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SUSITNA HYDROELECTRIC PROJECT

Response of Aquatic Habitat Surface Areas to Mainstem Discharge in the Talkeetna-to-Devil Canyon Reach of the Susitna River, Alaska

By

Sharon A. Klinger-Kingsley

E. Woody Trihey and Associates

Under Contract To

Harza-Ebasco Susitna Joint Venture

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ACKNOWLEDGEMENTS

This work was undertaken in cooperation with the Alaska Department of Fish and Game Susitna Hydro Aquatic Study Team and R & M Consultants, Inc., Anchorage, Alaska. ADF&G SuHydro personnel participated in the derivation of definitions for the various habitat types and the development of the aquatic habitat classification key. The aerial photography missions were scheduled through Mr. Steve Bredthauer, R & M Consultants, Inc. He did an exceptional job given the highly variable nature of streamflow and weather conditions. Aerial photography was flown and photo mosaics and enlargements prepared by Air Photo Tech, Inc., and North Pacific Aerial Surveys, Inc., Anchorage, Alaska, under contract to the Harza-Ebasco Susitna Joint Venture.

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INTRODUCTION

The proposed Susitna hydroelectric project will alter the natural streamflow regimes of the Susitna River. The river segment downstream from Devil Canyon to the Chulitna River confluence (Talkeetna) would experience notable alterations in naturally occurring streamflow patterns, due to its proximity to the proposed damsites and the limited amount of influence that tributary inflows have on total discharge in this river segment.

With-project discharges are expected to be lower than naturally occurring flows during summer and higher in the winter. These altered flows are expected to affect the amount and seasonal availability of the aquatic habitats present in the river. This report provides location and areal extent of various aquatic habitat types at different mainstem discharges. These data, in combination with the results of other studies focusing on biological features of habitats present in this segment of the river, will facilitate forecasting the effects of altered streamflows on the availability of aquatic habitat to anadromous and resident fish.

Aerial photography interpretation, along with field reconnaissance, is being used to identify and map various aquatic habitat types in the Talkeetna-to-Devil Canyon reach of the Susitna River (also referred to as the middle Susitna River). In 1984 initial work on aquatic habitat mapping and surface area measurements determined the location and amount of various aquatic habitat types at mainstem discharges of 23,000; 16,000; 12,500; and 9,000 cfs, as measured at the U. S. Geological Survey (USGS) Gold Creek gaging station (Klinger and Trihey 1984). This report presents the surface area response of aquatic habitat types to mainstem discharge at four additional streamflows: 18,000, 10,600, 7,400, and 5,100 cfs. The 18,000 cfs discharge falls within the 16,000 to 23,000 cfs range, where several side sloughs and side channels become inundated by mainstem water. The lower three discharges provide a good basis for evaluating low flow conditions in the river.

This report discusses the four sets of aerial photography analyzed in 1985 and presents the surface area measurements in combination with those analyzed in 1984. However, surface area measurements obtained from the 9,000 cfs photography have been omitted from this evaluation. The surface area measurements obtained from the 9,000 cfs photography were suspected of being somewhat inaccurate due to distortions associated with ice and snow cover (Klinger and Trihey 1984). The presence of snow and ice made it difficult to accurately determine the water's edge and measure the wetted surfaces. The 1984 surface area measurements obtained from the 9,000 cfs photography were compared with 1985 surface area data obtained at 7,400 and 10,600 cfs. The adverse influence of shoreline ice and snow cover on the accuracy of the 9,000 cfs data set is quite evident from this comparison (Klinger 1985).

Surface area measurements for the seven discharges evaluated in this report provide an adequate basis for identifying the response of specific areas to streamflow reductions, as well as for quantifying change in wetted surface area of middle river habitat types over a broad range of streamflows. Although wetted surface area may be used as an indicator of habitat availability, it does not represent habitat

quality. This report does not contain any statements concerning the suitability of the various habitat types for fish, nor does it address how the quality of these habitats may respond to changes in mainstem discharge.

METHODS

Habitat Type Designations

The total wetted surface area of the middle Susitna River was classified into six general aquatic habitat types based on criteria visually evident in aerial photography or helicopter overflights: mainstem, side channel, side slough, upland slough, tributary mouth, and tributary. These habitat types represent physical characteristics of the environment and do not necessarily depend upon any particular degree of utilization by fish.

The following brief descriptions were used to identify the six aquatic habitat types evaluated in this study. These definitions are limited to visually recognizable physical characteristics present during ice-free conditions and that are easily identified from the air during helicopter reconnaissance flights. A more detailed description of each aquatic habitat type has been prepared by the Alaska Department of Fish and Game (1983).

Mainstem habitat types are those channels of the river that normally convey streamflow throughout the entire year. They are visually recognizable by their turbid, glacial water and high velocities.

Side Channel habitat types are also characterized by turbid, glacial water. Velocities often appear lower than in mainstem sites. Side channel habitat may exist in well-defined channels or in areas typified by numerous islands and submerged gravel bars. When the upstream berms of side channels are dewatered and the channels contain clear water, they are classified as side sloughs.

Side slough habitat types contain clear water. Upwelling and local surface runoff are the primary sources supplying clear water to these areas. Side sloughs have non-vegetated upper thalwegs that are overtopped during periods of moderate to high mainstem discharge. When these areas are overtopped they convey turbid water and are then classified as side channels.

Upland slough habitat types also contain clear water and depend on upwelling and/or local surface runoff for their water sources. Upland sloughs possess vegetated upper thalwegs that are seldom overtopped by mainstem discharge.

Tributary mouth habitat types are clear water areas that exist where tributary streams flow into mainstem or side channel habitats. This habitat type is manifest as a clear water plume extending out into the turbid receiving water. Tributary mouth habitat also extends upstream into the tributary to the upper extent of any backwater influence that might exist. The surface

area of tributary mouth habitat is affected both by tributary discharge and mainstem stage.

Tributary habitat types are those reaches of tributary streams upstream of the tributary mouth habitats. Tributary habitat types have not been evaluated in this analysis because tributary habitat is not influenced by mainstem stage.

Non-wetted areas were classified as either vegetated islands or gravel bars. Areas within the control corridor that were quantified but not relevant to the surface area analysis were classified as "background". Figure 1 presents a descriptive key used to classify areas of the middle river into habitat types. This key was adapted from the Alaska Department of Fish and Game Susitna Hydro Aquatic Studies (1983) classification index for aquatic habitat types.

Field Methods

Complete photographic coverage was obtained for seven mainstem discharges in the Talkeetna-to-Devil Canyon reach of the Susitna River. Black-and-white aerial photographs were obtained at an approximate scale of 1 inch = 1000 feet, with a 60 percent overlap between adjacent photos. The dates of the photography and mainstem discharges as measured at the USGS Gold Creek gaging station (No. 15292000) at the time of photography are presented in Table 1.

Table 1. Dates and mainstem discharges at which aerial photography of the Talkeetna-to-Devil Canyon reach was obtained.

Date	Discharge (cfs)
6-1-82	23,000
8-24-80	18,000
9-11-83	16,000
9-6-83	12,500
9-9-84	10,600
10-4-84	7,400
10-14-84	5,100

Helicopter reconnaissance flights were conducted over the Talkeetna-to-Devil Canyon reach at mainstem discharges similar to those at which the aerial photography was obtained. During each of these reconnaissance flights, aquatic habitat types were identified using the key presented as Figure 1, and their locations were mapped on 1 inch = 1000 feet scale blueline prints of the Susitna River. Dewatered gravel bars and streambank areas were sketched on the blueline prints as were boundaries of the various habitat types.

Office Procedures

Photo Plates and Enlargements

Photographic mosaics were prepared from the overlapping black-and-white photos to provide continuous 1 inch = 1000 feet coverage of the Talkeetna-to-Devil Canyon reach for each of the seven discharges. The

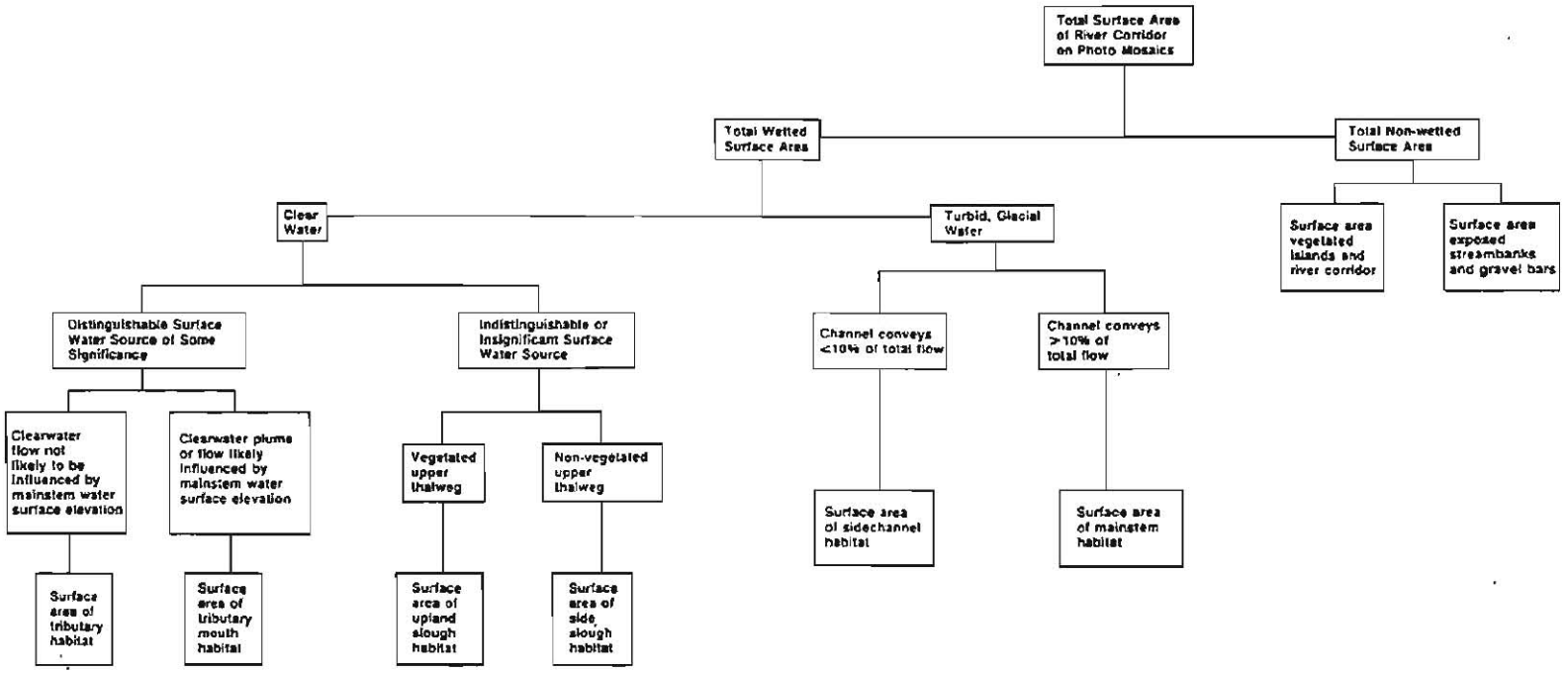

FIGURE 1 Key to aquatic habitat classification for the Talkeetna to Devil Canyon reach of the Susitna River. (RM 101 to 149).

photo mosaics were subdivided into eighteen sections of approximately the same length, with a small amount of overlap between adjoining river sections. A set of eighteen 4-1/2 inch by 15 inch photoplates was printed for each of the seven discharges (Appendix 1). For the sets of photography taken at 23,000; 18,000; 16,000; and 12,500 cfs, each photo plate was carefully examined and areas that were too small in size to provide detailed resolution were enlarged to a scale of 1 inch = 250 feet. All sets of photography taken at 10,600; 7,400; and 5,100 cfs, were enlarged to a scale of 1 inch = 250 feet.

Habitat Type Boundaries

Aquatic habitat boundaries mapped on the blueline prints during the helicopter reconnaissance flights were transferred to corresponding sets of photographs. Figure 2 provides an example of the technique used for the photography taken at 23,000; 18,000; 16,000; and 12,500 cfs. The technique used for the photography taken at 10,600; 7,400; and 5,100 cfs was essentially the same, with the exception that no enlargement areas were defined because the entire set of photography was printed at the enlarged scale of 1 inch = 250 feet. A total of 35 adjoining plates were needed to cover the entire Talkeetna-to-Devil Canyon reach at that scale. Matchlines were drawn on adjoining photo plates to ensure that habitat areas within overlapping sections near the edges of the plates were not counted twice. The boundary of each enlargement area was established using prominent topographic features in the photography and drawn on both the plate and the individual enlargement. This ensured that areas within the enlargement could be summed and compared with the enlargement area on the plate.

The external boundaries of the total area to be included in the surface area analysis (control area) were defined on each plate, so that sub-areas within the control area could be totaled and compared with the total control area of that plate. In many cases, it was necessary to go beyond the river channel boundaries to establish an identifiable control area boundary. The area located between the control area boundary and the river channel was digitized as "background" (refer to Figure 2b).

Digitizing

In this report, digitizing refers to the process of calculating the area within a perimeter circumscribed on the aerial photographs. Area calculations were made using a Numonics Model 2400 DigiTablet and Electronic Graphics Calculator connected to an Epson HX-20 Notebook Computer. Prior to digitizing each photo plate and enlargement, boundaries were drawn around each wetted and non-wetted habitat element. By tracing the perimeter of a given area with the Numonics DigiTablet cursor, the area circumscribed is calculated by the Graphics Calculator to an accuracy of 0.01 square inch. This accuracy is less than that of delineation and operator tracing error.

Digitizing strategy consisted of digitizing the control area, the enlargements (if present) and elements within the control area. If enlargements were present, the total area of the enlargement was digitized and then the elements within it. Each area calculation was performed twice. If the percent error between the two measurements was greater than five percent, the area was redigitized until the percent agreement was less than five. An interactive computer program was

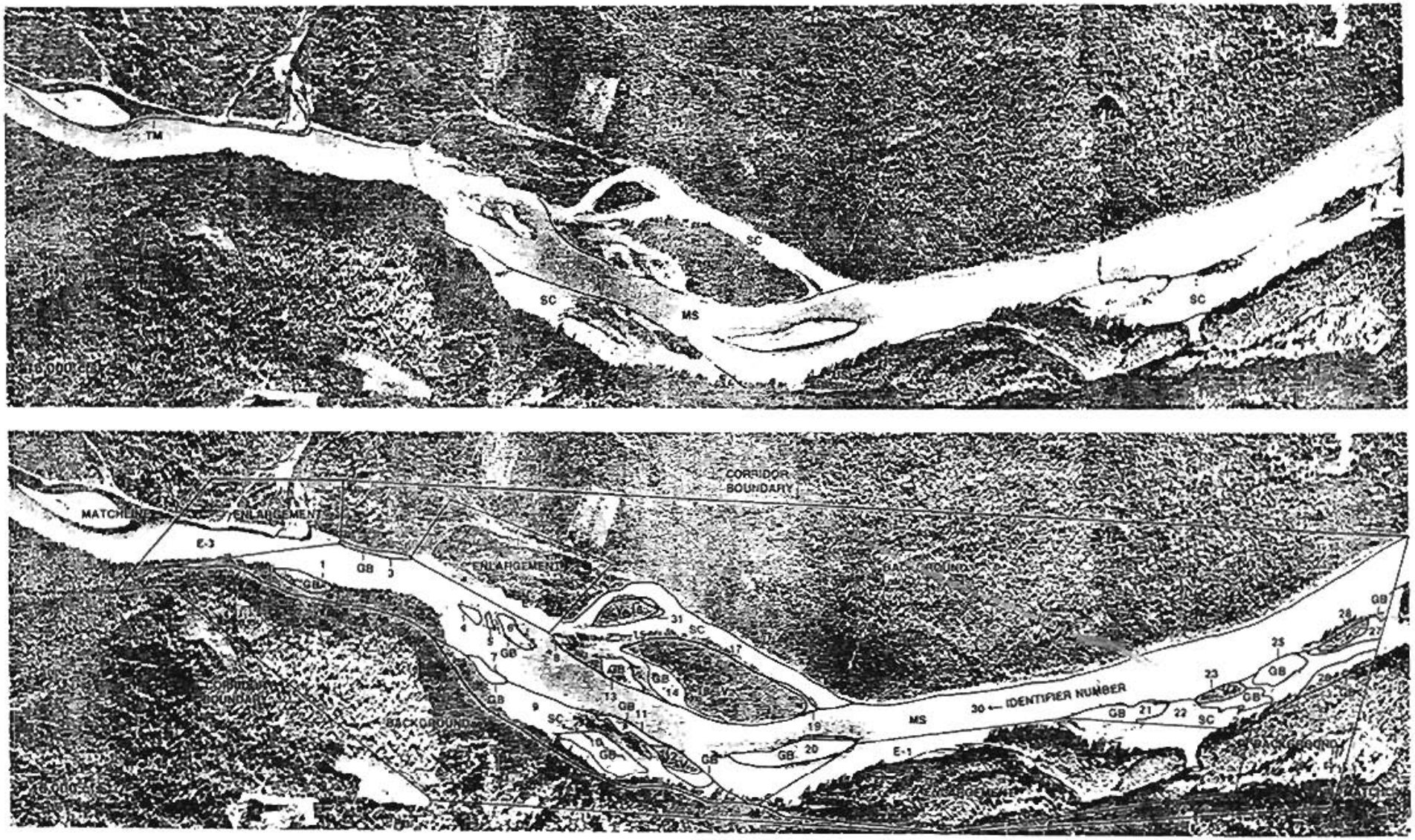

FIGURE 2a. Example of a Susitna River segment with habitat types mapped and classified.
2b. Example of the same river segment as delineated prior to digitizing.

developed for the HX-20, which prompted the digitizing operator for the plate number, flow code, control area number, enlargement number (if enlargement), enlargement factor, habitat code, element number and the digitized area (transferred from the graphics calculator). The program checked percent agreement for each measurement, and performed the summation of elements for comparison with the initial control area measurement.

Data Base

Surface area measurements that had been stored on the Epson magnetic tape cassettes were transferred into a computerized data base for storage, sorting, and subsequent analysis. Each individual surface area measurement was entered as a separate record that enabled identification by discharge, photograph (corresponding to a river mile index), and individual area number.

Correction factors were entered to standardize to a common scale of 1 inch = 1000 feet. Due to prevailing weather factors at the time the aerial photography flights, slight variations in scale occurred in the various photo sets. Surface areas within enlargement areas and for those sets of photos printed entirely at the enlarged scale were divided by a factor of 16 to account for the fourfold difference in scale between 1 inch = 250 feet and 1 inch = 1000 feet.

Analysis Procedures

Surface areas were summed by habitat type for the entire river corridor between Talkeetna and Devil Canyon for each of the seven discharges. Percentages of the total river surface area represented by each aquatic habitat type were calculated for each of the seven discharges.

Because the change in surface area of aquatic habitat is a function of discharge and channel geometry, the Talkeetna-to-Devil Canyon reach was subdivided into four segments, each possessing somewhat different geomorphological characteristics. RM 101 to 113 (Talkeetna-to-Lane Creek) is a relatively channelized segment of the middle river with few mid-channel vegetated islands or gravel bars; few side channels branch off from the mainstem. RM 113 to 122 (Lane Creek-to-Curry) is a more braided segment with mid-channel islands and side channels branching from the mainstem. RM 122 to 138 (Curry-to-Gold Creek) is a braided segment with large mid-channel islands and gravel bars. Numerous side channels branch off from the mainstem. RM 138 to 149 (Gold Creek-to-Devil Canyon) is a more channelized segment with some large side channels branching off from the mainstem. Total surface areas of each habitat type within these segments were determined to focus attention on the diversity of habitat types and surface area responses among segments with different morphologic characteristics.

Average monthly discharges for the Susitna River at Gold Creek range from 1,500 cfs in winter to 28,000 cfs during summer; the average annual discharge is 9,700 cfs (Figure 3a). Snowmelt runoff during June and early July accompanied by glacial melt and rainfall runoff during July

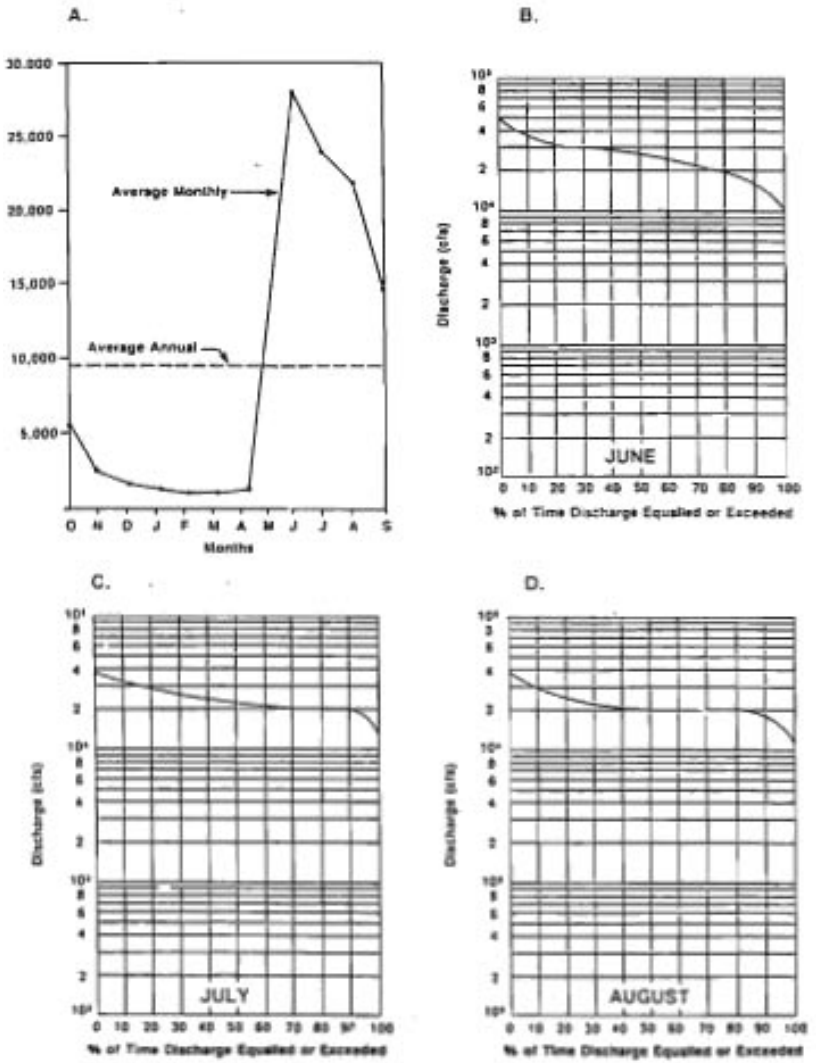

FIGURE 3 Average annual discharge and average monthly discharges for the Susitna River at Gold Creek (adapted from Scully, Leveen, and George 1978); b,c,d. Monthly flow duration curves for the Susitna River at Gold Creek (adapted from Acres American Inc. 1983).

and August provide stable and persistent high summer discharges (Figure 3b, c, d).

From an analysis of the hydrologic data, it was determined that the aerial photography obtained at a mainstem discharge of 23,000 cfs represents a typical mid-summer discharge for the Talkeetna-to-Devil Canyon reach of the Susitna River. Therefore, this photography was used to depict baseline mid-summer conditions. The percent change in habitat type surface areas as a function of mainstem discharge for other discharges was referenced to the digitized surface areas on the 23,000 cfs photography.

RESULTS

Total surface areas for aquatic habitat types in the Talkeetna-to-Devil Canyon reach of the Susitna River are presented in Table 2. These habitat types represent physical characteristics of the environment. In some cases, such as for tributaries and their mouths, habitat type is associated with specific geographical location and the habitat type persists over a broad range of streamflows even though the surface areas may respond significantly to changes in discharge. In other instances, specific geographic locations transform from one habitat type into another as river stage increases or decreases.

Surface area values presented in Table 2 were plotted to illustrate the surface area responses of individual habitat types in response to changes in mainstem discharge (Figure 4). Surface areas of mainstem and side channel habitats decreased with decreasing discharge.

Table 2. Total surface areas by habitat type within the Talkeetna-to-Devil Canyon reach of the Susitna River.

Habitat Type	Surface Area (acres) by Discharge						
	5,100 cfs	7,400 cfs	10,600 cfs	12,500 cfs	16,000 cfs	18,000 cfs	23,000 cfs
Mainstem	2458.1	2599.6	2805.9	2850.4	3158.5	DATA NOT AVAILABLE AT TIME OF PUBLICATION.	3737.2
Side Channel	729.7	768.7	968.7	1095.5	1222.2		1240.7
Side Slough	121.4	144.0	134.2	118.1	85.8		52.5
Upland Slough	15.3	22.9	19.6	23.6	22.6		24.4
Tributary Mouth	15.9	15.1	18.6	26.2	25.3		12.1
Gravel Bar	2518.5	2301.2	1848.4	1727.7	1419.2		815.8
Vegetated Bar	1945.4	2130.5	2080.2	1919.1	2011.4		1718.4

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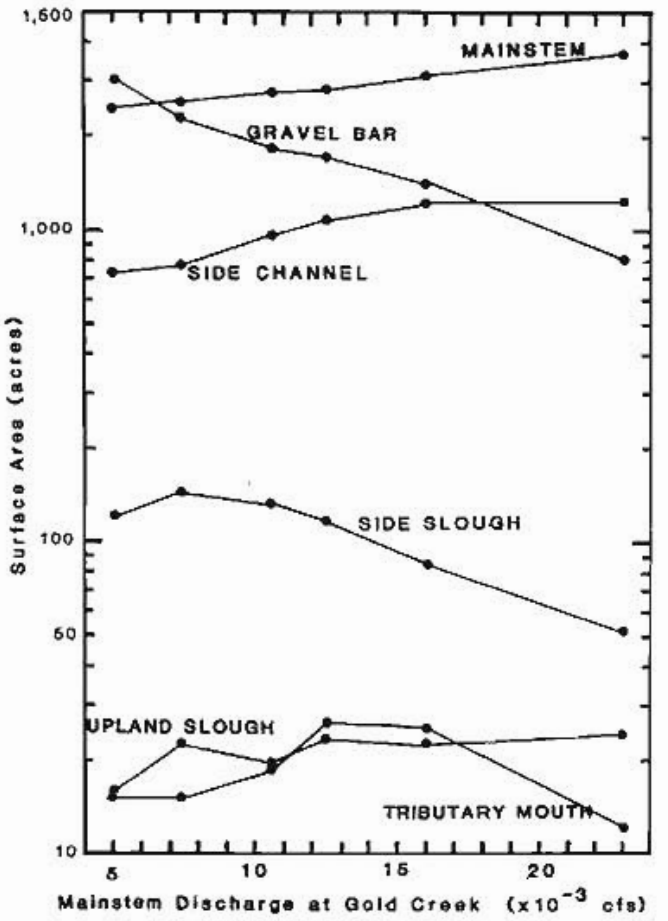

FIGURE 4 Surface area responses to mainstem discharge in the Talkeetna-to-Devil Canyon reach of the Susitna River (RM 101 to 149).

Concurrently, exposed gravel bar surface area increased with decreased discharge.

Side slough surface area increased with decreasing discharge down to a mainstem discharge of 7,400 cfs, and then decreased at 5,100 cfs. Upland slough surface area remained relatively constant over the range of mainstem discharges, decreasing somewhat at 5,100 cfs. Surface area of tributary mouth habitat peaked at intermediate flows of 16,000 and 12,500 cfs. Vegetated bar surface area remained relatively constant over the range of mainstem discharges.

Table 3 presents the percentage of the total river corridor represented by each habitat type for each of the seven mainstem discharges. Table 4 presents the percent change in the surface area of each habitat type with decreasing discharge as calculated from a baseline discharge of 23,000 cfs.

The Talkeetna-to-Devil Canyon reach was divided into four segments based upon differing geomorphological characteristics. These segments extend from approximately river miles (RM) 101 to 113, 113 to 122, 122 to 138, and 138 to 149. Because of differences in the amount of surface area within each river segment and the desire to accent the response of habitat surface areas within the river segments, surface areas for the various habitat types are reported as the percent of total area in the river corridor (Figure 5). Figure 6 presents a relative comparison of total surface areas calculated for various habitat types within the entire Talkeetna-to-Devil Canyon reach and within the four segments in response to changing mainstem discharge.

DISCUSSION

Air photo interpretation is highly dependent upon the quality of the photography. Although each set of photographs obtained for this study was generally clear and complete, the time of day, date, and prevailing weather conditions at the time the aerial photographic missions were flown affected the extent to which detailed riverine features were visible.

The 23,000 cfs photography, taken on June 1, 1982, was obtained at a time of the year when the sun was at a high angle and deciduous vegetation had not fully leafed-out. This resulted in few shadows, enabling excellent delineation of water's edge and slough boundaries. The 7,400 cfs and 5,100 cfs photography, obtained on October 4 and 14, 1984, respectively, have extensive areas of shadows along the south and east shorelines. This was due primarily to the low sun angle during that time of year. These shadows sometimes obscured the water's edge and made some surface area delineations more difficult. The remaining sets of photography had isolated shadow problems. In spite of the minor problems with photographic detail, accurate and reliable surface area measurements were obtained using various techniques to aid in delineations.

Table 3. Surface areas by habitat type within the Talkeetna-to-Devil Canyon reach of the Susitna River expressed as a percentage of the total river corridor area.

	Percentage by Discharge						
Habitat Type	5,100 cfs	7,400 cfs	10,600 cfs	12,500 cfs	16,000 cfs	18,000 cfs	23,000 cfs
Mainstem	31.5	32.5	35.6	36.7	39.7	DATA NOT AVAILABLE AT TIME OF PUBLICATION	49.1
Side Channel	9.3	9.6	12.3	14.1	15.4		16.3
Side Slough	1.6	1.8	1.7	1.5	1.1		0.7
Upland Slough	0.2	0.3	0.2	0.3	0.3		0.3
Tributary Mouth	0.2	0.2	0.2	0.3	0.3		0.2
Gravel Bar	32.3	28.8	25.4	22.2	17.9		10.7
Vegetated Bar	24.9	26.7	26.4	24.7	25.3		22.6

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Table 4. Percent change in digitized surface areas relative to corresponding areas present at 23,000 cfs.

	Percentage Change by Discharge					
Habitat Type	18,000 cfs	16,000 cfs	12,500 cfs	10,600 cfs	7,400 cfs	5,100 cfs
Mainstem	DATA NOT AVAILABLE AT TIME OF PUBLICATION	-15.5	-23.7	-24.9	-30.4	-34.2
Side Channel		-1.5	-11.7	-21.9	-38.0	-41.2
Side Slough		83.4	125.0	155.6	174.3	131.2
Upland Slough		-7..	-3.3	-19.7	-6.1	-37.3
Tributary Mouth		109.1	116.5	53.7	24.8	31.4
Gravel Bar		74.0	111.8	126.6	182.1	208.7

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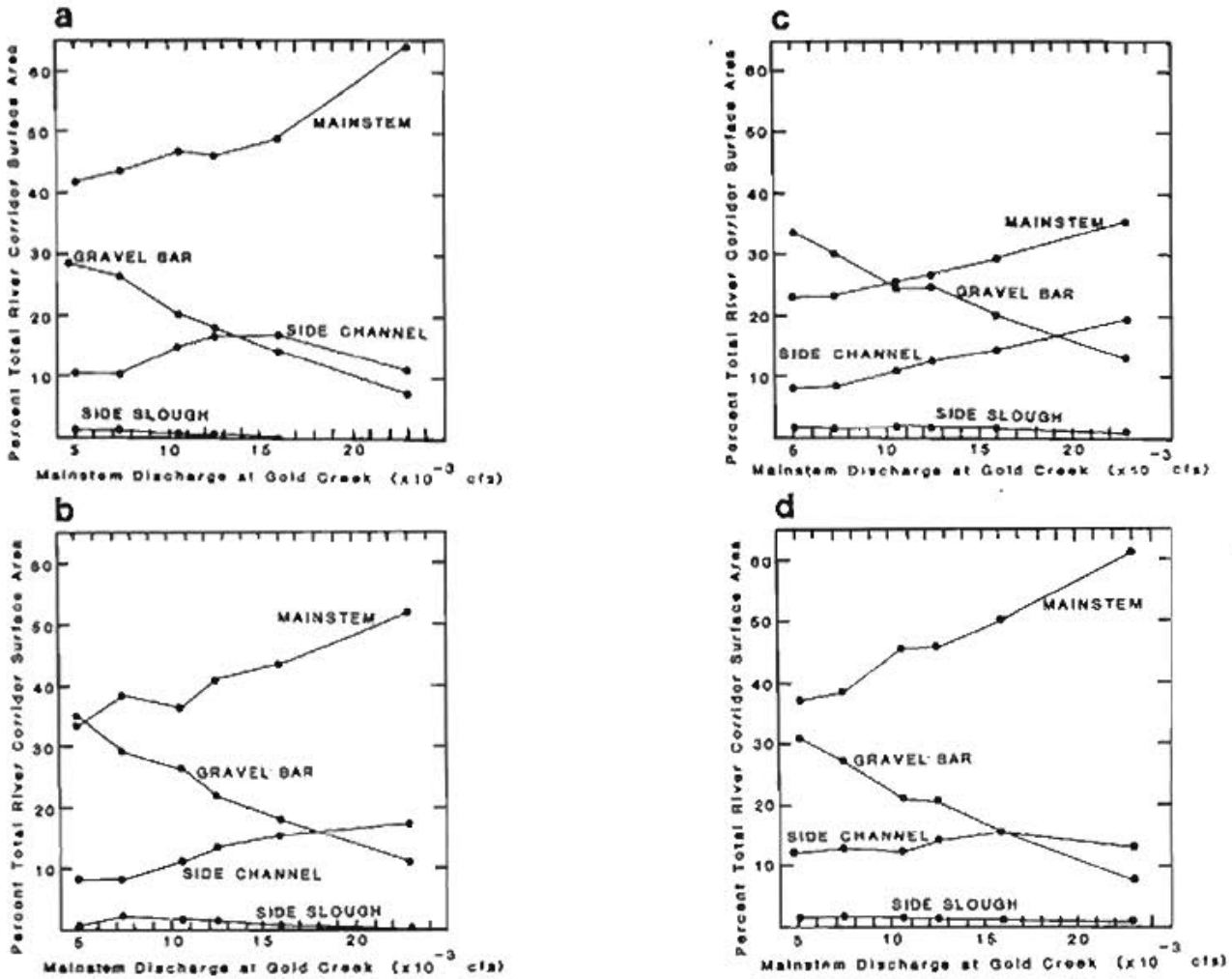

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Figure 5. Surface area responses to mainstem discharge expressed as a percentage of the total river corridor surface area. Segment a: Talkeetna-to-Lane Creek (RM 101 to 113); Segment b: Lane Creek-to-Curry (RM 113 to 122); Segment c: Curry-to-Gold Creek (RM 122 to 138); Segment d: Gold Creek-to- Devil Canyon (RM 138 to 149).

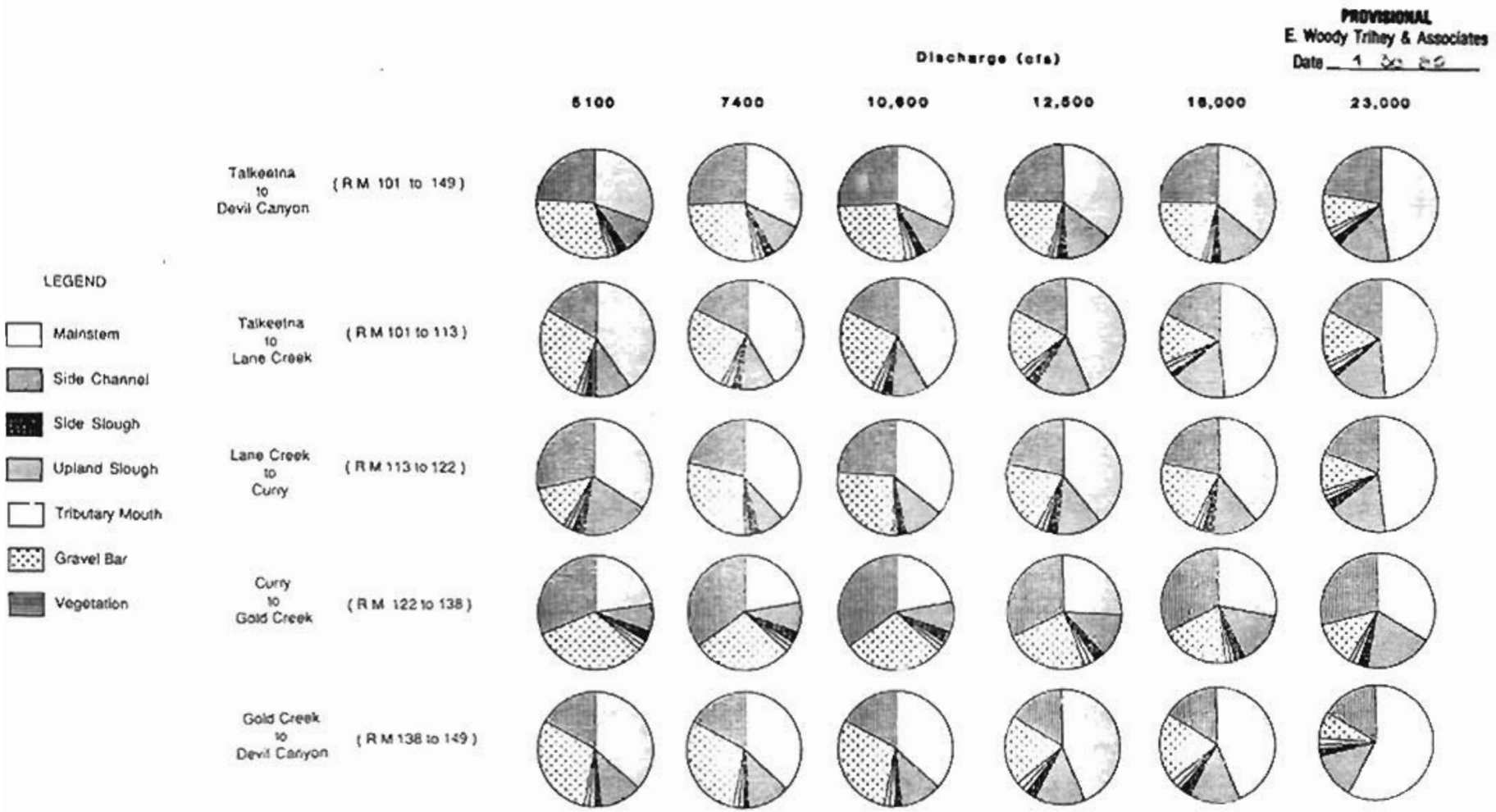

Figure 6. A comparison of relative amounts of the different habitat types comprising various segments of the Susitna River at six mainstem discharges.

Aquatic habitat surface area responses are a function of streamflow and channel geometry. Small local changes were observed during the time period in which the sets of photography were obtained. These small changes were thought to have an insignificant effect on the accuracy of the surface area measurements or the ability to make comparisons between photographs taken in different years. If channel geometry remains relatively constant over time, then the aquatic habitat surface area responses can also be expected to remain constant. Therefore, the results presented here are representative of open water conditions and existing channel geometry.

The proposed project is expected to result in a longer open-water season than is present under natural conditions. In addition, when freeze-up occurs, the location of the ice front is anticipated to occur farther downstream, leaving portions of the middle river ice-free (Harza-Ebasco 1985a,b).

Some changes in channel morphology are anticipated. The mainstem channel is expected to degrade by as much as a foot, leaving some side channel and slough areas perched. This would result in a higher mainstem stage required to overtop the alluvial berms (Harza-Ebasco 1985c).

The surface area response patterns presented here could be adjusted to account for altered breaching discharges of various sloughs and side channels and, therefore, be applicable to a post-project scenario. It must be re-emphasized, however, that the results of this study make no assessment of the quality of the habitats or their suitability for use by fish.

Definitions for aquatic habitat types used in this study represent a set of visually recognizable, streamflow dependent physical characteristics that do not restrict the occurrence of a particular habitat type to fixed geographical locations. An example of the flow-dependent nature of these definitions is reflected by side slough and side channel habitats. Side sloughs, by definition, are clear water habitats in which the flow is maintained by upwelling and local surface runoff. A non-vegetated alluvial berm at the upstream end of the dewatered overflow channel separates the clear water habitat from the active channel. When mainstem discharge increases and river stage rises, the alluvial berm at the head of the slough is overtopped. Turbid mainstem water flows into the channel and replaces the former clear water habitat with deeper, faster-flowing turbid water. The aquatic habitat at this location then fits the definition of side channel habitat. Conversely, as mainstem discharge decreases, areas classified as side channels may become cut off from mainstem flow at their upstream end and become clear water habitats. If the clear water inflow to these systems is sufficient to maintain a downstream connection with the mainstem, these areas then fit the definition of side slough habitat.

General trends in surface area response to mainstem discharge became apparent in this study. As mainstem discharge decreased, the surface area of both mainstem and side channel habitat types decreased. Concurrently, side slough habitat surface area increased with decreasing discharge. The decrease in side slough surface area shown at 5,100 cfs

was due to some of the sloughs dewatering at their downstream end leaving remnant, ponded water which was not considered available habitat.

The surface area response of mainstem, side channel, and side slough habitat is not necessarily directly correlated with habitat quality. In mainstem and some side channel habitats, velocity and depth are limiting factors for the distribution of fish. As mainstem and side channel surface areas decrease with decreasing mainstem stage, water depths and velocities in these areas are reduced, making these habitats more suitable for use by fish. Conversely, as mainstem discharge decreases and side slough habitat increases, these already shallow slough areas may become even shallower with very low velocities. Access into these areas may become a problem and/or the shallow depths of the sloughs themselves may result in less than suitable habitat.

Tributary mouths and upland sloughs are the other source of clear water habitats in the middle river. Tributary mouth habitat surface area is a function of both mainstem discharge and tributary flow. Surface area was low at a mainstem discharge of 23,000 cfs, increased at moderate mainstem discharges and then decreased at discharges of 10,600 cfs and below. At 23,000 cfs, the combination of high mainstem stage and water velocities resulted in a shearing off of the clear water plume as it entered the mainstem. The decrease in tributary mouth surface area at the lower mainstem discharges probably reflects lower tributary flows.

Upland slough surface area remained relatively constant over the range of mainstem discharges investigated. At 5,100 cfs, the surface area decrease was due to the mouths of some upland sloughs becoming dewatered leaving the sloughs as remnant, ponded areas inaccessible to fish.

As mainstem discharge decreased, the combined surface area of clear water habitats increased. This increase in clear water is important not only as potential juvenile salmon rearing habitat, but could be of importance for primary and secondary production if these clear water areas remained relatively stable. For example, a reduction in mainstem discharge from 23,000 to 10,600 cfs (essentially halving the mid-summer flow) results in a 200 percent increase in total clear water surface area with a 50 percent decrease in turbid water surface area, and a 125 percent increase in exposed gravel bars. Even a decrease in discharge from 23,000 to 16,000 cfs results in a 170 percent increase in clear water, primarily due to increased tributary mouth surface area.

It must be re-emphasized here that an increase in clear water surface area is not directly correlated with an increase in suitable fish habitat. By definition, side sloughs are clear water areas maintained by upwelling. Without field verification, it is difficult to distinguish between true side sloughs and areas containing clear water due to settling out of suspended sediments and possibly dilution by surface water runoff once the upstream berm of a side channel is dewatered.

Different segments of the middle Susitna River appear different morphologically and vary in the relative amounts of wetted areas, gravel bars, and vegetated islands. In all segments, mainstem and vegetated island surface areas predominate. The greatest diversity occurs in the

Lane Creek-to-Gold Creek segment (RM 113 to 138), in which a greater percentage of the total surface area is represented by gravel and vegetated bars. This river segment is characterized by a more braided channel pattern. In these areas, the relatively large edge effect due to the numerous islands and gravel bars may result in the potential for creation of more usable habitat along channel margins and in channels with higher streambed elevations as mainstem stage drops and water velocities are reduced. In contrast, relatively steep-banked, channelized segments of the river where edge effects are minimal will probably not show as large an increase in potential habitat.

The results of this study can be used to indicate the potential for increase or decrease in the amount of usable habitat by evaluating surface area responses of various habitat types. The term usable habitat would include not only fish habitat, but also aquatic habitats suitable for primary and secondary production. However, the limitations of the surface area data generated by this study must be realized. These limitations reflect the strictly physical descriptions of the habitat types defined here.

The results of this study, however, can be applied to both ongoing and future additional studies which focus more directly on various biological features of aquatic habitats. Habitat recon work (Aaserude, et al. 1985) focused on further defining and subdividing habitat types into categories which more specifically define habitat attributes and responses to flow. Fish utilization data (Hoffman 1985) will be applied to the results of the habitat recon work to provide a measure of the suitability of the various aquatic habitats for use by adult and juvenile salmon.

Measurements of primary production in the middle river are anticipated from AEIDC. This work, in combination with the development of a euphotic surface area response model (Reub, et al. 1985), will address the issue of with-project primary production potential. These studies will provide biological significance to the increase in total surface area of clear water habitats seen in this study as mainstem discharge decreased.

The surface area response data presented here represent a portion of a much larger integrated data base which, when complete, will facilitate the forecasting of the effects of altered streamflows on the biological and habitat components of the middle Susitna River.

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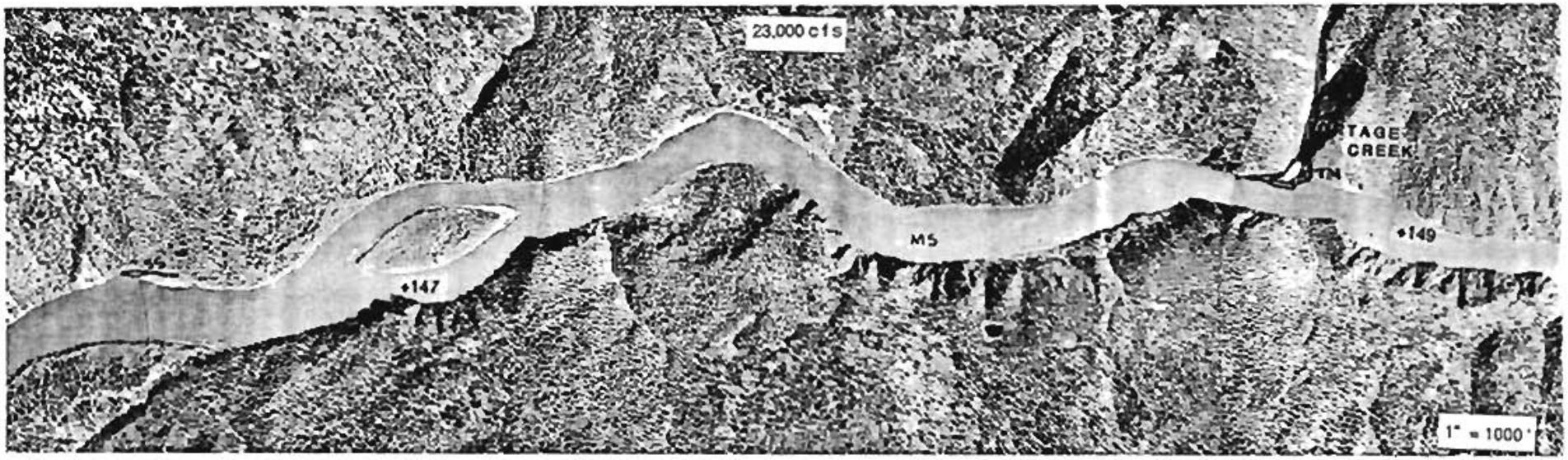
Appendix 1. Plates.



LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

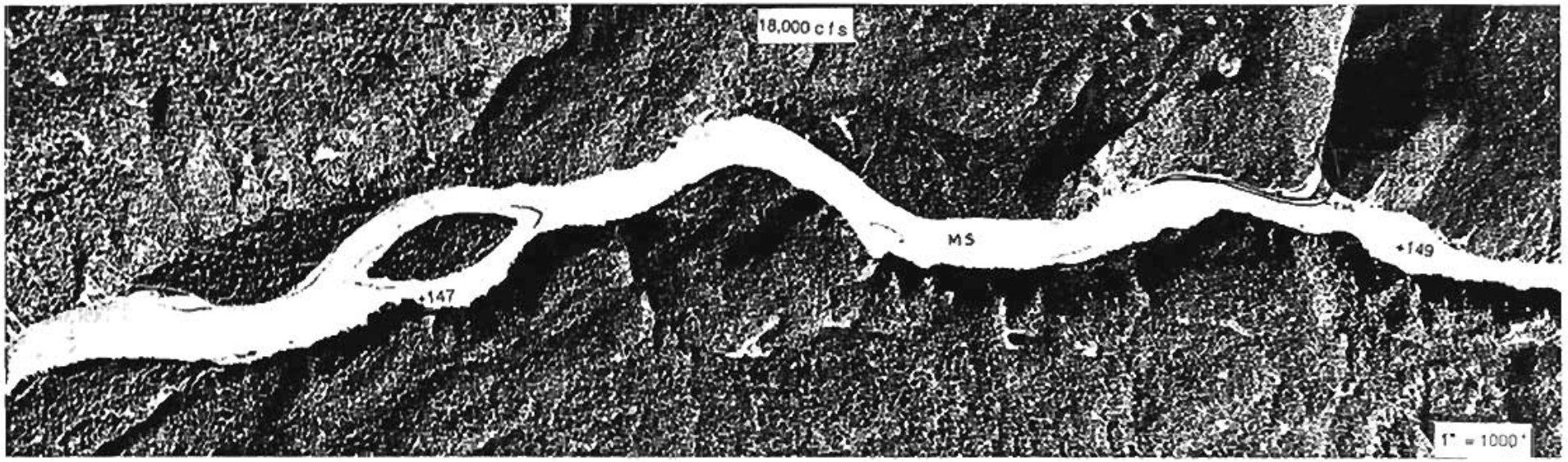
MIDDLE SUSITNA RIVER

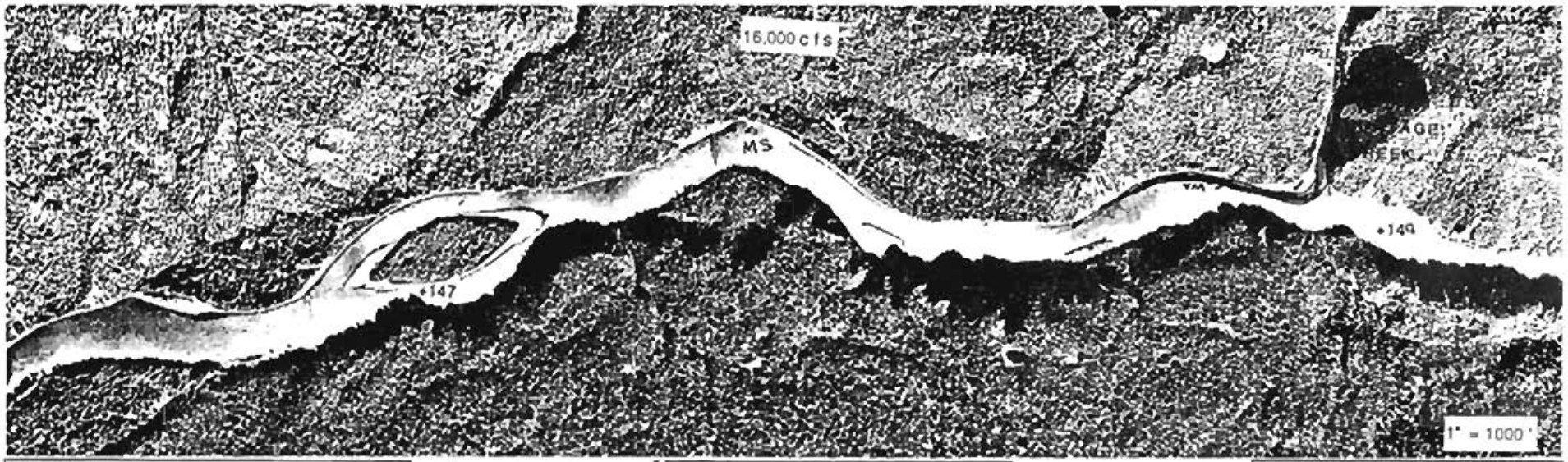
PLATE 1 OF 18 RIVER MILE 147 TO 149

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE





LEGEND

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SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 1 OF 18 RIVER MILE 147 TO 149

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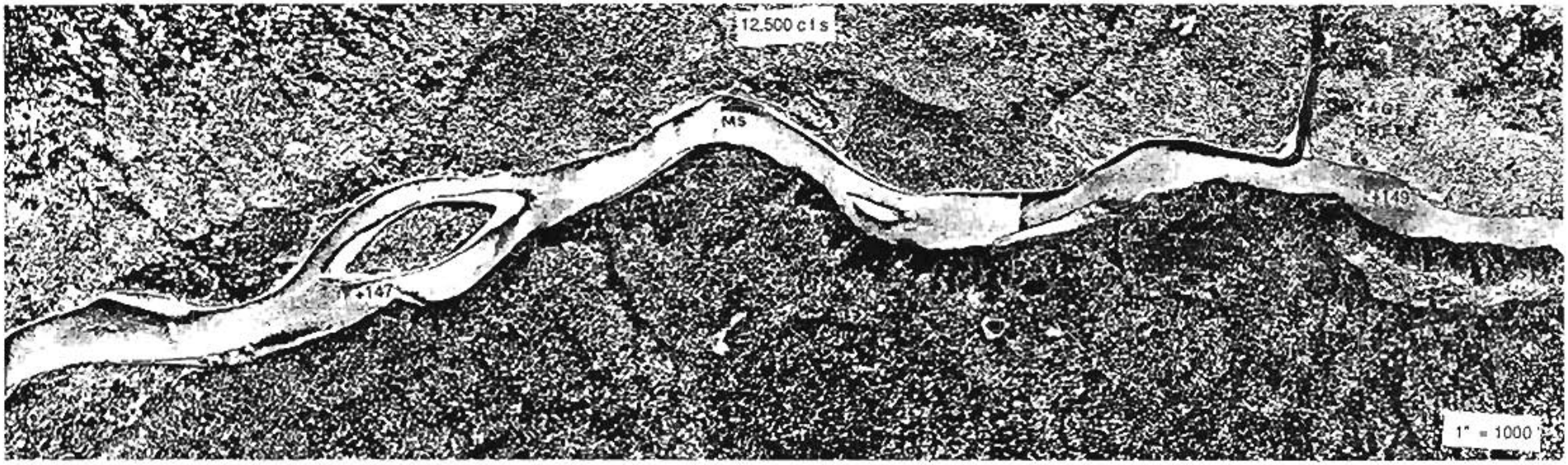

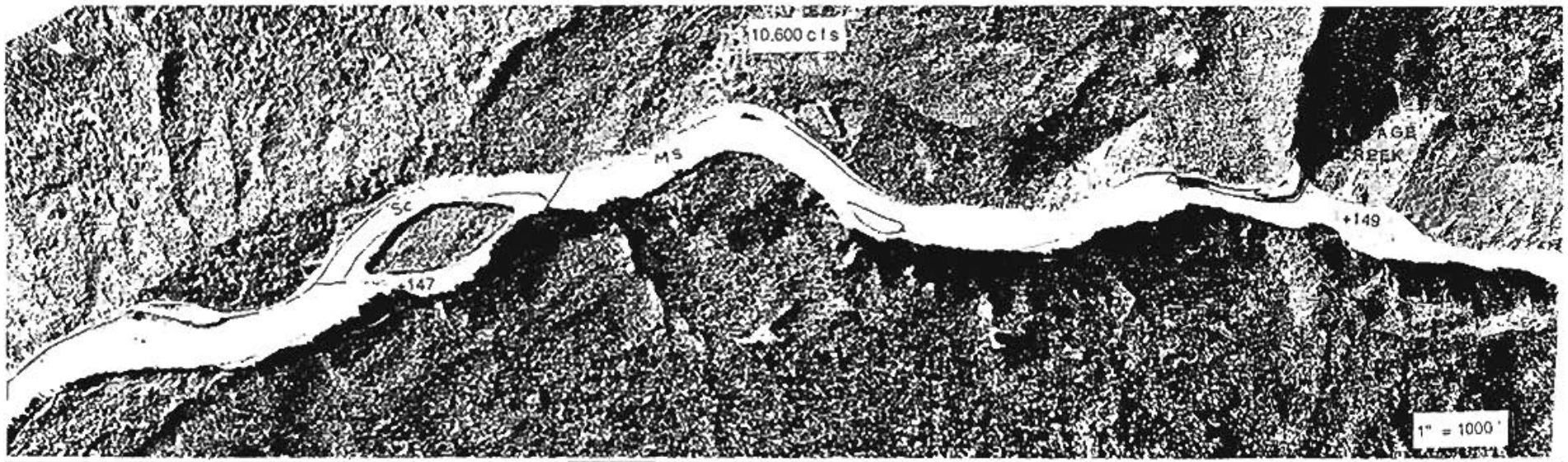

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SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 1 OF 18 RIVER MILE 147 TO 149

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTHIC PROJECT

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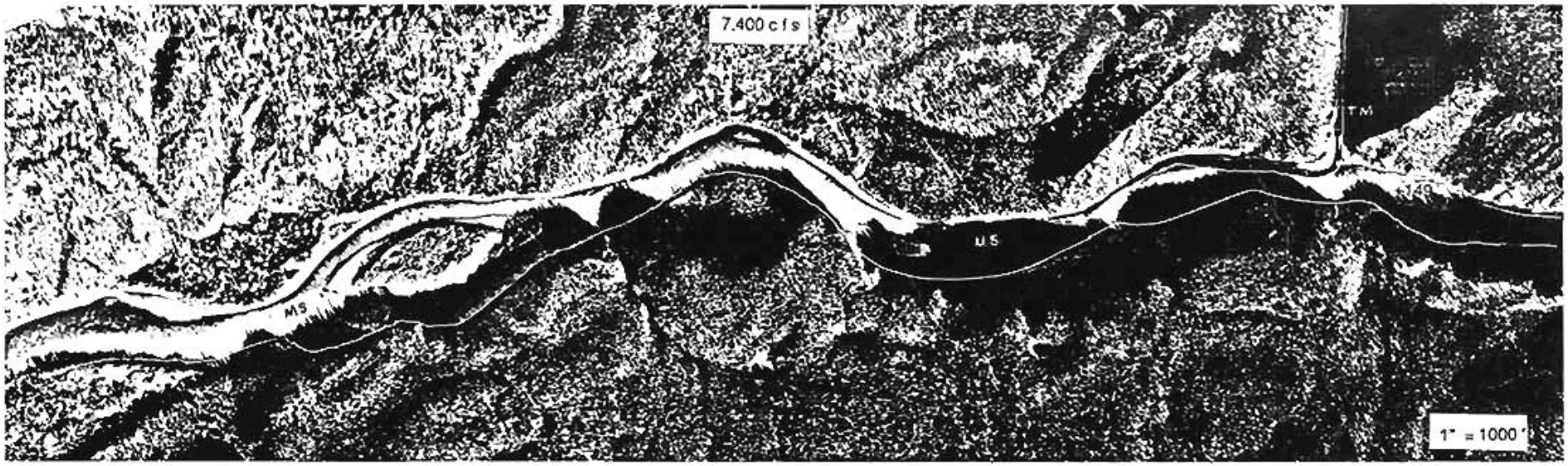
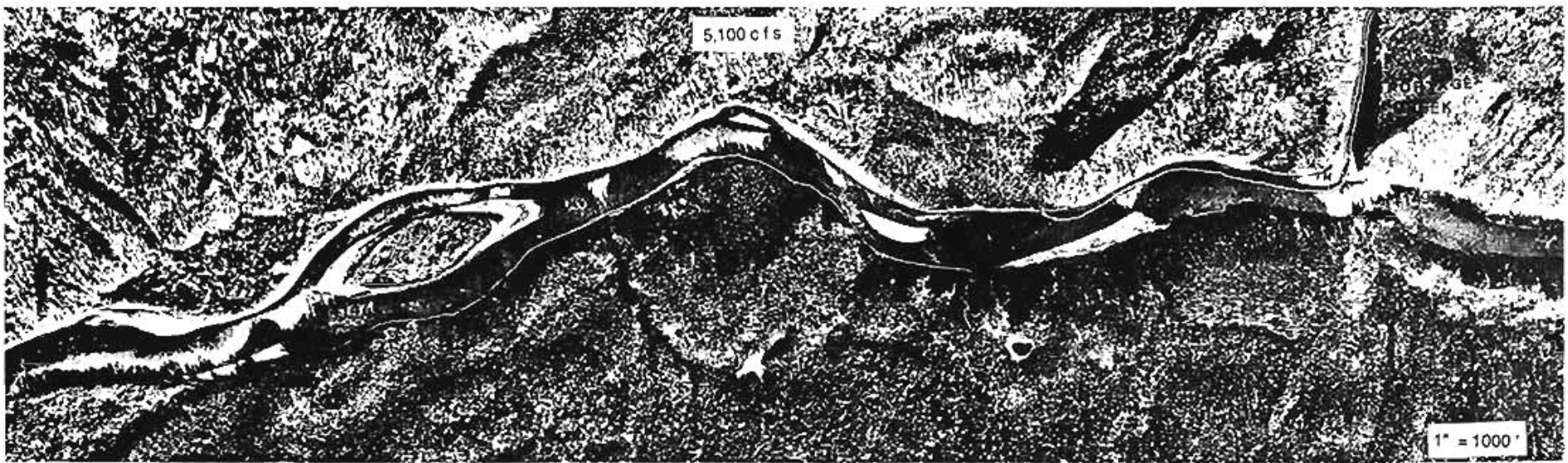
SUSITNA JOINT VENTURE





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MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 1 OF 18 RIVER MILE 147 TO 149

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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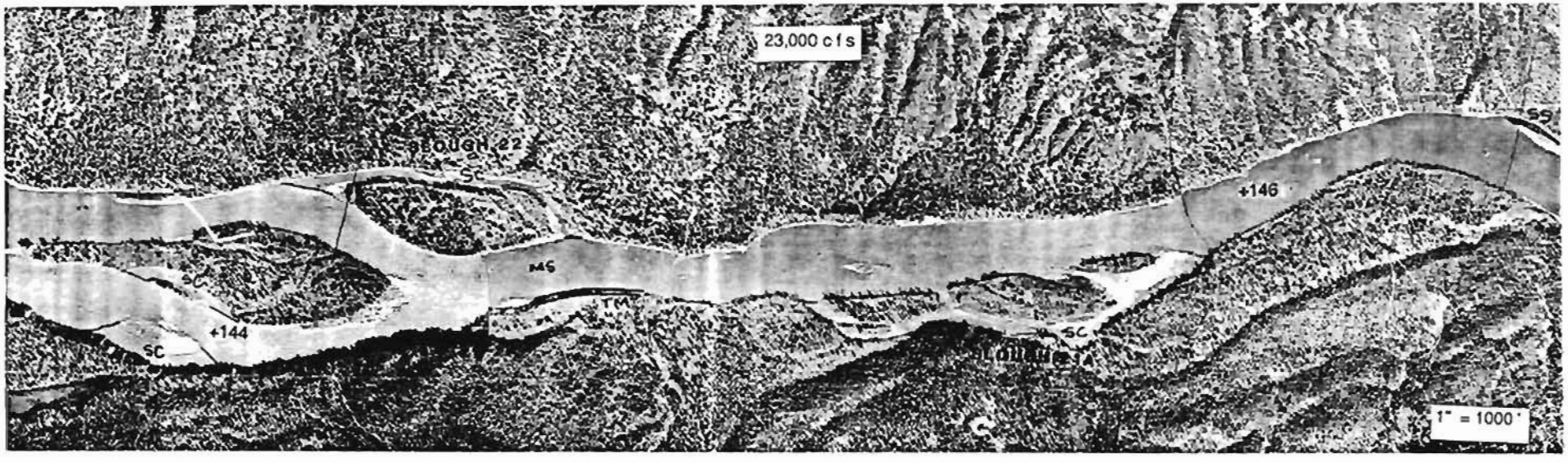
SUSITNA JOINT VENTURE



LEGEND

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SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 2 OF 18 RIVER MILE 144 TO 146

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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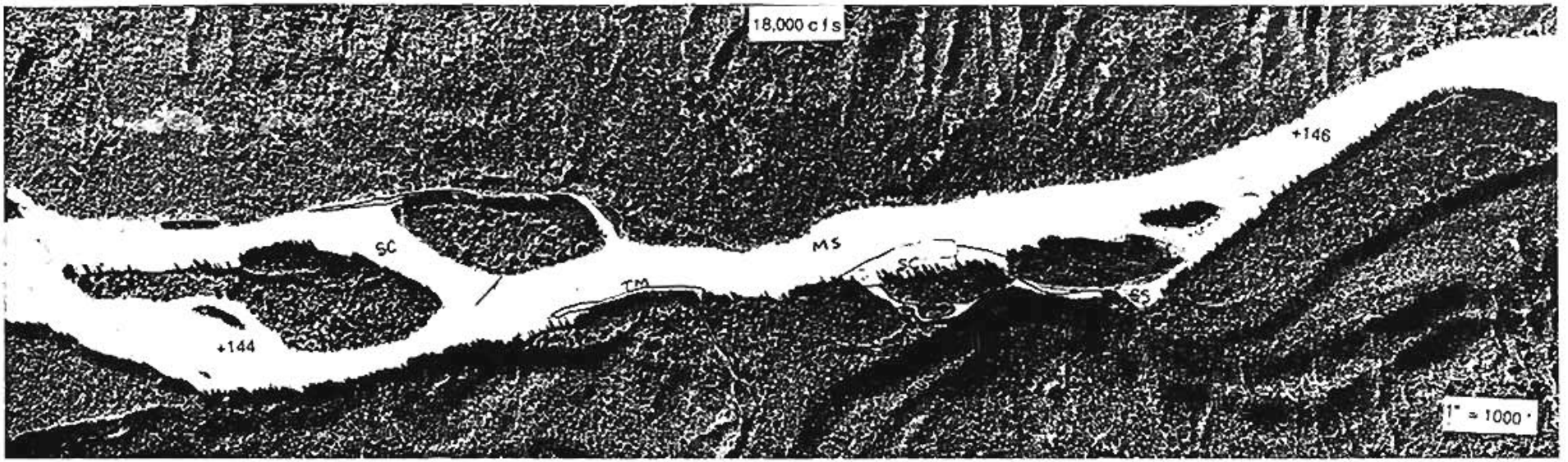
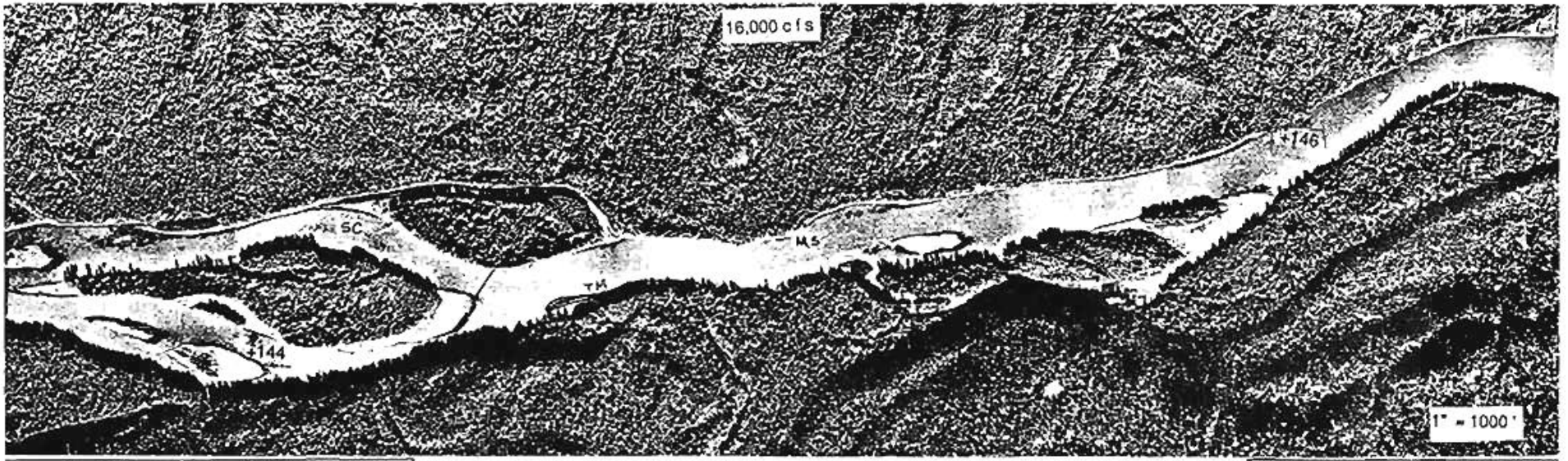
SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 2 OF 18 RIVER MILE 144 TO 146

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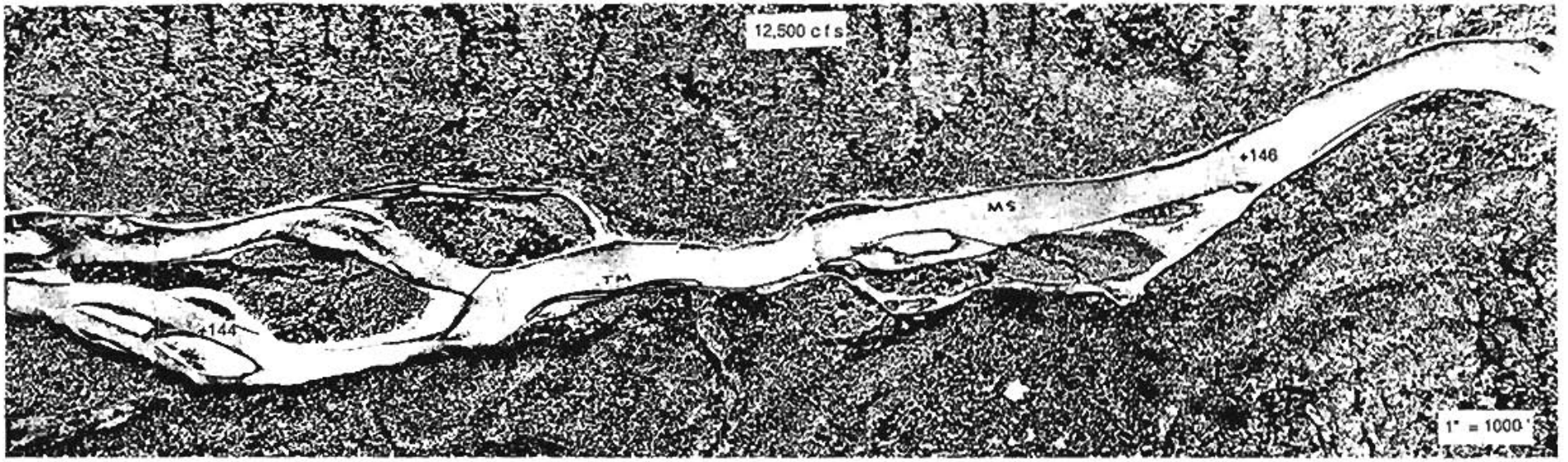
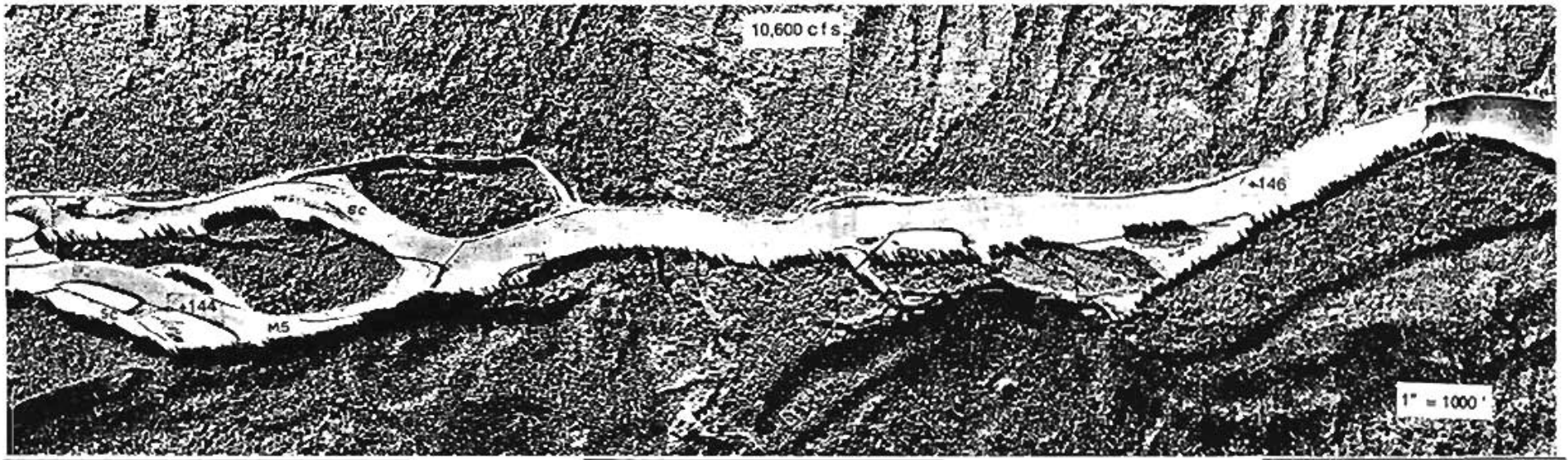
SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 2 OF 18 RIVER MILE 144 TO 146

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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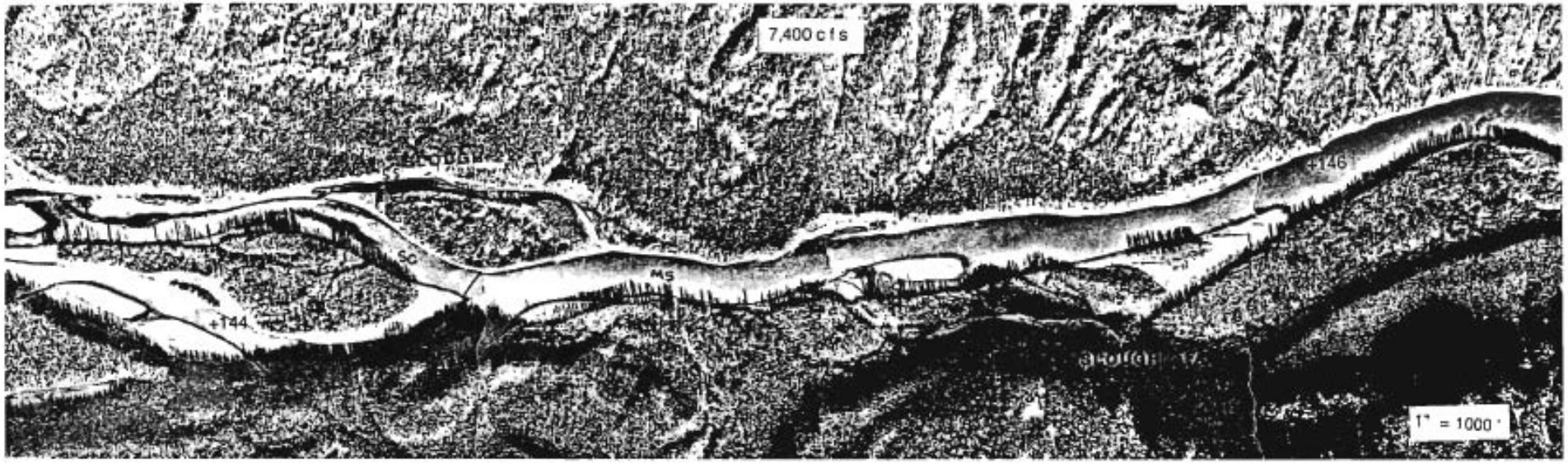
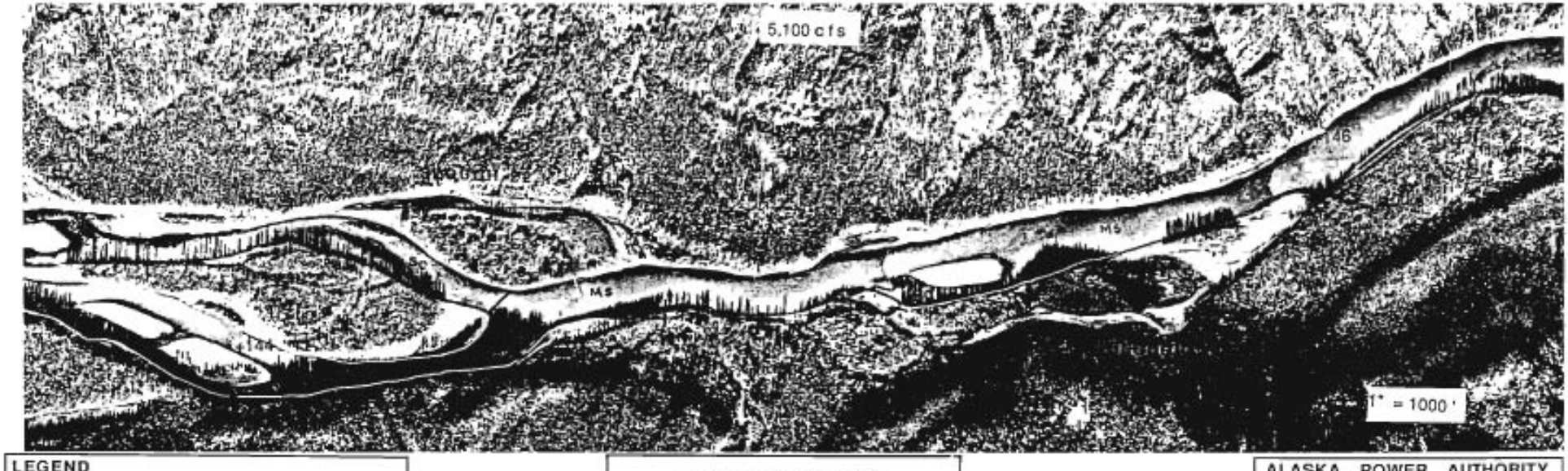
SUSITNA JOINT VENTURE





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MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 2 OF 18 RIVER MILE 144 TO 146

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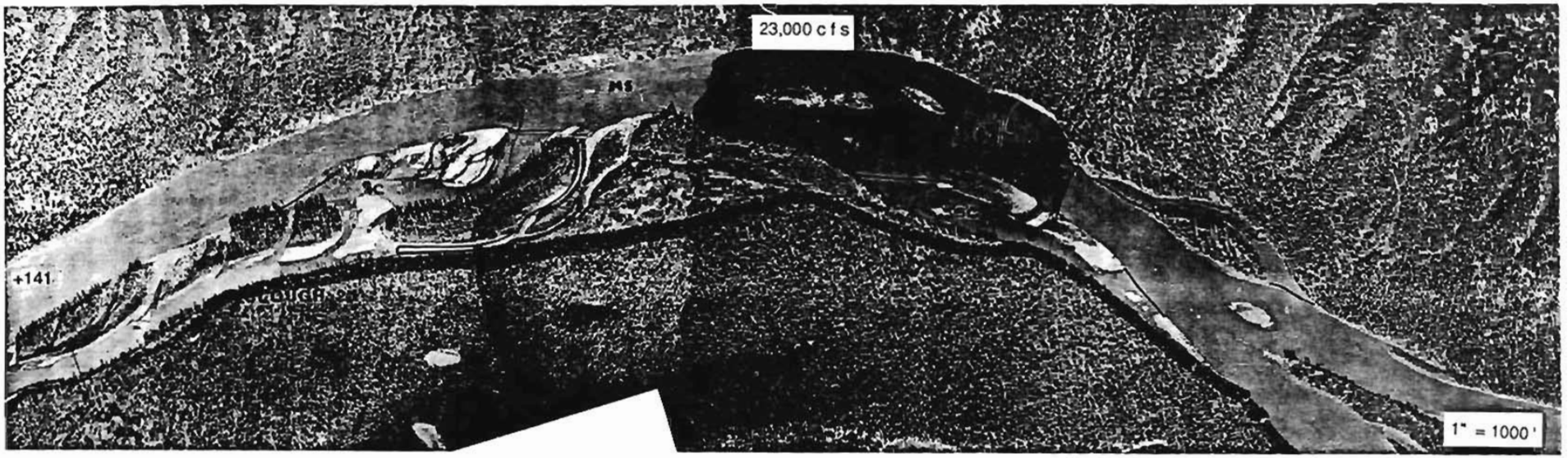

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MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 3 OF 18 RIVER MILE 142 TO 144

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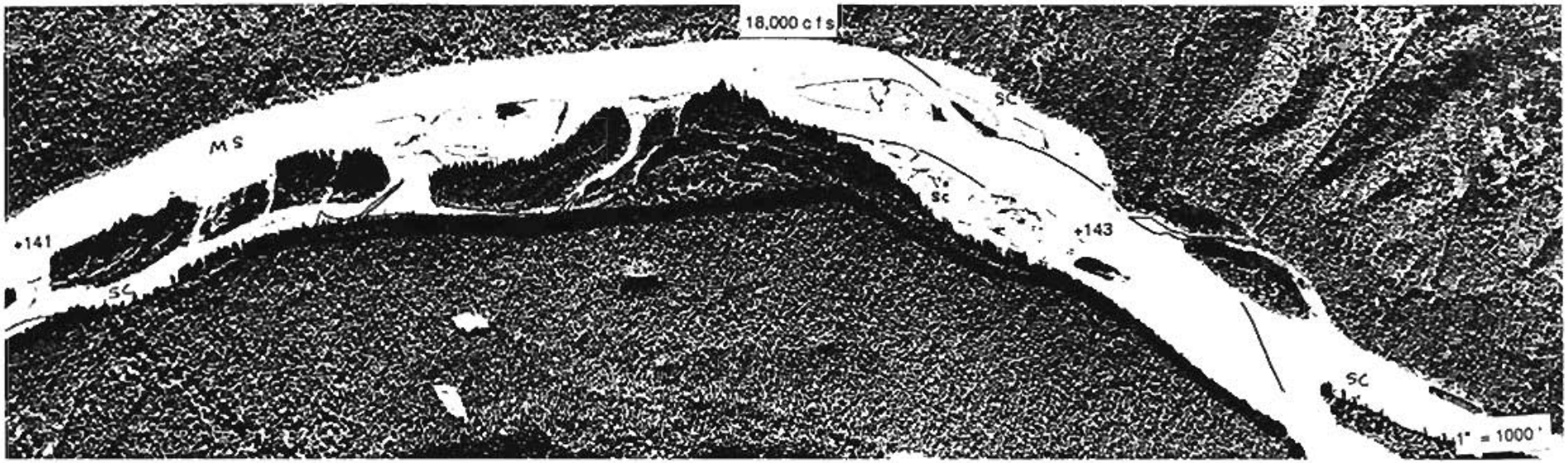

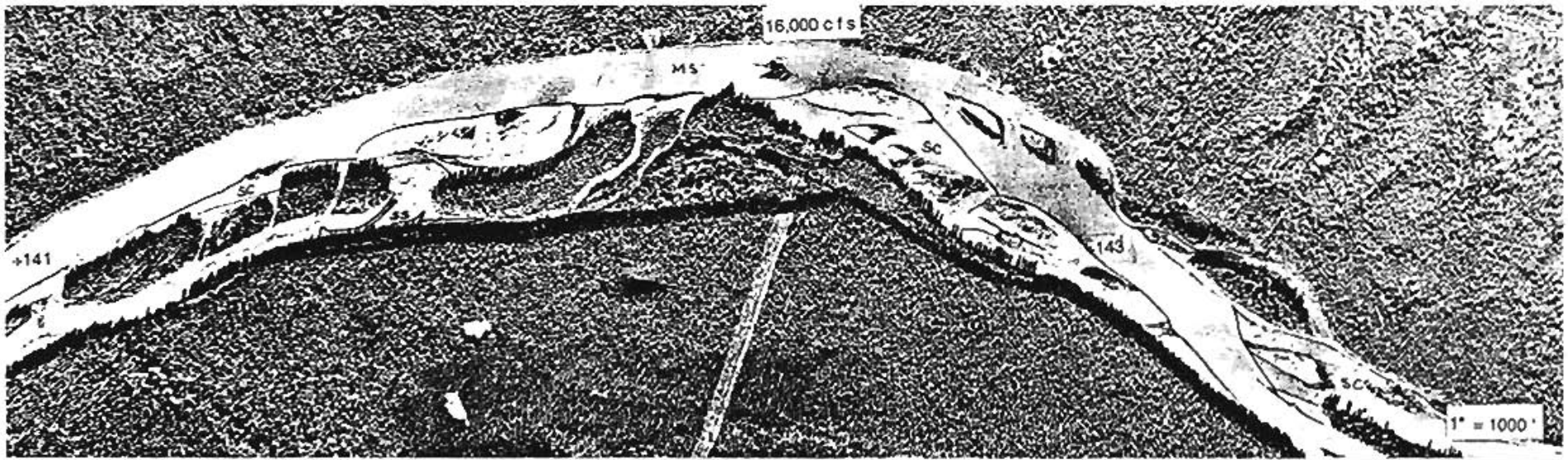

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SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 3 OF 18 RIVER MILE 142 TO 144

ALASKA POWER AUTHORITY
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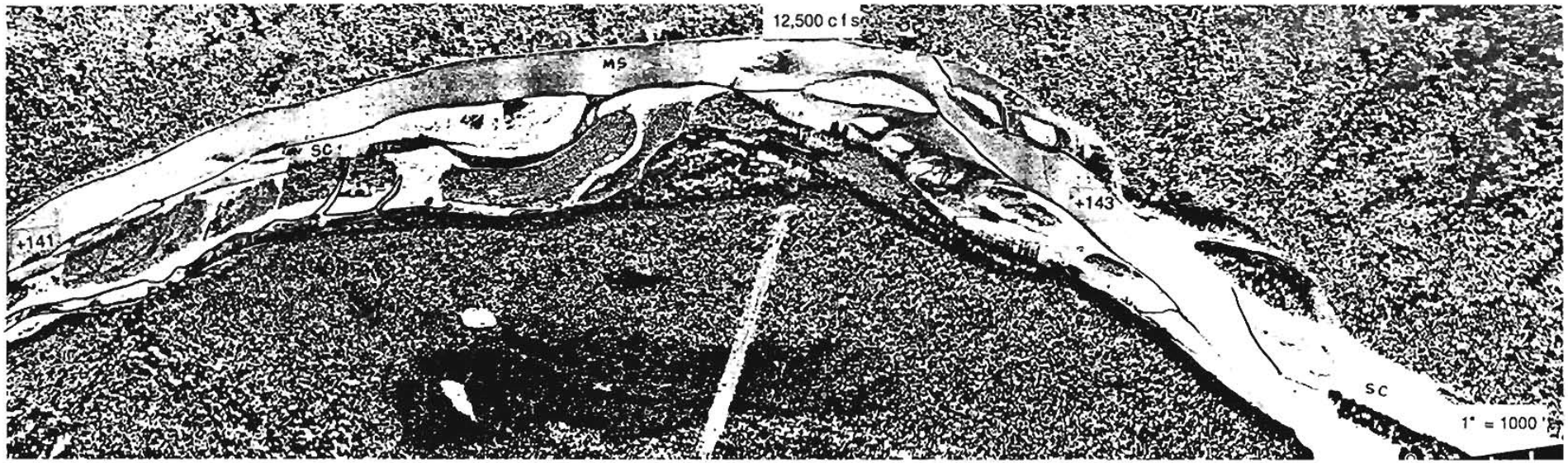

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SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 3 OF 18 RIVER MILE 142 TO 144

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SUSITNA HYDROELECTRIC PROJECT

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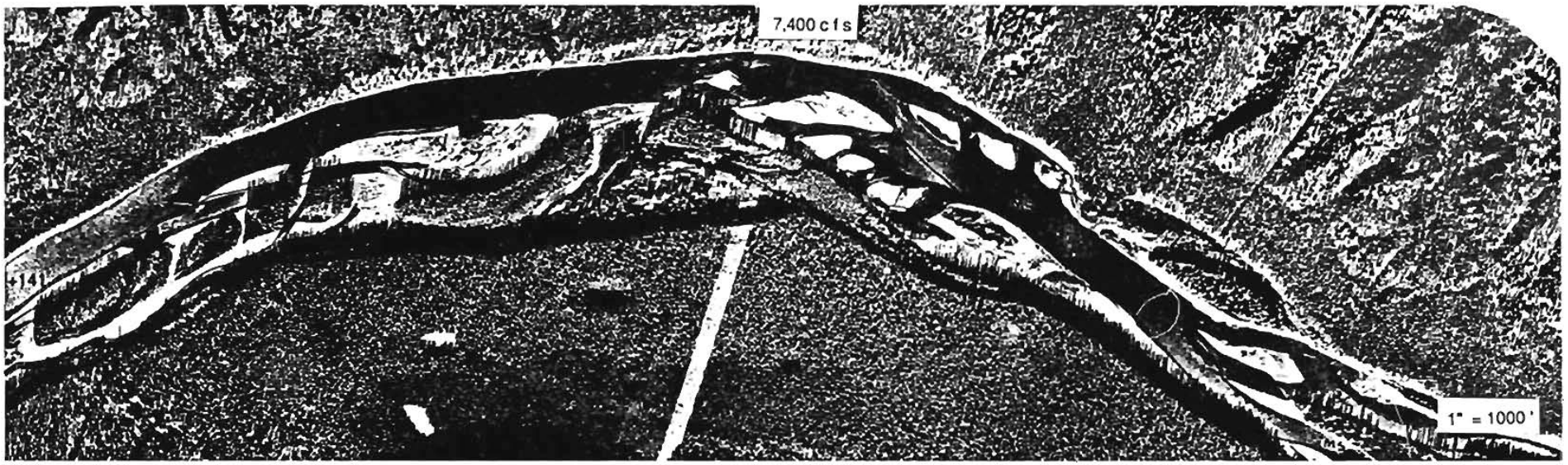
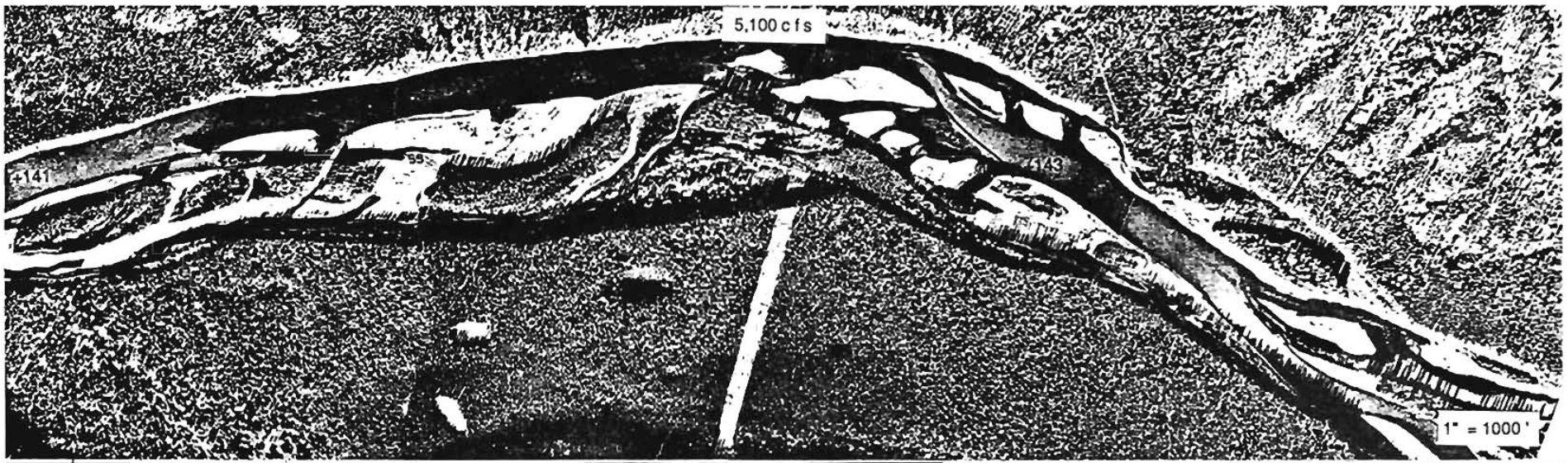
SUSITNA JOINT VENTURE





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SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 3 OF 18 RIVER MILE 142 TO 144

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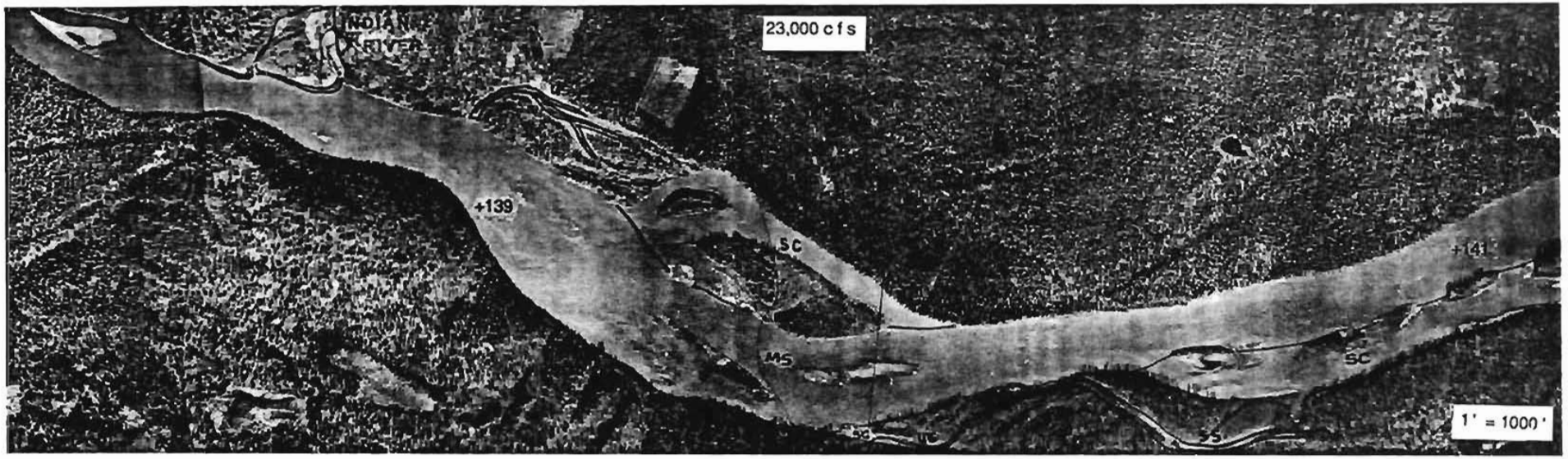

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SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLCUGH	+	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 4 OF 18 RIVER MILE 139 TO 141

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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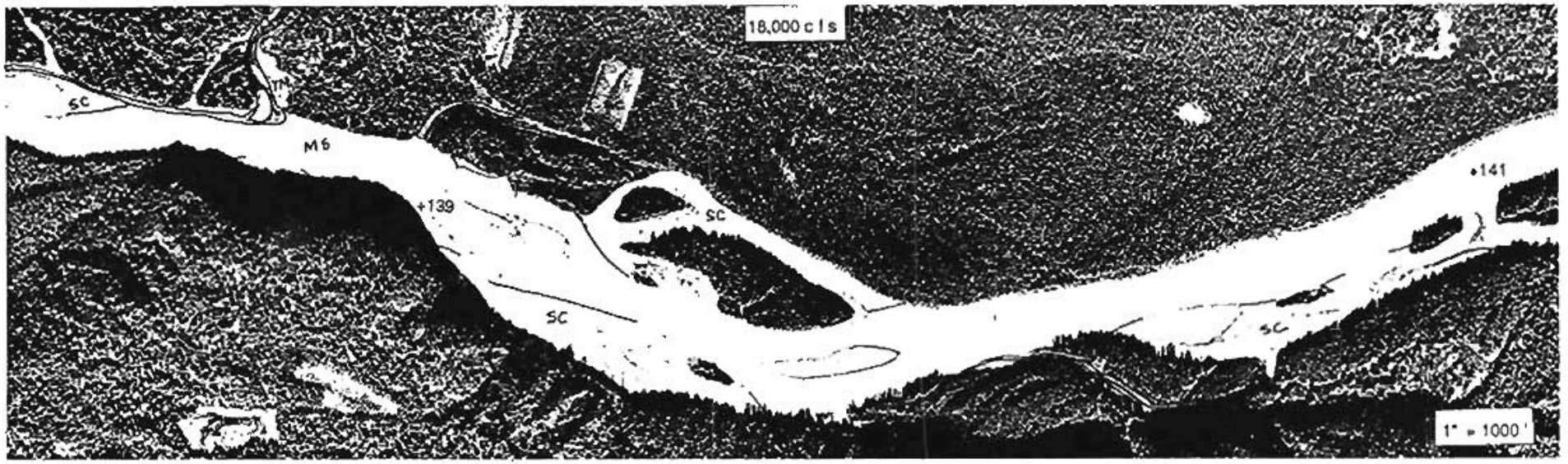
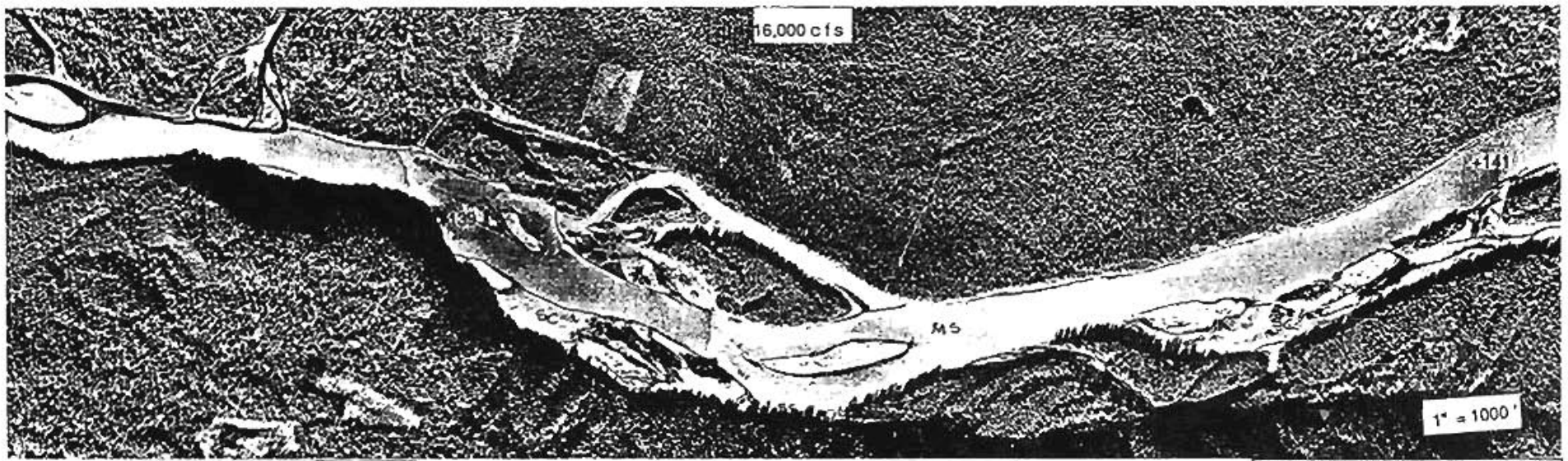
E. WOODY TRIHEY & ASSOCIATES	SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 4 OF 18 RIVER MILE 139 TO 141

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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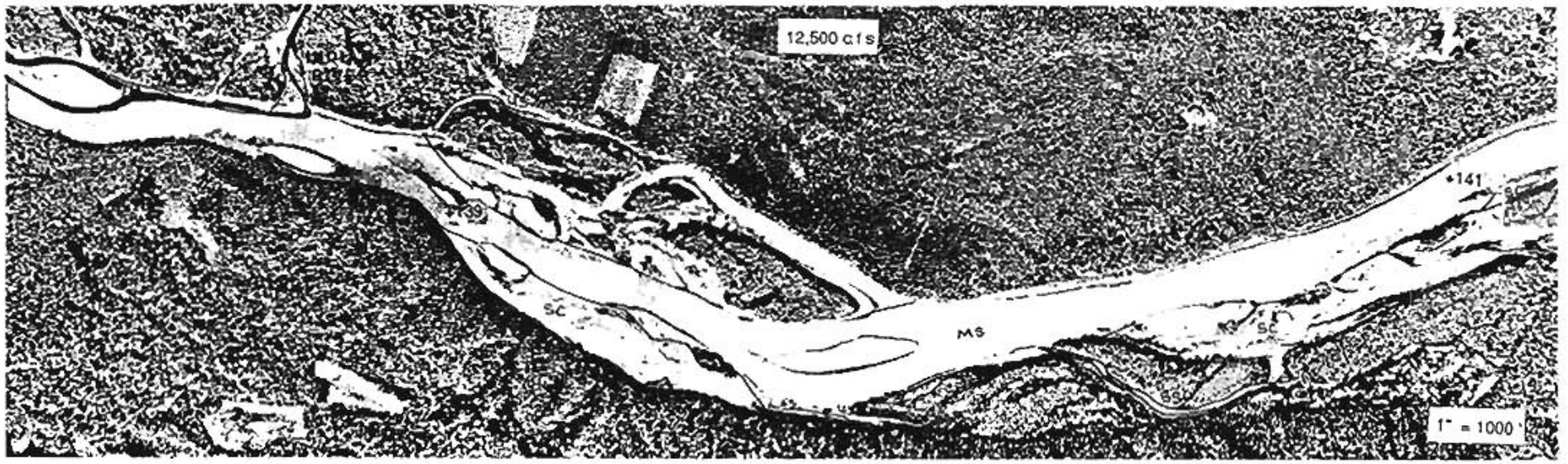
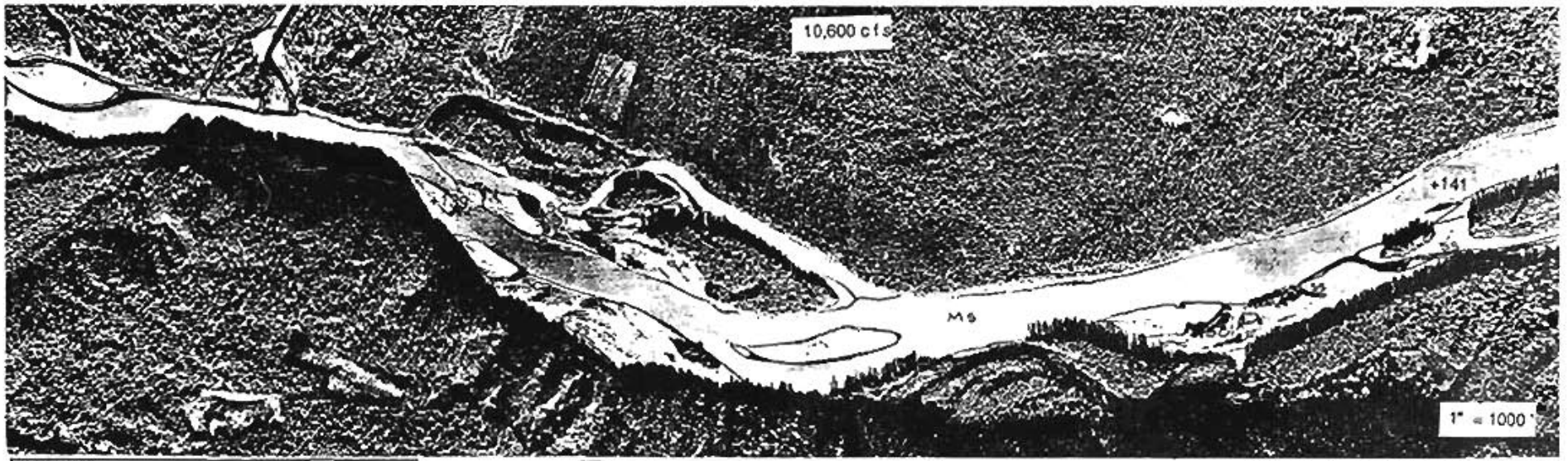
E. WOODY TRIHEY & ASSOCIATES	SUSITNA JOINT VENTURE





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SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 4 OF 18 RIVER MILE 139 TO 141

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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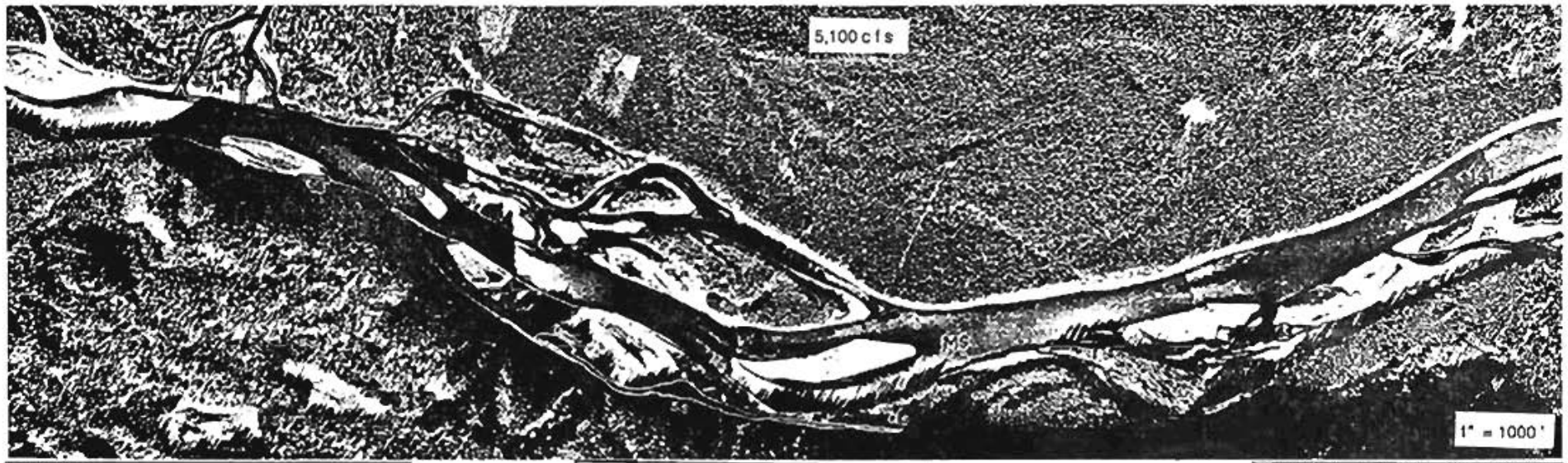

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SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 4 OF 18 RIVER MILE 139 TO 141

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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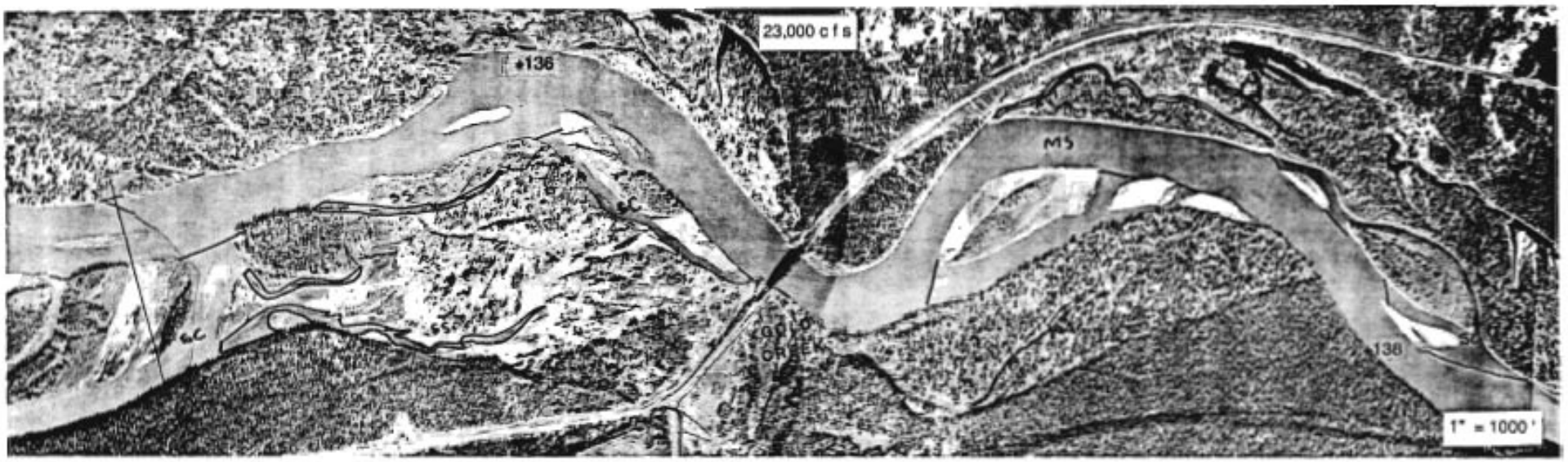
SUSITNA JOINT VENTURE



LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	*	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 5 OF 18 RIVER MILE 136 TO 138

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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E. WOODY TRIHEY & ASSOCIATES

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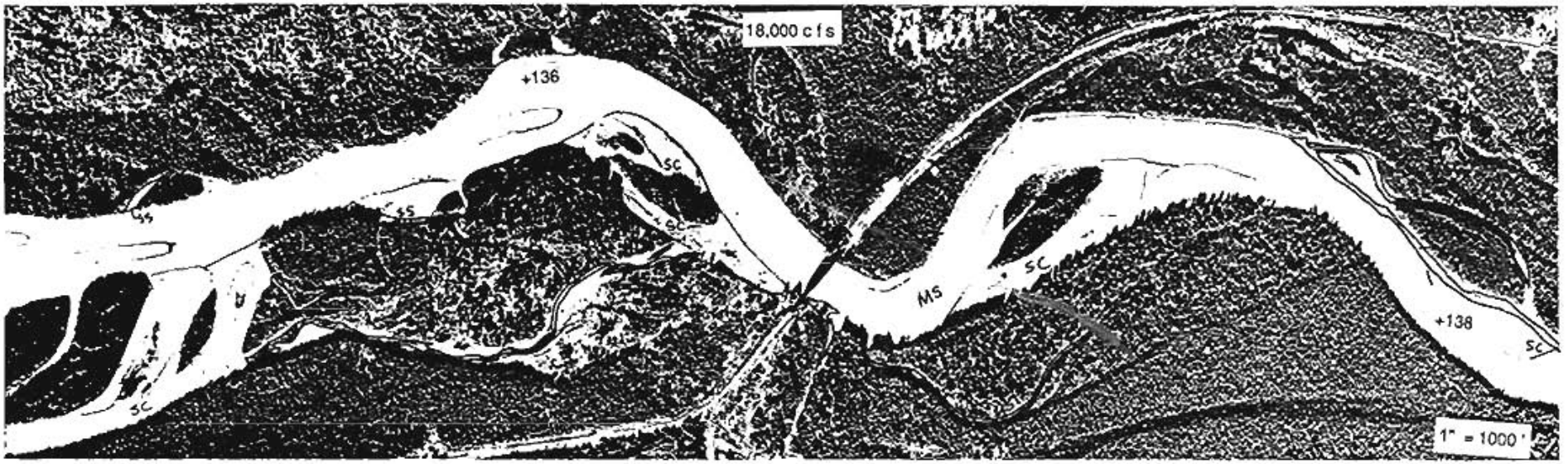
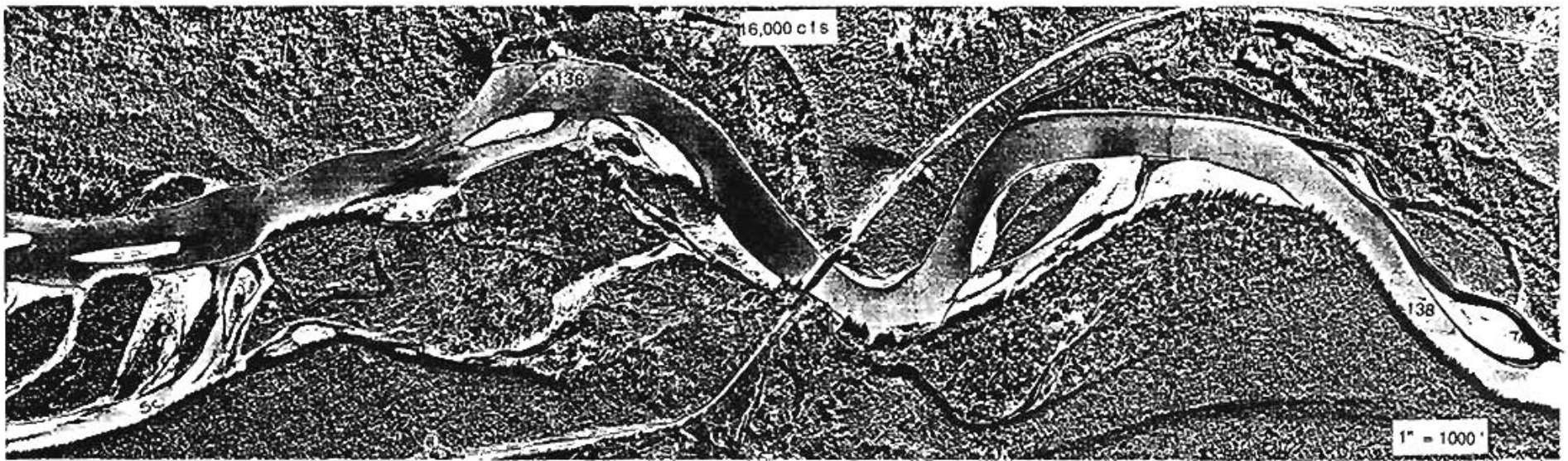
SUSITNA JOINT VENTURE





LEGEND

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SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 5 OF 18 RIVER MILE 136 TO 138

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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E. WOODY TRIHEY & ASSOCIATES

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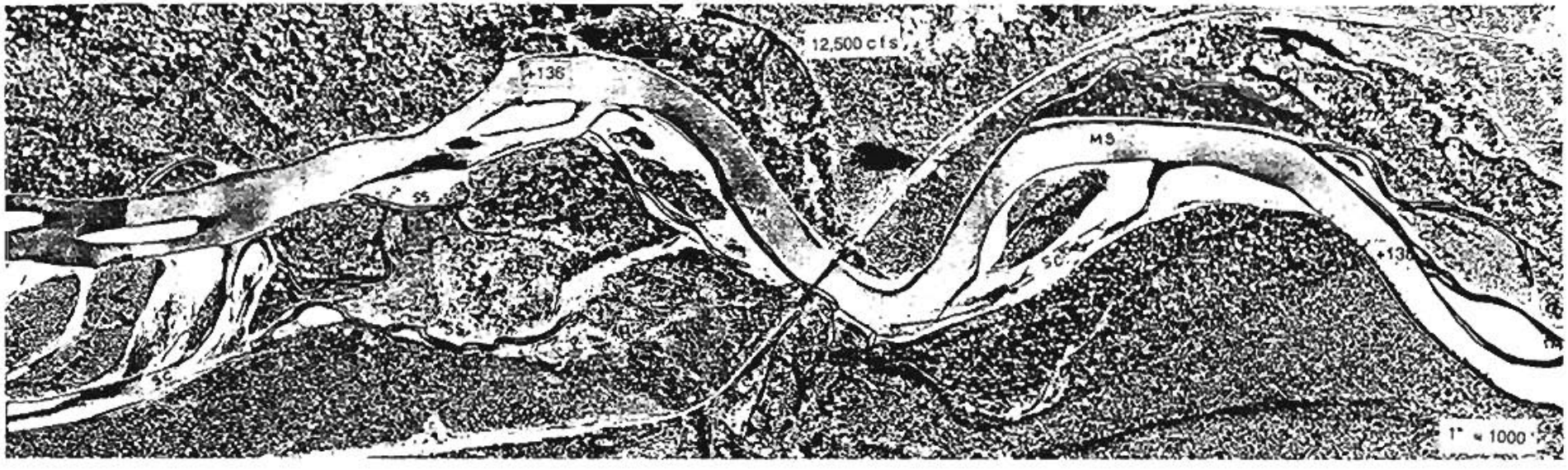
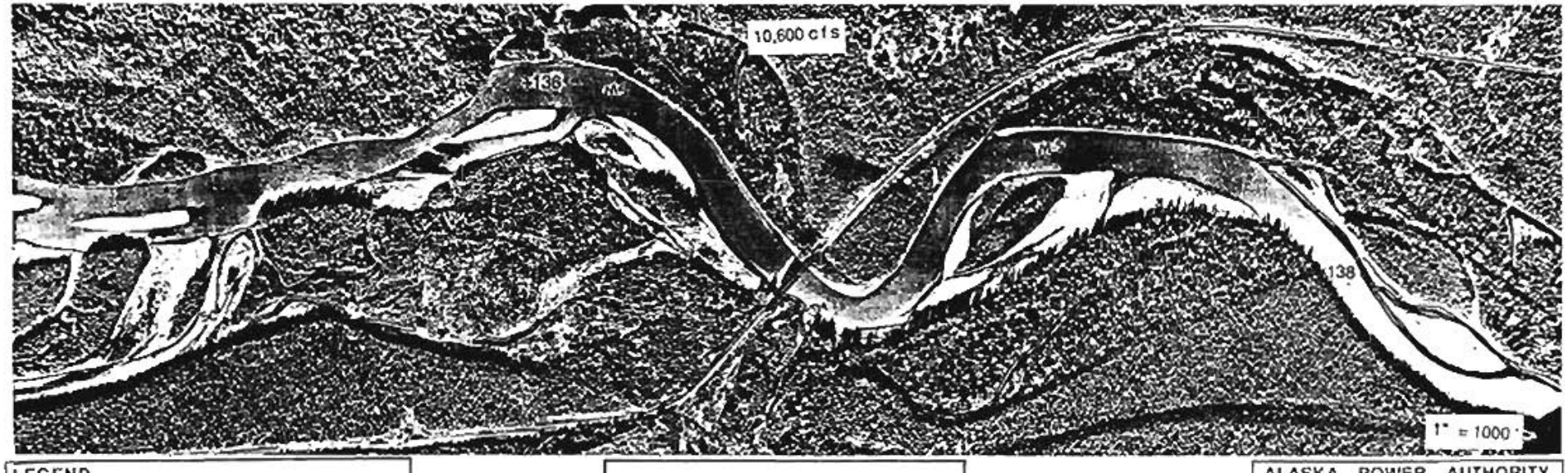
SUSITNA JOINT VENTURE





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SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 5 OF 18 RIVER MILE 136 TO 138

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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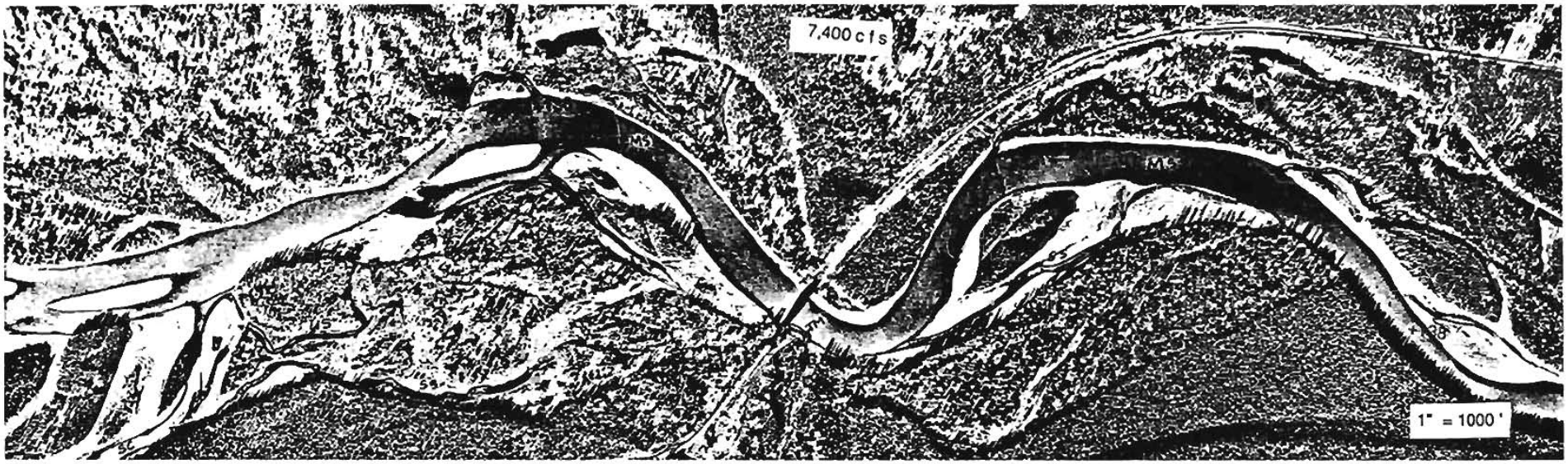
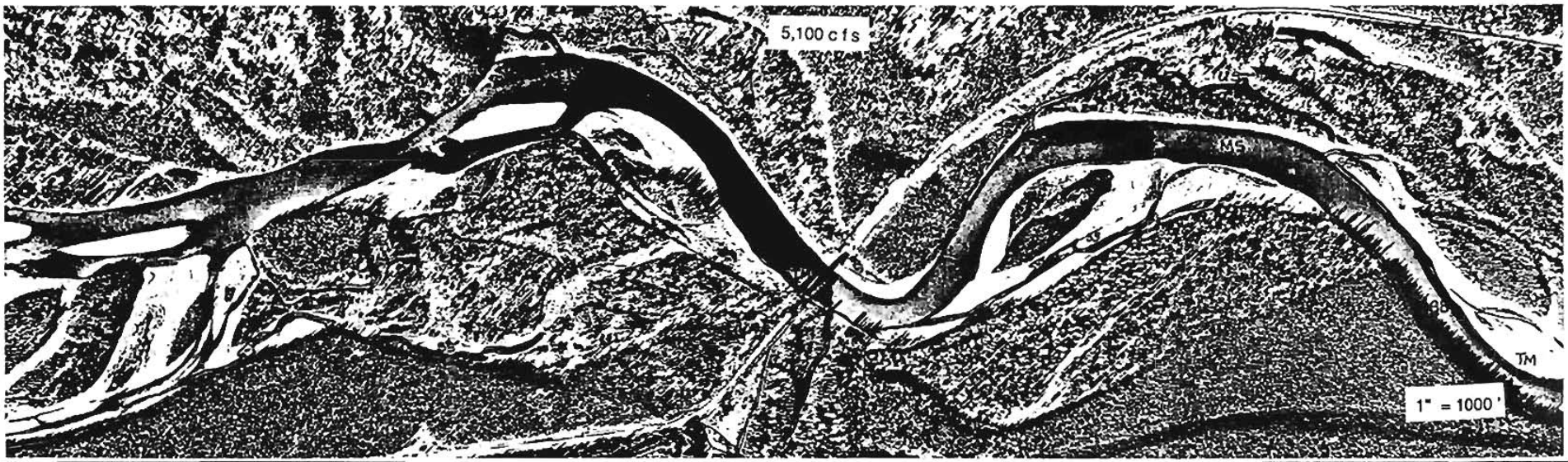




LEGEND

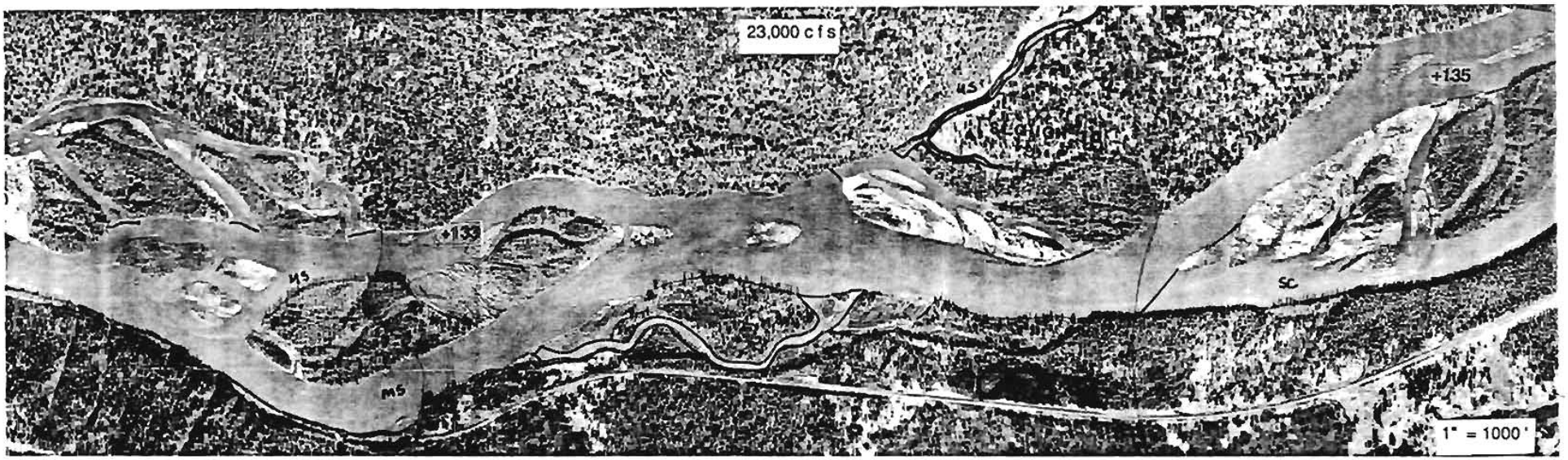
MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 5 OF 18 RIVER MILE 136 TO 138

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A	HARZA - EBASCO
E. WOODY TRIHEY & ASSOCIATES	SUSITNA JOINT VENTURE



LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

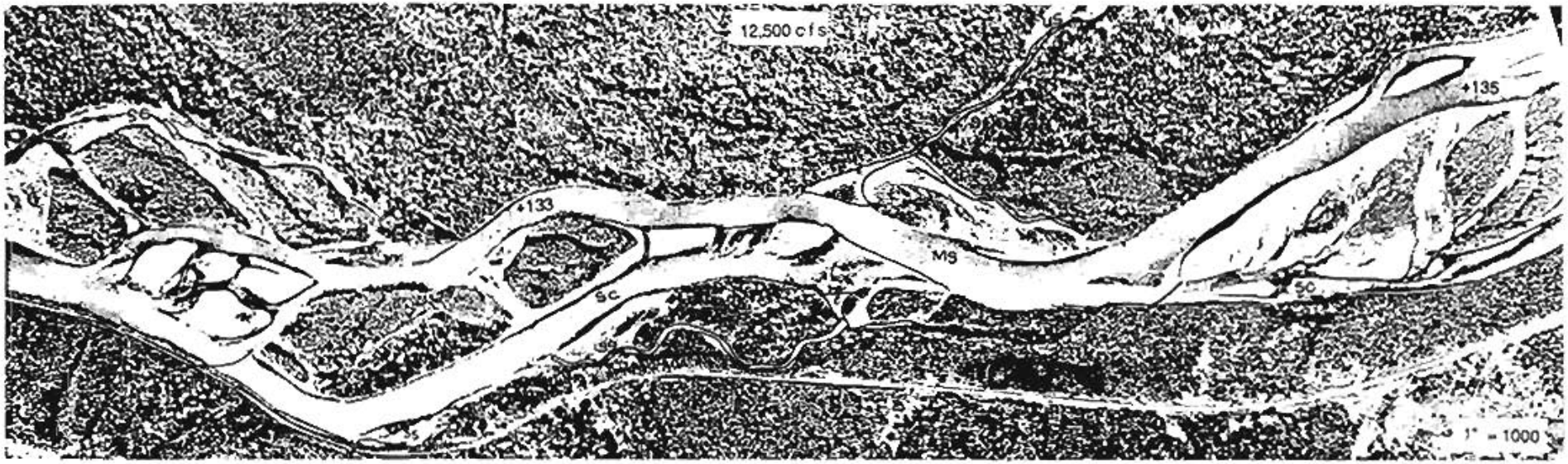
MIDDLE SUSITNA RIVER

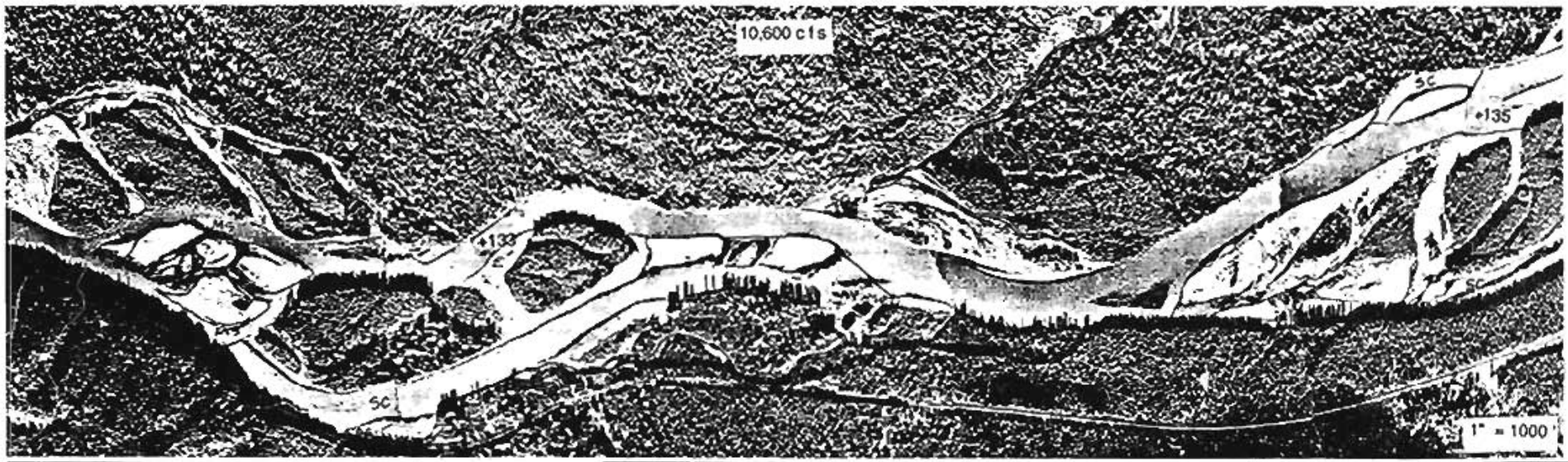
PLATE 6 OF 18 RIVER MILE 133 TO 136

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

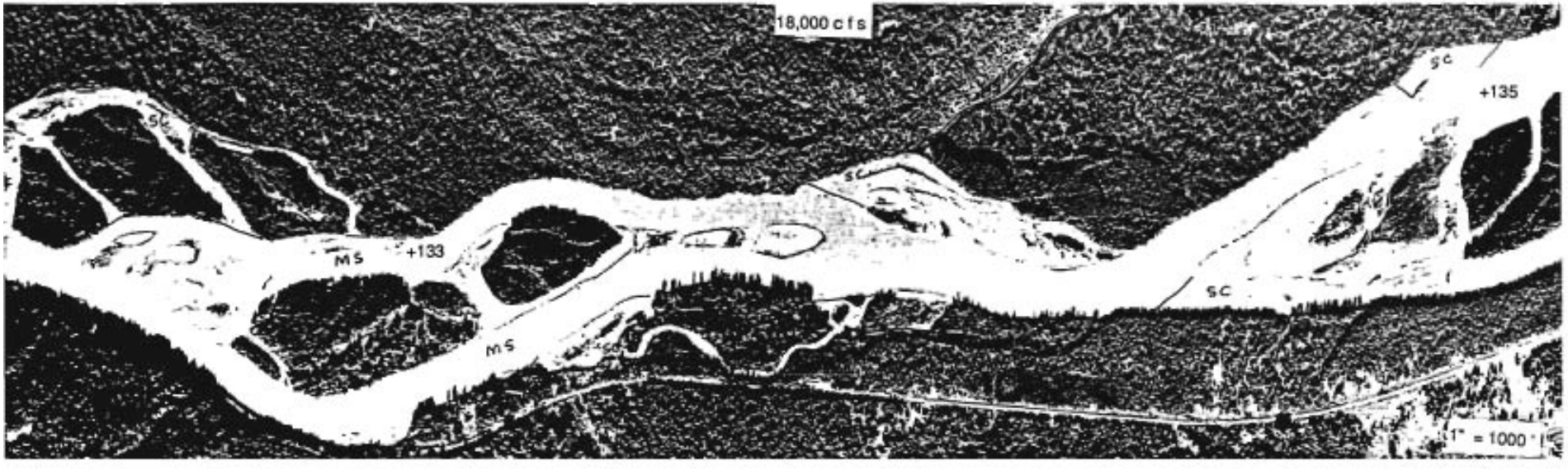
MIDDLE SUSITNA RIVER

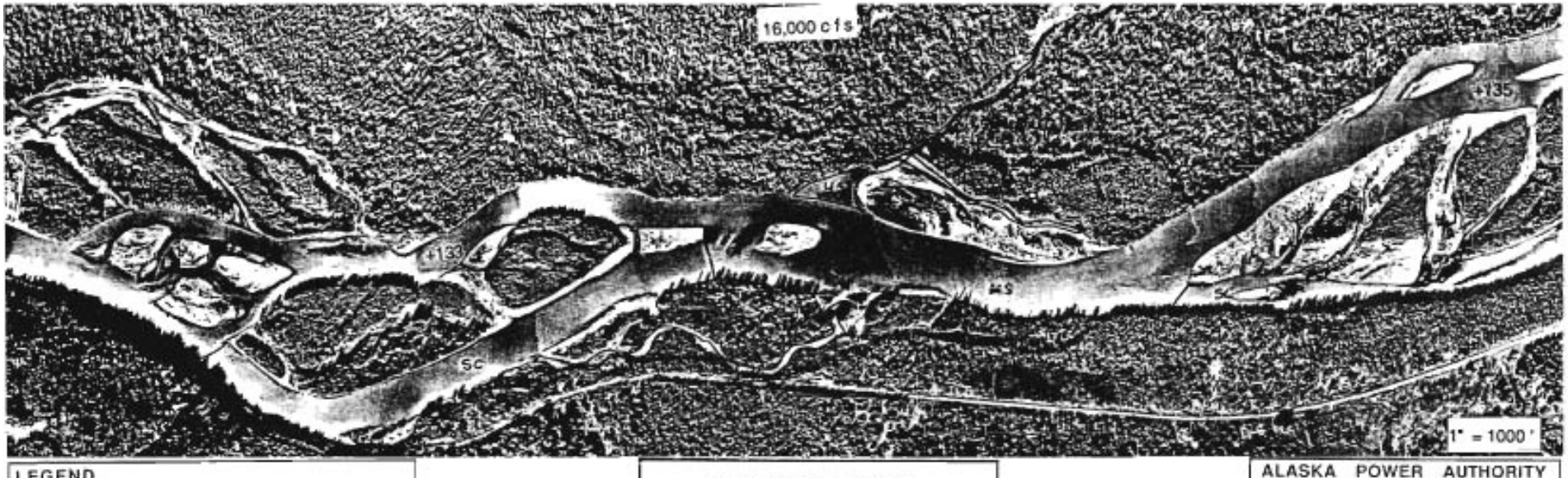
PLATE 6 OF 18 RIVER MILE 133 TO 136

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

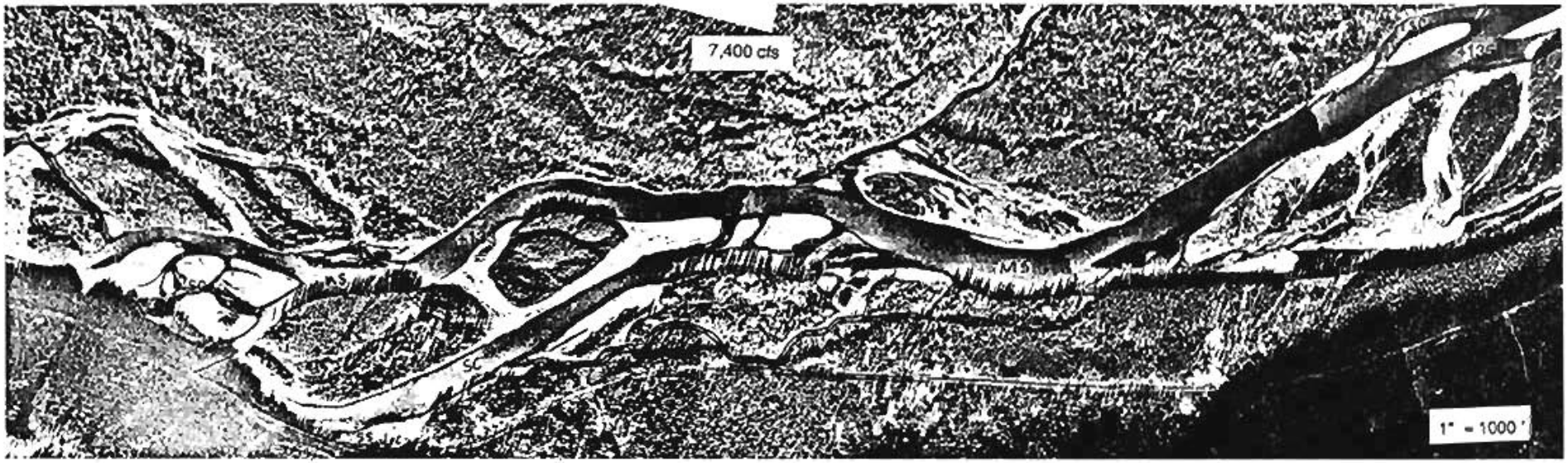
MIDDLE SUSITNA RIVER

PLATE 6 OF 18 RIVER MILE 133 TO 136

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE



LEGEND

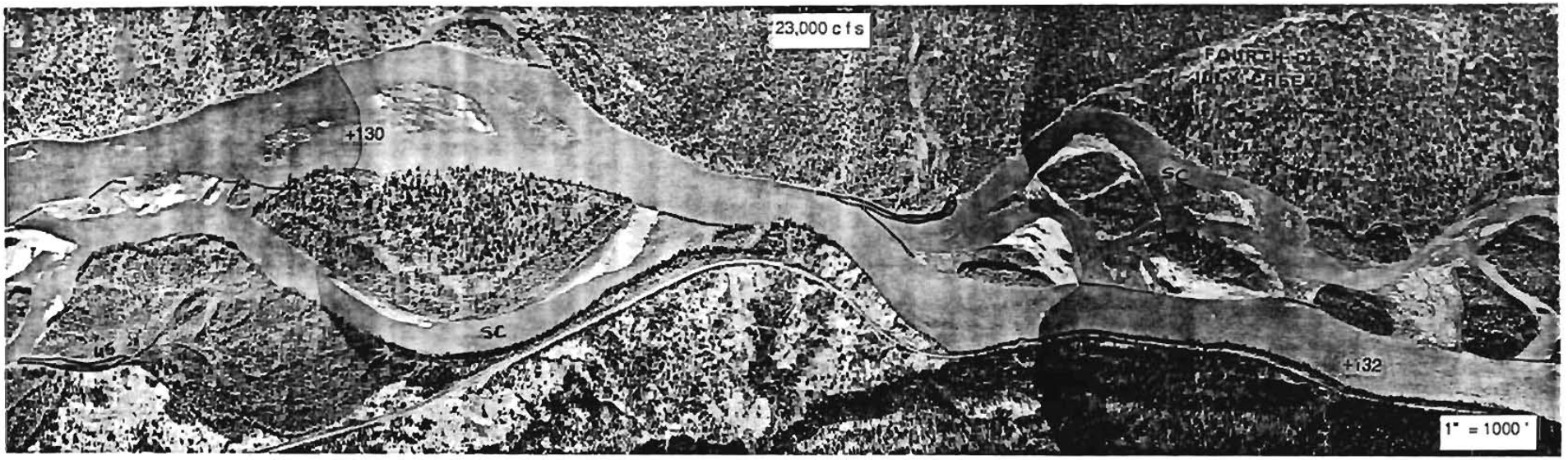
MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 6 OF 18 RIVER MILE 133 TO 136

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A E. WOODY TRIHEY & ASSOCIATES	HARZA - EBASCO SUSITNA JOINT VENTURE



LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

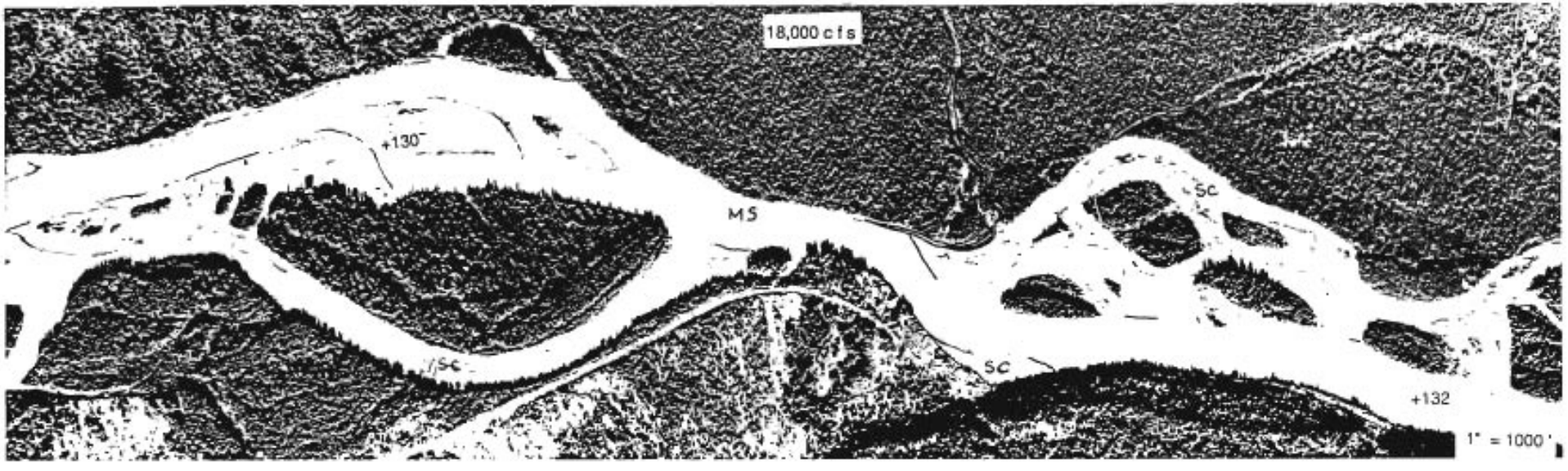
MIDDLE SUSITNA RIVER

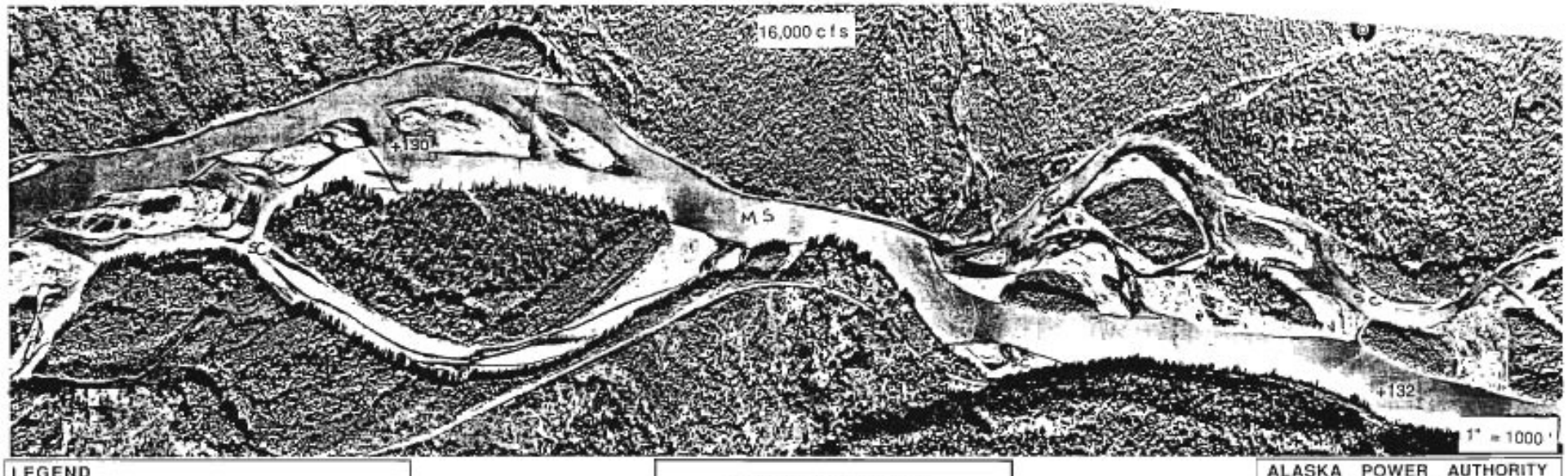
PLATE 7 OF 18 RIVER MILE 130 TO 132

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

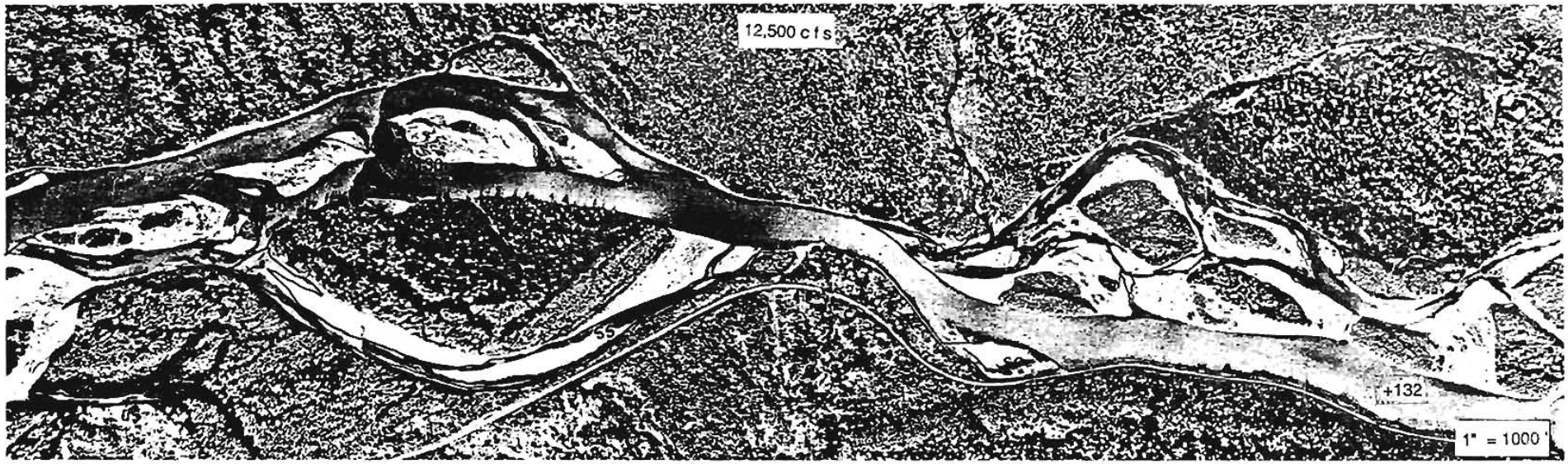
MIDDLE SUSITNA RIVER

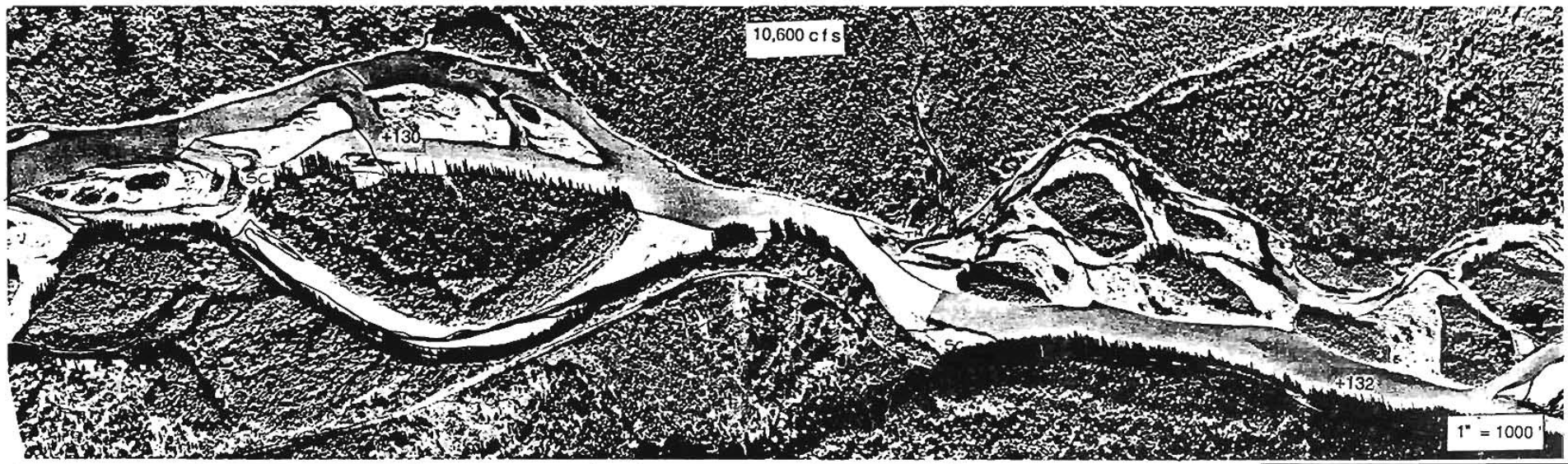
PLATE 7 OF 18 RIVER MILE 130 TO 132

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

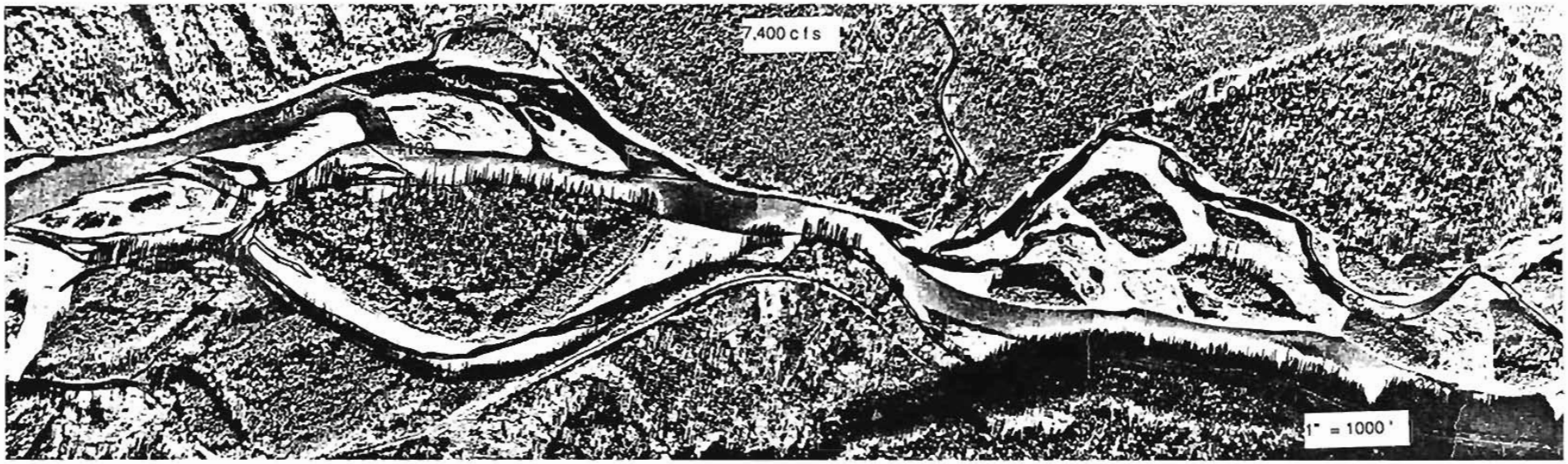
MIDDLE SUSITNA RIVER

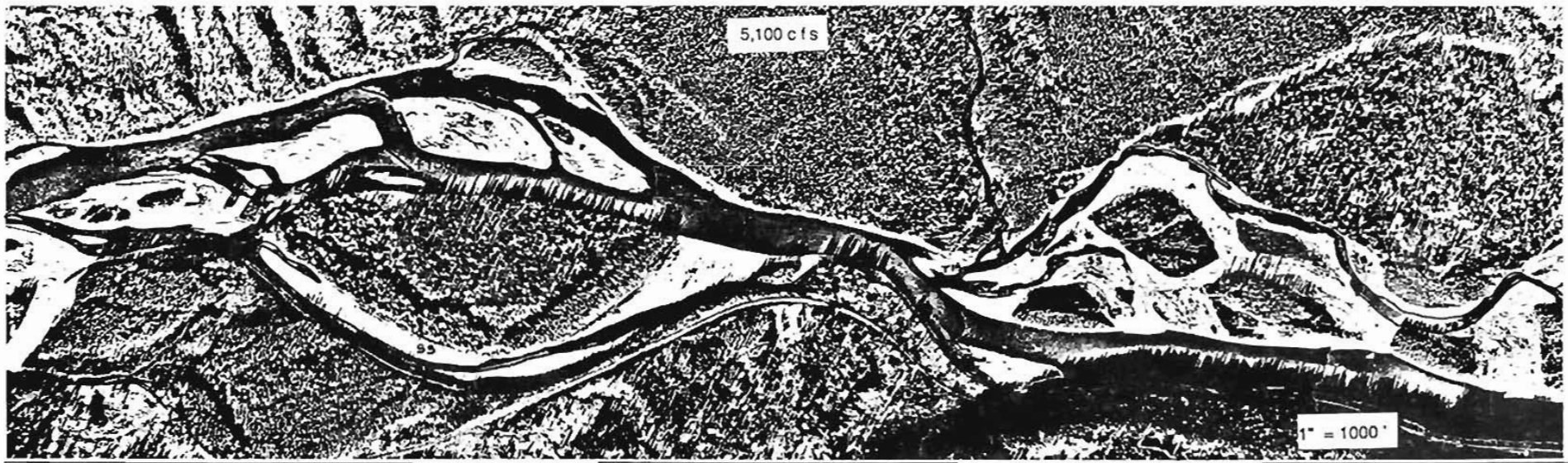
PLATE 7 OF 18 RIVER MILE 130 TO 132

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 7 OF 18 RIVER MILE 130 TO 132

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE

LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

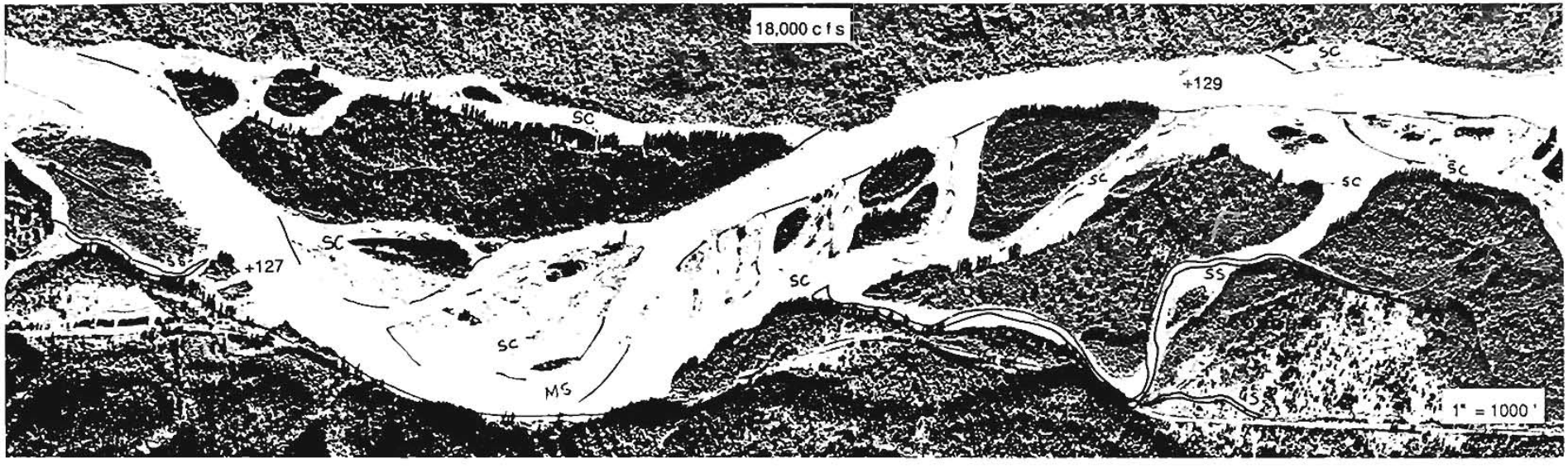
MIDDLE SUSITNA RIVER

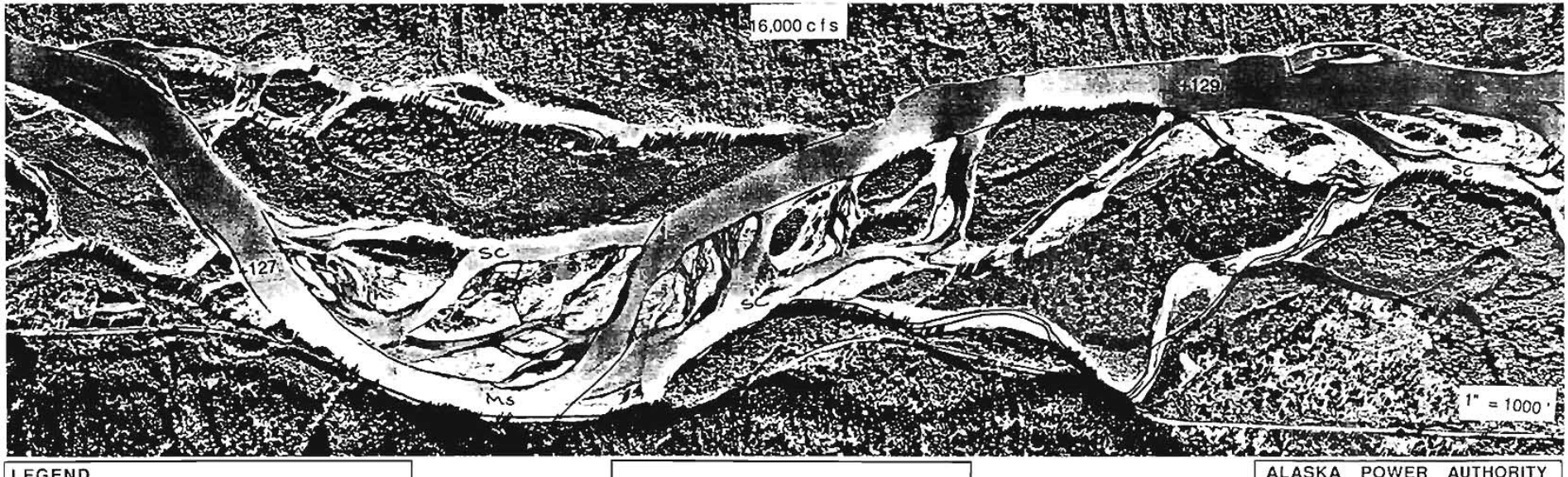
PLATE 8 OF 18 RIVER MILE 127 TO 129

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

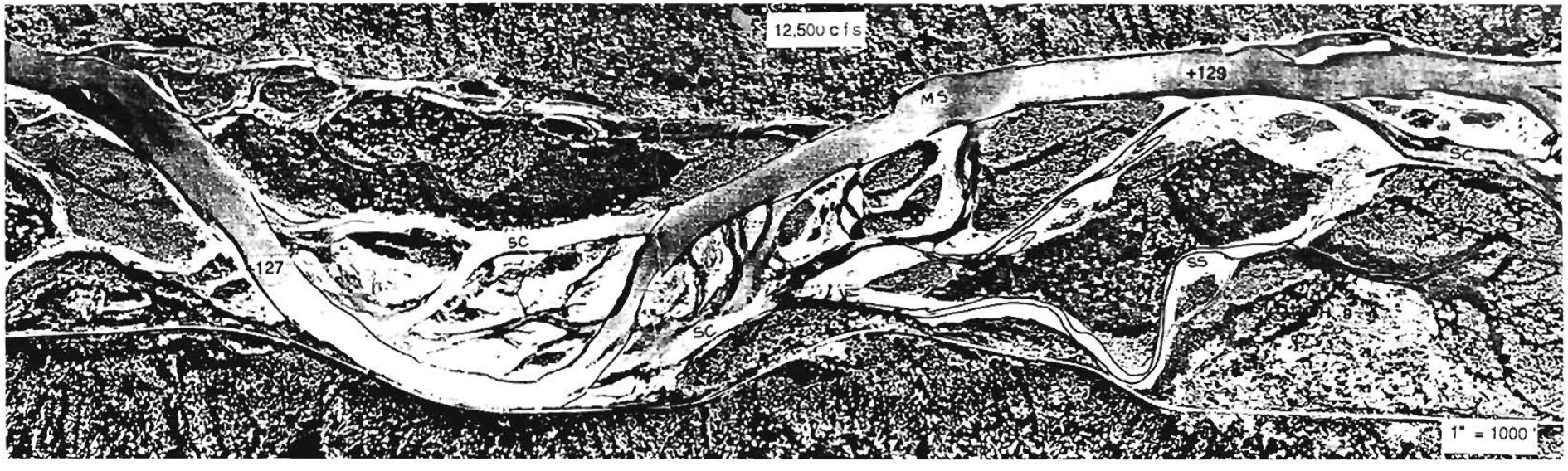
MIDDLE SUSITNA RIVER

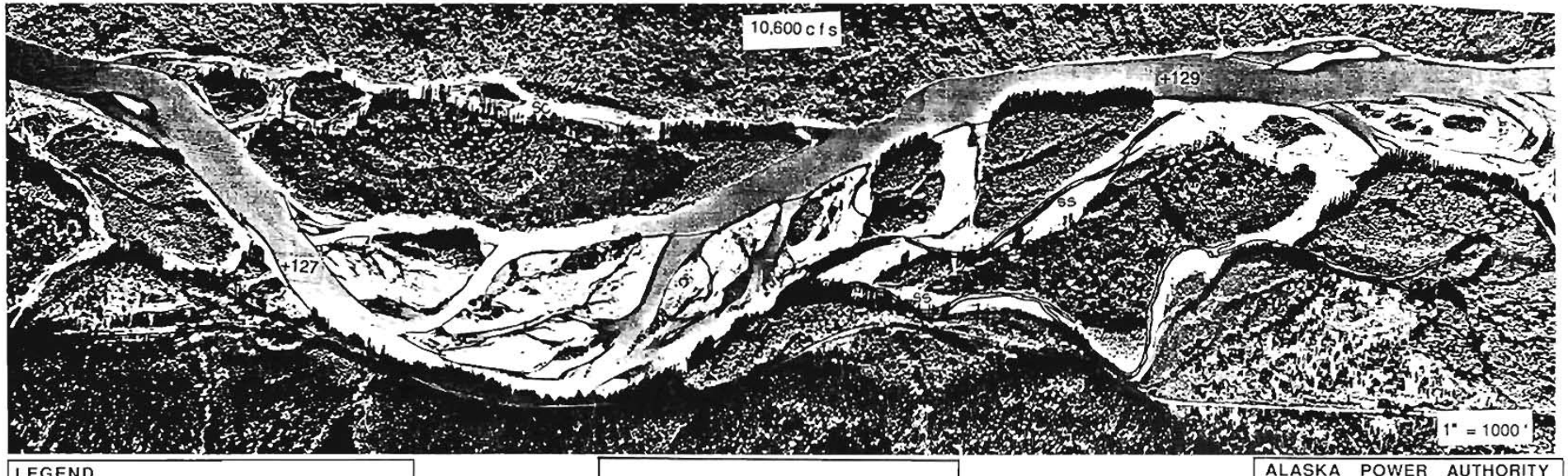
PLATE 8 OF 18 RIVER MILE 127 TO 129

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

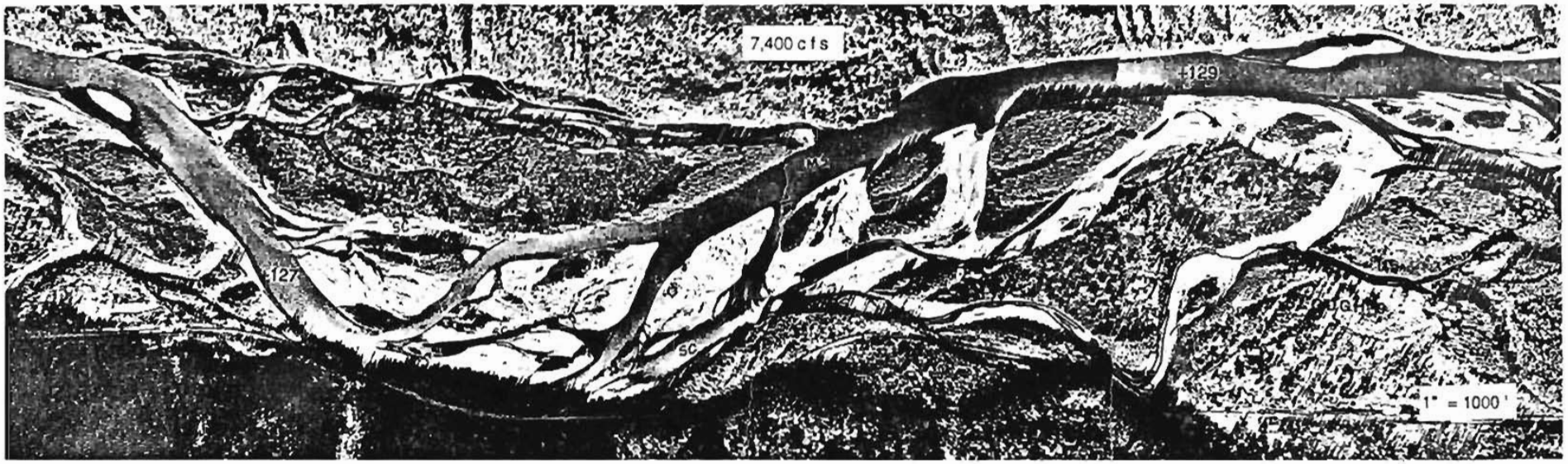
MIDDLE SUSITNA RIVER

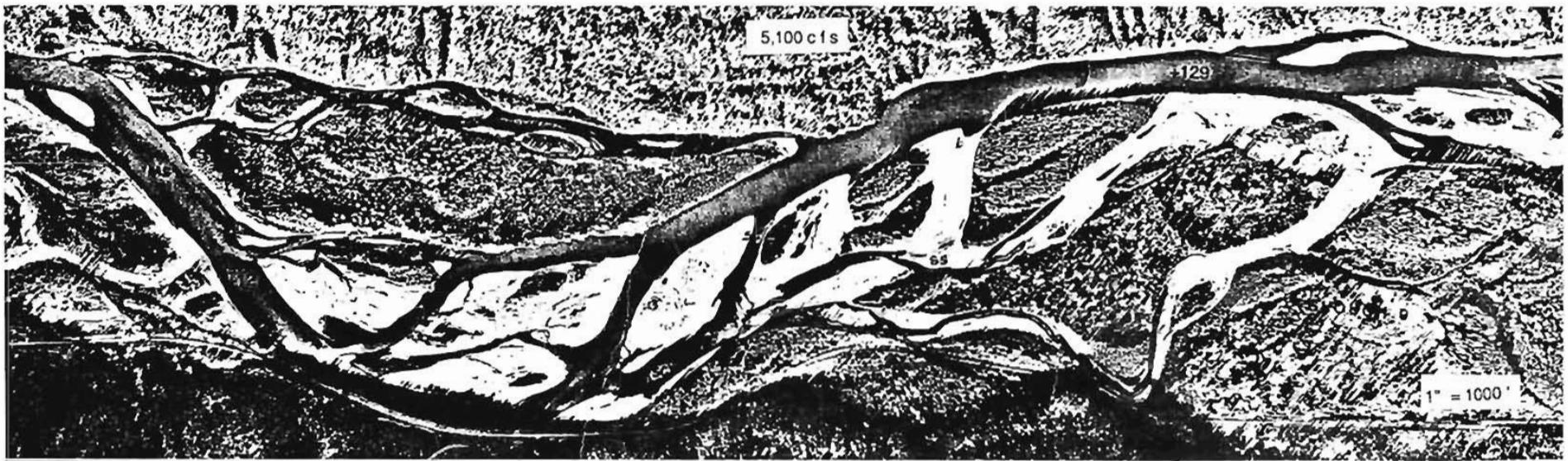
PLATE 8 OF 16 RIVER MILE 127 TO 129

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 8 OF 18 RIVER MILE 127 TO 129

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE

LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

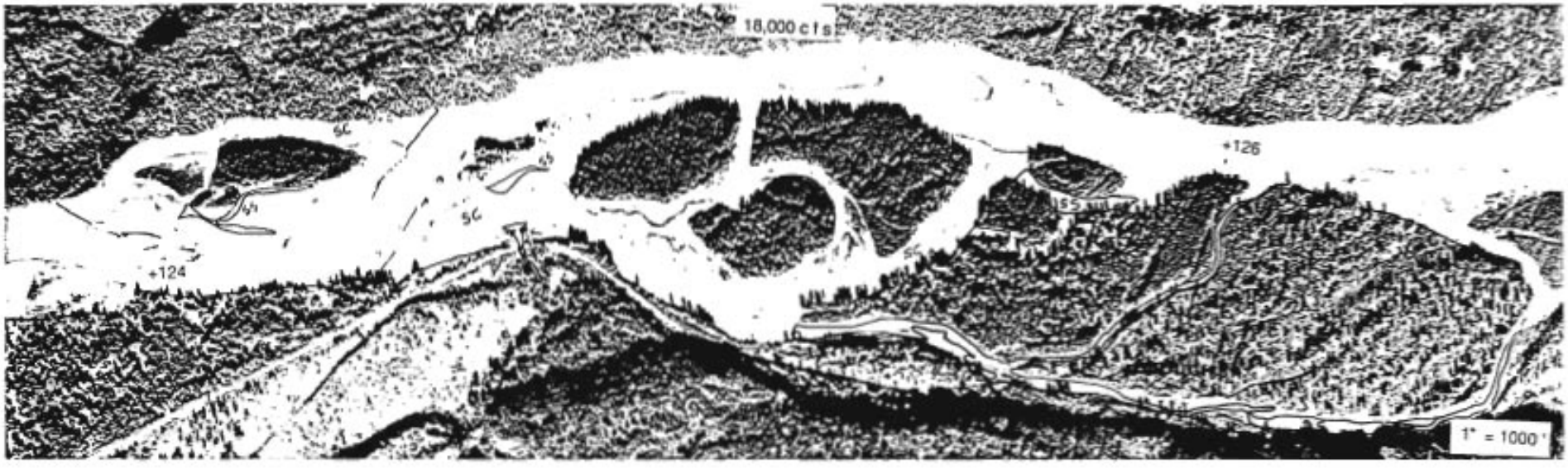
MIDDLE SUSITNA RIVER

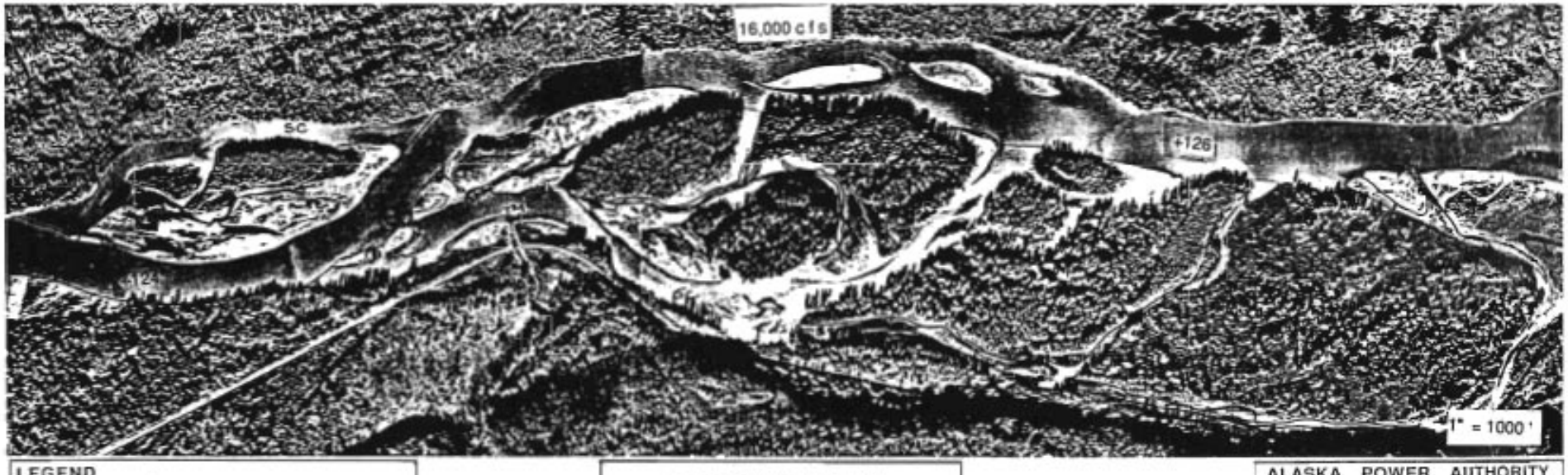
PLATE 9 OF 18 RIVER MILE 124 TO 126

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

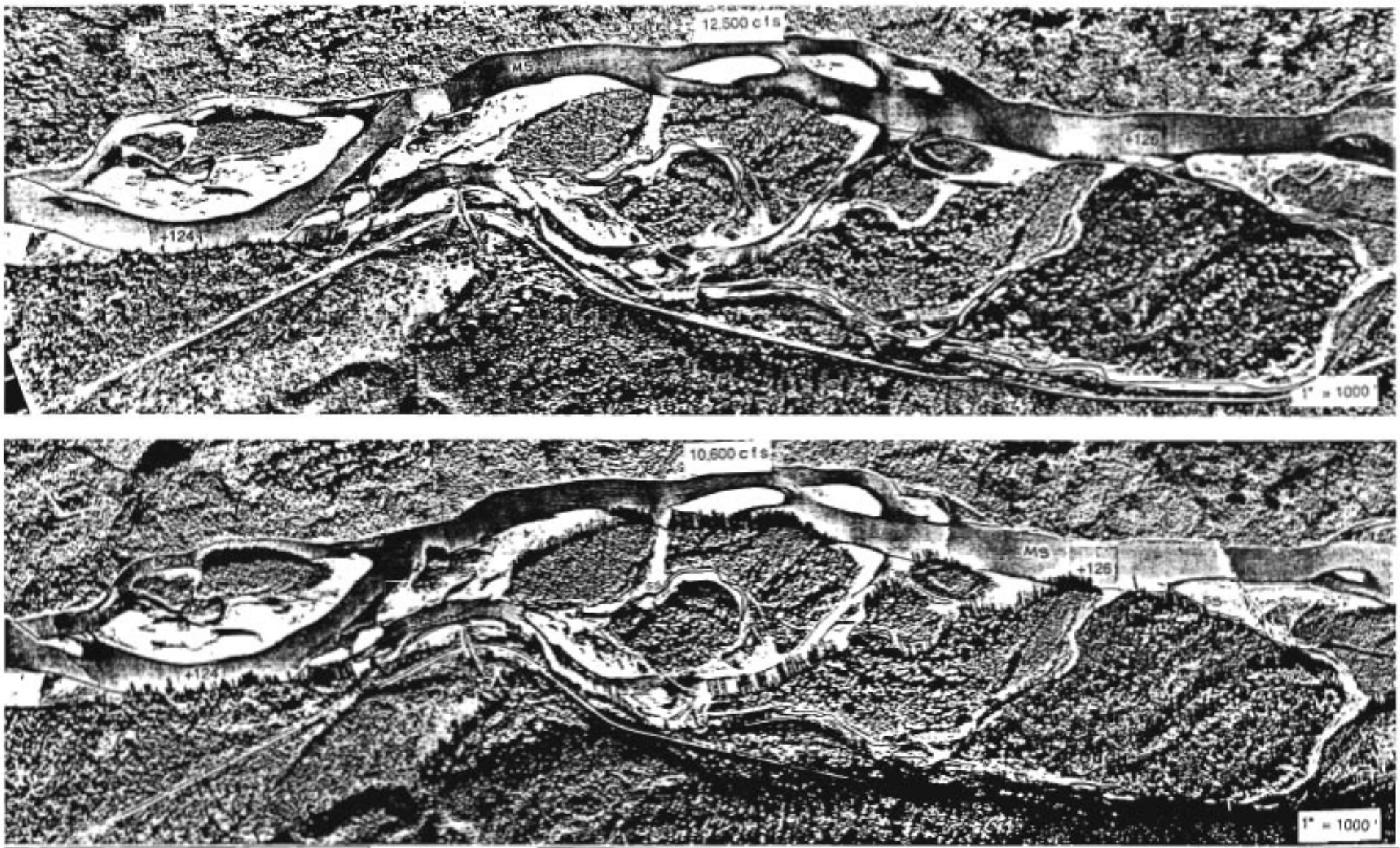
MIDDLE SUSITNA RIVER

PLATE 9 OF 18 RIVER MILE 124 TO 126

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE



LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 9 OF 18 RIVER MILE 124 TO 126

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE

LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

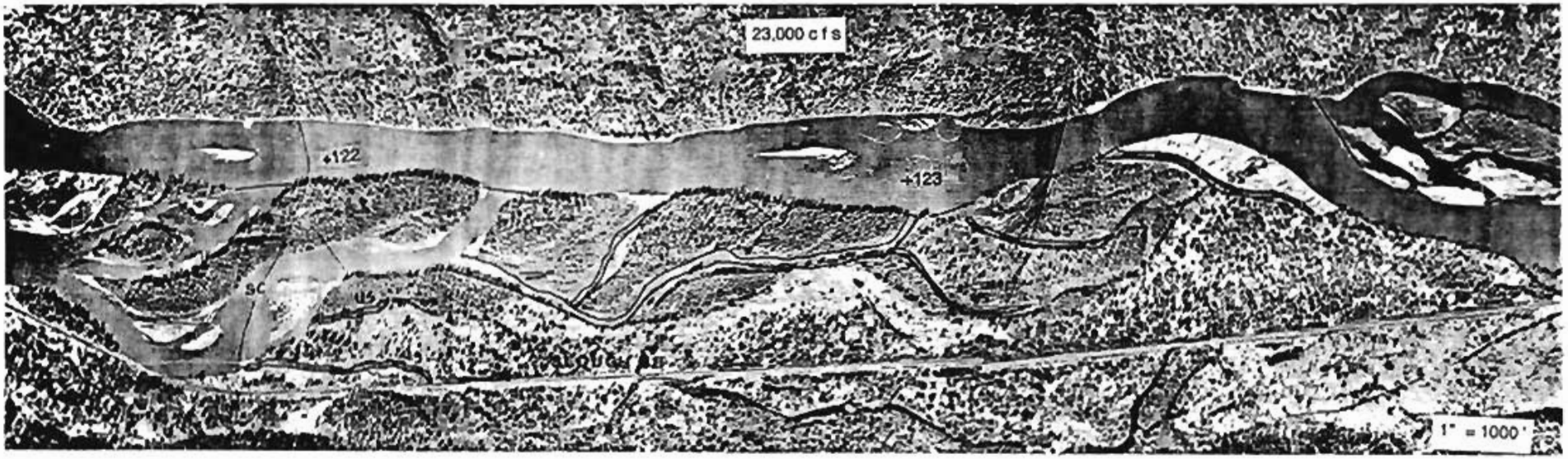
MIDDLE SUSITNA RIVER

PLATE 9 OF 18 RIVER MILE 124 TO 126

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE



LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

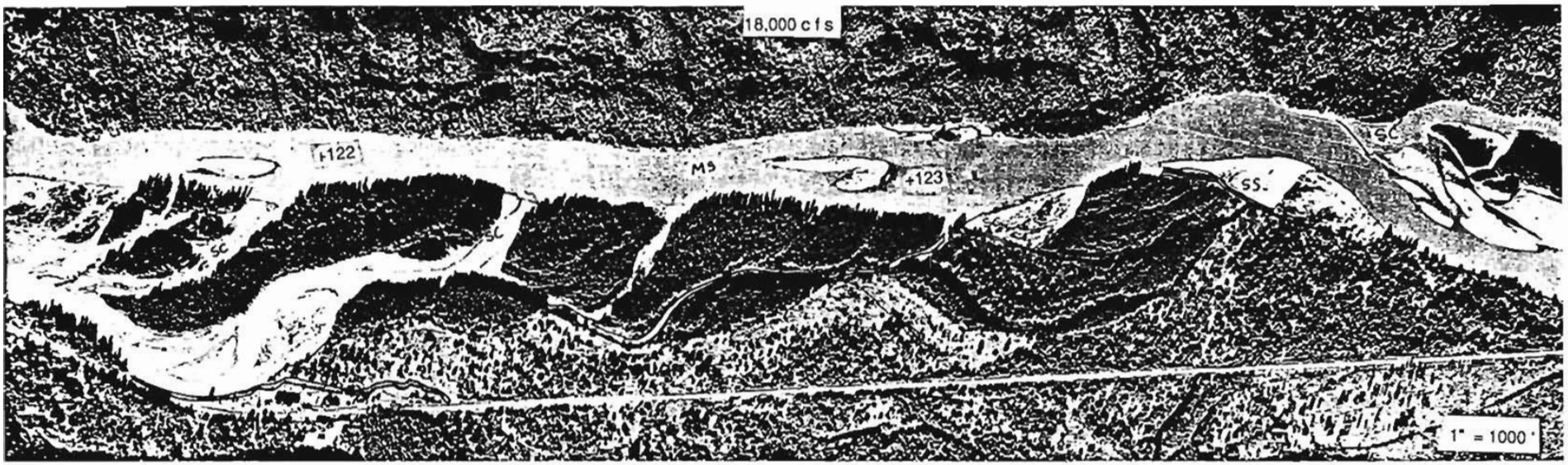
MIDDLE SUSITNA RIVER

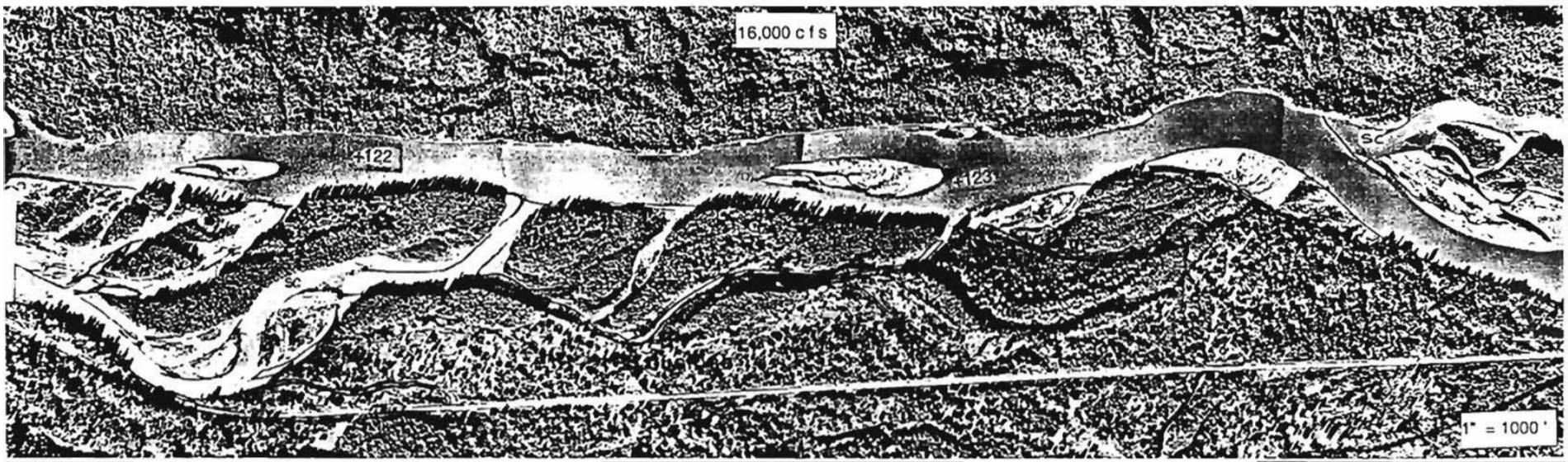
PLATE 10 OF 18 RIVER MILE 122 TO 124

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

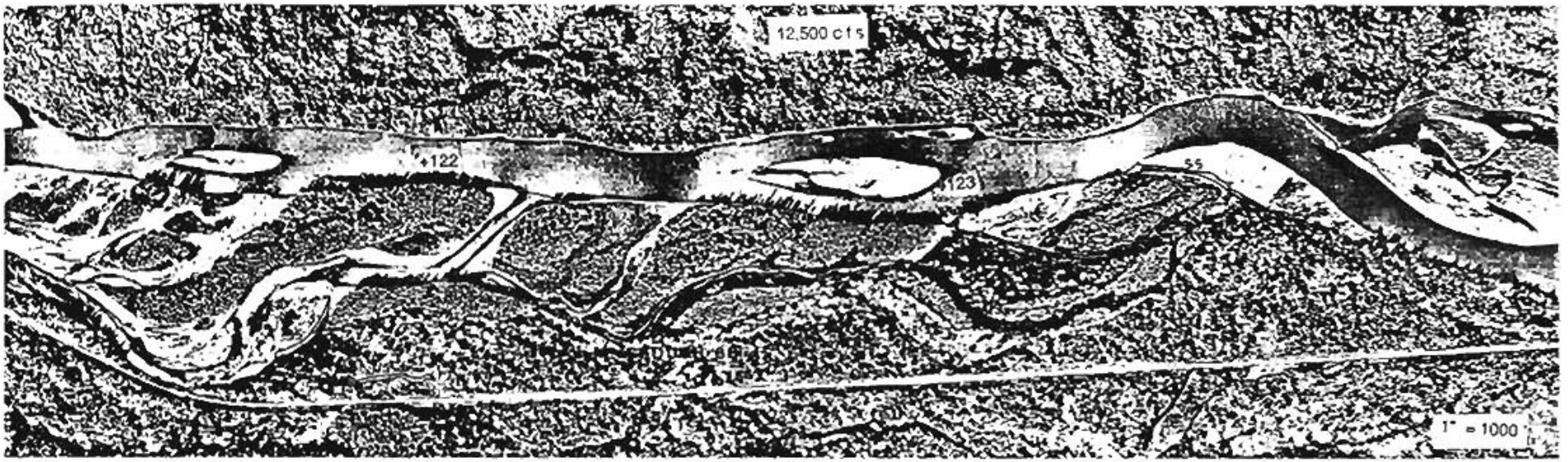
MIDDLE SUSITNA RIVER

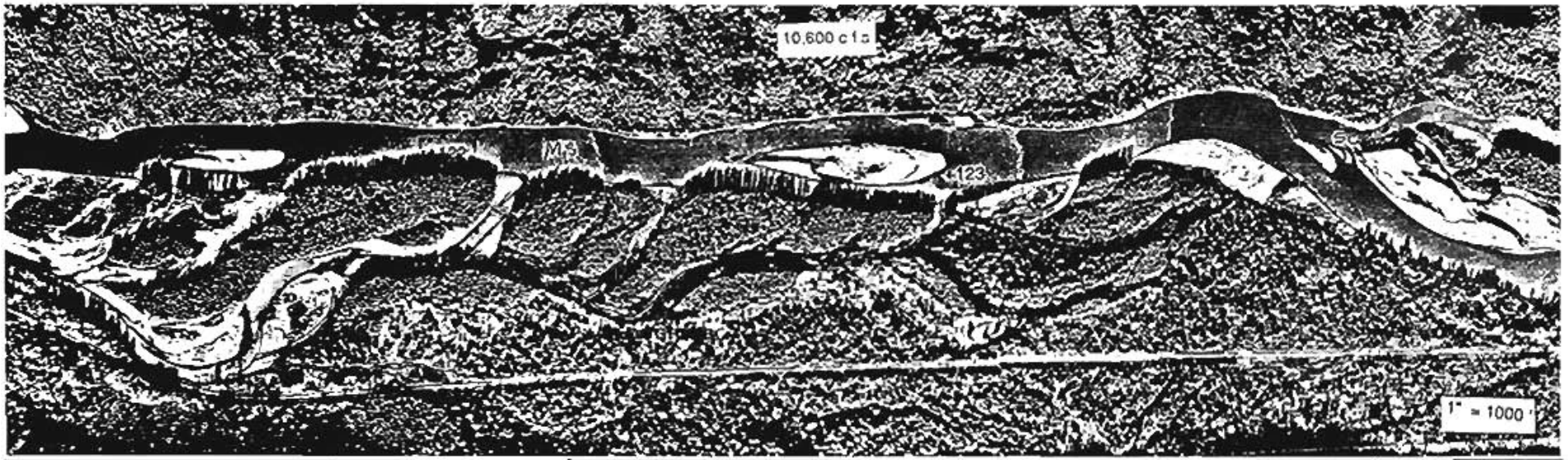
PLATE 10 OF 18 RIVER MILE 122 TO 124

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE





LEGEND

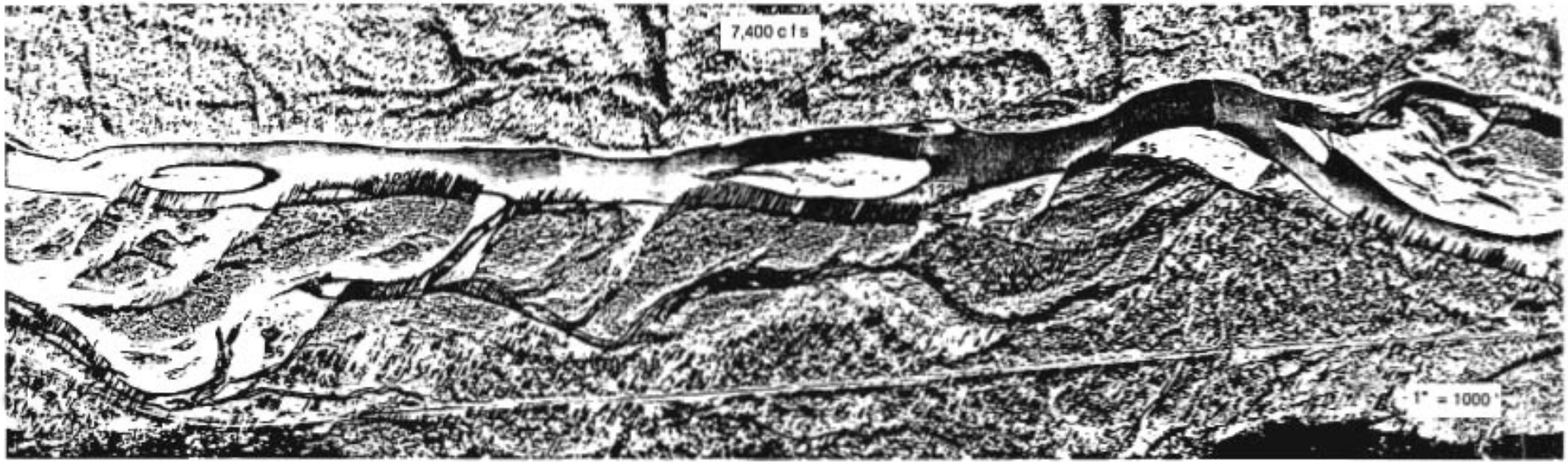
MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

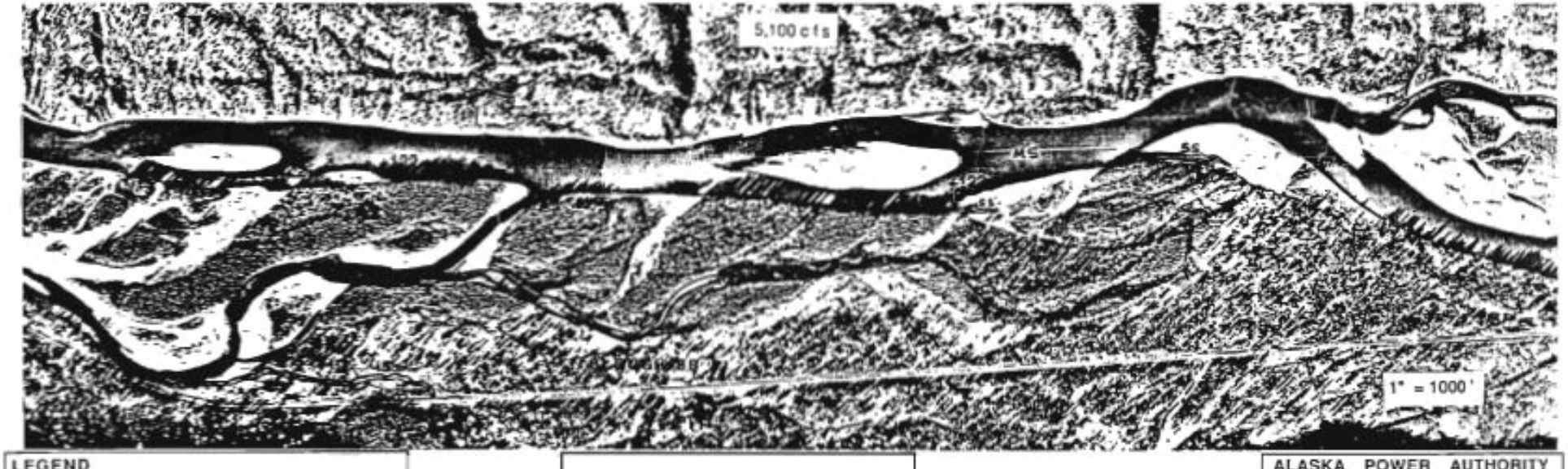
MIDDLE SUSITNA RIVER

PLATE 10 OF 18 RIVER MILE 122 TO 124

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

E.W.T. & A. E. WOODY TRIHEY & ASSOCIATES	HARZA - EBASCO SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

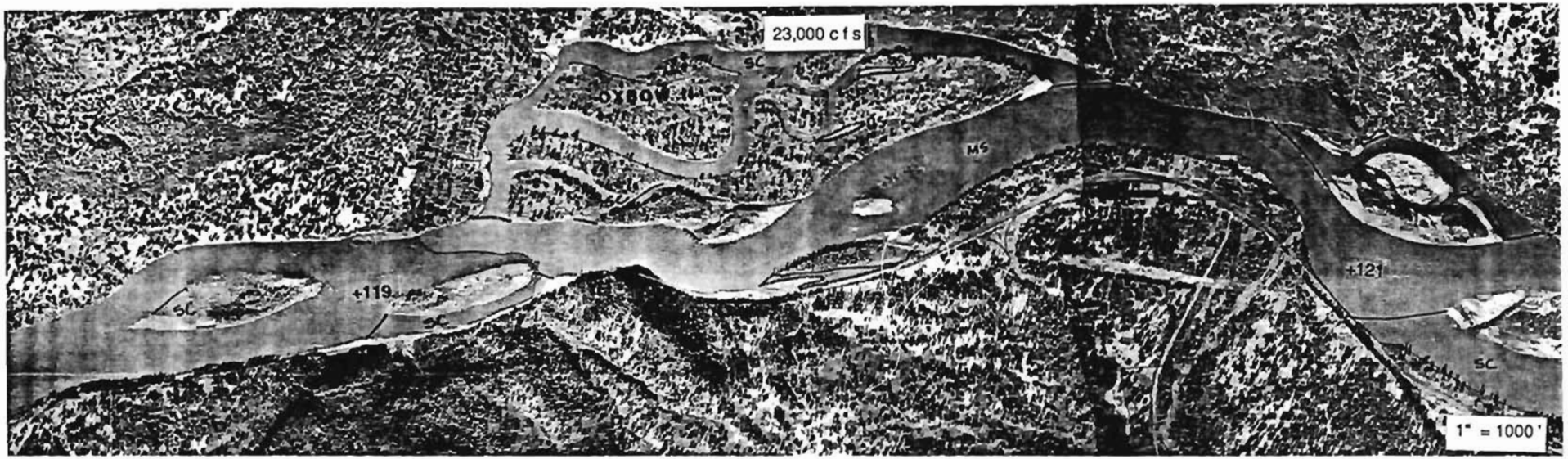
MIDDLE SUSITNA RIVER

PLATE 10 OF 18 RIVER MILE 122 TO 124

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE



LEGEND

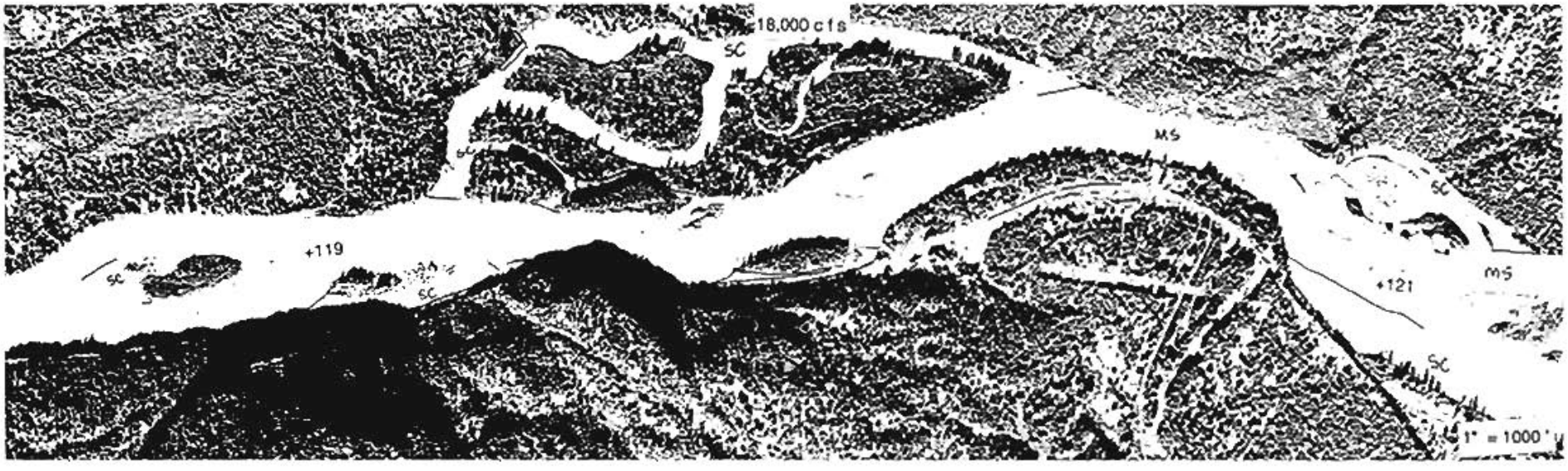
MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

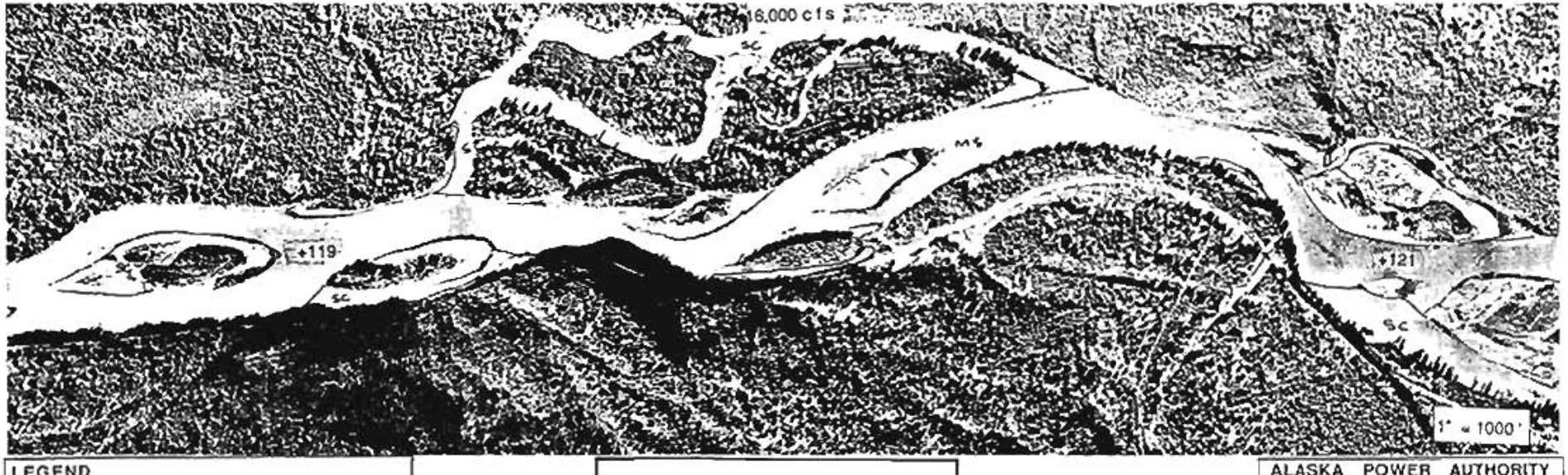
MIDDLE SUSITNA RIVER

PLATE 11 OF 18 RIVER MILE 119 TO 121

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A	HARZA - EBASCO
E. WOODY TRIHEY & ASSOCIATES	SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 11 OF 18 RIVER MILE 119 TO 121

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIKEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE

LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

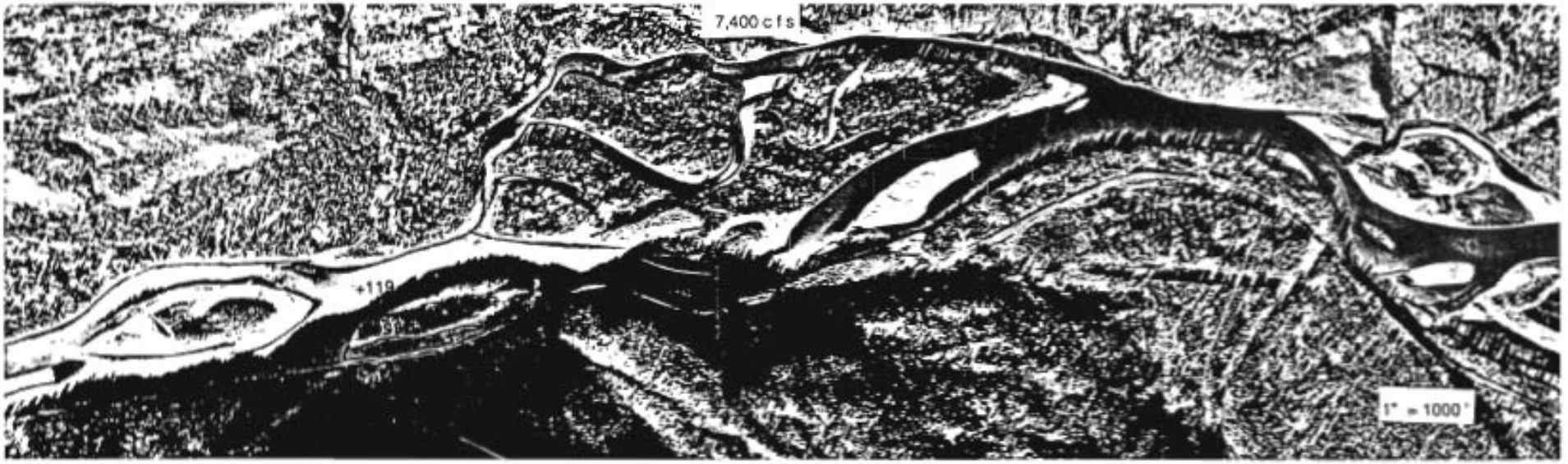
MIDDLE SUSITNA RIVER

PLATE 11 OF 18 RIVER MILE 119 TO 121

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE



LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

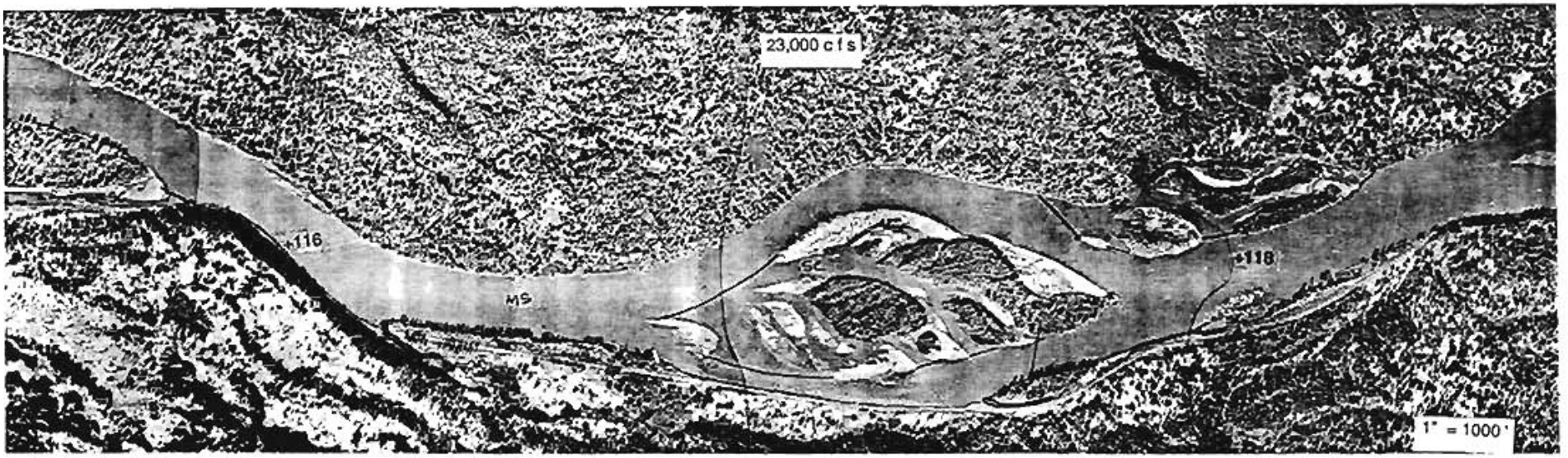
MIDDLE SUSITNA RIVER

PLATE 11 OF 18 RIVER MILE 119 TO 121

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE



LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

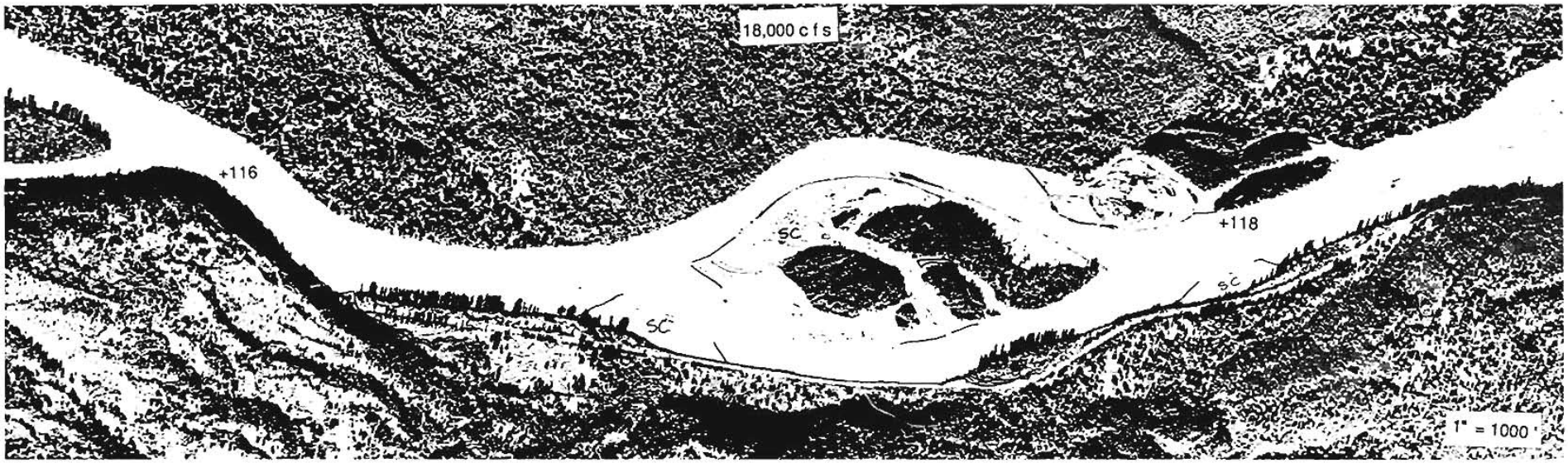
MIDDLE SUSITNA RIVER

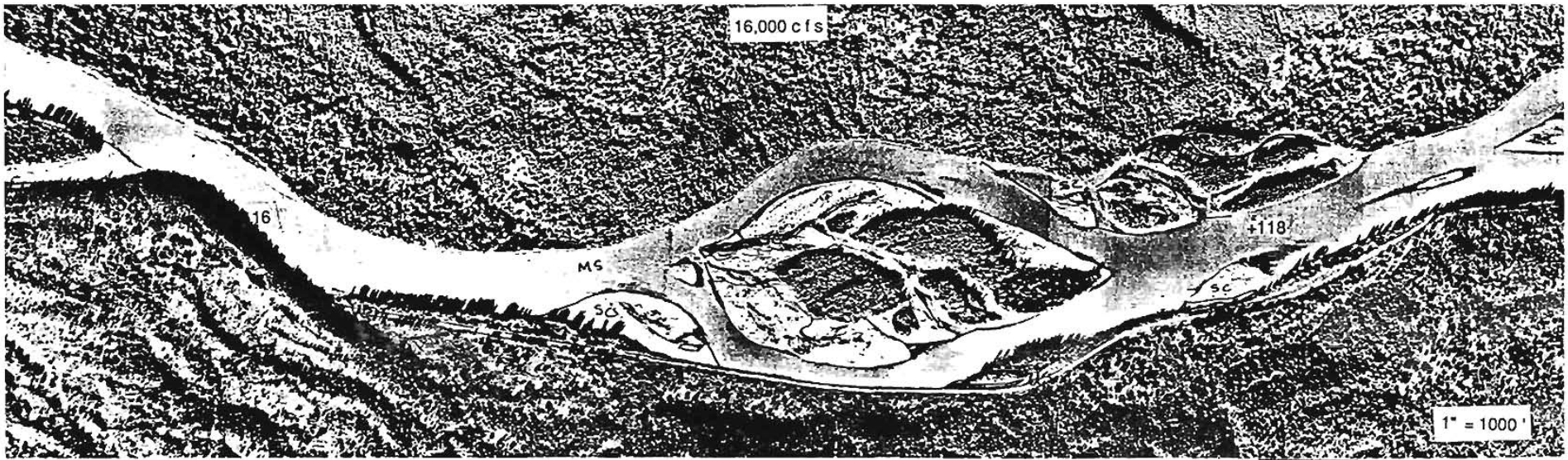
PLATE 12 OF 18 RIVER MILE 116 TO 118

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIMEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

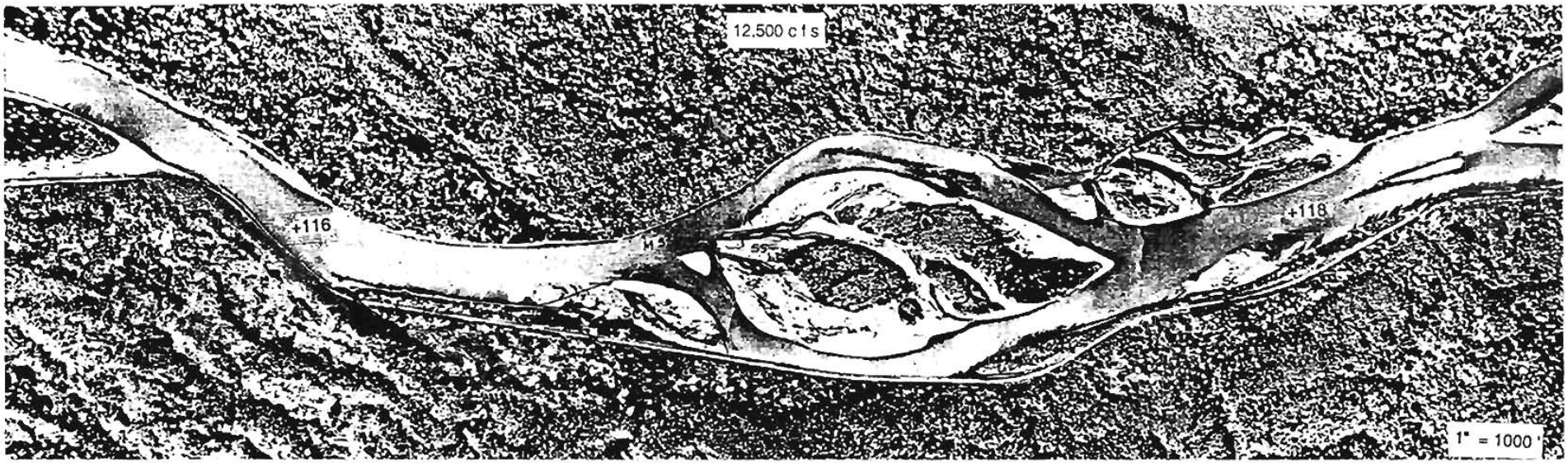
MIDDLE SUSITNA RIVER

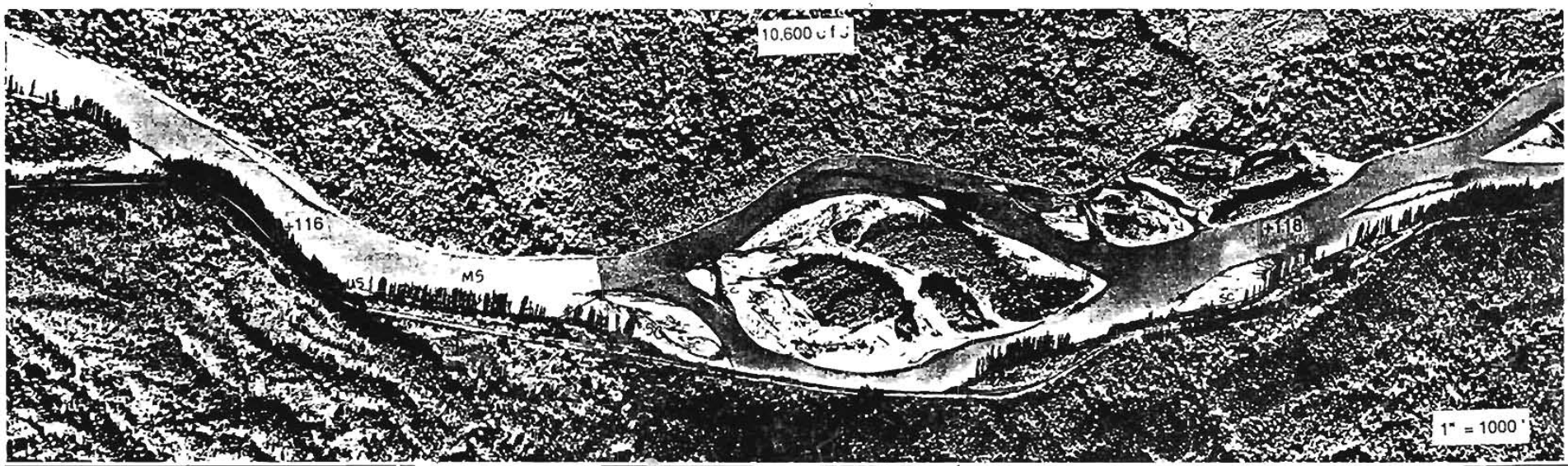
PLATE 12 OF 18 RIVER MILE 116 TO 118

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 12 OF 18 RIVER MILE 116 TO 118

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A	HARZA - EBASCO
E. WOODY TRIHEY & ASSOCIATES	SUSITNA JOINT VENTURE

LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

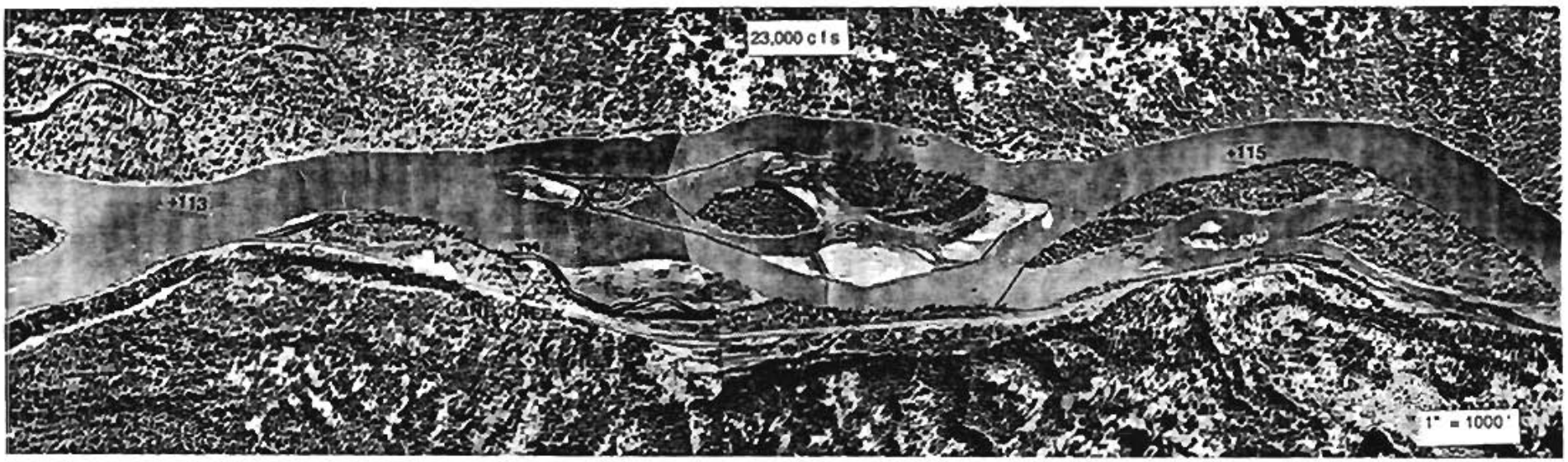
MIDDLE SUSITNA RIVER

PLATE 12 OF 18 RIVER MILE 116 TO 118

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE



LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

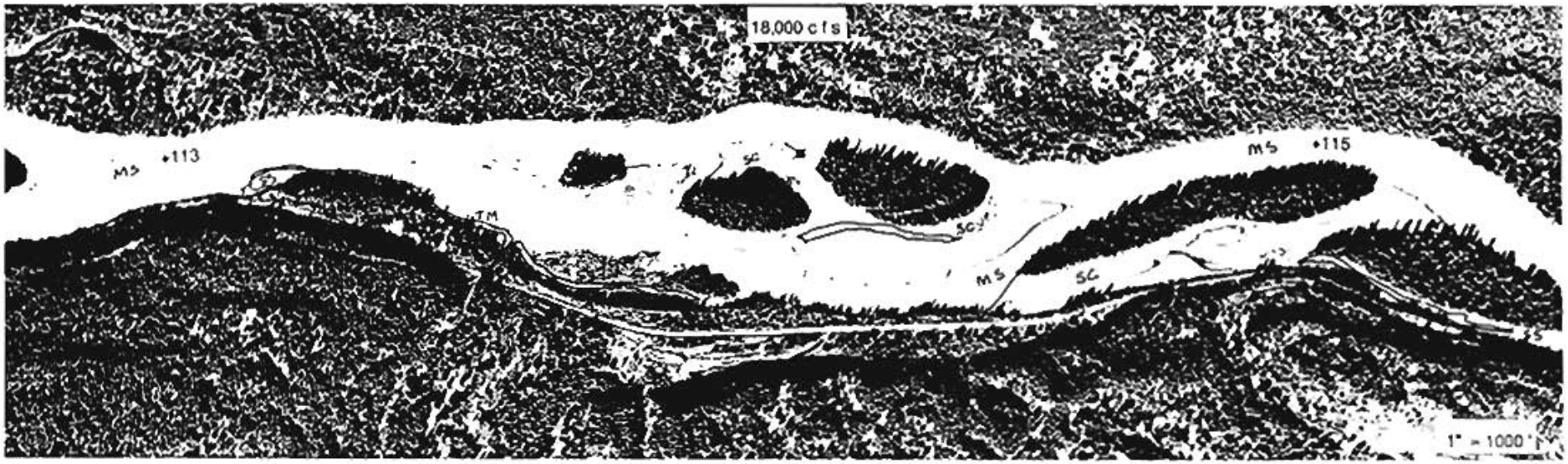
MIDDLE SUSITNA RIVER

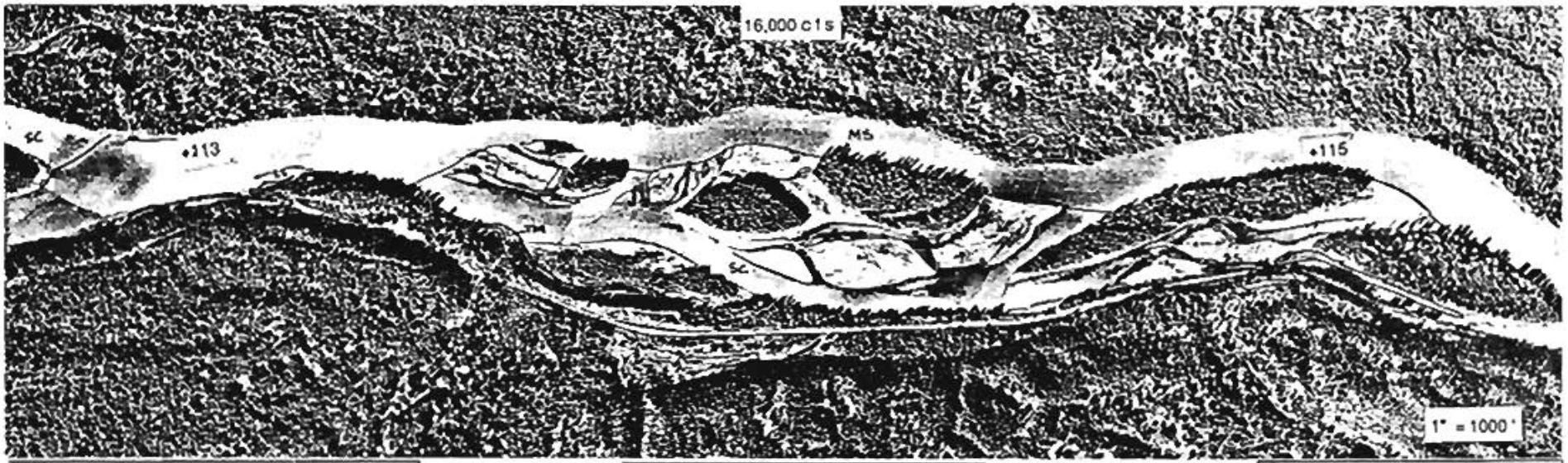
PLATE 13 OF 18 RIVER MILE 113 TO 115

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

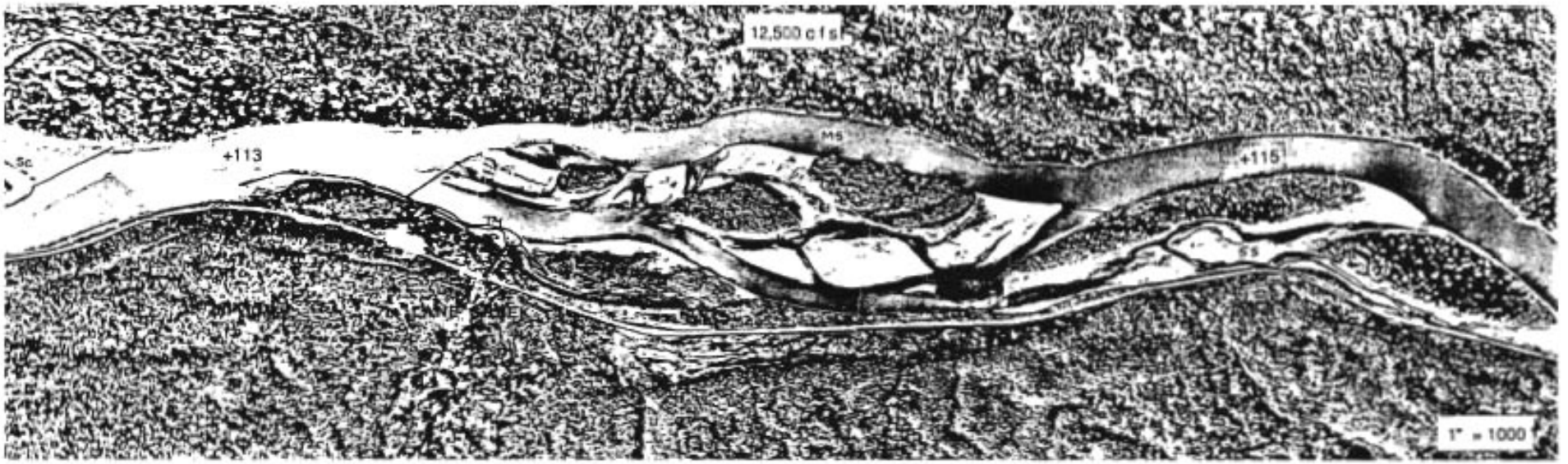
MIDDLE SUSITNA RIVER

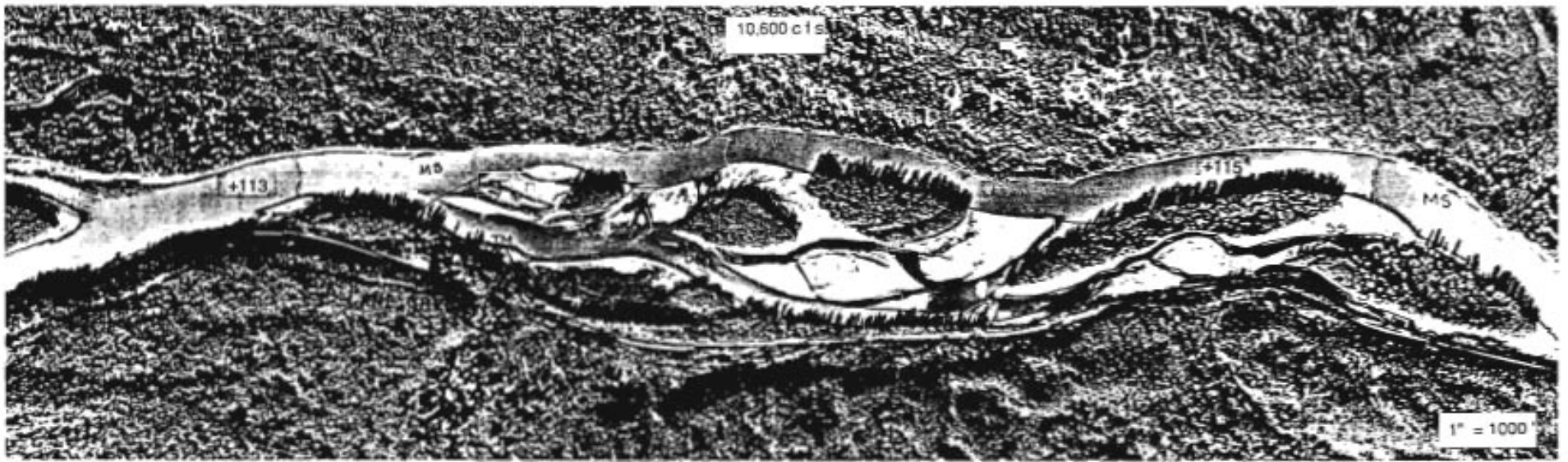
PLATE 13 OF 18 RIVER MILE 113 TO 115

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIBEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

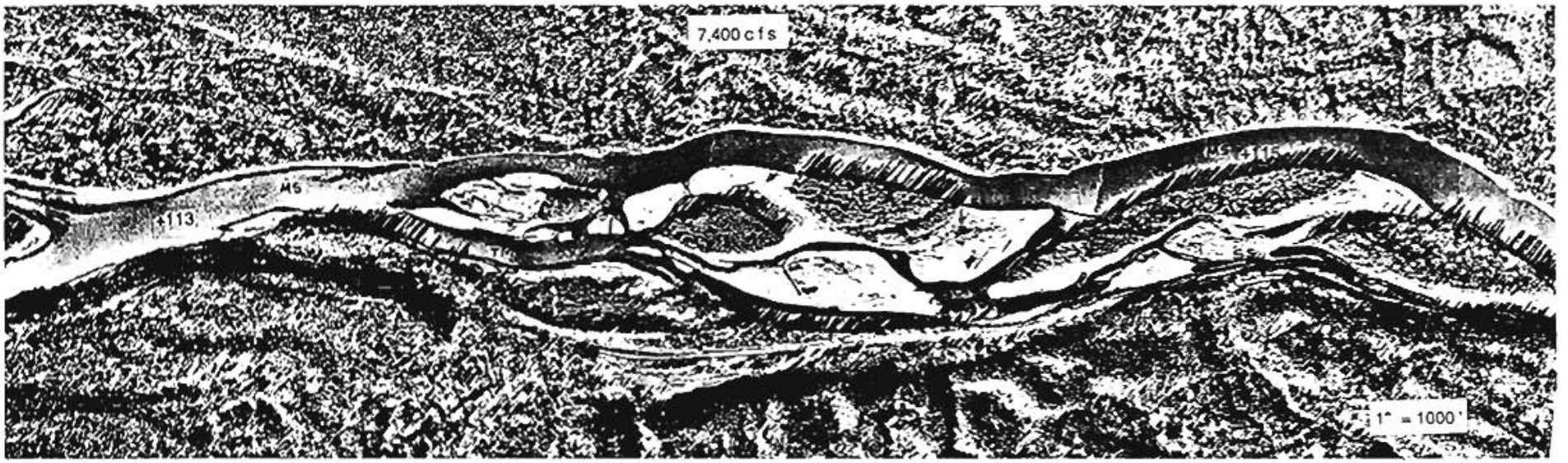
MIDDLE SUSITNA RIVER

PLATE 13 OF 18 RIVER MILE 113 TO 115

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE



LEGEND

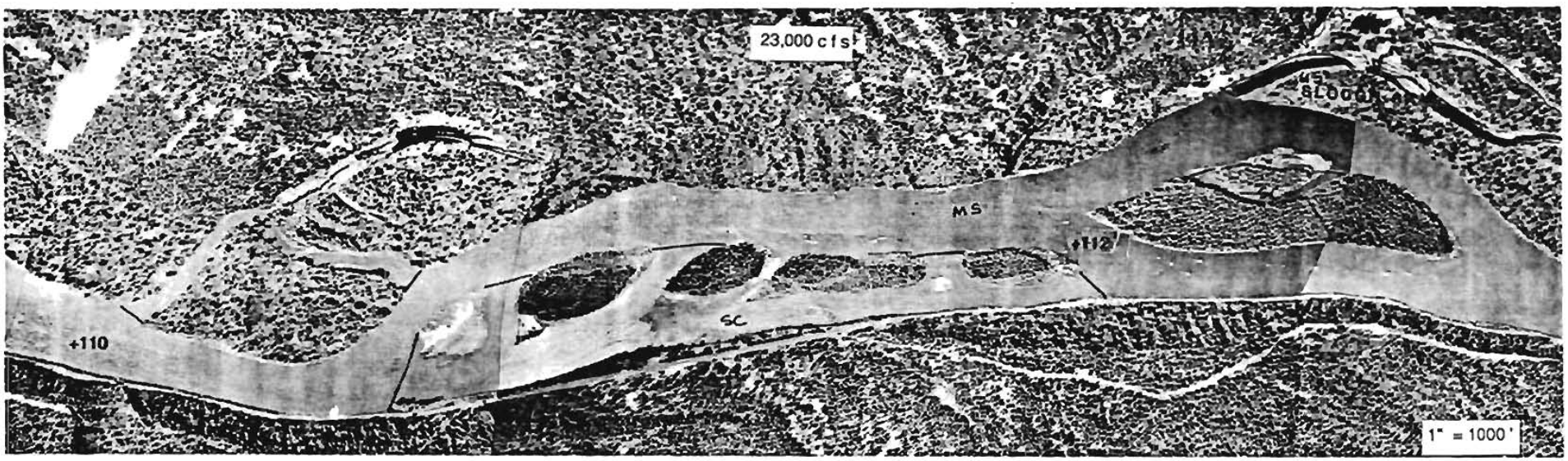
MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 13 OF 18 RIVER MILE 113 TO 115

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A E. WOODY TRIHEY & ASSOCIATES	HARZA - EBASCO SUSITNA JOINT VENTURE



LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

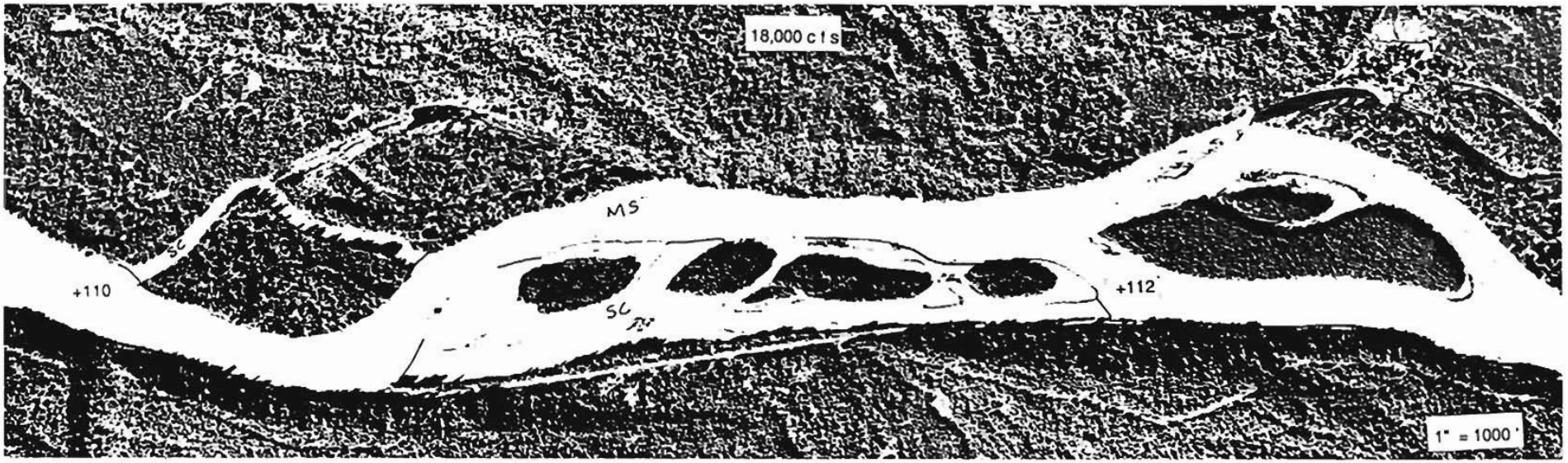
MIDDLE SUSITNA RIVER

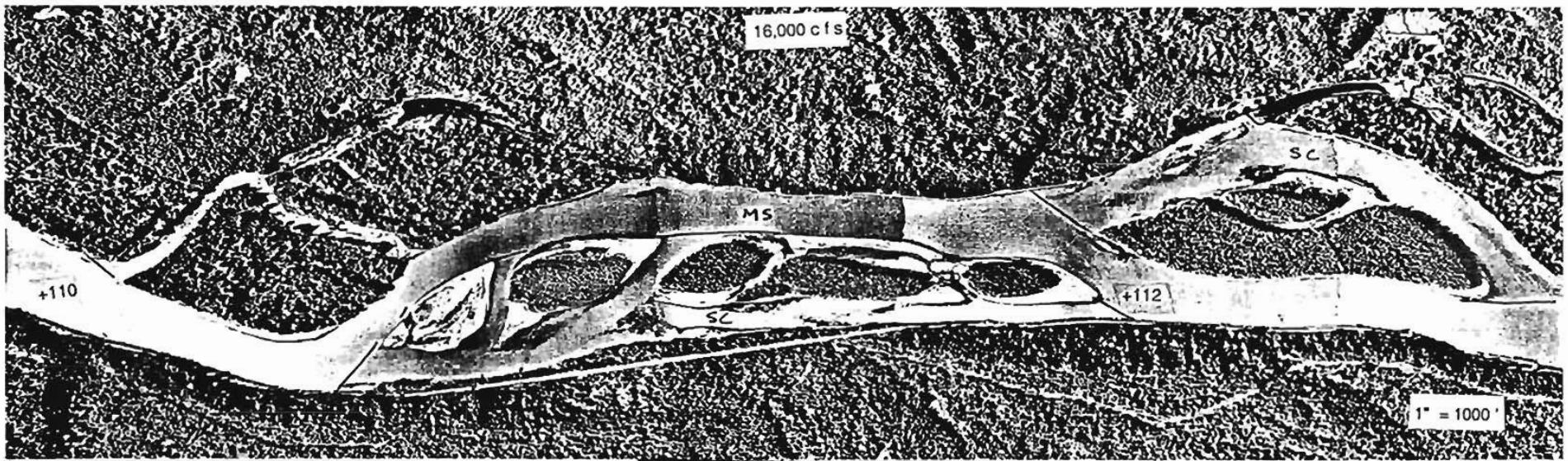
PLATE 14 OF 18 RIVER MILE 110 TO 112

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	S.DE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 14 OF 18 RIVER MILE 110 TO 112

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

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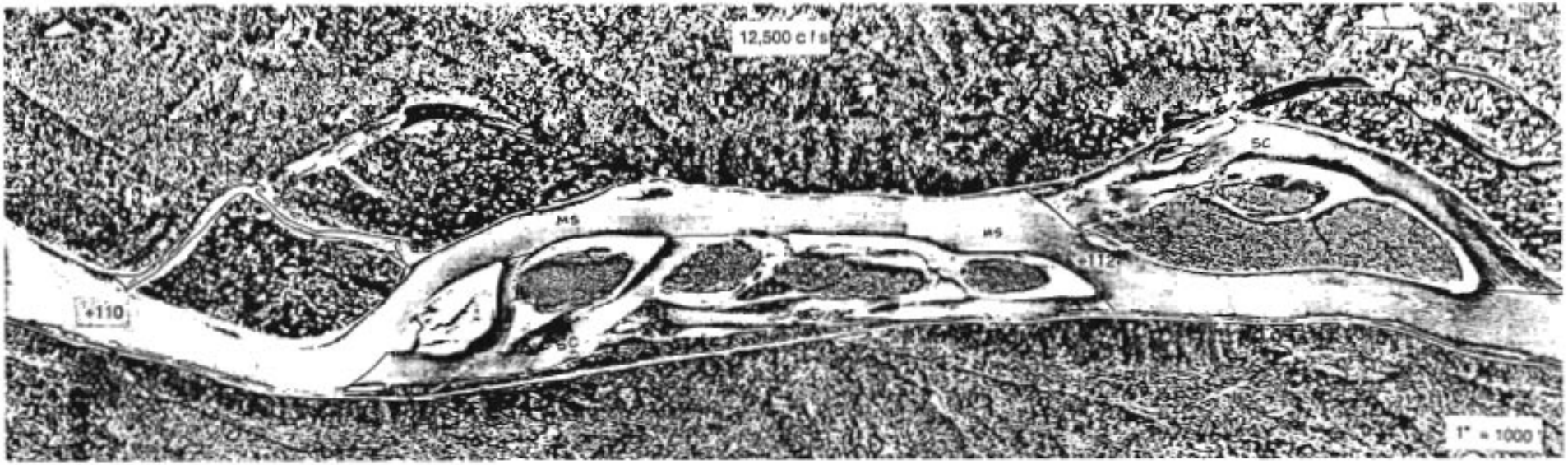
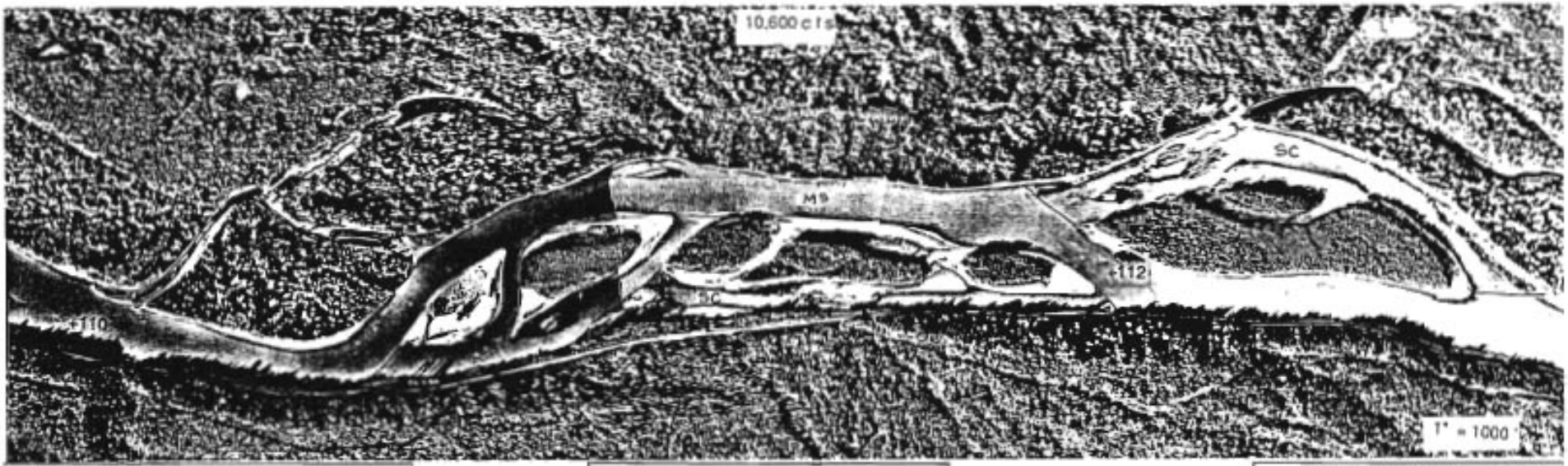
SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 14 OF 18 RIVER MILE 110 TO 112

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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E. WOODY TRIHEY & ASSOCIATES

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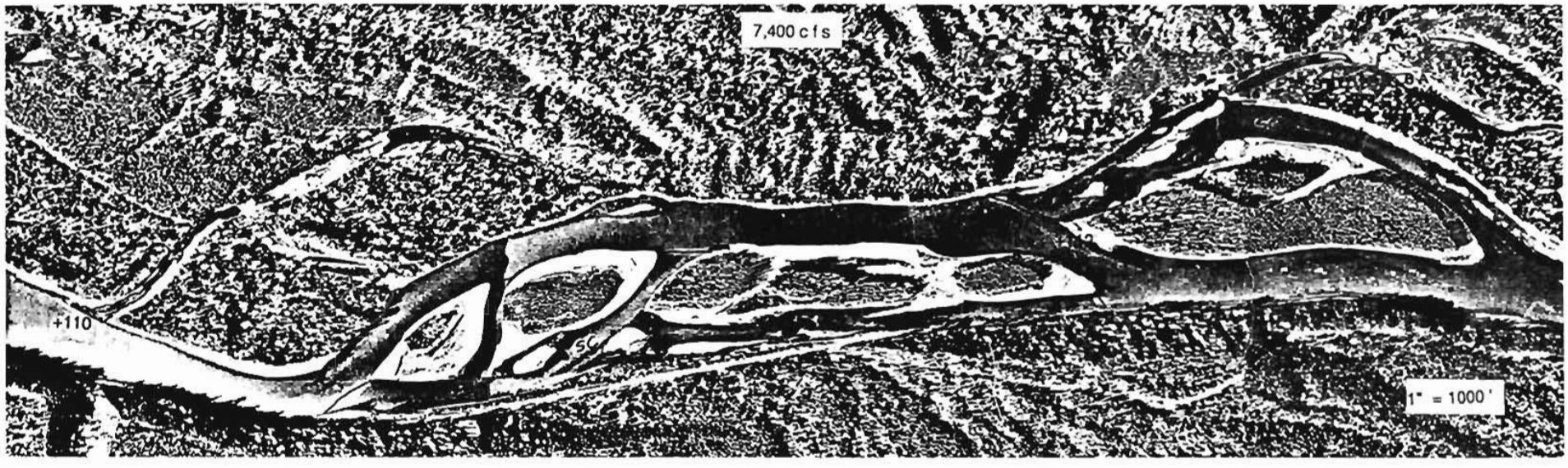
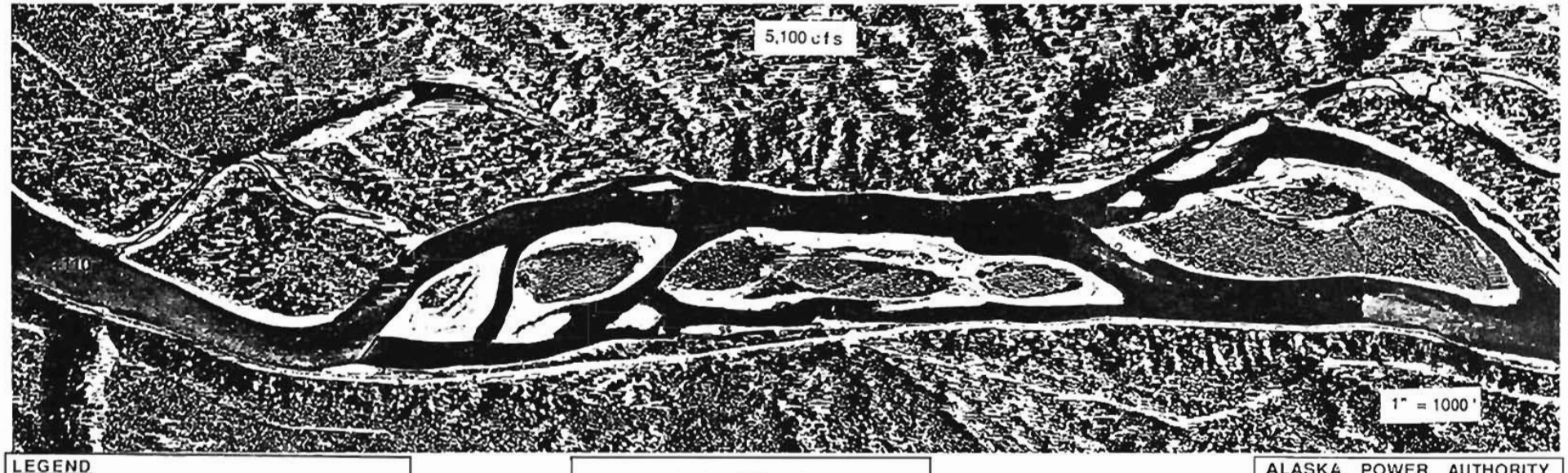
SUSITNA JOINT VENTURE





LEGEND

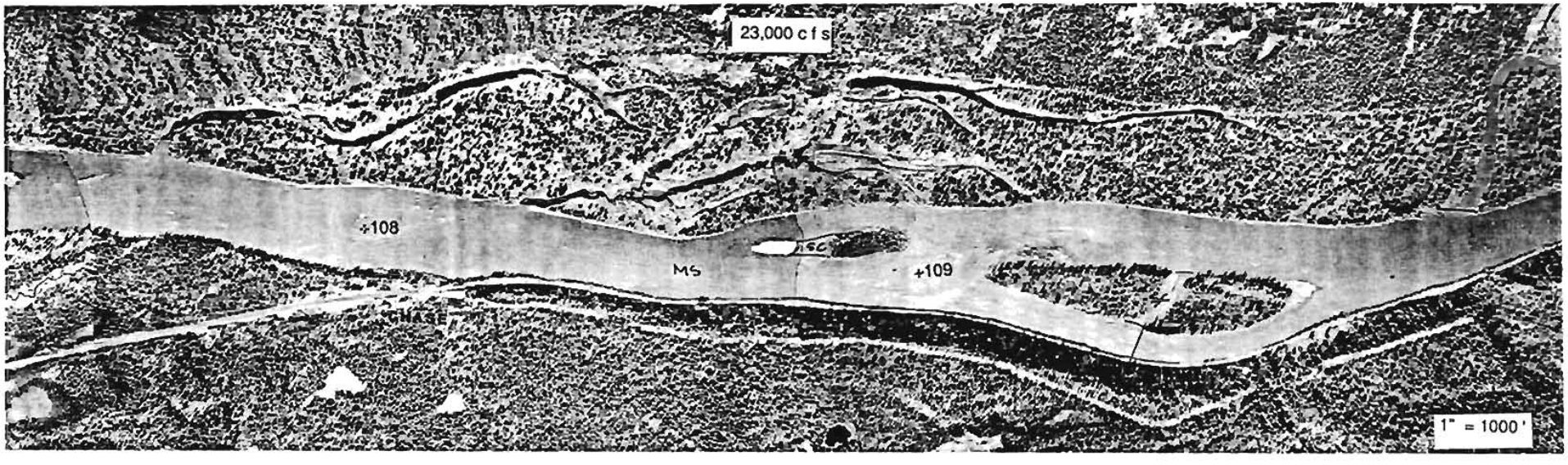
MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 14 OF 18 RIVER MILE 110 TO 112

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A E. WOODY TRIHEY & ASSOCIATES	HARZA - EBASCO SUSITNA JOINT VENTURE



LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

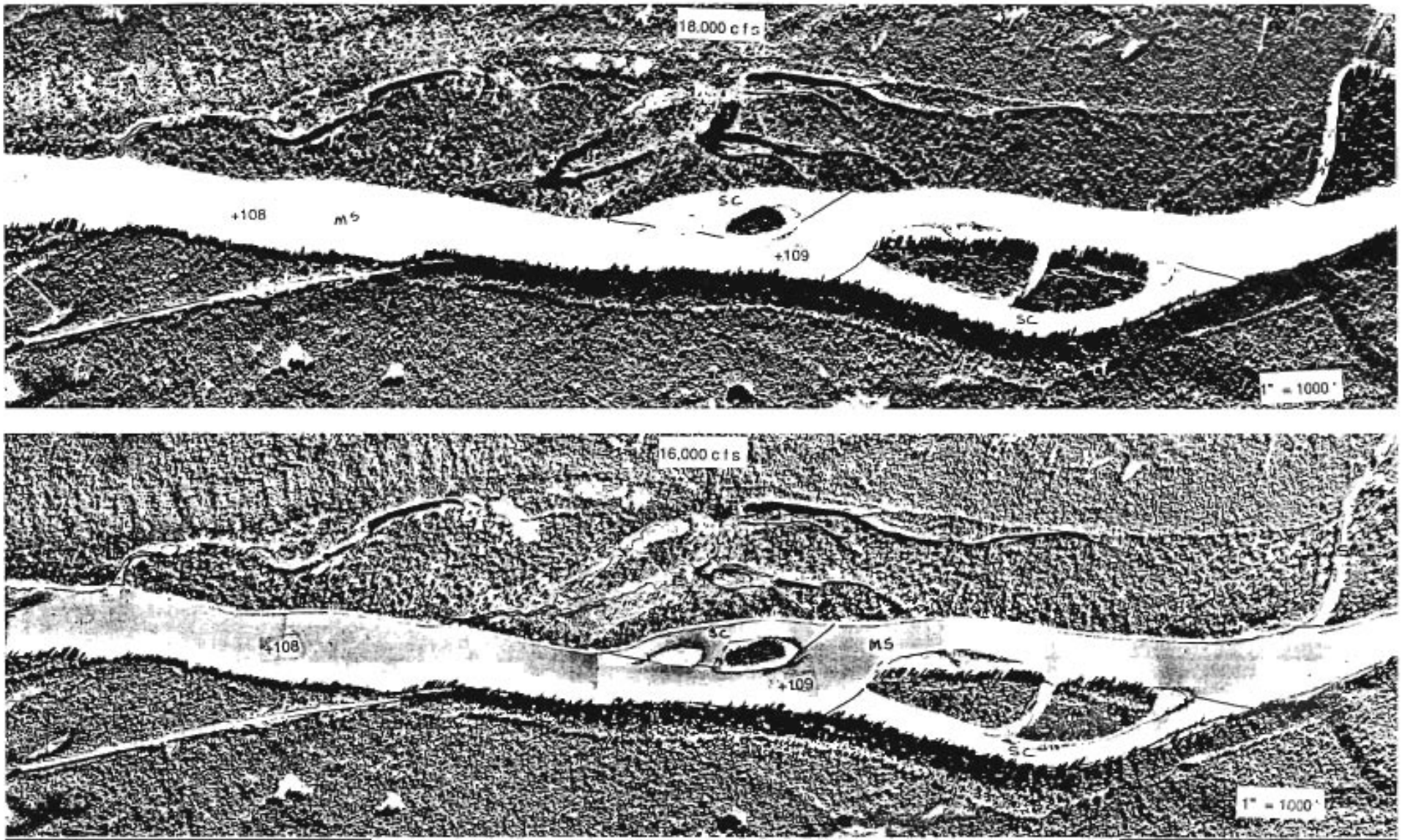
MIDDLE SUSITNA RIVER

PLATE 15 OF 18 RIVER MILE 108 TO 110

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE



LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 15 OF 18 RIVER MILE 108 TO 110

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

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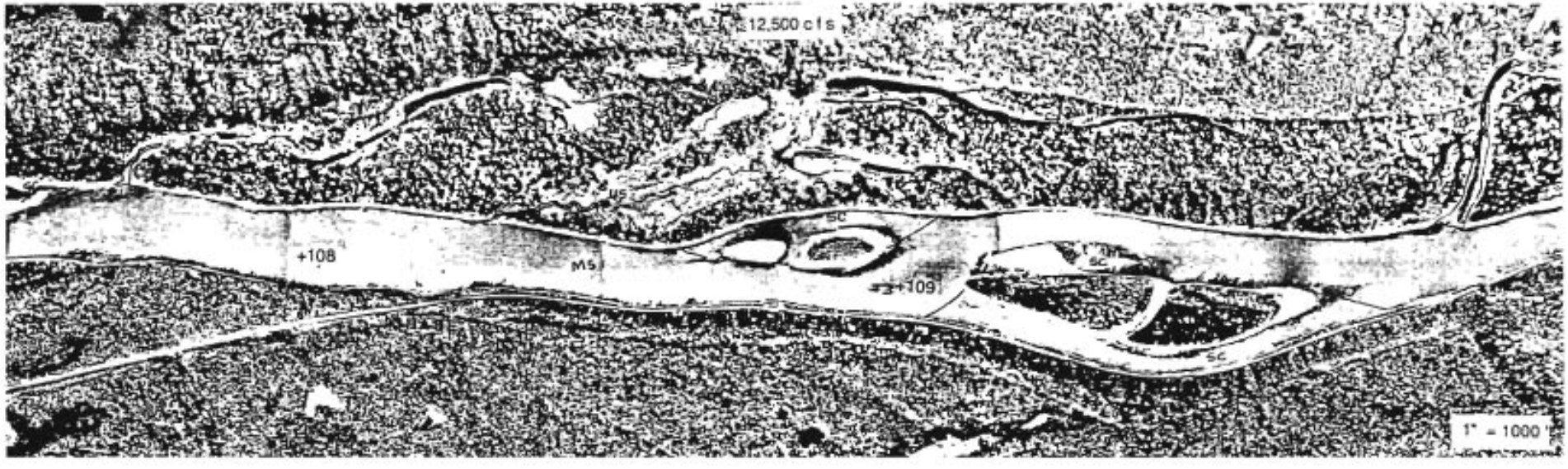
SUSITNA JOINT VENTURE



LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 15 OF 18 RIVER MILE 108 TO 110

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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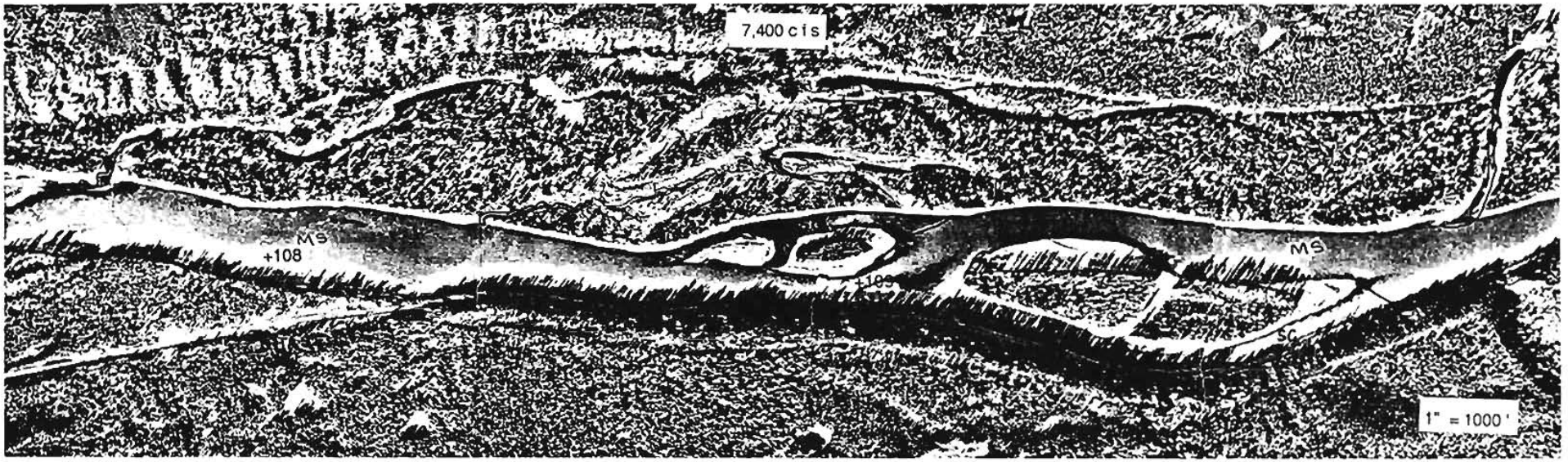
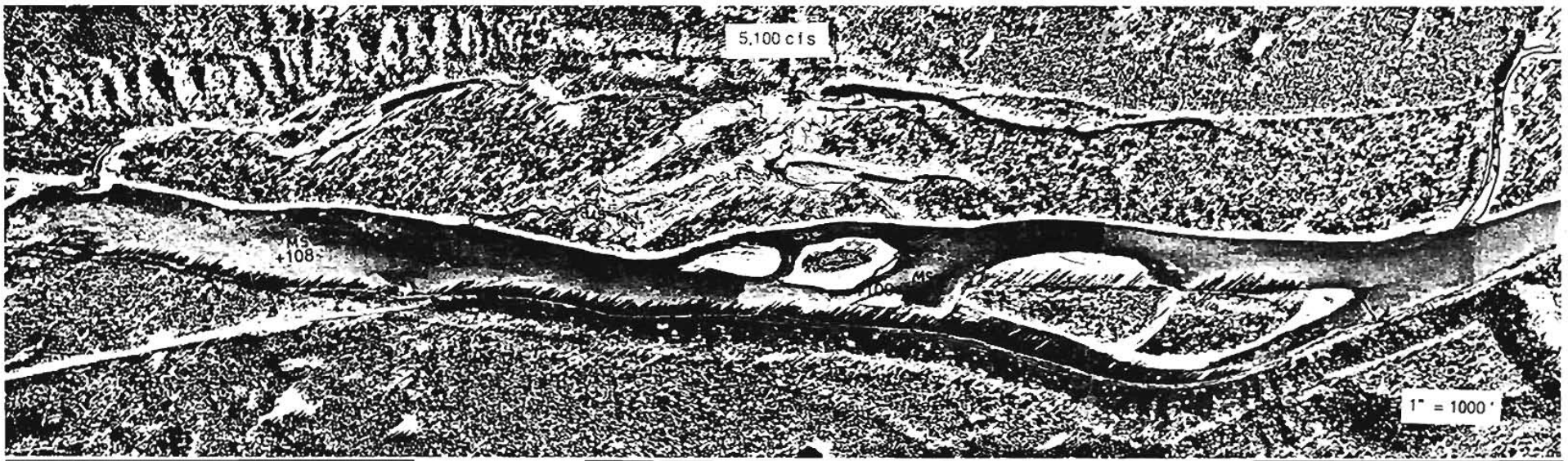
SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 15 OF 18 RIVER MILE 108 TO 110

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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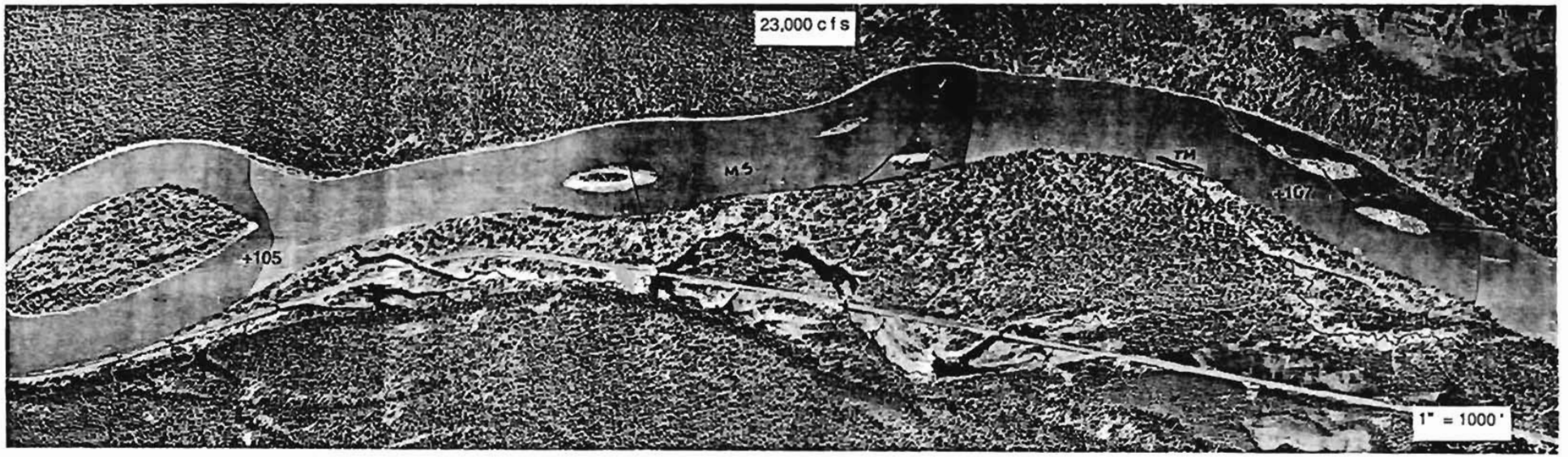
SUSITNA JOINT VENTURE



LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

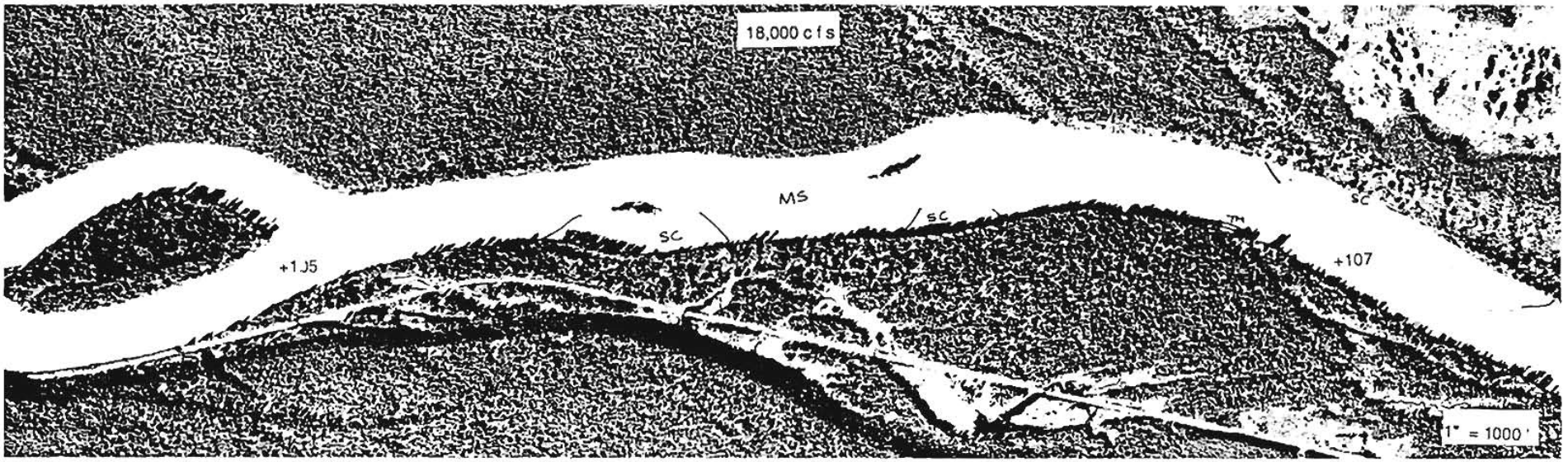
MIDDLE SUSITNA RIVER

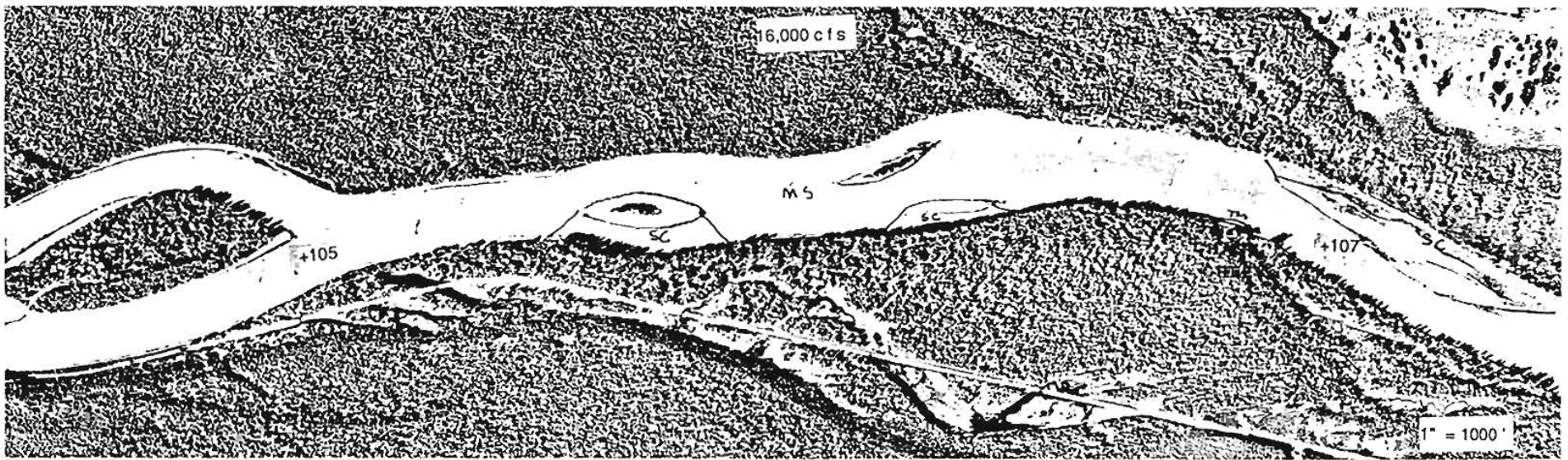
PLATE 16 OF 18 RIVER MILE 105 TO 107

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

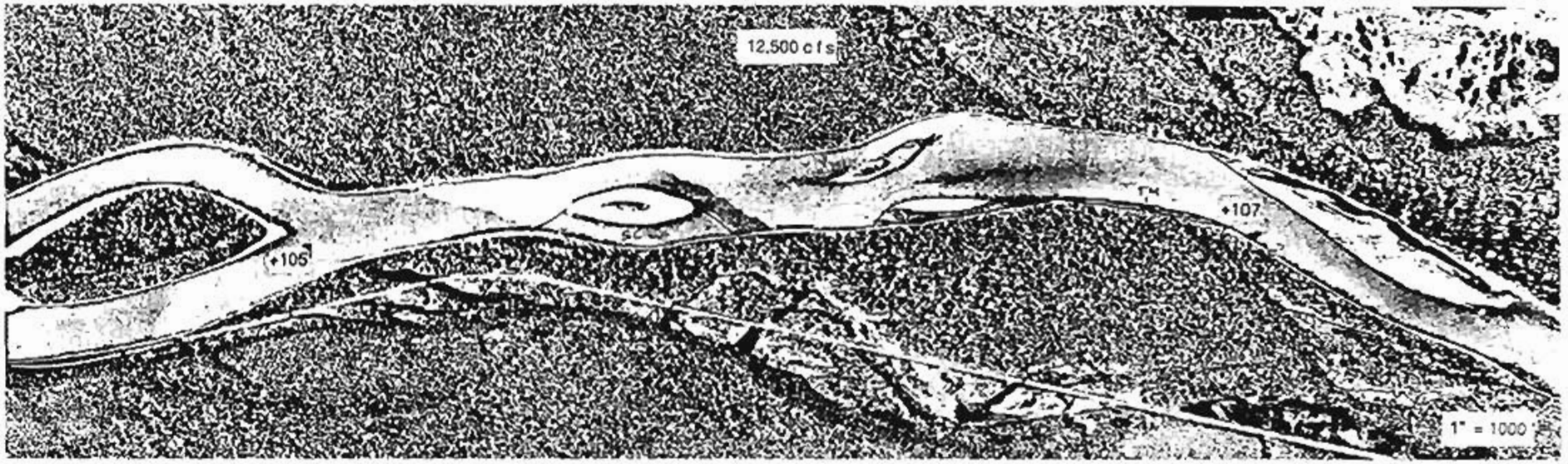
MIDDLE SUSITNA RIVER

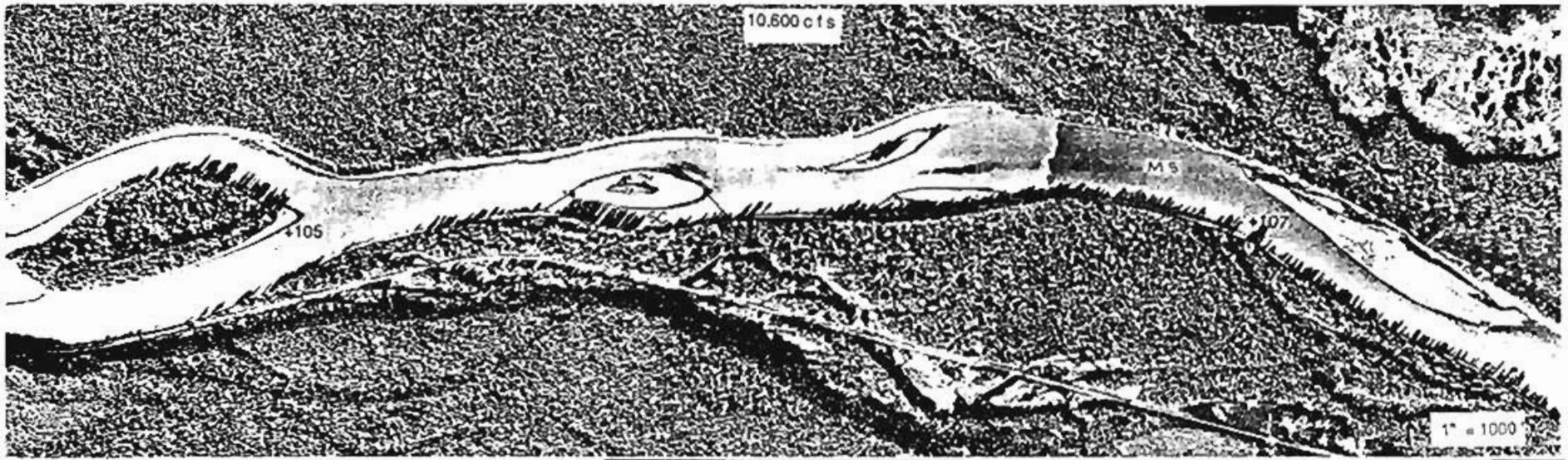
PLATE 16 OF 18 RIVER MILE 105 TO 107

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

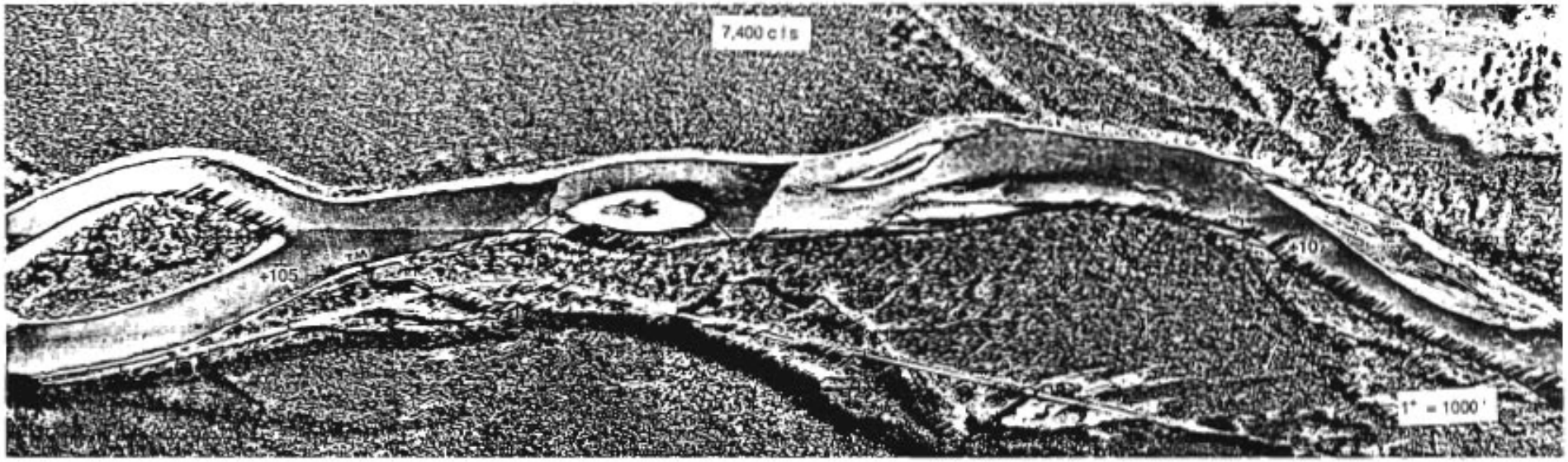
MIDDLE SUSITNA RIVER

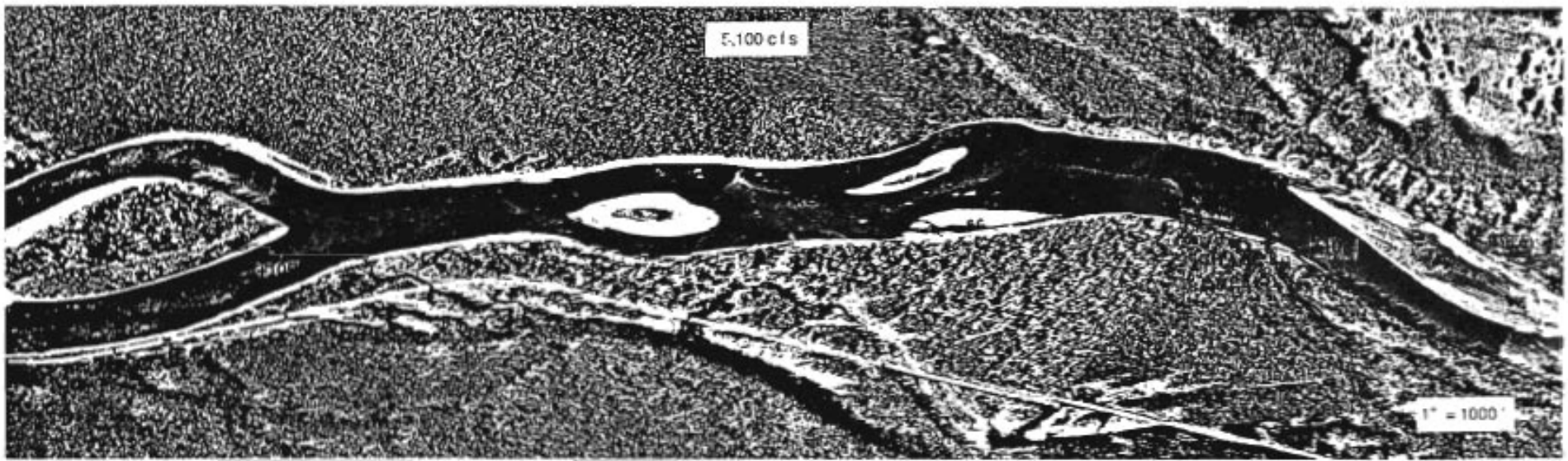
PLATE 16 OF 18 RIVER MILE 105 TO 107

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRINEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

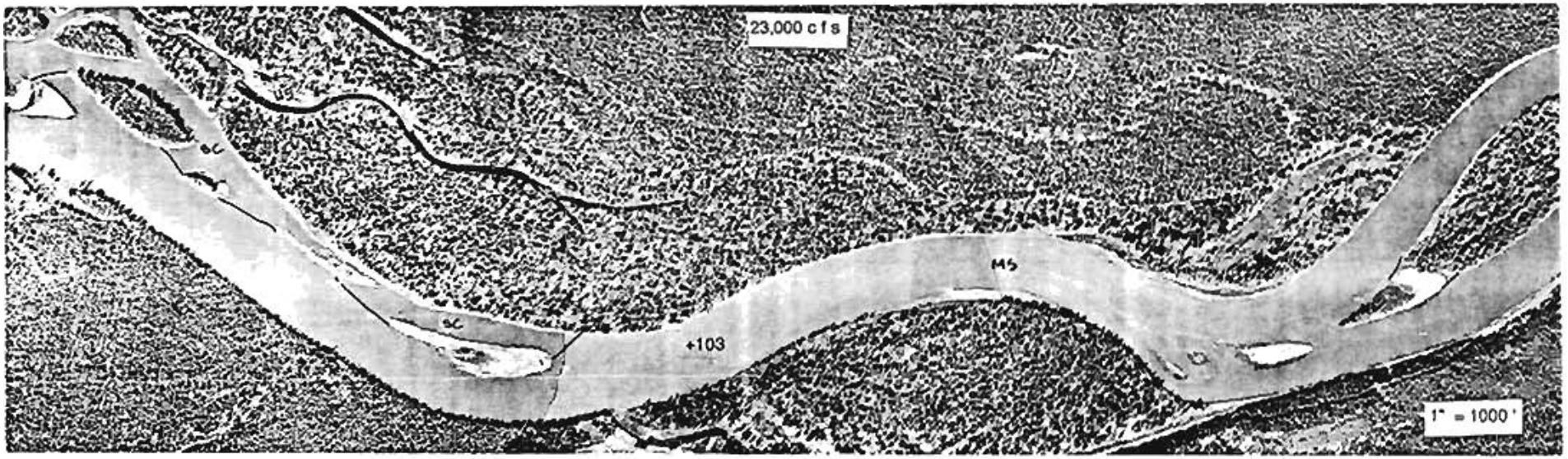
MIDDLE SUSITNA RIVER

PLATE 16 OF 18 RIVER MILE 105 TO 107

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE



LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

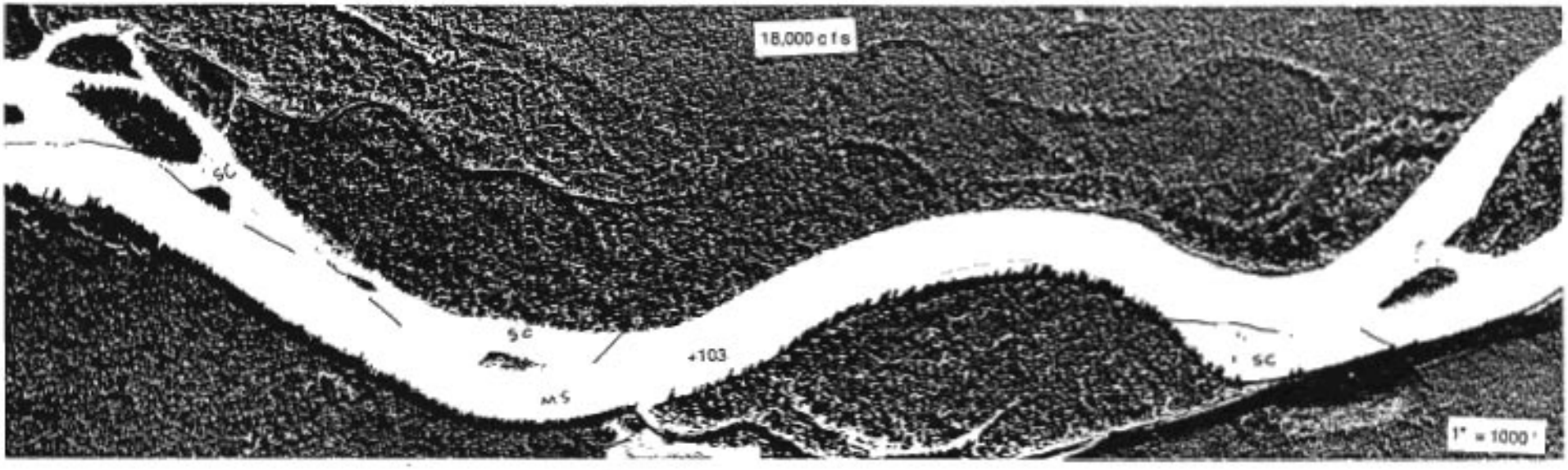
MIDDLE SUSITNA RIVER

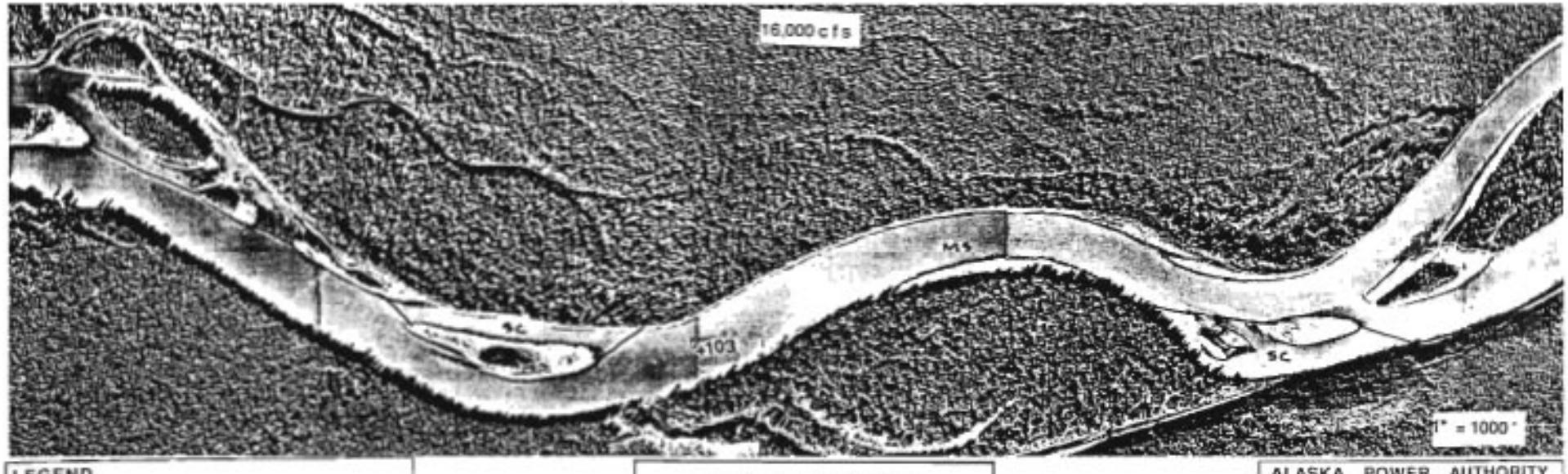
PLATE 17 OF 18 RIVER MILE 102 TO 104

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

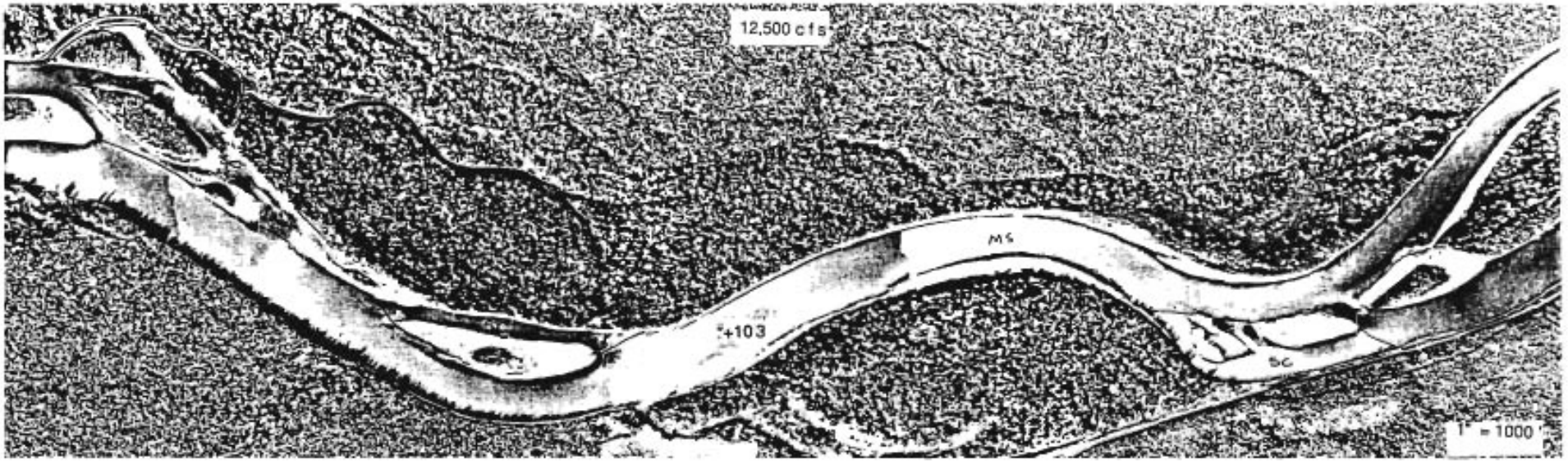
MIDDLE SUSITNA RIVER

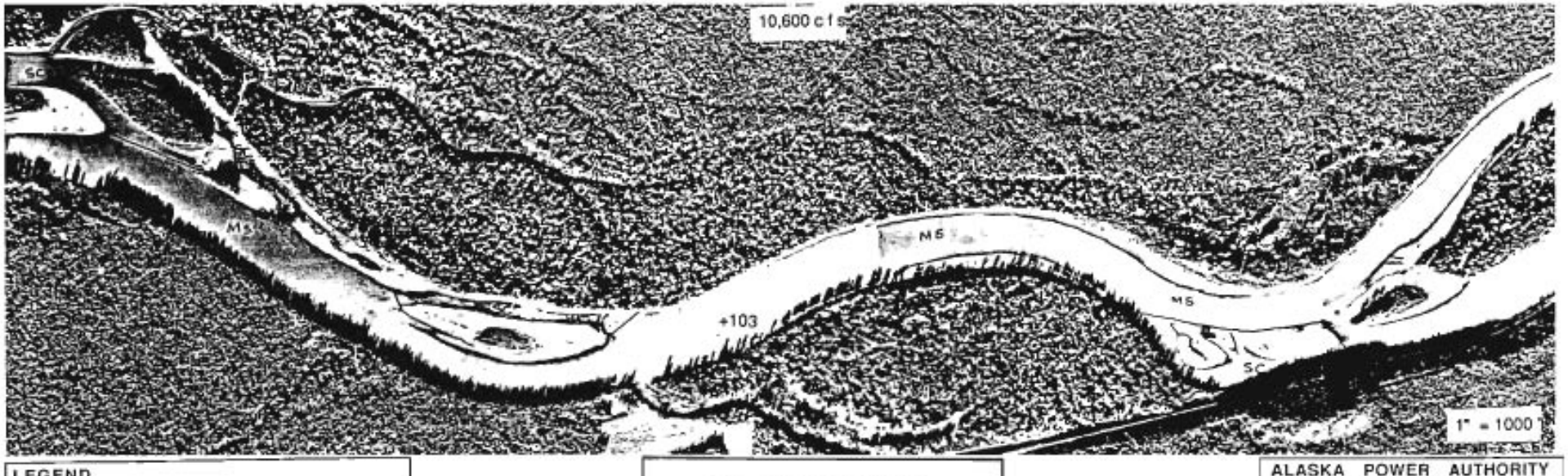
PLATE 17 OF 18 RIVER MILE 102 TO 104

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE





LEGEND

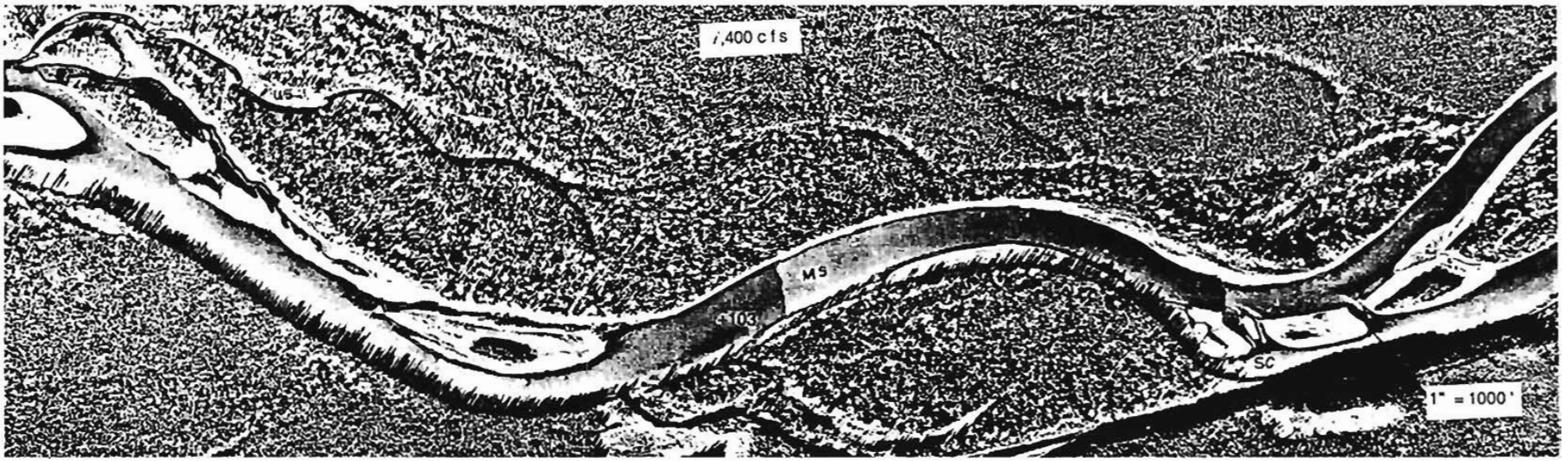
MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

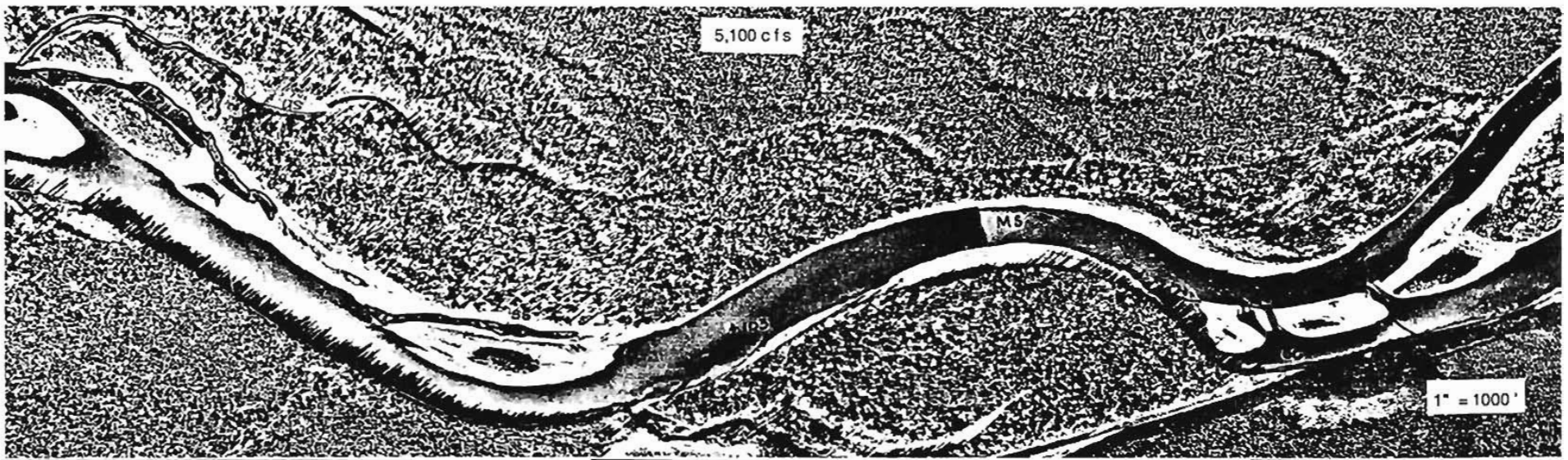
MIDDLE SUSITNA RIVER

PLATE 17 OF 18 RIVER MILE 102 TO 104

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A	HARZA - EBASCO
E. WOODY TRIMEY & ASSOCIATES	SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 17 OF 18 RIVER MILE 102 TO 104

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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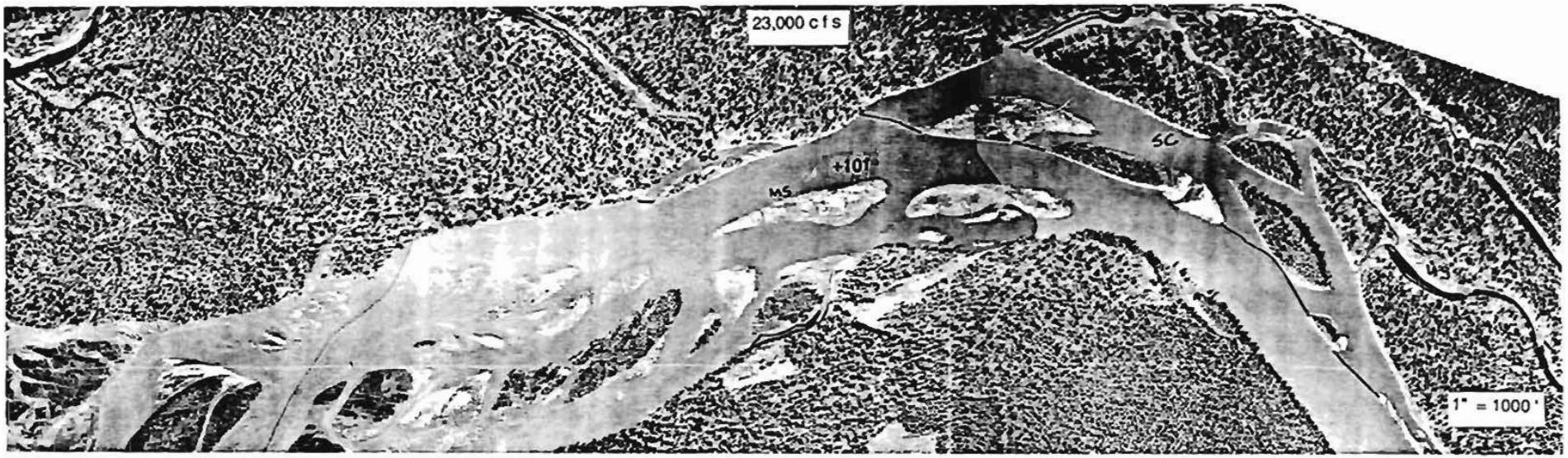
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE



LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	•	RIVER MILE
US	UPLAND SLOUGH		

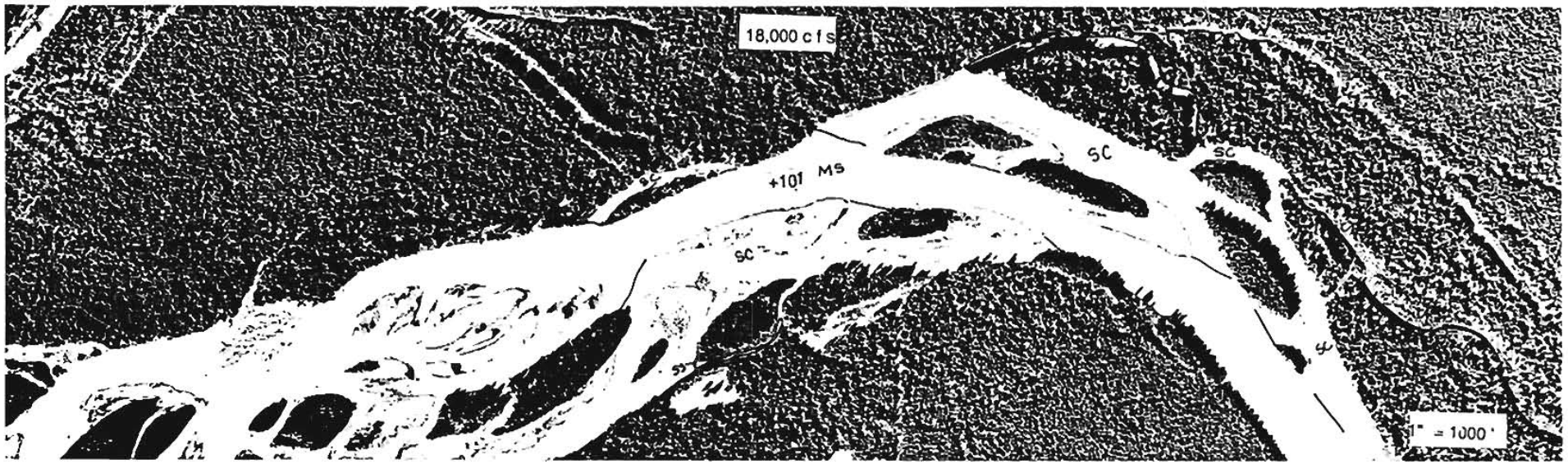
MIDDLE SUSITNA RIVER

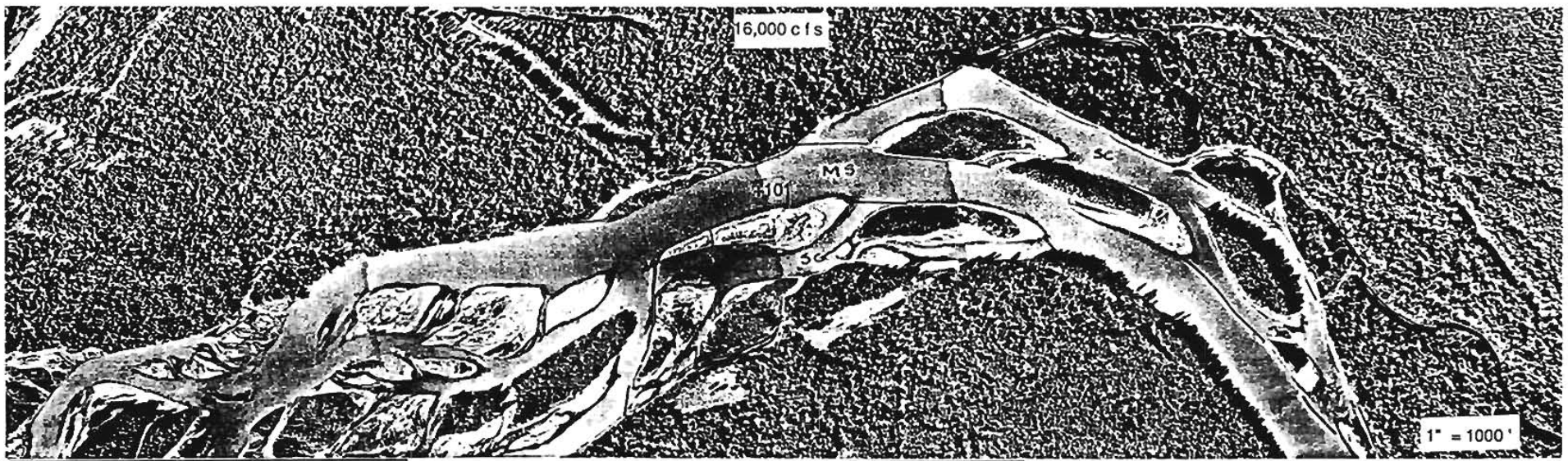
PLATE 18 OF 18 RIVER MILE 101 TO 102

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

EWT & A
E. WOODY TRIHEY & ASSOCIATES

HARZA - EBASCO
SUSITNA JOINT VENTURE





LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
SC	SIDE CHANNEL	T	TRIBUTARY
SS	SIDE SLOUGH	+	RIVER MILE
US	UPLAND SLOUGH		

MIDDLE SUSITNA RIVER

PLATE 18 OF 18 RIVER MILE 101 TO 102

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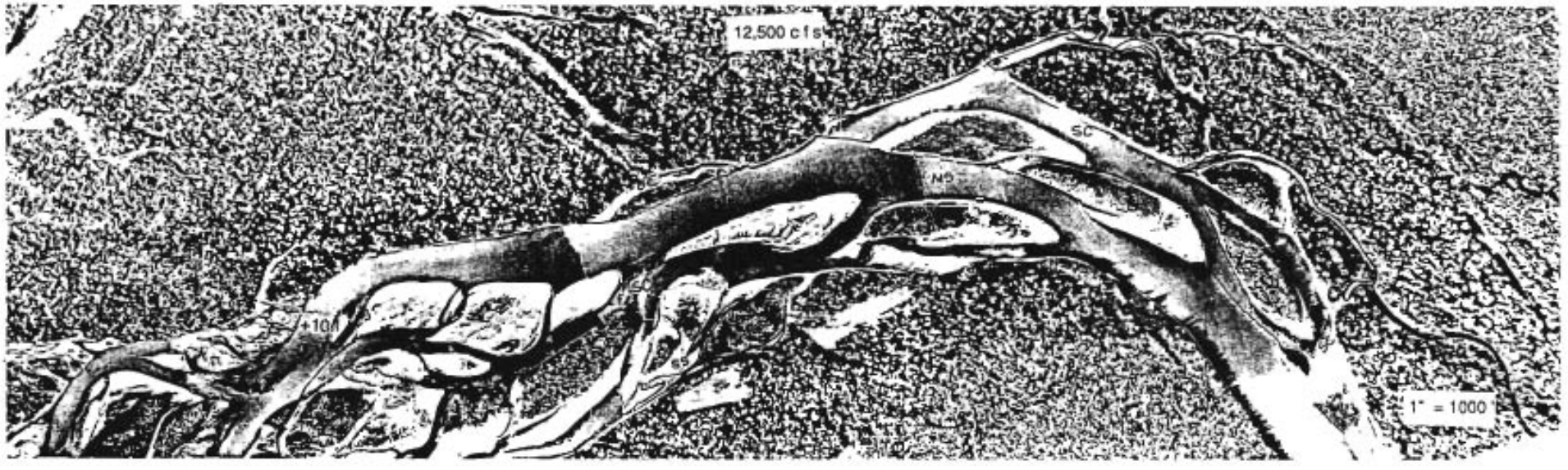

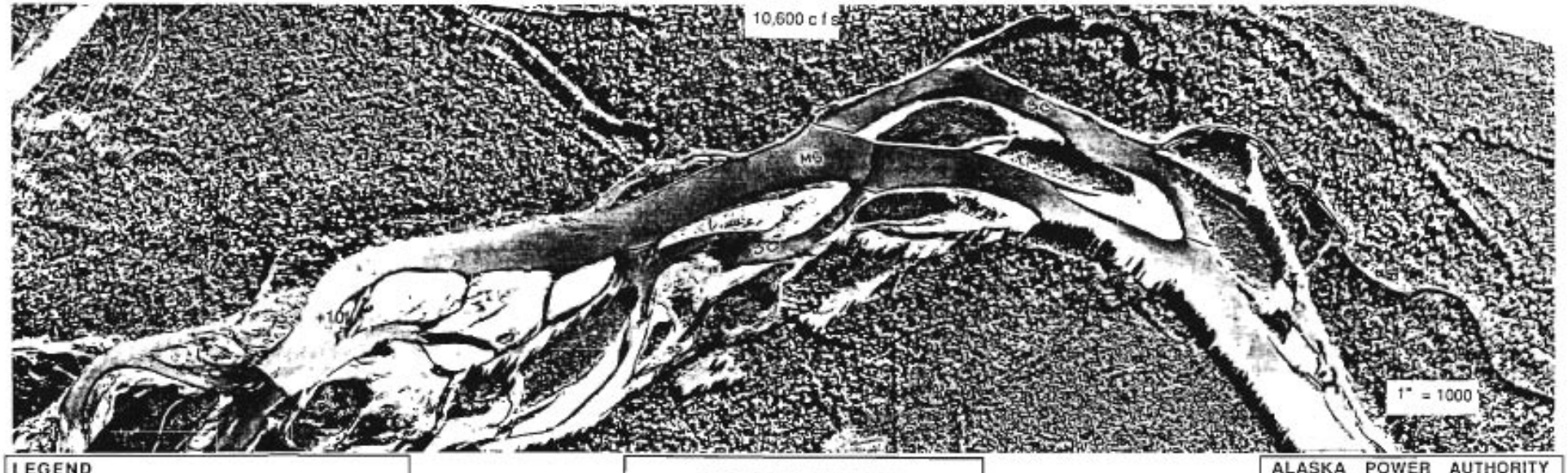

LEGEND

MS	MAINSTREAM	TM	TRIBUTARY MOUTH
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SS	SIDE SLOUGH	+	RIVER MILE
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MIDDLE SUSITNA RIVER

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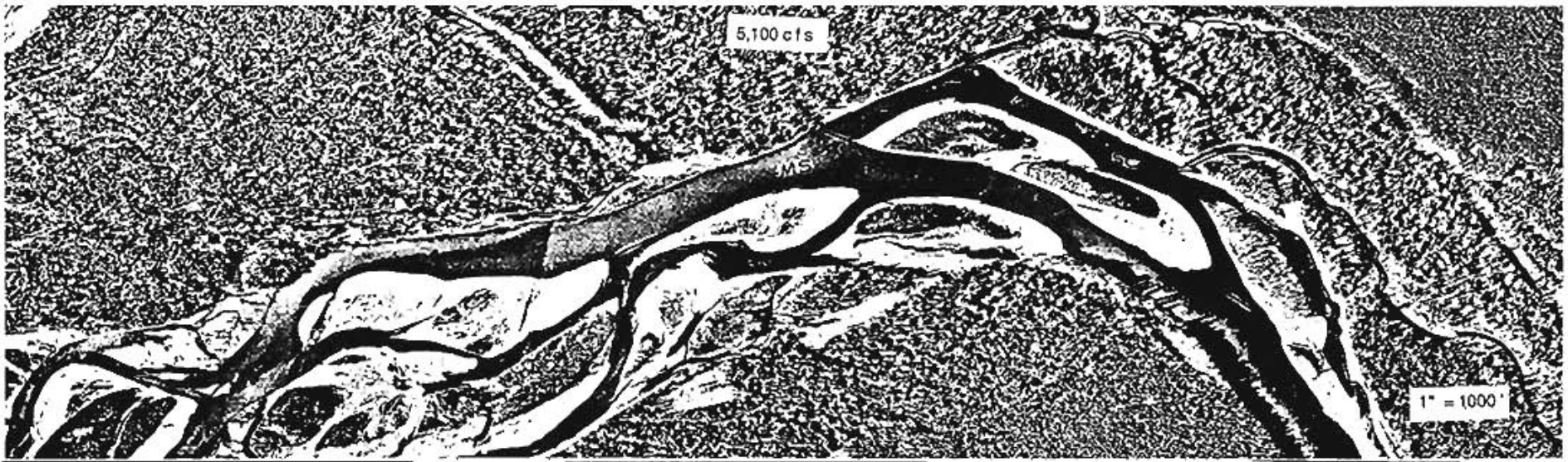

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MS	MAINSTREAM	TM	TRIBUTARY MOUTH
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