ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

TASK 3 - HYDROLOGY

SUBTASK 3.10 - INTERIM REPORT
LOWER SUSITNA STUDIES; PRELIMINARY OPEN WATER CALCULATIONS

APRIL 1981

Prepared for:

ACRES AMERICAN INCORPORATED

R&M CONSULTANTS, INC.
GEOLOGISTS PLANNERS SURVEYORS

ALASKA POWER AUTHORITY

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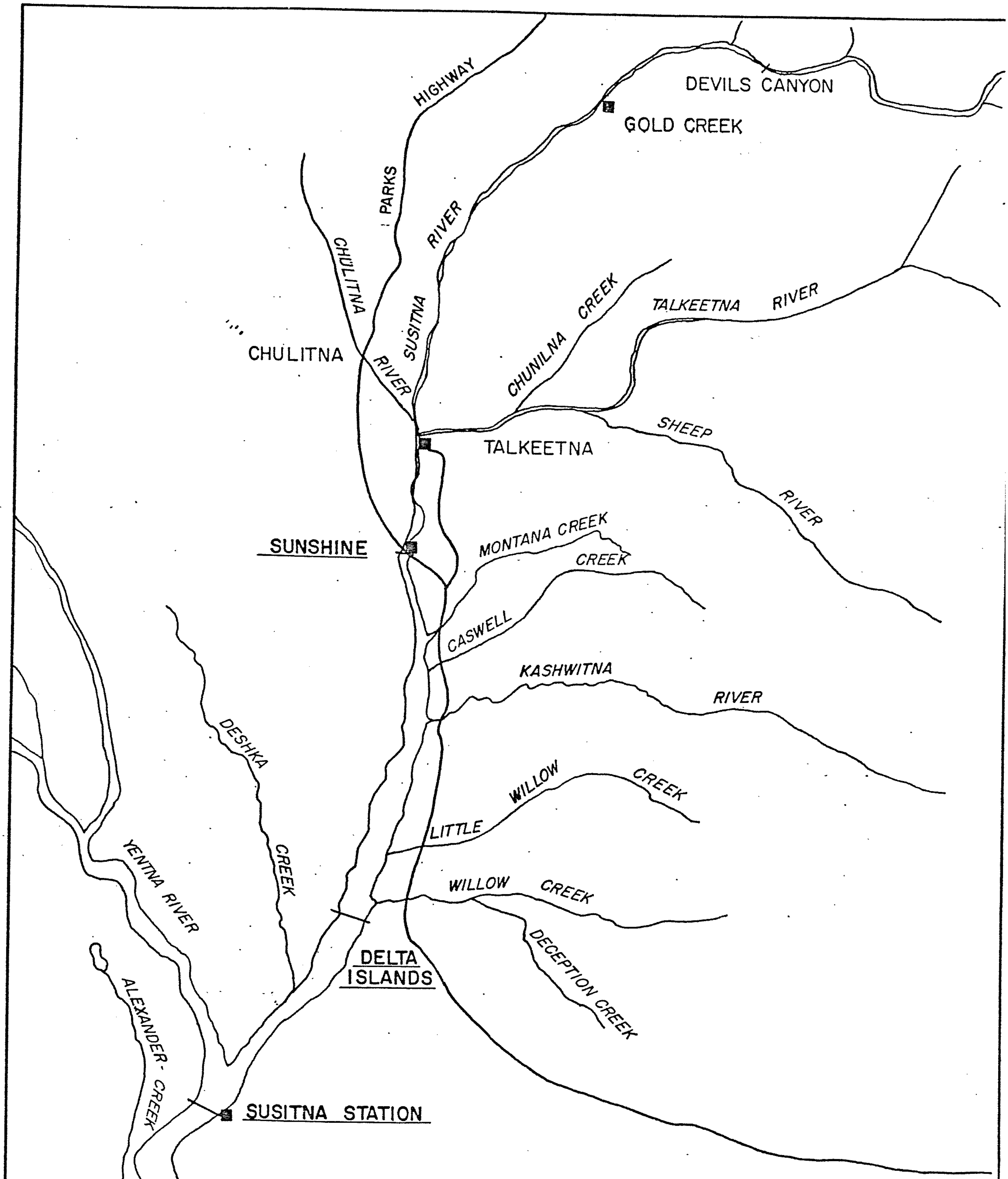
LOWER SUSITNA STUDIES
OPEN WATER CALCULATIONS

1 - 'INTRODUCTION

The Lower Susitna River is considered to be the reach downstream of Talkeetna to Cook Inlet. At the confluence with the Chulitna and Talkeetna Rivers, the Susitna River changes abruptly from a meandering single channel configuration to a predominantly braided pattern. Upstream of Talkeetna to the proposed damsites, the Susitna River is being studied quite extensively under Subtask 3.06 - "Hydraulic and Ice Studies" and Subtask 3.07 - "Sediment Yield and River Morphology Studies". Downstream of Talkeetna, a reconnaissance level study is being carried out under Subtask 3.10.

A prime objective of this interim report is to quantify, as best as is practical, the potential changes in the flow regime during floods. Vegetation and habitat study personnel indicated that estimates of change in water levels during various floods would benefit their programs.

There are currently only two stations that have existing hydrologic data; Susitna River at Sunshine and Susitna Station. At these two reaches, the river is constricted into a single channel which is not representative of the predominantly braided river pattern. With respect to potential changes in water levels during various floods under pre and post-project conditions, these two stations would probably reflect the extreme case. Therefore, a third station was added to this study which would represent the flow regime in a braided reach. A sample section was selected 8,000 feet downstream of the Willow Creek confluence at the Delta Islands. This cross-section was synthesized from a reconnaissance field trip and hydraulic regime relationships which enabled estimating hydraulic characteristics under pre and post- project conditions. With three sections in the Lower River, it is possible to interpolate the following results to intermediate locations of interest.



LOCATION MAP
LOWER SUSITNA RIVER

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Figure 1.1

2 - SUMMARY

Variances in flow and stage in the Lower Susitna as a result of flow regulation are reasonably bounded by this analysis for open water floods. The magnitude of change for pre and post-project floods of 2, 5, 10 and 25 year recurrence interval can be estimated from this analysis. Since the data base is scant, the procedures utilized in this study were basic and perhaps oversimplified. However, generally the assumptions made were conservative and reflect higher changes in flow and stage than may occur.

A summary comparing each station is presented on Table 2.1. At Sunshine, the stage in the river is expected to be 2.0 to 2.5 feet lower during floods with a recurrence interval of 2 to 25 years. At Susitna Station, a change in stage for the same flood intervals could vary from 1.9 feet to 3.2 feet. Comparing these two stations to the Delta Island Station shows that the potential decrease in stage for a braided section would be less at just below 2 feet. Since the rivers width increases more with an increase in stage, this is expected for a braided reach.

Based on these three points, estimates of post project stage changes could be made for intermediate river reaches. Sunshine is representative of an upstream constriction, Susitna station represents a narrow downstream section, and the Delta Island is representative of a broad braided reach. Therefore, other river reaches would have stage changes equal to or less than Sunshine or Susitna station and equal to or greater than the Delta Island section, depending on the characteristics of the river reach being considered.

Local variances in river reaches and effects of debris jamming, transitional channel changes and other natural influences could distort these results. However, for the purposes of establishing guidelines, it can generally be stated that stages after flow regulation will be 1.5 to 3.5 feet lower during floods, depending on the reach of river under consideration.

Additional field data, that is scheduled to be collected during the 1981 open water season, should provide sufficient information to carry this study through another degree of refinement. Proposed activities for 1981 consist of:

- Breakup observations by Acres, R&M, TES.
- Vertical aerial photography on 3" x5" prints at various water levels.
- Continuous stream gaging by USGS on the Susitna River at Sunshine and Susitna Station and on the Yentna River.
- Staff gage installation and monitoring by ADF&G.
- Field observations by hydrologists, aquatic biologists, terrestial biologists, etc.
- River Regime studies by R&M and Acres.

TABLE 2.1
PRELIMINARY ESTIMATES OF PRE AND POST PROJECT
DISCHARGE AND STAGE FREQUENCY ANALYSIS

Devils Canyon Damsite

Recurrence Interval	Preproject Q (cfs)	Postproject Q (cfs)
2	47,000	15,000
5	61,000	15,000
10	71,000	15,000
25	84,000	15,000

Susitna River at Sunshine Station

	Preproject		Postproject		
Recurrence Interval	Q (cfs)	Stage (ft)	Q (cfs)	Stage (ft)	Change In Stage (feet)
2	96,000	57.9	64,000	55.9	2.0
5	125,000	59.2	79,000	57.1	2.1
10	146,000	60.0	90,000	57.6	2.4
25	176,000	61.0	107,000	58.5	2.5

Susitna River at Delta Islands

	Preproject		Postproject		
Recurrence Interval	Q (cfs)	Stage (ft)	Q (cfs)	Stage (ft)	Change In Stage (feet)
2	105,000	94.6	72,000	92.7	1.9
5	136,000	95.6	90,000	93.7	1.9
10	159,000	96.3	103,000	94.5	1.8
25	193,000	97.3	124,000	95.3	1.8

Susitna River at Susitna Station

	Preproject		Postproject		
Recurrence Interval	Q (cfs)	Stage (ft)	Q (cfs)	Stage (ft)	Change In Stage (feet)
2	157,000	16.8	125,000	14.9	1.9
5	204,000	19.1	158,000	16.8	2.3
10	239,000	20.5	183,000	18.1	2.4
25	289,000	23.0	220,000	19.8	3.2

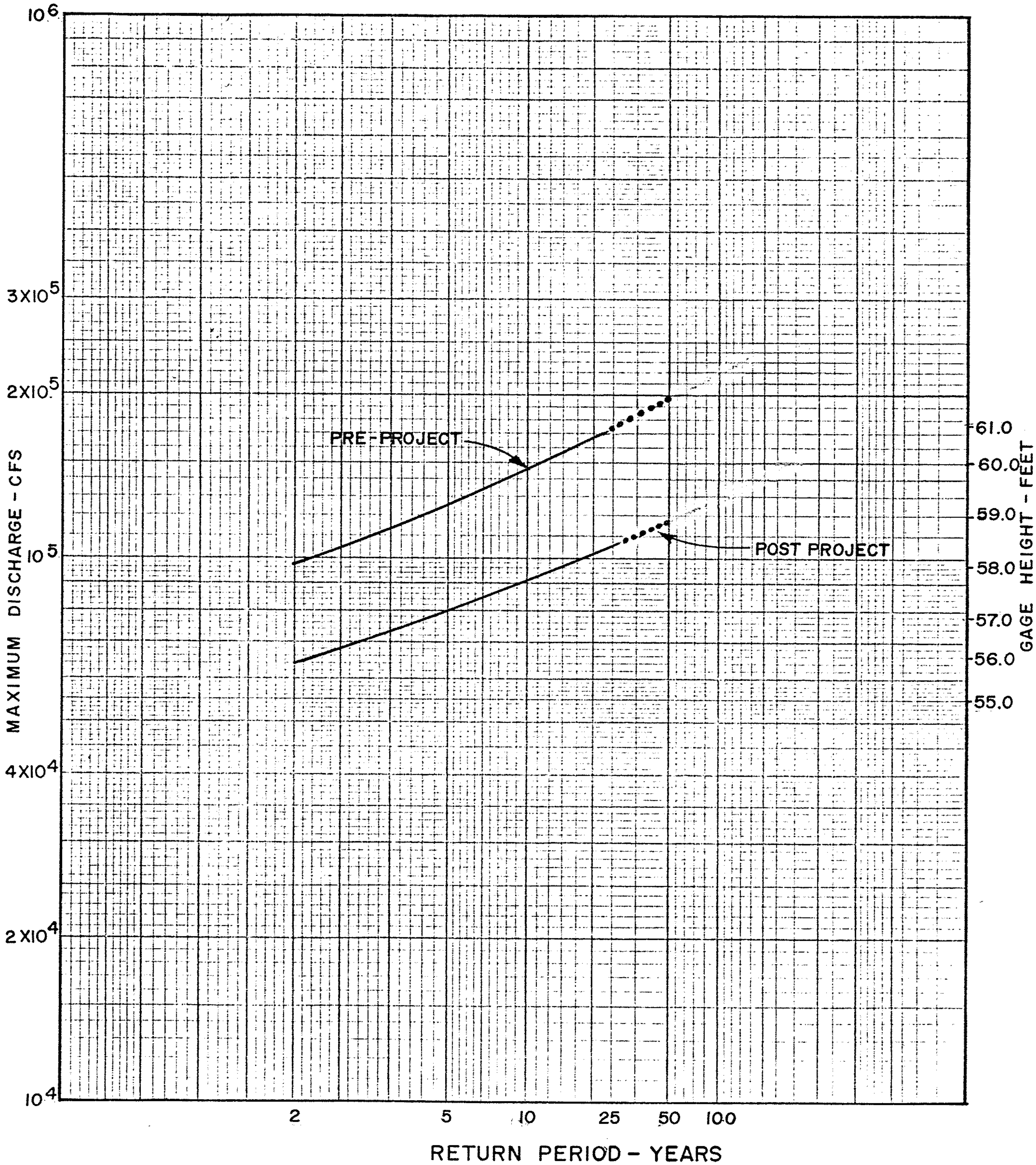
Note: Based on preliminary data, subject to revision

3 - ANALYSES AT SUNSHINE STATION

Due to absence of any flood record at this station, estimates of 2, 5, 10 and 25-year flood peaks under natural regime were made from regional flood frequency studies conducted by R&M under Subtask 3.05. Complete regulation of floods (up to a 25-year R.I.) by the project was assumed for the basin above Devils Canyon. The post-project flood peaks at Sunshine Station were thus estimated as the sum of flood peaks from unregulated catchment (Chulitna and Talkeetna Rivers, plus Susitna below Devils Canyon) and regulated flow (assumed to be 15,000 cfs) from the Watana-Devils Canyon developments. This assumption results in a conservatively high estimate of changes in flood peak levels due to the project. Figure 3.1 presents the flood frequency analysis with respect to discharge and stage. These results are superimposed on a cross-sectional plot of the river on Figure 3.2. Extensions of either figures for rarer floods should be made with caution.

Flood hydrograph shapes at Sunshine were synthesized from observed simultaneous flows at Gold Creek, Chulitna and Talkeetna gage stations for natural conditions and Chulitna and Talkeetna records for post-project situation. The results shown on Figure 3.3 provide an estimation of flood durations under pre and post-project conditions.

A stage discharge relationship is shown on Figure 3.4. This curve was generated from four miscellaneous measurements which have been made by the USGS. Continuous gaging through the 1981 summer will generate a more reliable curve.



NOTE: BASED ON PRELIMINARY DATA, SUBJECT TO REVISION

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SUSITNA RIVER AT SUNSHINE PRE AND POST PROJECT DISCHARGE - STAGE FREQUENCY CURVES

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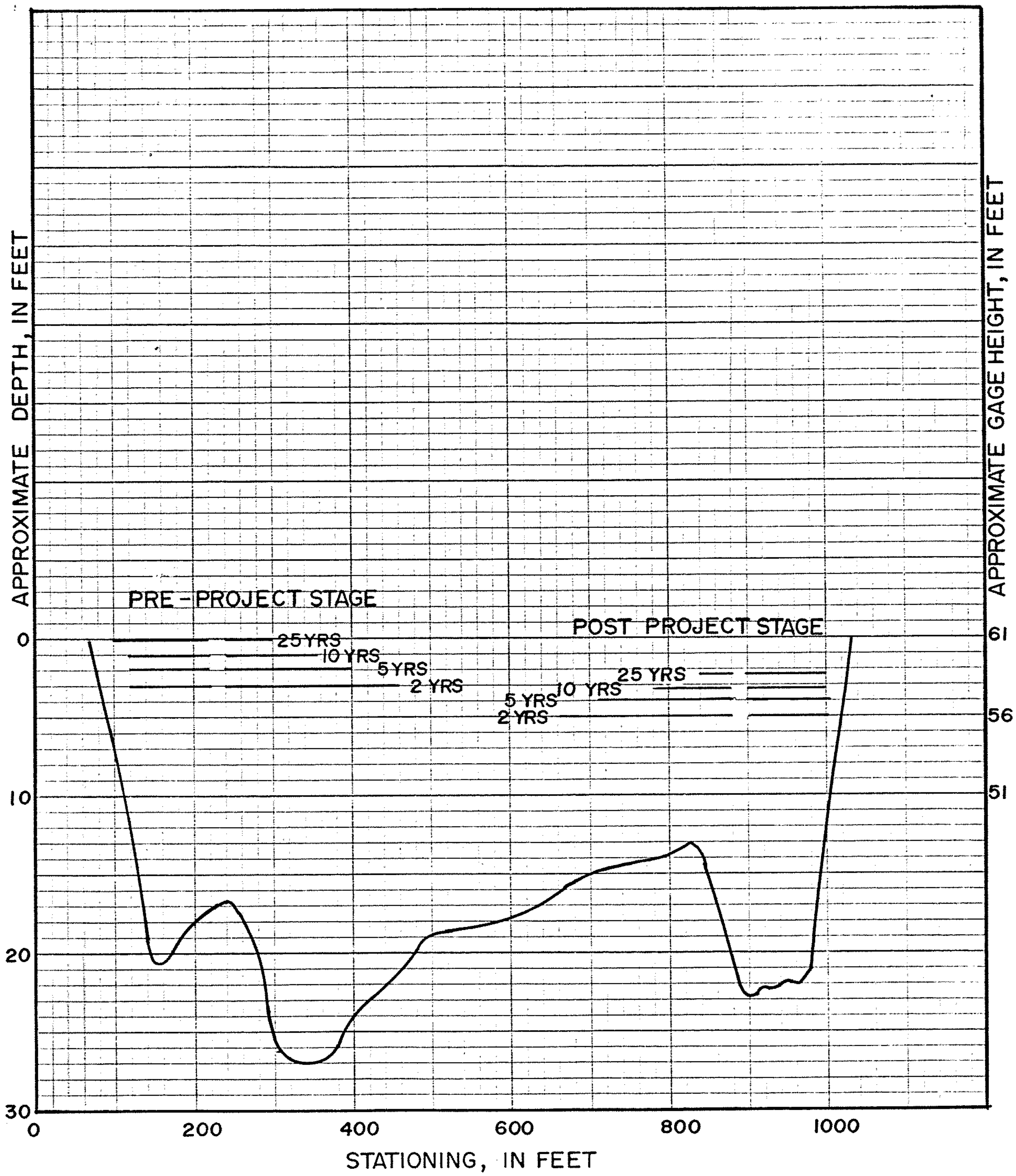
3.1



NOTE: BASED ON PRELIMINARY DATA, SUBJECT TO REVISION

SUSITNA RIVER AT SUNSHINE

R.I. yrs.	PREPROJECT Q cfs	PREPROJECT Stage (ft)	POST PROJECT Q cfs	POST PROJECT Stage (ft)
2	96,000	57.9	64,000	55.9
5	125,000	59.2	79,000	57.1
10	146,000	60.0	90,000	57.6
25	176,000	61.0	107,000	58.5

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SUSITNA RIVER AT SUNSHINE
PRE AND POST PROJECT
RIVER STAGE

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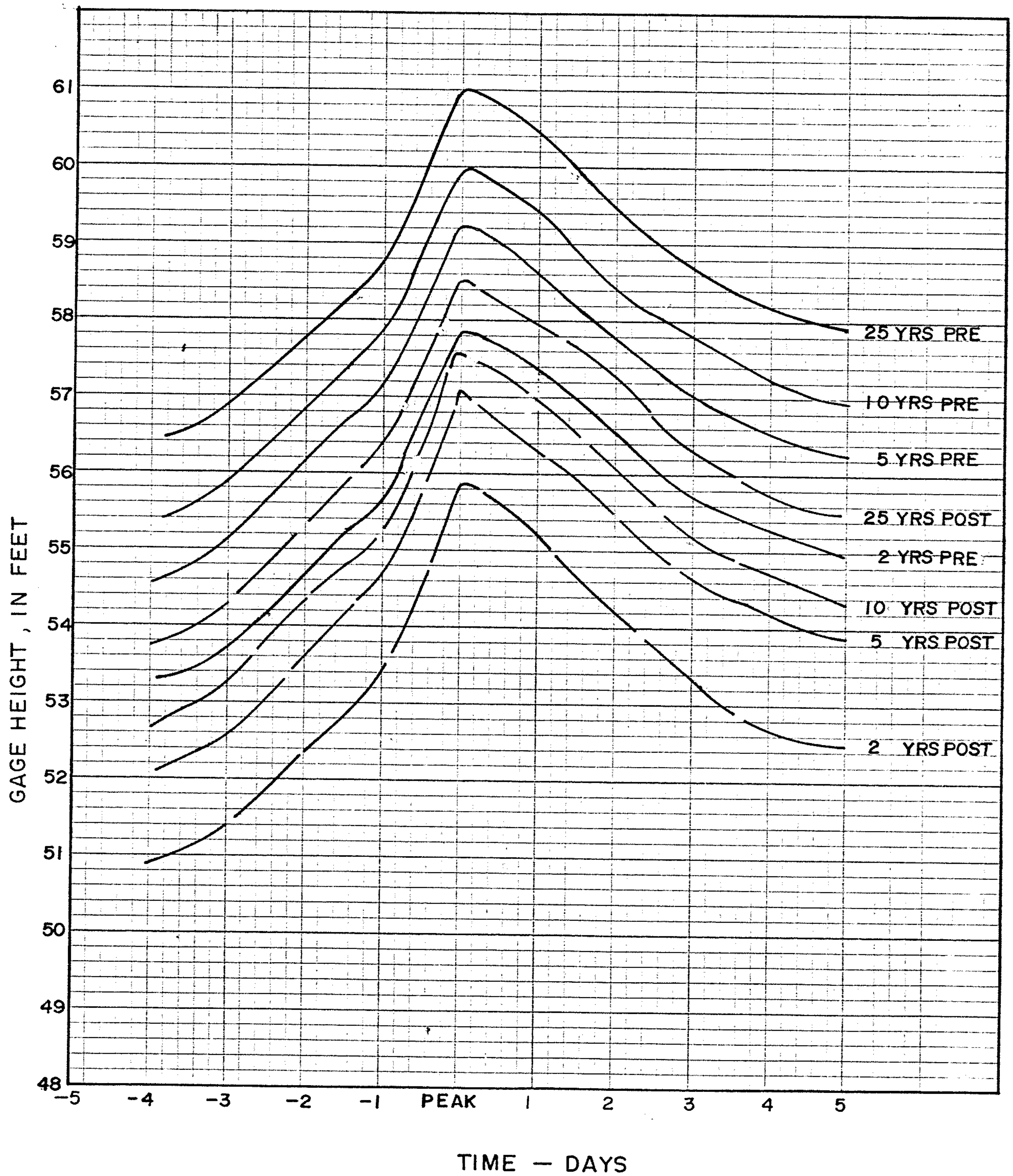
3.2



LEGEND: —— PRE PROJECT
– – POST PROJECT

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SUSITNA RIVER AT SUNSHINE
PRE AND POST PROJECT
FLOOD HYDROGRAPHS

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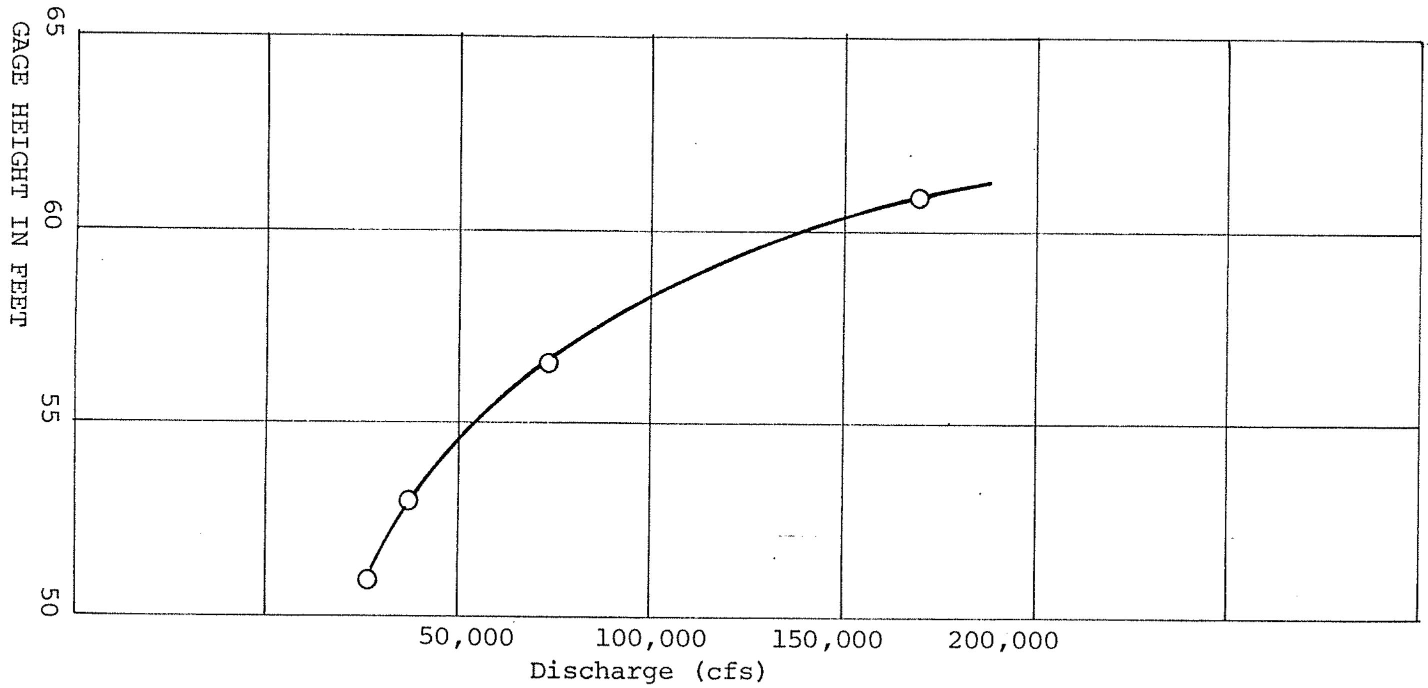
Notes:
1. Rating curve interpreted by R&M Consultants based on the following four discharge measurements made by U.S. Geological Survey.

Date	Gage Datum	Discharge (ft.^{3}/sec.)
May 27, 1971	52.9	37,400
July 2, 1971	56.6	64,600
August 11, 1971	60.8	171,000
October 4, 1977	51.0	27,400

2. Add 208.35 feet to correct gage height to mean sea level datum.

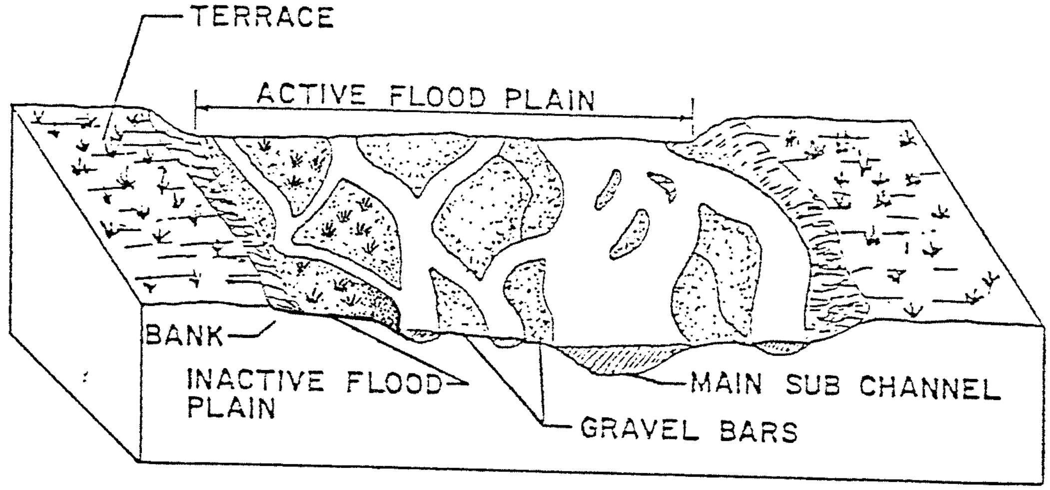


STAGE-DISCHARGE RELATIONSHIP
SUSITNA RIVER AT SUNSHINE
FIGURE 3.4

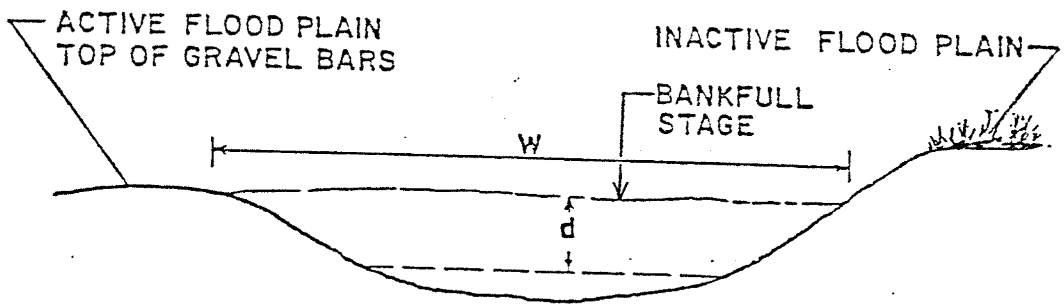
4 - SYNTHESIZED CROSS-SECTION AT DELTA ISLANDS

In order to compare pre and post-project flow conditions in the braided reaches of the Lower Susitna River, an example of the channel geometry is required. A representative section through a braided reach was selected 8,000 feet downstream of Willow Creek confluence. A reconnaissance field survey was carried out to define basic river geomorphic features such as channel widths, relative elevations between gravel bars and vegetated islands and ice surface elevations. With this basic data, it is possible to estimate channel hydraulic parameters utilizing regime theory or hydraulic geometry relationships for dominant discharges.

Dominant discharge refers to a discharge that occurs at regular intervals and shapes the river channel to accommodate it. The water level associated with dominant discharge is usually equivalent to a bankfull stage (close to incipient overflow onto the floodplain), and is commonly referred to as the mean annual flood (a flood that has a recurrence interval of 2 years). When the concept of dominant discharge in braided rivers is considered, the terms bankfull discharge and floodplains have a unique meaning. The geomorphic units of a typical braided river valley are shown on Figure 4.1. The terrace level is a remnant of a past geological deposition and it is not expected to be inundated by flood waters. From the terrace, the bank slopes down onto the inactive floodplain which is inundated only by rare floods. Old abandoned channels which normally supports a vegetative growth often scar the inactive floodplain. Braided active channels intertwine on the active floodplain with little or no vegetation existing on the active floodplain gravel bars. Active channel gravel bars have a roughly common horizontal maximum elevation when viewed in cross-section, which defines the bankfull stage.



GEOMORPHIC UNITS OF BRAIDED RIVERS



DEFINITION OF BANKFULL STAGE

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BRAIDED RIVER GEOMORPHIC UNITS

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4.1

Bankfull stage is illustrated in Figure 4.1. The top of the internal active channel gravel bar defines the bankfull stage which has a lower elevation than the inactive floodplain. The surface water width (W) is measured at incipient flooding of the bar and the hydraulic depth (d) is equal to the cross-sectional area (A) divided by W.

Bankfull discharge, as defined here, is believed to be the dominant discharge for braided rivers. As the discharge increases, flow and stage in the various sub-channels increase similar to single channel rivers, until the bankfull stage is reached. An additional increase in discharge does not significantly increase the river's stage because of a sudden increase in width of flow. A further increase in flow will result in gravel moving from bars into flow channels and subsequently change the channel network morphology.

Hydraulic geometry relationships were utilized to define the channel geometry for each sub-channel in the Delta Island cross-section. The following relationships were developed from field data collected in true braided rivers which have few or no intermediate vegetated islands (Drage & Carlson, 1977). Presence of vegetated banks tends to retard bank erosion and lateral migration, thereby deepening the channel in order to convey the flow, therefore upper limit mean hydraulic depths associated with channel widths was utilized in this study. This analysis is only an approximation which is suitable for making relative comparisons for problem identification.

$$d = 0.33\ W^{\frac{1}{2}} \quad \text{or} \quad W = 9\ d^2$$

$$d = 0.63\ d_{max} \quad \text{or} \quad d_{max} = 1.6\ d$$

$$W = 4.66\ Q_{bf}^{.47} \quad \text{or} \quad Q = \frac{W^{2.13}}{26.5}$$

$$A = Wd$$

where: d is the mean hydraulic depth (feet)

d_{max} is the maximum depth (feet) in a subchannel

Q_{bf} is the bankfull discharge (cfs)

A is the flow area at bankfull. (sq. ft.)

Utilizing the field measured river morphologic features of channel widths, miscellaneous channel depths, floodplain elevations and vegetative characteristics, in conjunction with these equations, hydraulic parameters for bankfull conditions were computed and are listed on Table 4.1. In viewing the cross-section shown on Figure 4.2, there is a common horizontal elevation at about 95 feet (assumed datum) that represents the top of gravel bars and was selected as bankfull elevation for the braided channels. Measuring the channel widths from the field survey, and utilizing air photos, 10 channels were anlayzed. The far west channel (No. 10) is the main subchannel and the far east channel (No. 1) is the second highest ranked subchannel. Intermediate channels are comprised of smaller braided subchannels and meandering single channels through the vegetated islands.

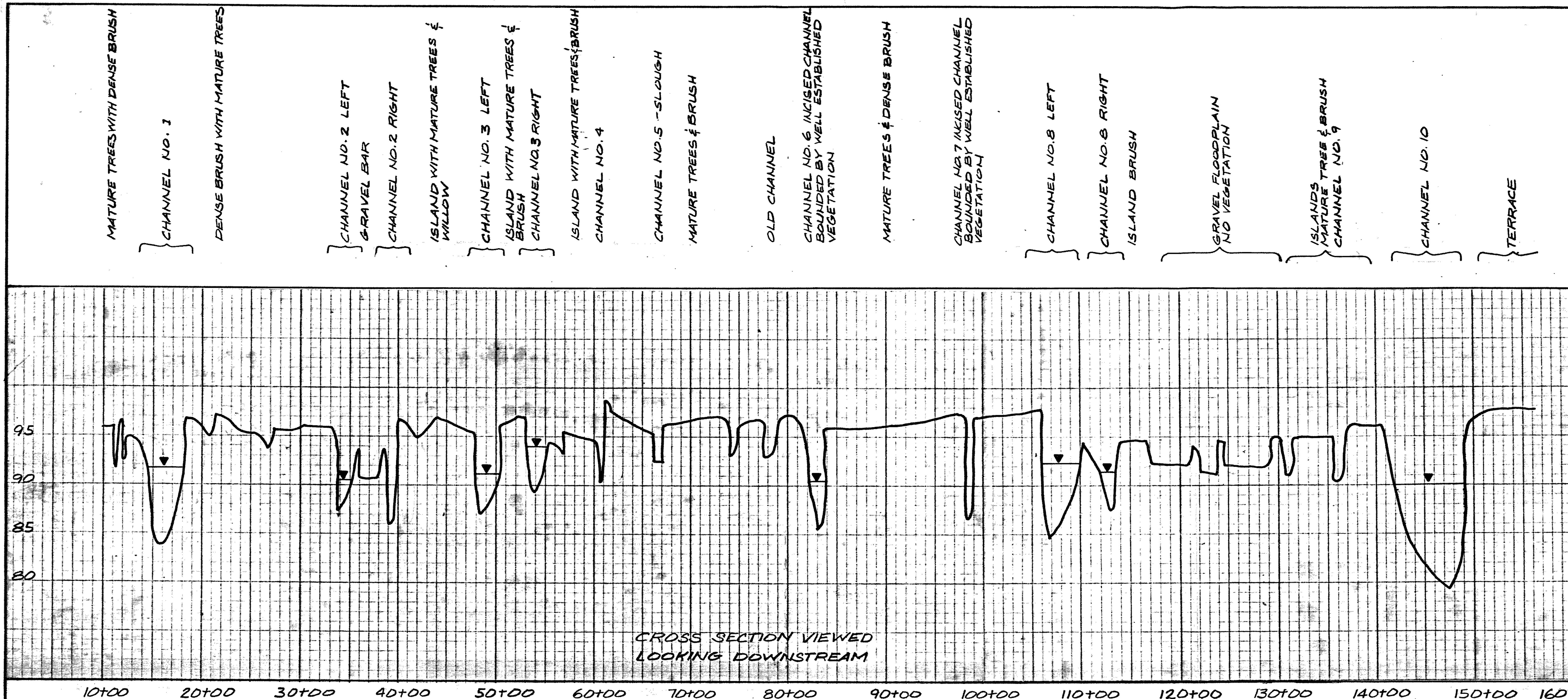
Summing the estimated discharge of each subchannel produced a total bankfull discharge of 115,600 cfs. Utilizing the basic assumption that the dominant discharge (bankfull conditions) is equivalent to the mean-annual flood (RI = 2 yrs.) we have developed one point on the frequency curve which can be related to stage for pre-project conditions. As a check on this procedure, the mean annual flood was determined from the Regional Flood Analysis shown on Figure 4.3. The two values correspond reasonably well, therefore, some support for the previous assumptions is provided.

As flows exceed bankfull discharge the water surface width increases very rapidly, and therefore, the stage rises at a slower rate with increasing discharges. Using the mean velocity as determined under bankfull conditions in conjuction with water widths and incrementing one foot at a time, a rough stage-discharge relationship was determined and is shown on Figure 4.4. A determination of relative changes in flows and stages at various floods from Figure 4.3 can be determined. Referencing the cross-section on Figure 4.2, the terrace level which supports mature trees is at an approximate elevation of 98 feet. This corresponds to a flood greater than a 50 year return interval, which seems reasonable.

TABLE 4.1

HYDRAULIC PARAMETERS
SYNTHESIZED CROSS-SECTION
DELTA ISLANDS
(8,000 Feet Downstream of Willow Creek Confluence)

Channel	Width (feet)	Mean Depth (feet)	Max. Depth (feet)	Area (sq. feet)	Q_{bf} (cfs)
1.	500	7.4	11.7	3,700	21,000
2. left	210	4.8	7.6	1,000	3,300
2. right	150	4.0	6.5	600	1,600
3. left	225	5.0	8.0	1,125	3,900
3. right	120	3.6	5.7	430	1,000
4.	90	3.0	4.8	270	600
5. slough					
6.	140	6.0	9.5	840	1,400
7.	70	5.0	8.0	350	300
8. left	400	6.6	10.4	2,640	13,100
8. right	220	4.9	7.8	1,080	3,600
9.	70	2.8	4.4	200	300
10.	850	9.6	15.3	8,160	65,500
			TOTAL		115,600 cfs



NOTE:

- ELEVATIONS BASED ON ASSUMED DATUM
- BANKFULL ELEVATION IS 95.0 FT.
- CROSS SECTION BASED ON RECONNAISSANCE FIELD SURVEY AND REGIME RELATIONSHIPS, ALL ELEVATIONS AND STATIONS APPROXIMATE
- ▼ INDICATES TOP ICE LEVEL ON MAR. 19, 1981
- CROSS SECTION LOCATED 8000' DOWNSTREAM OF WILLOW CREEK CONFLUENCE

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SUSITNA RIVER SYNTHESIZED CROSS SECTION DELTA ISLANDS

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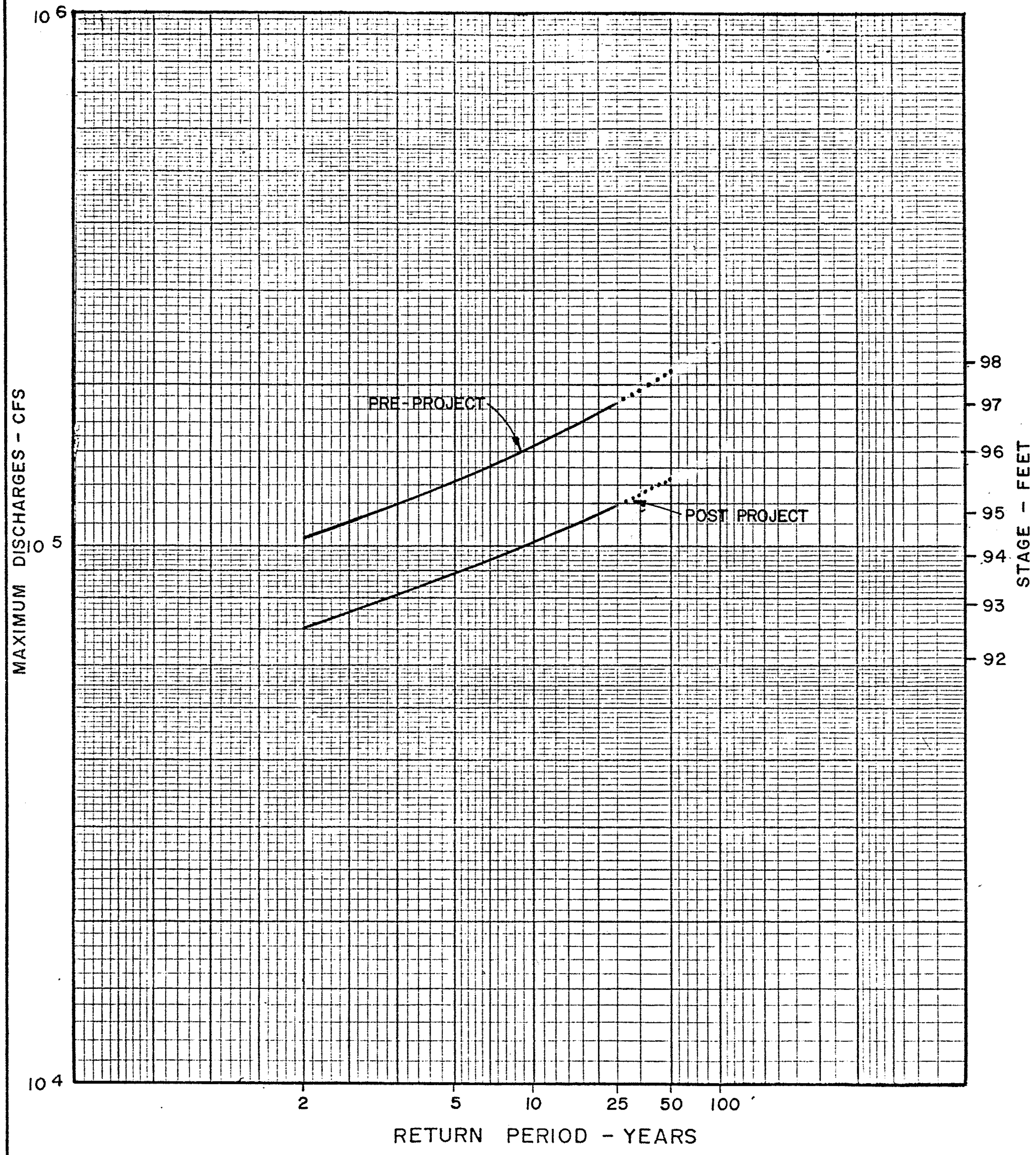

NOTE: BASED ON PRELIMINARY DATA, SUBJECT TO REVISION

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SUSITNA RIVER AT DELTA ISLANDS
PRE AND POST PROJECT
DISCHARGE-STAGE FREQUENCY CURVE

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4.3

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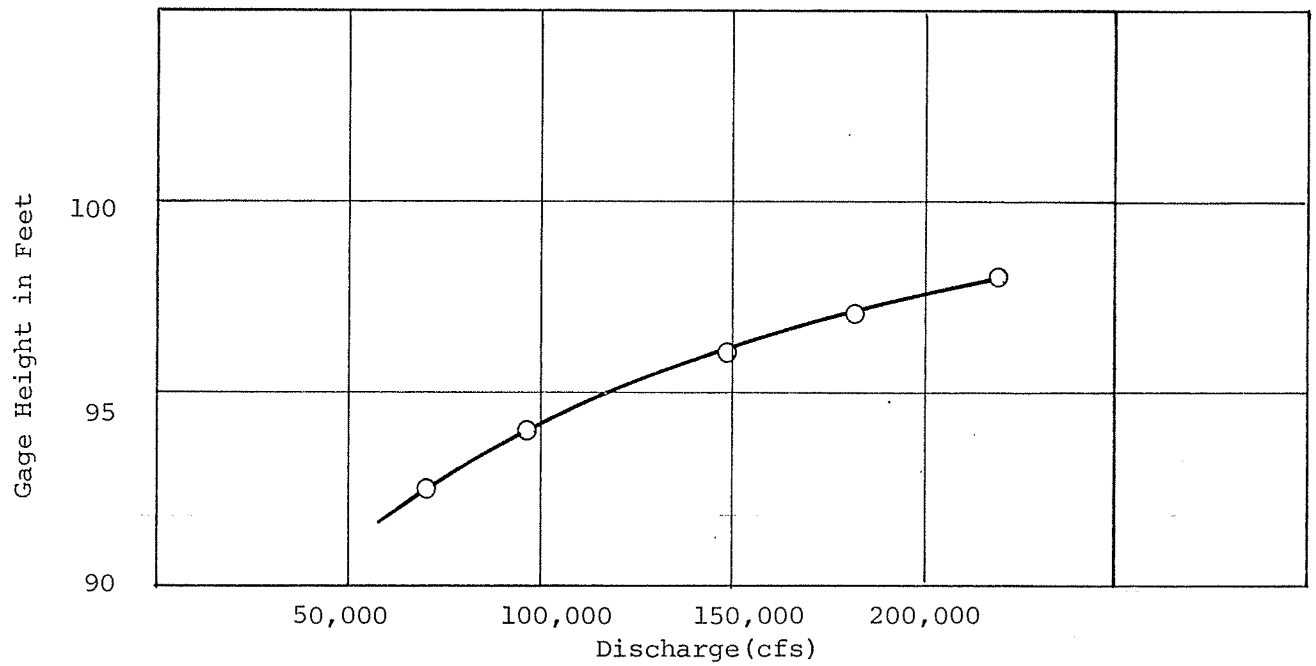


STAGE-DISCHARGE RELATIONSHIP
SUSITNA RIVER
DELTA ISLANDS CROSS SECTION
FIGURE 4.4

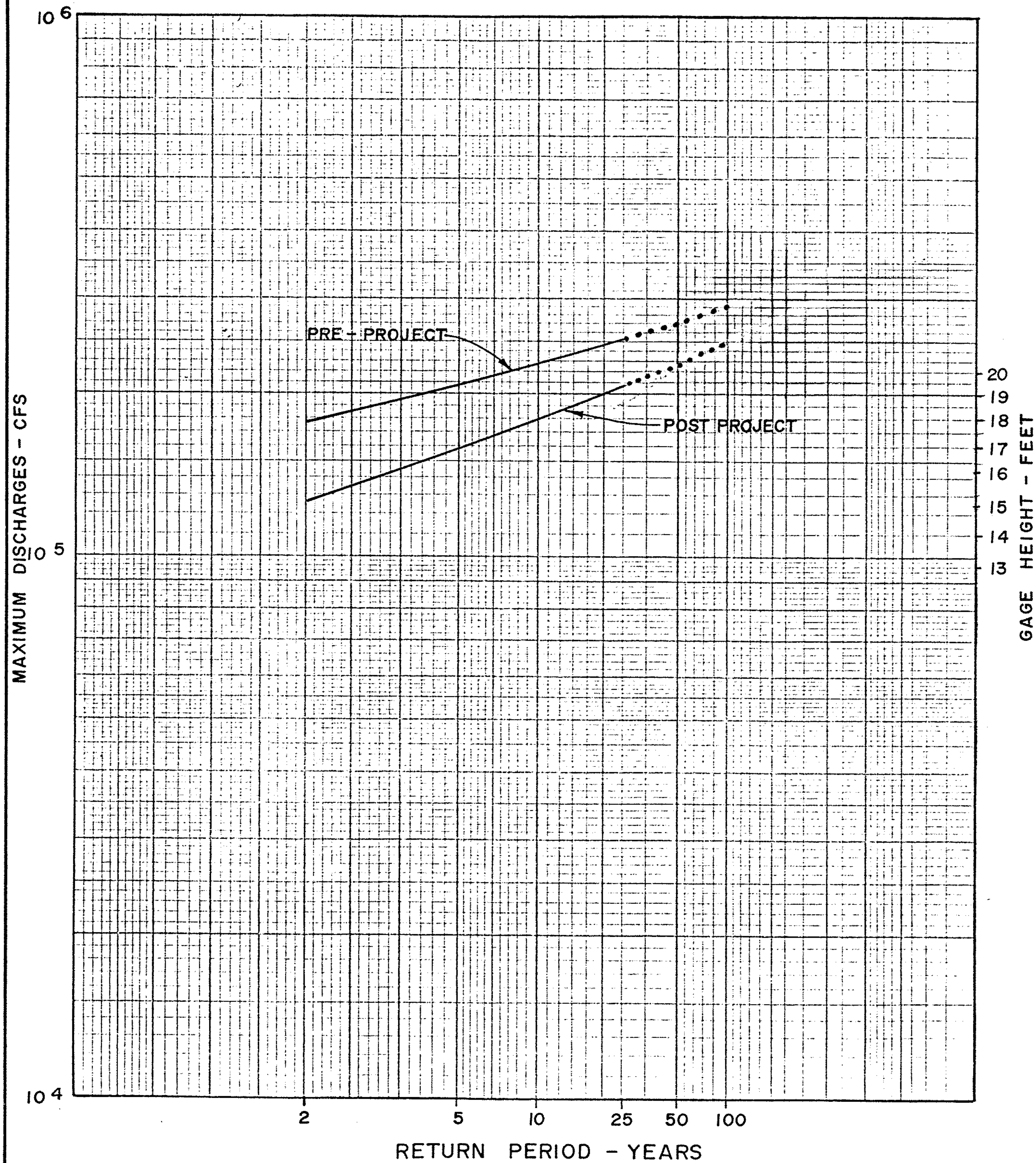
5 - ANALYSES AT SUSITNA STATION

Using available USGS stream flow records at this station, peaks and hydrograph shapes were synthesized for floods of different return periods. Post-project peaks were estimated in a manner similar to those at Sunshine Station.

Figure 5.1 presents estimated flood peaks for pre and post-project conditions. Using these, it is possible to estimate the effect of the project on recurrence of flood peaks and corresponding inundation. The results are also superimposed on the river cross-section on Figure 5.2, with the pre-project stages plotted on the left and post-project on the right.

Flood hydrograph shapes are presented on Figure 5.3, which can be used to determine duration of inundation under various flooding conditions.

Figure 5.4 presents a stage discharge relationship that was developed from USGS measurements at there continuous gaging station. Gage heights can be referenced to the cross section on Figure 5.2 and frequency curve on Figure 5.1.



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SUSITNA RIVER AT SUSITNA STATION
PRE AND POST PROJECT
DISCHARGE - STAGE FREQUENCY CURVE

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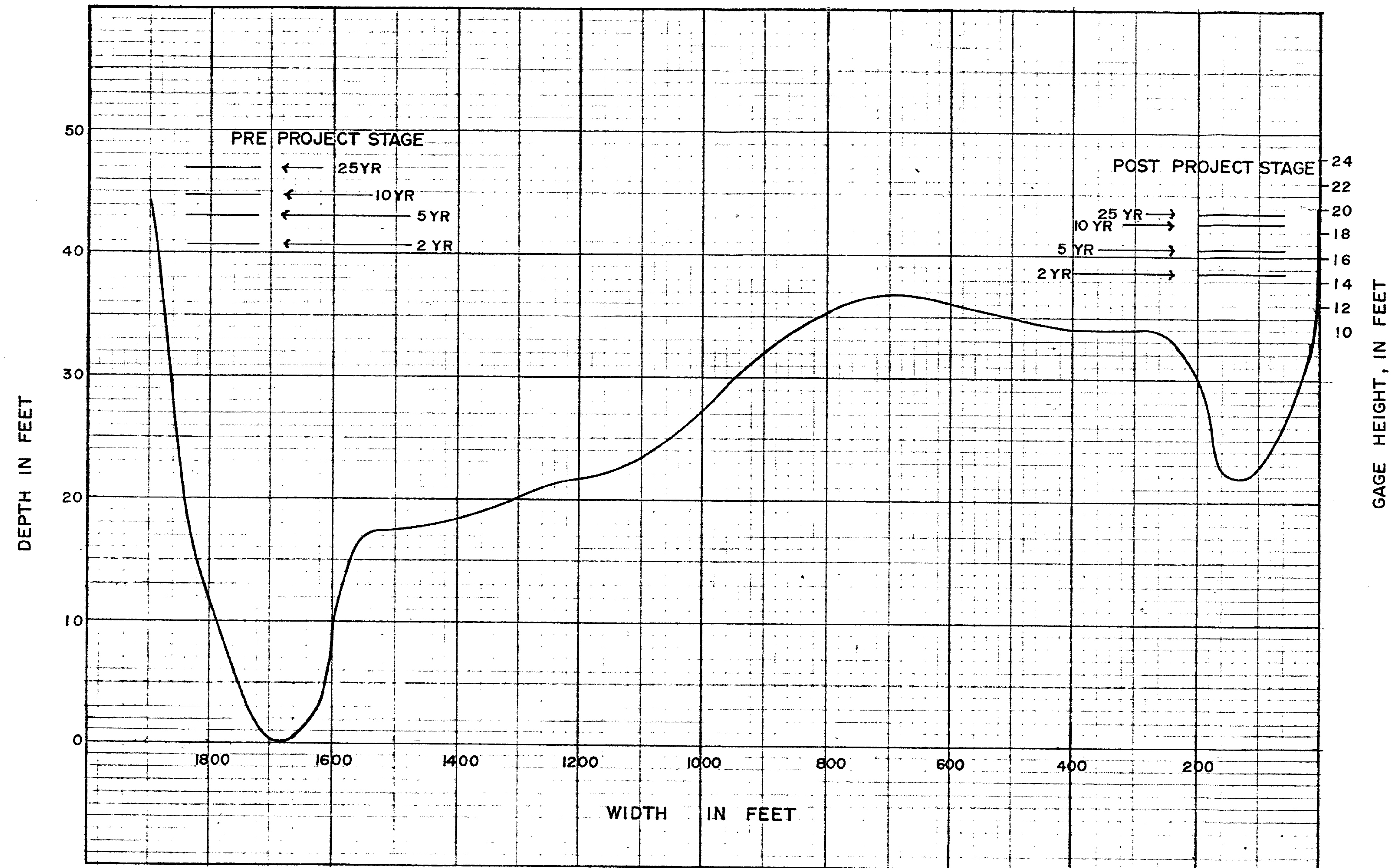
5.1



SUSITNA RIVER AT SUSITNA STATION

	PREPROJECT Q (cfs)	PREPROJECT Stage (ft)	POST PROJECT Q (cfs)	POST PROJECT Stage (ft)
2	157,000	16.8	125,000	14.9
5	204,000	19.1	158,000	16.8
10	239,000	20.5	183,000	18.1
25	289,000	23.0	220,000	19.8

NOTE: BASED ON PRELIMINARY DATA, SUBJECT TO REVISION

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SUSITNA RIVER AT SUSITNA STATION

PRE AND POST PROJECT RIVER STAGE

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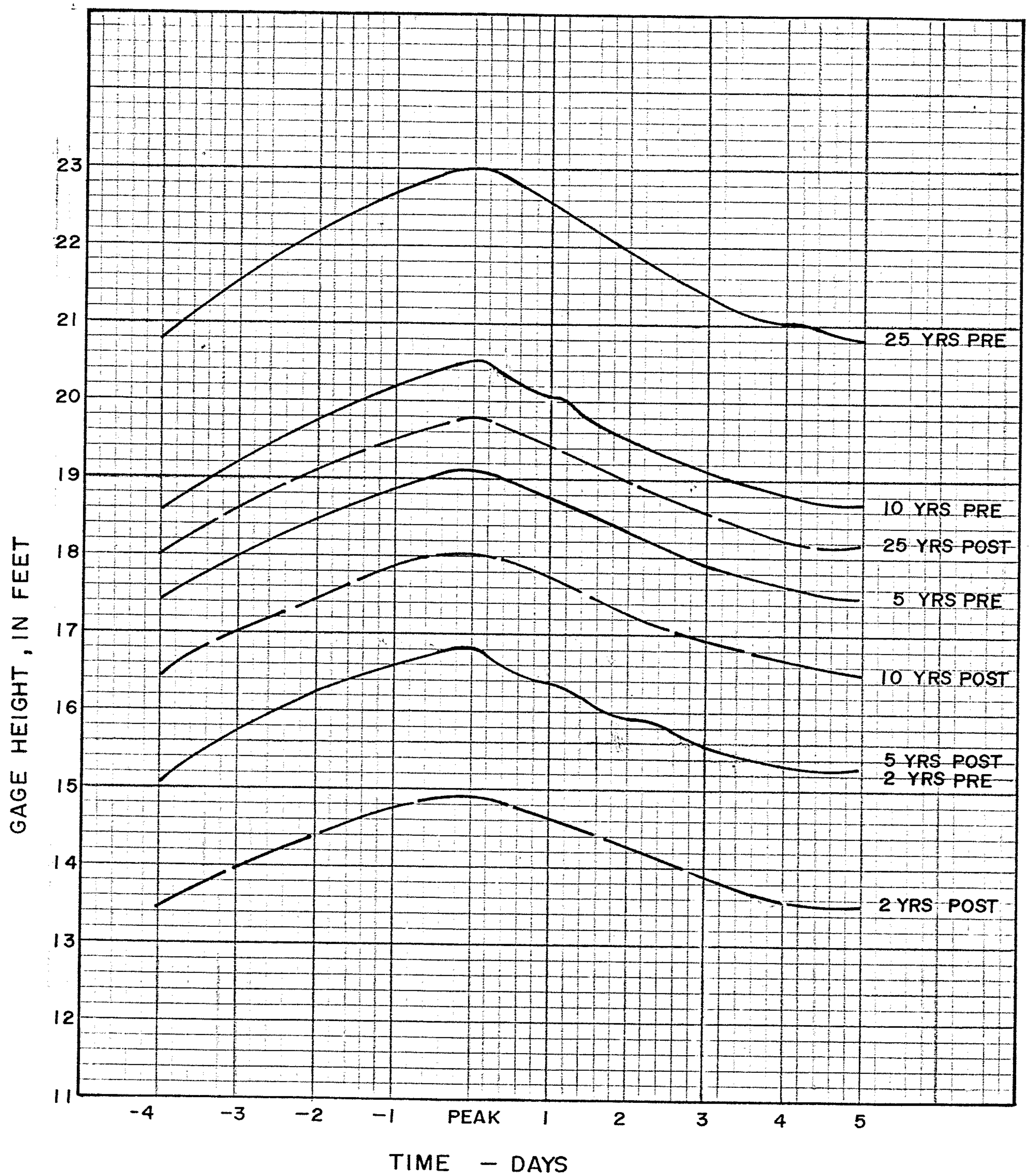

LEGEND —— PRE PROJECT

– – POST PROJECT

NOTE: BASED ON PRELIMINARY DATA, SUBJECT TO REVISION

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SUSITNA HYDROELECTRIC PROJECT

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PRE AND POST PROJECT
FLOOD HYDROGRAPHS

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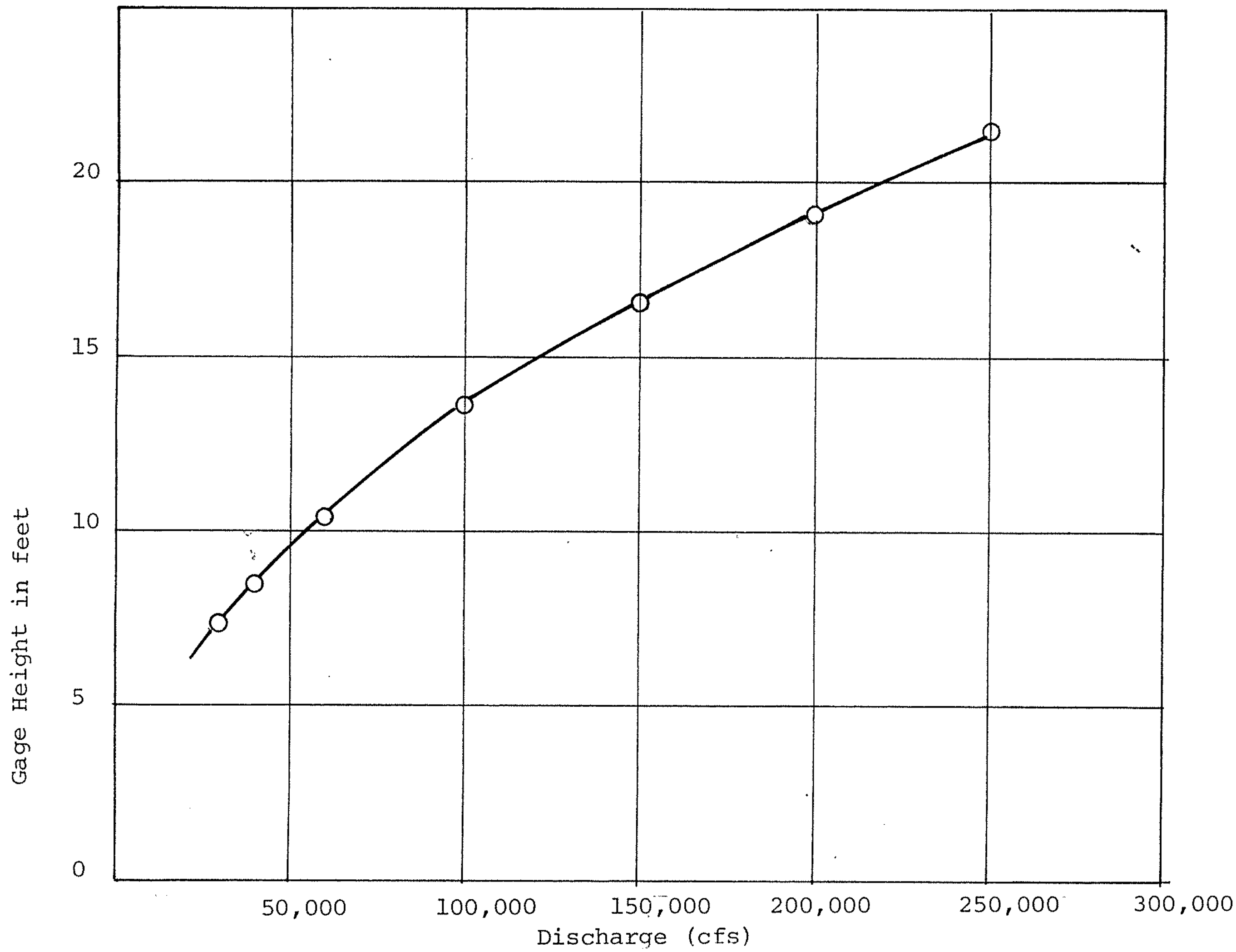
5.3



STAGE-DISCHARGE RELATIONSHIP
SUSITNA RIVER AT SUSITNA STATION
FIGURE 5.4

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6 - LOWER SUSITNA RIVER BASIN CHARACTERISTICS

As part of Subtask 3.05 - Flood Studies, a regional equation was developed to determine mean annual flood flows based on basin characteristics.

A forward steeping multiple linear regression computer program was utilized. Twelve watershed parameters were considered, including: drainage area, main channel slope, stream length, mean basin elevation, area of lakes and ponds, area of forests, area of glaciers, mean annual precipitation, precipitation intensity, mean annual snowfall, and mean minimum January temperature. The most influential parameters in predicting the mean annual instantaneous peak flow are drainage area, stream length, area of glaciers, mean annual precipitation, and mean annual snowfall.

The resulting equation was selected as being the most representative for determining the mean annual instantaneous peak flow:

$$Q = 7.06\,(D.A.) + 46.36\,(L) + 697.14\,(E) + 200.15\,(MAP) - 49.55\,(MAS) - 2594.44$$

Where:

D.A.	=	Drainage Area (mi^2)
L	=	Stream Length (mi)
E	=	Mean Basin Elevation (ft)
MAP	=	Mean Annual Precipitation (in)
MAS	=	Mean Annual Snowfall (in)

Table 6.1 lists a summary of basin characteristics at various locations along the lower Susitna River that were used in this study to determine flood flows. It is interesting to note the variance that exists within the Susitna basin. For example, the two major western tributaries, Chulitna and Yentna Rivers, have the highest percentage of glacial area. Susitna River at Gold Creek has the lowest percentage of forested area. Table 6.1 is a good reference for general comparison of basin characteristics.

misc6/p1

TABLE 6.1
LOWER SUSITNA RIVER BASIN CHARACTERISTICS
FOR MEAN ANNUAL FLOOD CALCULATIONS

	Drainage Area D.A. ($mi.^2$)	Glacial Area G (%)	Forested Area F (%)	Lake Area LP (%)	Mean Annual Precipitation M.A.P. (in.)	Mean Annual Snowfall M.A.S. (in.)	Mean Minimum January Temp. J (°F.)	Stream Length L (mi.)
Susitna River at Susitna Station	19,400	12	23	2	43	167	-4	301
Local Area: Susitna Station to Delta Islands x-section	640	1	60	5	30	70	0	-
Skwentna River nr. Skwentna	2,250	16	34	5	43	140	-5	98
Yentna River nr. Susitna Station	3,930	20	12	4	50	150	-5	-
Delta Islands x-section	12,580	9	23	1	41	182	-3	281
Local Area: Delta Islands x-section to Sunshine	1,080	1	60	5	30	70	0	-
Susitna River at Sunshine	11,500	10	19	1	42	193	-4	224
Local Area: Sunshine to Talkeetna	764	0	90	2	30	50	0	-
Chulitna River Talkeetna	2,570	27	22	1	55	250	-5	87
Talkeetna River nr. Talkeetna	2,006	7	25	0	70	150	-2	90
Susitna River at Gold Creek	6,160	5	7	1	29	200	-4	189
Local Area: Gold Creek to Devils Canyon	350	0	-	0	20	-	0	-
Devils Canyon	5,810	5	7	1	29	200	-4	-

REFERENCES

Drage, B.T. and Carlson R.F. May 1977. "Hydraulic Geometry Relationships for Northern Braided River", Proceedings of Third National Hydrotechnical Conference, Canadian Society for Civil Engineering.

APPENDIX A

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ENGINEERS
GEOLOGISTS
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January 30, 1981

R&M No. 052310

Project Manager
Susitna Hydroelectric Project
Acres American Incorporated
Liberty Bank Building
Main @ Court
Buffalo, New York 14202

Attention: Dr. Ian Hutchison

Re: Subtask 3.10, Lower River Studies, Flow Regime

Dear Ian:

Based on the regulated flows received from your office January 16, 1981 we have tabulated and plotted the probable mean monthly change in stage expected on the Susitna River below the project.

In table I are the flows and change of stage expected with Watana Dam, and table II is both Watana Dam and Devils Canyon Dams. In addition, to help illustrate the data in the two tables, the mean monthly discharge and stage hydrographs are enclosed. These hydrographs indicate the preliminary estimates of change that can be expected at the three gaging sites on the Susitna River, located at Gold Creek, Sunshine and Susitna Station.

Hopefully this information will assist in quantifying the possible effects caused by regulation in those areas of concern on the Lower Susitna River. If you have any questions or comments concerning the enclosed information, please contact me or Bob Butera.

Very truly yours,

R&M CONSULTANTS, INC.

Tim Renschler

Tim Renschler
Senior Hydrologist

TR/jjxj

Telecopy to [illegible]

March 4, 1981
P5700.11

Mr. Eric Yould
Executive Director
Alaska Power Authority
333 West 4th Avenue
Suite 31
Anchorage, AK 99501

Dear Eric:

Susitna Hydroelectric Project
Subtask 3.10 - Lower Susitna Studies

On February 23, 1981, we sent you a copy of R&M Consultant's letter of January 30, 1981, addressed to us on the flow regime in the lower Susitna under natural and regulated flow conditions.

The estimated water levels shown in the tables attached to the above letter are applicable only for the open-water season (end-May through mid-October). For periods with ice-cover in the river, there are no established rating curves. Furthermore, for winter conditions, it is expected that the discharge and timing of ice-cover formation after regulation will be different from current natural conditions. Studies have not progressed sufficiently to calculate precise level changes under ice conditions, but the order of changes in levels will be similar, in general, to those calculated with open-water rating curves.

During the winter, river stages, both under natural and regulated flows, will be higher than noted in these tables due to the presence of ice-cover. Please ensure that the numbers in the tables are interpreted correctly as described in this letter.

Yours truly,

John W. Hayden
Technical Study Director

GK:db

Attachments

cc J. Douma
S. Leopold
T. Trent (ADF&G)
W. Trihey
TES

TABLE I

WATANA DAM ONLY
PRELIMINARY ESTIMATES OF DOWNSTREAM STAGE CHANGES

	Susitna River at Gold Creek					Susitna River at Sunshine					Susitna River at Susitna Station				
	Preproject		Post Project			Preproject		Post Project			Preproject		Post Project		
	Q (cfs)	Stage (ft)	Q (cfs)	Stage (ft)	Change In Stage (feet)	Q (cfs)	Stage (ft)	Q (cfs)	Stage (ft)	Change In Stage (feet)	Q (cfs)	Stage (ft)	Q (cfs)	Stage (ft)	Change In Stag (feet
Oct.	5,639	6.5	8,224	7.3	+0.8	13,690	47.5	16,275	48.3	+0.8	30,050	7.3	32,639	7.6	+0.3
Nov.	2,467	4.6	8,276	7.4	+2.8	5,829	44.5*	11,638	46.7	+2.2	12,660	5.1*	18,467	5.8*	+0.7
Dec.	1,773	3.6	8,617	7.5	+3.9	4,199	43.8*	11,043	46.5	+2.7	8,210	4.3*	15,058	5.4*	+1.1
Jan.	1,453	3.0*	8,302	7.4	+4.4	3,498	43.4*	9,180	45.7	+2.3	7,905	4.3*	14,754	5.4*	+1.1
Feb.	1,235	2.5*	7,588	7.1	+4.6	2,952	43.1*	9,305	45.8	+2.7	7,040	4.2*	13,390	5.2*	+1.0
Mar.	1,114	2.2*	6,613	6.8	+4.6	2,631	43.0*	8,130	45.3	+2.3	6,320	4.1*	11,819	5.1*	+1.0
Apr.	1,367	2.7*	5,522	6.4	+3.7	3,177	43.2*	7,359	44.9	+1.7	6,980	4.2*	11,133	5.0*	+0.8
May	13,316	8.7	7,374	7.1	-1.6	27,717	51.1	21,775	49.6	-1.5	60,460	10.3	54,520	9.8	-0.5
June	27,927	11.1	9,186	7.6	-3.5	64,198	55.9	45,457	54.1	-1.8	123,700	14.9	104,956	13.7	-1.2
July	23,853	10.5	13,183	8.6	-1.9	63,178	55.8	52,508	54.8	-1.0	131,930	15.3	121,261	14.7	-0.5
Aug.	21,478	10.2	18,874	9.7	-0.5	55,900	55.1	53,296	54.9	-0.2	110,840	14.0	108,236	13.9	-0.1
Sept.	13,171	8.6	13,036	8.6	0.0	32,304	52.1	32,168	52.0	-0.1	65,963	10.8	85,827	10.8	0.0

* No stage discharge relationship available for winter months. Estimates based on extrapolation of rating curve to low flows

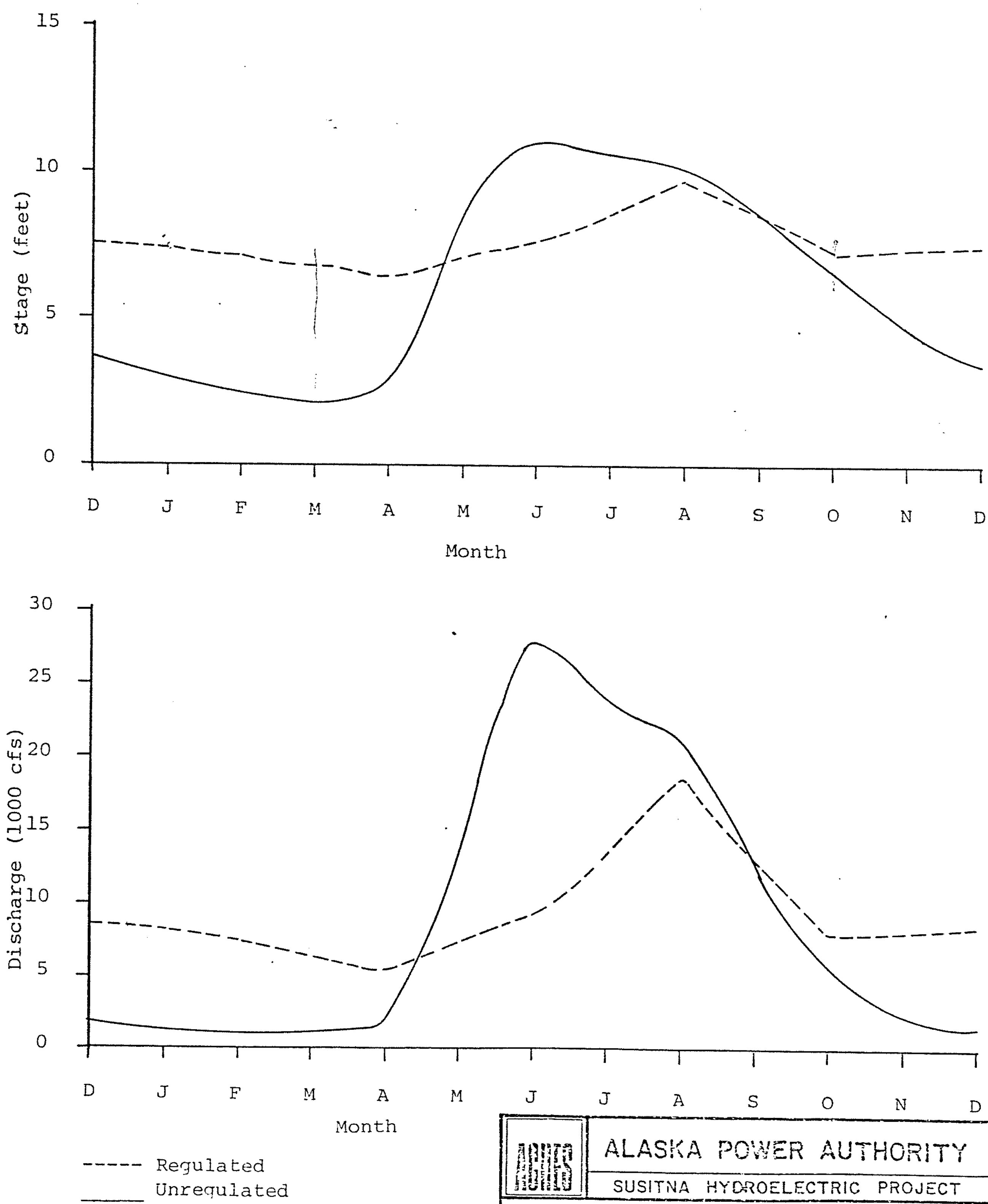
TABLE II

WATANA & DEVILS CANYON DAM
PRELIMINARY ESTIMATES OF DOWNSTREAM STAGE CHANGES

	Susitna River at Gold Creek					Susitna River at Sunshine					Susitna River at Susitna Station				
	Preproject		Post Project		Change In Stage (feet)	Preproject		Post Project		Change In Stage (feet)	Preproject		Post Project		Change In Stag (feet
	Q (cfs)	Stage (ft)	Q (cfs)	Stage (ft)		Q (cfs)	Stage (ft)	Q (cfs)	Stage (ft)		Q (cfs)	Stage (ft)	Q (cfs)	Stage (ft)	
Oct.	5,639	6.5	8,186	7.3	+0.8	13,690	47.5	16,237	48.2	+0.7	30,050	7.3	32,602	7.6	+0.3
Nov.	2,467	4.6	8,818	7.5	+2.9	5,829	44.5*	12,180	46.9	+2.3	12,660	5.1*	19,009	5.9*	+0.8
Dec.	1,773	3.6	9,251	7.6	+4.0	4,199	43.8*	11,677	46.7	+2.9	8,210	4.3*	15,692	5.5*	+1.2
Jan.	1,453	3.0*	8,522	7.4	+4.4	3,498	43.4*	10,567	46.3	+2.9	7,905	4.3*	14,975	5.4*	+1.1
Feb.	1,235	2.5*	9,008	7.6	+5.0	2,952	43.1*	10,724	46.4	+3.3	7,040	4.2*	14,809	5.4*	+1.2
Mar.	1,114	2.2*	7,478	7.1	+4.9	2,631	43.0*	11,063	46.6	+3.6	6,320	4.1*	14,752	5.4*	+1.3
Apr.	1,367	2.7*	6,629	6.8	+4.1	3,177	43.2*	8,438	45.5	+3.3	6,980	4.2*	12,240	5.1*	+0.9
May	13,316	8.7	8,690	7.5	-1.2	27,717	51.1	23,090	50.0	-1.1	60,460	10.3	55,836	9.9	-0.4
June	27,927	11.1	10,411	8.0	-3.1	64,198	55.9	46,681	54.2	-1.7	123,700	14.9	106,181	13.8	-1.1
July	23,853	10.5	10,052	7.9	-2.6	63,178	55.8	49,377	54.5	-1.3	131,930	15.3	118,131	14.5	-0.8
Aug.	21,478	10.2	15,088	9.0	-1.2	55,900	55.1	49,509	54.5	-0.6	110,840	14.0	104,450	13.6	-0.4
Sept.	13,171	8.6	12,666	8.5	-0.1	32,304	52.1	31,799	51.9	-0.2	65,963	10.8	65,458	10.8	0.0

* No stage discharge relationship available for winter months. Estimates based on extrapolation of rating curve to low flows

SUSITNA RIVER AT GOLD CREEK



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MEAN MONTHLY
Lower Susitna River
Discharges & stages
Watana Dam Only

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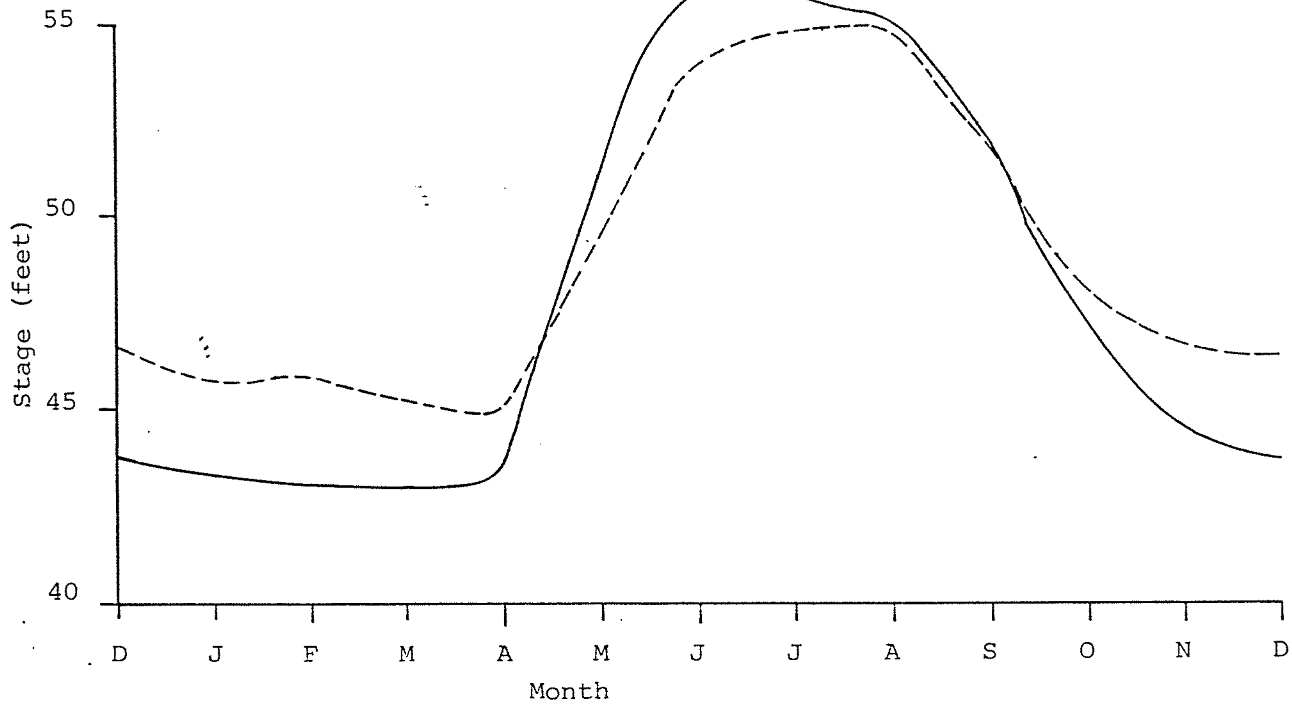
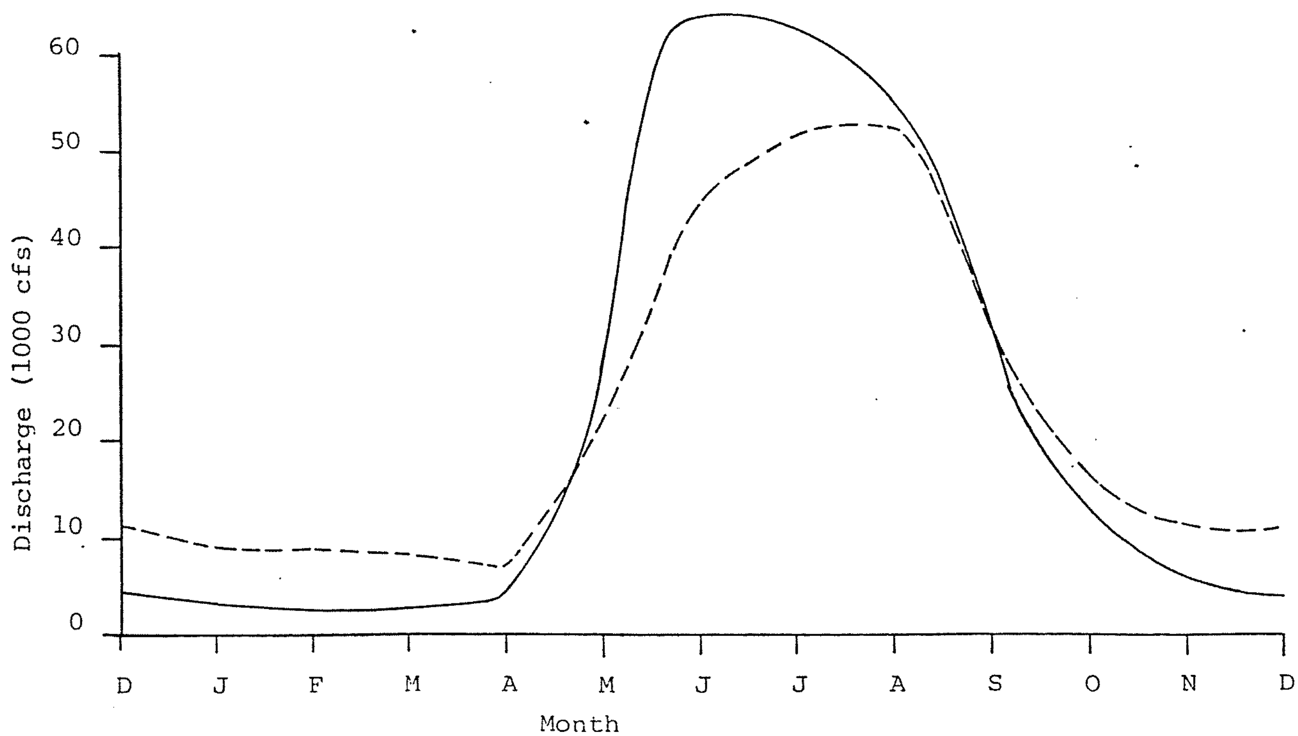
Jan. 28, 1981

SUSITNA RIVER AT SUNSHINE





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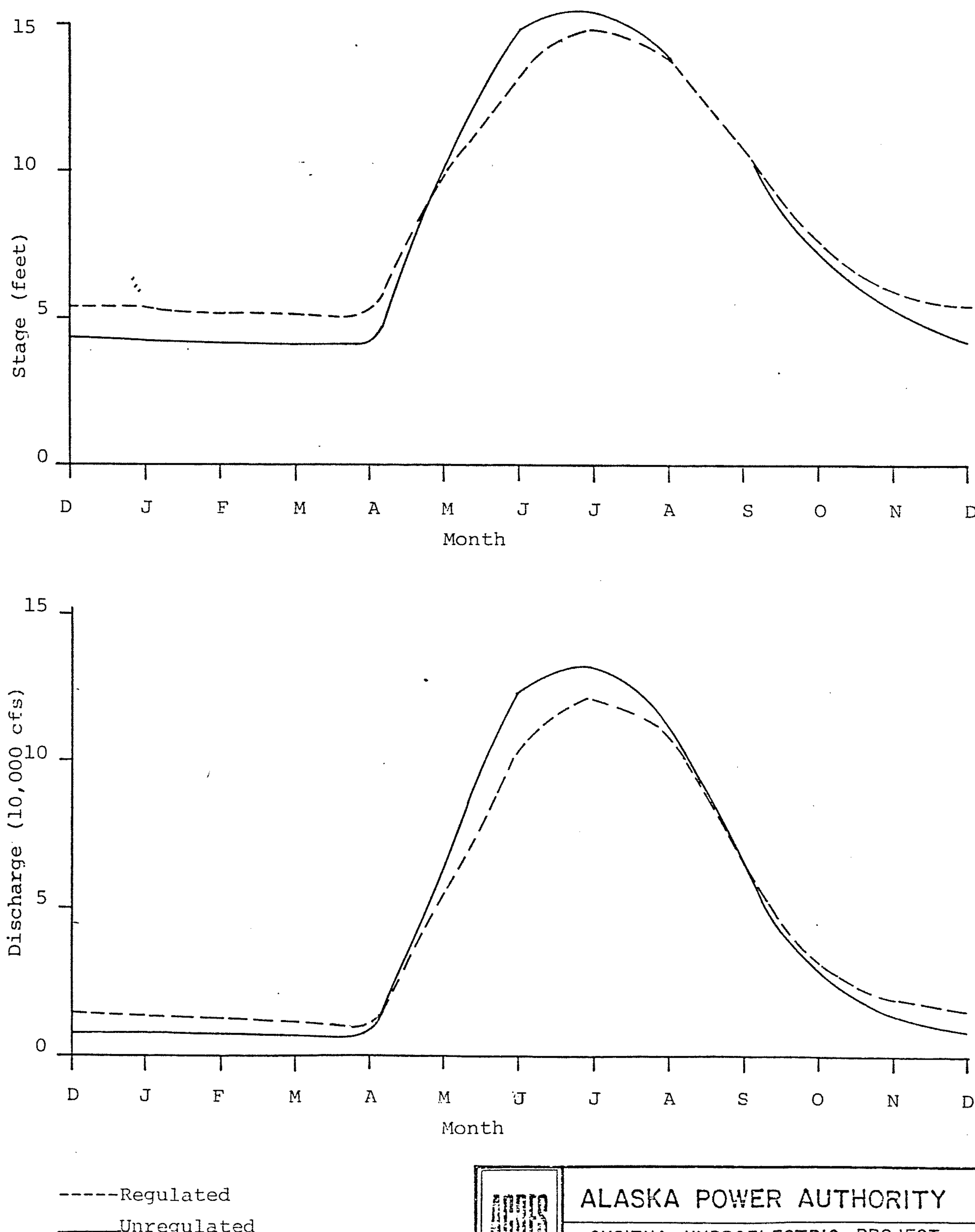
SUSITNA RIVER AT SUSITNA STATION



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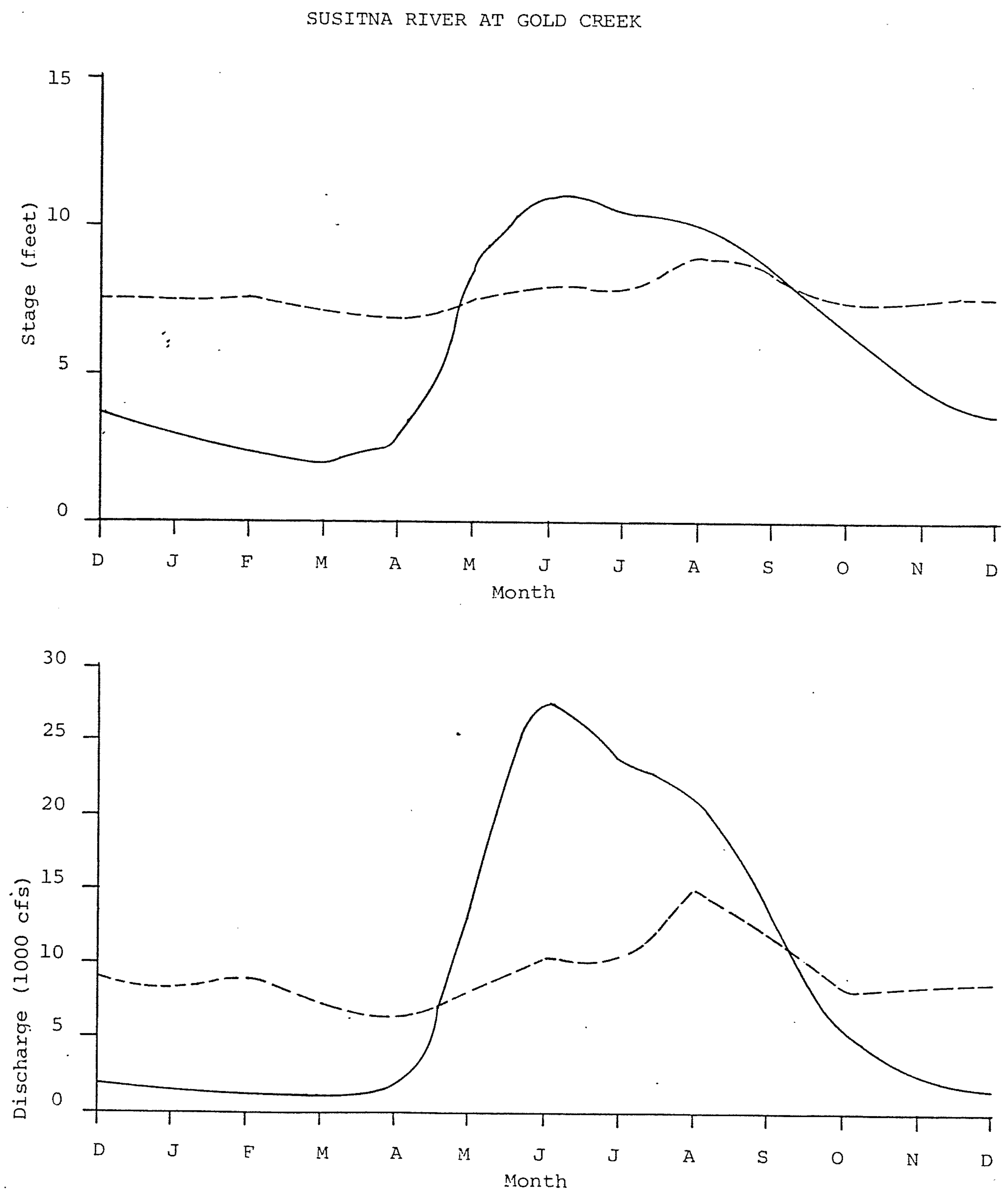

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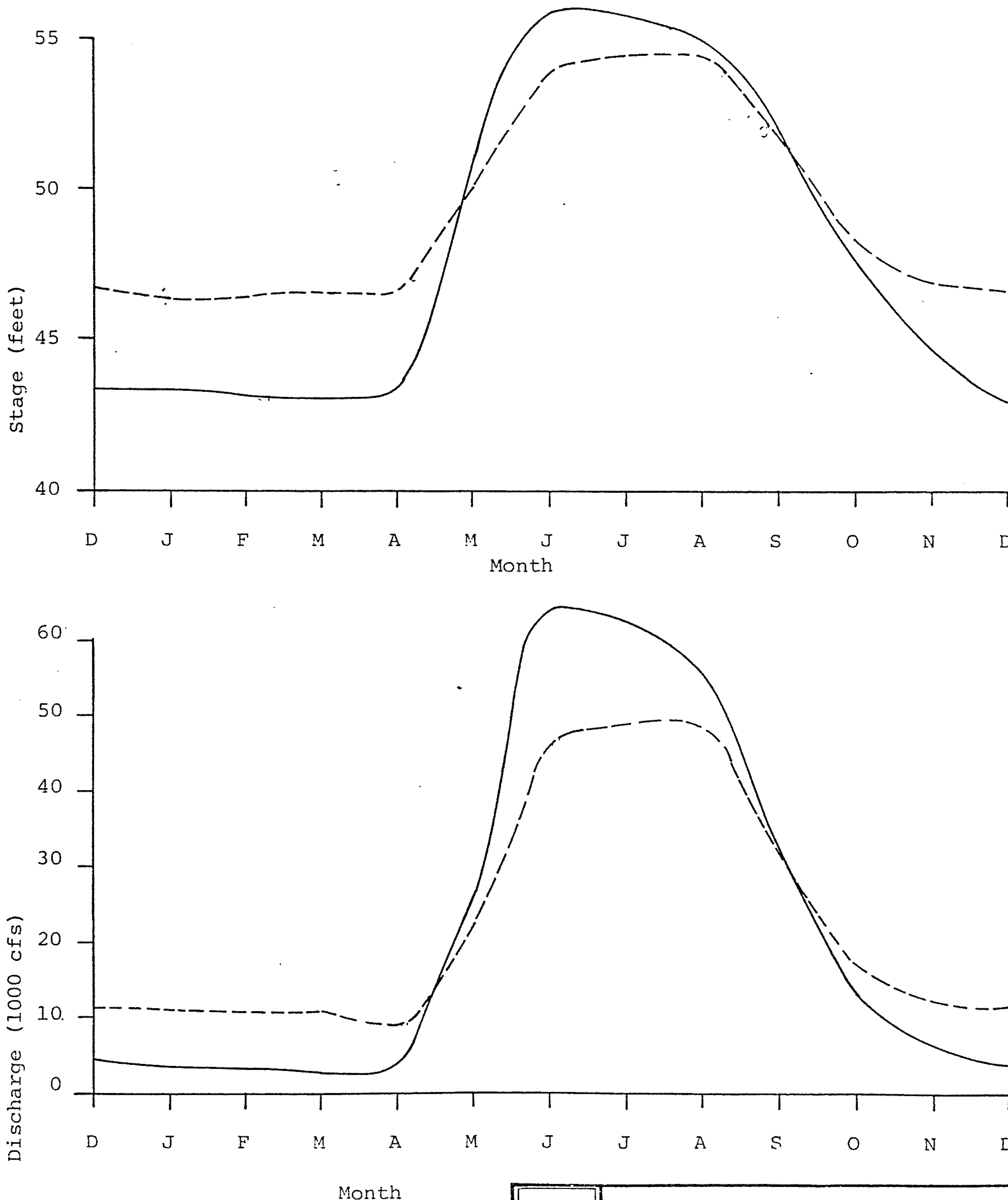
SUSITNA RIVER AT SUNSHINE



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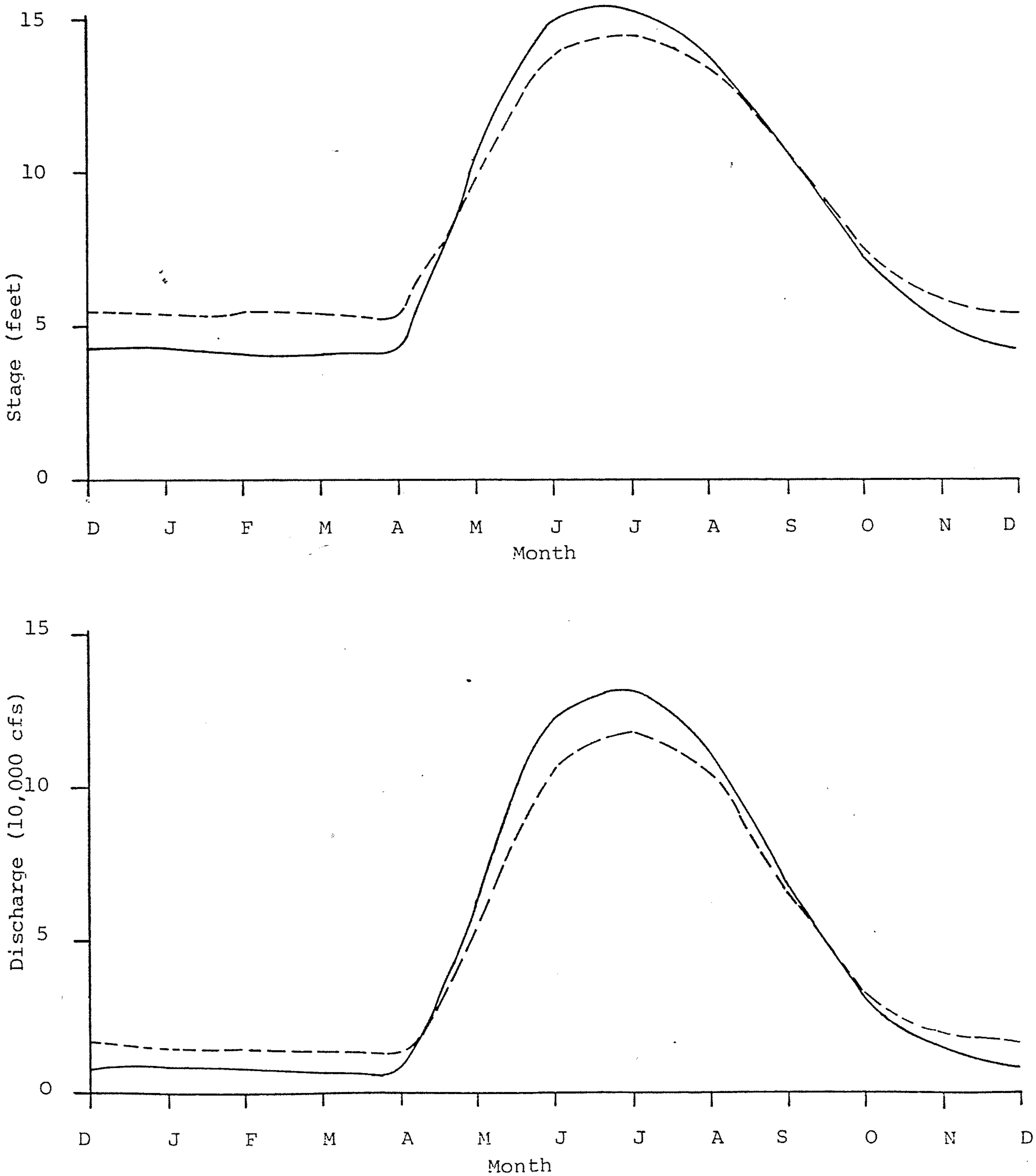

------Regulated
______Unregulated

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