.0	324.80	1.5	0.31	420.2
19	5	5.0	324.80	1.5	0.31	84.0
20	10	5.0	324.80	1.5	0.31	168.1
21	20	4.6	324.80	1.5	0.31	309.3
22	10	4.3	324.80	1.5	0.31	144.6
23	25	3.9	324.80	1.5	0.31	361.4
24	50	3.9	324.80	1.5	0.31	655.5
25	75	4.3	324.80	1.5	0.31	983.3
26	65	4.3	324.80	1.5	0.31	939.6
27	50	5.0	324.80	1.5	0.31	840.4
28	50	5.0	324.80	1.5	0.31	840.4
29	60	5.0	324.80	1.5	0.31	983.3
30	35	5.0	324.80	1.5	0.31	588.3
31	30	4.3	324.80	1.5	0.31	433.7

* Ice discharge is considered qualitative and is intended for compartive purposes only.

TABLE 7.5 (cont.)
SUSITNA RIVER at GOLD CREEK
ICE DISCHARGE COMPUTATIONS

$$Q_i = C_i\ V_s\ B_1\ t_s\ (1- E_s)$$

Date	Ice Concentration C_i (%)	Surface Velocity V_s (ft/s)	Channel Width B_1 (ft)	Slush Thickness t_s (ft	Porosity E_s	Ice Discharge* Q_i (ft³/S)
November 1983						
1	50	5.0	324.80	1.5	0.31	840.4
2	40	5.0	324.80	1.5	0.31	672.3
3	60	5.0	324.80	1.5	0.31	1,008.5
4	65	4.3	308.40	1.5	0.31	892.2
5	75	3.9	308.40	1.5	0.31	933.6
6	75	3.9	308.40	1.5	0.31	933.6
7	80	3.9	308.40	1.5	0.31	995.9
8	50	3.9	308.40	1.5	0.31	622.4
9	20	3.9	308.40	1.5	0.31	249.0
10	20	3.9	308.40	1.5	0.31	249.0
11	50	3.9	308.40	1.5	0.31	622.4
12	30	3.9	308.40	1.5	0.31	373.5
13	70	3.9	308.40	1.5	0.31	871.4
14	70	3.9	308.40	1.5	0.31	871.4
15	75	3.9	308.40	1.5	0.31	933.6
16	55	3.9	308.40	1.5	0.31	684.7
17	70	3.9	308.40	1.5	0.31	871.4
18	60	3.6	285.43	1.8	0.31	765.7
19	70	3.6	285.43	1.8	0.31	893.4
20	70	3.6	285.43	1.8	0.31	893.4
21	40	3.6	285.43	1.8	0.31	510.5
22	15	3.6	285.43	1.8	0.31	191.4
23	25	3.9	285.43	1.8	0.31	345.6
24	50	3.9	285.43	1.8	0.31	691.3
25	55	3.9	285.43	1.8	0.31	760.4
26	60	3.9	285.43	1.8	0.31	829.5
27	60	3.9	285.43	1.8	0.31	829.5
28	10	3.6	285.43	1.0	0.31	70.9
29	10	3.0	285.43	1.0	0.31	59.1
30	10	3.0	285.43	1.0	0.31	59.1

TABLE 7.5 (cont.)
SUSITNA RIVER at GOLD CREEK
ICE DISCHARGE COMPUTATIONS

$$Q_i = C_i V_s B_1 t_s (1- E_s)$$

Date	Ice Concentration C_i (%)	Surface Velocity V_s (ft/s)	Channel Width B_1 (ft)	Slush Thickness t_s(ft	Porosity E_s	Ice Discharge* Q_i(ft³/S)
December 1983						
1	10	3.0	285.43	1.0	0.31	59.1
2	10	3.0	285.43	1.0	0.31	59.1
3	15	3.0	285.43	1.0	0.31	88.6
4	25	3.0	285.43	1.0	0.31	151.4
5	15	3.0	285.43	1.0	0.31	88.6
6	10	3.6	285.43	1.0	0.31	70.9
7	35	3.6	285.43	1.0	0.31	248.2
8	40	3.6	285.43	1.0	0.31	283.6
9	55	3.6	285.43	1.0	0.31	389.9
10	55	3.0	285.43	1.0	0.31	324.9
11	65	3.0	285.43	1.3	0.31	499.3
12	80	3.0	285.43	1.3	0.31	714.5
13	80	3.0	255.90	1.3	0.31	550.9
14	80	3.0	255.90	1.3	0.31	550.9
15	80	3.0	255.90	1.3	0.31	550.9
16	80	3.0	255.90	1.3	0.31	550.9
17	60	3.0	255.90	1.3	0.31	413.2
18	70	3.0	255.90	1.3	0.31	482.0
19	50	3.0	255.90	1.3	0.31	344.3
20	35	3.0	255.90	1.3	0.31	241.0
21	20	3.6	255.90	1.3	0.31	165.3
22	50	3.6	255.90	1.3	0.31	413.2
23	50	3.0	255.90	1.3	0.31	344.3
24	30	3.0	255.90	1.3	0.31	206.6
25	30	3.0	255.90	1.3	0.31	206.6
26	40	2.6	255.90	1.3	0.31	238.7
27	50	2.6	255.90	1.3	0.31	298.4
28	55	2.6	255.90	1.3	0.31	328.3
29	60	2.6	255.90	1.3	0.31	358.1
30	70	2.6	255.90	1.3	0.31	417.8
31	50	2.6	255.90	1.3	0.31	298.4

* Ice discharge is considered qualitative and is intended for comparative purposes only.

TABLE 7.5 (cont.)
SUSITNA RIVER at GOLD CREEK
ICE DISCHARGE COMPUTATIONS

$$Q_i = C_i\ V_s\ B_1\ t_s\ (1-\ E_s)$$

Date	Ice Concentration C_i (%)	Surface Velocity V_s (ft/s)	Channel Width B_1 (ft)	Slush Thickness t_s(ft	Porosity E_s	Ice Discharge* Q_i(ft³/S)
January 1984						
1	-	-	-	-	-	
2	20	2.6	255.90	1.0	0.31	91.8
3	10	2.6	255.90	1.0	0.31	45.9
4	20	2.0	255.90	1.0	0.31	70.6
5	50	2.0	206.69	1.0	0.31	142.6
6	30	2.0	206.69	1.0	0.31	85.6
7	20	2.0	206.69	1.0	0.31	57.1
8	20	2.0	206.69	1.0	0.31	57.1
9	20	2.0	206.69	1.0	0.31	57.1
10	15	2.0	206.69	1.0	0.31	42.8
11	5	2.0	206.69	1.0	0.31	14.3
12	5	2.0	206.69	1.0	0.31	14.3
13	5	2.0	206.69	1.0	0.31	14.3
14	5	2.0	206.69	1.0	0.31	14.3
15	-	-	0	-	-	
16	-	-	0	-	-	
17	-	-	0	-	-	
18	-	-	0	-	-	
19	-	-	0	-	-	
20	-	-	0	-	-	
21	-	-	0	-	-	
22	-	-	0	-	-	
23	-	-	0	-	-	
24	-	-	0	-	-	
25	-	-	0	-	-	
26	-	-	0	-	-	
27	-	-	0	-	-	
28	-	-	0	-	-	
29	-	-	0	-	-	
30	-	-	0	-	-	
31	-	-	0	-	-	

* Ice discharge is considered qualitative and is intended for comparative purposes only.

TABLE 7.6
SUSITNA RIVER
WATER TEMPERATURES °C

Date	DENALI (RM 290.7) Min.	Max.	Mean	JAY CREEK (RM 209.5) Min.	Max.	Mean	WATANA (RM 183) Min.	Max.	Mean
September 1983									
1	-	-	-	3.5	7.0	5.3	-	6.1	-
2	-	4.6	-	3.9	5.8	4.9	5.5	6.5	6.0
3	1.8	4.6	3.2	3.6	5.0	4.3	5.0	5.8	5.4
4	1.3	3.0	2.2	3.7	5.2	4.5	4.3	5.5	4.9
5	1.0	3.5	2.3	4.3	5.0	4.7	3.8	5.2	4.1
6	0.8	3.7	2.3	4.6	5.6	5.1	3.2	5.0	4.1
7	1.3	3.4	2.4	4.9	7.0	6.0	3.3	4.6	4.0
8	2.0	4.0	3.0	4.7	6.2	5.5	4.0	5.2	4.6
9	2.4	4.0	3.2	3.9	5.2	4.6	4.2	5.6	4.9
10	2.4	5.0	3.7	3.8	4.6	4.2	4.8	6.2	5.5
11	1.4	4.8	3.1	3.0	5.3	4.2	4.5	5.2	4.9
12	2.1	3.8	3.0	2.5	5.0	3.8	4.5	5.3	4.9
13	1.8	3.2	2.5	0.5	6.2	3.4	4.6	5.0	4.8
14	2.0	3.3	2.7	0.0	-	-	3.4	4.1	3.8
15	1.2	3.1	2.2	3.0	6.5	4.8	3.7	4.7	4.2
16	0.2	3.2	1.7	4.0	5.5	4.8	2.8	4.3	3.6
17	0.1	2.9	1.5	4.5	4.9	4.7	2.5	3.7	3.1
18	0.3	2.3	1.3	0.0	1.9	1.0	2.0	3.2	2.6
19	0.9	2.6	1.8	0.0	1.8	0.9	2.4	3.2	2.8
20	1.5	3.0	2.3	0.0	2.5	1.3	3.0	4.0	3.5
21	2.2	2.9	2.6	0.0	2.0	1.0	3.8	4.5	4.2
22	1.8	2.2	2.0	0.0	1.8	0.9	4.2	4.6	4.4
23	Sensor In ice			0.0	0.0	0.0	1.0	3.5	2.3
24	Sensor In ice			0.0	0.0	0.0	0.0	0.0	0.0
25	Sensor In ice			0.0	0.0	0.0	0.0	0.0	0.0
26	Sensor In ice			0.0	0.0	0.0	0.0	0.0	0.0
27	Sensor In ice			0.0	0.0	0.0	0.0	0.5	0.0
28	Sensor In ice			Sensor In ice			Dewatered/Sensor		
29	Sensor In ice			Sensor In ice			Dewatered/Sensor		
30	Sensor In ice			Sensor In ice			Dewatered/Sensor		

TABLE 7.7
SUSITNA RIVER at GOLD CREEK
MEAN DAILY WATER TEMPERATURES °C

Date	Temperature °C	Date	Temperature °C	Date	Temperature °C
Oct. 1983		Nov. 1983		Dec. 1983	
1	-	1	0.2	1	0.5
2	-	2	0.3	2	0.4
3	-	3	0.3	3	0.3
4	-	4	0.2	4	0.2
5	0.8	5	0.2	8	0.3
6	0.7	6	0.1	6	0.4
7	0.5	7	0.1	7	0.2
8	0.2	8	0.1	8	0.1
9	0.2	9	0.2	9	0.1
10	0.4	10	0.1	10	0.1
11	0.7	11	0.2	11	0.1
12	0.8	12	0.1	12	0.1
13	0.5	13	0.1	13	0.1
14	0.2	14	0.1	14	0.1
15	0.6	15	0.1	15	0.1
16	0.7	16	0.1	16	0.1
17	0.8	17	0.1	17	0.1
18	0.8	18	0.1	18	0.1
19	0.4	19	0.1	19	0.2
20	0.1	20	0.1	20	0.3
21	0.4	21	0.1	21	0.1
22	0.2	22	0.3	22	0.1
23	0.4	23	0.3	23	0.1
24	0.3	24	0.1	24	0.1
25	0.3	25	0.1	25	0.1
26	0.4	26	0.4	26	0.1
27	0.2	27	0.4	27	0.0
28	0.3	28	0.4	28	0.0
29	0.2	29	0.5	29	0.0
30	0.4	30	0.5	30	0.0
31	0.3			31	0.1

FIGURE 7.1
October 17, 1983. Ice crystals obtained from a slush ice raft. These are clusters of four to five individual crystals. This ice originated far upstream and has metamorphosed into these large particles with little cohesion between grains.

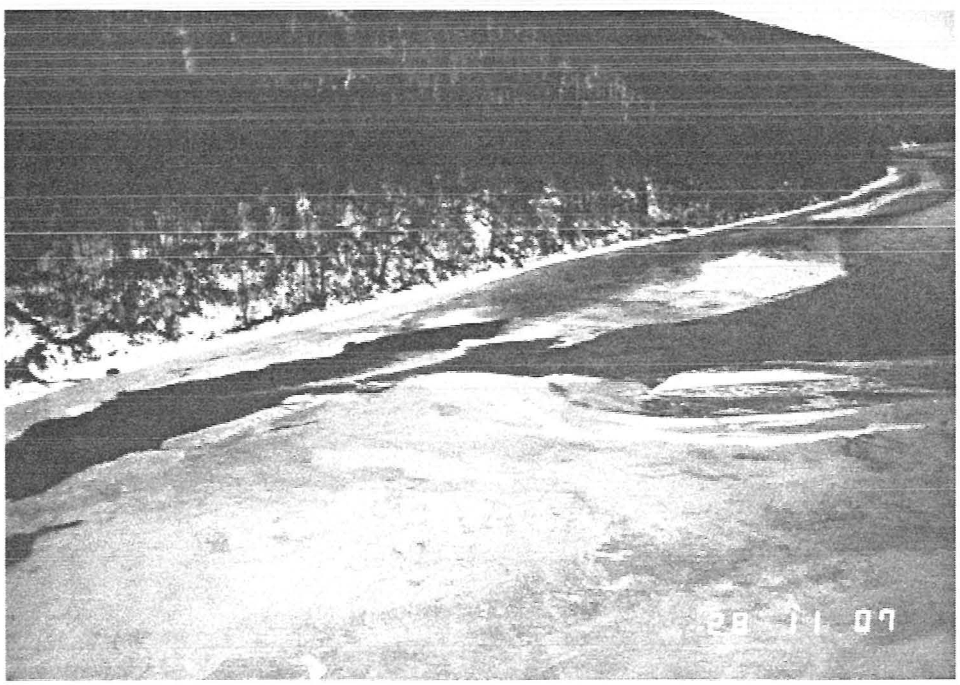


FIGURE 7.2
December 28, 1983. Anchor ice dam at RM 142.5. Anchor ice accumulates on the substrate and effectively raises the water level, which subsequently floods the surrounding border ice and snow cover. Flow is right to left.

s6/mm97

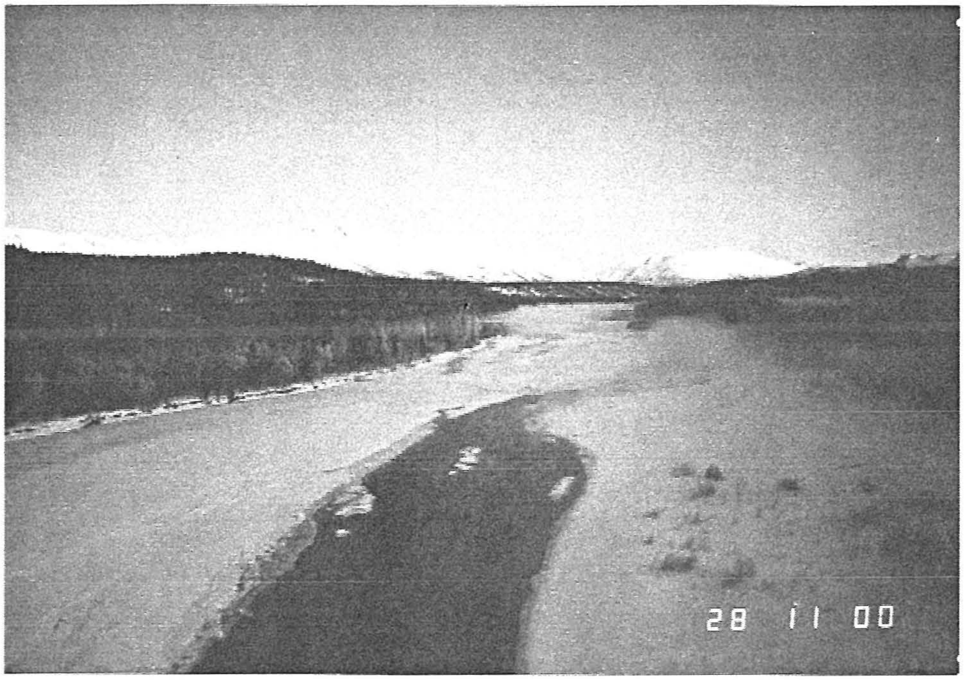


FIGURE 7.3
December 28, 1983. RM 130 looking upstream. In 1983 the continuous ice cover progression ended at Sherman (RM 135). Other processes then dominated the remaining open water freeze-up to Devil Canyon.

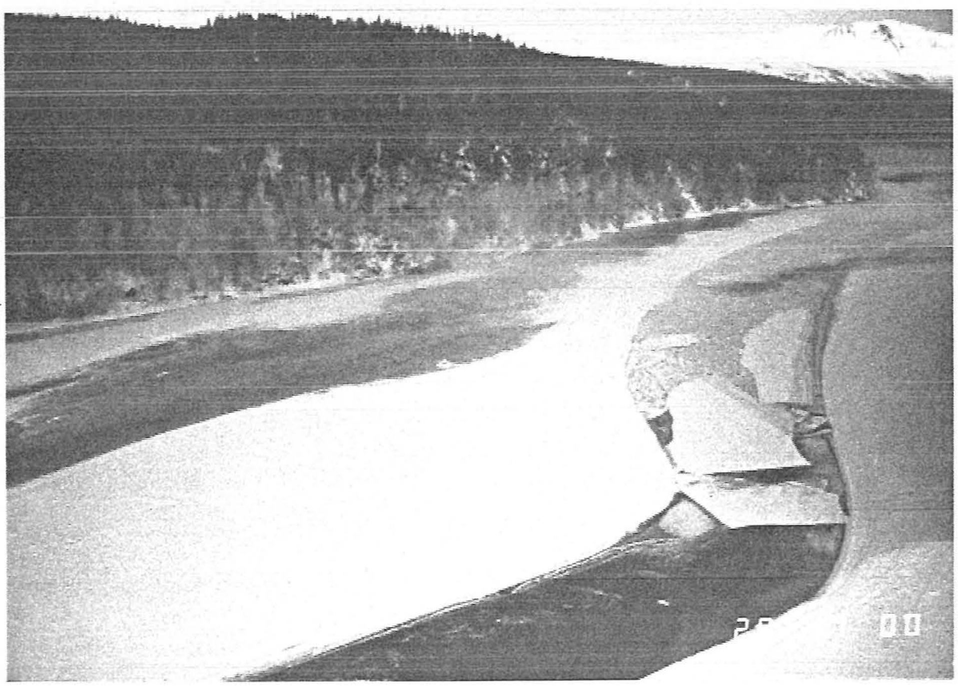
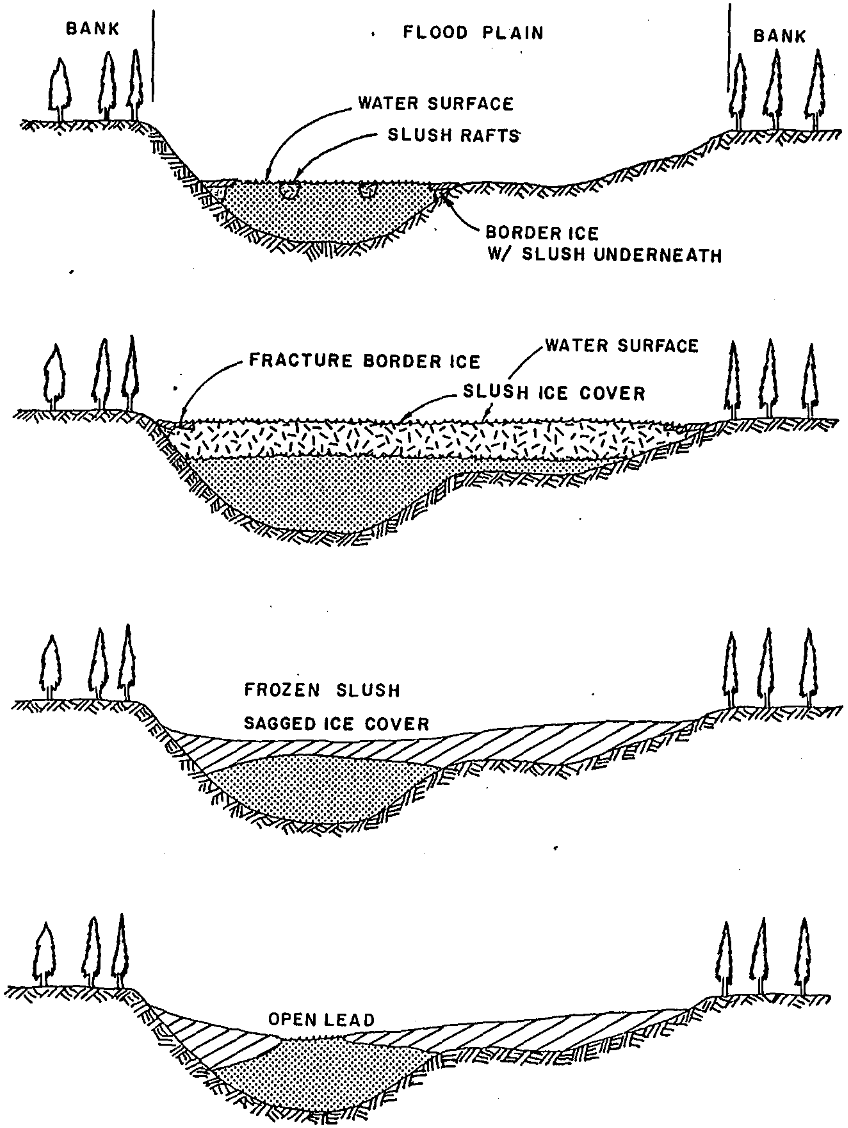


FIGURE 7.4
January 5, 1983. The elevated stage created by anchor ice caused border ice to fracture. The fragments drifted downstream and lodged, creating a barrier to incoming slush ice. This bridge occurred at RM 135.6. View is looking upstream.

MIDDLE RIVER TYPICAL CROSS SECTION



R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS PLANNERS SURVEYORS

FIGURE 7.5

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HARZA-EBASCO
SUSITNA JOINT VENTURE

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APPENDIX A

MONTHLY METEOROLOGICAL SUMMARIES FROM WEATHER STATIONS AT DENALI, WATANA, DEVIL CANYON, SHERMAN AND TALKEETNA

SEP 1983 26528
TALKEETNA, ALASKA
TALKEETNA AIRPORT

ISSN 0198-0424

LOCAL CLIMATOLOGICAL DATA

Monthly Summary

WEA SVC CONTRACT MET OBSY

LATITUDE 62° 18' N LONGITUDE 150° 06' W ELEVATION (GROUND) 345 FEET TIME ZONE ALASKAN WBAN #26528

DATE	TEMPERATURE °F: MAXIMUM	MINIMUM	AVERAGE	DEPARTURE FROM NORMAL	AVERAGE DEW POINT	DEGREE DAYS BASE 65°F: HEATING (SEASON BEGINS WITH JUL)	COOLING (SEASON BEGINS WITH JAN)	WEATHER TYPES: 1 FOG 2 HEAVY FOG 3 THUNDERSTORM 4 ICE PELLETS 5 HAIL 6 GLAZE 7 DUSTSTORM 8 SMOKE, HAZE 9 BLOWING SNOW	SNOW ICE PELLETS OR ICE ON GROUND AT 08AM INCHES	PRECIPITATION: WATER EQUIVALENT (INCHES)	SNOW, ICE PELLETS (INCHES)	AVERAGE STATION PRESSURE IN INCHES ELEV. 356 FEET ABOVE M.S.L.	WIND (M.P.H.): RESULTANT DIR.	RESULTANT SPEED	AVERAGE SPEED	FASTEST MILE: SPEED	FASTEST MILE: DIRECTION	SUNSHINE: MINUTES	PERCENT OF TOTAL POSSIBLE	SKY COVER (TENTHS): SUNRISE TO SUNSET	MIDNIGHT TO MIDNIGHT	DATE
1	2	3	4	5	6	7A	7B	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	58	42	50	-1	48	15	0	1	0	.06	0	29.21	16	3.9	4.6	15	17			10	10	1
2	60	37	49	-2	41	16	0	1	0	T	0	29.26	29	4.2	4.5	10	27			3	4	2
3	60	37	49	-2	41	16	0		0	T	0	29.23	34	1.7	3.2	7	28			9	8	3
4	56	35	46	-4	38	19	0		0	0	0	29.38	34	2.7	3.3	12	28			8	7	4
5	58	29	44	-6	36	21	0		0	0	0	29.47	19	.3	3.1	5	05			5		5
6	59	25	42	-8		23	0		0	0	0					12	03			1		6
7	60	27	44	-5	36	21	0		0	0	0	29.54	20	1.3	3.9	8	18			8		7
8	57	42	50	1	42	15	0		0	0	0	29.50	17	2.0	3.6	8	16			10		8
9	57	42	50	1	44	15	0		0	0	0	29.59	17	1.3	1.6	7	20			9	10	9
10	60	34	47	-1	42	18	0		0	0	0	29.68	24	1.8	1.9	6	23			7	7	10
11	62*	33	48	0	40	17	0		0	0	0	29.66	21	1.9	2.0	8	22			7	7	11
12	60	41	51*	3	42	14	0		0	T	0	29.58	17	1.3	3.5	9	22			9		12
13	56	40	48	1		17	0		0	.05	0					9	31			10		13
14	46	38	42	-5	40	23	0		0	.30	0	29.35	15	5.3	8.1	13	16			10		14
15	53	30	42	-4	38	23	0		0	.05	0	29.58	28	.9	4.1	9	32			7		15
16	60	27	44	-2	33	21	0		0	0	0	29.76	30	.4	2.9	6	26			0	0	16
17	56	26	41	-5	33	24	0		0	0	0	29.86	18	1.3	3.3	7	19			0	0	17
18	54	27	41	-4	35	24	0		0	0	0	29.75	35	2.5	4.8	7	34			10	8	18
19	54	37	46	1	38	19	0		0	.30	0	29.49	02	4.8	5.6	8	01			10		19
20	49	40	45	1		20	0	1	0	.57	0					6	30			10		20
21	54	44	49	5	47	16	0	2	0	.03	0	29.24	35	1.1	3.3	7	02			10		21
22	53	36	45	2	42	20	0	2	0	.23	.4	29.15	19	3.0	5.1	10	25			10		22
23	41	28	35	-8	21	30	0	1	T	.10	1.0	29.20	36	8.6	9.6	17	03			7	7	23
24	33	22	28*	-14	11	37	0		0	0	0	29.35	02	10.0	10.9	21	03			8	7	24
25	37	24	31	-11	13	34	0		0	0	0	29.64	02	9.5	9.9	21	02			3	2	25
26	42	17*	30	-12	16	35	0		0	0	0	29.79	34	4.2	6.1	8	36			0		26
27	40	19	30	-11		35	0		0	T	T					15	03			9		27
28	37	31	34	-7	34	31	0		T	.16	.8	29.76	36	5.5	6.7	10	33			10		28
29	42	37	40	0	39	25	0	1	0	1.12	0	29.41	01	5.5	6.9	12	02			10		29
30	51	41	46	7	43	19	0	1	0	.32	0	29.22	16	7.8	8.2	17	18			10	9	30
	SUM 1565	SUM 988				TOTAL 663	TOTAL 0	NUMBER OF DAYS		TOTAL 3.29	TOTAL 2.2	FOR THE MONTH:				21	02	TOTAL	% FOR MONTH	SUM 220	SUM	
	AVG. 52.2	AVG. 32.9	AVG. 42.6	DEP. -3.3	AVG.	DEP. 90	DEP. 0	PRECIPITATION > .01 INCH. 12		DEP. -0.68						DATE: 25+		POSSIBLE		AVG. 7.3	AVG.	

NUMBER OF DAYS				SEASON TO DATE			
MAXIMUM TEMP.		MINIMUM TEMP.		TOTAL	TOTAL	SNOW, ICE PELLETS > 1.0 INCH	1
> 90°	< 32°	< 32°	< 0°	1201	0	THUNDERSTORMS	0
0	0	13	0	DEP.	DEP.	HEAVY FOG	2
				104	0	CLEAR 6 PARTLY CLOUDY 5 CLOUDY 19	

GREATEST IN 24 HOURS AND DATES				GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE	
PRECIPITATION		SNOW, ICE PELLETS			
1.26	29-30	1.4	22-23	T	28+

* EXTREME FOR THE MONTH - LAST OCCURRENCE IF MORE THAN ONE.
T TRACE AMOUNT.
+ ALSO ON EARLIER DATE(S).
HEAVY FOG: VISIBILITY 1/4 MILE OR LESS.
BLANK ENTRIES DENOTE MISSING OR UNREPORTED DATA.
HOURS OF OPS. MAY BE REDUCED ON A VARIABLE SCHEDULE.

DATA IN COLS 6 AND 12-15 ARE BASED ON 7 OR MORE OBSERVATIONS AT 3-HOUR INTERVALS. RESULTANT WIND IS THE VECTOR SUM OF WIND SPEEDS AND DIRECTIONS DIVIDED BY THE NUMBER OF OBSERVATIONS. ONE OF THREE WIND SPEEDS IS GIVEN UNDER FASTEST MILE: FASTEST MILE - HIGHEST RECORDED SPEED FOR WHICH A MILE OF WIND PASSES STATION (DIRECTION IN COMPASS POINTS). FASTEST OBSERVED ONE MINUTE WIND - HIGHEST ONE MINUTE SPEED (DIRECTION IN TENS OF DEGREES). PEAK GUST HIGHEST INSTANTANEOUS WIND SPEED (A / APPEARS IN THE DIRECTION COLUMN). ERRORS WILL BE CORRECTED AND CHANGES IN SUMMARY DATA WILL BE ANNOTATED IN THE ANNUAL PUBLICATION.

I CERTIFY THAT THIS IS AN OFFICIAL PUBLICATION OF THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, AND IS COMPILED FROM RECORDS ON FILE AT THE NATIONAL CLIMATIC DATA CENTER, ASHEVILLE, NORTH CAROLINA, 28801

L. Ray Hoxit
ACTING DIRECTOR
NATIONAL CLIMATIC DATA CENTER

noaa

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NATIONAL ENVIRONMENTAL SATELLITE, DATA AND INFORMATION SERVICE

NATIONAL CLIMATIC DATA CENTER ASHEVILLE NORTH CAROLINA

SEP 1983
TALKEETNA, ALASKA

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WEATHER TYPES: 1 FOG, 2 HEAVY FOG, 3 THUNDERSTORM, 4 ICE PELLETS, 5 HAIL, 6 GLAZE, 7 DUSTSTORM, 8 SMOKE, HAZE, 9 BLOWING SNOW

DATE	TEMPERATURE °F: MAXIMUM	MINIMUM	AVERAGE	DEPARTURE FROM NORMAL	AVERAGE DEW POINT	DEGREE DAYS BASE 65°F: HEATING (SEASON BEGINS WITH JUL)	COOLING (SEASON BEGINS WITH JAN)	WEATHER TYPES	SNOW ICE PELLETS OR ICE ON GROUND AT 08AM INCHES	PRECIPITATION: WATER EQUIVALENT (INCHES)	SNOW, ICE PELLETS (INCHES)	AVERAGE STATION PRESSURE IN INCHES ELEV. 356 FEET ABOVE M.S.L.	WIND (M.P.H.): RESULTANT DIR.	RESULTANT SPEED	AVERAGE SPEED	FASTEST MILE: SPEED	DIRECTION	SUNSHINE: MINUTES	PERCENT OF TOTAL POSSIBLE	SKY COVER (TENTHS): SUNRISE TO SUNSET	MIDNIGHT TO MIDNIGHT	DATE
1	2	3	4	5	6	7A	7B	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	48	39	44	5	38	21	0	1	0	.17	0	29.30	17	5.4	8.9	15	17			10	10	1
2	52*	38	45*	7	35	20	0	1	0	.11	0	29.11	36	7.9	8.1	16	36			10	10	2
3	48	34	41	3	23	24	0		0	0	0	29.50	36	7.4	9.5	16	02					3
4	49	26	38	1		27	0		0	0	0					9	15			4		4
5	41	30	36	-1	31	29	0	1	0	.26	0	29.66	36	2.6	3.3	10	02			10		5
6	41	23	32	-4	23	33	0	1	0	.06	0	29.57	33	2.2	6.6	16	21			1		6
7	37	17	27	-9	16	38	0		0	0	0	29.81	36	5.6	5.9	14	03			5	3	7
8	35	17	26	-9	17	39	0		0	0	0	29.68	36	4.2	4.9	7	01			7	6	8
9	30	27	29	-6	28	36	0	1	T	.73	10.7	29.52	36	6.6	6.9	10	02			10	10	9
10	37	30	34	0	34	31	0	1	11	1.56	2.8	29.27	36	4.7	5.6	8	35					10
11	44	30	37	3		28	0	1	10	.58	0					16	16			9		11
12	43	32	38	5	36	27	0	2	4	.22	0	29.72	19	3.7	4.9	13	16			10		12
13	40	25	33	0	32	32	0	2	T	.01	0	29.79	36	.9	1.2	5	04			8		13
14	39	20	30	-2	23	35	0		T	0	0	29.73	36	4.0	4.5	9	35			0	3	14
15	39	30	35	3	24	30	0		T	0	0	29.57	35	6.2	6.3	12	01			10	8	15
16	37	27	32	1	21	33	0		T	T	T	29.30	36	6.8	7.1	15	36			9	6	16
17	43	30	37	6	26	28	0		T	0	0	29.02	36	4.8	5.8	13	03					17
18	48	25	37	7		28	0		T	0	0					8	36			7		18
19	38	27	33	3	23	32	0	4	T	T	T	28.91	34	1.1	2.3	7	25			6		19
20	33	23	28	-1	28	37	0	1	T	.23	4.0	28.86	35	4.3	5.6	8	32			10		20
21	44	32	38	9	30	27	0		4	0	0	28.66	35	4.8	6.9	12	01			10.	10	21
22	38	18	28	0	25	37	0		3	0	0	28.79	01	1.2	3.5	9	02			9	7	22
23	35	14	25	-3	21	40	0	1	3	.02	.6	29.12	04	2.5	4.6	9	17			4	4	23
24	34	10	22	-6	16	43	0		4	0	0	28.99	01	1.0	3.6	6	04					24
25	29	4*	17*	-10		48	0		4	.04	.4					6	18			2		25
26	25	14	20	-7	17	45	0		4	.08	1.6	29.17	17	2.6	4.3	12	19			10		26
27	39	21	30	4	20	35	0		4	T	T	28.82	35	6.4	7.9	12	35			10		27
28	39	21	30	4	27	35	0		4	.22	2.0	28.86	34	.9	2.2	12	35			10	10	28
29	31	17	24	-1	22	41	0	1	6	T	T	29.03	35	2.6	2.7	9	03			10	8	29
30	31	20	26	1	27	39	0	2	6	.11	2.1	29.15	16	1.8	2.1	9	15			10	10	30
31	29	20	25	1	25	40	0	1	8	.23	2.8	29.22	03	.8	3.7	12	17			10		31
	SUM	SUM				TOTAL	TOTAL	NUMBER OF DAYS		TOTAL	TOTAL	FOR THE MONTH:						TOTAL	% FOR MONTH	SUM	SUM	
	1196	741				1038	0			4.63	27.0					16	16					
	AVG.	AVG.	AVG.	DEP.	AVG.	DEP.	DEP.	PRECIPITATION		DEP.						DATE: 11+		POSSIBLE		AVG.	AVG.	
	38.6	23.9	31.3	-0.1		-4	0	> .01 INCH.	16	2.00												

NUMBER OF DAYS				SEASON TO DATE				GREATEST IN 24 HOURS AND DATES				GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE	
MAXIMUM TEMP.		MINIMUM TEMP.		TOTAL	TOTAL	SNOW, ICE PELLETS > 1.0 INCH	7	PRECIPITATION		SNOW, ICE PELLETS			
≥ 90°	≤ 32°	≤ 32°	≤ 0°	2239	0	THUNDERSTORMS	0	1.56	10	10.9	9-10	13	10
0	6	28	0	DEP.	DEP.	HEAVY FOG	3						
				100	0	CLEAR	PARTLY CLOUDY		CLOUDY				

* EXTREME FOR THE MONTH - LAST OCCURRENCE IF MORE THAN ONE.
T TRACE AMOUNT.
\+ ALSO ON EARLIER DATE(S).
HEAVY FOG: VISIBILITY 1/4 MILE OR LESS.
BLANK ENTRIES DENOTE MISSING OR UNREPORTED DATA.
HOURS OF OPS. MAY BE REDUCED ON A VARIABLE SCHEDULE.

DATA IN COLS 6 AND 12-15 ARE BASED ON 7 OR MORE OBSERVATIONS AT 3-HOUR INTERVALS. RESULTANT WIND IS THE VECTOR SUM OF WIND SPEEDS AND DIRECTIONS DIVIDED BY THE NUMBER OF OBSERVATIONS. ONE OF THREE WIND SPEEDS IS GIVEN UNDER FASTEST MILE: FASTEST MILE - HIGHEST RECORDED SPEED FOR WHICH A MILE OF WIND PASSES STATION (DIRECTION IN COMPASS POINTS). FASTEST OBSERVED ONE MINUTE WIND - HIGHEST ONE MINUTE SPEED (DIRECTION IN TENS OF DEGREES). PEAK GUST - HIGHEST INSTANTANEOUS WIND SPEED (A / APPEARS IN THE DIRECTION COLUMN). ERRORS WILL BE CORRECTED AND CHANGES IN SUMMARY DATA WILL BE ANNOTATED IN THE ANNUAL PUBLICATION.

I CERTIFY THAT THIS IS AN OFFICIAL PUBLICATION OF THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, AND IS COMPILED FROM RECORDS ON FILE AT THE NATIONAL CLIMATIC DATA CENTER, ASHEVILLE, NORTH CAROLINA, 28801

L. Ray Hoxit
ACTING DIRECTOR
NATIONAL CLIMATIC DATA CENTER

noaa

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NATIONAL ENVIRONMENTAL SATELLITE, DATA AND INFORMATION SERVICE

NATIONAL CLIMATIC DATA CENTER ASHEVILLE NORTH CAROLINA

OCT 1983
TALKEETNA, ALASKA

WS FORM F-6 (1-79)

U. S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE

PRELIMINARY LOCAL CLIMATOLOGICAL DATA

STATION: WSCMO, TALKEETNA, ALASKA

MONTH: November YEAR: 1983

LATITUDE: 62 ° 18 ' N LONGITUDE: 150 ° 06 ' W GROUND ELEVATION (ft): 345 FT. STANDARD TIME: YUKON

DAY	TEMPERATURE °F: MAXIMUM	MINIMUM	AVERAGE	DEPARTURE FROM NORMAL	DEGREE DAYS (Base 65°): HEATING	COOLING	PRECIPITATION (In.): TOTAL (Water equivalent)	SNOWFALL, ICE PELLETS	+ SNOW, ICE PELLETS OR ICE ON GROUND AT 0300Y	WIND: * AVERAGE SPEED (m.p.h.)	# FASTEST MILE: SPEED (m.p.h.)	DIRECTION	SUNSHINE: TOTAL (Min.)	* ~~PERCENT OF POSSIBLE~~	SKY COVER SUNRISE TO SUNSET (Tenths)	WEATHER OCCURRENCES	2/ 0300Y	2/ 0900Y		
1	2	3	4	5	6a	6b	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	33	20	27	+3	38	0	0	0	9+	5.4	9	36 1/		18	10		0	9		
2	38	23	31	+8	34	0	T	T	8	7.0	13	01		23	10					
3	39	15	27	+4	38	0	0	0	8	7.0	17	35		23	6					
4	25	9	17	-5	48	0	.08	1.7	8	(1.8)	6	19			9	1				
5	22	2	12	-10	53	0	0	0	10	(1.5)	4	07 1/			6	1				
6	22	-4	9	-12	56	0	0	0	10	3.9	9	36			7	2				
7	29	21	25	+4	40	0	0	0	10	13.9	21	02		23	10					
8	37	25	31	+10	34	0	0	0	9+	9.1	17	02		18	10		0	9		
9	36	21	29	+9	36	0	0	0	9	(6.1)	18	35		23	6					
10	35	28	32	+12	33	0	0	0	9	10.5	18	04		23	10					
11	37	17	27	+8	38	0	0	0	8	5.5	13	01			9					
12	30	17	24	+5	41	0	0	0	8	6.6	12	03			10					
13	25	0	13	-6	52	0	0	0	8	(3.0)	7	02 1/			0					
14	25	0	13	-5	52	0	0	0	8	6.5	10	01 1/		23	3					
15	32	19	26	+8	39	0	0	0	8+	7.5	12	03 1/		18	9		0	9		
16	28	17	23	+6	42	0	.05	0.8	8	7.8	14	04		23	5	1				
17	25	11	18	+1	47	0	.02	0.4	8	4.6	8	35 1/		23	10	1				
18	24	12	18	+1	47	0	.01	0.3	9	8.9	12	01 1/			7					
19	12	-4	4	-12	61	0	0	0	9	2.5	6	04 1/			2					
20	27	-1	13	-3	52	0	T	T	9	11.9	17	03 1/			10					
21	33	27	30	+15	35	0	.07	0.4	9	6.1	14	02	~~25~~	23	10	6				
22	35	30	33	+18	32	0	.02	(0.2)	8+	6.4	10	02 1/	~~18~~	18	9	6	0	9		
23	31	23	27	+12	38	0	T	0.1	8	3.1	8	01 1/		23	10	1				
24	24	4	14	0	51	0	0	0	8	2.6	6	32 1/		23	8	1				
25	24	2	13	-1	52	0	0	0	8	8.8	18	02			6					
26	28	24	26	+12	39	0	T	T	8	10.3	16	02			10					
27	33	24	29	+16	36	0	T	T	8	9.5	17	01			10					
28	37	32	35	+22	30	0	T	T	8	13.5	21	02		23	9					
29	39	26	33	+20	32	0	0	0	7+	(5.8)	15	02		18	9		0	9		
30	37	20	29	+17	36	0	0	0	7	5.9	9	01		23	10					
31																				
SUM	902	460	—	—	1262	0	.25	3.9	—	202.9	—	—	—	—		—				
AVG	30.1	15.3	—	—	—	—	—	—	—	6.8	FASTEST	DIRECTION	POSSIBLE	%	8.0	—				
										MISC. —	21	02 1/								

TEMPERATURE DATA

AVERAGE MONTHLY: 22.7
DEPARTURE FROM NORMAL: + 5.0
HIGHEST: 39 ON 29 1/
LOWEST: -4 ON 19 1/
NUMBER OF DAYS WITH –
MAX. 32° OR BELOW: 17
MAX. 90° OR ABOVE: 0
MIN. 32° OR BELOW: 30
MIN. 0° OR BELOW: 5

HEATING DEGREE DAYS (Base 65°)
TOTAL THIS MONTH: 1262
DEPARTURE FROM NORMAL: -157
SEASONAL TOTAL: 3500!
DEPARTURE FROM NORMAL: -587

COOLING DEGREE DAYS (Base 65°)
TOTAL THIS MONTH: 0
DEPARTURE FROM NORMAL: 0
SEASONAL TOTAL: 0
DEPARTURE FROM NORMAL: 0

PRECIPITATION DATA

TOTAL FOR THE MONTH: .25 IN.
DEPARTURE FROM NORMAL: -1.62 IN.
GREATEST IN 24 HRS.: .09 ON 21-22

SNOWFALL, ICE PELLETS
TOTAL FOR THE MONTH: 3.9 IN.
GREATEST IN 24 HRS.: 1.7 ON 4
GREATEST DEPTH ON GROUND: 10 ON 7 1/

PRESSURE DATA
HIGHEST SEA-LEVEL: 30.21 IN. ON 27
LOWEST SEA-LEVEL: 28.89 IN. ON 11

WEATHER

NUMBER OF DAYS –
CLEAR (Scale 0–3): 3
PARTLY CLOUDY (Scale 4–7): 7
CLOUDY (Scale 8–10): 20
WITH 0.01 INCH OR MORE PRECIP.: 6
WITH 0.10 INCH OR MORE PRECIP.: 0
WITH 0.50 INCH OR MORE PRECIP.: 0
WITH 1.00 INCH OR MORE PRECIP.: 0

SYMBOLS USED IN COLUMN 16

1 = FOG
2 = FOG REDUCING VISIBILITY TO ¼ MILE OR LESS
3 = THUNDER
4 = ICE PELLETS
5 = HAIL
6 = GLAZE OR RIME
7 = BLOWING DUST OR BLOWING SAND REDUCING VSBY TO ⅝ MILE OR LESS
8 = SMOKE OR HAZE
9 = BLOWING SNOW
X = TORNADO

MAXIMUM PRECIPITATION

Δt (Minutes)	5	10	15	20	30	45	60	80	100	120	150	180
PRECIPITATION (Inches)												
ENDED: DATE												
TIME												

*Average wind speed is based on 24 hours unless otherwise indicated.
#Fastest one minute wind speed and its direction.
+Snow data is obtained at 0900Y where indicated.
1/ Indicates only the last of several occurrences.
2/ Synoptic data is based on 6 hours unless otherwise indicated.

WS FORM F-6
(1-79)

U. S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE

PRELIMINARY LOCAL CLIMATOLOGICAL DATA

STATION: WSCMO, TALKEETNA, ALASKA

MONTH: December | YEAR: 1983

LATITUDE: 62° 18' N | LONGITUDE: 150° 06' W | GROUND ELEVATION (ft): 345 FT. | STANDARD TIME: Yukon

DAY	TEMPERATURE °F: MAXIMUM	MINIMUM	AVERAGE	DEPARTURE FROM NORMAL	DEGREE DAYS (Base 65°): HEATING	COOLING	PRECIPITATION (In.): TOTAL (Water equivalent)	SNOWFALL, ICE PELLETS	+ SNOW, ICE PELLETS OR ICE ON GROUND AT 0300Y	WIND: * AVERAGE SPEED (m.p.h.)	FASTEST MILE: # SPEED (m.p.h.)	DIRECTION	SUNSHINE: TOTAL (Min.)	* PERCENT OF POSSIBLE	SKY COVER SUNRISE TO SUNSET (Tenths)	WEATHER OCCURRENCES	2/ 0300Y	2/ 0900Y		
1	2	3	4	5	6a	6b	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	38	28	33	+21	32	0	0	0	7	5.2	14	02		23	10					
2	30	16	23	+11	42	0	0	0	7	0.9	6	05			9	1				
3	28	24	26	+15	39	0	.01	T	7	1.3	5	04			9	16				
4	27	24	26	+15	39	0	.27	2.7	7	6.1	10	36			10	1				
5	31	27	29	+18	36	0	.06	1.0	10	6.4	12	36		23	10					
6	32	14	23	+12	42	0	0	0	10+	3.5	6	02		18	10	1	0	9		
7	19	5	12	+2	53	0	0	0	10	3.9	7	35		23	9	1				
8	7	-4	2	-8	63	0	0	0	10	(2.9)	6	05		23	0					
9	11	-5	3	-7	62	0	0	0	10	11.9	20	01			5					
10	20	10	15	+5	50	0	T	T	10	14.9	21	01			10					
11	24	18	21	+12	44	0	.01	0.2	10	14.1	21	04			10					
12	22	6	14	+5	51	0	0	0	10	7.2	14	02		23	7					
13	21	6	14	+5	51	0	.09	1.8	10+	(5.7)	12	02		18	10	1	0	9		
14	8	-11	-2	-11	67	0	T	T	12	(2.1)	5	04		23	3	1				
15	6	-14	-4	-12	69	0	T	T	12	4.1	7	33		23	0					
16	13	-4	5	-3	60	0	T	T	12	6.6	17	04			10					
17	20	12	16	+8	49	0	.11	1.7	12	4.8	13	02			10	16				
18	23	6	15	+7	50	0	T	T	12	(3.7)	7	33			7	16				
19	24	4	14	+6	51	0	0	0	12	(4.6)	12	03		23	10					
20	30	23	27	+19	38	0	0	0	12+	7.2	10	35		18	10		0	9		
21	32	23	28	+20	37	0	.02	0.2	12	8.6	13	35		23	10	1				
22	28	-3	13	+6	52	0	0	0	12	5.3	13	02		23	0					
23	0	-8	-4	-11	69	0	0	0	11	3.1	6	04			0					
24	42	-9	17	+10	48	0	0	0	11	5.0	13	04			2					
25	45	35	40	+33	25	0	0	0	10	13.6	20	02			0					
26	41	5	23	+16	42	0	0	0	9	(6.6)	17	05		23	0					
27	9	-2	4	-3	61	0	0	0	9+	3.5	6	03		18	0	1	0	9		
28	-1	-8	-5	-12	70	0	0	0	9	3.8	6	06		23	0	1				
29	-4	-13	-9	-16	74	0	0	0	4	4.2	5	06		23	0	1				
30	9	-15	-3	-10	68	0	0	0	9	3.3	9	35			2					
31	21	9	15	+8	50	0	0	0	9	6.9	9	36			8					
SUM	656	199	—	—	1584	0	0.57	7.6	—	181.0	—	—		—	181	—				
AVG	21.2	6.4	—	—	—	—	—	—	—	5.8	FASTEST	DIRECTION	POSSIBLE	%	5.8	—				
										MISC. →	21	04				—				

TEMPERATURE DATA

AVERAGE MONTHLY 13.8

DEPARTURE FROM NORMAL +5.1

HIGHEST 45 ON 25

LOWEST -15 ON 30

NUMBER OF DAYS WITH –

MAX. 32° OR BELOW 27

MAX. 70° OR ABOVE 0

MIN. 32° OR BELOW 30

MIN. 0° OR BELOW 12

HEATING DEGREE DAYS (Base 65°)

TOTAL THIS MONTH 1584

DEPARTURE FROM NORMAL -161

SEASONAL TOTAL 5085

DEPARTURE FROM NORMAL -218

COOLING DEGREE DAYS (Base 65°)

TOTAL THIS MONTH 0

DEPARTURE FROM NORMAL 0

SEASONAL TOTAL 0

DEPARTURE FROM NORMAL 0

PRECIPITATION DATA

TOTAL FOR THE MONTH 0.57 IN.

DEPARTURE FROM NORMAL -0.84 IN.

GREATEST IN 24 HRS. .28 ON 4-5

SNOWFALL, ICE PELLETS

TOTAL FOR THE MONTH 7.6 IN.

GREATEST IN 24 HRS. 3.2 ON 4-5

GREATEST DEPTH ON GROUND 13 ON 17

PRESSURE DATA

HIGHEST SEA-LEVEL 31.08 IN. ON 23

LOWEST SEA-LEVEL 29.36 IN. ON 1

WEATHER

NUMBER OF DAYS –

CLEAR (Scale 0–3) 12

PARTLY CLOUDY (Scale 4–7) 3

CLOUDY (Scale 8–10) 16

WITH 0.01 INCH OR MORE PRECIP. 7

WITH 0.10 INCH OR MORE PRECIP. 2

WITH 0.50 INCH OR MORE PRECIP. 0

WITH 1.00 INCH OR MORE PRECIP. 0

SYMBOLS USED IN COLUMN 16

1 = FOG
2 = FOG REDUCING VISIBILITY TO ¼ MILE OR LESS
3 = THUNDER
4 = ICE PELLETS
5 = HAIL
6 = GLAZE OR RIME
7 = BLOWING DUST OR BLOWING SAND REDUCING VSBY TO ¼ MILE OR LESS
8 = SMOKE OR HAZE
9 = BLOWING SNOW
$\overline{X}$ = TORNADO

MAXIMUM PRECIPITATION

Δt (Minutes)	5	10	15	20	30	45	60	80	100	120	150	180
PRECIPITATION (Inches)												
ENDED: DATE												
TIME												

*Average wind speed is based on 24 hours unless otherwise indicated.

#Fastest one minute wind speed and its direction.

+Snow data is obtained at 0900Y where indicated.

1/ Indicates only the last of several occurrences.

2/ Synoptic data is based on 6 hours unless otherwise indicated.

WS FORM F-6
(1-79)

U. S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE

PRELIMINARY LOCAL CLIMATOLOGICAL DATA

STATION: WSCMO, TALKEETNA, ALASKA
~~XXXXXXX~~

MONTH: JANUARY | YEAR: 1984

LATITUDE: 62° 18' N | LONGITUDE: 150° 06' W | GROUND ELEVATION (ft): 345 FT. | STANDARD TIME: ALASKAN

DAY	TEMPERATURE °F: MAXIMUM	MINIMUM	AVERAGE	DEPARTURE FROM NORMAL	DEGREE DAYS (Base 65°): HEATING	COOLING	PRECIPITATION (In.): TOTAL (Water equivalent)	SNOWFALL, ICE PELLETS	+ SNOW, ICE PELLETS OR ICE ON GROUND AT 0900A	* WIND: AVERAGE SPEED (m.p.h.)	# FASTEST MILE: SPEED (m.p.h.)	DIRECTION	SUNSHINE: TOTAL (Min.)	* PER-CENT OF POSSIBLE	SKY COVER SUNRISE TO SUNSET (Tenths)	WEATHER OCCURRENCES	2/ 0300A	2/ 0300A		
1	2	3	4	5	6a	6b	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	35	21	28	+21	37	0	0	0	9	8.4	15	02		[illegible]	10					
2	32	27	30	+23	35	0	.37	5.0	9	8.0	14	02		23	10	16				
3	32	25	29	+22	36	0	.04	0.2	14+	5.1	13	03		18	10		0	9		
4	29	-16	7	0	58	0	.23	5.0	16	7.1	15	20		23	10	19				
5	9	-25	-8	-15	73	0	.11	1.9	19	4.8	10	01		23	10	1				
6	17	-6	6	-1	59	0	T	T	19	3.2	7	01			10	16				
7	23	-5	9	+2	56	0	T	T	19	4.6	9	32			10	16				
8	16	-10	3	-4	62	0	0	0	19	3.5	9	02			2	1				
9	28	8	18	+11	47	0	0	0	19	6.3	12	36[1]		23	8					
10	30	22	26	+19	39	0	.02	0.4	19+	11.3	16	01		18	10	1	0	9		
11	34	21	28	+21	37	0	.03	1.7	19	7.4	14	17		23	7	1				
12	37	32	35	+27	30	0	.07	0.8	21	5.9	9	35[1]		23	10	1				
13	34	22	28	+20	37	0	.04	0	18	3.2	8	03[1]			9	1				
14	33	24	29	+21	36	0	.15	2.1	18	2.5	7	18			10	1				
15	32	-2	15	+7	50	0	T	0	19	1.4	6	34			3	16				
16	24	-5	10	+2	55	0	0	0	19	3.0	6	32		23	9					
17	26	12	19	+11	46	0	.01	0.4	19+	(0.3)	4	01		18	10	1	0	9		
18	23	-2	11	+3	54	0	.07	1.2	20	2.3	5	03[1]		23	10	1				
19	18	-2	8	0	57	0	0	0	20	3.0	8	33[1]		23	10	1				
20	12	-14	-1	-10	66	0	0	0	19	2.8	7	34			0					
21	8	-16	-4	-13	69	0	0	0	19	4.2	8	02[1]			7	1				
22	12	-9	2	-7	63	0	0	0	19	10.9	16	01			0					
23	-4	-28	-16	-25	81	0	0	0	18	4.8	8	35		23	0					
24	-5	-35	-20	-30	85	0	0	0	18+	2.9	6	06		18	0		0	9		
25	3	-38	-18	-28	83	0	0	0	17	9.3	23	03		23	3					
26	12	-17	-3	-13	68	0	0	0	17	(7.0)	23	04		23	2					
27	11	-13	-1	-11	66	0	0	0	17	6.0	9	34			7					
28	14	-5	5	-5	60	0	.03	0.9	17	6.2	18	01			7	1				
29	28	14	21	+10	44	0	.40	7.7	19	10.3	21	02			10	19				
30	33	28	31	+20	34	0	.33	4.3	27	2.8	12	18[1]		23	10	16				
31	32	13	23	+12	42	0	T	T	28+	(2.6)	8	15		18	8		0	9		
SUM	668	21	—	—	1665	0	1.90	31.6	—	161.1	—	—		—	222	—				
AVG	21.5	0.7	—	—	—	—	—	—	—	5.2	FASTEST	DIREC-TION	POS-SIBLE	%	7.2	—				
										MISC. →	23	04[1]				—				

TEMPERATURE DATA

AVERAGE MONTHLY: 11.1
DEPARTURE FROM NORMAL: + 2.7
HIGHEST: 37 ON 12
LOWEST: -38 ON 25
NUMBER OF DAYS WITH –
MAX. 32° OR BELOW: 25
MAX. ~~90°~~ 70° OR ABOVE: 0
MIN. 32° OR BELOW: 31
MIN. 0° OR BELOW: 18

HEATING DEGREE DAYS (Base 65°)
TOTAL THIS MONTH: 1665
DEPARTURE FROM NORMAL: -90
SEASONAL TOTAL: 6750
DEPARTURE FROM NORMAL: -308

COOLING DEGREE DAYS (Base 65°)
TOTAL THIS MONTH: 0
DEPARTURE FROM NORMAL: 0
SEASONAL TOTAL: 0
DEPARTURE FROM NORMAL: 0

PRECIPITATION DATA

TOTAL FOR THE MONTH: 1.90 IN.
DEPARTURE FROM NORMAL: + .45 IN.
GREATEST IN 24 HRS.: .55 ON 29-30

SNOWFALL, ICE PELLETS
TOTAL FOR THE MONTH: 31.6 IN.
GREATEST IN 24 HRS.: 9.0 ON 29-30
GREATEST DEPTH ON GROUND: 29 ON 30

PRESSURE DATA
HIGHEST SEA-LEVEL: 30.70 IN. ON 15
LOWEST SEA-LEVEL: 28.88 IN. ON 1

WEATHER

NUMBER OF DAYS –
CLEAR (Scale 0–3): 8
PARTLY CLOUDY (Scale 4–7): 4
CLOUDY (Scale 8–10): 19
WITH 0.01 INCH OR MORE PRECIP.: 14
WITH 0.10 INCH OR MORE PRECIP.: 6
WITH 0.50 INCH OR MORE PRECIP.: 0
WITH 1.00 INCH OR MORE PRECIP.: 0

SYMBOLS USED IN COLUMN 16

1 = FOG
2 = FOG REDUCING VISIBILITY TO 1/4 MILE OR LESS
3 = THUNDER
4 = ICE PELLETS
5 = HAIL
6 = GLAZE OR RIME
7 = BLOWING DUST OR BLOWING SAND REDUCING VSBY TO 5/8 MILE OR LESS
8 = SMOKE OR HAZE
9 = BLOWING SNOW
X = TORNADO

MAXIMUM PRECIPITATION

Δt (Minutes)	5	10	15	20	30	45	60	80	100	120	150	180
PRECIPITATION (Inches)												
ENDED: DATE												
TIME												

* Average wind speed is based on 24 hours unless otherwise indicated.
\# Fastest one minute wind speed and its direction.
\+ Snow data is obtained at 0900A where indicated.
1/ Indicates only the last of several occurrences.
2/ Synoptic data is based on 6 hours unless otherwise indicated.

R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

ONTHLY SUMMARY FOR SHERMAN WEATHER STATION
DATA TAKEN DURING September, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	12.4	5.8	9.1	190	.2	.6	281	3.8	SSW	94	8.7	2.8	1370	1
2	15.3	-.9	7.2	046	.4	.5	045	3.2	N	38	-.1	0.0	5145	2
3	16.5	-1.5	7.5	023	.2	.5	340	2.5	ENE	48	3.1	0.0	3290	3
4	13.1	-2.3	5.4	066	.4	.4	094	3.8	NE	42	-1.0	0.0	2763	4
5	14.2	-3.6	5.3	269	.1	.5	195	3.2	NW	37	-1.7	0.0	4348	5
6	15.0	-4.3	5.4	052	.2	.5	084	3.8	NNW	30	-4.0	0.0	4625	6
7	14.7	-3.7	5.5	215	.1	.6	192	3.8	NNW	48	1.9	0.0	3553	7
8	12.8	3.8	8.3	258	.2	.4	227	3.2	SSW	61	5.1	.2	2093	8
9	14.6	4.7	9.7	236	.3	.6	222	4.4	N	55	4.4	.2	3210	9
10	15.0	.9	8.0	337	.2	.4	052	1.9	NNW	54	4.5	.4	2468	10
11	15.5	1.0	8.3	294	.2	.3	255	3.2	SSW	50	3.7	0.0	2398	11
12	14.8	3.3	9.1	229	.5	.6	245	4.4	SW	54	3.6	0.0	2388	12
13	12.9	1.5	7.2	051	.3	.4	071	3.2	ENE	65	4.8	0.0	2230	13
14	7.5	.1	3.8	186	.3	.7	203	3.8	S	90	4.7	.6	1113	14
15	11.9	-3.7	4.1	005	.3	.5	026	4.4	W	54	1.4	0.0	2953	15
16	15.7	-4.8	5.5	037	.4	.6	249	4.4	NNW	39	-.6	0.0	3815	16
17	12.8	-5.1	3.9	209	.4	.7	224	4.4	WSW	43	-.1	0.0	3698	17
18	13.5	-4.8	4.4	032	.3	.5	027	3.2	E	51	.2	0.0	2530	18
19	12.0	-3.0	4.5	039	.9	1.0	049	6.3	NNE	53	1.6	0.0	1430	19
20	8.8	5.0	6.9	033	.4	.4	045	2.5	NE	96	5.1	3.8	690	20
21	12.2	5.9	9.1	013	.2	.4	104	2.5	N	86	9.1	0.0	1533	21
22	9.8	.3	5.1	016	.2	.7	207	4.4	NNW	74	-4.0	.4	1108	22
23	3.4	-2.6	.4	055	1.4	1.5	048	8.9	NE	46	-10.3	0.0	2335	23
24	-.6	-3.4	-2.0	050	3.2	3.3	051	9.5	NE	42	-13.6	0.0	2205	24
25	3.7	-9.2	-2.8	054	2.0	2.1	040	7.6	NE	37	-13.6	0.0	3283	25
26	3.9	-11.6	-3.9	067	1.0	1.1	057	5.1	ENE	39	-11.2	0.0	3085	26
27	3.6	-11.1	-3.8	059	1.0	1.0	067	4.4	ENE	46	-9.0	0.0	1948	27
28	1.8	-.9	.5	034	.6	.6	015	2.5	NNE	89	-1.4	.2	598	28
29	3.4	.2	1.8	063	.4	.5	339	1.9	ENE	**	*****	8.0	473	29
30	10.2	2.3	6.3	223	1.0	1.3	236	7.0	SW	85	6.0	4.2	1363	30
MONTH	16.5	-11.6	4.6	050	.3	.8	051	9.5	NE	52	-.1	20.8	74033	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 8.3
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 8.3
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 7.0
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 8.9

OTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

*** SEE NOTES AT THE BACK OF THIS REPORT ****

R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR SHERMAN WEATHER STATION
DATA TAKEN DURING October, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	7.9	2.4	5.2	206	.5	1.0	209	5.1	SSW	80	2.5	2.2	1430	1
2	10.3	-.3	5.0	049	1.3	1.3	061	7.0	NE	54	-1.5	.4	1825	2
3	7.9	-3.2	2.4	063	1.1	1.2	044	5.7	NE	37	-9.1	0.0	2500	3
4	9.1	-6.7	1.2	075	.3	.5	084	2.5	E	32	-8.8	0.0	2403	4
5	3.6	-1.1	1.3	049	.2	.3	071	1.9	E	63	-3.3	0.0	590	5
6	5.2	-7.9	-1.4	135	.3	.4	138	3.2	S	66	-5.3	.2	1916	6
7	.9	-11.7	-5.4	076	.6	.7	041	3.2	ENE	36	-13.1	0.0	2230	7
8	1.0	-13.4	-6.2	059	.6	.7	060	3.2	ENE	40	-13.1	0.0	1955	8
9	-1.3	-3.4	-2.4	041	.9	.9	053	3.8	NE	86	-4.4	0.0	225	9
10	1.0	-1.2	-.1	032	.2	.3	070	1.9	N	**	*****	2.0	365	10
11	7.4	.5	4.0	175	.2	.8	208	4.4	ENE	83	2.0	3.4	1445	11
12	4.5	.5	2.5	206	.5	.7	215	3.8	SSW	85	.8	2.2	955	12
13	3.5	-4.2	-.4	017	.2	.4	049	1.9	N	87	-3.8	.4	945	13
14	3.0	-8.0	-2.5	054	.8	.7	059	2.5	NE	80	-8.3	0.0	2125	14
15	3.4	-3.7	-.2	054	1.2	1.0	069	5.1	NE	53	-7.0	0.0	1020	15
16	3.1	-4.6	-.8	060	1.4	1.5	058	5.1	ENE	52	-9.0	0.0	1110	16
17	7.2	-4.4	1.4	050	.9	1.0	074	4.4	NNE	58	-6.7	0.0	1400	17
18	6.5	-1.3	2.6	060	.9	.9	063	3.8	ENE	51	-4.6	0.0	1610	18
19	.2	-6.7	-3.3	023	.8	.9	003	3.2	NNE	69	-6.4	0.0	560	19
20	.1	-6.7	-3.3	036	.6	.7	020	2.5	NNE	79	-6.8	0.0	330	20
21	3.8	-2.9	.5	044	.7	.7	075	3.8	NE	73	-3.1	0.0	550	21
22	5.4	-7.2	-.9	063	.1	.7	224	5.7	NNE	65	-4.2	.2	1370	22
23	3.4	-11.7	-4.2	097	.3	.6	075	4.4	ENE	63	-6.5	0.0	1170	23
24	1.5	-12.1	-5.3	055	.9	1.0	032	3.8	ENE	49	-11.2	0.0	995	24
25	-.2	-13.2	-6.7	052	.9	1.0	066	5.1	E	47	-14.5	0.0	1300	25
26	1.7	-11.4	-4.9	221	.5	1.4	209	7.0	SSW	67	-9.8	0.0	920	26
27	2.6	-9.3	-3.4	050	1.1	1.2	048	5.1	NE	55	-8.8	0.0	955	27
28	2.0	-2.7	-.4	080	.2	.9	220	5.7	SSW	62	-6.3	0.0	550	28
29	-2.0	-9.0	-5.5	***	****	.4	***	****	***	**	*****	0.0	325	29
30	.1	-7.0	-3.5	196	.8	.9	199	3.2	SSW	88	-3.5	0.0	265	30
31	-1.9	-6.2	-4.1	206	.3	.7	219	3.8	SSW	86	-4.7	0.0	235	31
MONTH	10.3	-13.4	-1.2	061	.5	.8	061	7.0	ENE	62	-6.2	11.0	35574	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 5.7
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 5.7
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 5.1
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 5.7

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR SHERMAN WEATHER STATION
DATA TAKEN DURING November, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	-.6	-9.5	-5.1	041	.8	.9	049	3.8	NE	81	-6.5	0.0	270	1
2	4.2	-7.0	-1.4	064	.8	.9	059	3.8	ENE	67	-4.0	.4	390	2
3	3.5	-9.4	-3.0	056	.9	1.0	045	3.8	ENE	82	-6.3	0.0	1025	3
4	-1.8	-10.5	-6.2	079	.7	.8	046	3.8	E	84	-9.7	0.0	640	4
5	-1.4	-14.3	-7.9	072	.4	.5	047	1.9	E	61	-8.7	0.0	930	5
6	-8.4	-17.3	-12.9	065	.4	.4	076	3.2	ENE	**	*****	0.0	665	6
7	-1.6	-10.3	-6.0	047	1.2	1.2	051	4.4	NE	69	-9.1	0.0	460	7
8	2.7	-3.6	-.5	036	.9	1.0	040	3.8	NNE	67	-6.1	0.0	485	8
9	4.3	-3.2	.6	061	1.1	1.2	059	4.4	ENE	46	-10.6	0.0	745	9
10	2.9	-3.1	-.1	063	1.2	1.3	069	3.8	ENE	48	-9.9	0.0	595	10
11	.9	-9.1	-4.1	051	1.0	1.0	071	3.8	ENE	59	-9.7	0.0	555	11
12	-1.4	-7.5	-4.5	062	.6	.6	038	2.5	E	60	-10.2	0.0	385	12
13	-6.3	-15.4	-10.9	077	.6	.6	071	2.5	ENE	92	-14.0	0.0	490	13
14	-7.3	-17.8	-12.6	052	.6	.6	050	2.5	NE	90	-12.7	0.0	470	14
15	.3	-13.9	-6.8	055	.9	1.0	045	3.2	ENE	69	-9.3	0.0	475	15
16	-2.2	-10.6	-6.4	050	.7	.7	050	3.2	NE	88	-7.1	0.0	400	16
17	-6.9	-15.4	-11.2	068	.6	.6	062	2.5	ENE	**	*****	0.0	378	17
18	-6.5	-17.6	-12.1	057	.6	.7	037	2.5	ENE	69	-11.6	0.0	405	18
19	-15.0	-21.2	-18.1	064	.3	.3	059	1.3	ENE	**	*****	0.0	345	19
20	-2.4	-20.6	-11.5	057	.7	.7	052	3.2	ENE	82	-7.0	0.0	270	20
21	3.4	-2.0	.7	054	.8	.9	049	5.1	ENE	69	-4.6	0.0	305	21
22	.1	-4.5	-2.2	057	.2	.3	069	1.3	ENE	**	*****	0.0	215	22
23	-3.4	-9.9	-6.7	059	.3	.3	035	1.9	ENE	**	*****	0.0	285	23
24	-7.4	-19.6	-13.5	052	.1	.1	310	1.3	ENE	**	*****	0.0	235	24
25	-6.7	-17.5	-12.1	026	.3	.3	031	3.2	NNE	82	-10.1	0.0	255	25
26	-4.4	-9.3	-6.9	036	.8	.8	024	3.2	NNE	77	-9.6	0.0	260	26
27	-2.5	-8.8	-5.7	050	.7	.7	021	2.5	NE	96	-4.8	0.0	245	27
28	2.6	-4.1	-.8	055	1.0	1.0	054	3.8	ENE	69	-3.9	0.0	285	28
29	4.0	-3.4	.3	054	.8	.9	046	2.5	NE	73	-4.7	0.0	290	29
30	3.4	-7.0	-1.8	057	.7	.7	051	3.2	NE	61	-6.4	0.0	280	30
MONTH	4.3	-21.2	-6.3	055	.7	.7	049	5.1	ENE	67	-8.2	.4	13033	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 2.5
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 3.8
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 5.1
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 5.1

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR SHERMAN WEATHER STATION
DATA TAKEN DURING December, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	2.2	-3.1	-.5	059	.7	.7	064	2.5	ENE	63	-5.7	0.0	265	1
2	-2.9	-8.5	-5.7	026	.2	.3	075	1.9	NNW	**	*****	0.0	280	2
3	-3.4	-6.5	-5.0	042	.1	.1	059	1.3	N	**	*****	0.0	265	3
4	-2.8	-8.8	-5.8	052	.2	.2	046	1.9	NE	**	*****	0.0	170	4
5	-2.4	-3.8	-3.1	058	.3	.2	062	1.9	NE	**	*****	0.0	155	5
6	-1.5	-10.7	-6.1	071	.2	.2	067	1.3	ENE	**	*****	0.0	245	6
7	-10.7	-15.6	-13.2	***	0.0	0.0	025	.6	***	**	*****	0.0	290	7
8	-11.4	-20.6	-16.0	***	0.0	0.0	034	.6	***	**	*****	0.0	255	8
9	-12.9	-22.9	-17.9	054	.4	.4	049	3.8	ENE	68	-19.4	0.0	280	9
10	-6.1	-14.5	-10.3	070	1.8	1.8	066	5.1	ENE	63	-15.3	0.0	290	10
11	-4.5	-9.5	-7.0	067	1.6	1.6	081	4.4	ENE	67	-11.6	0.0	265	11
12	-7.2	-16.1	-11.7	046	.8	.9	038	3.2	NE	80	-13.9	0.0	240	12
13	-5.5	-14.3	-9.9	059	.9	1.0	066	4.4	ENE	71	-11.6	0.0	215	13
14	-16.0	-21.2	-18.6	057	.3	.3	045	1.9	NE	**	*****	0.0	215	14
15	-18.4	-25.7	-22.1	072	.2	.2	072	2.5	ENE	**	*****	0.0	270	15
16	-12.5	-17.7	-15.1	054	.8	.8	059	3.8	NE	73	-17.1	0.0	255	16
17	-8.5	-12.6	-10.6	052	.9	1.0	059	3.2	ENE	85	-13.0	0.0	170	17
18	-7.7	-17.8	-12.8	050	.7	.7	075	2.5	ENE	93	-13.9	0.0	215	18
19	-6.8	-17.5	-12.2	067	.5	.5	065	1.9	ENE	91	-16.6	0.0	190	19
20	-3.3	-7.1	-5.2	064	.5	.6	051	2.5	ENE	**	*****	0.0	180	20
21	-2.2	-5.8	-4.0	059	.5	.5	046	1.9	ENE	**	*****	0.0	175	21
22	-4.3	-19.8	-12.1	062	.5	.5	022	1.9	ENE	**	*****	0.0	220	22
23	-16.5	-21.3	-18.9	057	.3	.4	061	1.9	ENE	**	*****	0.0	245	23
24	-9.4	-19.5	-14.5	066	.6	.6	074	1.9	ENE	**	*****	0.0	250	24
25	.6	-10.0	-4.7	051	1.0	1.1	039	4.4	NE	67	-8.6	0.0	290	25
26	-7.7	-17.0	-12.4	080	.8	.8	053	2.5	ENE	77	-13.4	0.0	240	26
27	-13.3	-22.2	-17.8	052	.4	.4	082	1.9	NE	91	-15.6	0.0	250	27
28	-20.7	-23.9	-22.3	044	.3	.4	009	1.9	NE	**	*****	0.0	255	28
29	-21.7	-26.0	-23.9	057	.3	.3	042	1.3	NE	**	*****	0.0	265	29
30	-16.7	-27.3	-22.0	051	.1	.1	085	1.3	NNE	**	*****	0.0	265	30
31	-10.2	-16.3	-13.3	054	.5	.6	039	1.9	ENE	**	*****	0.0	240	31
MONTH	2.2	-27.3	-12.1	059	.5	.6	066	5.1	ENE	71	-13.5	0.0	7405	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 3.8
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 4.4
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 3.8
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 4.4

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

R & CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

NTHLY SUMMARY FOR DEVIL CANYON WEATHER STATION
TA TAKEN DURING September, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	10.2	5.6	7.9	173	.0	.8	274	5.1	ENE	14	-21.3	0.0	1080	1
2	12.1	1.0	6.6	146	.3	1.1	116	3.8	SE	36	-10.1	0.0	4495	2
3	13.0	.6	6.8	088	.9	1.3	297	4.4	E	66	.0	0.0	2748	3
4	8.9	-1.1	3.9	079	.8	1.3	019	5.7	ESE	69	-2.4	0.0	2264	4
5	11.6	-3.0	4.3	119	.5	1.3	231	4.4	E	65	-3.0	0.0	3498	5
6	11.4	-2.1	4.7	087	1.0	1.5	104	5.1	E	38	-12.2	0.0	4280	6
7	11.1	-10.5	.3	065	.6	1.1	047	3.2	NE	72	-1.2	0.0	2001	7
8	9.6	3.8	6.7	070	.1	.8	248	3.2	ESE	53	-9.2	0.0	1668	8
9	11.8	3.5	7.7	333	.3	.9	300	3.8	WNW	56	-3.1	0.0	1895	9
10	11.7	3.7	7.7	144	.2	.7	157	2.5	SE	60	-5.7	0.0	1895	10
11	13.0	3.2	8.1	069	.7	1.0	091	4.4	ENE	56	-4.7	0.0	2143	11
12	11.5	3.7	7.6	306	.6	1.3	319	5.7	WNW	71	3.2	0.0	2183	12
13	11.0	2.7	6.9	093	.9	1.2	013	5.7	E	49	-5.8	0.0	2010	13
14	6.4	2.6	4.5	245	.5	1.0	282	5.1	SSE	39	-15.3	0.0	1403	14
15	8.9	-1.6	3.7	238	.3	1.0	009	4.4	W	76	.4	0.0	2385	15
16	12.5	-3.0	4.8	110	.6	1.2	000	3.8	E	50	-7.2	0.0	3173	16
17	10.0	-2.6	3.7	158	.1	1.3	276	4.4	E	68	-1.9	0.0	3085	17
18	11.3	-8.4	1.5	090	1.1	1.4	058	3.8	ENE	68	-2.4	0.0	2705	18
19	9.4	-.2	4.6	109	1.3	1.5	094	5.1	ESE	66	.4	0.0	1443	19
20	8.7	3.6	6.2	121	.2	.5	141	1.9	E	13	-20.8	0.0	903	20
21	11.3	5.7	8.5	089	.3	.8	138	2.5	E	13	-20.2	0.0	1608	21
22	7.3	-.9	3.2	223	.4	1.1	033	5.1	W	17	-19.2	0.0	1285	22
23	-.1	-5.8	-3.0	089	1.7	2.0	041	8.9	ENE	54	-11.4	0.0	1228	23
24	6.4	-9.3	-1.5	035	1.9	2.4	028	9.5	ENE	50	-13.6	0.0	2351	24
25	-.8	-6.7	-3.8	083	2.0	2.6	143	10.2	ESE	45	-14.2	0.0	2847	25
26	0.0	-8.9	-4.5	136	1.6	1.8	108	6.3	S	50	-12.4	0.0	3048	26
27	.6	-9.0	-4.2	098	1.4	1.7	061	5.7	E	53	-10.5	0.0	2183	27
28	2.1	-2.8	-.4	092	1.2	1.3	081	5.1	E	66	-8.7	0.0	1015	28
29	3.7	.1	1.9	120	.9	1.1	116	3.2	ESE	28	-20.0	0.0	638	29
30	7.3	2.4	4.9	108	.4	1.0	121	3.8	E	17	-23.2	0.0	1090	30
MONTH	13.0	-10.5	3.6	093	.5	1.2	143	10.2	ESE	52	-9.2	0.0	64543	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 8.9
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 5.7
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 3.2
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 3.2

OTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

*** SEE NOTES AT THE BACK OF THIS REPORT ****

R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR DEVIL CANYON WEATHER STATION
DATA TAKEN DURING October, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	5.8	.2	3.0	209	.5	.9	144	3.8	WSW	17	-22.4	0.0	988	1
2	7.7	.2	4.0	118	.6	1.1	012	8.3	SE	60	-2.5	0.0	1540	2
3	4.4	-3.0	.7	083	1.2	1.8	020	7.6	ESE	57	-6.6	0.0	1988	3
4	6.6	-4.1	1.3	110	.7	1.2	045	4.4	E	60	-6.7	0.0	1987	4
5	2.2	-1.6	.3	066	.4	.6	062	2.5	ENE	72	-4.9	0.0	710	5
6	2.2	-8.3	-3.1	119	.7	.8	101	3.8	SE	80	-7.6	0.0	1497	6
7	-2.3	-10.9	-6.6	114	1.6	1.9	101	5.7	E	75	-11.5	0.0	1875	7
8	-.8	-13.2	-7.0	098	1.6	1.8	087	4.4	SE	69	-12.1	0.0	1790	8
9	-2.4	-5.2	-3.8	089	1.0	1.1	079	3.8	E	55	-18.2	0.0	630	9
10	1.0	-2.8	-.9	100	.3	.3	076	3.2	E	18	-21.6	0.0	350	10
11	7.7	.1	3.9	201	.6	.9	254	6.3	S	19	-24.6	1.6	1340	11
12	3.8	-.2	1.8	182	.3	.8	232	3.2	E	16	-25.2	.2	805	12
13	1.5	-5.6	-2.1	334	.1	.5	302	1.9	NNE	11	-29.5	0.0	430	13
14	-.5	-10.0	-5.3	131	1.0	1.3	132	3.2	SSE	45	-21.1	0.0	1470	14
15	.8	-7.0	-3.1	104	1.5	1.5	095	4.4	ESE	68	-5.2	0.0	830	15
16	.4	-8.9	-4.3	103	2.0	2.1	088	7.0	ESE	71	-6.8	0.0	1175	16
17	5.1	-5.1	0.0	132	1.2	1.4	112	3.8	SE	74	-3.9	0.0	1070	17
18	3.4	-1.1	1.2	102	1.5	1.6	074	4.4	ESE	81	-1.4	0.0	1215	18
19	-.7	-3.5	-2.1	110	1.2	1.3	085	4.4	E	80	-7.1	0.0	555	19
20	-.5	-3.5	-2.0	091	1.0	1.1	058	5.1	E	74	-9.8	0.0	485	20
21	4.3	-2.0	1.2	128	1.1	1.3	098	6.3	SE	77	-2.4	0.0	905	21
22	3.7	-3.5	.1	114	1.0	1.4	099	5.1	E	62	-9.2	0.0	795	22
23	.9	-8.7	-3.9	110	1.4	1.5	113	7.0	ESE	45	-18.4	0.0	878	23
24	-1.6	-10.9	-6.3	120	.8	.9	123	3.8	ESE	47	-15.0	0.0	1207	24
25	-3.3	-12.5	-7.9	117	1.1	1.3	112	4.4	ESE	72	-11.5	0.0	818	25
26	-1.6	-9.2	-5.4	108	1.1	1.6	114	6.3	E	59	-14.7	0.0	731	26
27	-.2	-28.4	-14.3	137	1.0	1.3	093	5.7	ESE	57	-6.4	0.0	846	27
28	.1	-4.0	-2.0	121	.7	1.2	105	5.7	SE	53	-12.7	0.0	614	28
29	-2.0	-10.0	-6.0	100	.8	1.0	077	3.8	E	14	-36.8	0.0	475	29
30	-1.4	-5.2	-3.3	253	.3	.6	243	2.5	WSW	22	-26.7	0.0	376	30
31	-3.5	-8.2	-5.9	166	.3	.7	127	3.2	WSW	7	-35.4	0.0	304	31
MONTH	7.7	-28.4	-2.5	112	.8	1.2	012	8.3	ESE	57	-14.1	1.8	30578	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 3.2
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 5.7
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 7.6
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 7.0

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR WATANA WEATHER STATION
DATA TAKEN DURING September, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	1
2	*****	*****	*****	***	****	****	***	****	***	**	*****	0.0	7669	2
3	6.1	1.4	3.8	078	1.8	2.0	048	5.1	E	55	-5.1	0.0	2755	3
4	10.0	4.4	7.2	043	2.2	2.9	095	6.1	NNE	50	-3.3	0.0	7428	4
5	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	5
6	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	6
7	8.3	2.3	5.3	089	1.3	1.7	266	8.3	E	82	2.7	2.8	920	7
8	3.4	3.2	3.3	018	1.2	1.2	024	1.9	NNE	99	3.1	****	240	8
9	8.8	3.6	6.2	288	1.2	1.5	280	6.3	W	74	2.6	1.0	2421	9
10	11.0	4.2	7.6	292	1.3	2.1	252	5.1	N	69	1.9	0.0	4151	10
11	11.1	1.6	6.4	084	1.2	1.6	093	4.4	E	71	.9	1.0	1814	11
12	11.2	2.6	6.9	283	.5	1.6	293	5.7	NNE	67	.9	0.0	3323	12
13	8.3	1.2	4.8	081	3.8	3.9	089	9.5	E	67	-3.5	0.0	1981	13
14	5.2	.1	2.7	036	.6	2.7	091	5.7	ENE	70	-6.2	1.2	1920	14
15	7.6	.1	3.9	015	.6	1.5	257	4.4	N	46	-11.9	0.0	2668	15
16	10.7	-3.2	3.8	066	1.3	1.8	126	6.3	NNE	62	-2.4	0.0	4123	16
17	10.0	-4.7	2.7	305	.9	2.1	243	6.3	NNE	67	-3.1	2.0	4414	17
18	8.6	-6.7	1.0	070	2.5	2.9	083	44.0	E	64	-4.0	0.0	2403	18
19	7.2	1.6	4.4	081	4.8	4.9	093	10.2	E	58	-6.0	1.8	1850	19
20	8.5	2.7	5.6	066	2.1	3.0	095	8.3	ENE	41	-14.9	1.2	1975	20
21	8.3	4.5	6.4	094	1.1	1.4	083	5.7	ESE	27	-20.0	0.0	1943	21
22	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	22
23	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	23
24	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	24
25	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	25
26	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	26
27	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	27
28	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	28
29	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	29
30	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	30
MONTH	11.2	-6.7	4.8	068	1.4	2.5	083	44.0	E	61	-4.0	11.0	53997	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 2.5
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 4.4
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 1.9
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 1.9

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR WATANA WEATHER STATION
DATA TAKEN DURING October, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	1
2	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	2
3	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	3
4	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	4
5	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	5
6	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	6
7	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	7
8	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	8
9	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	9
10	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	10
11	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	11
12	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	12
13	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	13
14	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	14
15	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	15
16	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	16
17	.9	-.8	.1	071	1.0	1.1	087	6.3	ENE	81	-2.2	0.0	1164	17
18	.5	-5.1	-2.3	066	2.7	2.7	074	7.6	ENE	75	-5.6	0.0	1510	18
19	-2.7	-6.3	-4.5	060	2.4	2.6	059	6.3	ENE	71	-8.8	0.0	875	19
20	-2.7	-5.2	-4.0	069	4.7	4.8	080	9.5	ENE	77	-7.6	.2	1405	20
21	1.8	-3.2	-.7	067	3.8	4.0	095	9.5	ENE	67	-6.4	0.0	1140	21
22	-.1	-4.6	-2.4	068	3.1	3.2	066	9.5	ENE	69	-7.3	.4	1290	22
23	-1.9	-7.1	-4.5	064	3.1	3.4	085	10.2	ENE	75	-8.6	0.0	1430	23
24	-2.4	-10.5	-6.5	076	1.6	2.0	105	5.7	E	65	-12.8	0.0	1360	24
25	-6.7	-9.4	-8.1	050	4.9	4.9	057	8.9	NE	51	-16.5	0.0	1495	25
26	-4.6	-9.1	-6.9	072	4.5	5.1	058	14.0	ENE	70	-11.9	.8	1180	26
27	-2.7	-11.8	-7.3	062	2.9	3.1	057	6.3	NE	68	-10.6	0.0	975	27
28	-2.9	-8.3	-5.6	080	3.2	3.6	084	11.4	ENE	77	-7.8	.8	780	28
29	-1.3	-9.6	-5.5	069	2.5	2.6	079	8.3	ENE	85	-6.5	0.0	630	29
30	-2.3	-6.0	-4.2	295	1.0	1.5	294	4.4	WNW	90	-6.4	.8	825	30
31	-3.6	-11.9	-7.8	075	.8	3.4	082	10.8	E	81	-8.6	0.0	470	31
MONTH	1.8	-11.9	-4.7	066	2.8	3.2	058	14.0	ENE	73	-8.5	3.0	16529	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 8.9
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 13.3
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 10.2
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 11.4

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR WATANA WEATHER STATION
DATA TAKEN DURING November, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	-2.3	-13.4	-7.9	068	3.9	4.0	084	8.9	ENE	69	-10.9	0.0	745	1
2	-1.8	-10.2	-6.0	065	5.1	5.4	057	11.4	ENE	68	-9.9	0.0	555	2
3	-1.8	-10.6	-6.2	067	2.1	2.3	051	5.7	E	72	-11.2	0.0	1445	3
4	-3.3	-11.9	-7.6	064	3.9	4.1	080	8.3	ENE	61	-13.6	0.0	615	4
5	-5.1	-12.0	-8.6	063	1.4	1.6	014	4.4	E	70	-12.8	0.0	630	5
6	-7.7	-14.8	-11.3	073	2.7	2.9	074	10.2	ENE	75	-15.0	0.0	1195	6
7	-6.8	-11.6	-9.2	061	6.5	6.6	056	12.1	ENE	69	-14.3	0.0	515	7
8	-.2	-7.0	-3.6	063	4.7	4.8	061	8.9	ENE	57	-11.1	0.0	510	8
9	-1.0	-8.4	-4.7	071	6.0	6.0	078	12.1	ENE	42	-15.4	0.0	880	9
10	-4.1	-8.4	-6.3	073	4.9	5.0	084	12.1	ENE	44	-16.4	0.0	680	10
11	-2.5	-9.9	-6.2	072	3.3	3.5	076	8.9	ENE	49	-16.1	0.0	590	11
12	-6.8	-12.3	-9.6	073	1.4	1.6	062	6.3	E	62	-15.8	0.0	360	12
13	-7.1	-15.6	-11.4	080	3.0	3.1	076	7.6	E	71	-15.4	0.0	1000	13
14	-9.2	-15.1	-12.2	084	3.2	3.3	088	8.3	E	72	-15.9	0.0	940	14
15	-6.6	-16.2	-11.4	085	5.0	5.1	068	9.5	E	65	-15.7	0.0	415	15
16	-8.6	-15.0	-11.8	073	2.6	2.7	080	10.2	ENE	83	-13.1	.4	597	16
17	-7.8	-15.9	-11.9	071	3.1	3.2	066	10.8	ENE	84	-14.7	0.0	395	17
18	-10.2	-18.1	-14.2	056	1.7	1.9	084	4.4	E	84	-16.9	0.0	615	18
19	-10.1	-18.0	-14.1	046	1.0	1.3	329	3.8	ENE	87	-16.6	0.0	525	19
20	-6.7	-18.5	-12.6	072	6.1	6.2	075	12.7	ENE	83	-13.8	0.0	250	20
21	.9	-6.2	-2.7	084	7.0	7.0	094	14.6	E	78	-5.1	0.0	240	21
22	-.8	-9.1	-5.0	069	2.2	2.3	089	8.3	E	88	-6.4	0.0	355	22
23	-6.4	-10.6	-8.5	096	2.0	2.0	095	5.1	E	88	-10.0	0.0	280	23
24	-7.5	-14.5	-11.0	078	3.4	3.6	066	7.0	E	81	-13.7	0.0	530	24
25	-11.0	-14.5	-12.8	063	4.6	4.7	076	9.5	ENE	83	-15.0	0.0	480	25
26	-7.5	-11.7	-9.6	068	4.7	4.8	059	8.3	ENE	74	-13.0	0.0	335	26
27	-5.1	-9.6	-7.4	062	3.4	3.5	055	7.6	ENE	82	-9.8	0.0	225	27
28	.8	-6.8	-3.0	075	6.7	6.8	085	14.0	ENE	78	-6.6	0.0	280	28
29	1.8	-1.6	.1	072	6.0	6.2	095	13.3	ENE	57	-7.2	0.0	295	29
30	.5	-2.5	-1.0	070	5.1	5.3	083	12.1	ENE	55	-9.1	0.0	315	30
MONTH	1.8	-18.5	-8.2	071	3.9	4.0	094	14.6	ENE	71	-12.7	.4	16792	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 13.3
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 13.3
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 14.0
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 13.3

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

**** SEE NOTES AT THE BACK OF THIS REPORT ****

R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR WATANA WEATHER STATION
DATA TAKEN DURING December, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	.3	-4.2	-2.0	070	4.0	4.2	084	8.3	ENE	68	-6.8	0.0	230	1
2	-2.4	-6.3	-4.4	038	.7	1.3	051	4.4	E	91	-6.0	0.0	275	2
3	-6.1	-10.6	-8.4	085	1.0	1.3	108	3.8	E	90	-9.8	0.0	320	3
4	-7.0	-8.6	-7.8	074	3.2	3.3	079	9.5	ENE	90	-9.0	0.0	140	4
5	-3.9	-7.9	-5.9	068	1.6	1.7	055	4.4	E	90	-6.8	0.0	140	5
6	-4.2	-6.4	-5.3	088	2.1	2.2	078	8.3	E	91	-6.7	0.0	205	6
7	-5.1	-8.7	-6.9	078	5.3	5.3	078	9.5	ENE	87	-8.0	0.0	335	7
8	-8.6	-14.5	-11.6	076	5.0	5.1	092	10.8	ENE	85	-13.8	0.0	385	8
9	-13.6	-20.2	-16.9	082	6.5	6.5	077	11.4	E	65	-23.1	0.0	345	9
10	-13.7	-19.2	-16.5	069	7.7	7.7	069	12.1	ENE	65	-21.8	0.0	245	10
11	-10.3	-15.2	-12.8	075	6.3	6.4	077	10.8	ENE	73	-16.6	0.0	215	11
12	-10.4	-15.2	-12.8	083	5.4	5.4	080	10.8	E	73	-16.1	0.0	175	12
13	-12.6	-14.7	-13.7	068	5.8	5.8	065	10.8	ENE	79	-16.3	0.0	150	13
14	-15.3	-22.7	-19.0	076	1.5	1.6	082	3.2	E	84	-21.0	0.0	320	14
15	-17.2	-24.3	-20.8	066	4.4	4.4	067	10.2	ENE	79	-22.4	0.0	380	15
16	-18.4	-21.9	-20.2	058	2.9	3.3	075	7.0	NNE	77	-23.2	0.0	220	16
17	-15.0	-19.7	-17.4	100	2.4	2.5	069	6.3	ESE	83	-19.2	0.0	180	17
18	-9.2	-16.7	-13.0	088	3.0	3.1	083	10.8	E	85	-15.6	0.0	275	18
19	-8.0	-14.0	-11.0	078	5.5	5.5	081	10.8	ENE	74	-13.9	0.0	190	19
20	-6.3	-10.2	-8.3	081	2.8	2.9	078	6.3	ENE	76	-11.5	0.0	180	20
21	-5.5	-13.0	-9.3	062	3.6	3.7	088	7.6	ENE	88	-9.3	0.0	190	21
22	-12.6	-16.9	-14.8	080	1.8	1.8	090	3.8	E	89	-15.9	0.0	340	22
23	-13.5	-17.2	-15.4	073	1.9	2.0	087	4.4	ENE	88	-16.7	0.0	375	23
24	-1.7	-17.7	-9.7	099	2.5	2.6	115	8.3	E	84	-14.7	0.0	375	24
25	-3.6	-13.9	-8.8	090	3.1	3.2	071	5.7	E	72	-13.7	0.0	355	25
26	-6.2	-13.4	-9.8	073	2.7	2.8	069	6.3	ENE	65	-15.4	0.0	285	26
27	-7.9	-18.1	-13.0	083	2.3	2.4	098	5.1	E	73	-19.1	0.0	270	27
28	-17.1	-22.7	-19.9	076	2.5	2.6	076	6.3	ENE	77	-22.2	0.0	350	28
29	-20.0	-22.7	-21.4	074	2.2	2.2	092	4.4	E	79	-23.9	0.0	360	29
30	-21.4	-26.7	-24.1	081	1.8	1.9	067	4.4	E	79	-26.4	0.0	345	30
31	-10.9	-22.2	-16.6	095	2.2	2.3	068	7.0	ESE	82	-19.1	0.0	145	31
MONTH	.3	-26.7	-12.8	077	3.3	3.5	069	12.1	ENE	80	-15.6	0.0	8295	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 10.8
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 10.8
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 10.8
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 10.8

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR DENALI WEATHER STATION
DATA TAKEN DURING September, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	*****	*****	*****	***	****	****	***	****	***	**	*****	.6	******	1
2	7.4	-.1	3.7	338	2.5	2.7	355	8.3	NNW	50	-5.0	.2	4531	2
3	9.4	-.6	4.4	173	1.5	2.2	162	7.0	S	52	-5.9	0.0	3922	3
4	5.3	.4	2.9	***	0.0	0.0	***	0.0	***	**	*****	0.0	3900	4
5	5.4	-1.5	2.0	***	****	****	***	****	***	47	-10.1	0.0	3324	5
6	6.6	-.9	2.9	***	****	****	***	****	***	53	-7.5	0.0	4861	6
7	8.0	-.9	3.6	***	****	****	***	****	***	52	-7.1	0.0	2685	7
8	7.6	1.1	4.4	***	****	****	***	****	***	49	-9.1	.4	2410	8
9	9.3	2.6	6.0	***	****	****	***	****	***	59	-5.4	.2	2706	9
10	10.0	.1	5.1	***	****	****	***	****	***	52	-8.5	0.0	3225	10
11	10.3	-2.5	3.9	***	****	****	***	****	***	58	-6.3	0.0	2768	11
12	10.1	2.4	6.3	***	****	****	***	****	***	46	-8.6	0.0	1984	12
13	8.0	.1	4.1	***	****	****	***	****	***	49	-8.7	0.0	2216	13
14	7.4	.6	4.0	***	****	****	***	****	***	56	-7.7	1.2	1552	14
15	6.0	-2.5	1.8	***	****	****	***	****	***	55	-10.7	0.0	3503	15
16	8.0	-2.0	3.0	***	****	****	***	****	***	43	-13.1	0.0	4070	16
17	9.4	-4.5	2.5	***	****	****	***	****	***	55	-7.8	0.0	4047	17
18	7.9	-5.2	1.4	***	0.0	0.0	***	0.0	***	**	*****	0.0	3130	18
19	6.8	.1	3.5	***	****	****	***	****	***	52	-10.0	.2	1859	19
20	9.3	.7	5.0	***	****	****	***	****	***	72	-2.5	5.2	1266	20
21	7.3	3.3	5.3	***	****	****	***	****	***	59	-6.0	.8	1098	21
22	5.2	-4.4	.4	***	****	****	***	****	***	47	-9.0	1.4	1246	22
23	-4.8	-8.2	-6.5	***	****	****	***	****	***	57	-15.7	0.0	2336	23
24	-7.6	-10.0	-8.8	***	****	****	***	****	***	67	-14.8	0.0	1971	24
25	-5.0	-12.7	-8.9	***	****	****	***	****	***	52	-18.4	0.0	3263	25
26	-5.5	-17.1	-11.3	***	****	****	***	****	***	50	-20.2	0.0	3327	26
27	-3.7	-15.7	-9.7	***	****	****	***	****	***	57	-17.4	0.0	2773	27
28	.7	-4.8	-2.1	***	****	****	***	****	***	60	-9.8	0.0	1315	28
29	.7	-4.8	-2.1	***	****	****	***	****	***	60	-9.8	0.0	1315	29
30	7.3	3.3	5.3	***	****	****	***	****	***	59	-5.9	1.0	1249	30
MONTH	10.3	-17.1	1.1	240	.1	.9	355	8.3	S	55	-9.7	11.2	77852	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 999.0
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 999.0
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 6.3
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 7.0

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

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R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR DENALI WEATHER STATION
DATA TAKEN DURING November, 1983

DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	-6.0	-13.0	-9.5	342	1.2	2.1	172	7.6	N	**	*****	0.0	775	1
2	-2.4	-12.7	-7.6	182	2.7	3.7	176	14.0	S	**	*****	0.0	605	2
3	-7.5	-19.4	-13.5	342	.9	1.2	339	3.2	N	**	*****	0.0	1360	3
4	-11.7	-20.5	-16.1	352	.9	1.2	017	3.8	N	**	*****	0.0	760	4
5	-9.5	-17.2	-13.4	327	.4	1.1	167	4.4	NNW	**	*****	0.0	645	5
6	-13.4	-20.8	-17.1	355	.3	.8	309	5.7	NNE	**	*****	0.0	1020	6
7	-6.6	-14.9	-10.8	193	5.7	5.9	181	11.4	S	**	*****	0.0	560	7
8	-2.1	-11.9	-7.0	204	1.0	2.3	209	7.6	SSW	**	*****	0.0	640	8
9	-3.8	-14.4	-9.1	195	1.5	2.9	197	14.0	SSW	**	*****	0.0	985	9
10	-6.8	-16.8	-11.8	027	.2	1.7	155	8.3	N	**	*****	0.0	710	10
11	-8.1	-15.7	-11.9	173	1.2	2.8	173	10.8	N	**	*****	0.0	935	11
12	-8.2	-16.0	-12.1	182	.2	1.1	182	8.3	SSW	**	*****	0.0	540	12
13	-12.0	-20.5	-16.3	022	.1	.6	027	1.9	S	**	*****	0.0	1055	13
14	-15.9	-20.8	-18.4	029	.8	.8	006	1.9	NNE	**	*****	0.0	560	14
15	-16.8	-24.3	-20.6	360	.2	.6	278	2.5	N	**	*****	0.0	475	15
16	-9.4	-19.4	-14.4	144	.3	1.3	153	8.9	NNE	29	-22.7	0.0	725	16
17	-17.8	-21.9	-19.9	347	.5	.9	000	3.2	N	25	-35.3	0.0	485	17
18	-14.7	-21.2	-18.0	009	.8	.8	006	2.5	N	36	-30.7	0.0	755	18
19	-7.8	-22.0	-14.9	295	.1	.9	149	2.5	SSW	47	-24.0	0.0	390	19
20	-3.5	-16.9	-10.2	169	5.4	5.8	143	17.1	S	46	-23.7	0.0	355	20
21	2.6	-2.8	-.1	150	6.9	7.3	152	22.2	SE	61	-9.8	0.0	355	21
22	-1.1	-11.6	-6.4	183	2.9	3.3	191	10.8	S	47	-17.5	0.0	410	22
23	-5.0	-16.0	-10.5	014	2.2	2.4	357	7.0	NNE	36	-22.9	0.0	620	23
24	-8.5	-21.8	-15.2	000	.8	1.7	021	6.3	NNE	38	-27.7	0.0	755	24
25	-12.1	-17.7	-14.9	170	2.3	3.4	175	10.2	S	76	-16.9	0.0	505	25
26	-11.8	-18.3	-15.1	339	.3	1.1	180	3.8	NNE	65	-20.3	0.0	425	26
27	-7.6	-16.1	-11.9	289	.3	1.6	188	6.3	N	62	-21.2	0.0	330	27
28	4.2	-10.6	-3.2	152	6.5	6.9	154	21.6	SE	52	-10.6	0.0	375	28
29	5.0	-2.1	1.5	177	2.2	2.8	142	14.6	SSW	50	-8.7	0.0	355	29
30	.9	-5.3	-2.2	193	1.7	2.4	182	11.4	S	54	-10.4	0.0	400	30
MONTH	5.0	-24.3	-11.7	170	1.0	2.4	152	22.2	N	51	-20.2	0.0	18865	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 21.0
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 15.9
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 15.2
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 15.9

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

R & M CONSULTANTS, INC.

SUSITNA HYDROELECTRIC PROJECT

MONTHLY SUMMARY FOR DENALI WEATHER STATION
DATA TAKEN DURING December, 1983

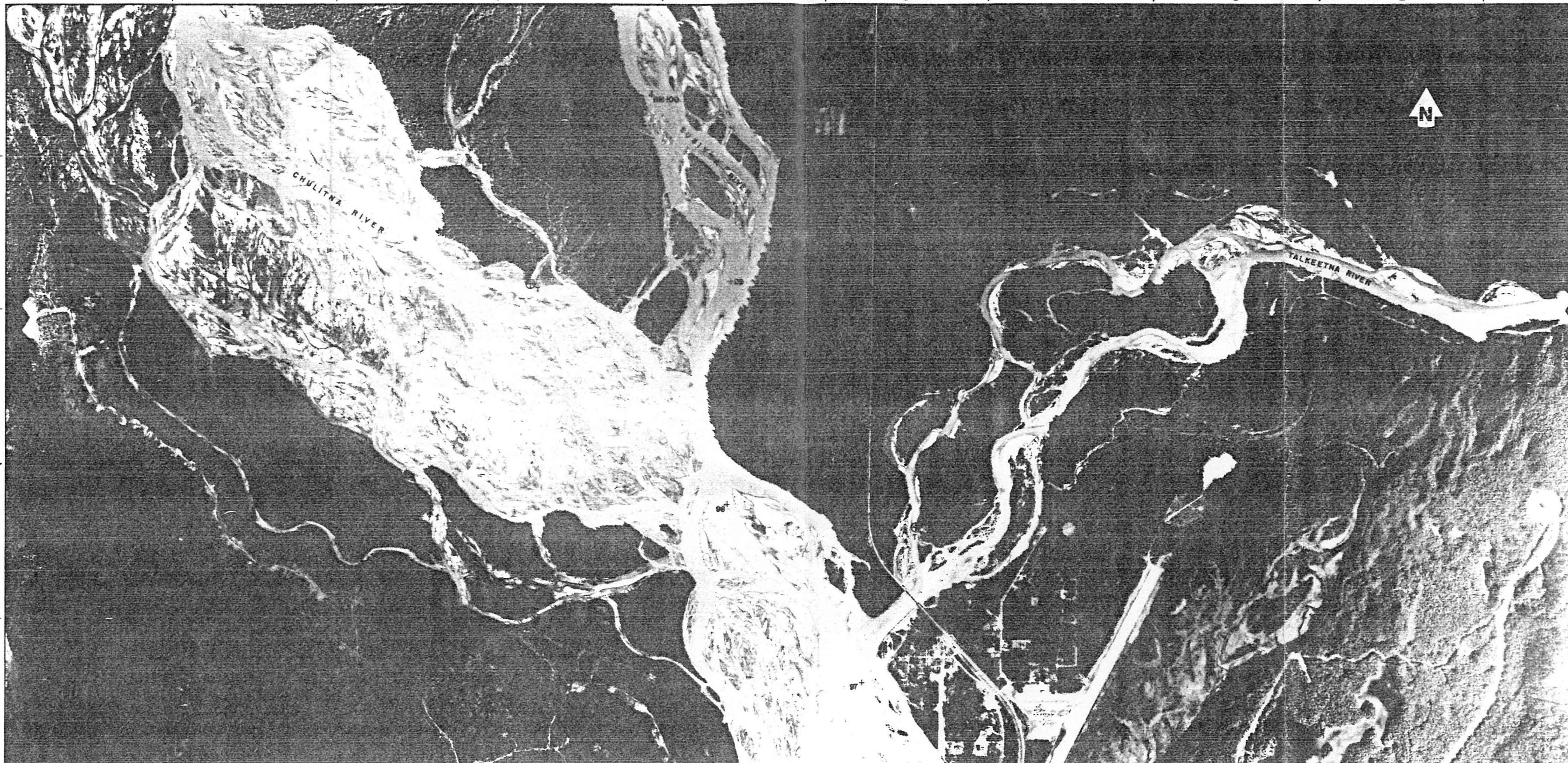
DAY	MAX. TEMP. DEG C	MIN. TEMP. DEG C	MEAN TEMP. DEG C	RES. WIND DIR. DEG	RES. WIND SPD. M/S	AVG. WIND SPD. M/S	MAX. GUST DIR. DEG	MAX. GUST SPD. M/S	P'VAL DIR.	MEAN RH %	MEAN DP DEG C	PRECIP MM	DAY'S SOLAR ENERGY WH/SQM	DAY
1	-.8	-4.9	-2.9	179	.9	1.5	189	7.0	S	54	-12.7	0.0	355	1
2	-2.0	-7.5	-4.8	170	1.3	1.6	163	5.7	SSE	47	-14.4	0.0	340	2
3	-3.1	-11.7	-7.4	209	.5	1.0	189	3.8	SSW	37	-20.7	0.0	295	3
4	-6.2	-10.8	-8.5	177	3.7	4.0	183	10.8	S	23	-26.5	0.0	280	4
5	-5.4	-9.3	-7.4	177	1.1	1.5	176	6.3	S	27	-22.8	0.0	280	5
6	-6.5	-7.0	-6.8	268	.4	.7	303	1.9	WNW	**	*****	0.0	120	6
7	-5.3	-7.1	-6.2	158	.7	1.3	174	9.5	SSW	31	-21.2	0.0	271	7
8	-5.4	-12.6	-9.0	165	2.0	3.0	172	8.9	S	38	-23.3	0.0	315	8
9	-12.5	-14.0	-13.3	333	.9	.9	343	1.9	NNW	7	-41.2	0.0	240	9
10	-14.4	-17.2	-15.8	009	.7	.7	010	8.9	N	21	*****	0.0	640	10
11	-16.6	-16.6	-16.6	047	2.0	2.1	052	6.3	NNE	44	*****	0.0	720	11
12	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	12
13	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	13
14	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	14
15	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	15
16	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	16
17	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	17
18	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	18
19	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	19
20	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	20
21	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	21
22	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	22
23	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	23
24	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	24
25	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	25
26	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	26
27	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	27
28	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	28
29	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	29
30	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	30
31	*****	*****	*****	***	****	****	***	****	***	**	*****	****	******	31
MONTH	-.8	-17.2	-9.0	174	1.3	1.9	183	10.8	S	36	-22.8	0.0	3855	

GUST VEL. AT MAX. GUST MINUS 2 INTERVALS 9.5
GUST VEL. AT MAX. GUST MINUS 1 INTERVAL 9.5
GUST VEL. AT MAX. GUST PLUS 1 INTERVAL 9.5
GUST VEL. AT MAX. GUST PLUS 2 INTERVALS 9.5

NOTE: RELATIVE HUMIDITY READINGS ARE UNRELIABLE WHEN WIND SPEEDS ARE LESS THAN ONE METER PER SECOND. SUCH READINGS HAVE NOT BEEN INCLUDED IN THE DAILY OR MONTHLY MEAN FOR RELATIVE HUMIDITY AND DEW POINT.

APPENDIX B

BLUELINE PRINTS OF AERIAL PHOTO-MOSAICS OF SUSITNA RIVER FROM COOK INLET TO TALKEETNA



NOTES:

1. SOLID LINES DEPICT CROSS SECTION.
2. TEMPORARY BENCHMARKS ARE LOCATED AT EACH END OF EVERY CROSS SECTION.
3. NUMBERS REFER TO THE LRX DESIGNATION.

△ - STAFF GAGE SITE

▲ - STAGE RECORDER

⊕T - THERMOGRAPH LOCATION

+ - RIVER MILES

DATE	NO.	REVISIONS	CH.	APP.	APP.

ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

SUSITNA RIVER HYDROGRAPHIC MAPS

R&M CONSULTANTS, INC.

DATE JAN 1981

SCALE 1" = 2000'

DEPARTMENT

PROJECT 052216

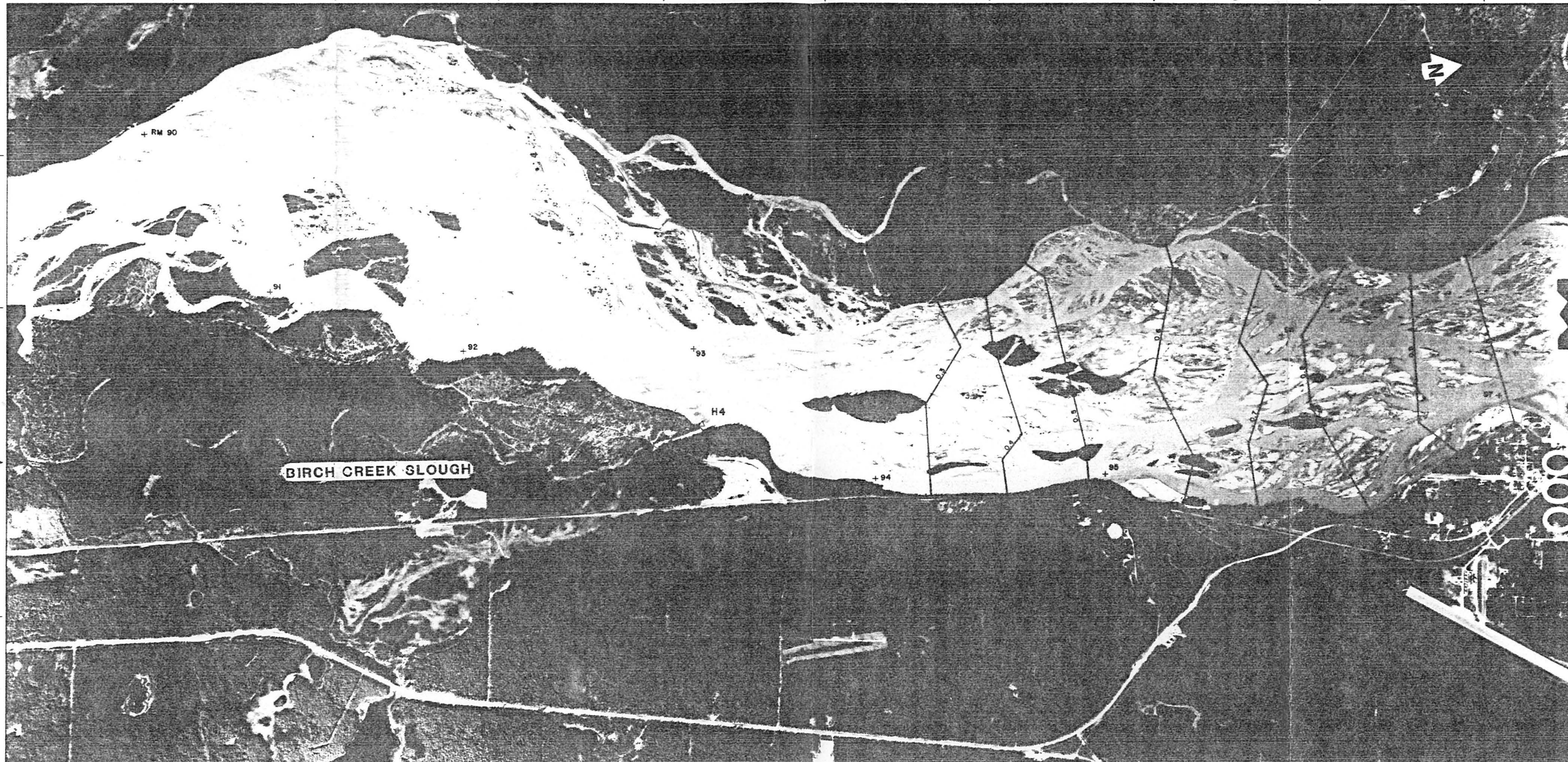
DRAWING No.

SHEET 18 OF 37

REV.

Prepared by: NORTH PACIFIC AERIAL SURVEYS, INC. ANCHORAGE, ALASKA

BRUNING 44-132 40973



NOTES:

1. SOLID LINES DEPICT CROSS SECTION.
2. TEMPORARY BENCHMARKS ARE LOCATED AT EACH END OF EVERY CROSS SECTION.
3. NUMBERS REFER TO THE LRX DESIGNATION.

△ - STAFF GAGE SITE

▲ - STAGE RECORDER

⊕T - THERMOGRAPH LOCATION

+ - RIVER MILES

DATE	NO.	REVISIONS	CH.	APP.	APP.

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

SUSITNA RIVER HYDROGRAPHIC MAPS

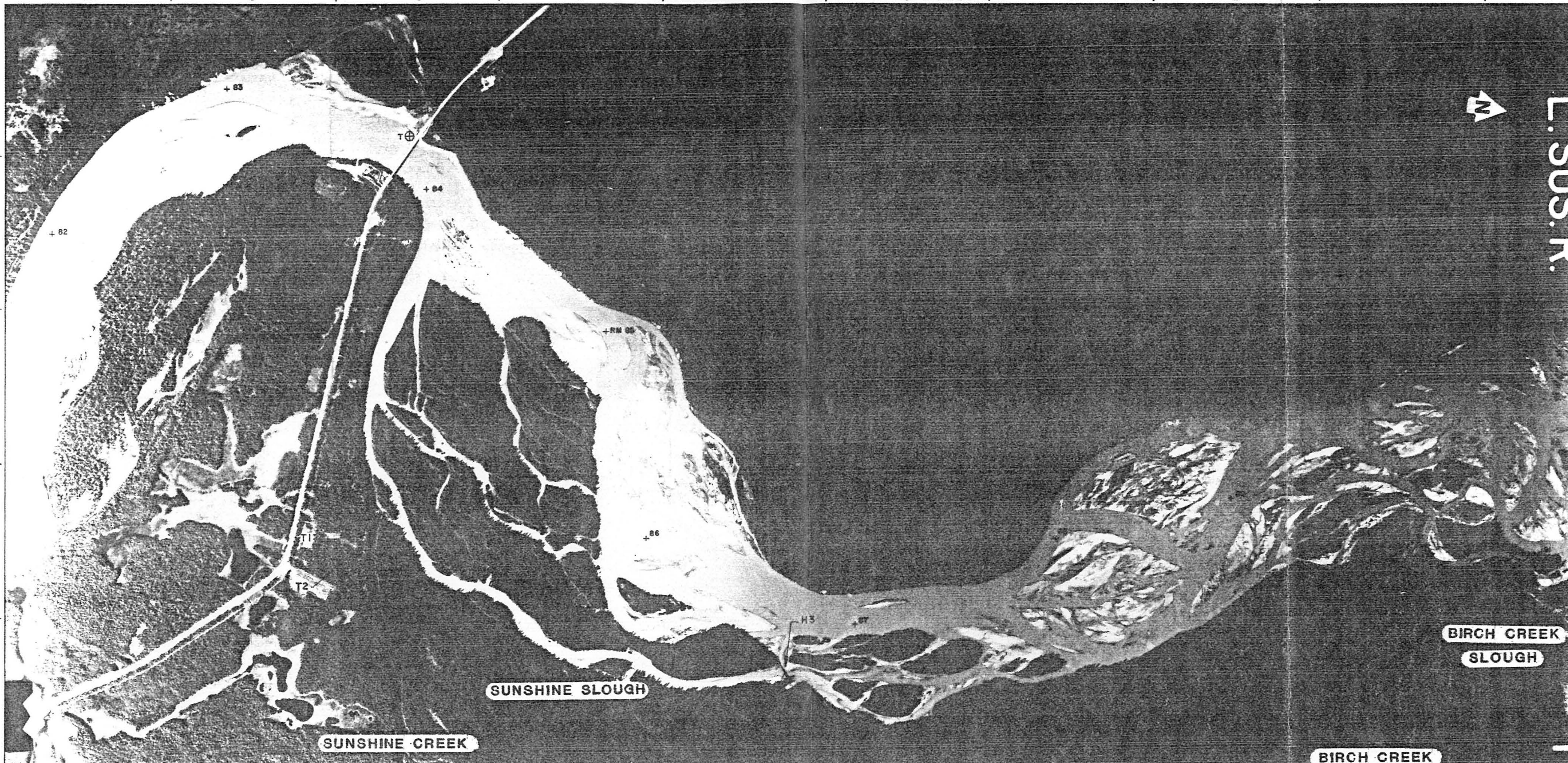
R&M CONSULTANTS, INC.

DATE JAN. 1981
DEPARTMENT
PROJECT 052216
SCALE 1" = 2000'
DRAWING NO.
SHEET 19 OF 37
REV.

Prepared by: NORTH PACIFIC AERIAL SURVEYS, INC. ANCHORAGE ALASKA

APPLIED MECHANICS | ARCHITECTURAL | CIVIL | CONSTRUCTION | ELECTRICAL | GEOTECHNICAL | HYDRAULIC | MECHANICAL | DESIGNED | DRAWN | CHECKED

BRUNING 44-132 40973



NOTES:

1. SOLID LINES DEPICT CROSS SECTION.
2. TEMPORARY BENCHMARKS ARE LOCATED AT EACH END OF EVERY CROSS SECTION.
3. NUMBERS REFER TO THE LRX DESIGNATION.

△ - STAFF GAGE SITE

▲ - STAGE RECORDER

⊕T - THERMOGRAPH LOCATION

+ - RIVER MILES

DATE	NO.	REVISIONS	CH.	APP.	APP.

ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

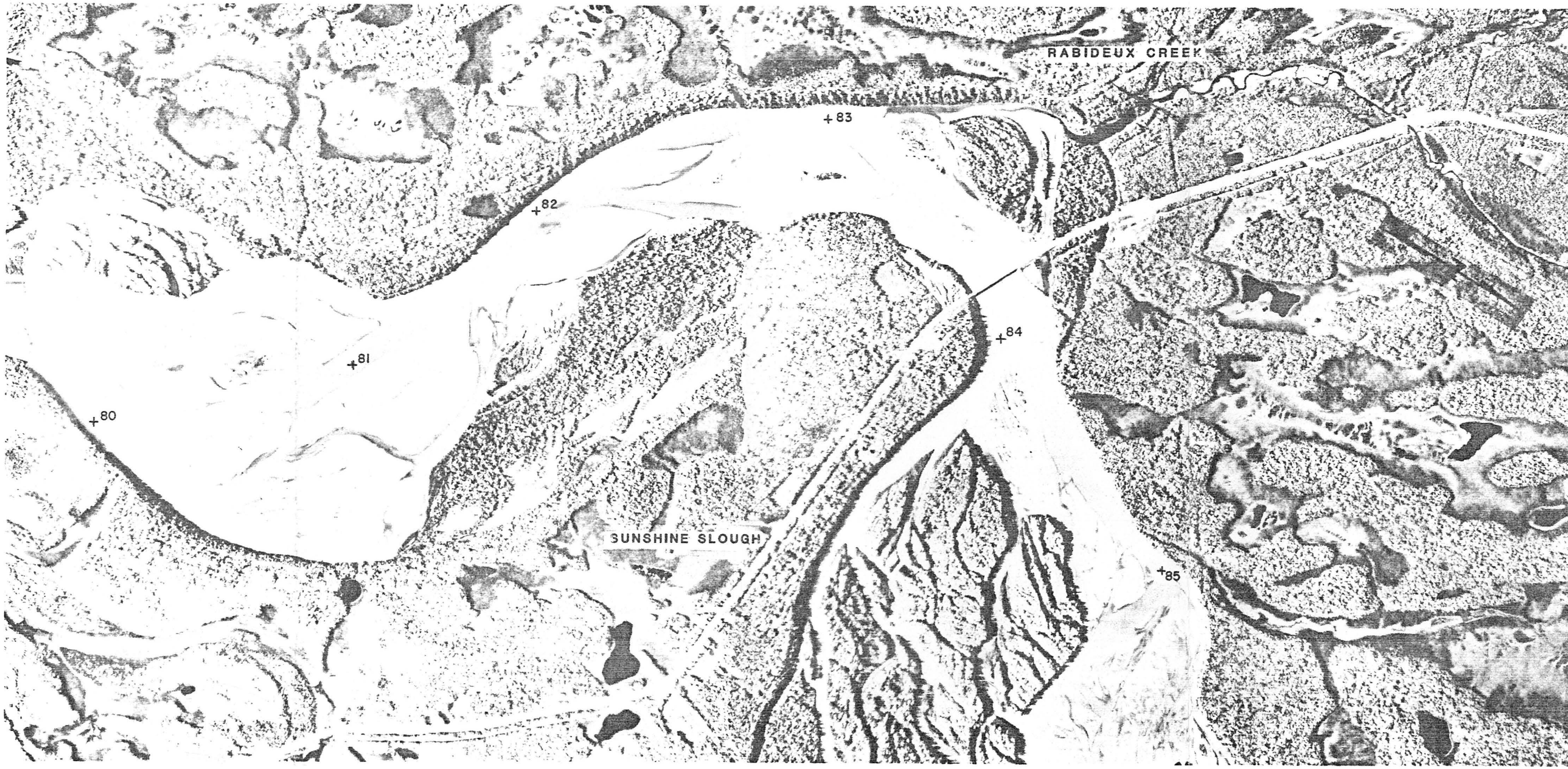
SUSITNA RIVER HYDROGRAPHIC MAPS

R&M CONSULTANTS, INC.

DATE JAN. 1981 | SCALE 1" = 2000'

PROJECT 052216 | SHEET 20 OF 37

Prepared by: NORTH PACIFIC AERIAL SURVEYS, INC. ANCHORAGE, ALASKA



ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT. 16, 1983
SCALE: 1" = 2000'
SHEET: 5 OF 28
DATE: 2-7-84

R&M CONSULTANTS, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE

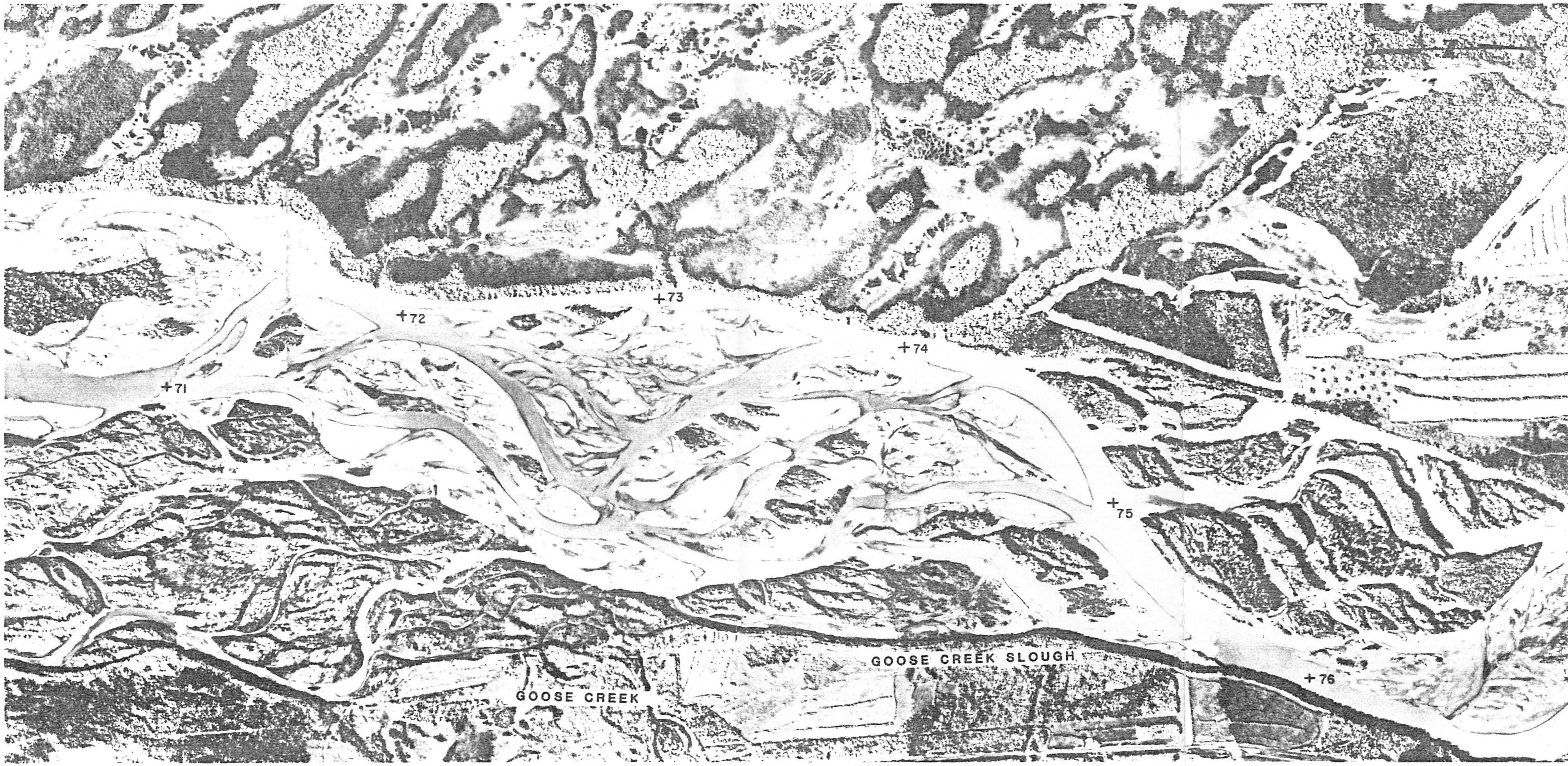
ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT. 16, 1983
SCALE: 1" = 2000'
SHEET: 6 OF 28
DATE: 2-7-84

R&M CONSULTANTS INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE



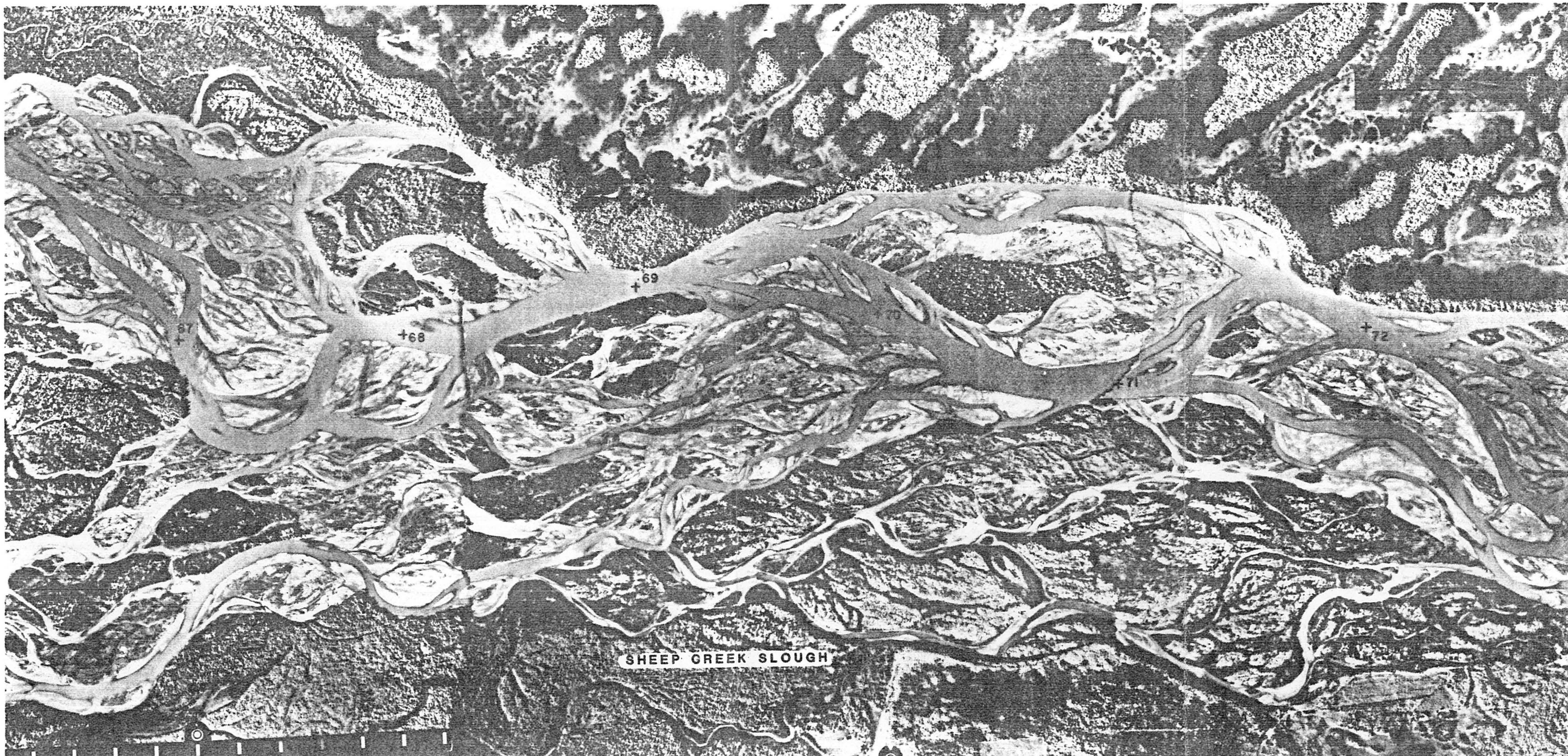
ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT. 16, 1983
SCALE: 1" = 2000'
SHEET: 7 OF 28
DATE: 2-7-84

R&M CONSULTANTS, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE



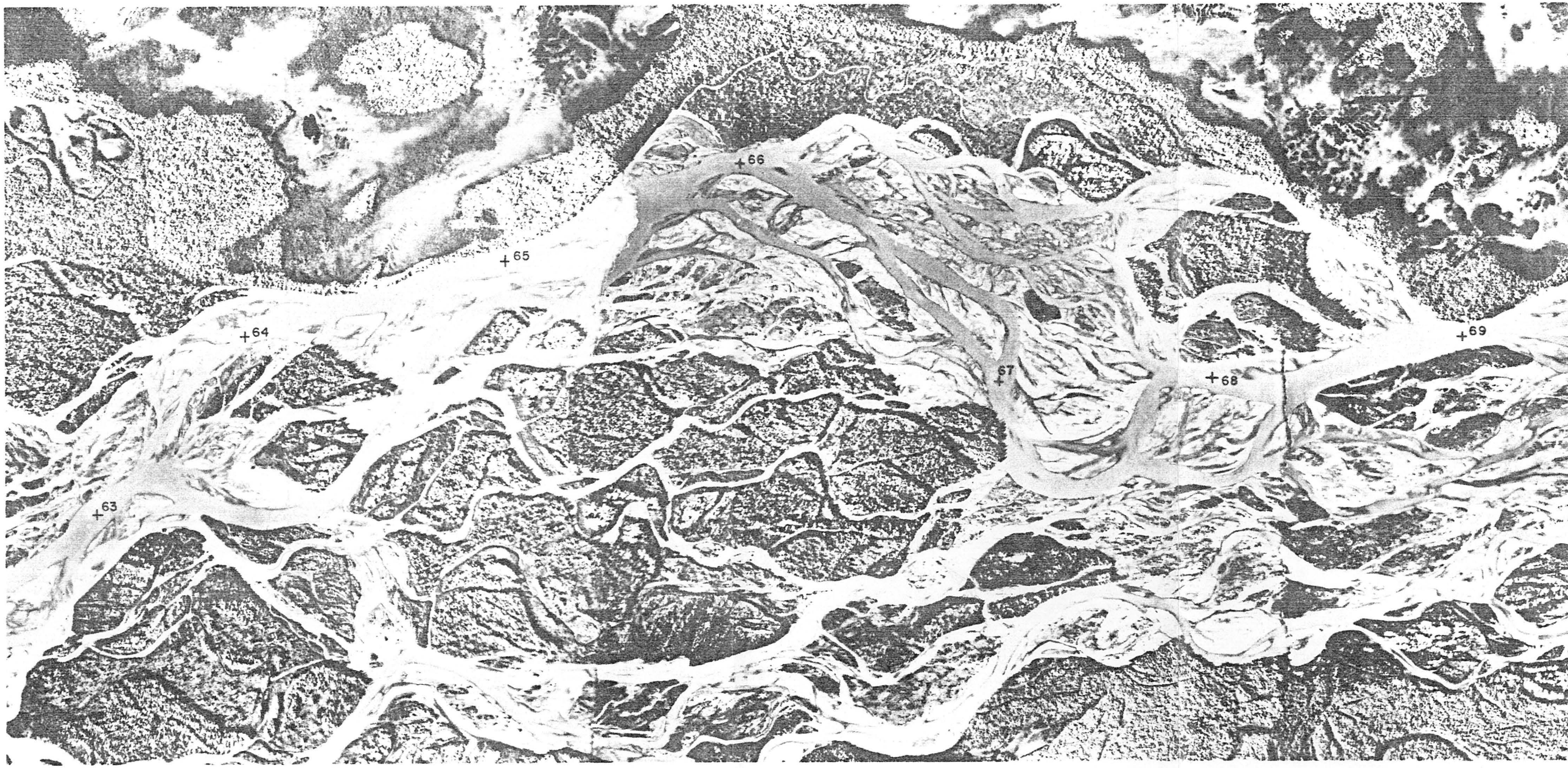
ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT. 16, 1983
SCALE: 1" = 2000'
SHEET: 8 OF 28
DATE: 2-7-84

R&M CONSULTANTS, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE



ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT. 16, 1983
SCALE: 1" = 2000'

SHEET: 9 OF 28
DATE: 2-7-84

R&M
R&M CONSULTANTS, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT. 16, 1983
SCALE: 1" = 2000'
SHEET: 10 OF 28
DATE: 2-7-84

R&M CONSULTANTS, INC.
HARZA-EBASCO
SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT. 16, 1983
SCALE: 1" = 2000'
SHEET: 11 OF 28
DATE: 2-7-84

R&M CONSULTANTS, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT. 16, 1983
SCALE: 1" = 2000'
SHEET: 12 OF 28
DATE: 2-7-84

R&M CONSULTANTS, INC.

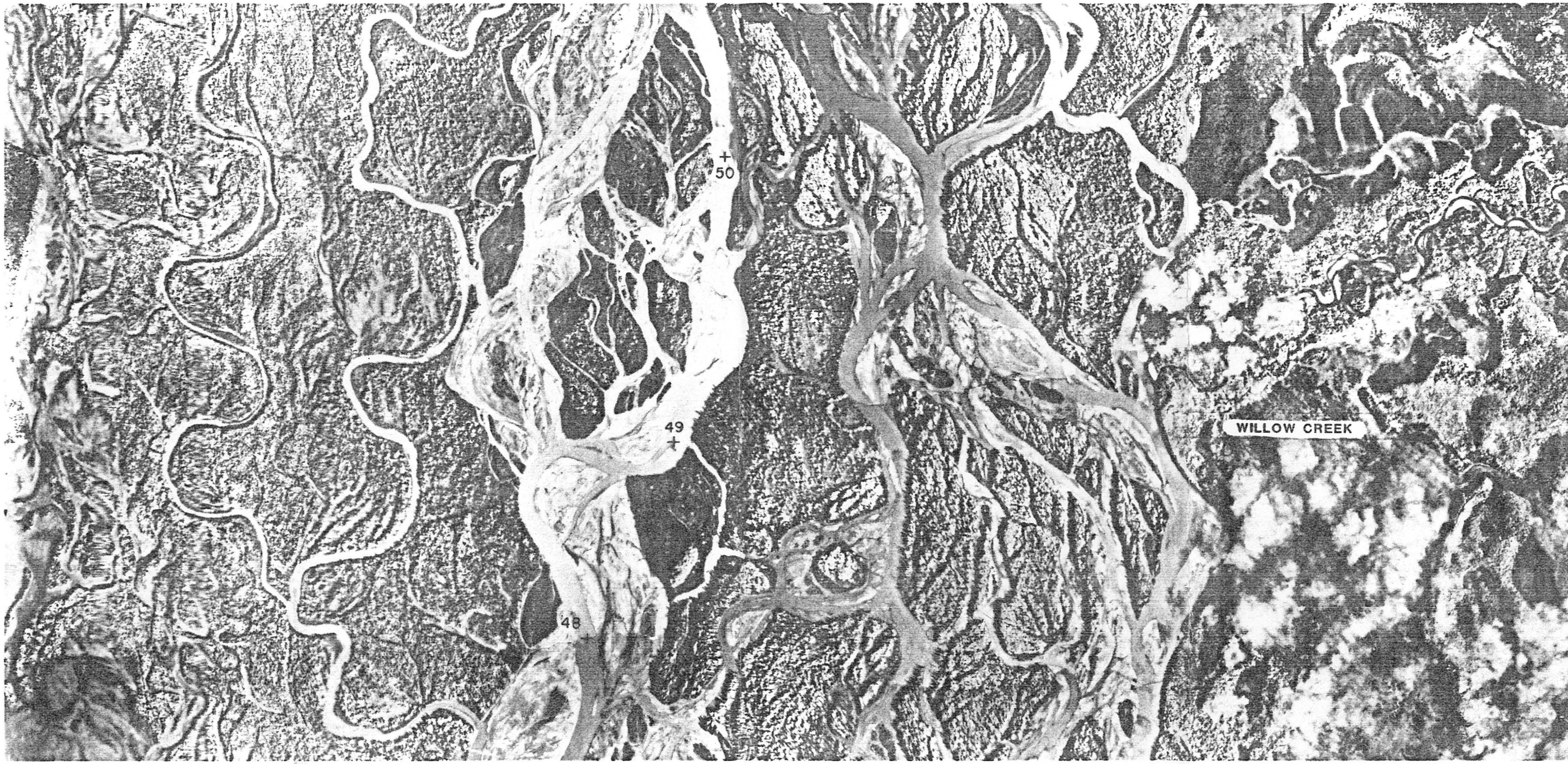
HARZA-EBASCO
SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT. 16, 1983
SCALE: 1" = 2000'
SHEET: 13 OF 28
DATE: 2-7-84

R&M CONSULTANTS, INC.
HARZA-EBASCO
SUSITNA JOINT VENTURE



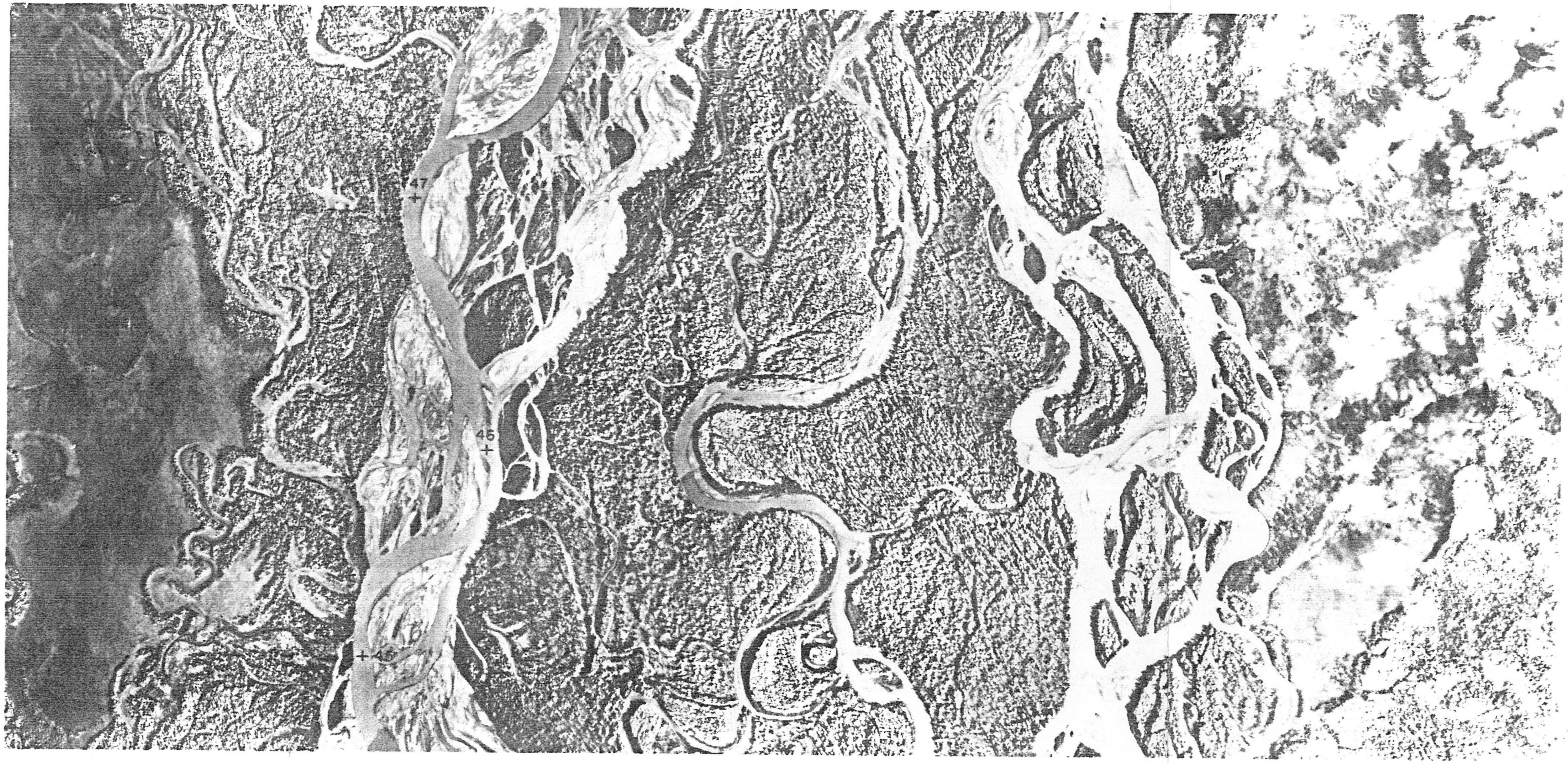
ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT. 16, 1983
SCALE: 1" = 2000'
SHEET: 14 OF 28
DATE: 2-7-84

R&M CONSULTANTS, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE



ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT. 16, 1983
SCALE: 1" = 2000'
SHEET: 15 OF 28
DATE: 2-7-84

R&M CONSULTANTS, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT. 16, 1983
SCALE: 1" = 2000'
SHEET: 16 OF 28
DATE: 2-7-84

R&M CONSULTANTS, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT. 16, 1983
SCALE: 1" = 2000'
SHEET: 17 OF 28
DATE: 2-7-84

R&M CONSULTANTS, INC.
HARZA-EBASCO
SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT. 16, 1983
SCALE: 1" = 2000'
SHEET: 18 OF 28
DATE: 2-7-84

R&M CONSULTANTS, INC.
HARZA-EBASCO
SUSITNA JOINT VENTURE

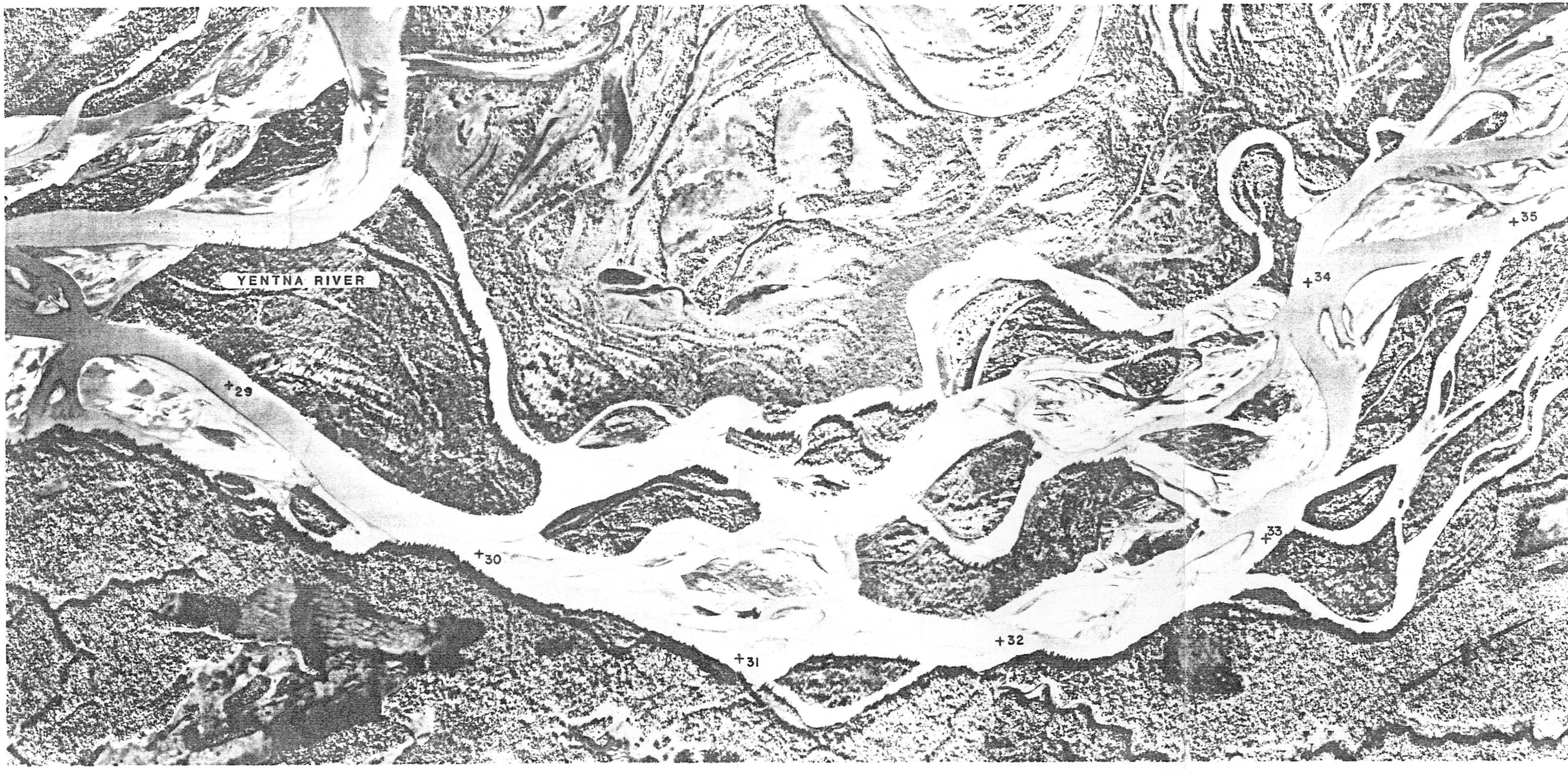
ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT. 16, 1983
SCALE: 1" = 2000'
SHEET: 19 OF 28
DATE: 2-7-84

R&M CONSULTANTS, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE



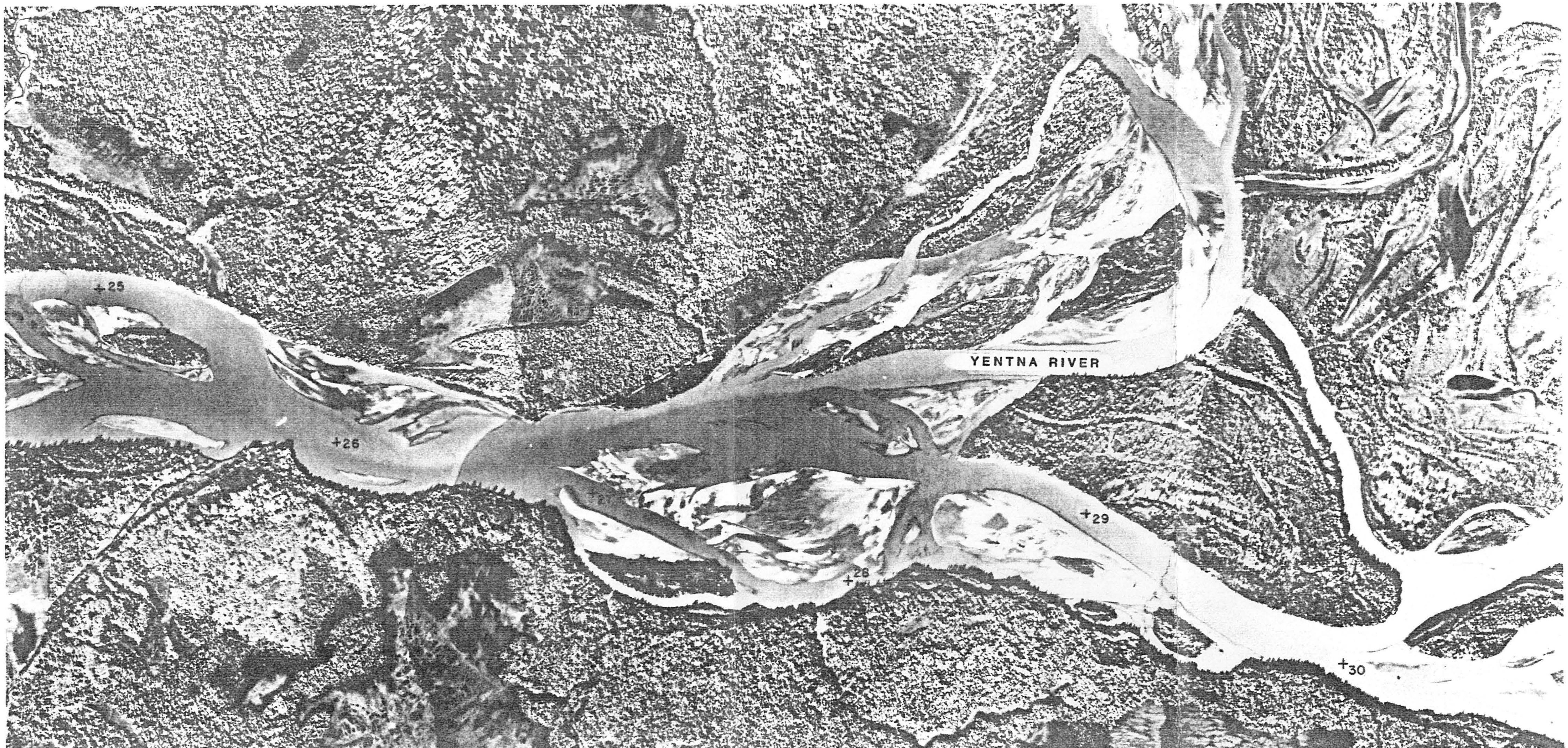
ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT. 16, 1983
SCALE: 1" = 2000'
SHEET: 20 OF 28
DATE: 2-7-84

R&M CONSULTANTS, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE



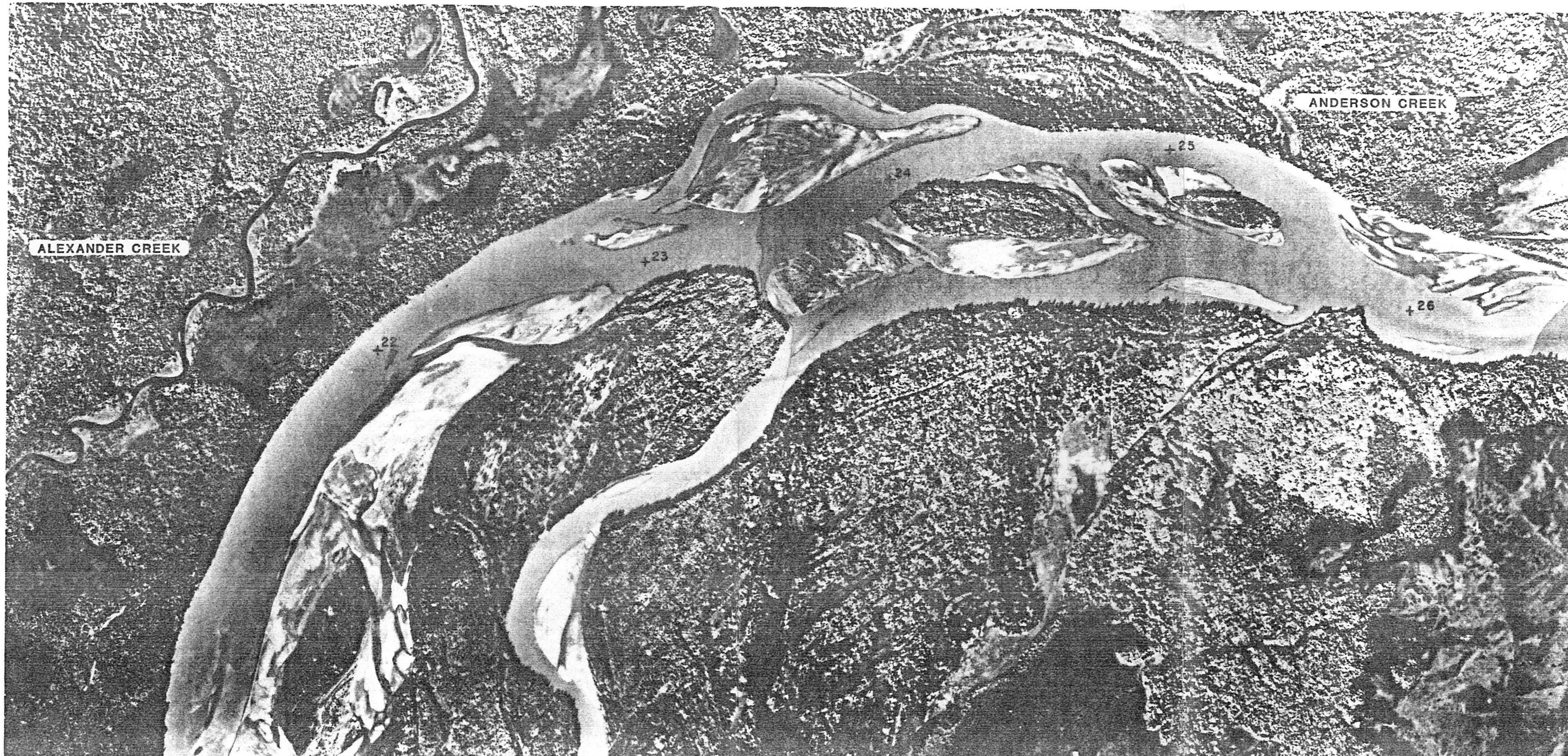
ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT. 16, 1983
SCALE: 1" = 2000'
SHEET: 21 OF 28
DATE: 2-7-84

R&M CONSULTANTS, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE



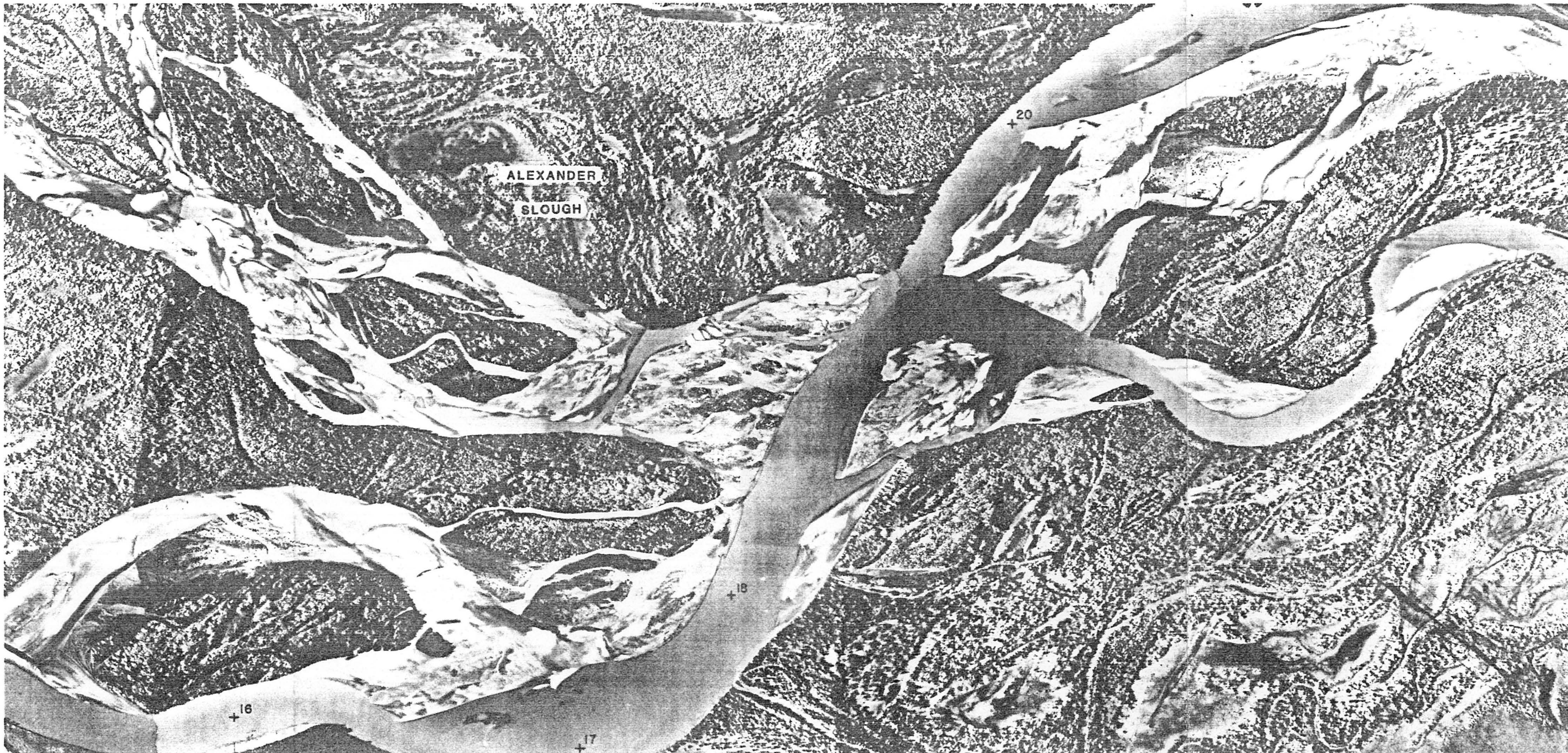
ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT. 16, 1983
SCALE: 1" = 2000'
SHEET: 22 OF 28
DATE: 2-7-84

R&M CONSULTANTS, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE

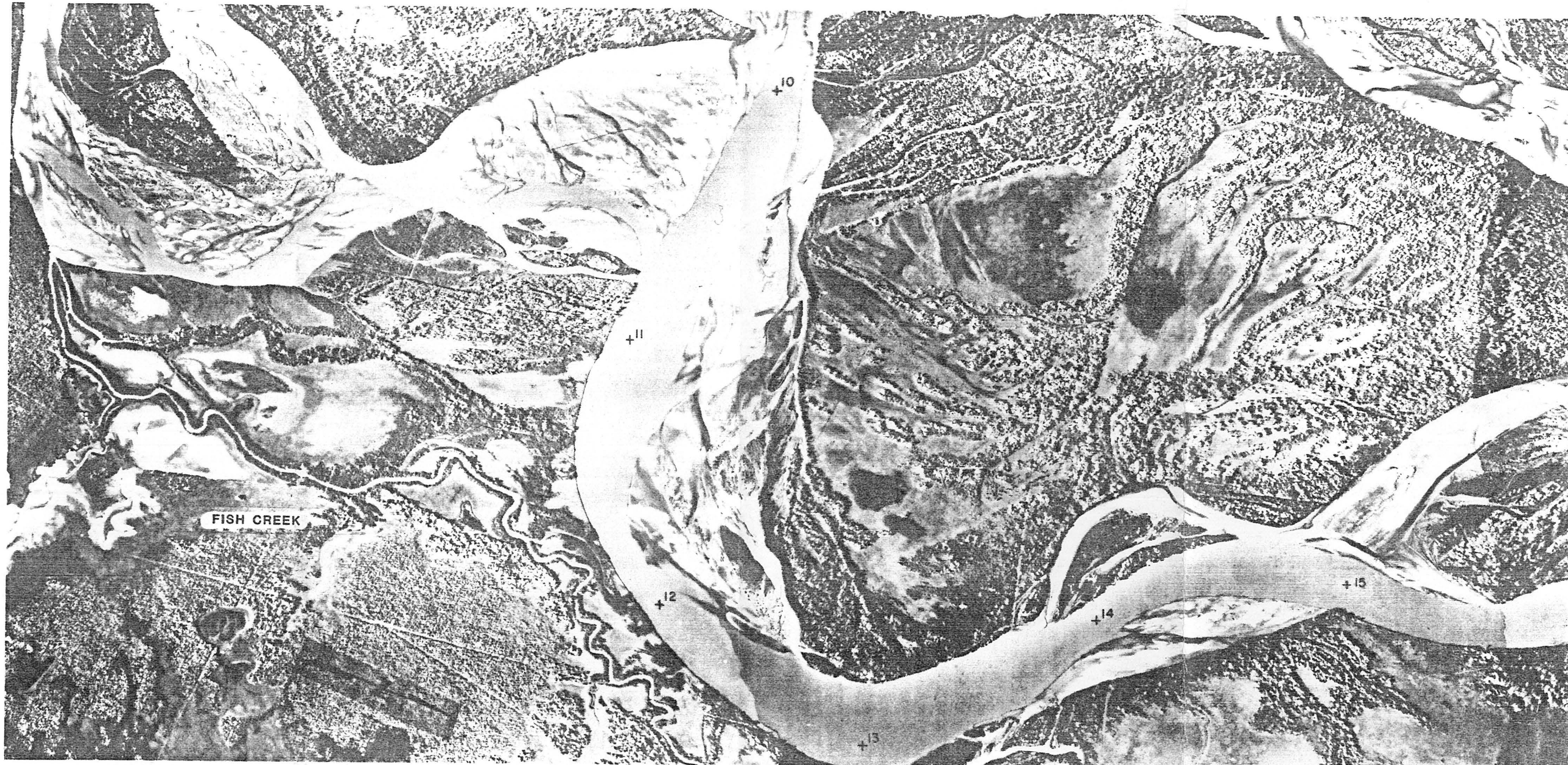


ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT. 16, 1983
SCALE: 1" = 2000'
SHEET: 23 OF 28
DATE: 2-7-84

R&M CONSULTANTS, INC.
HARZA-EBASCO
SUSITNA JOINT VENTURE



ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT. 16, 1983
SCALE: 1" = 2000'
SHEET: 24 OF 28
DATE: 2-7-84

R&M CONSULTANTS, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE

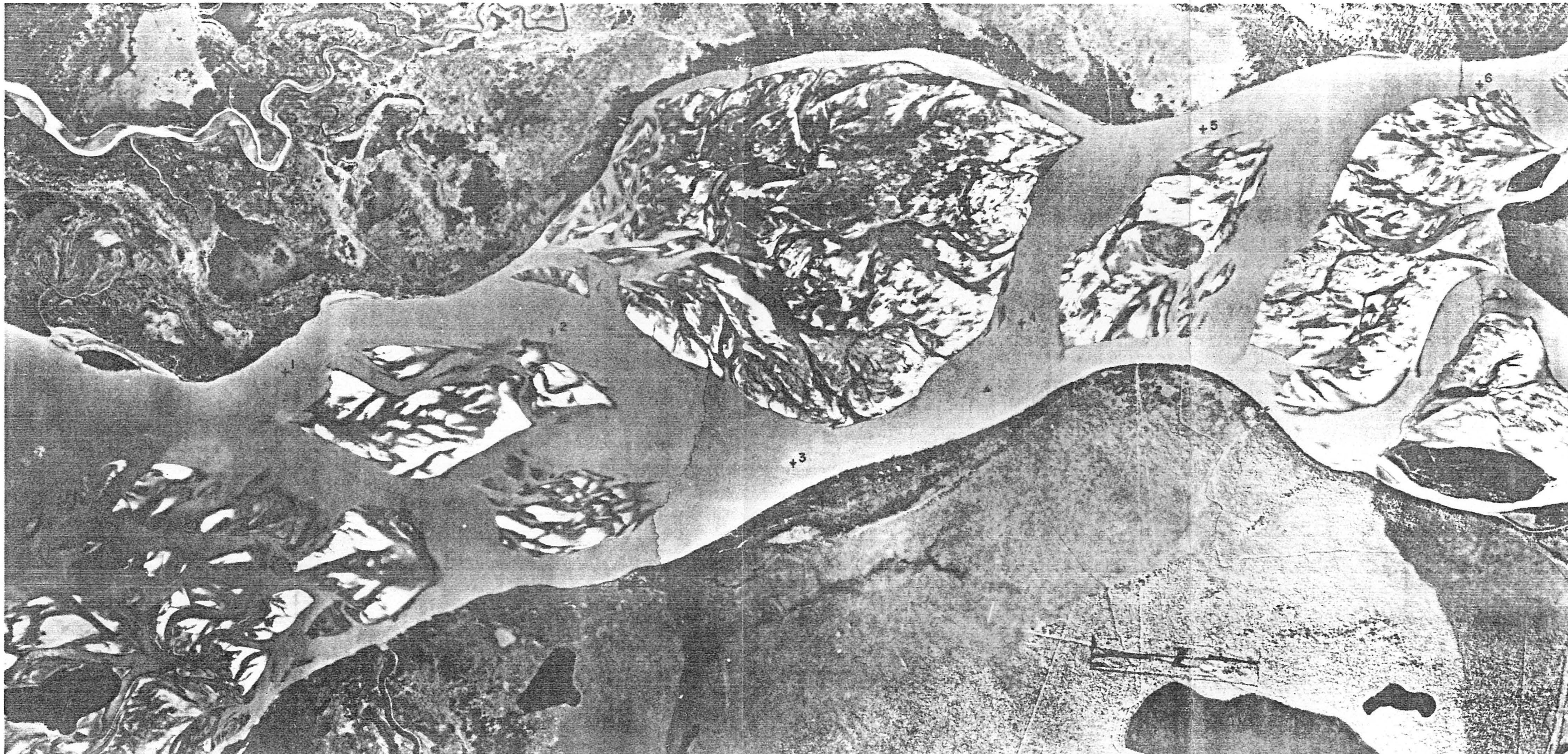
ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT. 16, 1983
SCALE: 1" = 2000'
SHEET: 25 OF 28
DATE: 2-7-84

R&M CONSULTANTS, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE



ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT. 16, 1983
SCALE: 1" = 2000'
SHEET: 26 OF 28
DATE: 2-7-84

R&M CONSULTANTS, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT. 16, 1983
SCALE: 1" = 2000'
SHEET: 27 OF 28
DATE: 2-7-84

R&M CONSULTANTS, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT. 16, 1983
SCALE: 1" = 2000'
SHEET: 28 OF 28
DATE: 2-7-84

R&M CONSULTANTS, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE