EFFECTS OF SEASONABILITY AND VARIABILITY

OF STREAMFLOW ON NEARSHORE COASTAL AREAS

(final report)

Effects of seasonability adn variability of streamflow on nearshore coastal areas
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FINAL REPORT

I. SUMMARY OF OBJECTIVES WITH RESPECT TO OCS OIL AND GAS DEVELOPMENT

An understanding of the seasonability and variability of streamflow is of considerable engineering importance to the imminent oil and gas development in nearshore coastal areas. Streamflow variability, effects of seasonal ice, sediment characteristics, and ice-jam flooding all have considerable impact on nearshore and estuarine areas. This is especially so in areas where sea-ice remains intact after the initiation of river break-up. This phenomenon occurs in nearly all rivers and streams in the North Bering, Chukchi, and Beaufort Seas, and is attributable to the extensive shorefast ice formed annually in these areas. The estuarine and shorefast areas are presently being developed and leased and this development is likely to continue throughout the Outer Continental Shelf (OCS) program. An analysis of the annual seasonability of streamflow, expected break-up data, expected freeze-up data, and sediment characteristics are all necessary information to ensure safe and efficient offshore development.

However, the higher precipitation and comparatively reduced effects of offshore ice on the coast of the Gulf of Alaska, together with the sparseness of available data, have made it necessary to establish indices of seasonability and variability to allow for extrapolation to ungaged streams in order to estimate streamflow variation and spring flooding.

II. INTRODUCTION

A. General nature and scope of the study:

This study examines the variability of streamflow in all gaged Alaskan rivers and streams which terminate in the ocean. Forty-one such streams have been gaged for varying periods of time by the U. S. Geological Survey, Water Resources Division. Attempts have been made to characterize streamflow statistically using standard hydrological methods. The analysis scheme which was employed is shown in the flow chart which follows. In addition to the statistical characterization, the following will be described for each stream when possible:

1. average period of break-up initiation (10-day period)
2. average period of freeze-up (10-day period)
3. miscellaneous break-up and freeze-up data.
4. relative hypsometric curve for each basin
5. observations on past ice-jam flooding
6. verbal description of annual flow variation
7. original indices developed in this study to relate streamflow variability to basin characteristics and regional climate.

B. Specific Objectives:

1. The primary objective of this study is the development of a characterization of coastal streams in Alaska which is relevent for engineering applications, useful to the imminent OCS petroleum development, and which may also be generally useful to as many other agencies, individuals, and commercial interests as may have need for such information.

2. Realizing that characterization of streams in other regions of the United States may not be adequate to describe Alaskan streams, an original approach was developed in order to derive an index for stream characterization in this study. After trying several indices, it was decided that graphic plot of the ratio of the 1-, 3-, 7-, 10-, and 30-day maximum cumulative daily flows to the mean annual flow was an adequate characterization index. This index is a good expression of short-term variability.

3. A grouping of most ungaged streams is accomplished using regional and physical similarities to gaged streams as criteria. This grouping is intended to be a guide for extrapolation of the characterization of gaged streams to streams which have similar basin areas, climate, and elevation distributions, but which are not gaged by the U. S. Geological Survey.

4. An attempt is made to establish a relationship between precipitation and elevation in order to better characterize snowmelt patterns.

5. NOAA and LANDSAT satellite imagery are used as major sources of information to characterize snowmelt in both gaged and ungaged basins.

C. Relevance to problems of petroleum development:

1. Spring break-up presents critical engineering problems which need to be considered for nearshore oil development and exploration. Logistics and scheduling may be severely

disrupted by unforeseen or unknown problems related to rivers, spring run-off, and ice. A problem unique to the Arctic is that of flooding of the shorefast ice at the mouths of rivers during spring break-up. Satellite observations of several ungaged streams in the Arctic indicate that this event is endemic, but the timing of the initial flooding is variable. Ice jams are a problem, especially on the Yukon River. A major danger from ice jams in the possibility of a rapid break of the jam which could release dammed water and cause flooding downstream. Floating ice is also an engineering hazard. Ice jams will be discussed further in the results sections.

Snow cover and snowmelt characteristics which will be investigated in this study should lead to a better understanding of snowmelt rate. The relationships which exist between melt rate and runoff may also become more evident. A knowledge of these influences on nearshore development will be important to petroleum development as well as the planning and public works agencies of government.

III. CURRENT STATE OF KNOWLEDGE

As stated in our original proposal, we know of no directly related research being carried out by others. A bibliographic search was made using the OASIS system. A report entitled "Environmental Studies of an Arctic Estuarine System" (EPA, 1975) contains baseline information on the effects of river flow in an Arctic estuary, which is relevant to this work. Many papers address the problem of coastal breakup in

Arctic areas (Newburg, 1974; Antonov, *et al.*, 1972; Reimnitz, *et al.*, 1974; Barnes, *et al.*, 1973; Walker, 1973; McCloy, 1970; Reimnitz, *et al.*, 1972; and Walker, 1970). Carlson (1972) repsents discussion of the land hydrology of the southcenteral Alaska coastal zone. A regional discussion of sediment yield in Alaskan streams is given by Guymon (1974).

Some correlative studies of snow measurements made on the ground with remote sensing observations have been done by Bilello (1974). Poulin (1974) used infrared staellite imagery to determine the hydrologic characteristics of snow-covered terrain.

Carlson (1974) and Newburg (1974) both address the effects of permafrost on river hydrology. Permafrost or glacial influences affect nearly all major hydrologic systems in Alaska.

The general state of knowledge for characterizing streams in lieu of coastal development is inadequate. More hydrologic research has been done in the Beaufort Sea drainage than elsewhere in Alaska and no area of Alaska has been or is being as well studied.

IV. STUDY AREAS

This report includes characterization of all gaged streams in all the OCS areas of interest:

1. Gulf of Alaska
2. Southern Bering Sea
3. Northern Bering - Chukchi Seas
4. Beaufort Sea

V. SOURCES, METHODS

The major source of data for this study is the U. S. Geological Survey streamflow records. Programs were written in order to extract the statistical parameters and hydrograph records from a tape containing all the stream records of interest. This data enabled us to characterize the seasonability and variability of streamflow.

To obtain break-up and freeze-up information, the standard U. S. Geological Survey annual water resources data catalogs were examined for evidence of those events in the record. Some data on break-up and freeze-up were also available from the U. S. Weather Service and from the Environmental Atlas of Alaska (Johnson and Hartman, 1969).

The snowmelt characterization was accomplished using both NOAA - VHRR (Very High Resolution Radiometer) and LANDSAT satellite imagery.

Much of our data have been updated to include the 1974 data which recently have become available.

Our computer processing work has been additionally aided by existing programs supplied by the Alaska district of the U. S. Army Corps of Engineers in Anchorage. The selection of the 1-, 3-, 7-, 10-, and 30-day maximum period flows has been accomplished through one of the Corps' programs. By determining the ratio of these flow durations to the mean annual flow, a quantitative indicator of streamflow variability has been established.

VI. RESULTS

Presentation of the results of the statistical analyses and supplementary information is graphical wherever possible. Freeze-up and break-up information is tabulated.

The characterizations of the streams follow closely the characterization flow chart (Table 1). For ease of drafting, each set of parameters was grouped together for each region, i.e. all the flow duration curves are in a series followed by all the short-term variability indices, etc. The order of presentation of the streams is the same as that used by the U. S. Geological Survey in presenting the streamflow data in its annual publications. The order is established by following a traverse along the coast starting (in this case) with the Copper River and traveling westward along the coast; rivers are similarly ordered.

Explanatory notes precede each graphical presentation.

A. Notes on determination of break-up and freeze-up date: Since both break-up and freeze-up are variable from year to year and depend greatly upon weather conditions, it is not possible to arrive at an average single date of freeze-up or break-up. Rather, a most likely 10-day period for each annual event is determined from the streamflow data. Freeze-up is determined by the period, usually in October or November, when the streamflow record is monotonically decreasing for 10 consecutive days; or, if there is a field note describing the termination of streamgage function due to ice formation, that data is used as the mid-date of the 10-day freezing period. Freeze-up is difficult to determine because its occurrence in the steamflow records is much more subtle and few direct observations of the freezing date are available.

Break-up, in this description, is used in the broadest sense of the term, implying snowmelt runoff initiation as well as the break-up of river ice. Break-up was determined to

TABLE 1

FLOW CHART - OCS STREAM CHARACTERIZATION

U.S. Geological Survey Streamflow Data

Extreme Hydrographs:

Record High Year, Record Low Year

Flow Duration Curve

Flow Mass Curve
(Cumulative)

Exceedance Series

Short Term Variability Index
1-, 3-, 7-, 10-, 30-Day Duration Series
In Ratio to Mean Annual Flow

Statistical Streamflow Parameters:

Mean
Mode

Range (over complete duration series)

Snowmelt Characterization

Total Stream Characterization

be that period of the streamflow record during which the discharge begins a steady increase after having reached minimum discharge for the year. Because this is an indirect method of determining break-up and freeze-up, it is very possible that the measurements involve instances of error. This is another reason why the term "most probably period" of break-up or freeze-up is used instead of attempting to narrow the estimates to a single mean date. The stated ranges will be the mean 10-day period during which the streamflow record indicated a snowmelt flow contribution or a steady decline to a baseflow condition.

Variations from this method of determining the break-up dates may occur in river analysis if other direct observations are used as input, such as LANDSAT or NOAA satellite imagery. Satellites were used to aid break-up determinations for large or rapidly responsive rivers such as the Yukon and the Kvichak Rivers. In these streams, flow is large all year. Large changes in stage and flow volume can take place in a river such as the Yukon, before the ice is swept away or broken. According to the empirical definition of break-up in this study, the Yukon River should have been ice-free and flowing by April 26-May 5, 1975. From satellite imagery it is evident that the Yukon was still ice covered in Alaska on May 8 and was not ice-free in the Yukon flats until on or about May 12 Ice often persists as much as a week or two later in the lower Yukon nearer the delta than it does upstream. Other large rivers may also be subject to large increases in stage over its minimum level before the ice is removed, especially the Kuskokwim, Kobuk, Copper, Susitna, Kvichak, and Wood Rivers.

The method of estimating break-up and freeze-up is only useful after 1965. Before this period, gages were not usually in operation before break-up in the spring, and were removed before freeze-up in autumn. Estimates were usually poor when ice cover prevailed since ice affected the stage-discharge relationship. Records of break-up and freeze-up dates are shown in Table 2 and additional records of freeze-up and break-up from the U. S. Coast and Geodetic Survey (1964) are presented in Table 3 for further historical information.

B. Hypsometric curves:

These curves (Figures 1-3), which are essentially area-altitude curves, relate the horizontal cross-sectional area of a drainage basin to relative elevation above the basin mouth. Through use of dimensionless parameters (a/A = area of interest/Total basin area, h/H height of interest/highest elevation), curves can be read and compared irrespective of true scale. Curves show distinctive differences both in form and proportionate area below the curve. Further development of the uses of thehypsometric curve is discussed by Strahler, 1952.

Practical applications of hypsometric curves have value in many areas. The area-altitude relation provides a means of estimating the mean depth of snow over a basin, or its water equivalent. Because precipitation normally increases with elevation, the hypsometric curve can be used to estimate

TABLE 2
1976 Tabulation of Breakup and Freezeup Dates
of Alaskan Coastal Rivers
Determined from Streamflow Measurements

River Name	Most Probable Break-Up Dates	Most Probable Freeze-Up Dates	Other Data	Comments
Copper R.	May 3-12	Oct. 17-26		
Power Cr.	Apr. 23-May 2	Nov. 24-Dec. 3		Fluctuations throughout winter
Olsen Bay Cr.(W.fork)	Apr. 12-21	Nov. 18-27		
Nellie Juan R.	Apr. 25-May 4	Nov. 14-23		
Resurrection R. (Seward)	Apr. 23-May 2	Nov. 10-19		
Lowell Cr.	Apr. 26-May 5	Nov. 26-Dec. 5		
Spruce Cr.				Insufficient record length
Bradley R.	May 4-13	Nov. 4-13		
Anchor R.	Apr. 18-27	Nov. 4-13		
Ninilchik R.	Apr. 17-26	Nov. 6-15		
Kasilof R.	Apr. 5-14	Nov. 3-12	4/13 breakup USWS 16-yr. avg.	Difficult to determine from record
Kenai R. (Soldotna)	Apr. 22-May 1	Nov. 5-14	4/16 breakup USWS 15-yr. avg.	
Resurrection Cr. (Hope)	Apr. 22-May 1	Nov. 1-10		
Glacier Cr.	Apr. 10-19	Nov. 7-16		
Campbell Cr.	Apr. 22-May 1	Nov. 5-14		Freeze-up difficult to determine
Chester Cr.	Apr. 9-18	Oct. 31-Nov. 9		
Ship Cr.(Elmendorf)	Apr. 30-May 9	Dec. 3-12		Power plant probably affects freeze-up
Eagle R.	May 4-13	Nov. 1-10		
Knik R.	Apr. 24-May 3	Oct. 26-Nov. 4		
Matanuska R.	Apr. 26-May 4	Oct. 24-Nov. 3		

TABLE 2 Continued

River Name	Most Probable Break-Up Dates	Most Probable Freeze-Up Dates	Other Data	Comments
Little Susitna R.	May 2-11	Oct. 22-Nov. 1		
Susitna R. (Gold Cr.)	May 5-14	Oct. 16-25	5/9 breakup USWS 9-yr. avg. @ Talkeetna	
Chakachatna R.	May 16-25	Oct. 16-25		
Terror R.				No freeze cycle detectable
Myrtle Cr.	Mar. 24-Apr. 5	Dec. 2-11		
Uganik R.				same as above
Kvichak R.	May 10-19	Nov. 27-Dec. 6		Freeze-up difficult to determine
Nuyakuk R.	May 10-19	Oct.31-Nov. 9		
Kuskokwim R. (Crooked Cr.)	Apr. 28-May 27	Oct. 23-Nov. 2	5/8 breakup 10/30 freezeup USWS 10-yr. avg.	
Kuzitrin R.	May 9-18	Oct. 17-26		
Kobuk R. (Ambler)	May 12-21	Oct. 9-18	5/21 breakup 10/12 freezeup USWS 11-yr. avg.	
Kuparuk R.	May 29-June 8	Sept. 20-29		
Putuligayuk R.	June 3-12	Sept. 26-Oct 5		
Sagavanirktok R.	May 13-22	Sept. 27-Oct. 6		
Wood R.	Apr. 26-May 5	Nov. 3-12		

TABLE 3

HISTORICAL DATES OF ICE BREAKUP AND FREEZEUP (FROM U. S. COAST AND GEODETIC SURVEY, 1964)

Place	Waters	Ice breakup			Ice freezeup			Avg. Years Record	Period
		Average	Earliest	Latest	Average	Earliest	Latest		
				Gulf of Alaska					
Susitna	Susitna R.	May 1	4/12/41	5/10/46	Nov 1	10/19/33	11/14/36	12	1933 - 1946
Talkeetna	do	May 8	4/12/41	5/25/52	Dec 2	11/12/39	12/23/47	12	1919 - 1952
Kasilof	Kasilof R.	Apr 13	3/27/41	4/29/46	Dec 3	11/13/45	12/24/48	10	1937 - 1947
Kenai	Kenai R.	Apr 2	3/18/52	4/14/51	Dec 10	11/23/51	12/26/37	6	1937 - 1952
Anchorage	Ship Cr.	Mar 29	2/16/44	4/17/42	Nov 24	11/10/35	12/10/36	21	1915 - 1953
				Bering Sea					
Egegik	Egegik R.	Apr 14	3/16/41	5/01/39	Dec 12	11/12/42	1/11/39	10	1937 - 1952
Naknek	Naknek R.	Apr 9	3/19/41	4/25/49	Nov 17	10/17/39	12/15/17	7	1916 - 1951
Koggiung	Kvichak R.	May 4	4/26/38	5/13/40	Dec 22	11/23/39	1/30/41	3	1937 - 1940
Dillingham	Nushagak Bay	May 9	4/25/26	5/27/52	Nov 7	10/16/32	12/22/40	19	1919 - 1952
Kanakanak	do	May 2	4/17/40	5/22/39	Nov 20	10/14/42	12/21/38	4	1937 - 1943
Platinum	Goodnews Bay	May 1	4/08/42	5/25/52	Nov 19	10/23/30	12/12/47	12	1928 - 1952
Kwinhagak	Kuskokwim Bay	May 1	4/10/45	5/17/46	Nov 15	10/20/29	12/20/38	10	1929 - 1952
Bethel	Kuskokwim R.	May 15	4/24/40	5/28/52	Oct 29	10/08/28	11/24/51	27	1923 - 1952
Crooked Creek	do	May 7	4/22/40	5/23/52	Nov 18	11/03/39	12/02/52	12	1937 - 1952
McGrath	do	May 10	4/24/40	5/24/52	Nov 5	10/23/41	11/15/52	12	1939 - 1952
Mekoryuk Nunivak Is.	Mekoryuk R.	May 12	4/18/50	5/30/46	Nov 27	11/20/52	12/13/47	5	1943 - 1951
Gambel, St. Lawrence Is.		May 26	5/01/43	7/01/50	Nov 21	10/15/49	12/14/40	10	1940 - 1952
Savoonga, St. Lawrence Is.		May 26	4/25/48	6/17/45	Nov 19	9/30/30	12/13/40	10	1929 - 1949
Hooper Bay	Hooper Bay	May 26	5/15/42	6/04/45	Nov 12	10/19/26	11/20/41	4	1926 - 1945
St. Michael	Norton Sound	Jun 9	5/19/12	7/03/01	Nov 10	10/10/84	12/07/81	53	1874 - 1952
Unalakleet	Unalakleet R.	May 17	4/28/40	5/30/52	Oct 25	10/08/39	11/19/37	14	1937 - 1952
Moses Point	Kwiniuk R.	May 24	5/02/51	6/11/49	Oct 20	10/01/51	11/02/52	6	1943 - 1952
Golovin	Golivnin Bay	May 23	5/13/40	6/14/39	Nov 2	10/08/42	11/19/37	6	1937 - 1943
White Mountain	Fish R.	May 21	5/05/40	6/02/37	Oct 14	9/27/31	11/01/25	24	1923 - 1951
Solomon	Solomon R.	May 20	5/01/42	5/30/45	Oct 29	10/10/40	11/29/48	10	1940 - 1952
Council	Nuikluk R.	May 17	4/27/40	5/31/52	Oct 30	10/13/20	11/09/40	12	1920 - 1952
Nome	Norton Sound	May 29	4/28/42	6/28/48	Nov 12	10/13/18	12/13/47	50	1900 - 1952
Teller	Grantley Harbor	Jun 7	5/12/36	6/18/39	Nov 10	10/13/42	12/26/50	16	1936 - 1952
				Yukon River					
Akulurak	Kwikluak Pass	May 27	5/20/42	6/04/20	Oct 24	10/11/39	11/07/23	14	1917 - 1948
Hamilton	22	May 22	5/06/40	6/05/52	Oct 25	10/15/39	11/02/38	14	1938 - 1952
Azacharak	85	May 20	5/03/38	6/06/52	Nov 13	11/01/39	12/22/49	12	1937 - 1952
Pilot Station	115	May 17	5/01/26	5/24/24	Nov 8	10/27/24	11/13/25	5	1924 - 1943
Russian Mission	195	May 12	4/25/40	5/25/39	Nov 4	10/21/28	11/15/37	8	1928 - 1944
Holy Cross	257 Nautical	May 17	4/25/40	5/28/52	Oct 31	10/12/31	11/30/34	32	1917 - 1952
Galena	481 Miles	May 17	5/08/51	5/26/52	Nov 6	10/11/47	12/08/50	10	1943 - 1952
Ruby	526 Above	May 15	4/30/40	5/22/20	Nov 7	10/28/17	11/18/37	11	1917 - 1946
Tanana	628 Apoon	May 14	4/29/40	5/25/35	Nov 4	10/13/30	11/22/37	33	1917 - 1952
Rampart	688	May 16	5/01/30	5/25/52	Nov 6	10/13/30	11/23/45	21	1917 - 1952
Ft. Yukon	896	May 14	5/07/40	5/22/27	Oct 28	10/14/41	11/15/52	30	1918 - 1952
Coal Creek	1002	May 12	5/07/43	5/18/45	Nov 9	11/01/38	11/20/40	8	1938 - 1950
Eagle	1089	May 9	4/25/40	5/18/52	Nov 19	10/18/30	12/11/49	29	1917 - 1952
Dawson, Canada	1197	May 8	4/28/40	5/16/45	Nov 17	11/03/41	12/18/42	12	1917 - 1947
				Arctic Ocean					
Wales	Bering Strait	Jun 8	5/15/47	6/30/49	Dec 3	10/08/48	1/08/51	16	1927 - 1952
Shishmaref	Arctic Ocean	Jun 22	5/30/36	7/08/33	Nov 10	10/06/39	12/18/34	18	1921 - 1952
Candle	Kiwalik R.	May 18	5/05/43	5/27/27	Oct 17	10/10/42	10/23/43	8	1922 - 1950
Deering	Inmachuk R.	Jun 4	5/11/43	6/30/41	Oct 23	10/03/46	11/04/41	4	1937 - 1948
Kotzebue	Kotzebue Sound	May 31	5/17/40	6/08/45	Oct 23	10/02/39	11/05/38	14	1929 - 1952
Selawik	Selawik R.	May 28	5/13/40	6/07/45	Oct 17	10/03/46	10/30/38	12	1927 - 1952
Noorvik	Kobuk R.	May 29	5/18/25	6/11/22	Oct 11	9/26/48	10/25/22	17	1918 - 1952
Kiana	do	May 18	5/07/40	5/29/39	Oct 18	10/10/39	11/04/38	6	1938 - 1944
Kobuk	do	May 19	5/11/43	5/29/45	Oct 21	10/09/39	11/02/38	12	1937 - 1952
Shungnak	do	May 21	5/12/41	5/29/45	Oct 16	10/07/19	10/25/40	8	1919 - 1950
Kivalina	Kivalina R.	May 22	5/15/43	5/27/49	Oct 25	10/15/48	11/01/46	6	1943 - 1952
Point Hope	Arctic Ocean	Jun 20	5/30/27	7/08/46	Nov 11	10/06/42	12/19/47	8	1927 - 1951
Point Lay	do	Jun 24	6/01/43	7/10/53	Nov 4	10/12/43	11/27/48	4	1943 - 1953
Wainwright	do	Jun 29	6/07/44	7/26/48	Oct 2	9/26/48	10/09/45	7	1939 - 1953
Point Barrow	do	Jul 22	6/15/44	8/22/31	Oct 3	8/31/27	12/19/47	31	1920 - 1953

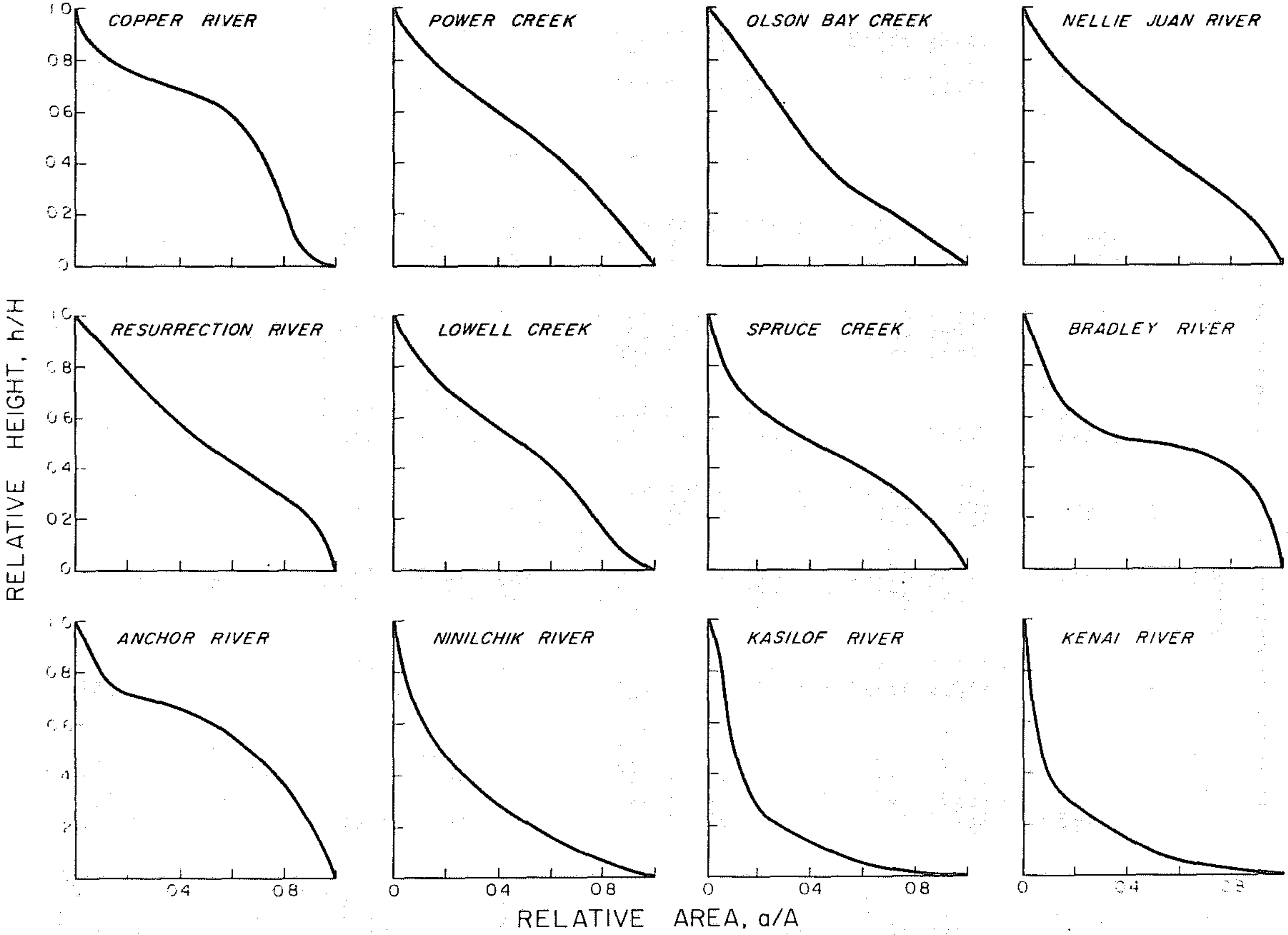


FIGURE 1 - HYPSOMETRIC CURVES

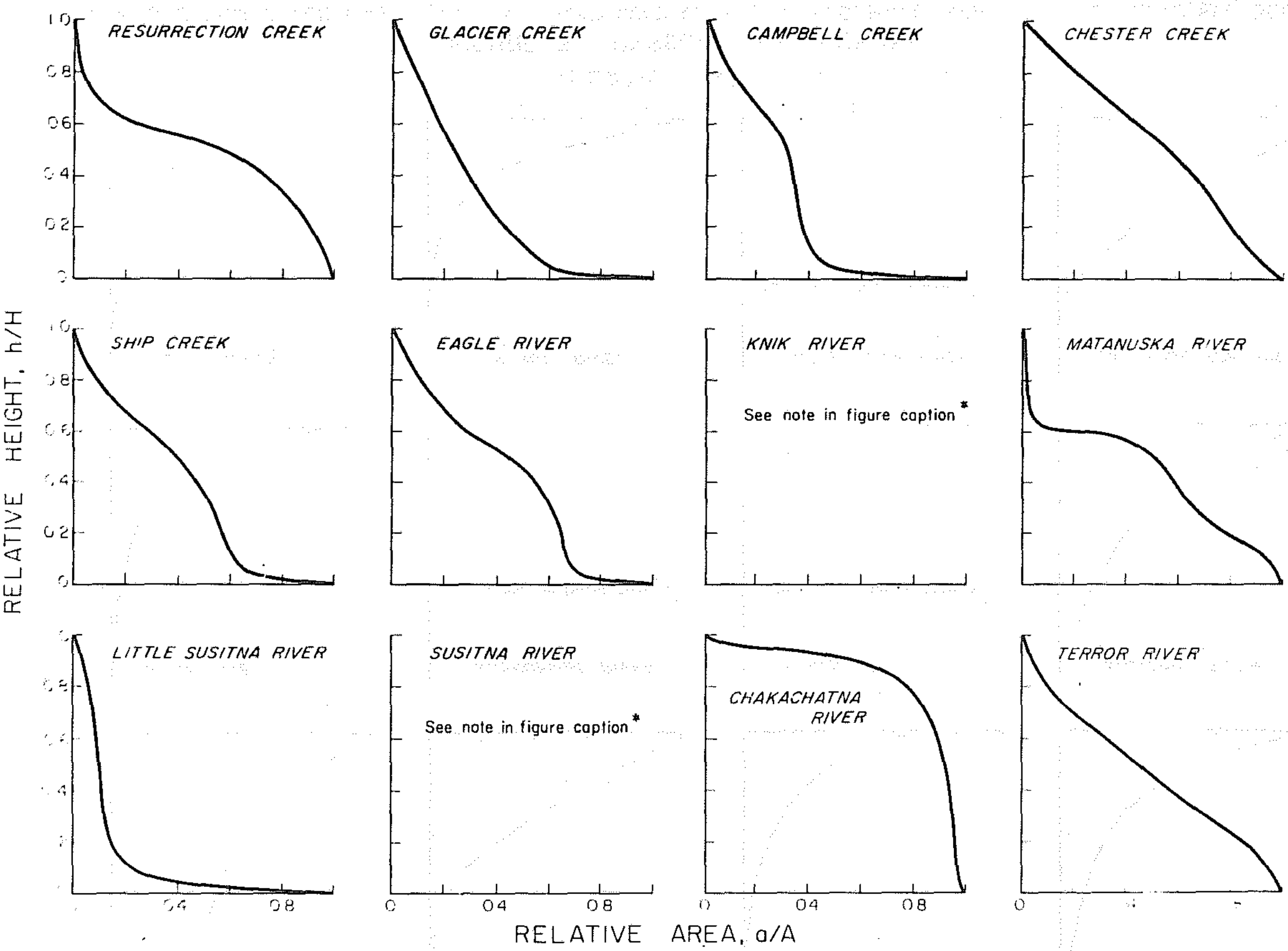


FIGURE 2 - HYPSOMETRIC CURVES

THE KNIK AND SUSITNA RIVERS HAVE INADEQUATE MAPS AVAILABLE FOR ACCURATE HYPSOMETRIC ANALYSIS

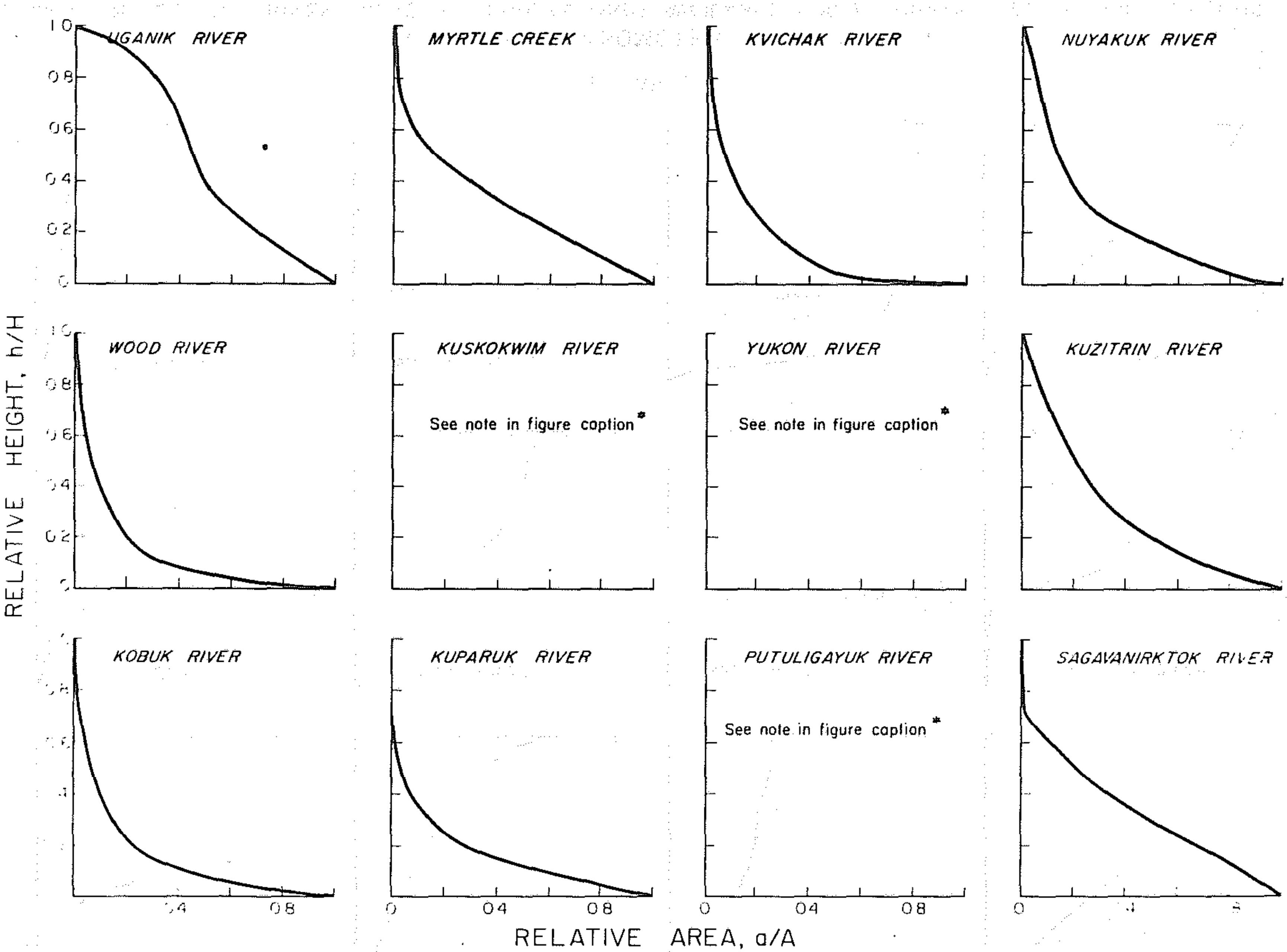


FIGURE 3 - HYPSOMETRIC CURVES

THE KUSKOKWIM RIVER HAS INADEQUATE MAP AVAILABLE FOR ACCURATE HYPSOMETRIC ANALYSIS. BECAUSE OF ITS BASIN SIZE, A HYPSOMETRIC ANALYSIS OF THE YUKON RIVER WAS NOT FELT TO BE MEANINGFUL. THE PUTULIGAYUK RIVER IS CONFINED TO ELEVATIONS LESS THAN 50 METERS.

precipitation at elevations where measurements are not made directly. The use of satellite imagery in snowcover mapping is aided by the use of hypsometric curves, making it a simple matter to calculate the areal coverage of snow if the mean "snow line" is determined, or to find the mean elevation of snowcover if the areal coverage of snow is more easily measured.

In order to more easily use the hypsometric curves, the highest elevation in each basin (H), and the basin area (A) are tabulated on Table 4.

C. Extreme hydrographs:

Both the record high and record low year of flow (based on mean annual flow) is shown for each river of interest, Figures 4 through 21. This information is available from the U. S. Geological Survey Water Resources division and is presented here in graphical form. Although some of the records are of short duration, these hydrographs provide an indication of the range of flow of each river for a relatively dry year and a relatively wet year.

D. Flow Duration Curves:

Flow duration curves (Figures 22 through 27) are a rank ordering of the magnitudes of daily mean flow during the entire period of record. The plots are arranged so as to enable one to associate a given rate of flow with the percent of time flow exceeded this rate over the length of record, i.e., the axes are streamflow in cubic feet per second vs. percent of time. Since the range of flows measured over the

TABLE 4
HYPSOMETRIC DATA

River Basin	Highest Elevation (H)	Basin Area (A) mi^2	Basin Area (A) km^2
Copper River	19,850 ft. (6616 m)	20,600	53,400 @ Chitna
Power Creek	4,660 ft. (1420 m)	20.5	53.1
WF Olson Bay Creek	3,720 ft. (1133 m)	4.78	12.38
Nellie Juan River	6,182 ft. (1884 m)	125	322
Resurrection River (Seward)	5,309 ft. (1618 m)	169	438
Lowell Creek	4,003 ft. (1220 m)	4.02	10.4
Spruce Creek	4,003 ft. (1220 m)	9.26	23.98
Bradley River	4,921 ft. (1500 m)	54.0	139.9
Anchor River	2,060 ft. (628 m)	133	344
Ninilchik River	2,010 ft. (612 m)	131	339
Kasilof River	6,560 ft. (2000 m)	738	1,910
Kenai River (Soldotna)	5,520 ft. (1680 m)	2,010	5,210
Resurrection Creek (Hope)	5,079 ft. (1548 m)	149	386
Glacier Creek	5,202 ft. (1586 m)	62	160.6
Campbell Creek	3,940 ft. (1200 m)	69.7	180.5
Chester Creek	1,148 ft. (350 m)	20.0	51.8
Ship Creek (Elmendorf)	6,370 ft. (1941 m)	115	298
Eagle River	4,920 ft. (1500 m)	192	497
Knik River	10,610 ft. (3230 m)	1,180	3,060
Matanuska River	13,176 ft. (4016 m)	2,070	5,360
Little Susitna River	1,937 ft. (590 m)	61.9	160.3
Susitna River (Gold Creek)	20,320 ft. (6190 m)	160	15,950
Chakachatna River	9,350 ft. (2850 m)	1,120	2,900
Terror River	4,405 ft. (1340 m)	15.0	38.9
Uganik River	4,405 ft. (1340 m)	123	319
Myrtle Creek	2,079 ft. (630 m)	4.74	12.28
Kvichak River	10,197 ft. (3110 m)	6,500	16,800
Nuyakuk River	6,000 ft. (1829 m)	1,490	3,860
Wood River	2,950 ft. (900 m)	1,110	
Kuskokwim River (Crooked Creek)	11,670 ft. (3560 m)	31,100	80,500
Yukon River (Ruby)	20,300 ft. (6190 m)	259,000	671,000
Kuzitrin River	2,682 ft. (817 m)	1,720	4,450
Kobuk River (Ambler)	8,800 ft. (2680 m)	6,570	17,020
Kuparuk River	1,968 ft. (600 m)	3,130	8,107
Putuligayuk River	230 ft. (15 m)	176	456
Sagavanirktok River	7,370 ft. (2246 m)	2,208	5,719

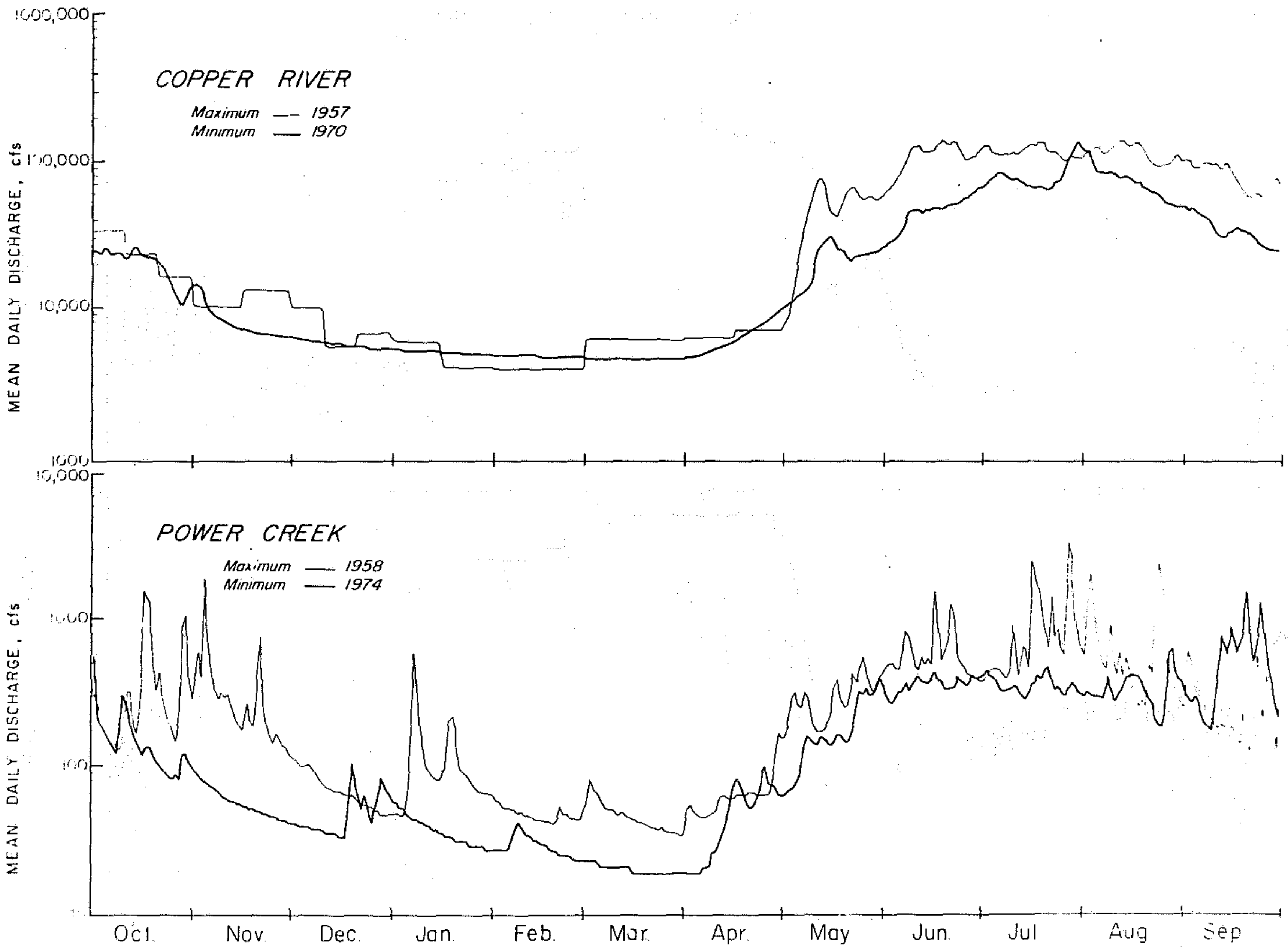


FIGURE 4, HYDROGRAPHS - Copper River / Power Creek

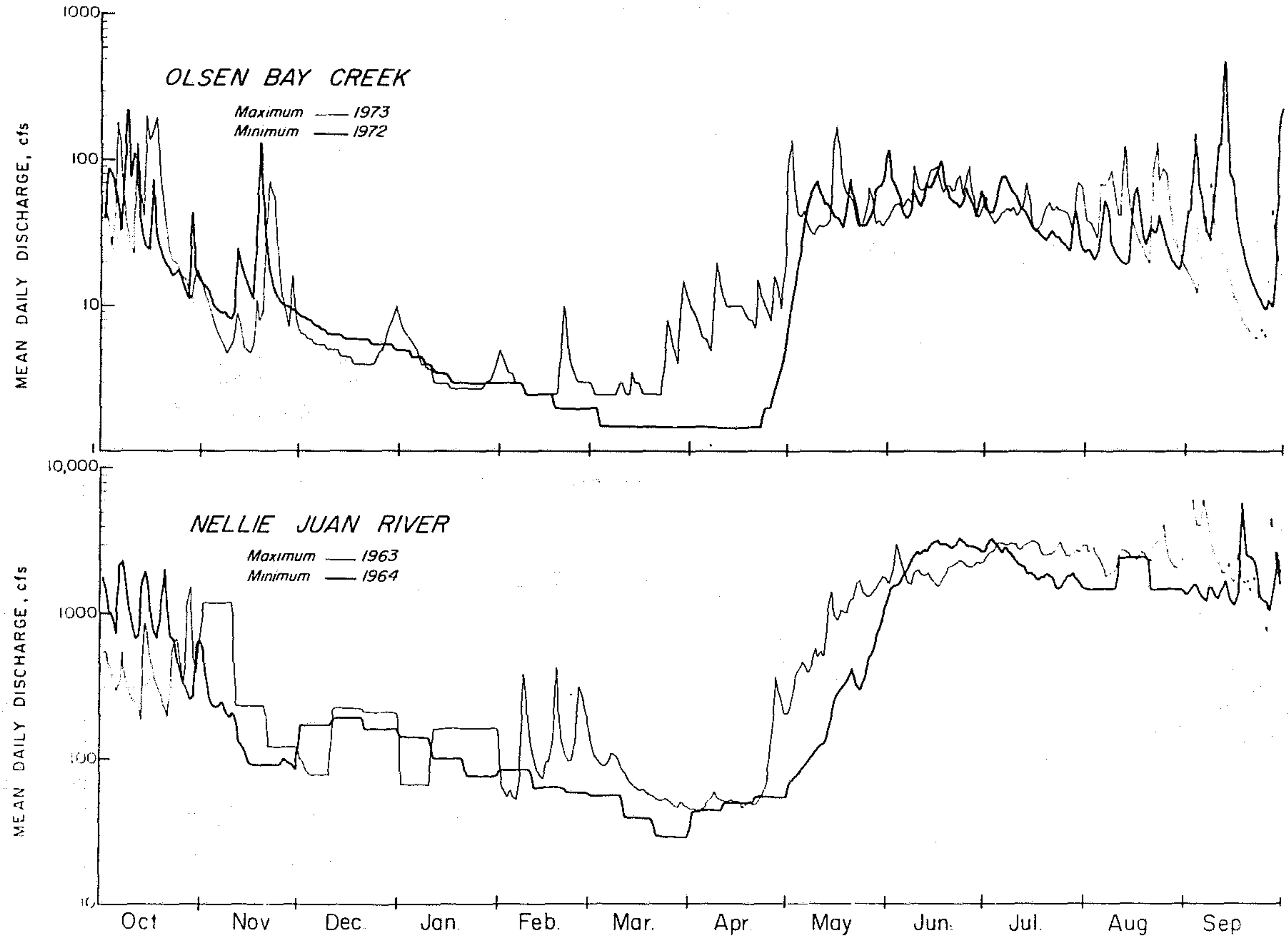


FIGURE 5, HYDROGRAPHS - Olsen Bay Creek / Nellie Juan River

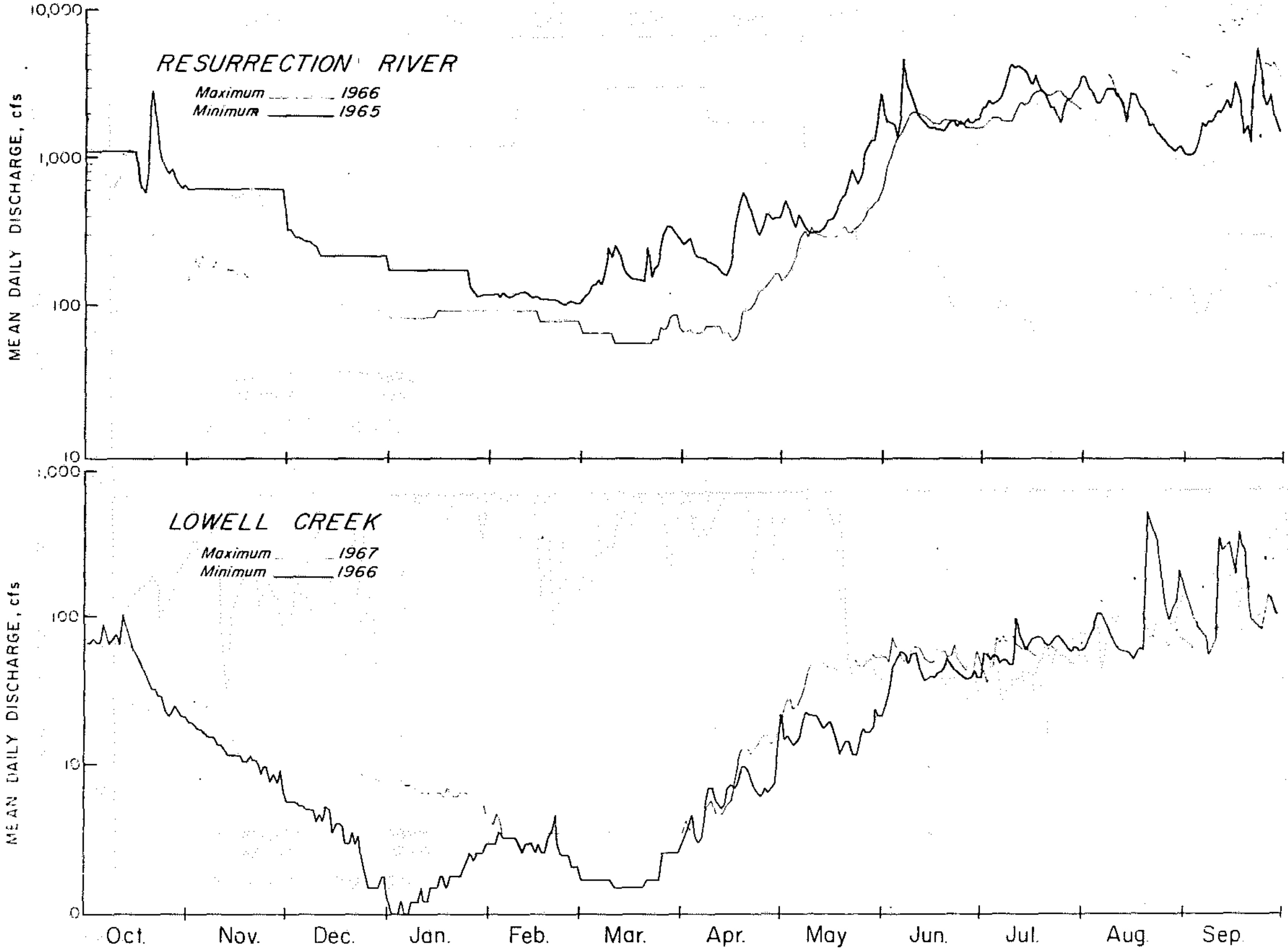


FIGURE 6, HYDROGRAPHS - Resurrection River / Lowell Creek

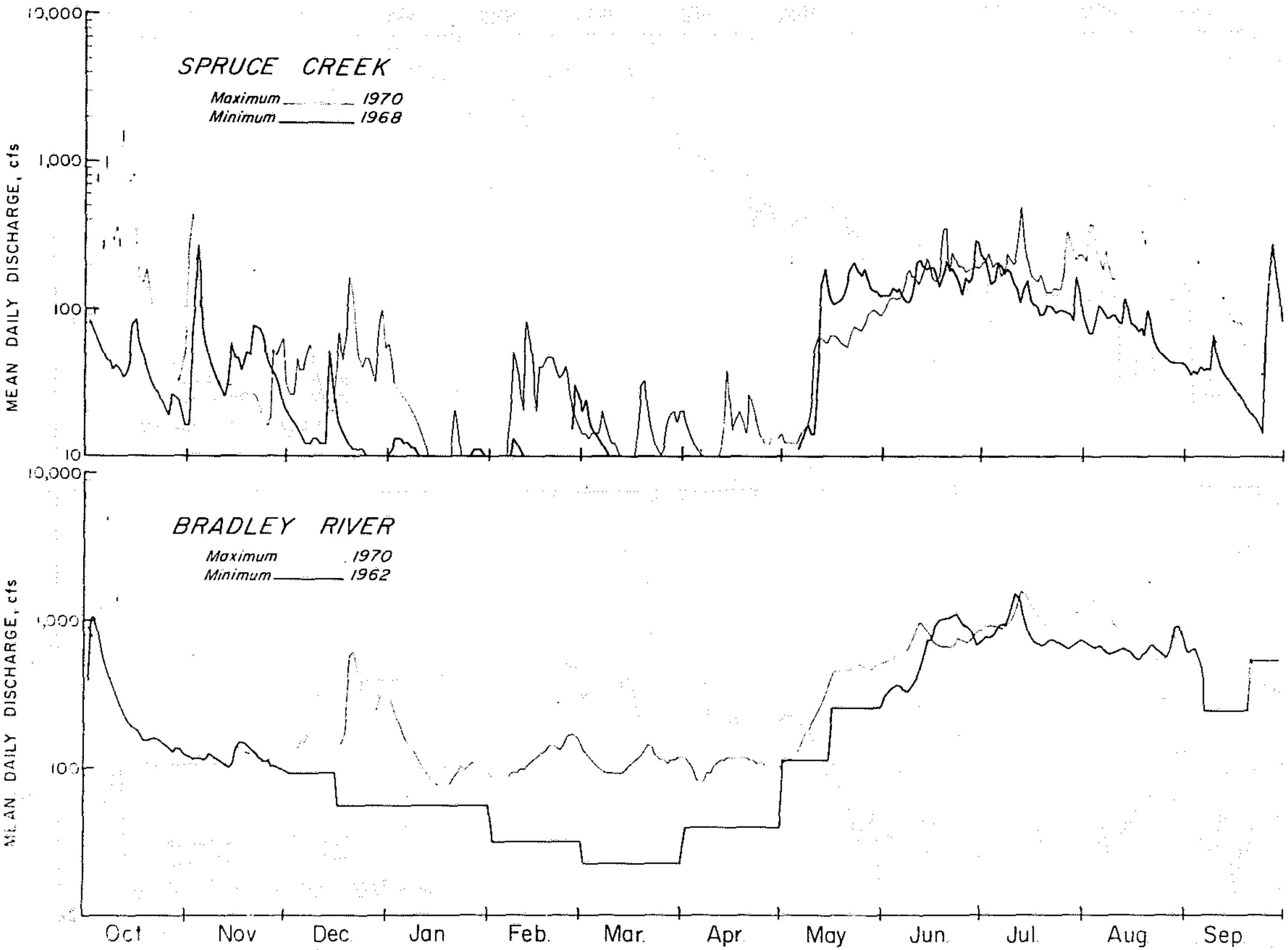


FIGURE 7, HYDROGRAPHS - Spruce Creek / Bradley River

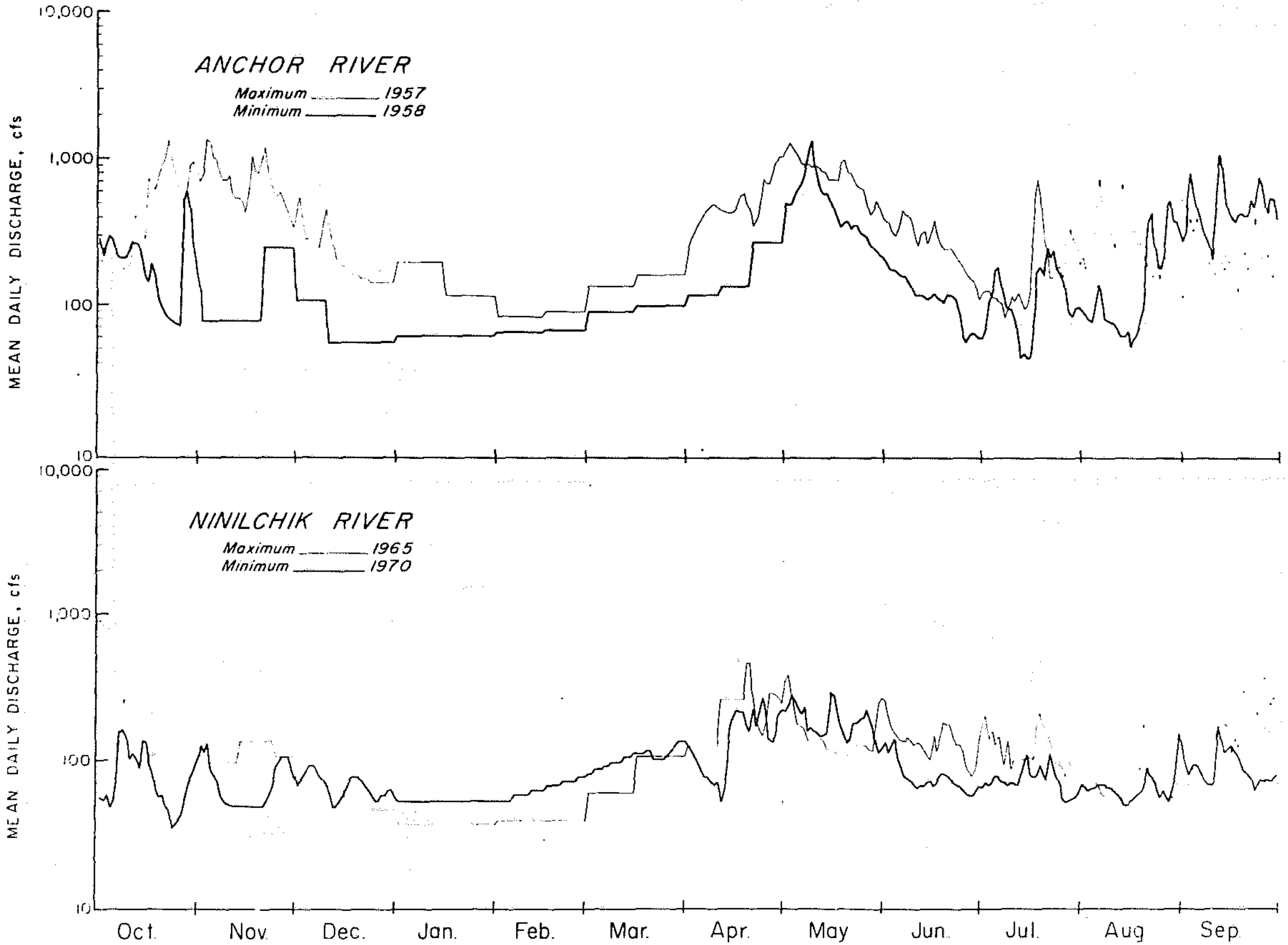


FIGURE 8, HYDROGRAPHS - Anchor River / Ninilchik River

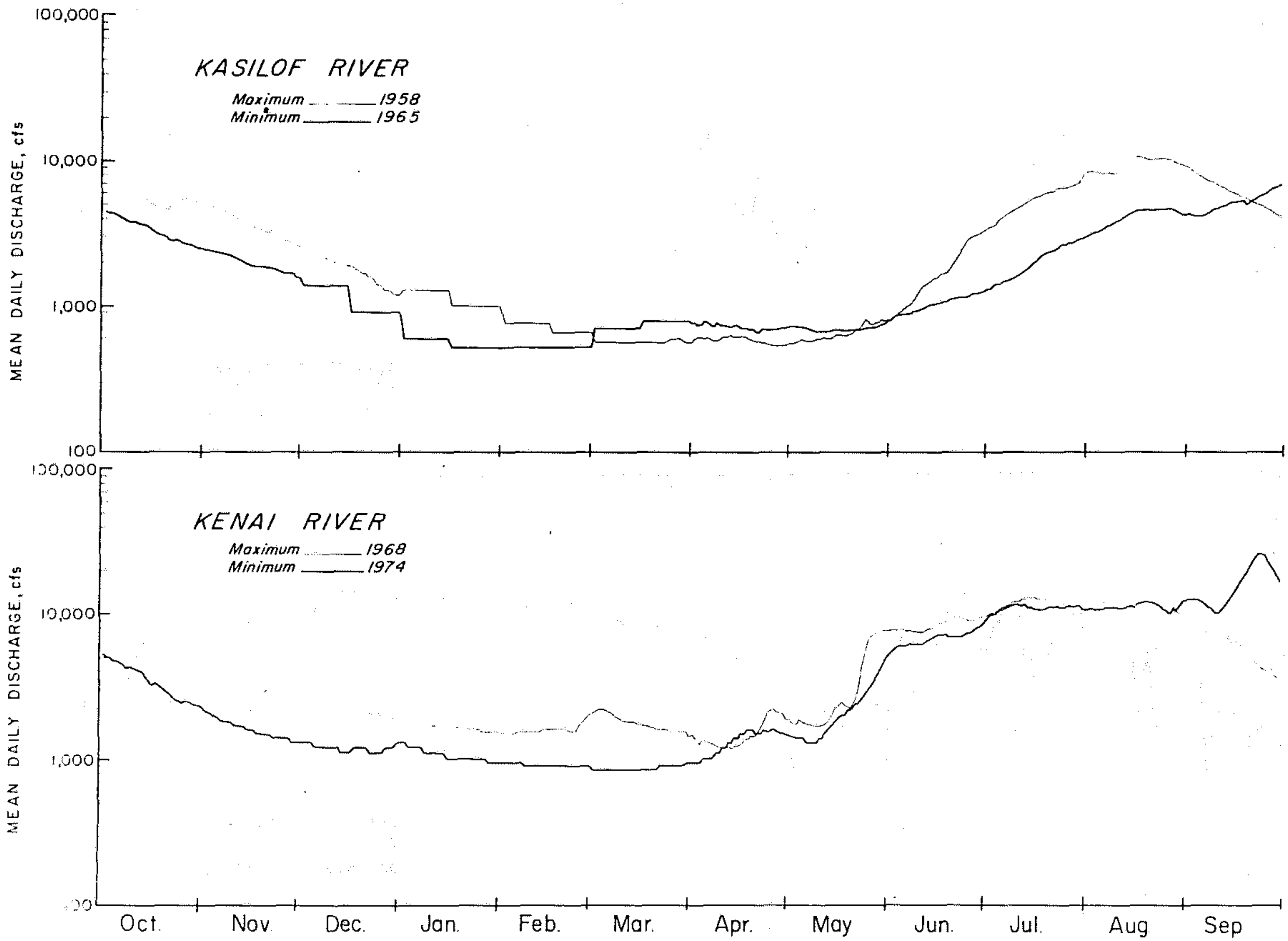


FIGURE 9, HYDROGRAPHS - Kasilof River / Kenai River

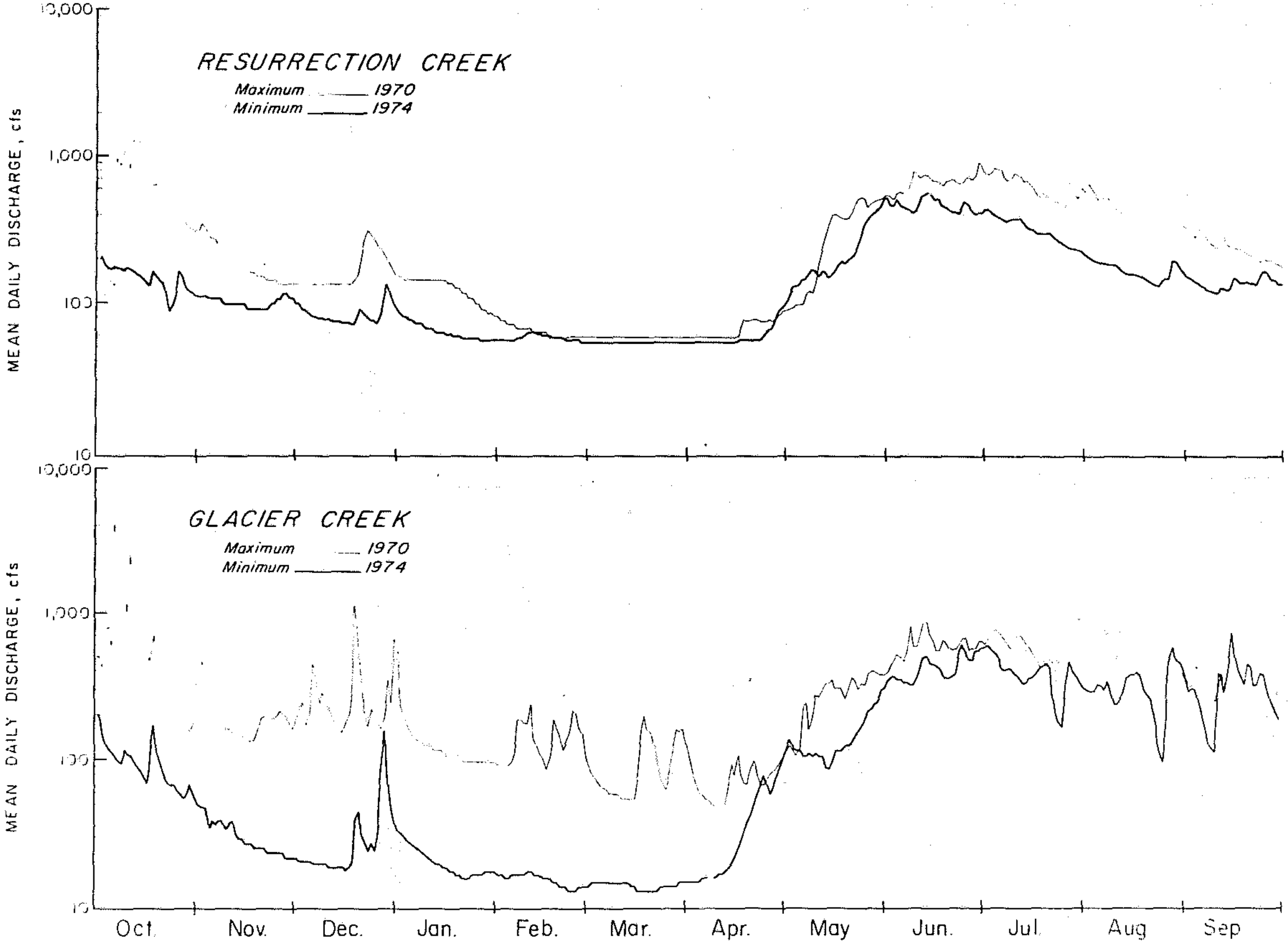


FIGURE 10, HYDROGRAPHS - Resurrection Creek / Glacier Creek

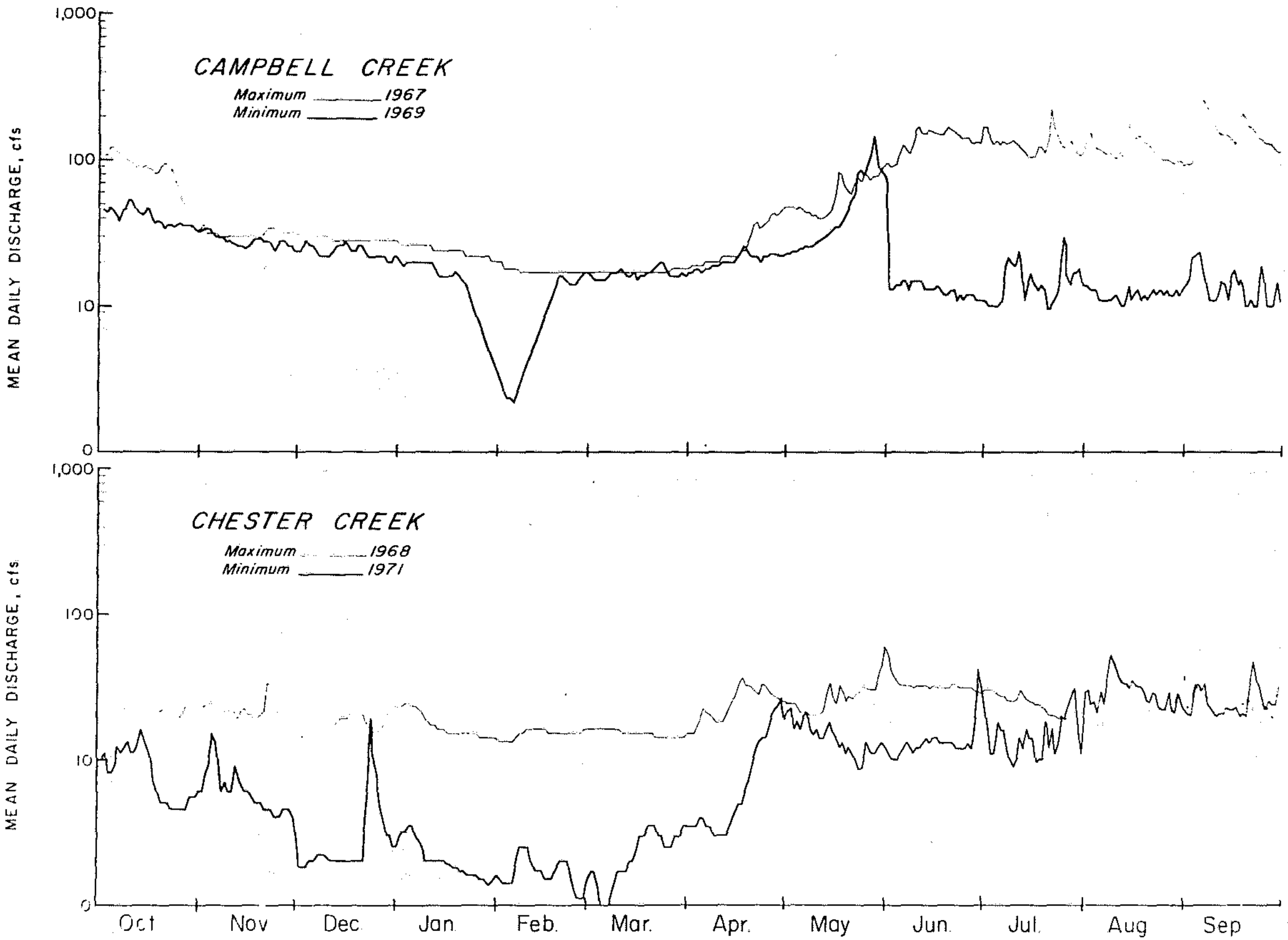


FIGURE 11, HYDROGRAPHS – Campbell Creek / Chester Creek

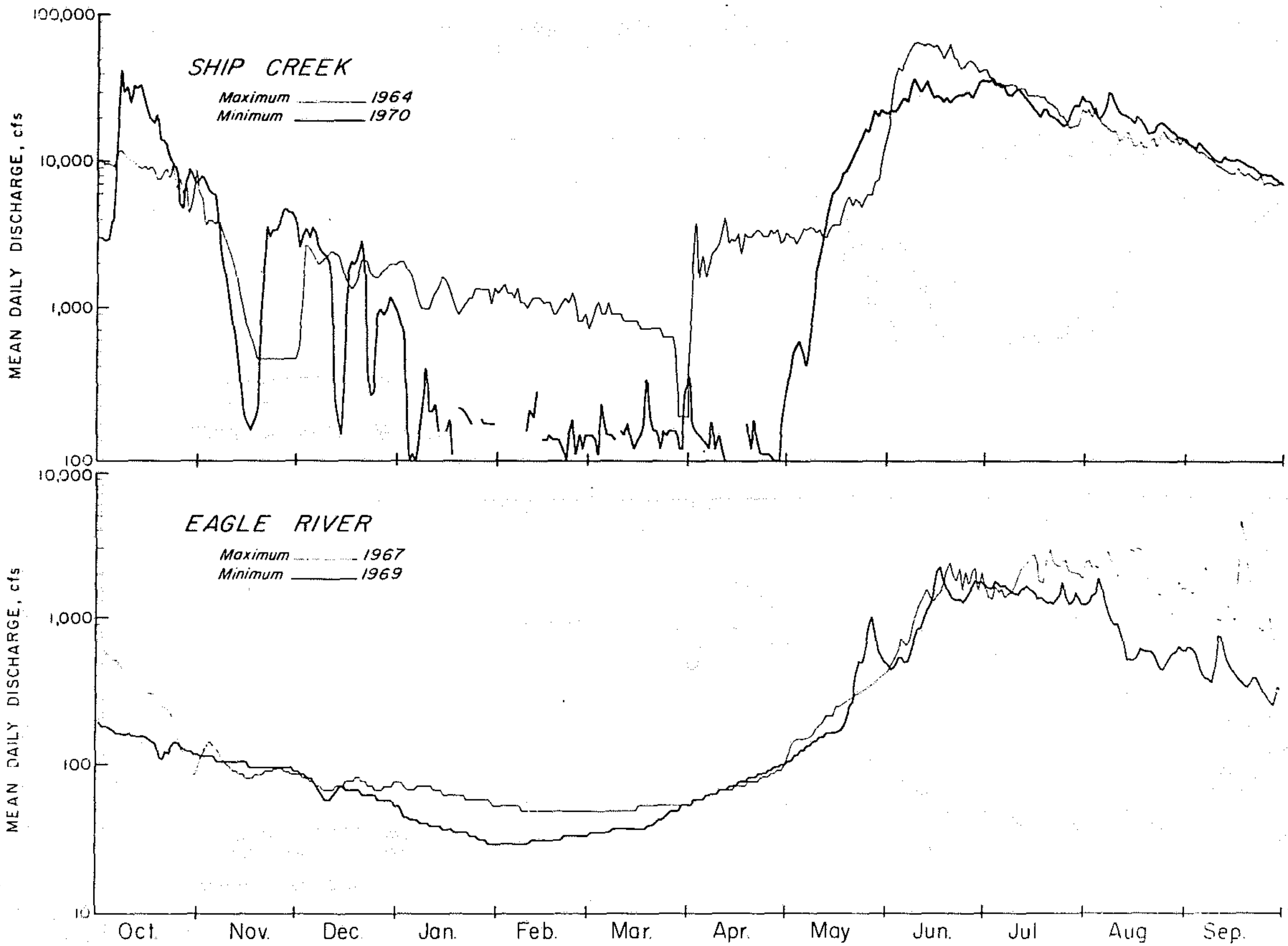


FIGURE 12, HYDROGRAPHS - Ship Creek / Eagle River

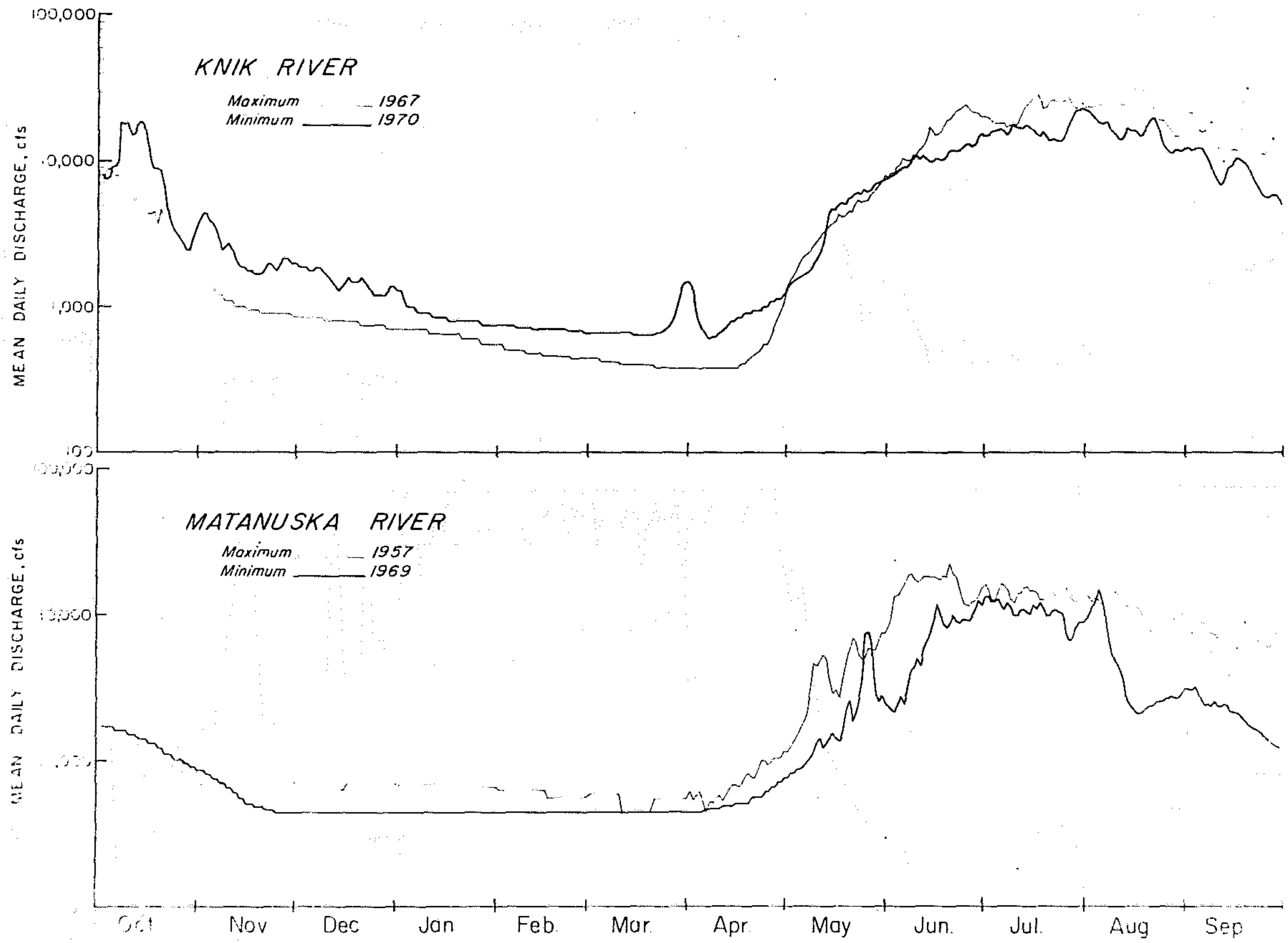


FIGURE 13, HYDROGRAPHS - Knik River / Matanuska River

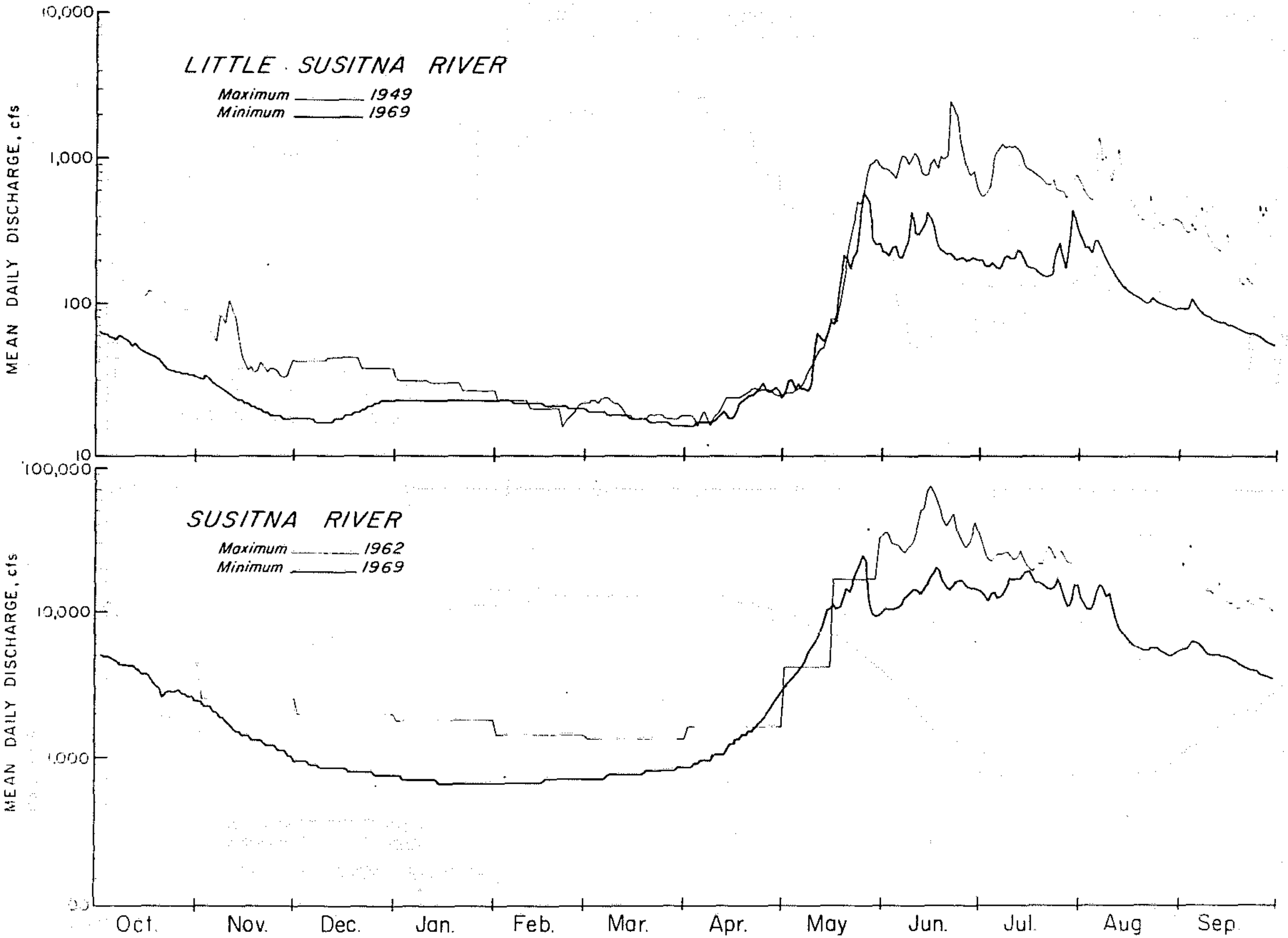


FIGURE 14, HYDROGRAPHS - Little Susitna River / Susitna River

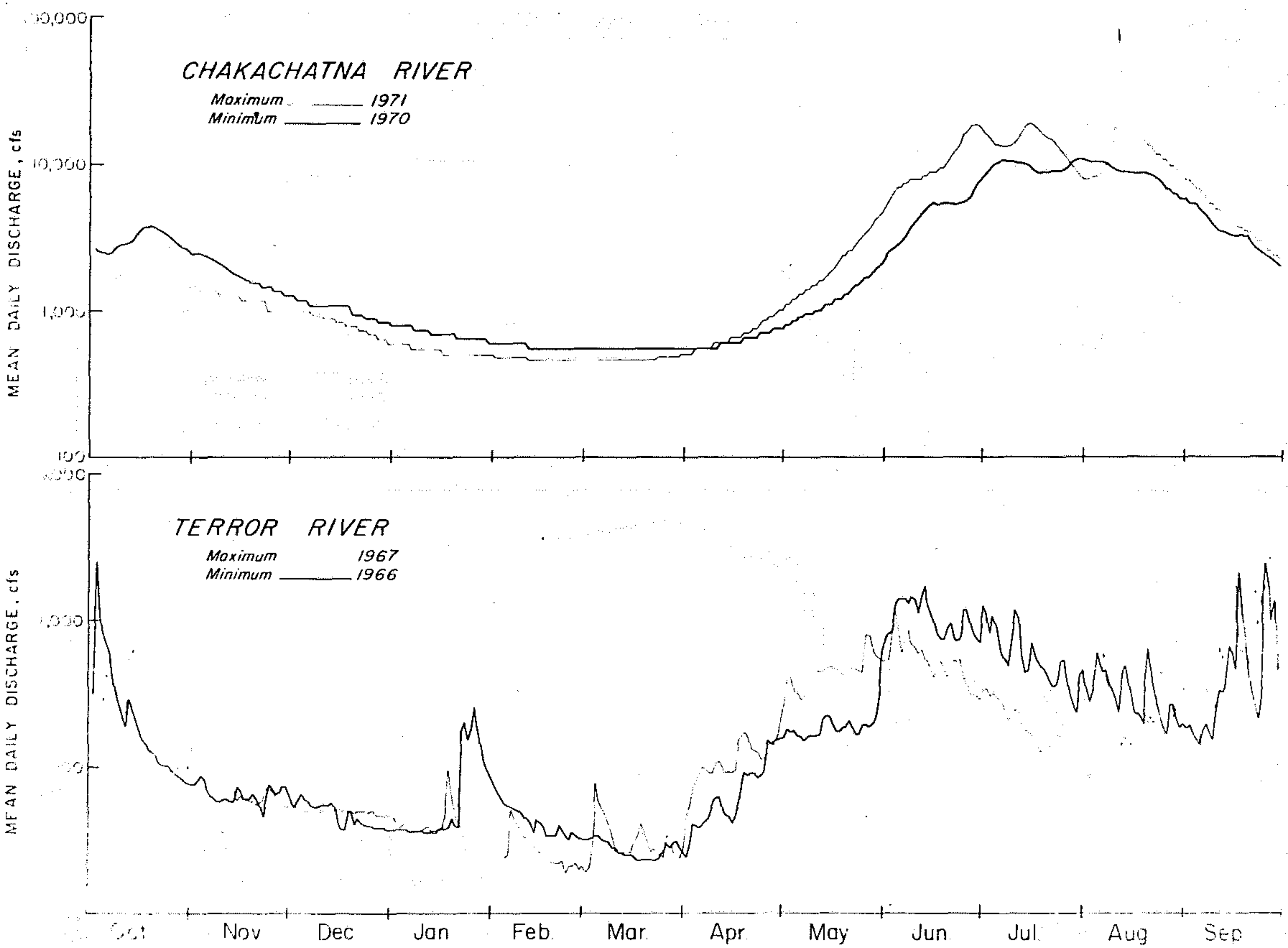


FIGURE 15, HYDROGRAPHS - Chakachatna River / Terror River

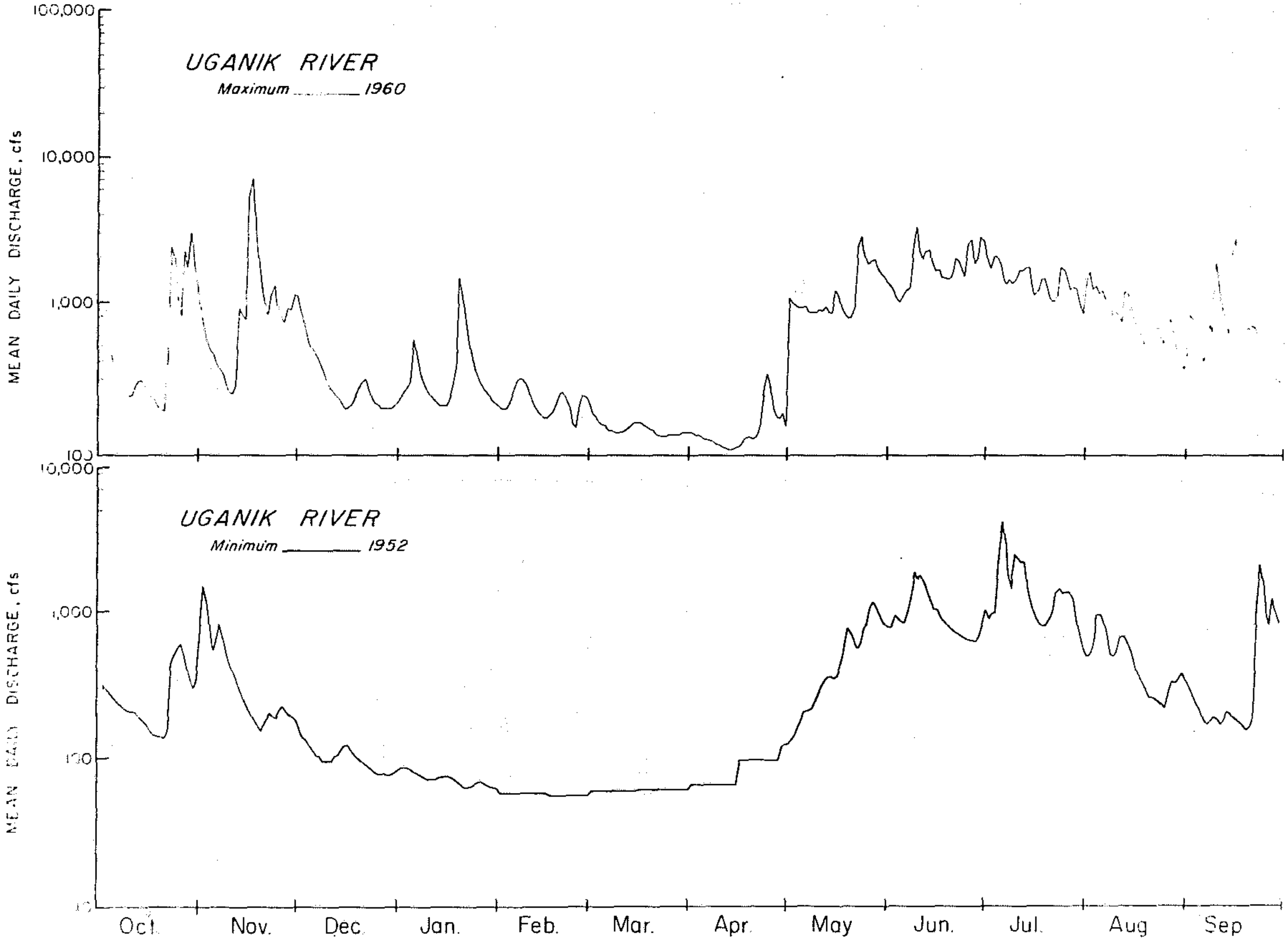


FIGURE 16, HYDROGRAPHS-Uganik River

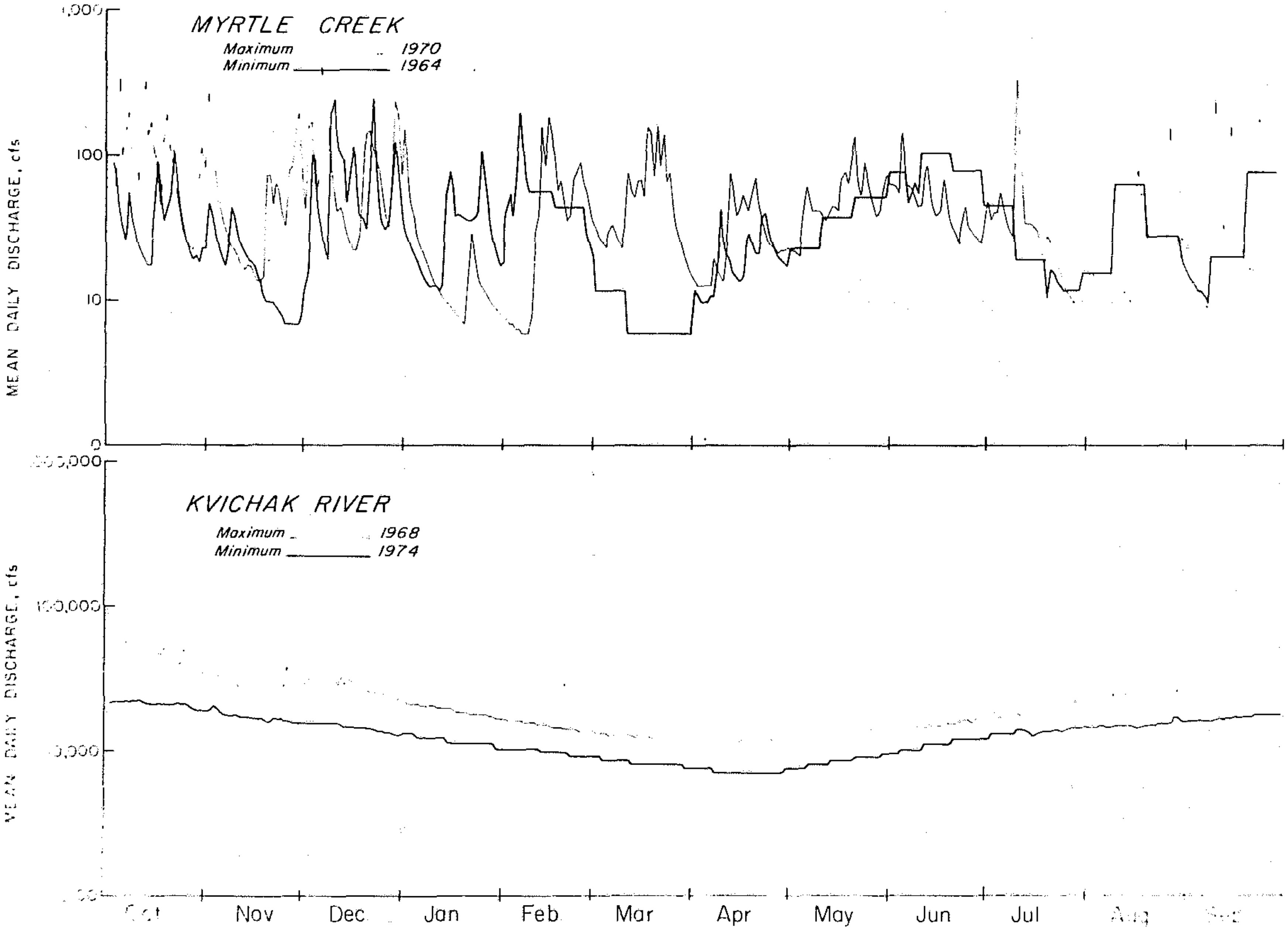


FIGURE 17, HYDROGRAPHS - Myrtle Creek / Kvichak River

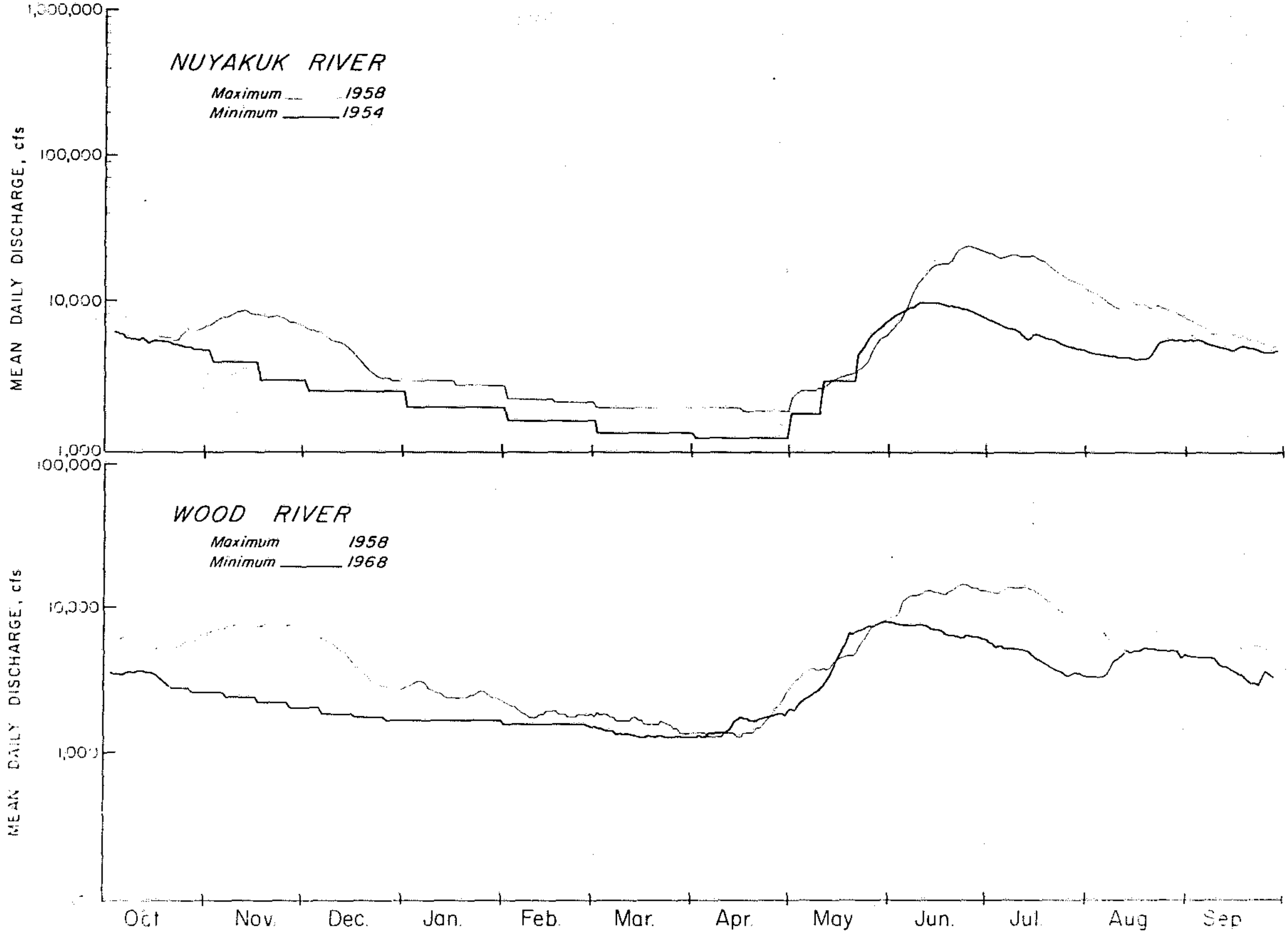


FIGURE 18, HYDROGRAPHS - Nuyakuk River / Wood River

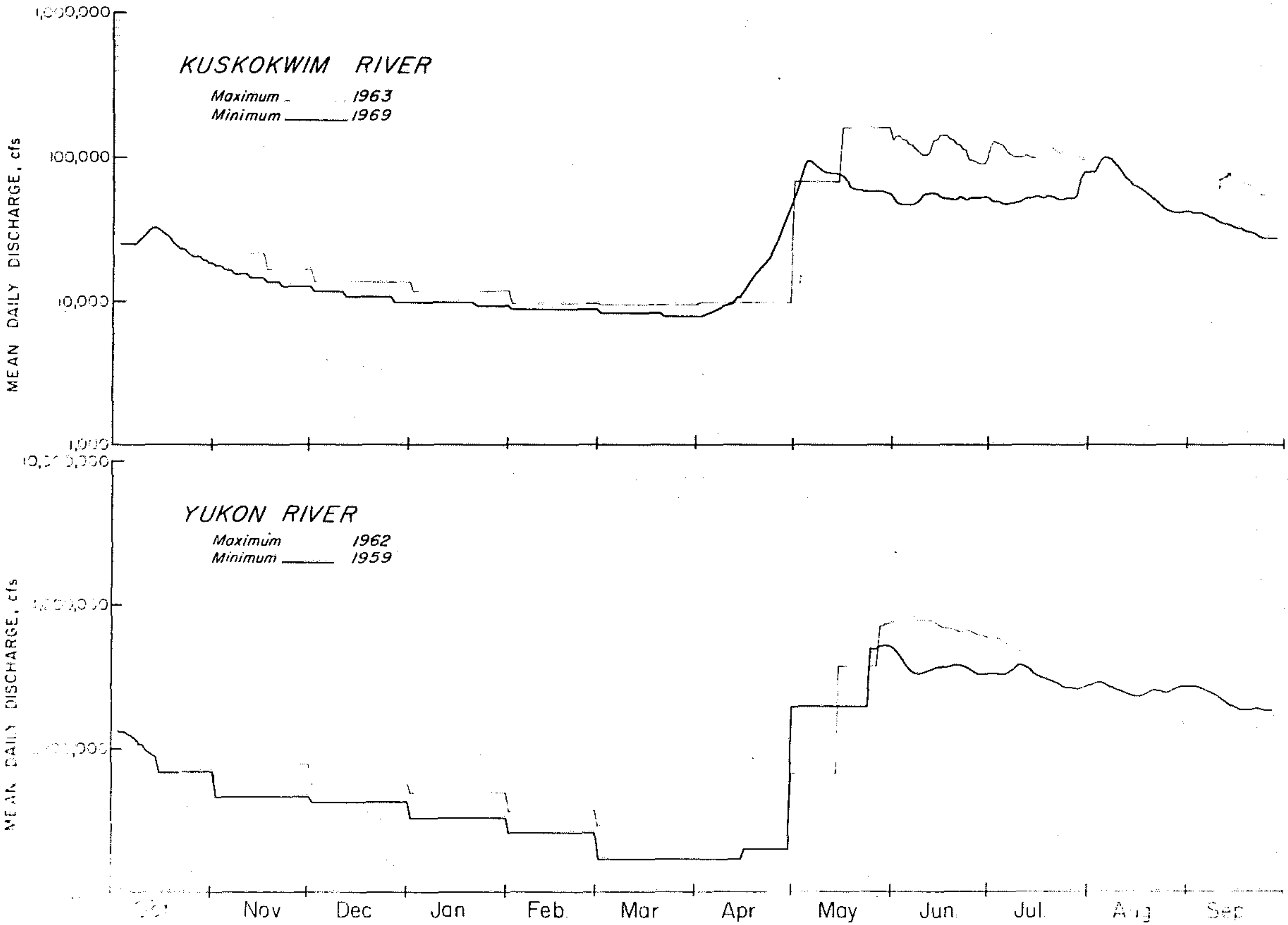


FIGURE 19, HYDROGRAPHS - Kuskokwim River / Yukon River

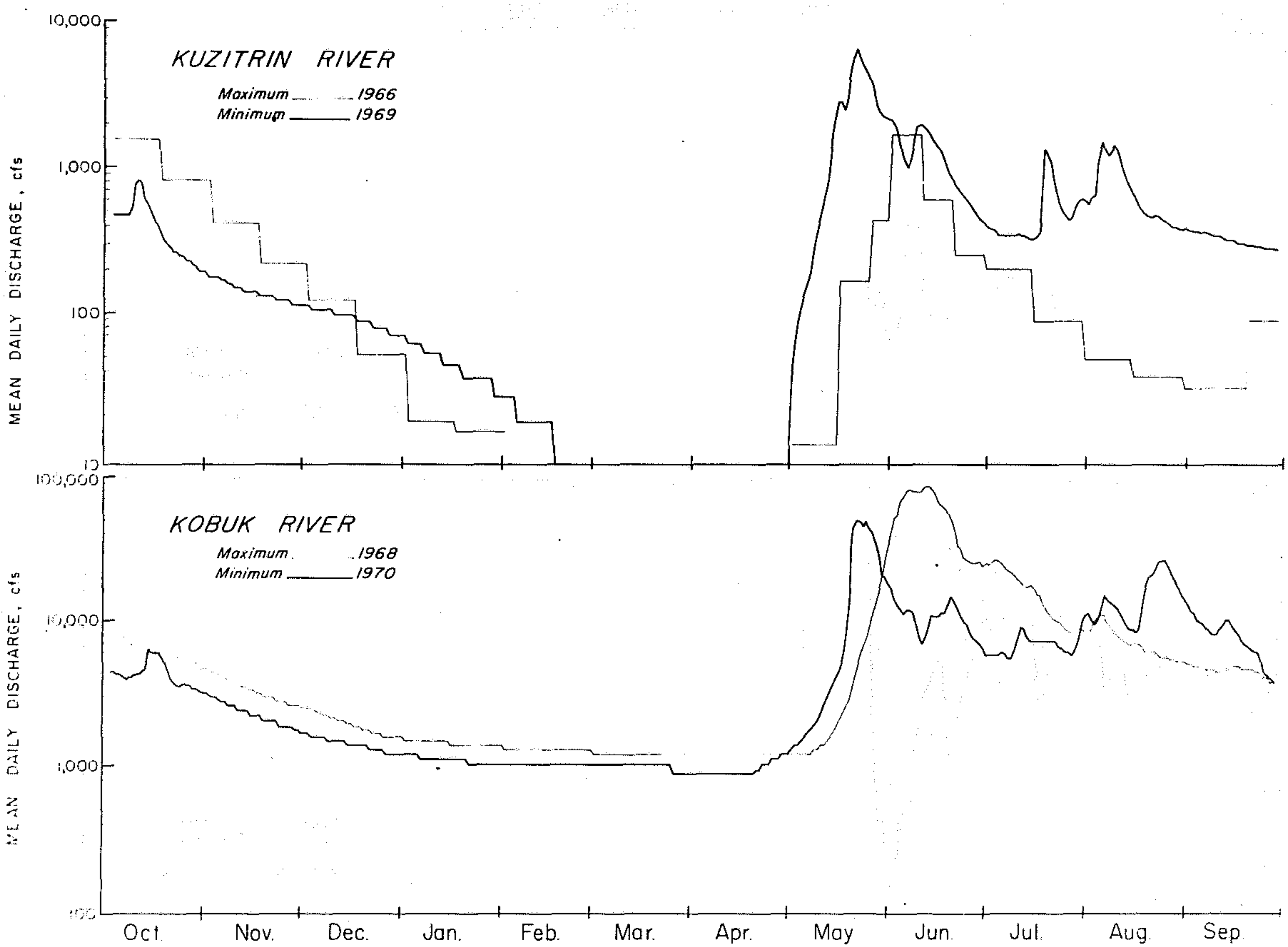


FIGURE 20, HYDROGRAPHS - Kuzitrin River / Kobuk River

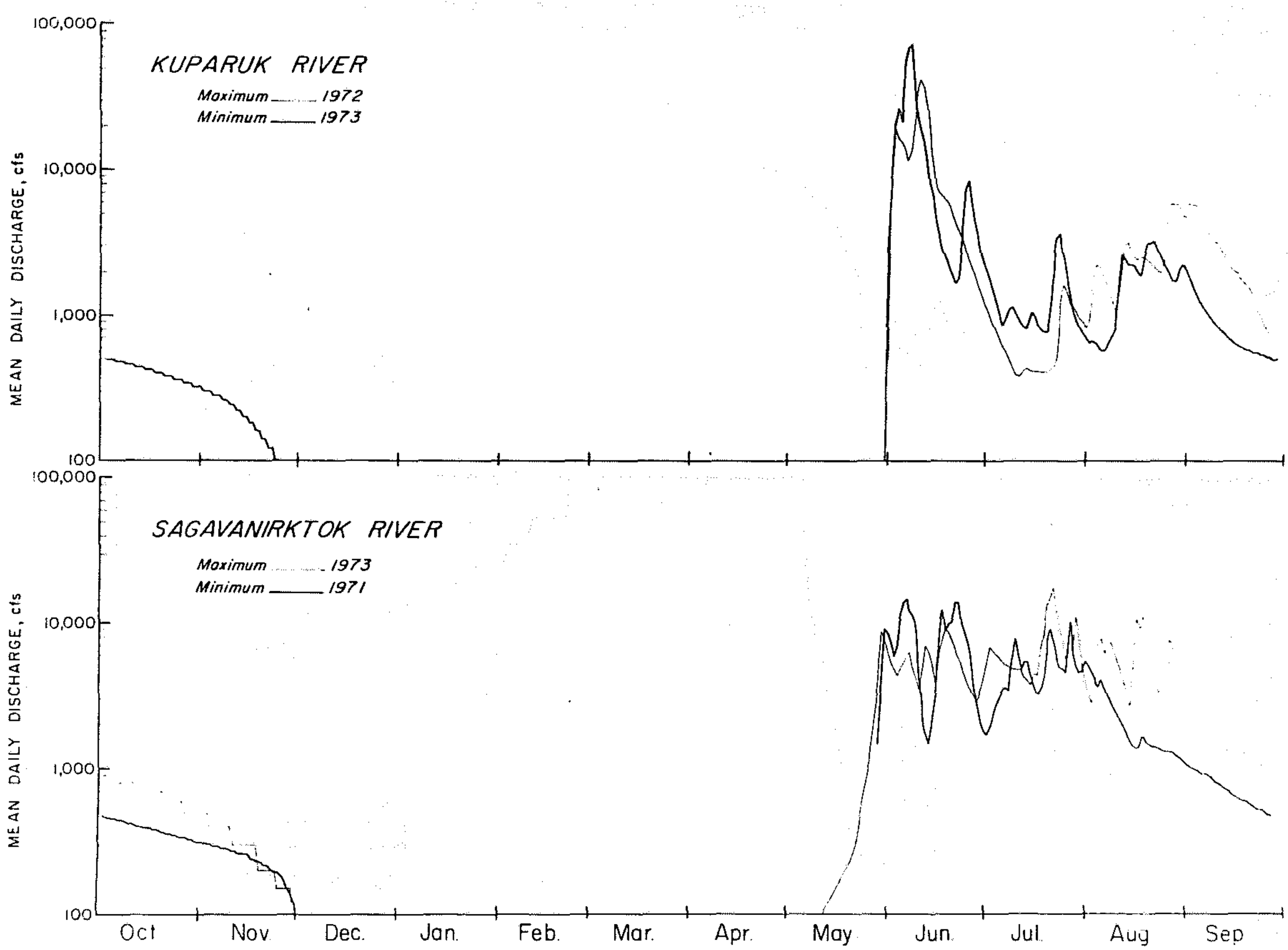


FIGURE 21, HYDROGRAPHS - Kuparuk River / Sagavanirktok length of record are the endpoints of the flow duration curves, the range is stated on each respective flow duration curve plot.

E. Flow Mass Curves:

A flow mass curve (Figure 28) is the cumulative sum of the flow of a stream over its length of record. Often flow-mass curves are valuable for reservoir studies, but they also are valuable as subtle indicators of streamflow variability and seasonability. Normally, flow drops off quickly in the late autumn and reaches its lowest point during March and early April. This is especially true of the Arctic rivers and those which are in the continental climatic zone. This is indicated by a cyclic flow mass curve which is somewhat predictable and is essentially a seasonally controlled variable. Rivers confined to the coastal areas, especially the smaller streams such as Power Creek near Cordova, Lowell Creek and Spruce Creek near Seward; Myrtle Creek; and the Terror and Uganik Rivers on Kodiak Island, all have high variability of flow which usually continues throughout the year. These basins are probably more subject to thaw periods and rainstorms in winter than are the larger coastal basins. Flow-mass curves are illustrated by two examples, the Copper River and Power Creek near Cordova. For the additional rivers, the value of the average annual flow contribution is tabulated in Table 5.

F. Exceedance Series:

The following graphs (Figures 29 through 37) for each river of OCS interest are plotted in order to show the his-

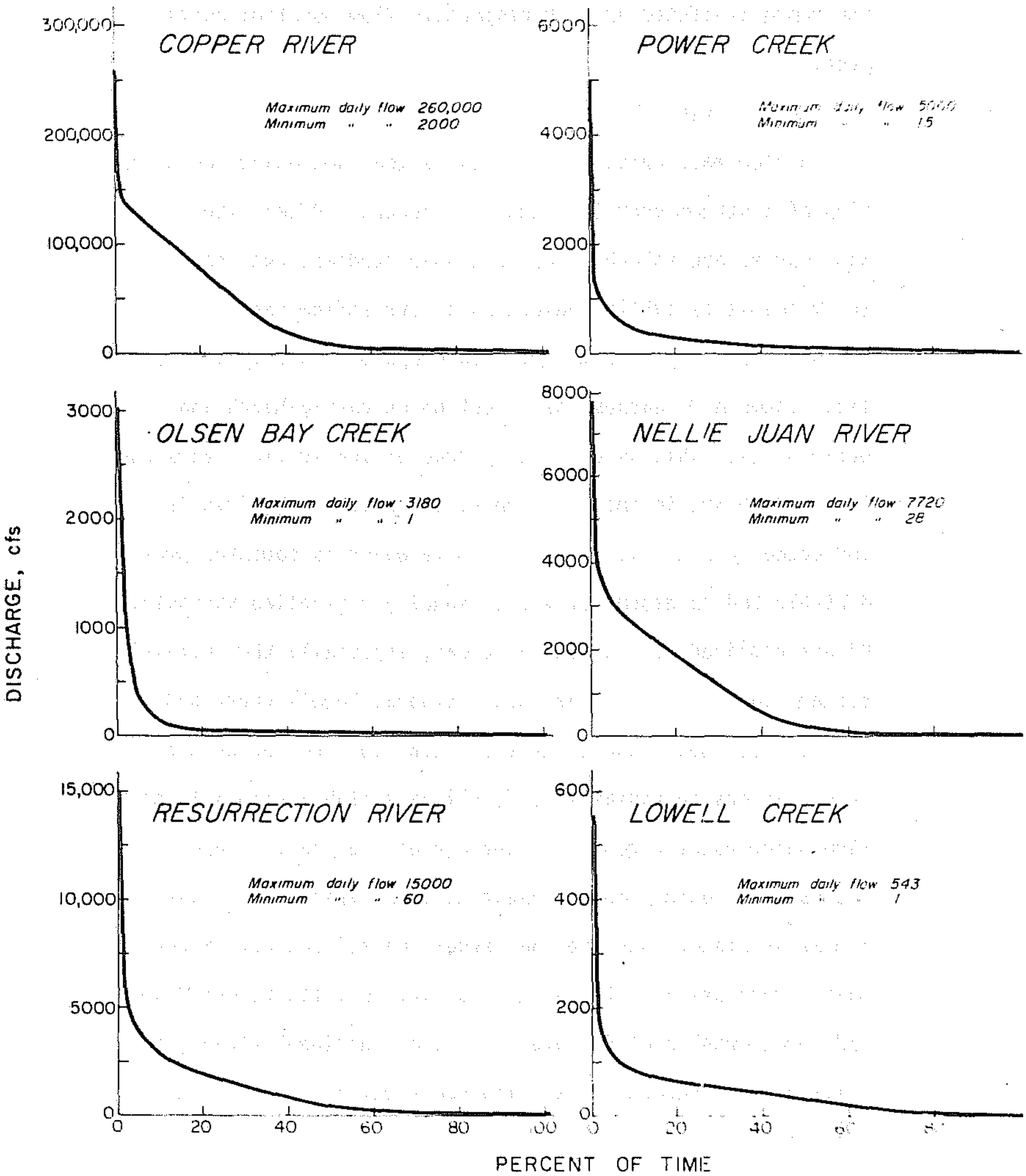


FIGURE 22, FLOW DURATION CURVES

Copper River, Power and Olsen Bay Creeks, Nellie Juan and Resurrection Rivers, and Lowell Creek

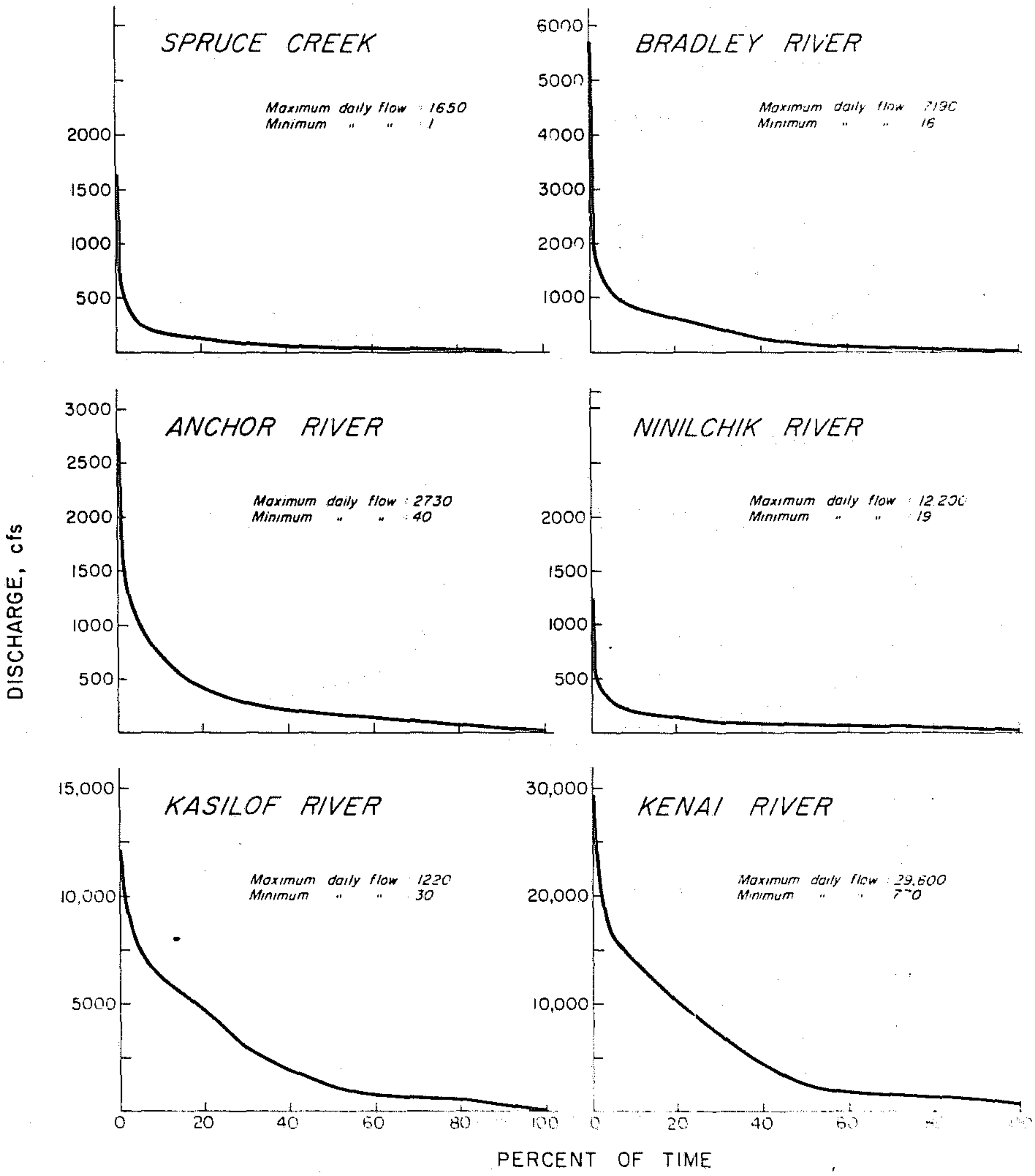


FIGURE 23, FLOW DURATION CURVES

Spruce Creek, Bradley, Anchor, Ninilchik, Kasilof & Kenai Rivers

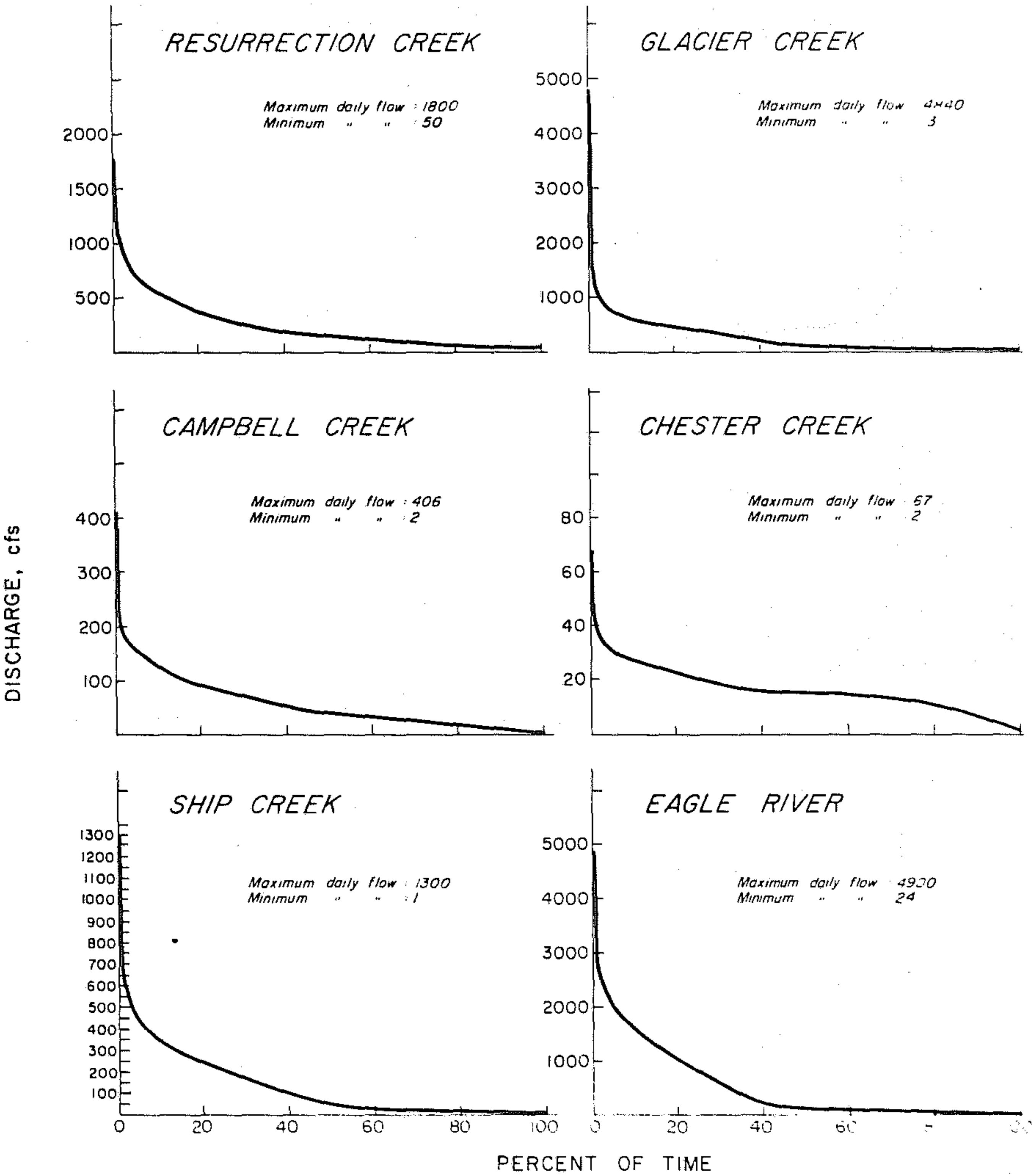


FIGURE 24, FLOW DURATION CURVES

Resurrection, Glacier, Campbell, Chester, & Ship Creeks and Eagle River

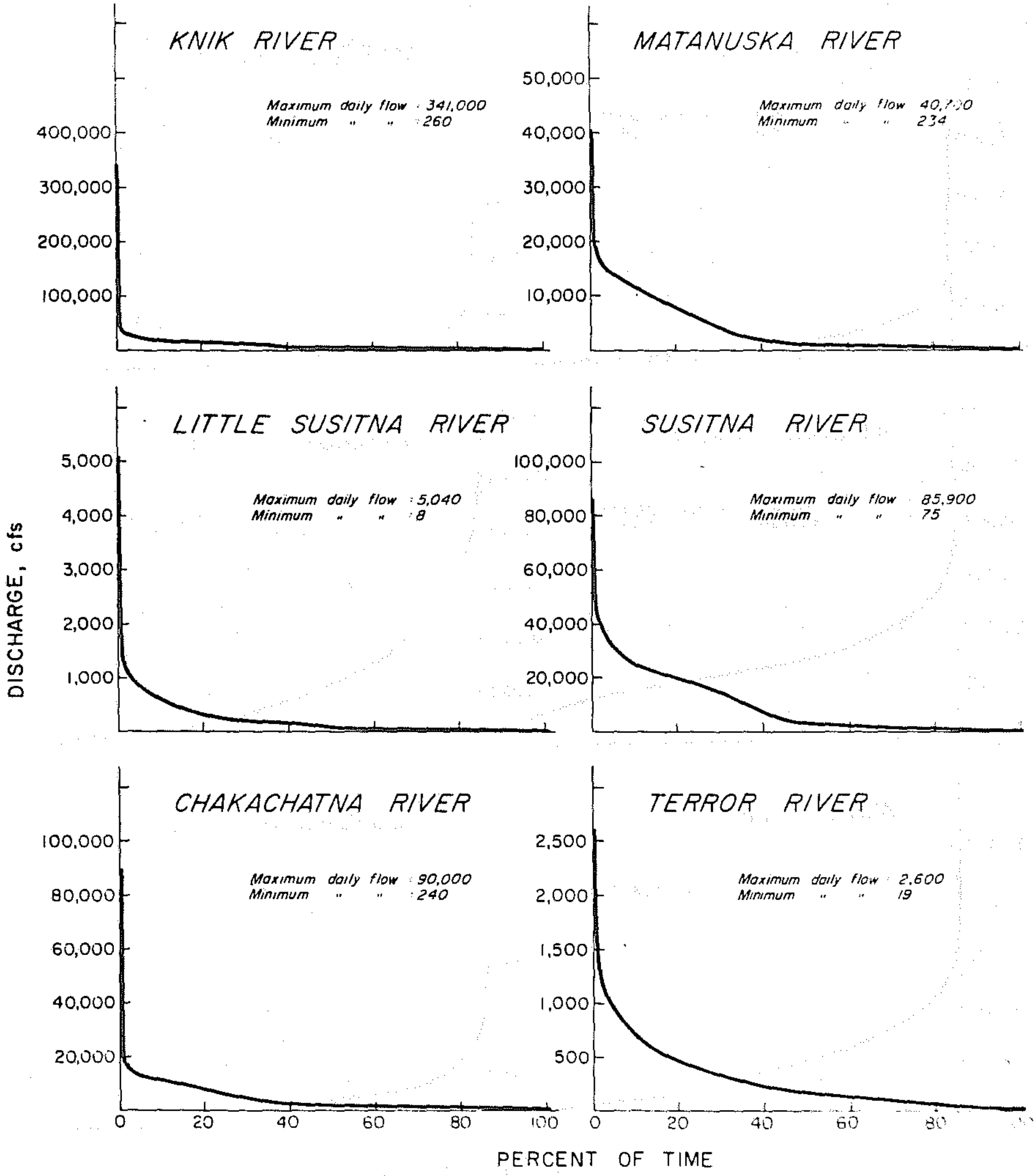


FIGURE 25, FLOW DURATION CURVES

Knik, Matanuska, Little Susitna, Susitna, Chakachatna & Terror Rivers

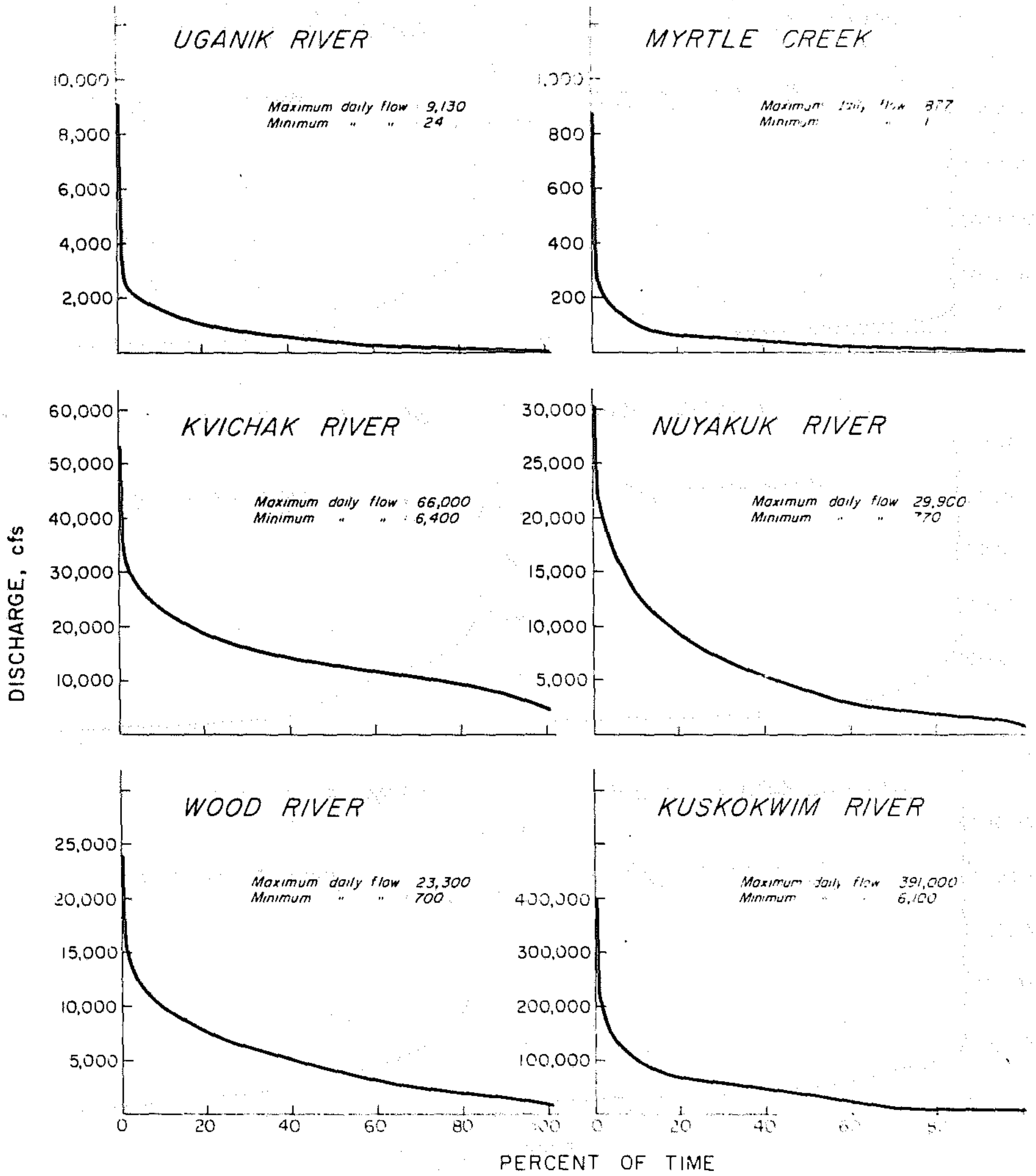


FIGURE 26, FLOW DURATION CURVES

Uganik River, Myrtle Creek, Kvichak, Nuyakuk, Wood and Kuskokwim Rivers

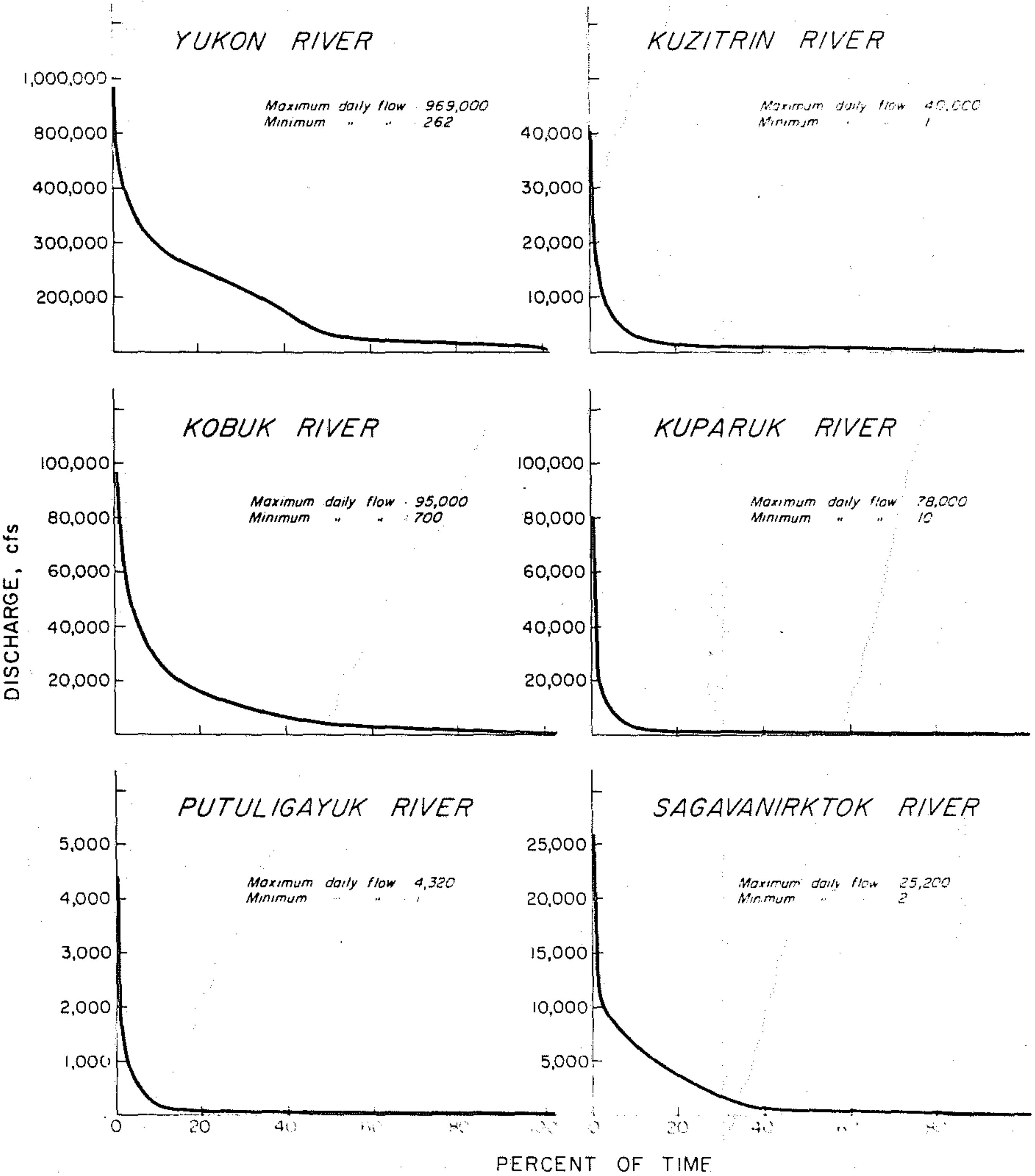
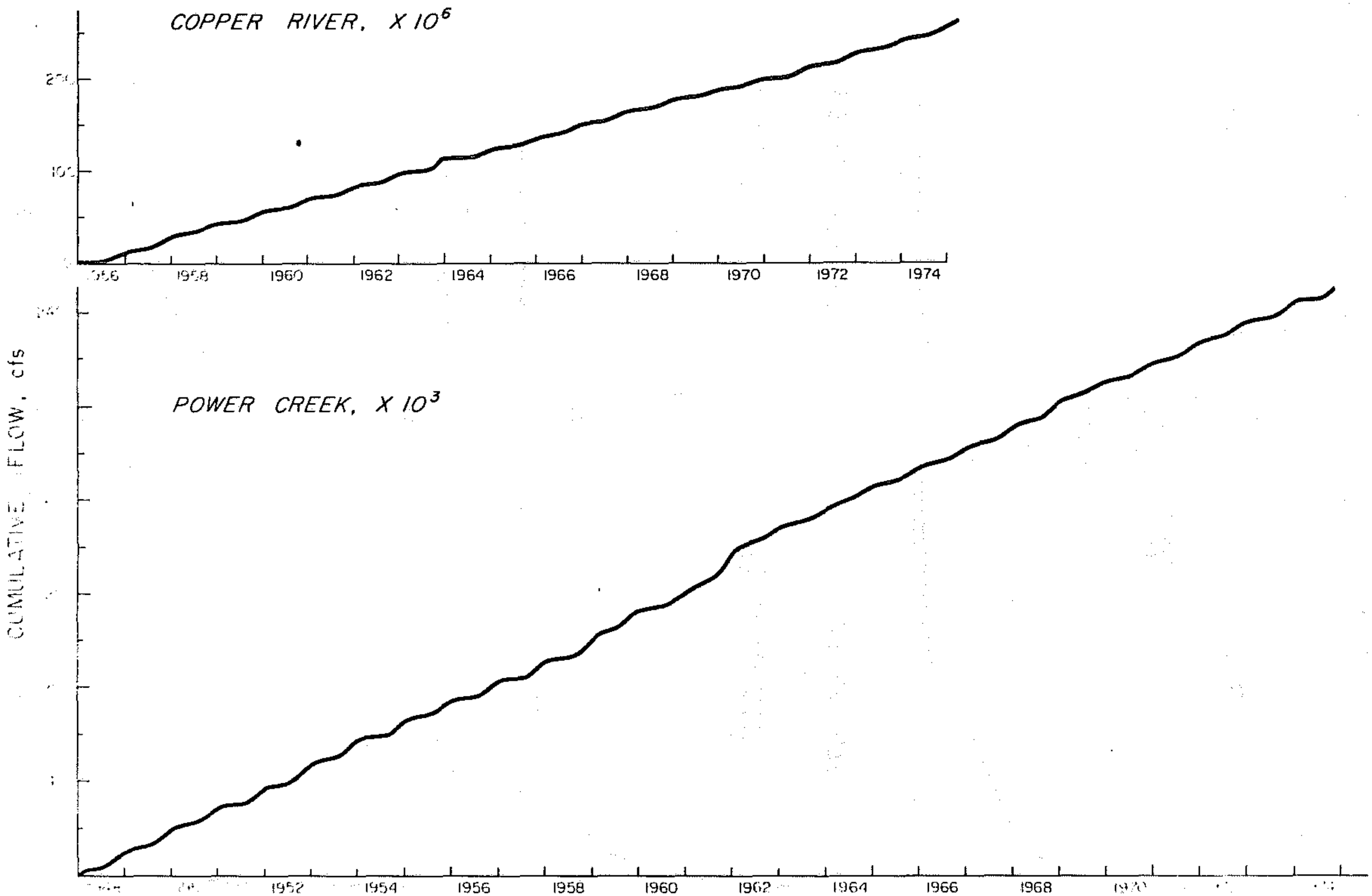


FIGURE 27, FLOW DURATION CURVES
Yukon, Kuzitrin, Kobuk, Kuparuk, Putuligayuk and Sagavanirktok Rivers



EXAMPLES OF FLOW MASS CURVES

FIGURE 28, EXAMPLES OF FLOW MASS CURVES
Copper River and Power Creek

torical flow as a percentage of exceedance. This can best be understood by discussing an example. For instance, the points on the graph of the Copper River for July 1 (Figure 28) are interpreted in the following way. Maximum flow on that date was approximately 260,000 cubic feet per second (the uppermost dark line). The second line (dashed) intercepts July 1 at 150,000 cubic feet per second. This is the 0.25 exceedance curve, and indicates that on July 1, 25% of the years of record had a flow which exceeded 150,000 cubic feet per second. Likewise the third line (dotted) indicates that in one half of the years of record (0.50 exceedance) flow exceeded 135,000 cubic feet per second on July 1. The bottom curve indicates the minimum flow which has occurred on each date.

Period of record (P.O.R.) is indicated for each river on the upper right edge of the exceedance graph. For some rivers, the maximum and .25 exceedance curves will be the same because only a few years of record exist for those rivers.

G. Short-Term Variability Indices:

Short-term variability (Figures 38 through 43) is an important consideration in the hydrology of Alaskan coastal streams, especially in the Arctic. Here seasonability is most dramatic and large changes in flow can take place over a short period of time. An extreme example is the Putuligayuk River, a small river basin which is confined to the Arctic coastal plain. Flow during June 1972 went from 0 cubic feet per second on June 9, to 4000 cubic feet per second on June 13, then back to 762 cubic feet per second on June 16.

TABLE 5
AVERAGE ANNUAL FLOW-MASS VALUE

USGS Reference Number	River	Beginning Record CFS-Month	End of Record CFS	Period of Record (POR) Years	Avg. Annual Value CFS-Year
15212000	Copper	$ 440,200	242,396,420	19	8,343,310
15219000	W. F. Olsen Bay Cr.	799	359,122	6	59,720
15216000	Power Cr.	9,700	2,495,000	27	92,048
15237000	Nellie Juan R.	4,640	1,501,102	4.5	332,544
15237700	Resurrection R. Nr., Seward	36,518	1,551,409	3.33	403,944
15238500	Lowell Cr.	667	52,002	<1.0	15,415
15238600	Spruce Cr.	7,964	190,749	7.0	26,112
15239000	Bradly R.	20,656	2,516,850	17.0	1,468,835
15240000	Anchor R.	10,316	1,419,686	13.0	108,413
15241600	Ninilchik R.	6,597	395,959	10.4	37,390
15242000	Kasilof R.	128,660	18,290,219	21.0	864,836
15258000	Kenai R.	121,780	26,833,381	26.0	1,027,369
15267900	Resurrection Cr. (Hope)	11,320	633,374	7.0	88,865
15272550	Glacier Cr.	5,884	834,926	9.0	92,116
15274600	Campbell Cr.	2,577	166,715	8.0	20,517
15275100	Chester Cr.	399	44,224	9.75	4,495
15276000	Ship Cr.	6,200	382,945	12.5	30,139
15277100	Eagle R.	13,170	1,507,742	8.0	186,821
15281000	Knik R.	118,490	35,283,653	14.0	2,511,797
15284000	Matanuska R.	72,390	32,752,329	23.0	1,420,867
15290000	Little Susitna R.	4,237	2,764,635	27.0	102,393
15292000	Susitna R.	196,370	85,475,225	24.0	3,553,285
15294500	Chakachatna R.	62,670	17,308,733	13.0	1,326,620
15295700	Terror R.	1,017	463,929	4.0	115,728
15296000	Uganik R.	9,550	5,247,624	22.0	238,094
15297200	Myrtle Cr.	450	177,919	10.33	17,179
15300500	Kvichak R.	889,000	40,878,420	6.167	6,484,420
15302000	Nuyakuk R.	183,190	44,487,480	21.0	2,109,728

TABLE 5 CONTINUED

USGS Reference Number	River	Beginning Record CFS-Month	End of Record CFS	Period of Record (POR) Years	Avg. Annual Value CFS-Year
15303600	Wood R.	210,000	28,350,000	13.0	2,164,615
15304000	Kuskokwim R.	1,162,200	397,850,000	24.0	16,428,658
15564800	Yukon R. (Ruby)	785,000	1,122,000,000	18.0	62,289,722
15712000	Kuzitrin R.	48	48,970,000	11.0	4,451,813
15744000	Kobuk R. (Ambler)	270,000	28,100,000	8.0	3,478,750
15896000	Kuparuk R.	10	199,800	4.0	49,948
15896700	Putuligayuk R.	100	45,080	4.0	11,245
15910000	Sagavanirktok R.	35,000	2,715,000	4.0	670,000

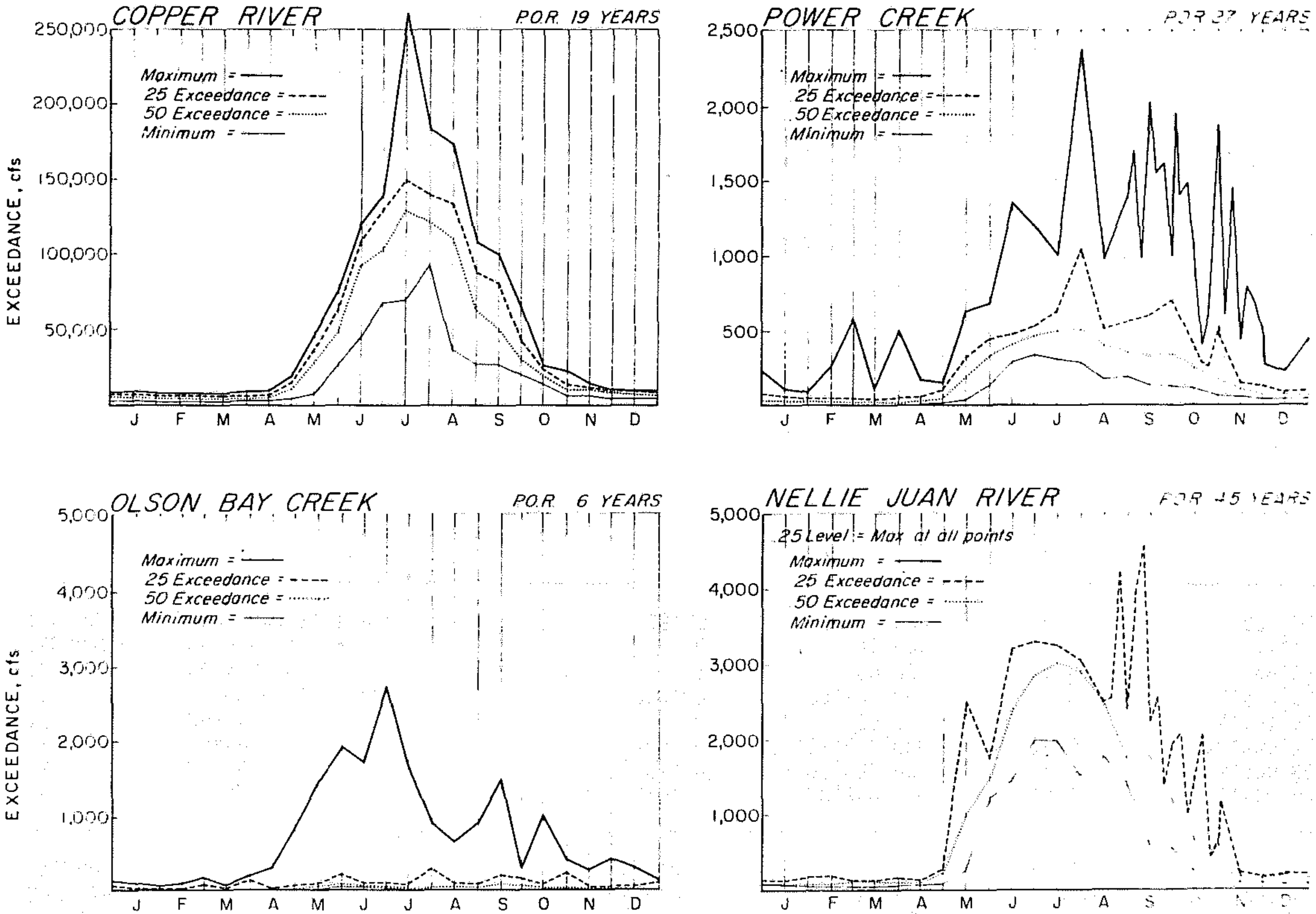


FIGURE 29, EXCEEDANCE PROBABILITIES BASED ON PERIOD OF RECORD (POR)
Copper River, Power Creek, Olson Bay Creek, & Nellie Juan River

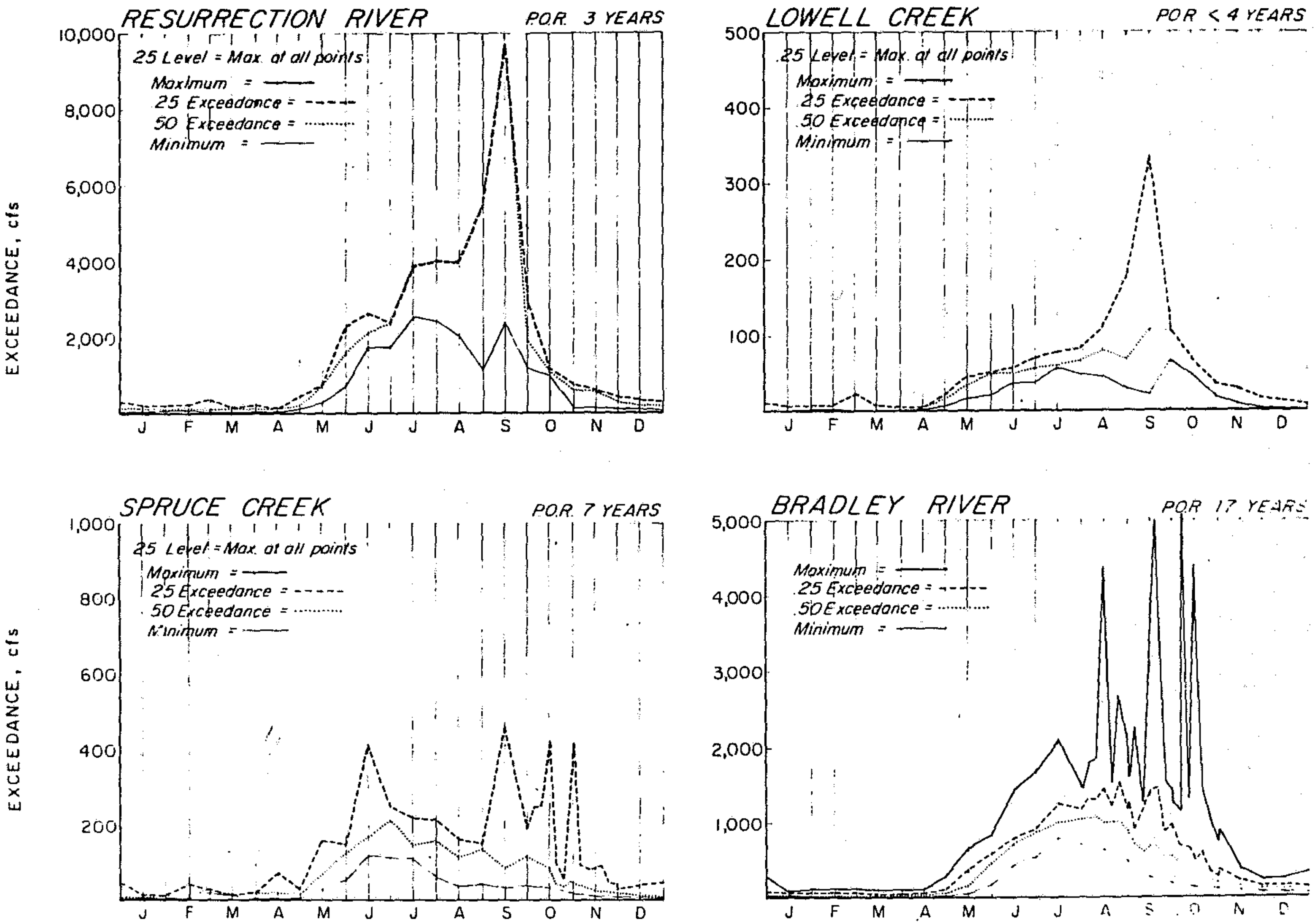


FIGURE 30, EXCEEDANCE PROBABILITIES BASED ON PERIOD OF RECORD (POR)
Resurrection River, Lowell Creek, Spruce Creek & Bradley River

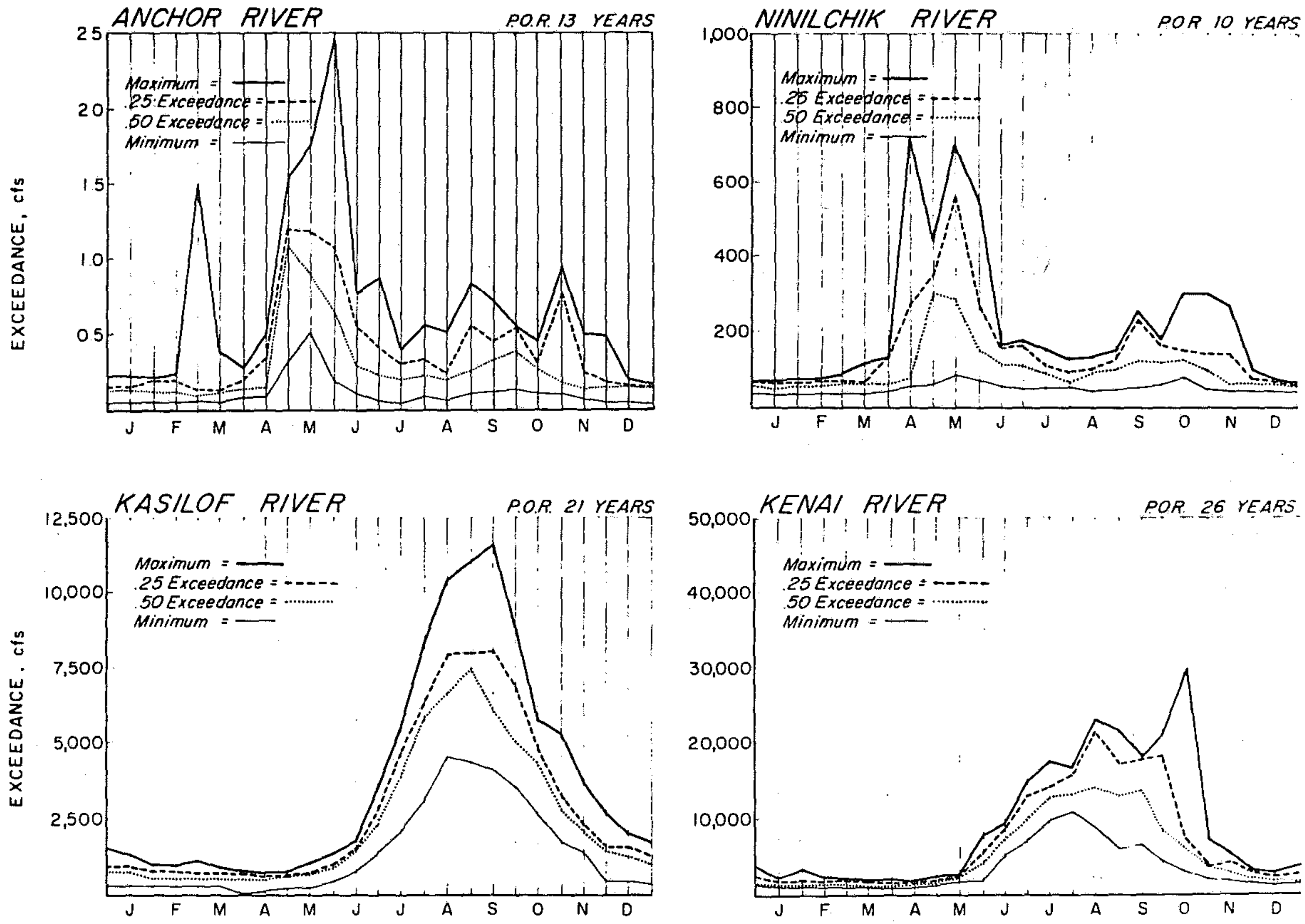


FIGURE 31, EXCEEDANCE PROBABILITIES BASED ON PERIOD OF RECORD (POR)
Anchor, Ninilchik, Kasilof & Kenai Rivers

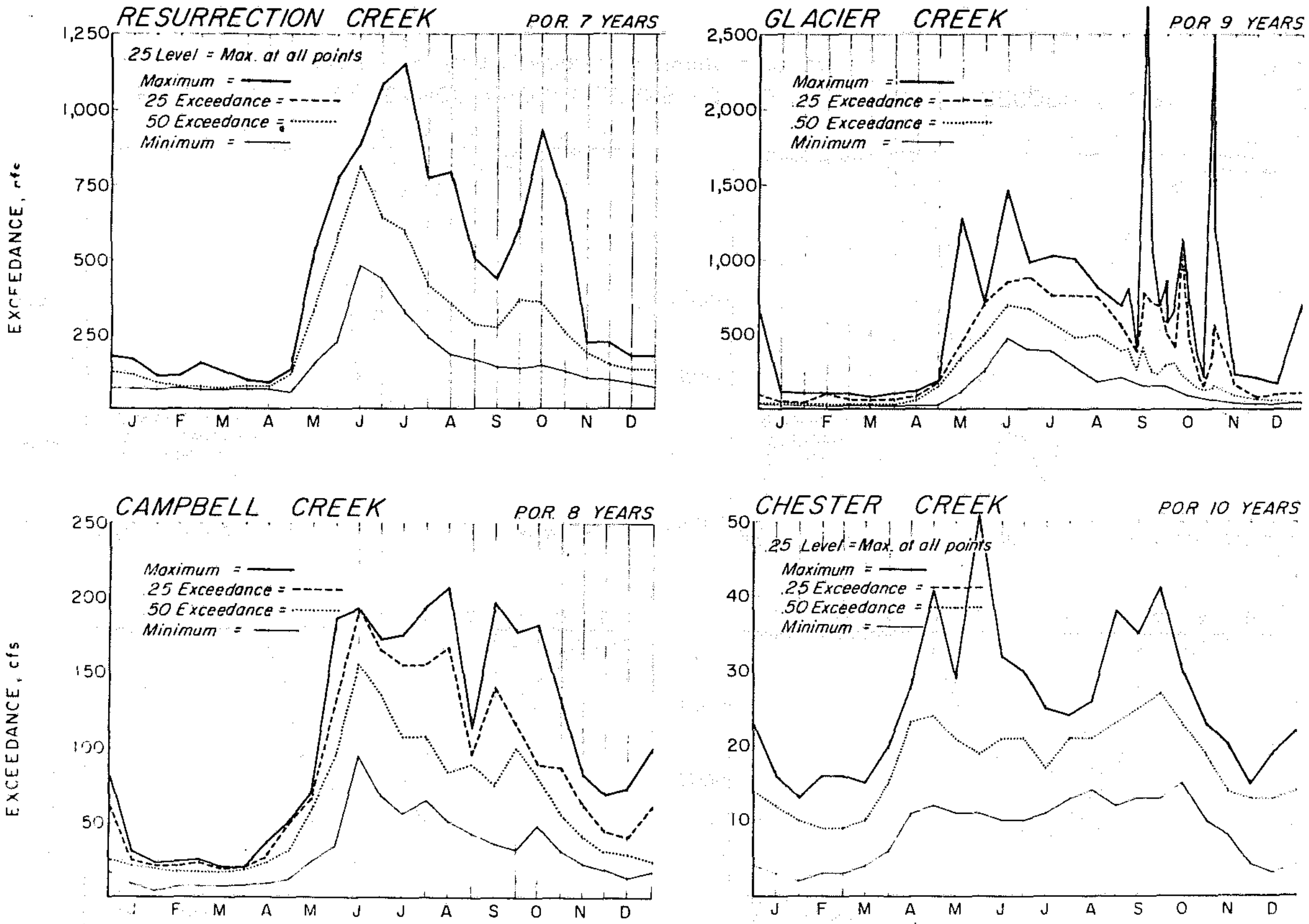


FIGURE 32, EXCEEDANCE PROBABILITIES BASED ON PERIOD OF RECORD (POR)
Resurrection, Glacier, Campbell & Chester Creeks

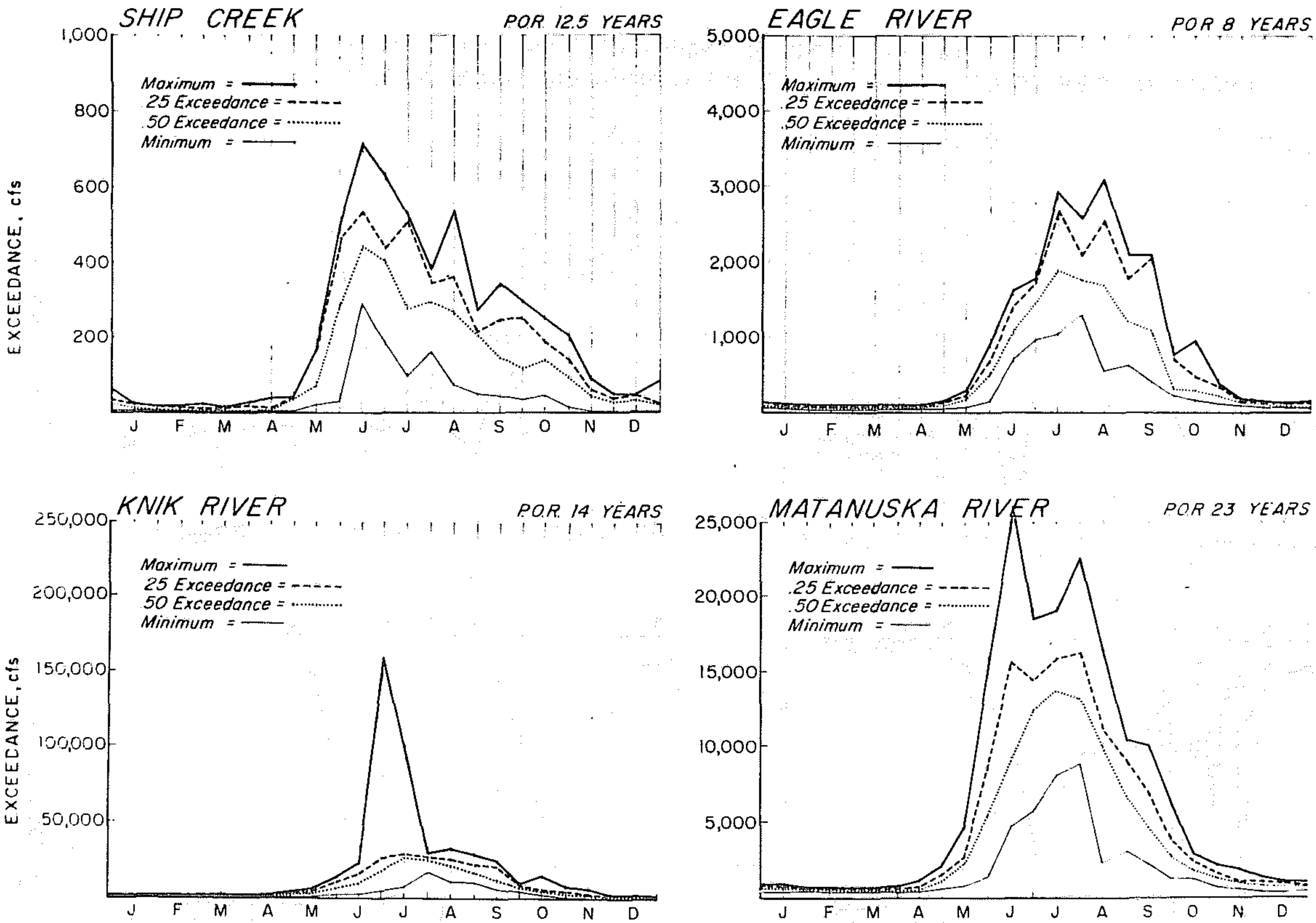


FIGURE 33, EXCEEDANCE PROBABILITIES BASED ON PERIOD OF RECORD (POR)
Ship Creek, Eagle, Knik & Matanuska Rivers

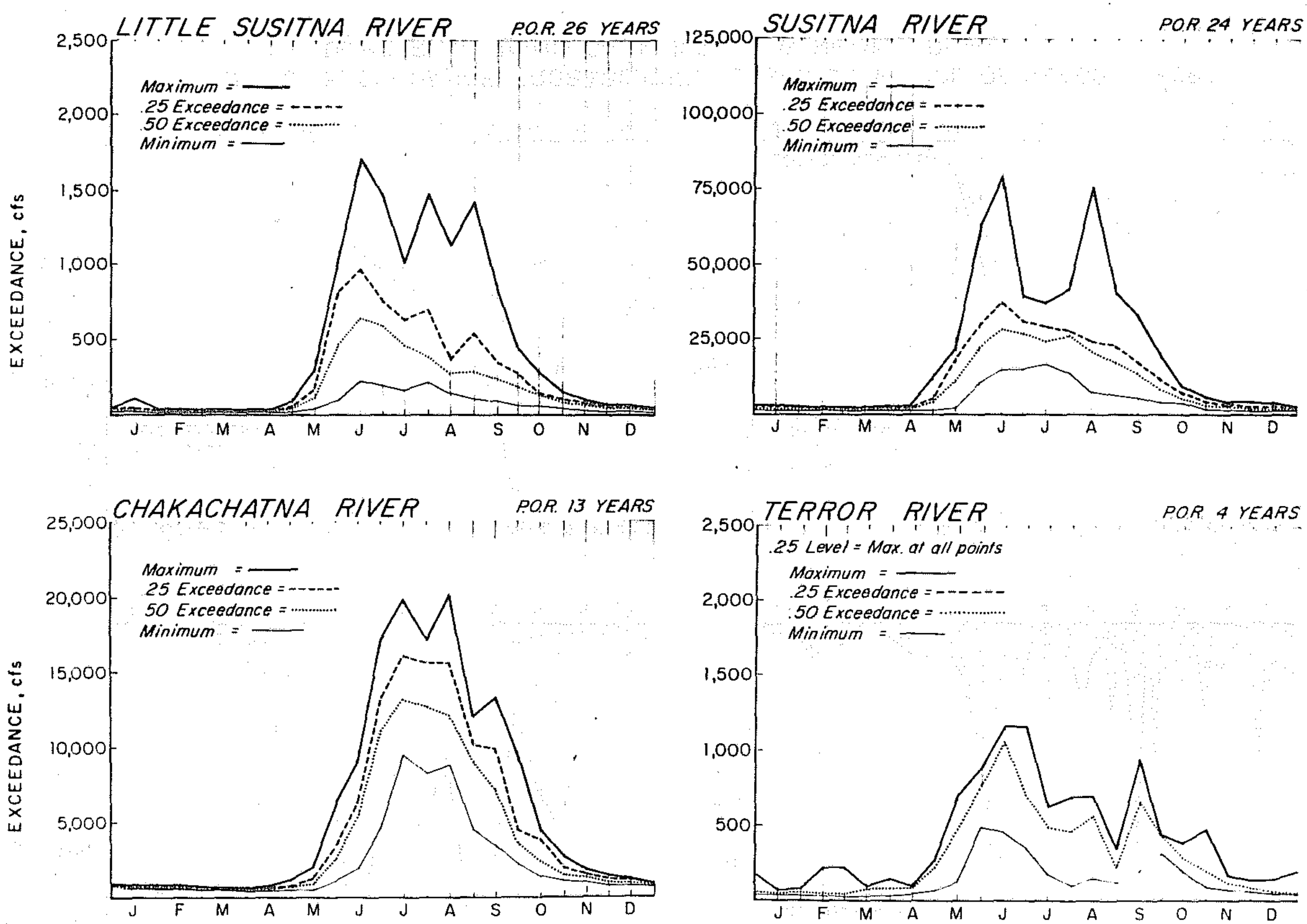


FIGURE 34, EXCEEDANCE PROBABILITIES BASED ON PERIOD OF RECORD (POR)
Little Susitna, Susitna, Chakachatna & Terror Rivers

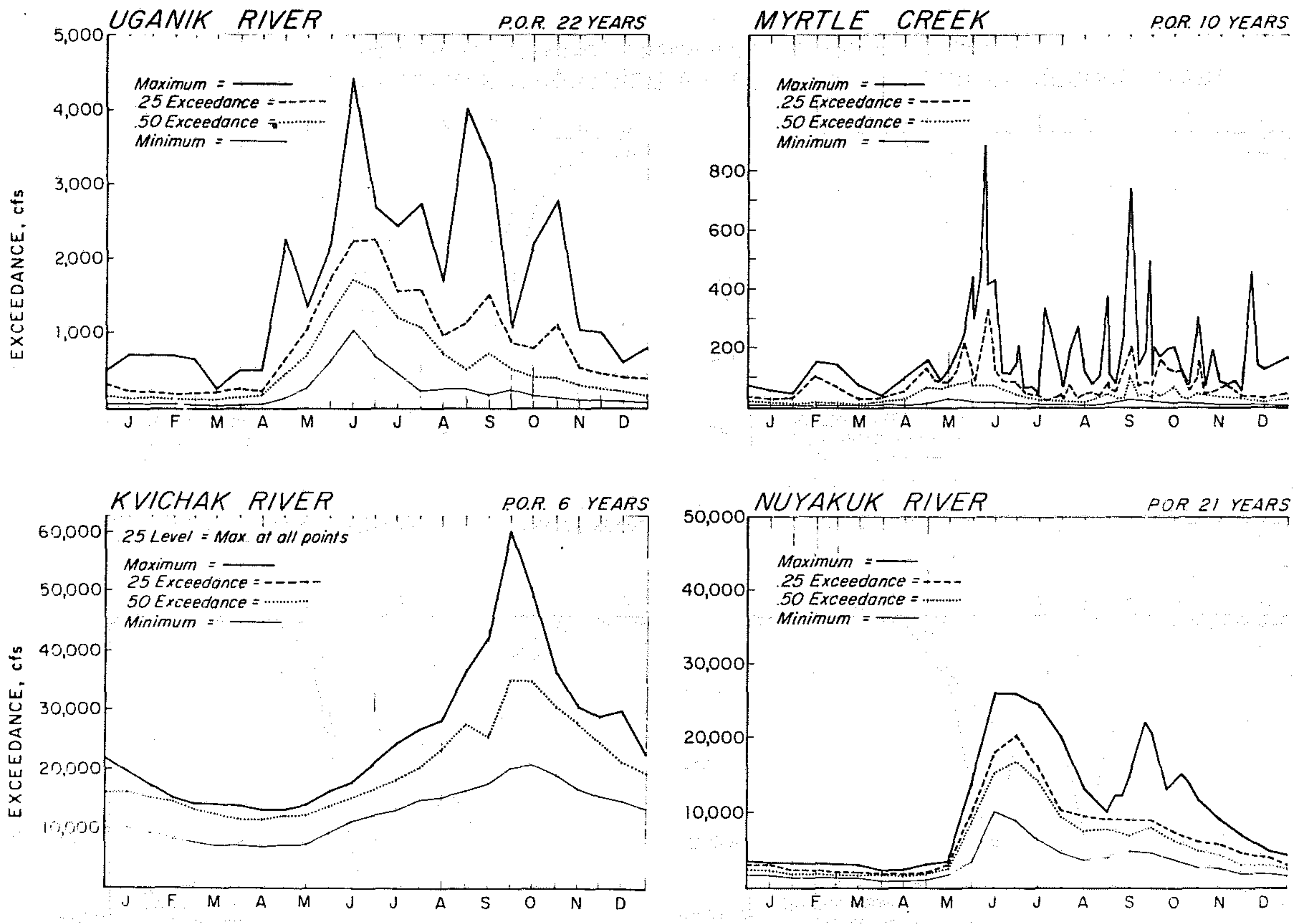


FIGURE 35, EXCEEDANCE PROBABILITIES BASED ON PERIOD OF RECORD (POR)
Uganik River, Myrtle Creek, Kvichak & Nuyakuk Rivers

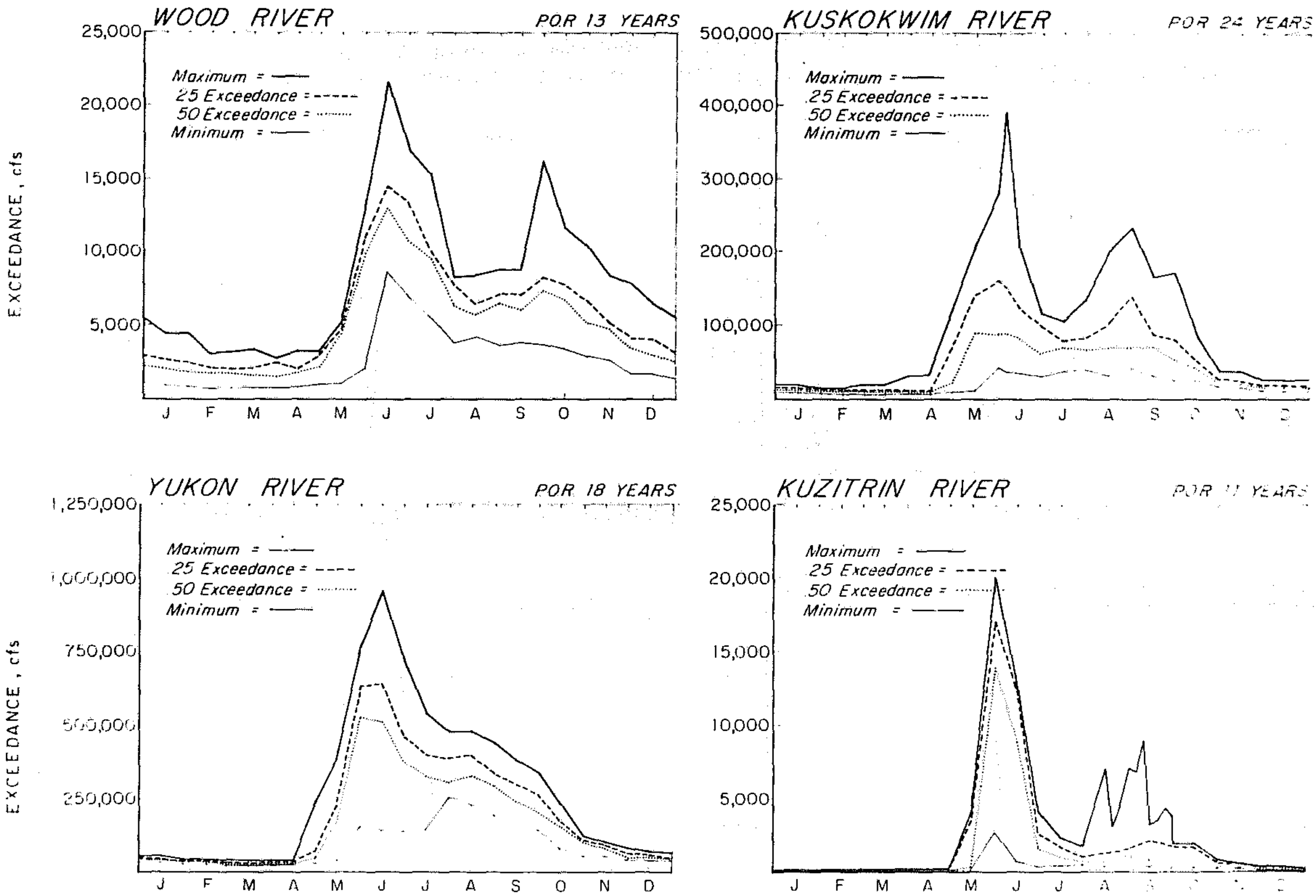


FIGURE 36, EXCEEDANCE PROBABILITIES BASED ON PERIOD OF RECORD (POR)
Wood, Kuskokwim, Yukon, & Kuzitrin Rivers

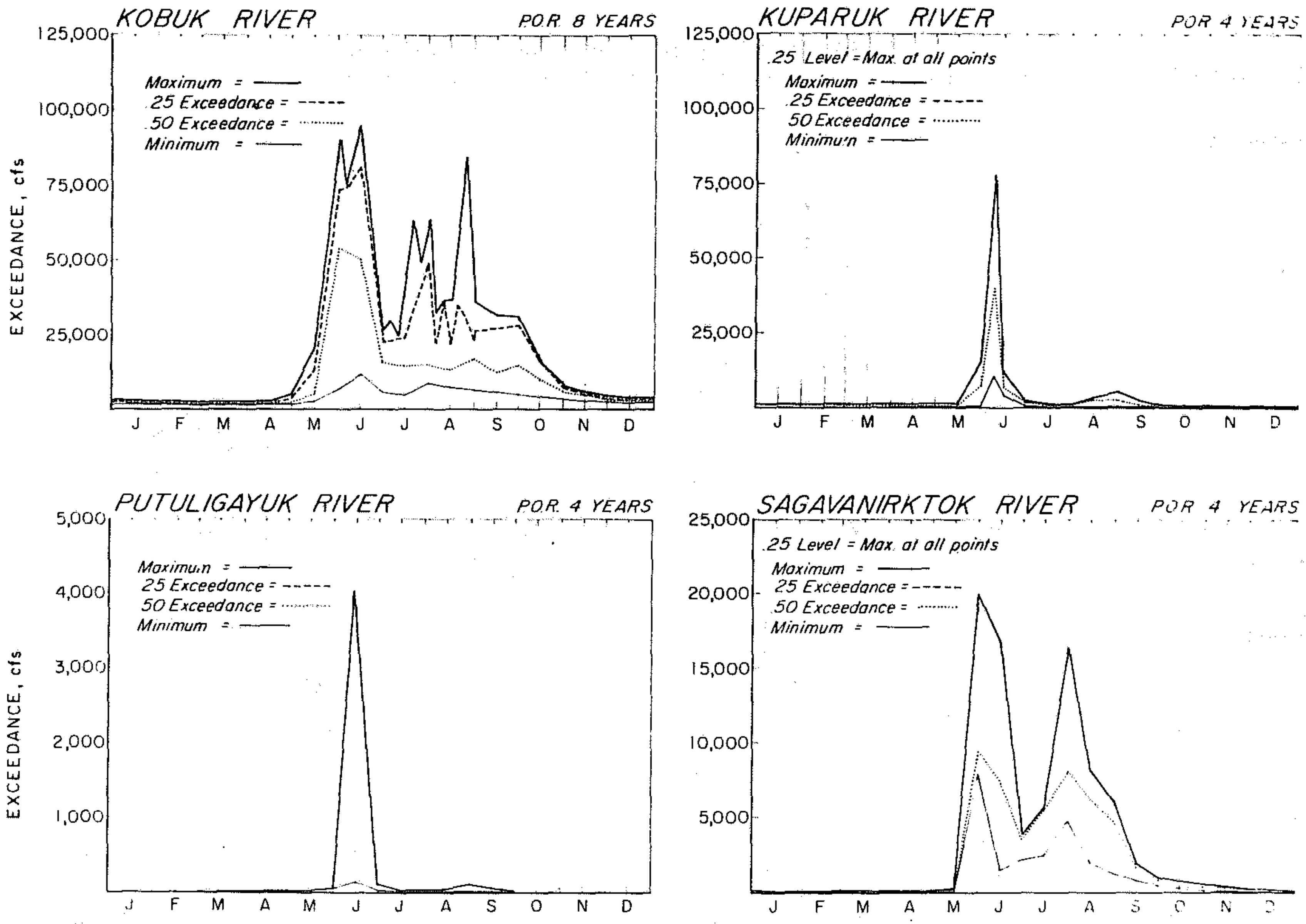


FIGURE 37, EXCEEDANCE PROBABILITIES BASED ON PERIOD OF RECORD (POR)
Kobuk, Kuparuk, Putuligayuk & Sagavanirktok Rivers

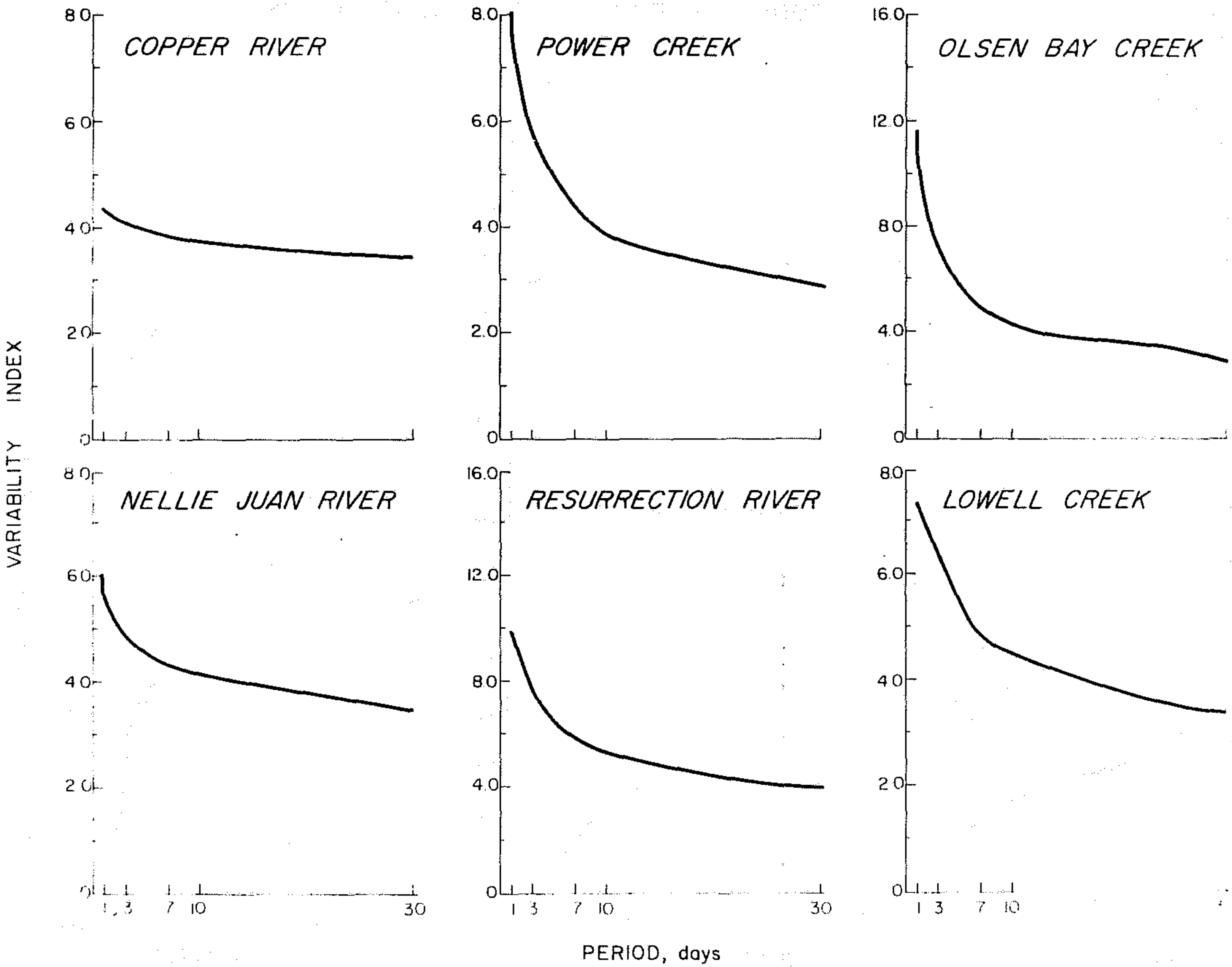


FIGURE 38, SHORT-TERM VARIABILITY INDEX
Copper, Nellie Juan, Resurrection Rivers, Power, Olsen Bay & Lowell Creeks

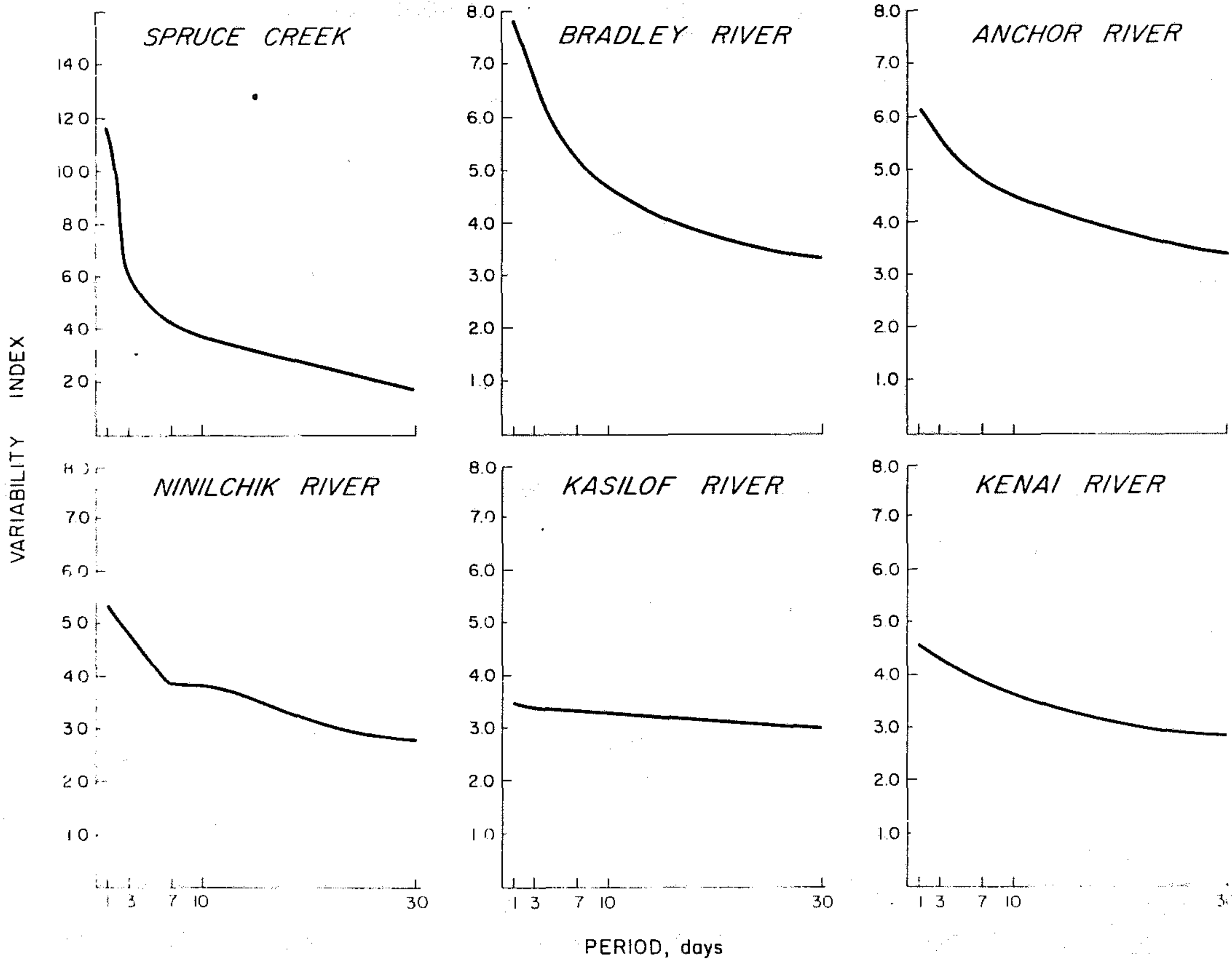


FIGURE 39, SHORT-TERM VARIABILITY INDEX
Spruce Creek, Bradley, Anchor, Ninilchik, Kasilof & Kenai Rivers

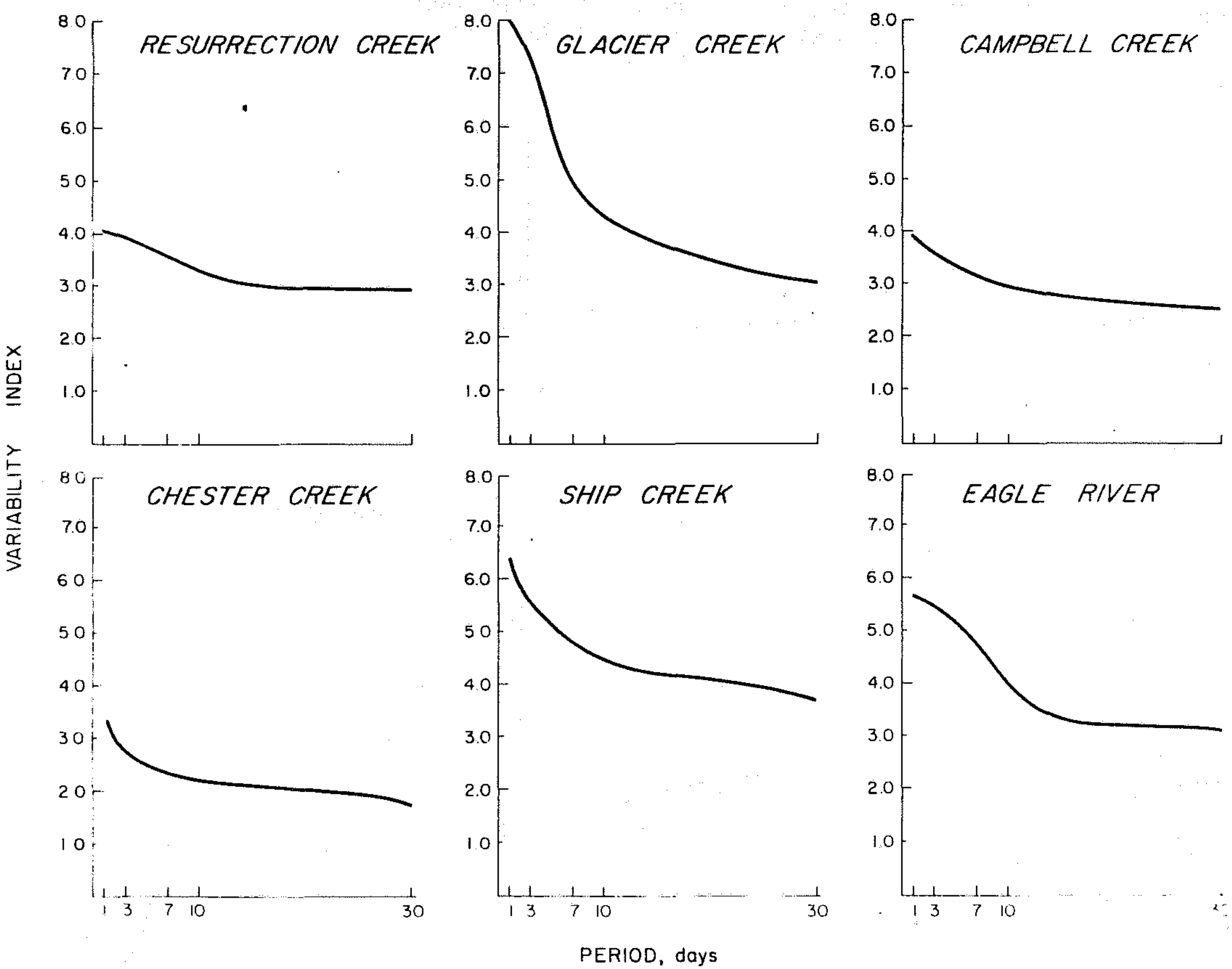


FIGURE 40, SHORT-TERM VARIABILITY INDEX
Resurrection, Glacier, Campbell, Chester, Ship Creeks & Eagle River

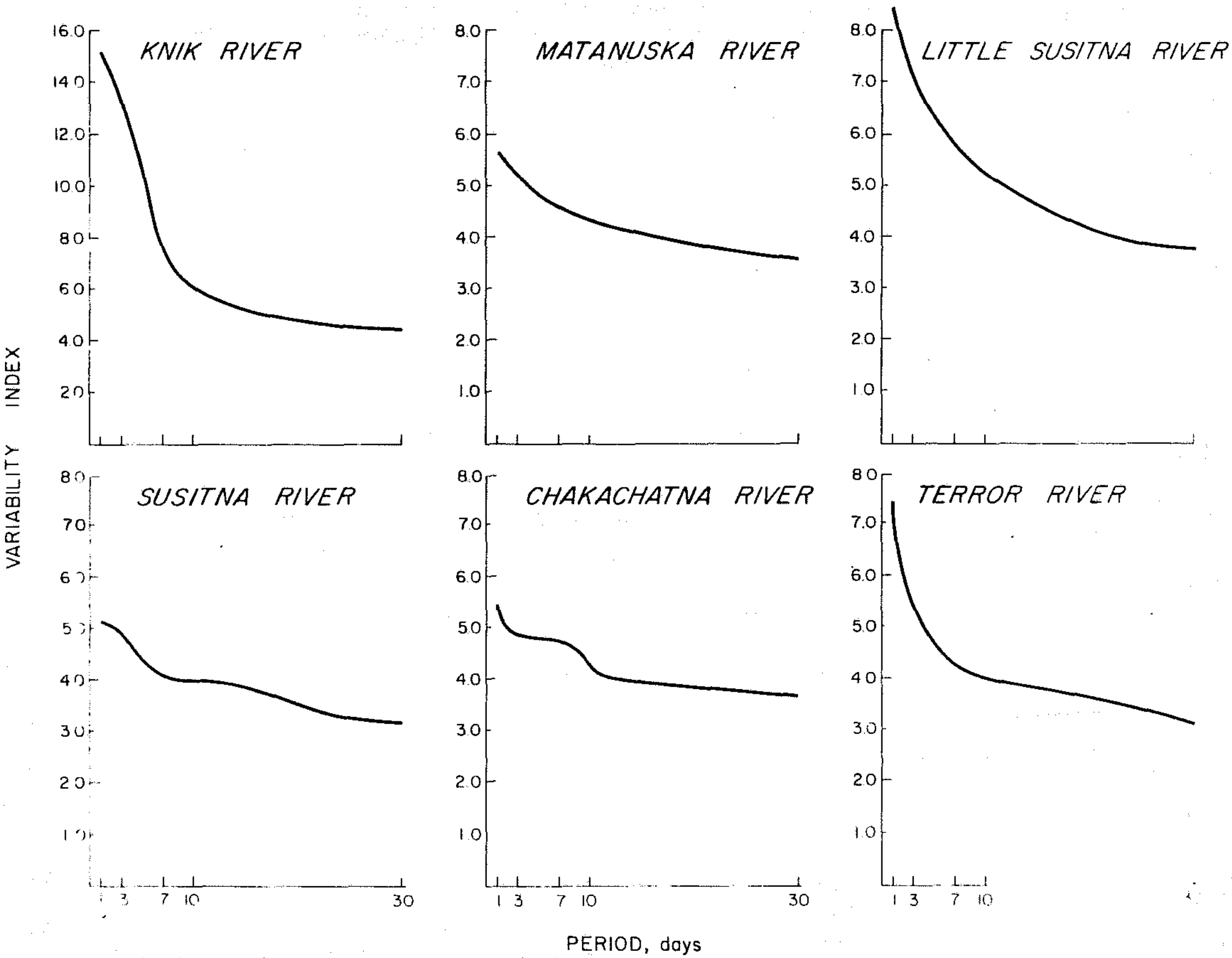


FIGURE 41, SHORT-TERM VARIABILITY INDEX
Knik, Matanuska, Little Susitna, Susitna, Chakachatna & Terror Rivers

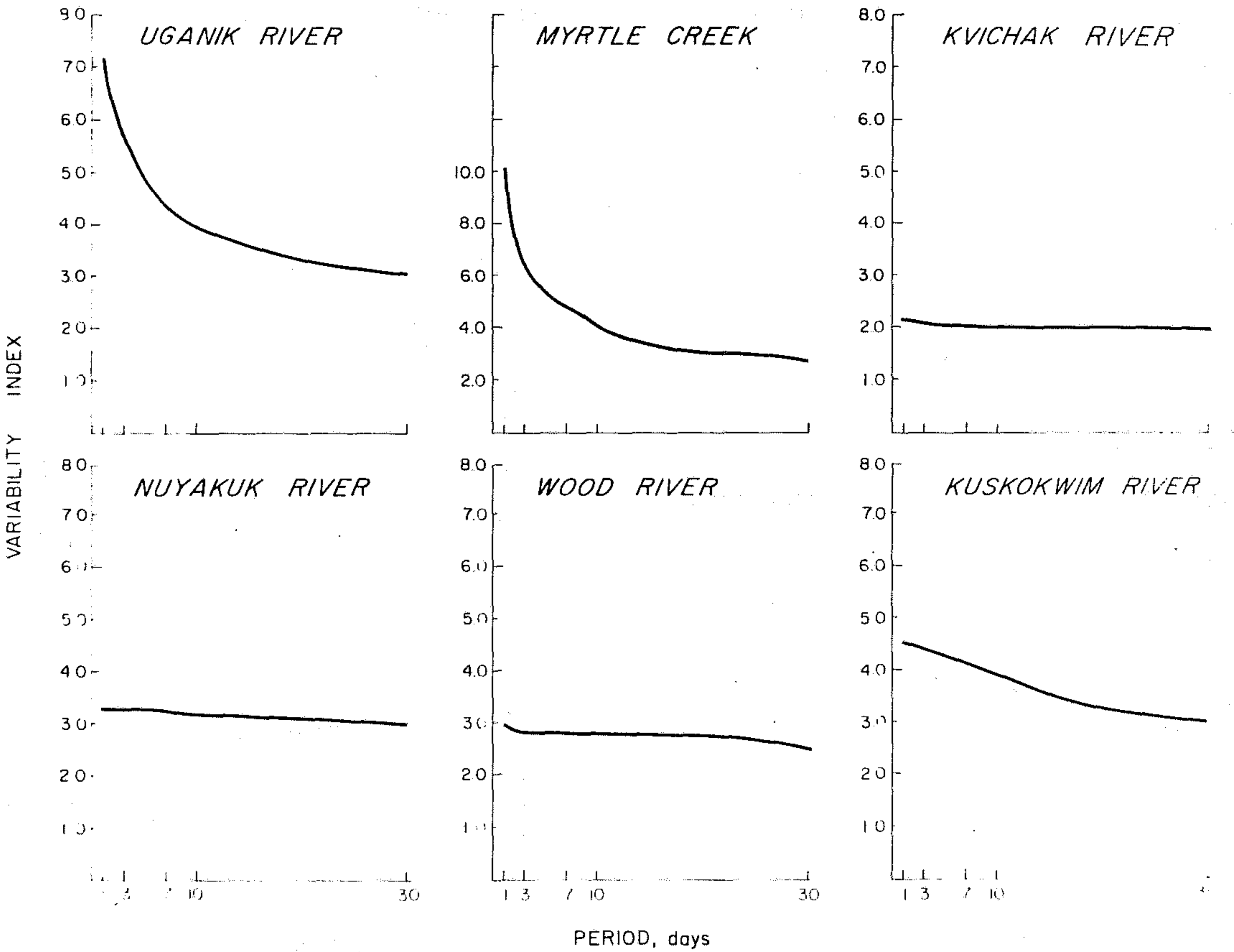


FIGURE 42, SHORT-TERM VARIABILITY INDEX
Uganik, Kvichak, Nuyakuk, Wood, Kuskokwim Rivers & Myrtle Creek

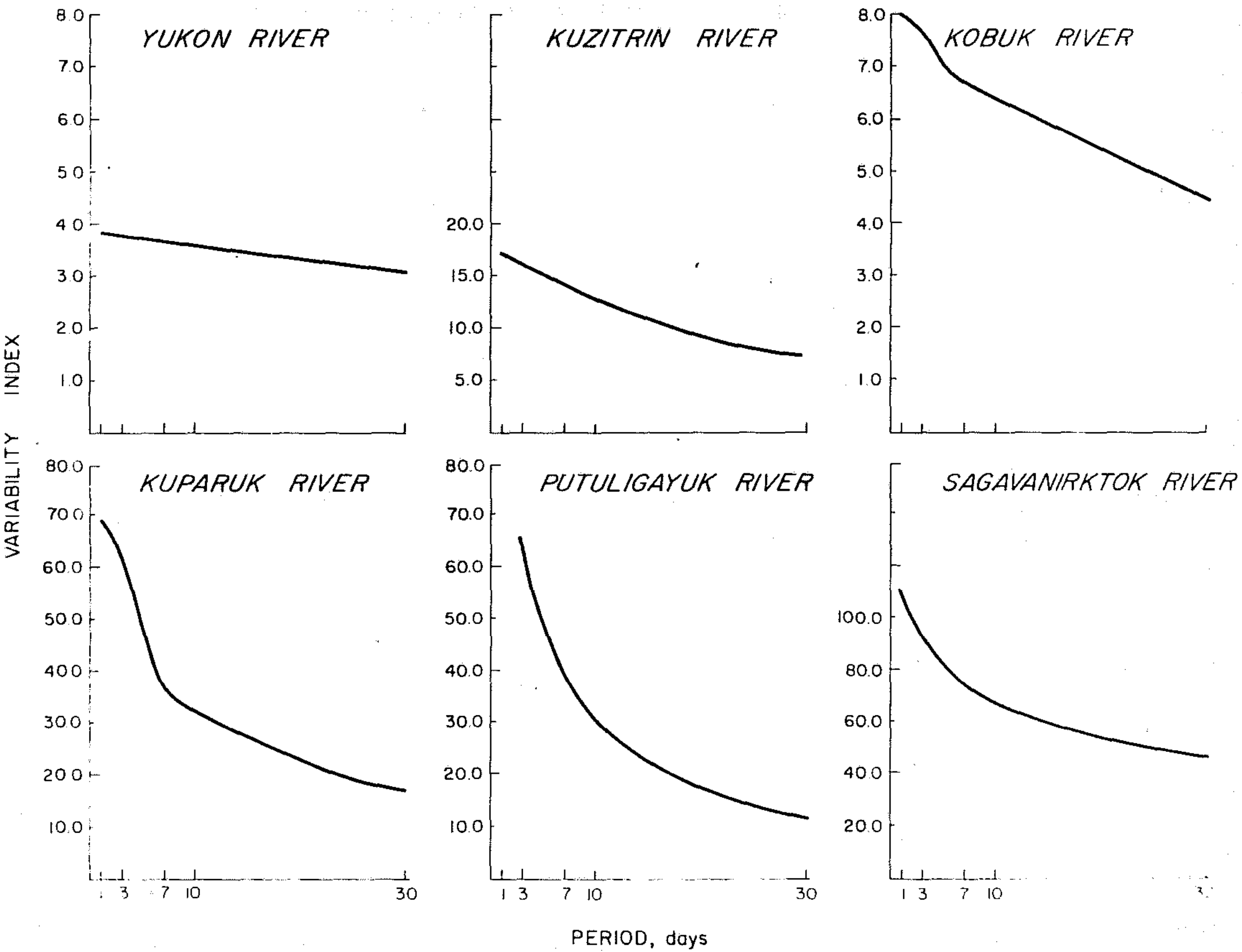


FIGURE 43, SHORT-TERM VARIABILITY INDEX
Yukon, Kuzitrin, Kobuk, Kuparuk, Putuligayuk & Sagavanirktok Rivers

In order to evaluate the short term variability of a stream, ratios were used. The maximum flows of 1, 3, 7, 10, and 30 days duration for each year were ratioed to the mean annual flow. These ratios were then plotted versus time to yield a graphic description of short term variability. The plotted values are averages of the ratios for each water year for the period of record of the stream.

H. Statistical Streamflow Parameters:

The statistical parameters given are based both on monthly and annual variations. They are:

1. The mean daily flow by month, giving both the maximum and minimum daily flows for each month, and the year and day for each occurrence.
2. The maximum, minimum, and average daily flow data for the length of the streamflow record.
3. The mean monthly flow data, giving the maximum and minimum mean monthly flow and the respective years of occurrence.
4. The maximum and minimum mean annual flows for the length of record.

Rivers with less than 3 years of record are not included. These parameters are listed by river in Appendix I.

I. Sediment Relationships:

Although sediment load data for Alaskan streams is available, most of it is not continuous and consequently cannot be correlated with seasonal streamflow variations. For a few rivers, however, continuous daily data is available for one or more years which makes possible a correlation between

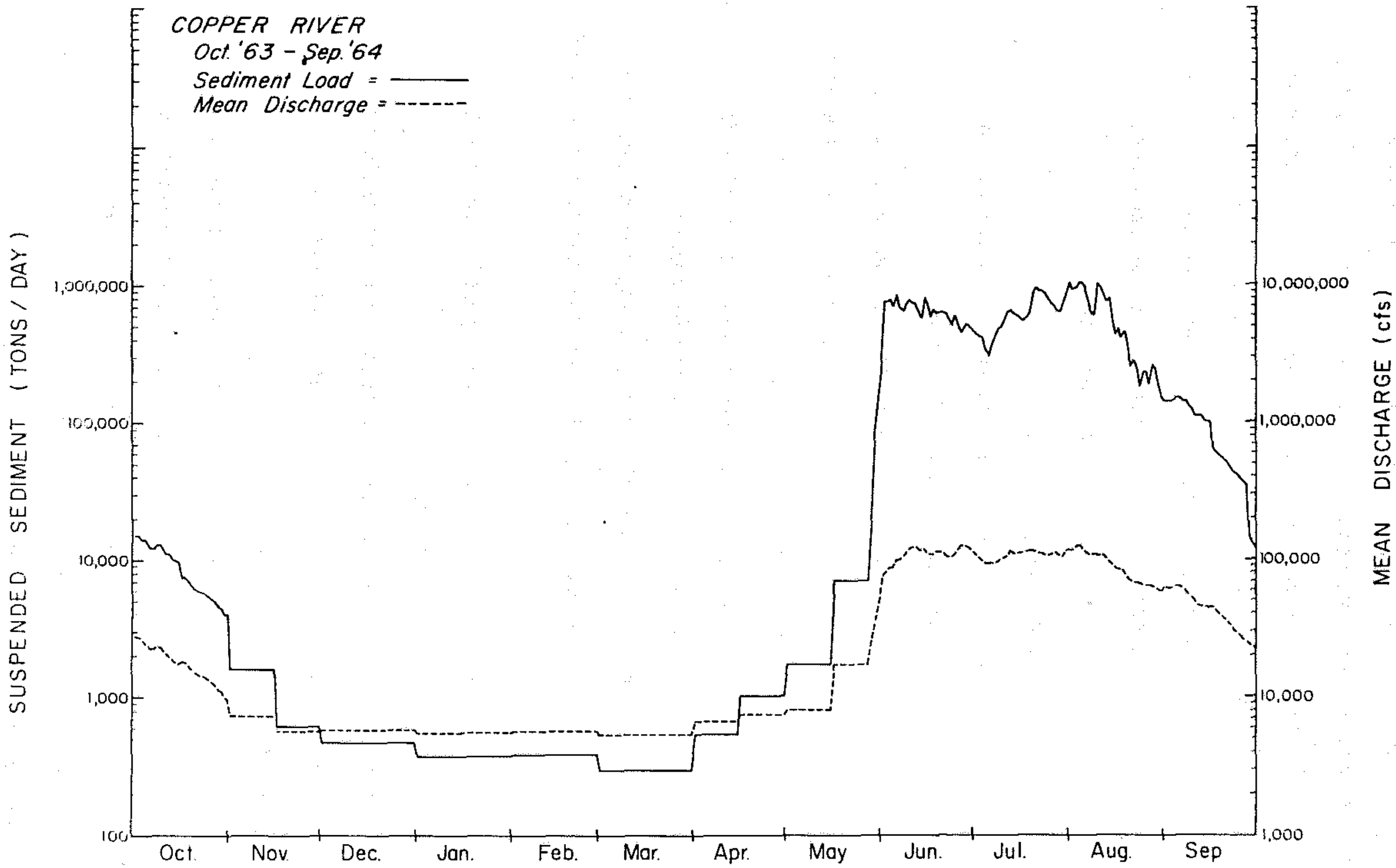


FIGURE 44, SEDIMENT LOAD - HYDROGRAPH Copper River, 10/63 - 9/64

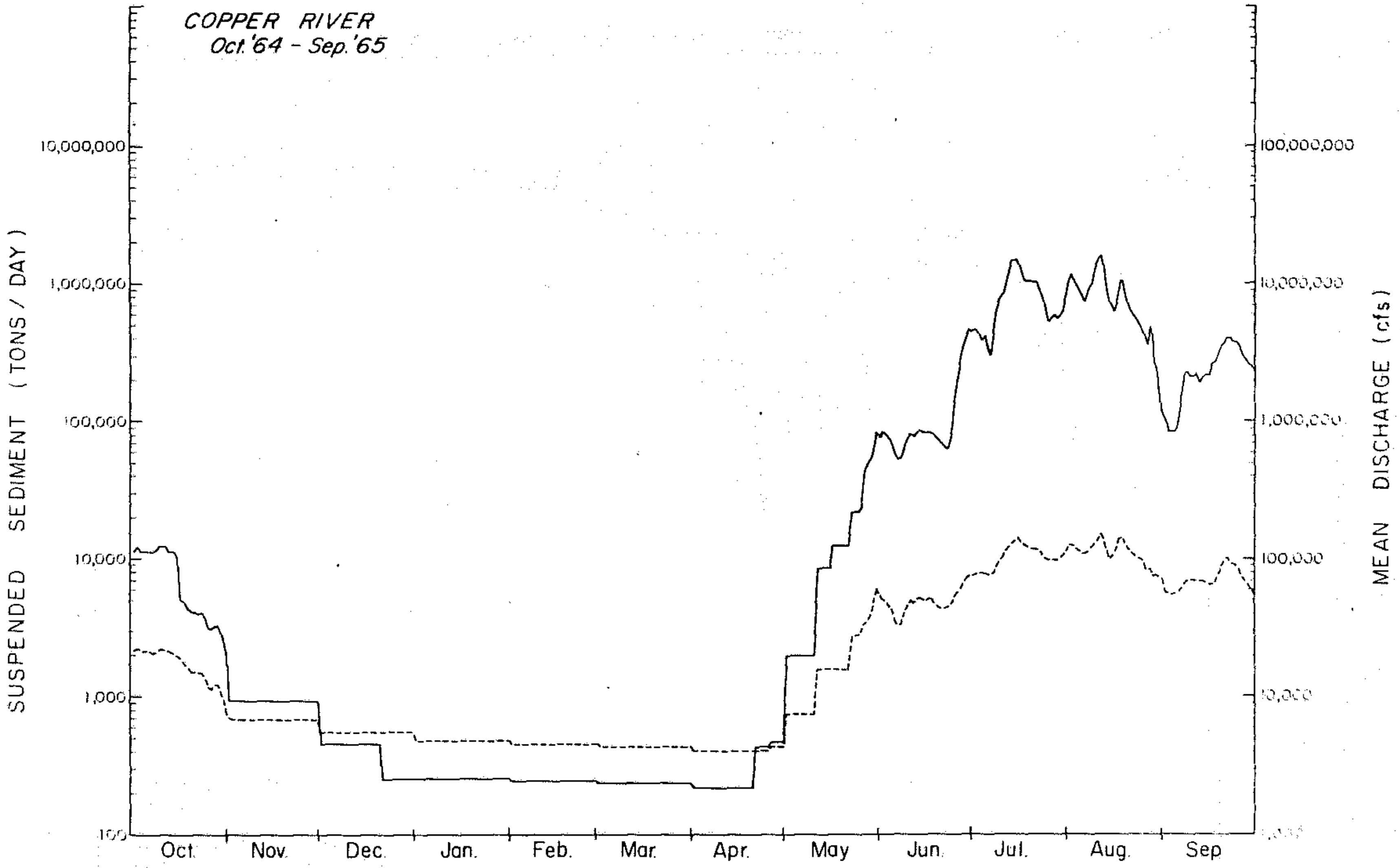


FIGURE 45, SEDIMENT LOAD - HYDROGRAPH Copper River 10/64 - 9/65

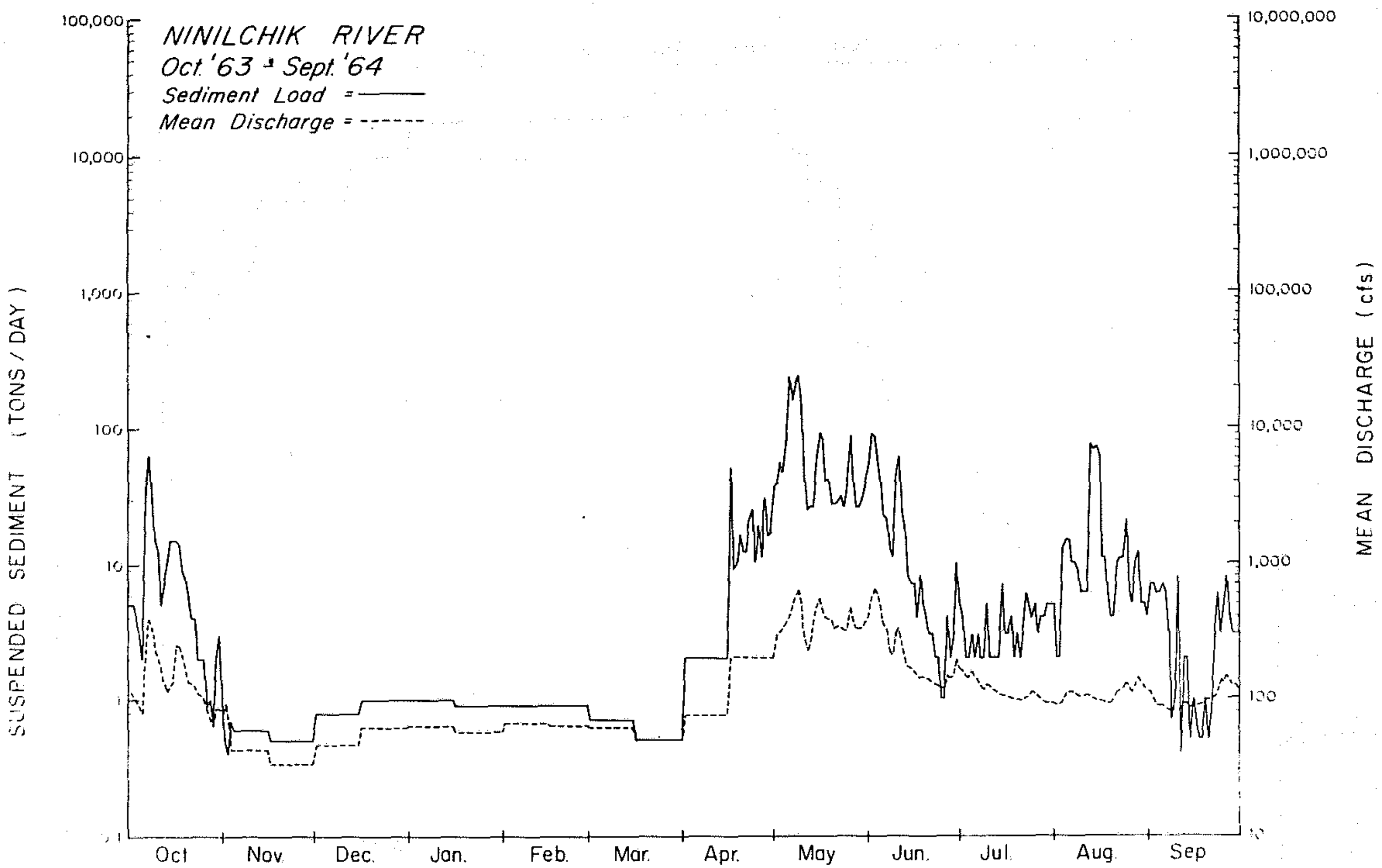


FIGURE 46, SEDIMENT LOAD - HYDROGRAPH Ninilchik River 10/63-9/64

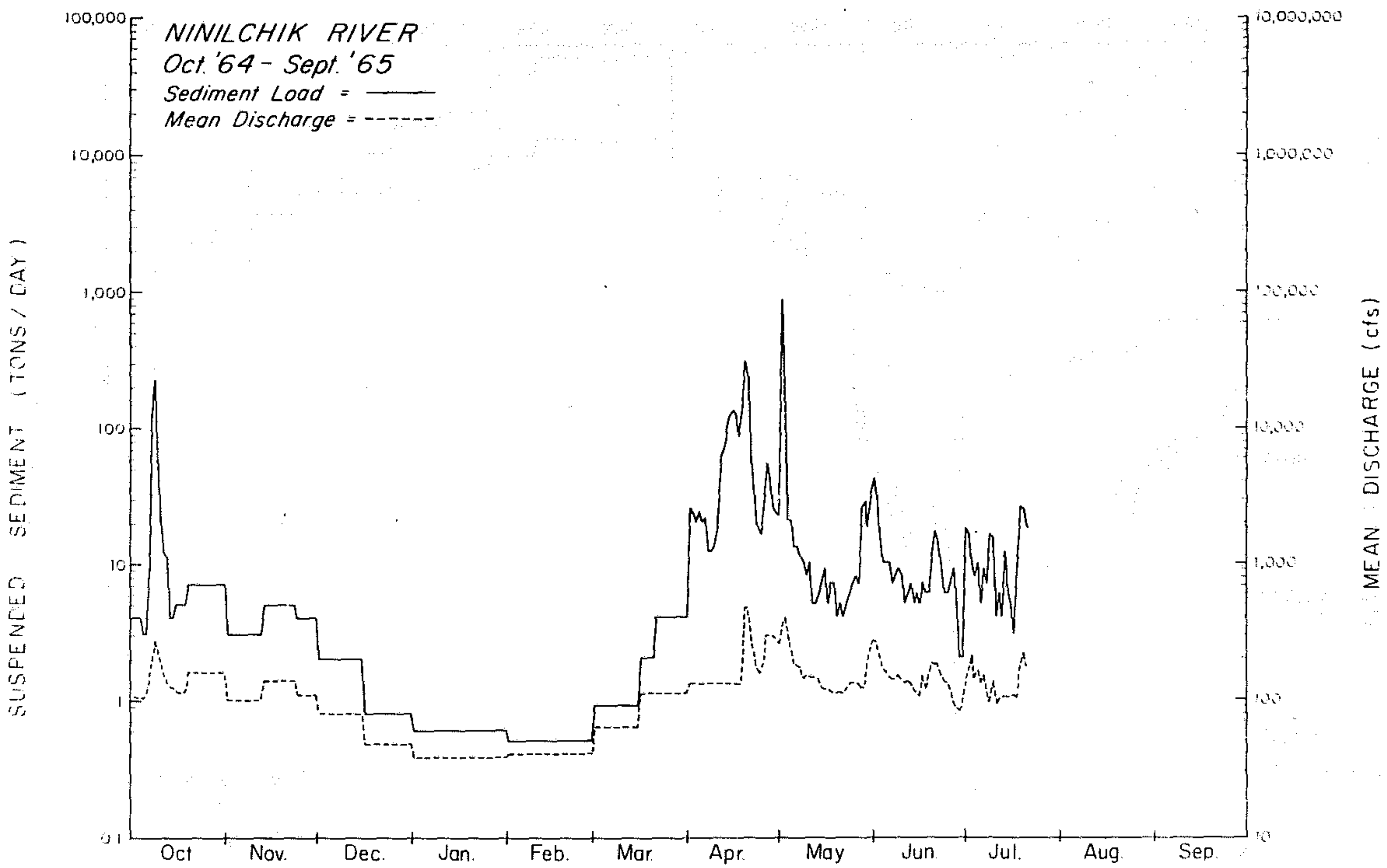


FIGURE 47, SEDIMENT LOAD - HYDROGRAPH Ninilchik River 10/64-9/65

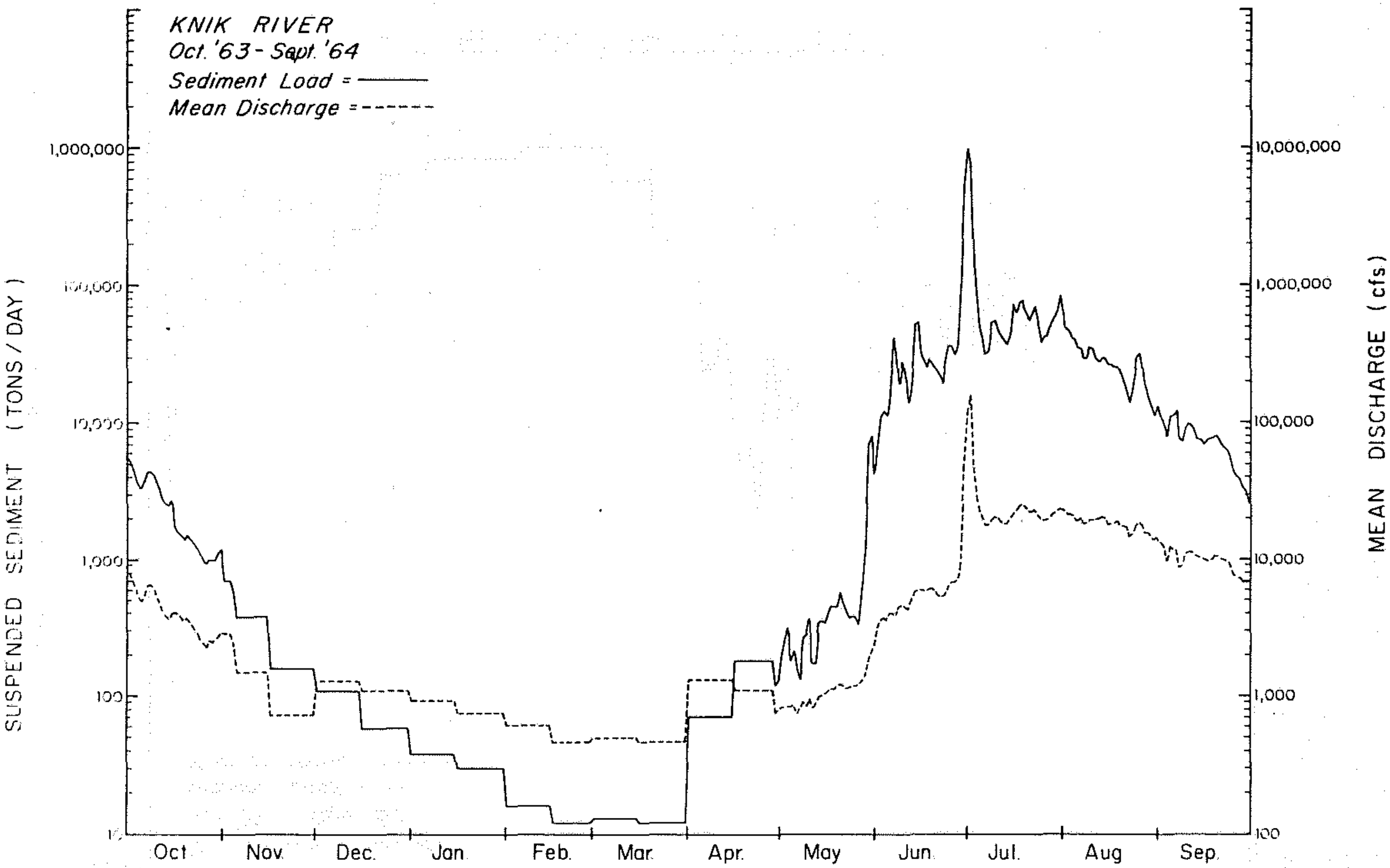


FIGURE 48, SEDIMENT LOAD - HYDROGRAPH Knik River 10/63 - 9/64

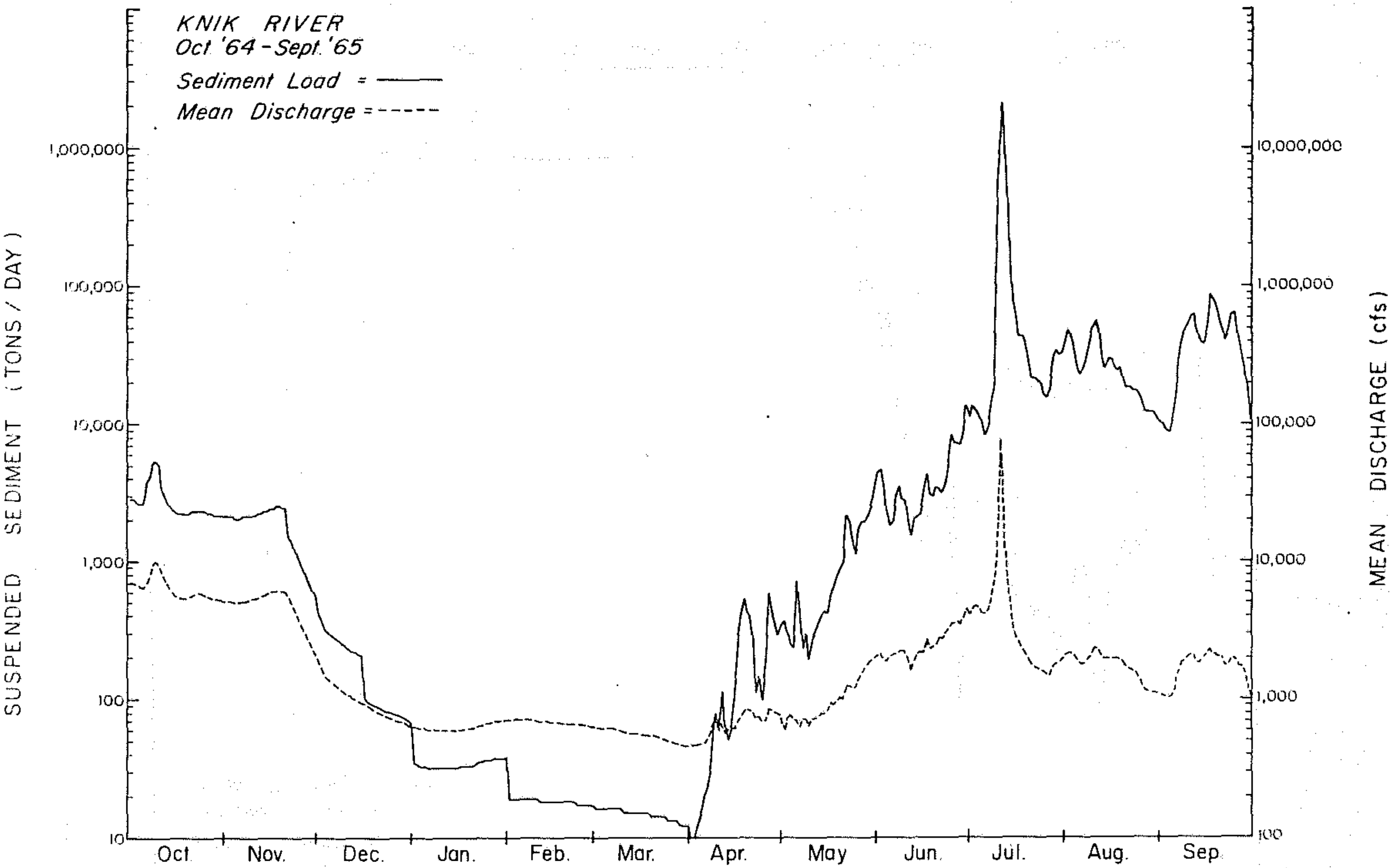


FIGURE 49, SEDIMENT LOAD - HYDROGRAPH Knik River 10/64-9/65

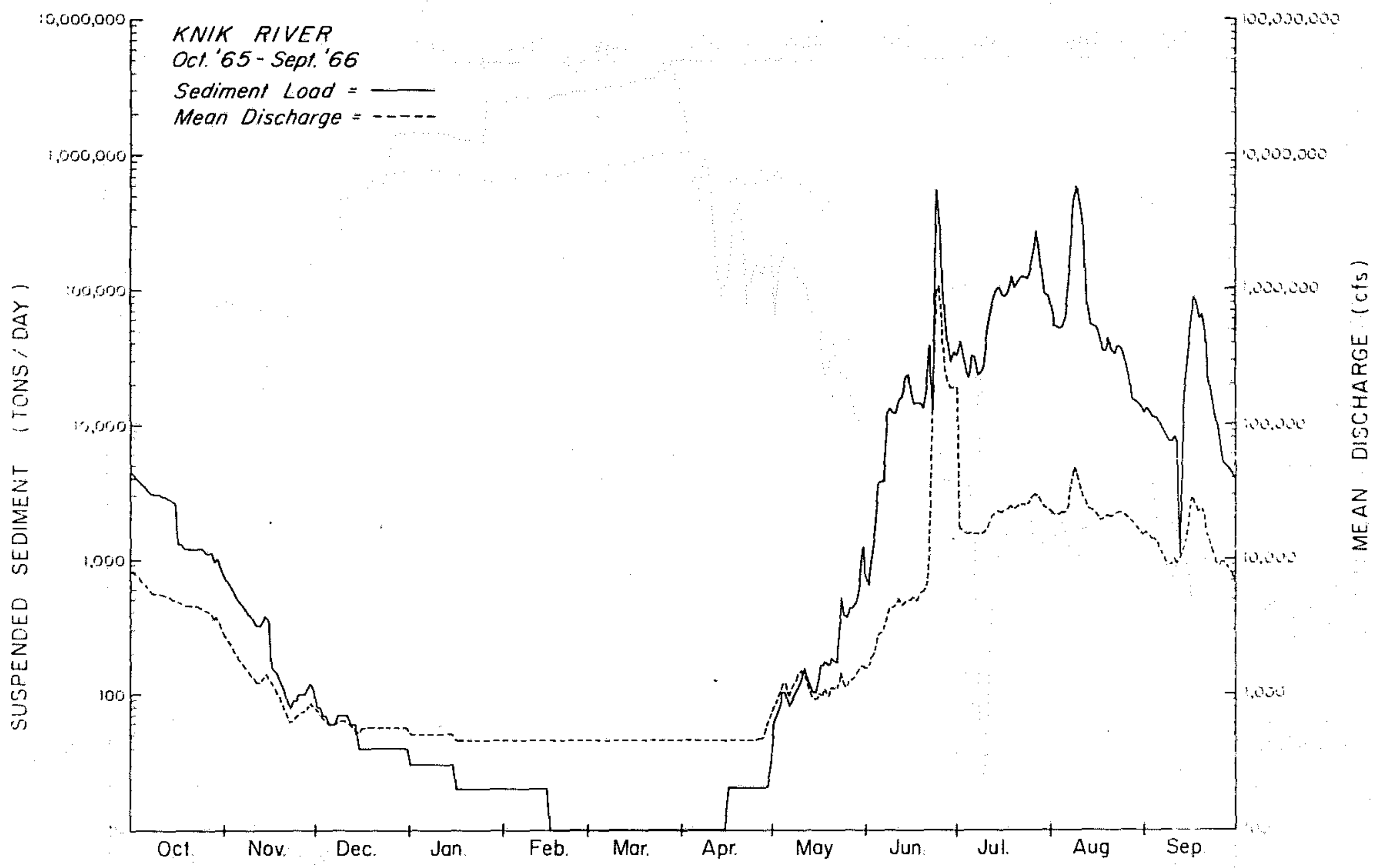


FIGURE 50, SEDIMENT LOAD - HYDROGRAPH Knik River 10/65 - 9/66

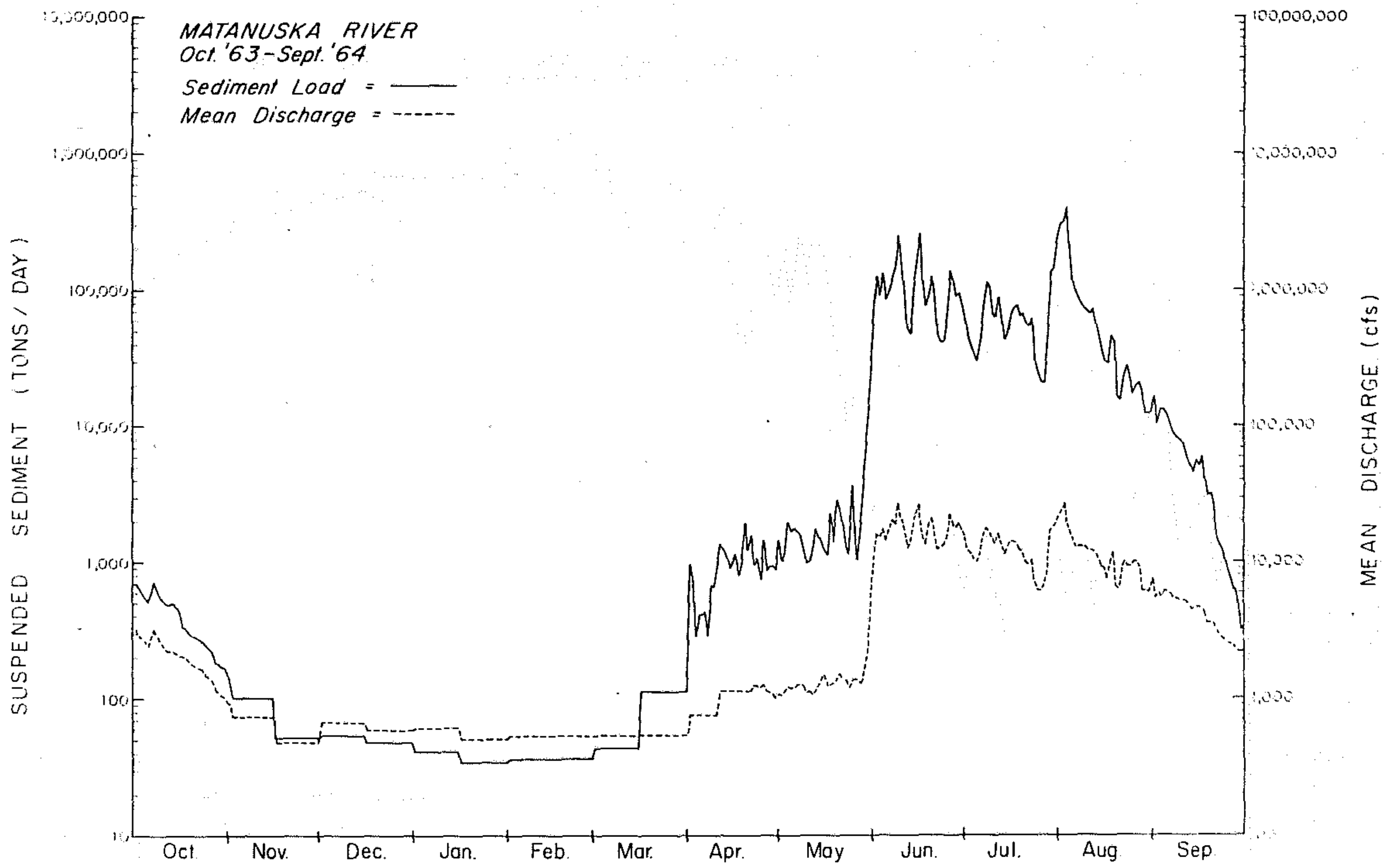


FIGURE 51, SEDIMENT LOAD - HYDROGRAPH Matanuska River 10/63-9/64

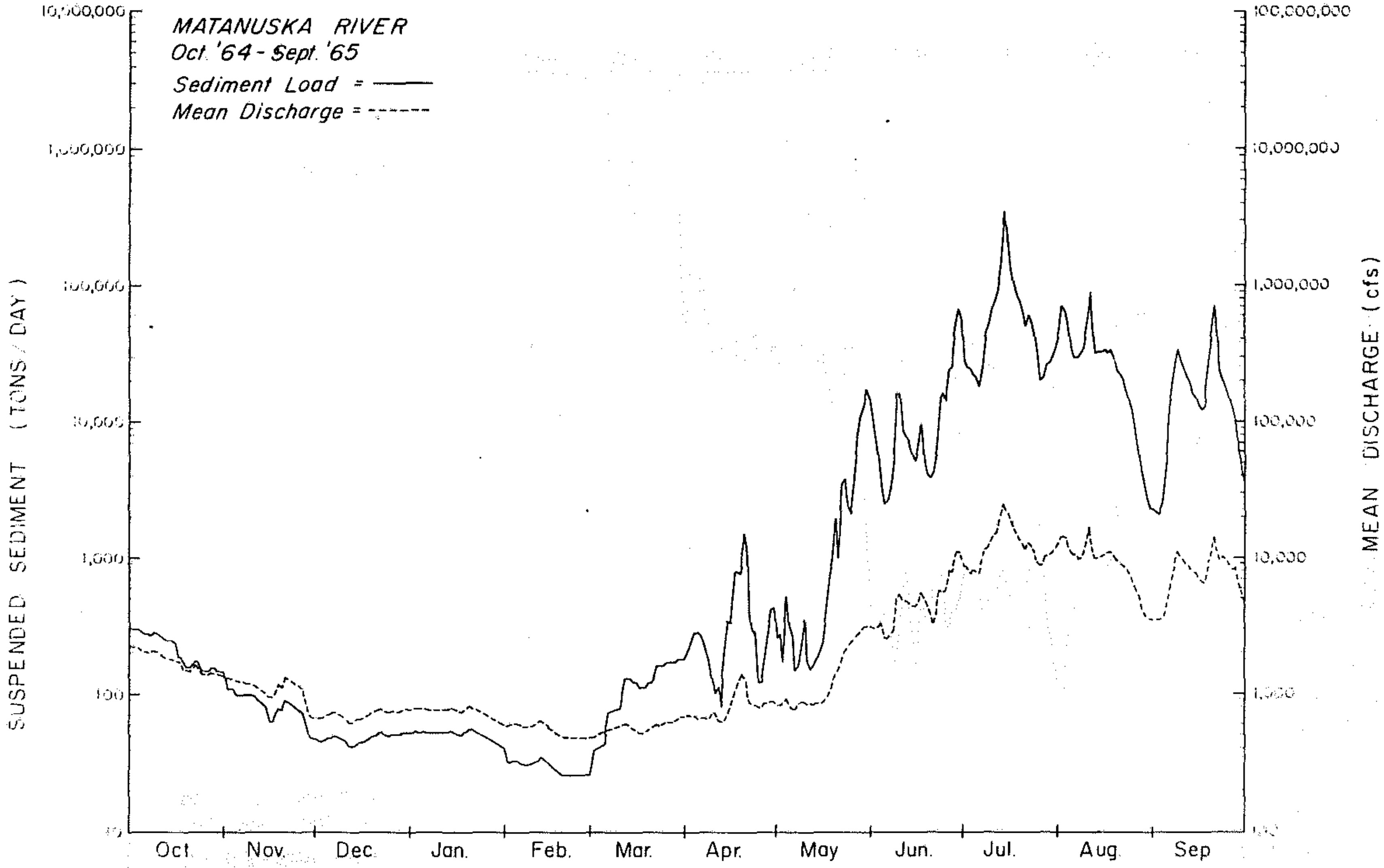


FIGURE 52, SEDIMENT LOAD - HYDROGRAPH Matanuska River 10/64-9/65

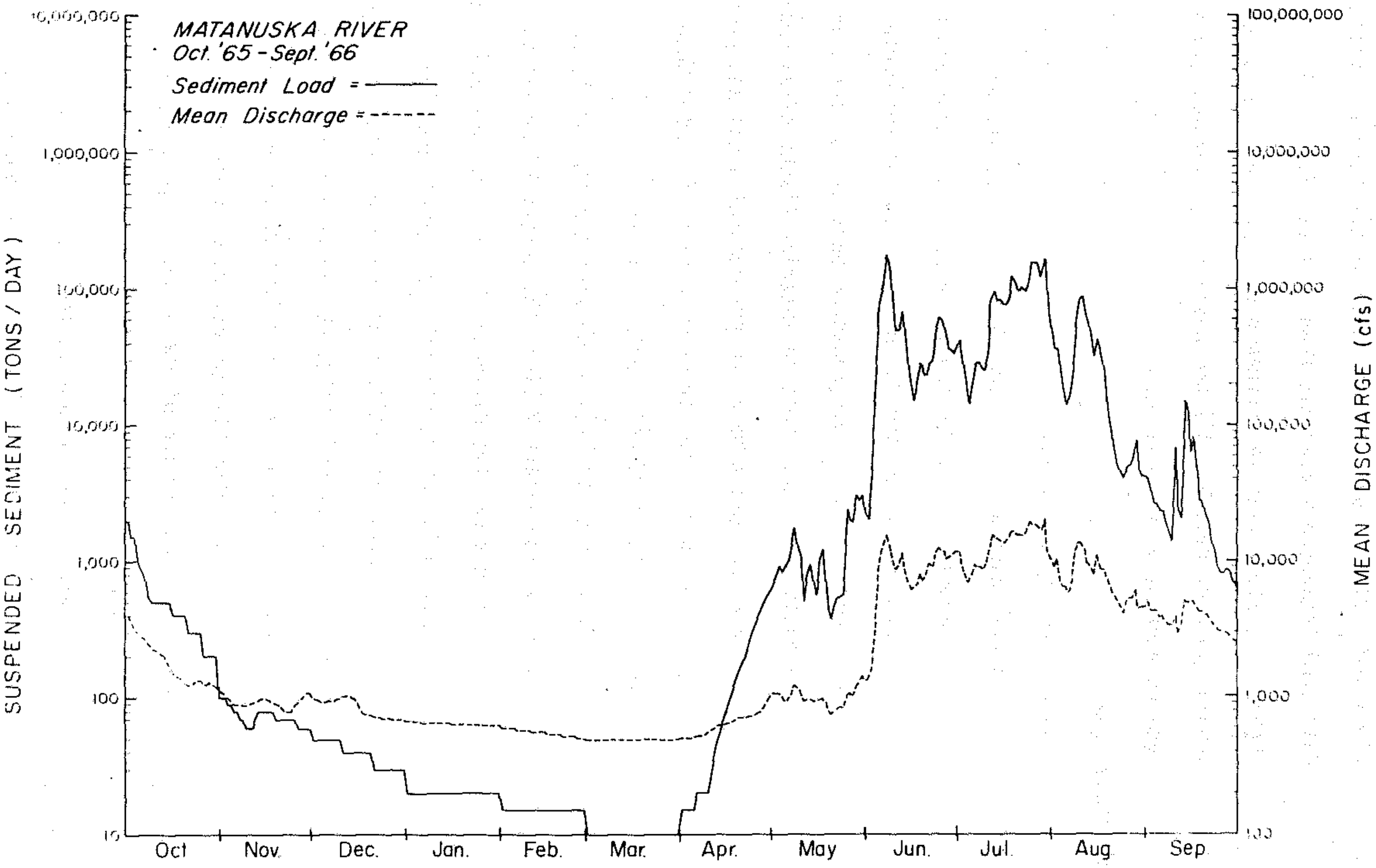


FIGURE 53, SEDIMENT LOAD - HYDROGRAPH Matanuska River 10/65 - 9/66 flows and sediment loads. This data for the Copper, Ninilchik, Knik, and Matanuska Rivers has been plotted (Figures 44 through 53) along with the stream hydrograph for the corresponding year of record. All the available continuous daily records have been included here.

VII. DISCUSSION

A. Snowmelt Characterizations:

1. General observations - NOAA VHRR satellite imagery:

Snowmelt begins in the lowlands of the southern half of Alaska (south of the Yukon River) during the month of April and in the extreme southern part of the state in the month of March. Melt in interior Alaska often begins at about the same time as in the coastal areas and proceeds rapidly because of the drier conditions (lighter snowpacks) and the more continental climate.

First areas to become snowfree are the low-lying regions of the Tanana Valley, the Copper River valley north of Chitina, the Matanuska Valley, and low areas of the Yukon Valley above Rampart, and downstream from Tanana to Ruby. The valleys of the upper Sagavanirktok, Itkillik, Killik, and Anaktuvuk Rivers and some of their tributary valleys are also snowfree early in the season. However, these river valleys are more often subject to extensive wind erosion of the snowpack, particularly on steep slopes.

Snowmelt then spreads to the lower Koyukuk, and throughout the interior lowlands of the Tanana and Yukon Valleys. Slowly, the areal extent of snowmelt increases through the lowlands of the state, including the lower Kuskokwim River valley. As the days become warmer by mid-May, most of the elevations less than 900 meters are snowfree and coastal areas in the southern half of Alaska are melting or snowfree. Enhanced thermal IR imagery from the NOAA-3 satellite indicates that on May 12, 1975, melting was occurring or complete at most elevations everywhere in Alaska except the coastal plain and lower foothills of the Arctic Slope region.

Generally, shorefast ice and snow near the western Alaskan coast lags other areas of melt. Probably this is a result of the "heat sink" effect of the shorefast ice, sea ice, ice-covered lakes, and the overall influence of the cooler marine climate. These combined effects also dominate the snowmelt on Alaska's Arctic Slope. The snowcover in this region is the last area of seasonal snow cover to disappear and often persists until early June. This results in an anomalous pattern of snowmelt in the North Slope region. The mid-elevations (600-900 meters) are the areas of snowmelt initiation on the Arctic Slope, and snowmelt proceeds in both directions from these elevations, with the lowest elevations often the last to become snowfree.

A chronology of the snowmelt in Alaska using NOAA imagery (of use in OCS characterization) follows for the years 1975 and 1976 (Table 6).

TABLE 6

NOAA IMAGERY OF USE IN OCS CHARACTERIZATION - 1975

NOAA IMAGERY ORBIT NO. & DATE	SNOWMELT OBSERVATION	PLUME OF SEDIMENT OR OVERFLOW	LOCATION OBSERVATION	FLOODING/ CAUSE	CIRCULATION FEATURE	NOTES
#2081 30 Apr. 75	Melting Temp. Present		Throughout Interior and Lower Yukon and Kuskokwim Valley			Some evidence of Snowfree area
#2093 01 May 75	Melting and Snowfree Areas Present		Interior (Tan. Valley) Yukon, Lower Kuskokwim		Coastal Weather Effects Domate	*
#2105 02 May 75	Matanuska Valley & Copper R. Valley Clear Observation Lowlands Snowfree		Cook Inlet, Copper River Valley & Interior			First Clear Weather Obs. of Cook Inlet & Copper R. Val.
#2143 05 May 75	Generally Snowfree in Cen. Yukon & Porcupine R. Valleys		Interior & Cook Inlet		Ice in Cook Inlet W. Side of Inlet	
#2156 06 May 75	Snowfree Area of North Slope Clearly Visible		N. Slope of Brooks Range		Clearing of Ice in Norton Sound	Sag R. Visible Effects of Flow or Haul Road
#2168 07 May 75	Further Melting Throughout Int. & Copper Valley		Entire State		Coastal Ice Degrading So. of Bering Str.	" "
#2193 09 May 75	Extensive Melt in Interior Alaska		S. Coast Cloudy - Rest of State Clear or P. Cldy.			Yukon R. Ice Still Intact
#2218 11 May 75	Extensive Further Melting Occurred		Entire State			Record High Temps Interior
#2231 12 May 75	75% Complete in Interior		North of Alaska Range			Brooks Range Melting
#2281 16 May 75	80% Complete So. of Brooks and No. of Alaska Range		Alaska N. of Alaska Range		Coastal Weather Variance Indicated	*Cloudy S. of Alaska Range
#2306 18 May 75	Melt Completed on Most Cook Inlet Lowlands		Entire State			Strong Wave Cloud/ Wind Effect

*Good Demonstrative Example

TABLE 6 (coninued)

NOAA IMAGERY OF USE IN OCS CHARACTERIZATION - 1975

NOAA IMAGERY ORBIT NO. & DATE	SNOWMELT OBSERVATION	PLUME OF SEDIMENT OR OVERFLOW	LOCATION OBSERVATION	FLOODING/ CAUSE	CIRCULATION FEATURE	NOTES
#2594 10 Jun 75	Coastal Shorefast Ice Generally Absent So. of Cape Rodney, Seward Peninsula No. Slope Snowmelt 50% Complete		Western Alaska & No. No. Slope			
#2607 11 Jun 75	Snowmelt on No. Slope 70% Complete		Entire State		Coastal Fog and Weather Again Evident	
#2619 12 Jun 75	No. Slope Snowmelt 80% Complete		Entire State		Coastal Weather * Again Evident-Fog-Stratus	
#2920 06 Jul 75	Teschekpuk L. Still Frozen Ice Still Intact No. of Icy Cape	Huge Sediment Plume off McKenzie R.	No. Slope			Ice Normally Still Present Along Beaufort Sea Coast in Early July
#3132 23 Jul 75	Ice Lead Open to Barrow					Ice Close but Only Obstructs Passage Between Barrow & Smith Bay
#6538 20 Apr. 1976	Initiation of Melt in Interior Alaska		Tanana Valley			
#6563 22 Apr. 76	Increasing Melt in Interior Alaska and East Cook Inlet		Copper, Tanana Valleys and Cook Inlet			Sea Ice still at Maximum Extent but Discont.
#6576 23 Apr. 76	Interior Snowmelt also Cook Inlet Interior Areas		Interior Alaska and Cook Inlet			
#6601 25 Apr 76			Entire State		Wave Clouds-Strong Erosive Winds Indicated	Ice Free Wake S. of St. Law. Island
#6613 26 Apr 76	Extensive Melt in Tanana Valley Lowlands		Interior Third of State and Gulf Coast		Wave Clouds and High Cloudiness Windy Again-Esp. Aloft	Sea Ice intact

*Good Demonstrative Example

TABLE 6 (continued)

NOAA IMAGERY OF USE IN OCS CHARACTERIZATION - 1975

NOAA IMAGERY ORBIT NO. & DATE	SNOWMELT OBSERVATION	PLUME OF SEDIMENT OR OVERFLOW	LOCATION OBSERVATION	FLOODING/ CAUSE	CIRCULATION FEATURE	NOTES
19 thru 22 May Cloudy						
#2364 23 May 75	Melt Proceeding Coastal Lowlands Kusk-Yuk. Delta				Coastal Area Much Cloudier Again	
#2381 24 May 75	Ice Persists Along Coastal Areas (North of Togiak) Probably Shorefast		Yukon River Innoko R.	Aniak/Holycross Flood Ice Jam 1000 mi.		*Breakup of Rivers Dominate
#2444 29 May 75	Melt Complete Throughout Most of Brooks Range, Interior S. Central Seward Peninsula of Alaska	Ice Flooded Off Sag R. on N. Slope also off Canning R.	Entire State	Yukon Delta Flooded Ice Jam, Tidal Effects 1050 mi^2		Sag R. Not Visible for 4 previous Days Flow Initiation Indeterminate
#2494 02 June 75	Melt Complete Except for N. Slope					N. Slope Nearly Continuously Cloudy Since 29 May
#2506 03 Jun 75		Sea Ice Flooded Off: Sag, Colville, Canning, Sadlerochit, Hulahula, Jago, Oklilak	Kuparuk Nichilik Egaksrak Kukpowruk Kokolik Rivers		Sea Ice Still Intact Along Shore N. of Hazen Bay	
#25 1 05 Jun 75	Snow Definitely Melting on No. Slope	Major Overflow Water at Mouths of Most Rivers on No. Slope		Overflow Flooding No. Slope Rivers		
#2544 06 Jun 75			Northern Alaska	Kasegaluk Lagoon Completely Flooded by Overflow Water		

*Good Demonstrative Example

TABLE 6 (coninued)

NOAA IMAGERY OF USE IN OCS CHARACTERIZATION - 1976

NOAA IMAGERY ORBIT NO. & DATE	SNOWMELT OBSERVATION	PLUME OF SEDIMENT OR OVERFLOW	LOCATION OF OBJECTS	FLOODING CAUSE	CIRCULATION FEATURE	NOTES
#6638 28 Apr 76	Extensive Melt in Tanana, Yukon, Copper, Valleys	Sediment Plumes @ Copper, Bering Many other S. Coast Rivers, Cook Inlet	Interior, South Coast of Alaska		Sediment Plums Swept in Direction (Westward) of Alaska Current	
#6651 29 Apr. 76	West Side of Alaska Peninsula Melting Upper Kuskokwim R.	Plumes Permeate Water off S. Coast	W. Alaska Peninsula Upper Kuwkokwim Valley			
#6701 3 May 76	Melting Beginning in Brooks Range, Extensive in Interior Alaska				Wave Clouds in the Brooks Range, Leads in increasing off North Slope	
#6763 8 May 76	Moist Cloudy Air Spreading Slow Melt over Entire State S. of Brooks Range		Entire State		Coastal Weather Effects Evident	
#6776 9 May 76	N. Slope Melt Pattern Evident. 80% Snowfree S. of Brooks Range. Sag R. Flow Evident	Sag. R. Overflow Initiated	Entire State	Sag River Snowmelt Runoff	Norton Sound 50% Ice Free	
#6801 11 May 76		Canning R. Overflow in Addition to Sag. Also Jago and Sadlerochit Rivers	North Slope	N. Slope Snowmelt Runoff	Sea Ice very Degraded S. of Bering Straits	
12 May - 14 May			Clouded Everywhere			
#6876 17 May 76			Interior Alaska		Superb Example of Orographic Cloudiness in Yukon Tanana Uplands	
#6914 20 May 76 #6914 IR "	Melt 90% Complete S. of Brooks Range. New snow-fall N. of Brooks Range, Destroying Melt Pattern.		Entire State	Ice Jam on Middle Yukon (IR Image)	Ice covers Lake Iliamna S. Coast Clouded Nearly 10 Days Consecutively. IR Image Excellent Detail.	

*Good Demonstration Example

TABLE 6 (continued)

NOAA IMAGERY OF USE IN OCS CHARACTERIZATION - 1976

NOAA IMAGERY ORBIT NO. & DATE	SNOWMELT OBSERVATION	PLUME OF SEDIMENT OR OVERFLOW	LOCATION OF OBJECTS	FLOODING CAUSE	CIRCULATION FEATURE	NOTES
#6939 22 May 76	N. Slope still 95% Snowcovered Shorefast Ice Still Intact over Most of W. Coast		Entire State			
#6989 26 May 76	Colville River Channel Flow Evident		N. Slope	Snowmelt	Coastal Weather Evident	
#7026 29 May 76	Lake Iliamna Breaking up		S. of Alaska Range			
#7051 31 May 76 IR Image	Excellent Resolution of Snowfree areas south of Brooks Range to Coast		South of Brooks Range			
# 11665 (NOAA 3) 4 June 76	Snowmelt Progressing N. Slope Pattern very evident	Sea Ice Flooded Off: Sag Jago Kuparuk, Colville Sadlerochit Rivers. Also Kasegaluk Lagoon	N. Slope of Alaska	Snowmelt		
#11727 (NOAA 3) 9 June 76	Melt 40% Complete on N. Slope Pattern very evident		N. Slope of Alaska		Sea ice deteriorated 100 miles N. Bering Str. 90% ice free S. of Bring Strait.	
#7190 11 June 76	Snowmelt Continuing on N. Slope	Huge Flooded area off Colville River	N. Slope	Snowmelt and Ice Erosion		
#1176 (NOAA 3) 13 June 76	Snowmelt 80% Complete, still persistent snow around Sagavanirktak and Lower Kuparuk, on N. Slope		N. Slope		Ice deteriorating in Chukchi Sea	
#11814 (NOAA 3) 16 June 76	Snowmelt 95% complete, no more sea ice flooded		N. Slope			

*Good Demonstration Example

B. Regional Character of Streams - Climatic Influences

1. Gulf of Alaska Region: Climatic hazards.

The Gulf of Alaska is nearly surrounded on all its continental boundaries by high mountain ranges, including the Chugach, the Robinson, and the Kenai Mountains. Cook Inlet is also bounded by the ridges of the Aleutian Range on the west. This topography, combined with the moderating influence of the Alaska current, serves to give the Gulf coast region of Alaska its relatively mild and wet climate.

Rather than describe the snowmelt pattern of each basin individually, it was felt that discussion of specific anomalies and trends throughout the region would reveal more of the region's hydrologic character. Some of the individual basins are devoid of groundbased snowmelt or snowcover measurements, whereas others contain USDA Soil Conservation Service snowcourses. In the past five years, an archive of satellite imagery from the LANDSAT (ERTS) and NOAA satellites has been accumulating. For remote areas and isolated river basins, these sources provide the best and most accurate snowmelt observations available. Snowmelt observations made from NOAA satellite imagery are tabulated in Table 6.

Many of the river basins in the Gulf Coast region of Alaska are subject to the hazard of glacier-dammed lake outburst floods. These floods are caused by the release, either sudden or gradual, of headwater areas of the streams. A detailed description of glacier-dammed lake outburst floods and a list of streams subject to them has been compiled by Post and Mayo (1971). Gulf Coast rivers on which known glacier dammed lake outburst floods have occurred are:

a. Knik River - this river is famous for the flood activity of Lake George, the largest glacier-dammed lake in Alaska; however, since 1966 Knik Glacier has failed to form an ice dam and the lake has not filled.

b. Snow and Kenai Rivers - floods on this river system originate from a glacier-dammed lake at the headwaters of the Snow River (Post and Mayo, 1971), a tributary to the Kenai River. Outburst floods have occurred since December 1911 and outburst peak discharge has varied regularly as a function of changes in the amount of water impounded due to glacier melt. Since 1961, the outburst flood peaks have exceeded the annual storm peaks.

c. Tazlina and Copper Rivers - the Tazlina basin, tributary to the Copper River contains four major lakes which are susceptible to outburst flooding. The flood history of the Tazlina River is much more complex than for the other examples mentioned here as more than one lake is involved, and changes in the basin have not been systematic.

d. Bering River - the Ungaged Bering River system includes Berg Lake, presently dammed by the Bering glacier. This lake has a complex history and presents one of the greatest potential floods of any glacier-dammed lake in Alaska. Post and Mayo (1971) state that catastrophic draining will occur in the near future if the ice dam restraining Berg Lake continues to thin, and the situation is becoming unstable. The ice dam now holding Berg Lake could erode rapidly, thus releasing the entire lake in a few hours. This could create a devastating flood which would sweep the Bering River Valley with a peak flow far exceeding 30000 cubic meters per second ($\sim$ 1000000 CFS). As an additional cautionary observation, it should be pointed out that outburst floods are not seasonal in nature and have occurred in winter as well as mid- to late summer. It is also possible that outburst floods could be caused by volcanic eruptions which rapidly melt glacier ice on volcanic peaks thus resulting in catastrophic floods which occur without warning.

2. South Bering Region: Climatic Hazards

Although glaciation is present in the Kvichak River system and some glacier-dammed lakes have formed, they are not considered to be a hazard to coastal development because of the storage capacity of Lake Iliamna, which would serve to moderate any rapid discharges from glacier dammed lakes. The major climatic hazards for this region are considered to be ice jams and severe storms.

A few small glacier-dammed lakes are also present in the headwaters of the Kuskokwim River; however, since they are small they also do not appear to represent any substantial hazard.

3. North Bering - Chukchi Region: Climatic Hazards

Again, as in the South Bering Region, the major hazards are spring ice jams and floods. Severe storms can be expected, but less often than in the South Bering Region.

4. Beaufort Sea Region: Climatic Hazards

The arctic rivers of Alaska have somewhat unique patterns of snowmelt in the respective basins which result in a mid-elevation snowmelt and a streamflow which begins before the river channel is free of ice. Water consequently will flow in the channel but on top of the ice. This results in large areas of flooded shorefast sea ice at the mouths of the rivers. A satellite image depicting this flooding hazard is shown in Figure 54. This flooding at the mouth is not predictable as to its extent and is apparently quite variable from year to year. Walker (1972) observes that surface flooding of the Colville River extended 12 to 18 km from the Colville Delta. More data on this hazard is shown in Table 7. These measurements were made from NOAA satellite imagery.

FIGURE 54: NOAA SATELLITE IMAGE, ORBIT NO. 2519, June 4, 1975, VISIBLE band. This image clearly shows the North Slope snowmelt pattern. Runoff is flooding the shorefast sea ice off the mouths of the Colville, Kuparuk, Sagavanirktok and Canning Rivers.

TABLE 7

AREA (km^2) OF FLOODED SEA ICE

Date	Kaparuk River River	Sagavanirktok River	Colville River
21 May 74	--	61	15
26 May 74	10	151	50
4 June 74	30	185	61
6 June 74	30	40	120
4 June 75	101	208	219
9 June 75	69	179	276

C. Snowmelt Characterizations-Regional:

1. Gulf of Alaska Region:

Snowmelt along the south coast generally occurs from one to two weeks after it occurs in interior regions of Alaska. Johnson and Hartman (1969) indicate a seasonal lag of 3 to 14 days when comparing the coastal lag to the earlier summers of interior Alaska. The seasonal lag, heavier snows (especially at higher elevations), and marine climatic effects result in delayed runoff.

Snowfall, as well as rainfall, is generally greater in the Prince William Sound Coastal Area and the coast east of the Copper River Delta. U.S.D.A. Soil Conservation Service snowcourses are generally clustered around the Anchorage area and the Kenai Peninsula. They give a general, albeit incomplete in areal coverage, description of snowcover and water equivalents prior to the snowmelt period in the spring. The snowcourse locations are shown in Figure 55. Data for Gulf of Alaska snow-

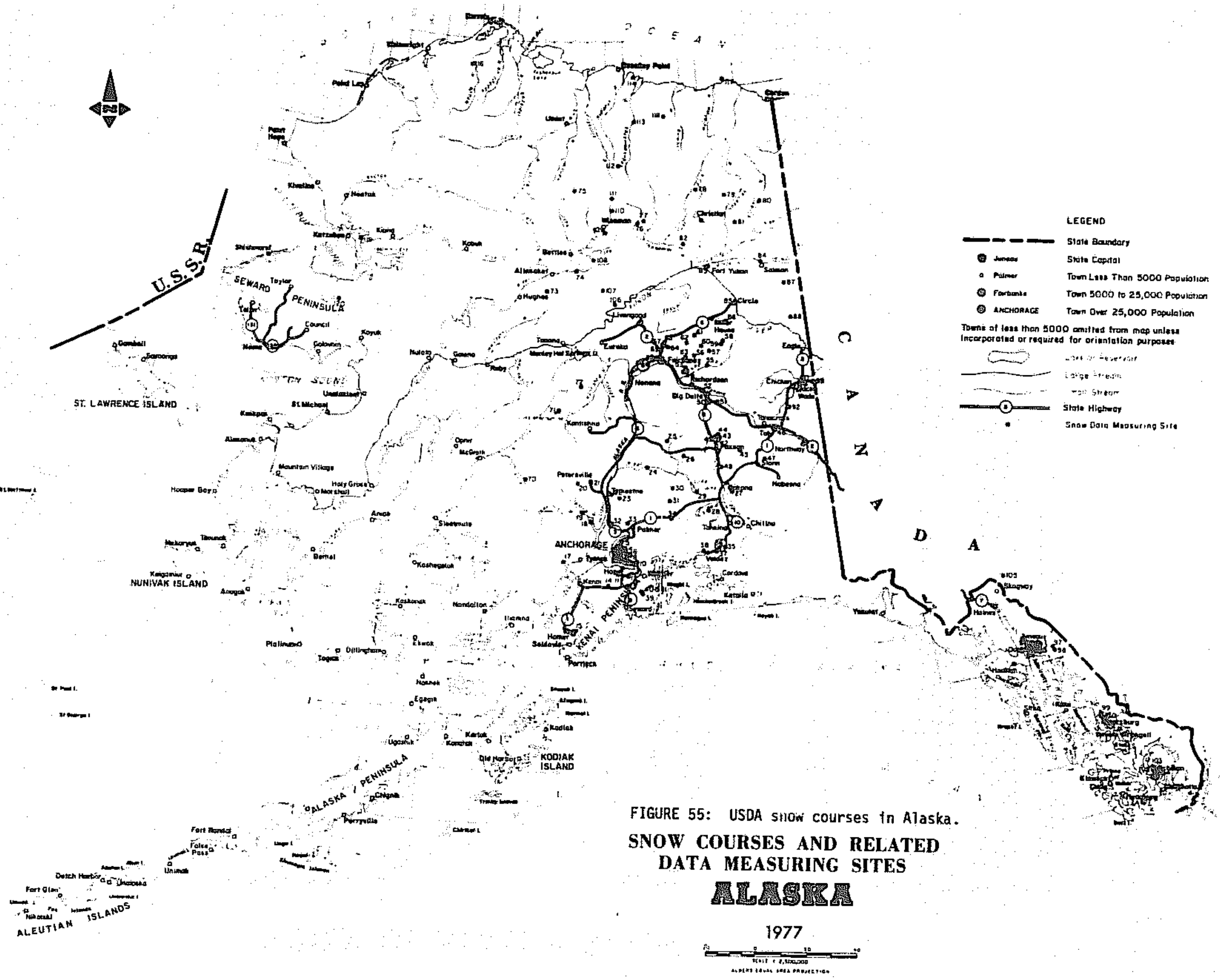


FIGURE 55: USDA snow courses in Alaska.

INDEX OF ALASKA SNOW COURSES

MAP NO.	COURSE NAME	COURSE NO. **	ELEV.	LAT.	LONG.	MEAS. DATES *	MEAS. BY **
1	Arctic Valley #1	49MM1	500	61°13'N	149°40'W	2,3,4,5	c
2	Arctic Valley #2	49MM2	1000	61°13'N	149°37'W	2,3,4,5	c
3	Arctic Valley #3	49MM3	2030	61°14'N	149°35'W	2,3,4,5	c
4	Arctic Valley #4	49MM4	2330	61°14'N	149°33'W	2,3,4,5	c
5	Arctic Ski Bowl	49MM5	3000	61°15'N	149°31'W	2,3,4,5	c
6	Ship Creek	49MM7MPS	1750	61°08'N	149°28'W	2,3,4,5	a
7	Indian Pass	49MM8A	2350	61°05'N	149°29'W	2,3,4,5	a
8	Bird Creek	49MM6A	2350	61°06'N	149°20'W	2,3,4,5,7	a
9	South Campbell Creek	49MM11	1200	61°08'N	149°42'W	2,3,4,5	a
10	Mt. Alyeska	49LL15S	1200	60°57'N	149°05'W	2,3,4,5	a,b
11	Bertha Creek	49LL2	850	60°45'N	149°51'W	2,3,4,5	a
12	Kenai Summit	49LL3	1390	60°40'N	149°28'W	2,3,4,5	a
13	Moose Pass	49LL4	700	60°31'N	149°30'W	2,3,4,5	a
14	Jean Lake	50LL1	620	60°31'N	150°11'W	2,3,4,5	a
15	Bridge Creek (UP)	51KK1	1300	59°42'N	151°28'W	3,4,5	a
16	Bridge Creek (LO)	51KK2	1100	59°40'N	151°32'W	3,4,5	a
17	McArthur	52LL1A	120	61°00'N	152°00'W	2,3,4,5	a,c
18	Alexander Lake	50MM1A	200	61°45'N	150°54'W	2,3,4,5	a,c
19	Skwentna	51MM1A	160	61°58'N	151°12'W	2,3,4,5	a,c
20	Chelatna Lake	51NN1a	1650	62°31'N	151°29'W	2,3,4,5	a,c
21	Peters Hills	50NN1a	2010	62°31'N	150°57'W	2,3,4,5	a,c
22	Talkeetna	50NN2	350	62°18'N	150°05'W	2,3,4,5	a,c
23	Bald Mtn. Lake	49NN1A	2150	62°15'N	149°45'W	2,3,4,5	a,c
24	Fog Lakes	48NN2A	2250	62°47'N	148°29'W	2,3,4,5	a,c
25	Monahan Flat	47001A	2710	63°18'N	147°39'W	2,3,4,5	a,c
26	Clearwater Lake	46NN1A	3100	62°59'N	146°58'W	2,3,4,5	a,c
27	Sanford River	45NN2A	2280	62°13'N	145°04'W	2,3,4,5	a,c
28	St. Anne's Lake	46MM1A	1990	61°53'N	146°03'W	2,3,4,5	a,c
29	Lake Louise	46NN2A	2400	62°17'N	146°30'W	2,3,4,5	a,c
30	Oshetna Lake	47NN1A	2950	62°23'N	147°29'W	2,3,4,5	a,c
31	Little Nelchina	47NN2a	4160	62°07'N	147°36'W	2,3,4,5	a,c
32	Willow Airstrip	50MM2	150	61°45'N	150°03'W	2,3,4,5	a,c
33	Independence Mine	49MM10	3300	61°45'N	149°25'W	3,4,5	a
34	Sheep Mountain	47MM2	2900	61°47'N	147°30'W	3,4,5	a
35	Tsaina River	45MM4	1500	61°12'N	145°30'W	3,4,5	a
36	Worthington Glacier	45MM2	2400	61°10'N	145°45'W	3,4,5	a
37	Lowe River	45MM3	550	61°06'N	145°50'W	3,4,5	a
38	Valdez	46MM2	50	61°08'N	146°20'W	2,3,4,5	a
39	Wolverine Glacier (A)	48LL1	2130	60°23'N	148°54'W	1,2,4,5,6,7	g
40	Wolverine Glacier (B)	48LL2	3610	60°25'N	148°55'W	2,3,4,5,6,7	g
41	Wolverine Galcier C	48LL3	4430	60°25'N	148°55'W	1,2,4,6,7	g
42	Gulkana Glacier A	45006	4590	63°15'N	145°29'W	2,3,4,5,6,7	g
43	Gulkana Glacier B	45007	5480	63°17'N	145°26'W	2,3,4,5,6,7	g
44	Gulkana Glacier C	45008	6360	63°19'N	145°29'W	5,6,7	g
45	Mankomen Lake	44NN1	3050	63°00'N	144°32'W	2,3,4,5	a
46	Tok Junction	43001	1650	63°18'N	143°00'W	2,3,4,5	a
47	Mentasta Pass	43NN1	2430	62°51'N	143°30'W	2,3,4,5	a
48	Haggard Creek	45NN1A	2540	62°42'N	145°28'W	2,3,4,5	a
49	Fielding Lake	45001A	3000	63°18'N	145°33'W	2,3,4,5	a
50	Ft. Greely	45005	1420	63°57'N	145°45'W	1,2,3,4,5,7	a
51	Granite Creek	45004	1240	63°57'N	[illegible]	1,2,3,4,5,7	a
52	Big Delta	45PP1	980	64°14'N	145°58'W	2,3,4,5	a
53	French Creek	46PP2MA	2010	64°43'N	146°40'W	2,3,4,5,7	a
54	Little Salcha	46PP3	1500	64°38'N	146°44'W	2,3,4,5,7	a
55	Caribou Mine	45PP2A	1115	64°40'N	145°40'W	2,3,4,5,7	a
56	Munson Ridge	46PP1AP	3100	64°52'N	146°13'W	2,3,4,5,7	a
57	Teuchet Creek	45PP3	1640	64°57'N	145°31'W	2,3,4,5	a
58	Upper Chena	44QQ1AP	3000	65°07'N	144°55'W	2,3,4,5,7	a
59	Lower Chena	44QQ6	2000	65°04'N	144°59'W	2,3,4,5,7	a
60	Monument Creek	45QQ2	1900	65°03'N	145°55'W	2,3,4,5	a
61	Mt. Ryan	46QQ1AP	2950	65°16'N	146°07'W	2,3,4,5,7	a
62	Little Chena	46QQ2AP	2200	65°08'N	146°32'W	2,3,4,5,7	a
63	Colorado Creek	46PP4S	750	64°52'N	146°39'W	1,2,3,4,5,7	a
64	Cleary Summit	47QQ1A	2230	65°03'N	147°24'W	1,2,3,4,5,7	a
65	Yak Pasture	47PP1	540	64°52'N	147°55'W	2,3,4,5	a
66	Bonanza Creek	48PP1	1150	64°45'N	148°20'W	2,3,4,5	b
67	Haystack Mtn.	47QQ2	1950	65°08'N	147°38'W	2,3,4,5	d
68	Caribou Creek	47QQ3	1440	65°09'N	147°35'W	2,3,4,5	d
69	Poker Creek	47QQ4S	1025	65°08'N	147°32'W	2,3,4,5,7	d
70	Farewell Lake	53NN1A	1090	62°34'N	153°35'W	3,4	a
71	Lake Minchumina	52001A	730	63°53'N	152°18'W	3,4	a
72	Wien Lake	51PP1A	1020	64°22'N	151°18'W	3,4	a
73	Lake Todatonten	52RR1a	980	66°10'N	152°55'W	3,4	a
74	Bettles Field	51RR1A	640	66°35'N	151°32'W	3,4	a
75	Anaktuvuk Pass	51TT1A	2100	68°09'N	151°41'W	3,4	a
76	Chandalar Lake	48SS1A	2040	67°30'N	148°30'W	3,4	a
77	Squaw Lake	48SS2a	2150	67°33'N	148°15'W	3,4	a
78	Arctic Village	45TT1A	2300	68°05'N	145°35'W	3,4	a
79	Koness Lake	44SS1A	1790	67°55'N	144°08'W	3,4	a
80	Coleen River	42SS1A	1100	67°44'N	142°28'W	3,4,7	a
81	Vundik Lake	43SS1a	950	67°23'N	143°45'W	3,4	a
82	Venetie	46SS1A	610	67°03'N	146°25'W	3,4,7	a
83	Fort Yukon	45RR1AM	430	66°35'N	145°15'W	3,4,7	a
84	Black River	42RR1A	650	66°36'N	142°45'W	3,4,7	a
85	Circle City	44QQ3A	600	65°50'N	144°05'W	3,4,7	a
86	Circle Hot Springs	44QQ5	860	65°29'N	144°39'W	3,4	a
87	Dempsey Creek	41RR2A	950	66°06'N	141°48'W	3,4	a
88	Nation River	41QQ1a	3050	65°25'N	141°40'W	3,4	a
89	Eagle Village	41PP1A	900	64°08'N	141°08'W	3,4,7	a
90	Boundary	41PP3A	3300	64°05'N	141°27'W	3,4	a
91	Chicken Airstrip	41PP2A	1650	64°05'N	141°45'W	3,4,7	a
92	Mt. Fairplay	42001a	3100	63°42'N	142°17'W	3,4,5	a
93	Douglas Ski Bowl	34JJ1	1640	58°16'N	134°27'W	3,4,5	b
94	Cropley Lake	34JJ2	1650	58°16'N	134°31'W	1,2,3,4	b
95	Eagle Crest	34JJ3	1000	58°17'N	134°32'W	1,2,3,4	b
96	Fish Creek	34JJ4	500	58°19'N	134°33'W	1,2,3,4	b
97	Upper Long Lake	33JJ2aS	1000	58°11'N	133°53'W	3,4,5,6,7	e
98	Speel River	33JJ3A	280	58°09'N	133°43'W	3,4,5,6,7	e
99	Petersburg Reservoir	32HH1	550	56°47'N	132°56'W	2,3,4,5	b
100	Mitkof Island	32HH2	1050	56°46'N	132°56'W	2,3,4,5	b
101	Crystal Lake	32HH3	1375	56°36'N	132°50'W	2,3,4,5	b
102	Harriet Top	31GG1	2000	55°29'N	131°37'W	3,4,5	b
103	Hunt Saddle	31GG2	1500	55°30'N	131°37'W	3,4,5	b
104	Lake Shore	31GG3	660	55°29'N	131°36'W	3,4,5	b
105	Log Cabin (B.C.)	34KK1	2880	59°45'N	134°58'W	3,4,5	e
106	Five Mile Camp	49RR1	400	65°55'N	149°48'W	2,3,4,5	i
107	Thirty Mile	50RR2a	1300	66°13'N	150°15'W	2,3,4,5	i
108	Prospect Creek	50RR1	980	66°47'N	150°45'W	2,3,4,5	i
109	Cold Foot Camp	50SS1	1000	67°16'N	150°10'W	1,2,3,4	i
110	Dietrich Camp	49SS1A	1550	67°42'N	149°45'W	2,3,4,5	i
111	Table Mountain	49SS3a	2200	67°58'N	149°45'W	2,3,4,5	i
112	Toolik River	49TT1	3100	68°37'N	149°26'W	7	d
113	Sagwon	48UU1	1000	69°26'N	148°34'W	7	d
114	Prudhoe Bay	48VV1	30	70°15'N	148°30'W	7	h
115	Barrow	56WW1	15	71°20'N	156°40'W	7	h
116	Meade River	57VV1	200	70°29'N	157°25'W	7	h
117	Barter Island	43VV1	15	70°08'N	143°37'W	7	h
118	Kavik River	47UU1	200	69°30'N	147°00'W	7	h
119	Candle	61QQ1	20	66°55'N	161°56'W	3,4	a,f
120	Kugruk River	62QQ1	225	65°40'N	162°27'W	3,4	a,f

LEGEND

* Numerals 1,2,3,4,5, and 6 refer to January 1, February 1, March 1, April 1, May 1, June 1, and 7 - for special dates.

* Letters refer to Agency that secures the snow survey, as follows:
*
- a. Soil Conservation Service
- b. Forest Service
- c. U.S. Army Corps of Engineers
- d. U.S. Army Cold Regions Research & Engineering Lab
- e. Alaska Power Administration
- f. Bureau of Land Management
- g. U.S. Geological Survey
- h. University of Alaska
- i. Alaska Pipeline Office

* Letters following the snow course no. refer to:
*
*
- A. Snow course and aerial stadia marker
- a. Aerial stadia marker only
- M. Soil Moisture Station
- P. Precipitation Storage Gage
- S. Snow Pillow

courses for March, 1976, are given in Table 8 showing average depths of snow given as an equivalent depth of water, both for 1976 and for the period of record.

Snowfall is characterized as strongly influenced by orographic effects and locally variable. Winter thaws also can melt snow on the ground, and snow that falls at low elevations along the coast seldom remains more than a few weeks. As snowmelt becomes more extensive in late spring (early to mid-May) the snowmelt pattern is determined by slope aspect and elevation. The pattern is typical of temperate areas, with melt proceeding from lowest to higher elevations. Of the few relatively flat, low-lying areas in the region such as the western Kenai Peninsula, the Copper River Delta, and the Matanuska Valley; the Kenai Peninsula and Matanuska Valley areas generally are the first areas to become snowfree, usually in early May.

Chronological documentation of the snowmelt patterns in the region are best documented by satellite imagery. Table 6 gives chronological observations using NOAA satellite imagery which is available for the 1975 and 1976 snowmelt periods. NOAA imagery is available in both the visible band (.6 → .7 μ) and the thermal infrared (10.5 → 12.5 μ) band. The resolution is 900 meters at nadir, which is about an order of magnitude less than LANDSAT. However, NOAA imagery provides a much better sequence of snowmelt since it is available daily. At times, the infrared imagery is also a valuable

USDA SCS SNOW COURSES - GULF OF ALASKA REGION

TABLE 8

DRAINAGE BASIN and/or SNOW COURSE NAME	Number	Elevation	Date of Survey	1976 Snow Depth (inches)	Water Content (inches)	PAST RECORD Water Content (inches) Last Year	Average +	Years of Previous Record
COPPER RIVER:								
Haggard Creek	34	2540	2/26	14	2.4	5.6	4.7	11
Little Nelchina	40	4160	2/29	19a	3.2e	6.0e	4.5	8
Mankomen Lake	32	3050	DELAYED REPORT			7.7	6.0	9
St. Anne's Lake	54	1985	2/29	17	3.4	6.1	4.4	11
Sanford River	37	2280	2/29	19a	3.4e	6.2e	4.7	9
Tsaina River	119	1550	2/26	43	11.5	16.7	12.3	3
Worthington Glacier	55	2500	2/26	56	18.5	25.9	15.1	9
MATANUSKA-SUSITNA:								
Alexander Lake	49	200	2/28	26	6.6	12.2e	9.6	12
Bald Mountain Lake	47	2150	2/28	14	3.6	7.2e	6.0	11
Chelatna Lake	44	1650	2/28	40a	8.0e	10.0e	8.6	12
Clearwater Lake	36	3100	2/28	16e	2.7e	6.3	4.9	10
Fog Lakes #2	96	2250	2/28	18	2.8	6.1	5.6	6
Independence Mine	51	3300	3/1	48	1.0	18.7	14.8	9
Lake Louise	41	2400	2/29	14	2.1	4.3	3.5	10
Monahan Flat	35	2710	2/28	25	4.4	9.0	6.3	11
Oshetna Lake	39	2950	2/29	13	2.2	4.5	3.3	12
Peters Hills	45	2010	2/28	49a	10.8e	14.3e	12.2	8
Sheep Mountain #2	120	2900	2/26	18	3.8	4.9	4.3	3
Skwentna	48	158	2/28	27	6.6	10.0	8.4	9
Talkeetna	46	350	2/28	25	5.8	10.4	7.0	9
Willow Airstrip	50	150	2/29	19	4.0	7.9	6.1	12
UPPER COOK INLET:								
Arctic Ski Bowl	65	3000	3/2	26	7.4	11.9	10.5	12
Arctic Valley #1	61	500	3/2	9	1.6	7.0	3.1	12
Arctic Valley #2	62	1000	3/2	12	1.8	6.3	3.2	12
Arctic Valley #3	63	2030	3/2	21	4.1	8.5	5.3	12
Arctic Valley #4	64	2330	3/2	23	4.8	8.5	5.8	12
Bird Creek	66	2350	2/27	39	12.2	20.4	13.8	9
Indian Pass	68	2350	2/27	50	15.3	17.4	16.5	9
McArthur	52	120	NO SURVEY			23.1e	17.4	11
Mt. Alyeska	128	1200	3/1	81	29.0	37.5	26.3	3
Ship Creek	67	1750	2/27	31	8.2	11.6	9.0	9
South Campbell Creek	129	1200	2/27	17	3.2	9.2	6.8	3
PRINCE WILLIAM SOUND:								
Lowe River	118	550	2/26	50	13.5	16.8	---	2
Valdez	117	50	2/26	50	15.7	16.5	---	2
KENAI PENINSULA:								
Bertha Creek	98	850	2/26	48	12.6	13.3	11.2	6
Bridge Creek, Lower	122	1100	2/25	33	9.0	14.6	10.6	4
Bridge Creek, Upper	121	1300	2/25	33	9.6	13.9	10.5	4
Jean Lake	101	620	2/26	14	3.0	4.8	3.1	6
Kenai Summit	99	1390	2/26	34	8.7	9.8	9.4	6
Moose Pass	100	700	2/26	22	5.9	7.0	4.8	6

a - aerial marker reading   e - estimated   N/S - No Survey tool for use in determining the melting condition and extent of melting in a region. Further discussion of the use of NOAA satellite imagery for applications in snow hydrology are found in Seifert et al. (1975) and Kane et al. (1975).

2. Southern Bering Sea Region

Four rivers in this region are presently gauged by the U.S. Geological Survey. They are the Kvichak, Nuyakuk, Wood, and Kuskokwim. All these rivers excepting the Kuskokwim are strongly influenced by large lakes in their respective drainages. These lakes serve as storage mechanisms which moderate flow and consequently streamflow has a low index of seasonal variability. Snowmelt still contributes to most of the peak runoff events in these river systems, however, the seasonability is masked more so by the lake effects in this region than in any other subregion in Alaska. Snowmelt begins in this transitional region about May 1. and continues through early May, with no observed anomalies to the typical temperate elevational snowmelt pattern.

The Kuskokwim River more closely resembles an interior subarctic river system in most of its characteristics. Precipitation is generally lower and snowmelt runoff is the major contribution to streamflow. Consequently the Kuskokwim is also more seasonal and is subject to the additional hazard of ice-jam flooding. No chronology of ice jams is presently available. However, the U.S.

Weather Service River Forecast office in Anchorage does keep records of ice jams and they are often documented by on-site observation notes and photographs. Ice-jam flooding potential exists throughout the snowmelt period from roughly May 1 to the end of May. Ice-jam flooding can result in rapid, unpredictable increases in water levels and equally rapid releases of flood water. More discussion on ice jams is found in the section on the Yukon River in the North Bering-Chukchi Region.

There are observations which indicate subtle snowmelt anomalies in the South Bering region. Snowmelt initiates in the inland (∿ 100 km inland) lowlands and slowly spreads coastward and upward in elevation. This slight anomaly is due to the seasonal lag caused by the shorefast and sea ice and cooler marine influence in the coastal areas. This influence becomes more apparent farther north as the climate becomes more arctic and the influences of sea ice become more pronounced. The anomaly attains its fullest development on Alaska's North Slope, and will be described further in the Beaufort Sea section. Except for the coastal areas, the snowmelt pattern is otherwise elevation-determined.

There are no snowcourses in this region.

3. North Bering - Chukchi Sea Region:

Three rivers in this region are gauged by the U.S. Geological Survey: the Yukon at Ruby, the Kuzitrin River in Nome on the Seward Peninsula, and the Kobuk River at Ambler.

TABLE 9
National Weather Service AHOS/T Sites in Alaska
Installation completed in August 1976

Station	Sensor	
	Precip	River Gage
Healy	x	
Tanacross (Cathedral Bluffs)	x	
Sutton	x	
Little Susitna River	x	
Eagle River	x	
South Fork Eagle River	x	
Tuxedni Park	x	
Glen Alps	x	
Alyeska	x	
Lawing	x	
Auke Bay	x	
Little Rabbit Creek	x	

National Weather Service Proposed AHOS/S Sites
To be installed in the Summer of 1977

Station	Precip	River Gage
Stevens Village (Yukon River Bridge)	x	x
South Fork Campbell Creek (Anchorage)		x
North Pole (Chena River)		x
Little Chena River #2	x	x
Upper Chena River #3	x	x
Nenana (Tanana River)		x
Salchaket (Salcha River)		x
Harding Lake (Tanana River)	x	x
Ship Creek (Anchorage)		x
Eagle River		x

An attempt to characterize the snowmelt of the Yukon River basin is not a meaningful task. The Yukon drains such a huge area (259,000 sq. miles at Ruby) and encompasses nearly every climatic zone in the north. Rather than characterize the snowmelt, which is complex and best observed via satellite, this discussion will center on ice-jam observations and the hazards they produce, and some satellite observations of ice jams. (For a satellite chronology of the snowmelt, see Figures 56-63, following Table 10).

Ice jams have been a seasonal event for Alaska natives since prehistory. Most native villages are associated with rivers and depend on them for food and transportation. Ice jams which flood villages are a fact of life on the Yukon and lower Kuskokwim rivers. At present it is nearly impossible to predict the location of ice jam formations. Present strategy involves monitoring of ice jams once the U.S.W.S. river forecast office is aware of their existence, and warning villagers up- and downstream of the situation. Recently (Bowers, 1976) installations have been made of real-time reporting networks which record precipitation and river stage. These new devices, called Automatic Hydrologic Observing Stations (AHOS/T) with a telephone coupler, have been installed (or will be installed) at the sites listed below (Table 9). AHOS/S sites are similar to AHOS/T except that the data are relayed via the GOES satellite. These real-time data systems will allow earlier detection of rapid increases in river stage and, hopefully, more timely warnings.

The U.S.W.S. river forecast office for Alaska maintains records and photographs of ice jam floods. However, perhaps the most insightful examples of ice jam floods are those which have been observed via satellite. May, 1975, was a particularly fortunate observation period for users of satellite imagery, since the two major floods on the lower Yukon were both recorded by satellite imagery during that month. The first flood occurred near Holy Cross, Alaska, on May 24, 1975 and is best depicted on the thermal infrared imagery of the NOAA satellite. An enlargement of this image showing the flooded area is shown in Figure 62. The flooded area was measured with a polar compensating planimeter and was found to be 2590 $km^2 \pm 5\%$. NOAA imagery provided the only measurement of areal extent of this flood. A second flood, caused by ice jams and of even greater interest to offshore development interests, it occurred in the Yukon Delta on May 29, 1975. This flood was visible on both NOAA and LANDSAT imagery for that date. The LANDSAT image is shown in Figure 60 and a map of the area is shown as Figure 61.

The other river basins in the North Bering-Chukchi Region have no snowcourses, so the only means of characterizing them is via satellite observations. Both the Kuzitrin and Kobuk rivers begin the melt sequence about

May 8-10 each year. Both have elevationally related snowmelt patterns. Melt is 95% complete by June 10 and no significant glaciation is present in either basin.

Relating specifically to the Kobuk River, although Hotham Inlet remained frozen until at least June 10, 1975, there were never any signs of the sea ice being flooded by fresh water from the Kobuk River.

4. Beaufort Sea Region:

The north slope river basins have a unique and interesting snowmelt pattern which results mainly from a combination of severe climate variation and diverse physiography. The pattern is characterized by mid-elevation snowmelt initiation. The first areas to become snowfree in the North Slope are at those elevations between 300 and 600 meters. Runoff begins in late May and flows down channels which are still frozen and filled with ice. When thisinitial meltwater reaches the mouth of the rivers, it encounters still intact shorefast sea ice, and consequently the water flows out over the sea ice, flooding large areas of the ice until it finds a crack or other drainage route.

The snowmelt progresses from the mid-elevation range in both directions. The last areas to become snowfree are the highest peaks in the Brooks Range and the lowest nearshore coastal areas. This is the clearest example of seasonal lag and "thermal inertia" caused by the presence of a large area of sea ice offshore and surface lake ice on the coastal plains, which delays snowmelt until mid-June. Melt occurs rapidly and snowcover is usually slight (< 20 cm), so that the region usually is 95% snowfree by June 25. Runoff is obviously very seasonal. As a further example of this seasonability of runoff, it is interesting to note that in the five years of record, 60 to 80% of all the volume of runoff in the Kuparuk River drainage occurred during the month of June.

A NOAA image (No. 2519), dated June 4, 1975, (Figure 54) shows most of the major seasonal features of interest to OCS development. Meltwater is flooding the shorefast ice at the mouths of the Colville, Kuparuk, Sagavanirktok, and Canning Rivers, and in Kasegaluk lagoon on the Northwest coast of Alaska. The anomalous snowmelt pattern of the North Slope region is also very well documented on this image.

5. Additional Snowmelt Information:

Table 10 classifies ungaged rivers by similarity to gauged streams. This is helpful and necessary since there are many streams which are ungaged, but which have climatic, basin-size, and topographic similarities to gaged basins. These are the characteristics that were used to develop the table.

C. NOAA Satellite Imagery:

A pictorial chronology of the 1975 snowmelt season follows. Figures 56 through 62. Figure captions stress the

TABLE 10
CLASSIFICATION OF UNGAGED RIVERS
BY SIMILARITY TO GAGED RIVERS

Gaged River	Ungaged River	Region
Chakachatna River	Drift River	Gulf Coast - Cook Inlet
	MacArthur River	
	Katnu River	
	Grecian River	
	Johnson River	
	Beluga River	
Nellie Juan River	Rude River	
	Lowe River	
Little Susitna River	Chuit River	
	Theodore River	
Eagle River	Peter's Creek	South Bering - Bristol Bay
	Naknek River	
	Egegik River	
	Ugashik River	
Kuzitrin River	Utokok River	North Bering - Chukchi
	Kokolik River	
	Avalik River	
	Kukpowruk River	
	Pitmegea River	Coastal Streams
	Kukpuk River	Draining N.W. Alaska
	Kivalina River	
	Wulik River	
	Hot Spring Creek	
	Aglapuk River	
	Mudyutok River	Seward Peninsula Drainages
	Buckland River	
	Koyuk River	
	Tagagawik River	Selawik Basin
Kobuk River	Noatak River	Beaufort Sea-Arctic Alaska
Kuparuk River	Ikpikpuk River	Low Elevation dist.
	Shaviovik River	and long stream length
Putuligayuk River	Meade River	
	Ivisaruk River	
	Kaoluk River	
	Avalik River	Coastal Plain drainages
	Okpiksak River	
	Kadleroshilik River	
	Fish Creek	

TABLE 10 Continued

Gaged River	Ungaged River	Region
Sagavanirktok River	Tamavariak River Katakturuk River Sadlerochit River Hulahula River Jago River Okpilak River Aichilik River Egaissrak River Kongakut River Marsh Creek	Beaufort Sea Steep gradient, Immature River Some Braiding

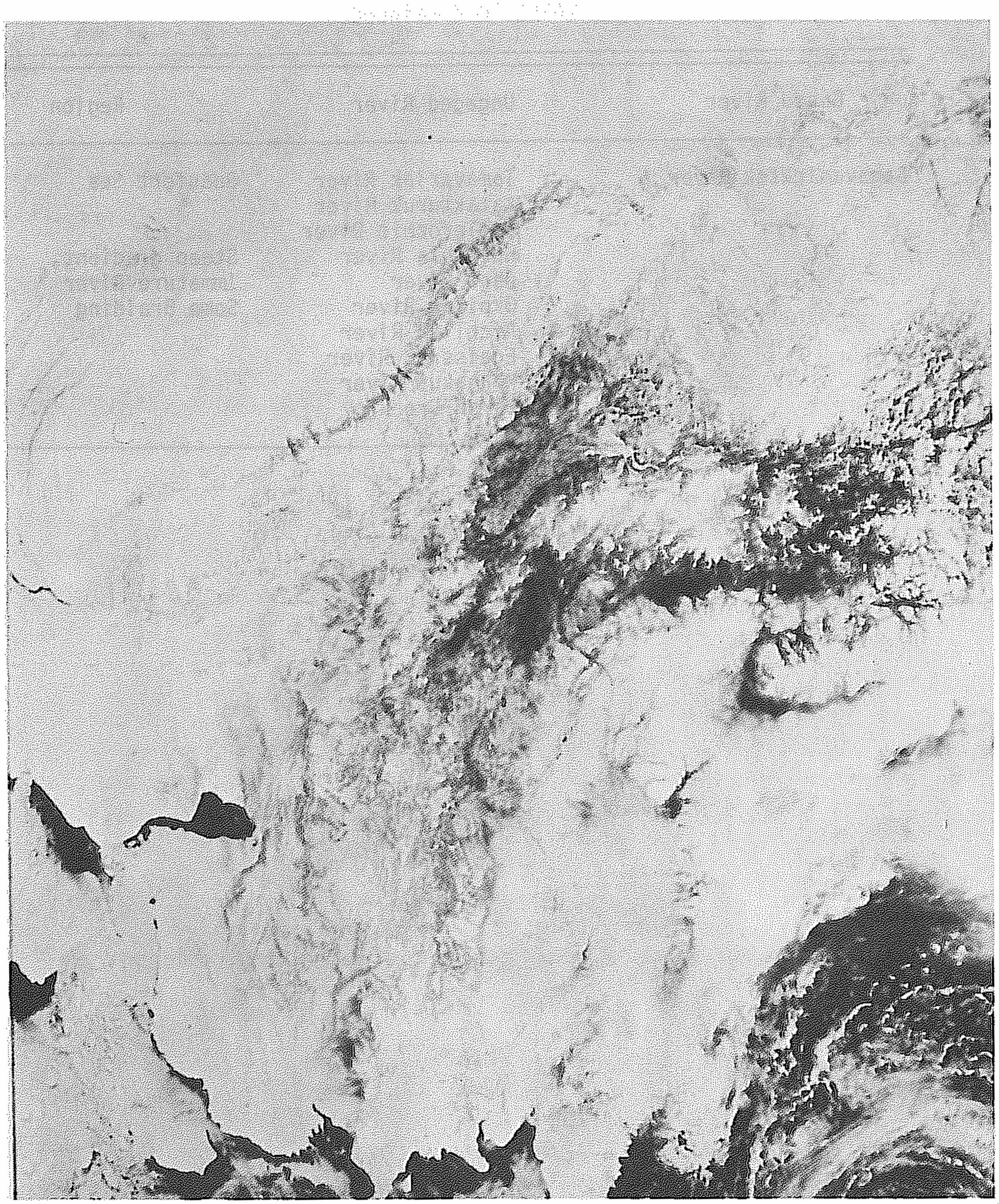


FIGURE 56: NOAA VISIBLE BAND IMAGE, ORBIT NO. 2093, May 1, 1975. This image depicts the earliest days of snowmelt. Unfortunately, the south coast is mostly clouded; however, the original darkening due to snowmelt is evident in the Tanana and Copper River Valleys.

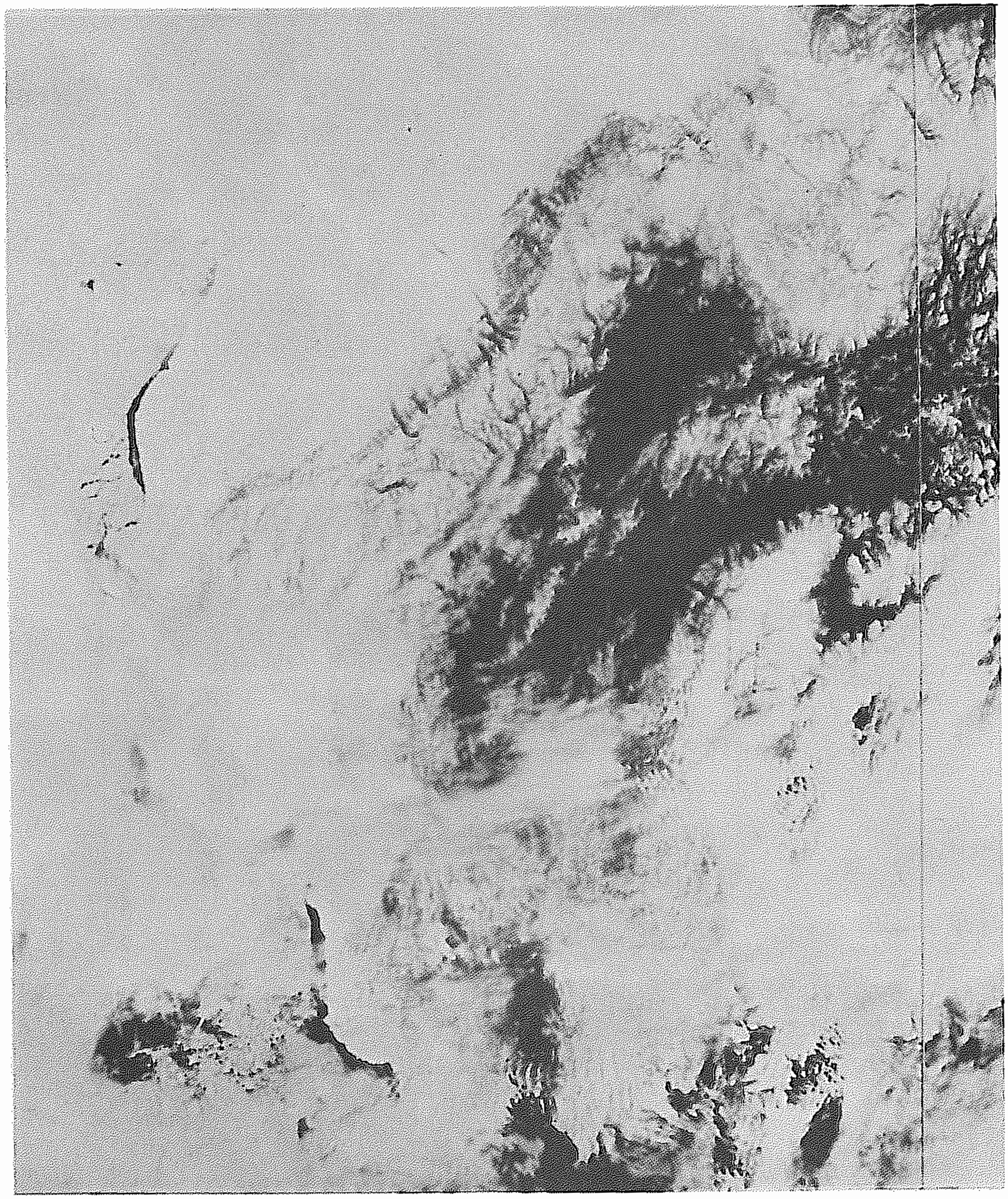


FIGURE 57: NOAA IMAGE, ORBIT NO. 2206, May 10, 1975, VISIBLE BAND. About half the state has now had melting temperatures and conditions. Snowmelt is evident in the Yukon, Tanana, Copper basins and on the Alaska Peninsula. The lower Kuskokwim River area is also partly snowfree.

FIGURE 58: This image is identical to that of Figure 57 except that it is in the thermal infrared band (10.5 - 12.5 μ). This image is also specifically calibrated to depict both snowfree area (black) and areas at 0° C (stippled white and black). This imagery is quite valuable for monitoring rates and areal extent of snowmelt.

FIGURE 59: NOAA IMAGERY, ORBIT NO. 2256, May 14, 1975. Another infrared-enhanced image showing the areas of melting snow statewide in stippled white and the snowfree areas in black. The north slope snowmelt pattern is beginning to emerge at about this date. Note the Yukon River ice cover, indicated as a "melting" area.

FIGURE 60: LANDSAT IMAGE - ORBIT NO. 21363, SPECTRAL BAND 6, May 29, 1975. This image shows the large flooded area of the Yukon Delta, which was caused by a series of ice jams in the delta area. Much ice can still be seen in the main channels.

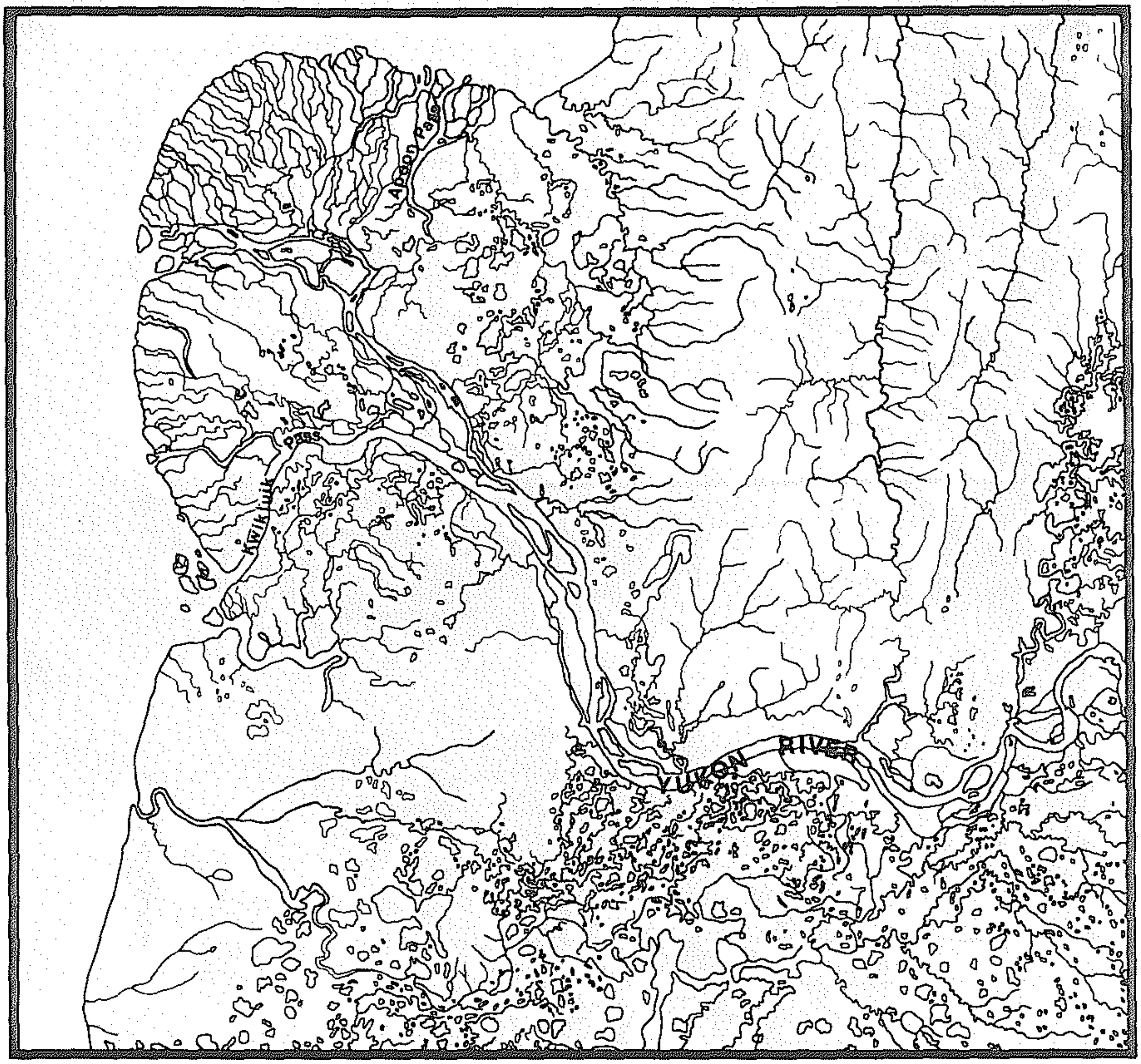


FIGURE 61
NORMAL CHANNEL SIZE OF YUKON RIVER, SAME SCALE AS LANDSAT IMAGE FIGURE 60. (USGS)

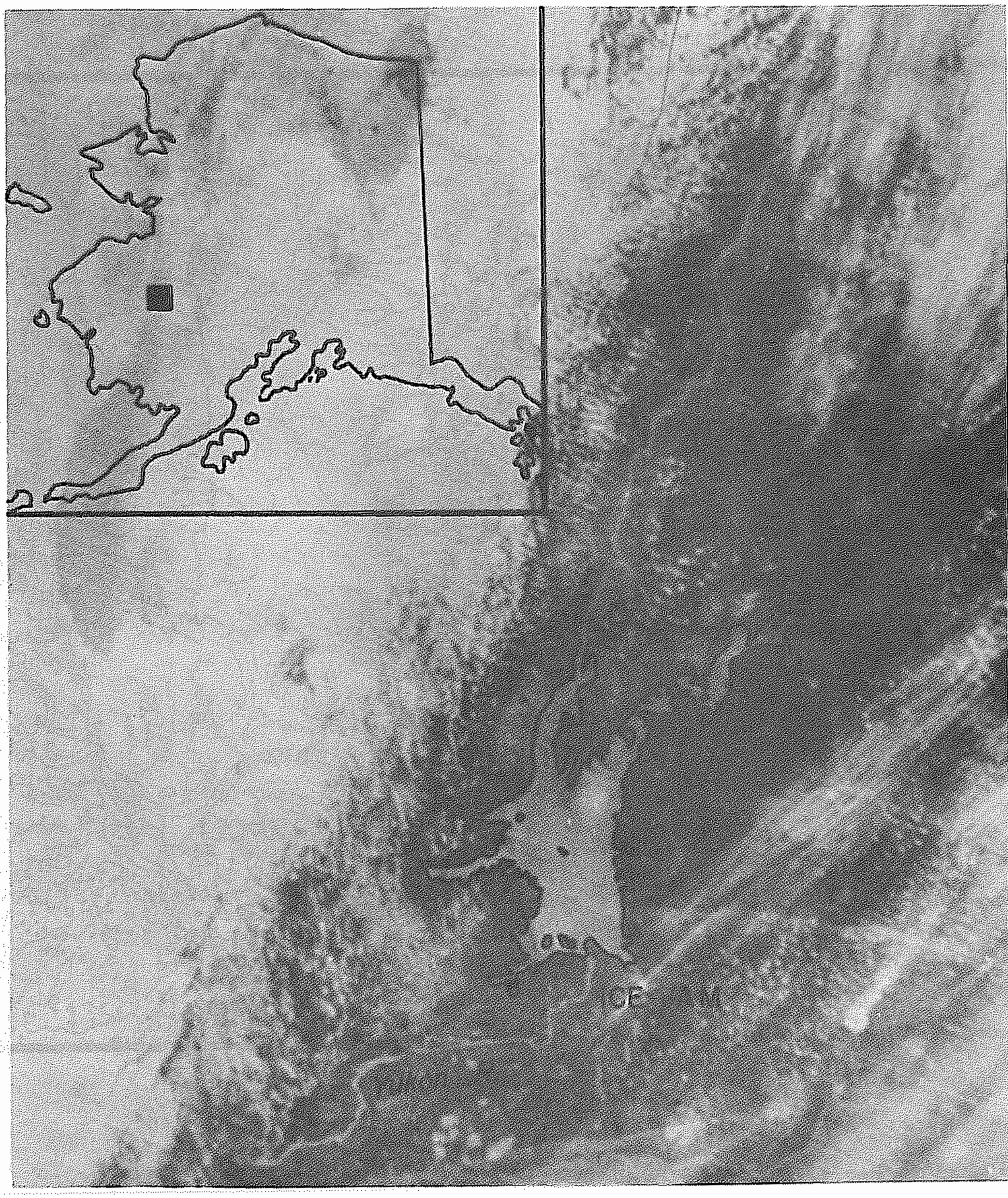


FIGURE 62: NOAA IR IMAGERY ENLARGEMENT, #2381, May 24, 1975. This is one of the most spectacular ice jam floods ever observed by satellite. The site is just upstream from the village of Holy Cross near the confluence of the Yukon and Innoko Rivers. The flooded surface area was measured using a polar compensating planimeter and found to be approximately 2590 km^2 ± 5%.

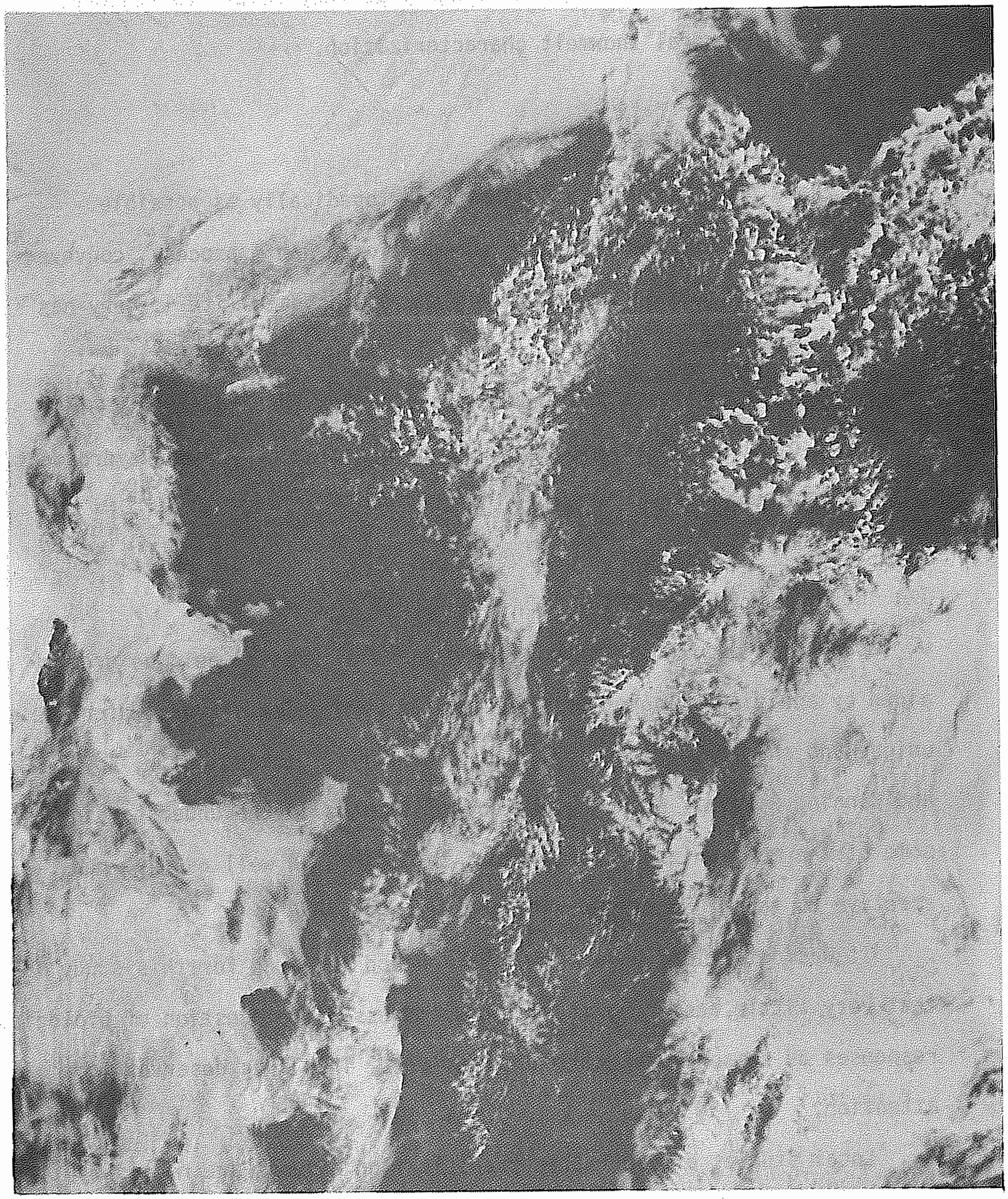


FIGURE 63: NOAA IMAGE, ORBIT NO. 2619, June 12, 1975, VISIBLE BAND. Snowmelt is 95% complete by this date throughout the state. This image is an excellent example of the strong local influences of the oceans in coastal Alaska.

salient features of the imagery as they relate to regional and general snowmelt characterization.

VIII. CONCLUSIONS

Streams have been classified as encyclopedically as possible. A conceptual understanding of the snowmelt and runoff process, conveyed by description and especially through the use of satellite imagery has also been attempted.

These characterizations should prove useful for engineering evaluations of offshore sites as they might be affected by various hydrologic hazards and seasonal variation.

IX. NEEDS FOR FURTHER STUDY

Characterization of the coastal streams of Alaska would be greatly aided by additional gaging of streams. In particular, rivers which are unique and should be gaged include the Colville, Utukok, Wulik, Koyuk, and Canning Rivers. Such gaging would fill gaps in the understanding of some of the more unique river systems in Alaska, as well as give perspective to the study of those rivers already gaged.

It was determined while doing background research for this study that very little research, if any, has addressed the question of biological responses to seasonal streamflow variations. This area deserves more attention.

Local studies of orographic precipitation effects are necessary to understand better this effect in Alaska. There is presently too little available data for adequate assessment of snow depth increases with elevation on either a local or regional basis.

The availability of fresh water in the Beaufort Sea/Chukchi regions is a critical factor in the orderly development of the areas. At present, too little is known about sources of winter and spring (April and May) flow to properly allocate water use by industry and yet still maintain adequate water levels in streams for fish populations. This is especially true in the Sagavanirktok River. Water use may well be one of the major onshore impacts of OCS development, and it is advisable to get more adequate and accurate information on the fresh water available, especially during the critically low late winter periods. For these reasons, it is strongly suggested that a detailed hydrologic reconnaissance be undertaken of all the major rivers in the Chukchi and Beaufort Sea drainages. Documentation of winter sources, flow regimes, springs, the possible availability of groundwater or subsurface flow in streambeds, and a study of minimum flows allowable are all required to ensure protection of the fish and hydrologic resources of the regions. Suggested rivers for hydrologic reconnaissance are the Canning, Sagavanirktok, Kuparuk, Colville, Ikpikpuk, Meade, Utukok, Kokolik, Kukpowruk, Kukpuk, and Wulik Rivers.

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APPENDIX

15210000 POWER CREEK NEAR CORDOVA, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
OCT	2150.	1954	31	70.	1950	31	293.
NOV	1880.	1957	4	40.	1973	30	170.
DEC	550.	1969	29	32.	1973	15	80.
JAN	580.	1958	7	20.	1972	28	57.
FEB	940.	1968	27	18.	1950	16	52.
MAR	1000.	1969	31	15.	1972	16	43.
APR	500.	1969	1	15.	1972	1	48.
MAY	909.	1961	16	20.	1972	1	186.
JUN	1540.	1958	16	138.	1950	1	434.
JUL	3340.	1958	27	281.	1959	27	548.
AUG	2470.	1954	2	176.	1969	14	490.
SEP	5000.	1949	25	94.	1959	21	476.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
5000.	1949	15.	1972	241.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
OCT	594.	1952	123.	1950
NOV	334.	1957	53.	1950
DEC	190.	1969	37.	1950
JAN	129.	1961	25.	1951
FEB	175.	1968	19.	1972
MAR	134.	1968	15.	1972
APR	104.	1963	16.	1972
MAY	308.	1961	94.	1952
JUN	598.	1958	328.	1972
JUL	925.	1958	352.	1974
AUG	716.	1956	252.	1969
SEP	1024.	1951	218.	1969

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
321.	1958	180.	1974

15212000 COPPER RIVER NEAR CHITINA, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
OCT	64500.	1957	1	7440.	1964	31	19682.
NOV	22000.	1957	1	5000.	1966	21	9311.
DEC	9900.	1956	1	4400.	1955	1	6766.
JAN	8500.	1961	1	2700.	1956	1	5528.
FEB	10000.	1968	28	2300.	1956	1	4757.
MAR	8000.	1974	1	2000.	1956	1	4532.
APR	16000.	1974	30	3000.	1959	1	5401.
MAY	80800.	1960	26	3800.	1959	1	29460.
JUN	170000.	1969	18	27300.	1970	1	82447.
JUL	260000.	1971	15	66400.	1970	21	118275.
AUG	226000.	1971	11	27000.	1969	29	102263.
SEP	130000.	1960	13	17700.	1958	30	51183.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
260000.	1971	2000.	1956	36866.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
OCT	29035.	1957	13655.	1968
NOV	15060.	1957	6000.	1955
DEC	9000.	1960	4400.	1955
JAN	8500.	1961	2700.	1956
FEB	8000.	1974	2300.	1956
MAR	8000.	1974	2000.	1956
APR	10933.	1974	3000.	1959
MAY	49945.	1957	15403.	1964
JUN	114967.	1957	48050.	1970
JUL	143794.	1971	84423.	1970
AUG	135523.	1971	53361.	1969
SEP	83893.	1957	27933.	1969

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
46411.	1957	26791.	1970

15219000 W F OLSEN BAY CREEK NEAR CORDOVA, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
SEP	2430.	1973	13	4.	1974	9	141.
OCT	1680.	1972	16	7.	1973	27	85.
NOV	830.	1972	19	3.	1973	24	63.
DEC	400.	1972	1	2.	1973	7	33.
JAN	160.	1973	9	1.	1966	3	15.
FEB	317.	1968	27	1.	1965	1	19.
MAR	355.	1969	31	1.	1966	1	18.
APR	500.	1973	30	2.	1972	1	36.
MAY	3000.	1973	28	10.	1972	1	193.
JUN	2400.	1973	30	25.	1974	30	231.
JUL	3180.	1973	13	11.	1974	31	221.
AUG	1550.	1973	6	5.	1974	23	118.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
3180.	1973	1.	1966	98.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
SEP	889.	1973	18.	1969
OCT	501.	1972	20.	1967
NOV	424.	1972	5.	1973
DEC	218.	1972	4.	1966
JAN	95.	1973	2.	1965
FEB	85.	1973	2.	1966
MAR	87.	1973	2.	1972
APR	213.	1973	2.	1972
MAY	1503.	1973	36.	1971
JUN	1787.	1973	41.	1974
JUL	1841.	1973	19.	1974
AUG	831.	1973	14.	1968

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
643.	1973	25.	1972

15237000 NELLIE JUAN RIVER NEAR HUNTER, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
DEC	220.	1962	11	56.	1961	16	128.
JAN	310.	1961	16	48.	1966	1	113.
FEB	430.	1963	18	40.	1962	1	95.
MAR	140.	1965	11	28.	1964	21	72.
APR	1760.	1965	18	43.	1963	3	167.
MAY	4340.	1961	16	68.	1964	1	738.
JUN	3890.	1962	21	1030.	1965	6	2110.
JUL	5690.	1961	10	1520.	1964	24	[illegible]
AUG	4990.	1961	9	1490.	1961	26	2343.
SEP	7720.	1961	11	480.	1962	18	1913.
OCT	3890.	1964	7	122.	1961	27	594.
NOV	1330.	1964	18	85.	1963	30	275.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
7720.	1961	28.	1964	897.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
DEC	173.	1963	73.	1961
JAN	198.	1961	58.	1962
FEB	167.	1961	40.	1962
MAR	115.	1965	33.	1962
APR	438.	1965	50.	1964
MAY	1088.	1961	324.	1964
JUN	2652.	1964	1635.	1965
JUL	3445.	1962	2195.	1964
AUG	2600.	1963	1823.	1964
SEP	2779.	1963	1192.	1962
OCT	1025.	1963	451.	1961
NOV	517.	1962	138.	1961

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
1098.	1963	861.	1964

15237700 RESURRECTION RIVER NEAR SEWARD, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
OCT	3260.	1955	21	200.	1955	31	957.
NOV	2000.	1967	3	150.	1965	26	479.
DEC	480.	1967	1	100.	1965	29	236.
JAN	382.	1959	1	90.	1955	1	175.
FEB	500.	1959	27	85.	1955	16	158.
MAR	430.	1958	1	60.	1955	11	152
APR	548.	1955	19	70.	1956	4	[illegible]
MAY	3060.	1955	31	150.	1955	1	553.
JUN	5340.	1965	7	750.	1956	1	[illegible]
JUL	4850.	1955	10	1800.	1956	1	2707.
AUG	15000.	1966	21	1230.	1955	29	[illegible]
SEP	14000.	1957	18	1160.	1955	2	[illegible]

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
15000.	1966	60.	1966	1133.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
OCT	1179.	1966	662.	1957
NOV	685.	1957	183.	1965
DEC	384.	1957	119.	1955
JAN	295.	1959	95.	1956
FEB	321.	1958	93.	1955
MAR	220.	1955	59.	1956
APR	338.	1955	99.	1956
MAY	886.	1958	351.	1955
JUN	2268.	1958	1830.	1956
JUL	3294.	1955	2529.	1957
AUG	4271.	1955	2439.	1955
SEP	5745.	1966	2409.	1955

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
1360.	1966	1178.	1955

15238500 LOWELL CREEK AT SEWARD, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
MAY	63.	1968	23	8.	1968	1	29.
JUN	85.	1968	29	22.	1966	1	53.
JUL	101.	1966	12	37.	1967	3	66.
AUG	543.	1966	21	31.	1968	29	88.
SEP	400.	1966	18	19.	1968	24	105.
OCT	185.	1966	5	22.	1965	25	55.
NOV	95.	1967	3	7.	1965	30	23.
DEC	26.	1967	13	2.	1965	24	10.
JAN	12.	1968	1	1.	1966	1	5.
FEB	38.	1968	27	2.	1966	25	6.
MAR	24.	1968	1	2.	1966	1	5.
APR	16.	1967	26	3.	1966	1	7.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
543.	1966	1.	1966	42.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
MAY	43.	1967	18.	1965
JUN	60.	1968	45.	1966
JUL	75.	1965	51.	1967
AUG	139.	1966	46.	1968
SEP	169.	1966	31.	1968
OCT	68.	1966	41.	1967
NOV	38.	1967	13.	1965
DEC	15.	1967	4.	1965
JAN	10.	1968	2.	1966
FEB	11.	1968	3.	1966
MAR	10.	1968	2.	1966
APR	9.	1967	6.	1968

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
45.	1967	32.	1966

15238600 SPRUCE CREEK NEAR SEWARD, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
SEP	1160.	1972	3	14.	1968	24	117.
OCT	1650.	1969	11	16.	1967	30	97.
NOV	440.	1969	1	5.	1973	28	34.
DEC	153.	1969	19	2.	1973	13	14.
JAN	45.	1971	3	1.	1969	6	6.
FEB	80.	1970	11	1.	1969	1	12.
MAR	32.	1970	19	1.	1969	26	11.
APR	91.	1969	17	1.	1973	4	13.
MAY	220.	1969	22	1.	1972	1	59.
JUN	1000.	1969	17	51.	1973	2	174.
JUL	493.	1970	12	68.	1974	25	167.
AUG	704.	1970	20	31.	1974	25	118.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
1650.	1969	1.	1969	77.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
SEP	220.	1974	56.	1968
OCT	333.	1969	38.	1973
NOV	63.	1969	10.	1973
DEC	51.	1969	4.	1973
JAN	15.	1970	1.	1969
FEB	31.	1970	1.	1969
MAR	15.	1970	1.	1969
APR	36.	1969	1.	1972
MAY	100.	1968	31.	1971
JUN	298.	1969	116.	1972
JUL	234.	1971	110.	1974
AUG	218.	1970	57.	1969

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
105.	1970	57.	1968

15239000 BRADLEY RIVER NEAR HOMER, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
OCT	7190.	1969	14	90.	1958	30	436.
NOV	1380.	1957	3	50.	1963	29	181.
DEC	596.	1969	21	38.	1968	16	93.
JAN	300.	1961	16	24.	1972	27	66.
FEB	165.	1970	25	18.	1972	23	50.
MAR	150.	1968	3	16.	1972	26	41.
APR	115.	1970	1	16.	1972	1	44.
MAY	1190.	1961	17	24.	1972	1	254.
JUN	2890.	1958	22	170.	1973	1	722.
JUL	2230.	1971	14	549.	1972	1	1007.
AUG	5140.	1958	13	507.	1968	31	1084.
SEP	6000.	1961	12	184.	1968	24	861.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
7190.	1969	16.	1972	405.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
OCT	1728.	1969	160.	1959
NOV	502.	1957	73.	1968
DEC	239.	1969	41.	1968
JAN	199.	1961	32.	1974
FEB	116.	1970	20.	1972
MAR	109.	1970	17.	1972
APR	103.	1970	17.	1972
MAY	593.	1960	87.	1964
JUN	1358.	1969	517.	1972
JUL	1394.	1971	788.	1959
AUG	1693.	1966	656.	1962
SEP	1557.	1966	306.	1959

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
541.	1970	285.	1962

15240000 ANCHOR RIVER AT ANCHOR POINT, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
OCT	1530.	1957	22	80.	1956	26	351.
NOV	1550.	1957	3	70.	1965	21	232.
DEC	610.	1957	2	45.	1965	15	135.
JAN	400.	1961	16	45.	1966	1	128.
FEB	460.	1963	21	50.	1954	1	121.
MAR	1500.	1963	1	50.	1966	11	151.
APR	2230.	1959	29	80.	1956	1	323.
MAY	2730.	1964	31	188.	1963	27	914.
JUN	2500.	1964	1	62.	1957	26	392.
JUL	1080.	1964	28	47.	1957	15	228.
AUG	2000.	1963	23	40.	1955	21	252.
SEP	1960.	1961	12	103.	1962	2	347.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
2730.	1964	40.	1955	299.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
OCT	611.	1957	197.	1962
NOV	832.	1957	89.	1965
DEC	259.	1957	50.	1965
JAN	284.	1961	50.	1954
FEB	285.	1963	50.	1954
MAR	681.	1963	57.	1966
APR	591.	1958	140.	1955
MAY	1312.	1964	473.	1963
JUN	808.	1955	131.	1957
JUL	365.	1964	133.	1957
AUG	382.	1966	106.	1962
SEP	599.	1961	129.	1962

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
394.	1958	208.	1957

15241600 NINILCHIK RIVER AT NINILCHIK, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
MAY	1000.	1972	12	58.	1969	1	222.
JUN	650.	1964	2	44.	1969	29	123.
JUL	218.	1965	19	30.	1966	20	86.
AUG	350.	1971	7	39.	1969	10	88.
SEP	500.	1966	18	44.	1968	1	119.
OCT	394.	1963	7	36.	1969	23	121.
NOV	500.	1970	2	34.	1963	16	95.
DEC	100.	1967	1	40.	1973	18	57.
JAN	64.	1964	1	36.	1974	11	49.
FEB	80.	1970	26	36.	1974	1	53.
MAR	140.	1970	29	36.	1974	1	63.
APR	1220.	1974	24	40.	1968	1	159.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
1220.	1974	30.	1966	104.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
MAY	381.	1964	82.	1969
JUN	238.	1964	62.	1969
JUL	124.	1965	60.	1969
AUG	144.	1966	48.	1969
SEP	199.	1966	55.	1969
OCT	203.	1966	78.	1968
NOV	248.	1967	41.	1963
DEC	70.	1967	42.	1965
JAN	52.	1972	37.	1974
FEB	67.	1970	36.	1974
MAR	108.	1970	37.	1974
APR	548.	1974	52.	1969

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
139.	1965	76.	1970

15242000 KASILOF RIVER NEAR, KASILOF ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
OCT	8720.	1957	1	1670.	1968	31	4001.
NOV	5230.	1969	1	580.	1955	30	2042.
DEC	2560.	1957	1	310.	1955	16	1142.
JAN	1510.	1970	1	290.	1956	1	716.
FEB	1100.	1970	21	280.	1956	1	569.
MAR	1100.	1970	1	23.	1964	31	515.
APR	792.	1961	5	19.	1964	2	517.
MAY	1200.	1967	25	205.	1964	1	664.
JUN	3380.	1958	30	409.	1964	1	1369.
JUL	8390.	1958	31	1310.	1965	1	3868.
AUG	11400.	1967	25	3060.	1965	1	6698.
SEP	12200.	1957	14	3250.	1970	30	6378.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
12200.	1957	19.	1964	2385.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
OCT	5885.	1957	2584.	1968
NOV	3706.	1957	1161.	1955
DEC	1885.	1952	358.	1955
JAN	1156.	1968	290.	1956
FEB	955.	1961	280.	1956
MAR	919.	1970	270.	1956
APR	719.	1965	113.	1964
MAY	981.	1967	264.	1964
JUN	1821.	1953	824.	1952
JUL	5513.	1958	2093.	1965
AUG	10025.	1967	4168.	1965
SEP	10482.	1957	3982.	1969

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
3196.	1958	1874.	1965

15266300 KENAI RIVER AT SOLDOTNA, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
MAY	7600.	1958	30	1100.	1955	1	2352.
JUN	14700.	1959	28	2520.	1971	2	7256.
JUL	17300.	1971	14	6820.	1972	1	11455.
AUG	23200.	1966	11	5800.	1959	30	[illegible]
SEP	26800.	1974	24	3700.	1958	29	12913.
OCT	29500.	1969	15	1830.	1958	31	5287.
NOV	7000.	1969	1	1300.	1973	28	2758.
DEC	3700.	1959	29	1100.	1973	13	1787.
JAN	8000.	1969	18	950.	1974	23	1516.
FEB	3200.	1959	1	900.	1974	9	1337.
MAR	2500.	1970	30	800.	1973	21	[illegible]
APR	2200.	1958	25	770.	1955	1	1218.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
29500.	1969	770.	1955	5513.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
MAY	3361.	1958	1950.	1973
JUN	10219.	1959	4940.	1972
JUL	15239.	1971	9606.	1973
AUG	18958.	1966	8706.	1959
SEP	20843.	1967	5873.	1969
OCT	14375.	1969	2851.	1958
NOV	4507.	1969	1631.	1973
DEC	2828.	1959	1190.	1973
JAN	2842.	1969	1068.	1974
FEB	2417.	1969	913.	1974
MAR	1781.	1958	842.	1973
APR	1703.	1970	812.	1972

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
6927.	1958	3859.	1974

15267900 RESURRECTION CREEK NEAR HOPE, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
OCT	1450.	1959	11	44.	1958	28	[illegible]
NOV	577.	1970	1	90.	1958	25	175.
DEC	350.	1959	22	55.	1958	25	127.
JAN	170.	1970	1	52.	1974	25	95.
FEB	140.	1959	29	60.	1974	25	76.
MAR	170.	1958	4	50.	1959	1	73.
APR	120.	1971	30	50.	1972	29	74.
MAY	814.	1958	29	51.	1972	1	[illegible]
JUN	1800.	1971	27	201.	1971	2	514.
JUL	1550.	1971	13	239.	1974	31	531.
AUG	1730.	1971	9	146.	1974	23	353.
SEP	555.	1971	5	122.	1959	27	[illegible]

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
1800.	1971	50.	1972	[illegible]

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
OCT	655.	1959	131.	1958
NOV	235.	1957	98.	1953
DEC	192.	1959	77.	1953
JAN	133.	1970	55.	1958
FEB	110.	1958	64.	1974
MAR	125.	1958	50.	1974
APR	92.	1959	58.	1972
MAY	422.	1958	175.	1971
JUN	780.	1970	439.	1973
JUL	954.	1971	334.	1959
AUG	755.	1971	136.	1974
SEP	429.	1971	139.	1959

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
335.	1970	176.	1974

15272550 GLACIER CREEK AT GIRDWOOD, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
OCT	2610.	1959	11	34.	1973	31	272.
NOV	1200.	1970	1	22.	1973	28	12[illegible].
DEC	1150.	1959	19	18.	1973	15	75.
JAN	532.	1970	1	16.	1974	21	42.
FEB	245.	1970	11	13.	1974	23	41.
MAR	207.	1970	18	13.	1974	15	32.
APR	197.	1959	26	13.	1972	1	55.
MAY	1651.	1959	22	21.	1972	1	341.
JUN	2250.	1959	16	226.	1972	5	539.
JUL	1470.	1971	13	277.	1972	2	573.
AUG	2700.	1966	8	101.	1974	25	643.
SEP	4840.	1957	17	83.	1953	25	475.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
4840.	1957	13.	1974	254.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
OCT	817.	1959	99.	1973
NOV	255.	1970	31.	1973
DEC	309.	1959	34.	1973
JAN	140.	1970	21.	1974
FEB	145.	1970	16.	1974
MAR	97.	1970	14.	1974
APR	94.	1959	13.	1972
MAY	453.	1959	152.	1974
JUN	850.	1959	385.	1972
JUL	883.	1971	422.	1974
AUG	900.	1971	274.	1969
SEP	975.	1957	157.	1968

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
355.	1970	152.	1974

15274600 CAMPBELL CREEK NEAR SPENARD, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
OCT	182.	1972	15	30.	1969	2	72.
NOV	130.	1970	1	18.	1973	30	44.
DEC	100.	1967	31	12.	1973	15	31.
JAN	80.	1968	1	4.	1974	28	21.
FEB	25.	1968	10	2.	1969	3	14.
MAR	24.	1970	1	6.	1971	1	14.
APR	85.	1968	24	7.	1971	1	22.
MAY	202.	1968	31	11.	1971	1	52.
JUN	222.	1972	16	28.	1971	3	120.
JUL	256.	1971	28	42.	1969	23	114.
AUG	406.	1971	9	40.	1974	23	98.
SEP	264.	1967	6	30.	1969	23	80.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
406.	1971	2.	1969	57.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
OCT	128.	1972	41.	1968
NOV	81.	1972	23.	1973
DEC	68.	1972	17.	1973
JAN	35.	1973	8.	1974
FEB	21.	1968	7.	1974
MAR	19.	1970	6.	1971
APR	45.	1968	8.	1971
MAY	90.	1968	27.	1971
JUN	162.	1968	88.	1969
JUL	149.	1971	70.	1969
AUG	188.	1971	56.	1974
SEP	159.	1967	35.	1969

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
71.	1967	38.	1969

15275100 CHESTER CREEK AT ARCTIC BLVD. IN ANCHORAGE, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
JUN	51.	1968	1	9.	1970	17	19.
JUL	47.	1969	25	9.	1970	8	19.
AUG	60.	1971	9	12.	1970	4	21.
SEP	67.	1967	5	11.	1969	9	23.
OCT	46.	1971	16	7.	1970	19	20.
NOV	33.	1967	21	5.	1970	30	14.
DEC	30.	1970	23	3.	1970	2	12.
JAN	24.	1968	3	2.	1971	25	11.
FEB	16.	1968	9	2.	1971	1	9.
MAR	23.	1974	31	2.	1971	4	11.
APR	36.	1968	17	5.	1971	10	18.
MAY	59.	1968	31	10.	1970	5	20.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
67.	1967	2.	1971	17.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
JUN	33.	1968	10.	1970
JUL	24.	1968	12.	1970
AUG	33.	1971	15.	1974
SEP	36.	1967	13.	1970
OCT	29.	1971	11.	1970
NOV	21.	1967	9.	1970
DEC	18.	1967	5.	1970
JAN	17.	1968	3.	1971
FEB	15.	1968	3.	1971
MAR	15.	1968	4.	1971
APR	25.	1968	11.	1970
MAY	31.	1972	11.	1970

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
22.	1968	10.	1971

15276500 SHIP CREEK AT ELMENDORF AFB, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
MAY	552.	1963	31	1.	1971	6	113.
JUN	827.	1971	26	31.	1971	3	333.
JUL	725.	1963	3	68.	1959	23	299.
AUG	1300.	1971	9	47.	1959	27	233.
SEP	789.	1967	18	28.	1959	25	171.
OCT	476.	1969	7	7.	1958	29	119.
NOV	203.	1970	1	2.	1958	14	44.
DEC	101.	1967	30	2.	1958	1	23.
JAN	51.	1968	1	1.	1970	4	10.
FEB	17.	1968	29	1.	1959	1	5.
MAR	34.	1965	25	1.	1959	1	5.
APR	48.	1965	26	1.	1959	1	11.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
1300.	1971	1.	1971	125.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
MAY	227.	1958	20.	1971
JUN	594.	1964	245.	1959
JUL	508.	1963	118.	1959
AUG	450.	1971	82.	1959
SEP	380.	1967	40.	1959
OCT	185.	1965	36.	1958
NOV	75.	1970	10.	1958
DEC	34.	1966	2.	1958
JAN	18.	1966	2.	1969
FEB	12.	1964	1.	1959
MAR	15.	1965	1.	1959
APR	32.	1964	1.	1970

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
150.	1964	70.	1970

15277100 EAGLE RIVER AT EAGLE RIVER, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
OCT	2740.	1969	7	80.	1970	20	320.
NOV	340.	1969	2	60.	1973	21	121.
DEC	170.	1967	30	50.	1973	10	91.
JAN	120.	1970	1	24.	1974	29	61.
FEB	90.	1970	1	24.	1974	1	50.
MAR	90.	1970	1	28.	1974	1	51.
APR	140.	1974	30	35.	1971	16	65.
MAY	1060.	1969	27	36.	1971	1	236.
JUN	2700.	1967	24	129.	1971	3	993.
JUL	3430.	1971	14	901.	1971	4	1701.
AUG	4500.	1971	9	465.	1969	25	1603.
SEP	4900.	1967	18	220.	1968	27	869.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
4900.	1967	24.	1974	516.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
OCT	707.	1969	155.	1968
NOV	174.	1969	86.	1973
DEC	119.	1969	54.	1973
JAN	99.	1970	39.	1969
FEB	90.	1970	26.	1974
MAR	85.	1970	36.	1972
APR	79.	1969	36.	1971
MAY	356.	1968	82.	1971
JUN	1507.	1967	689.	1972
JUL	2116.	1967	1303.	1970
AUG	2221.	1967	874.	1969
SEP	1593.	1967	457.	1969

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
709.	1967	418.	1969

15281000 KNIK RIVER NEAR PALMER, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
OCT	19100.	1969	13	850.	1958	30	4276.
NOV	7000.	1970	1	550.	1958	26	1734.
DEC	2700.	1960	10	500.	1973	1	897.
JAN	5000.	1961	22	450.	1960	16	657.
FEB	1800.	1961	1	290.	1962	16	570.
MAR	1500.	1970	30	260.	1962	1	478.
APR	2000.	1969	30	320.	1962	1	683.
MAY	14200.	1974	30	400.	1972	1	3089.
JUN	153000.	1964	30	1550.	1966	1	11717.
JUL	341000.	1961	26	4120.	1965	4	25098.
AUG	47600.	1966	8	9420.	1974	25	20845.
SEP	33800.	1967	19	4160.	1958	26	12102.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
341000.	1961	260.	1962	6899.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
OCT	9419.	1969	2087.	1973
NOV	4844.	1964	637.	1968
DEC	1529.	1969	500.	1973
JAN	1401.	1961	474.	1966
FEB	1378.	1961	338.	1962
MAR	778.	1963	260.	1962
APR	1177.	1964	348.	1972
MAY	7223.	1969	1039.	1965
JUN	19957.	1969	2598.	1965
JUL	37454.	1960	17435.	1970
AUG	25103.	1971	15261.	1969
SEP	16962.	1974	8461.	1958

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
7872.	1967	6317.	1970

15284000 MATANUSKA RIVER AT PALMER, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
OCT	6230.	1951	1	686.	1950	31	1920.
NOV	2100.	1971	1	380.	1958	30	971.
DEC	1300.	1971	1	350.	1958	1	716.
JAN	1000.	1961	16	310.	1959	16	615.
FEB	660.	1961	1	360.	1971	16	514.
MAR	580.	1965	30	340.	1957	20	466.
APR	2220.	1958	30	234.	1956	25	637.
MAY	18700.	1960	26	587.	1970	1	2715.
JUN	26600.	1964	8	1320.	1966	1	10031.
JUL	24800.	1965	13	5780.	1957	1	12848.
AUG	40700.	1971	10	2080.	1959	17	10147.
SEP	15600.	1951	5	1250.	1959	30	4885.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
40700.	1971	234.	1956	3898.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
OCT	2923.	1951	1170.	1969
NOV	1793.	1971	568.	1958
DEC	1024.	1971	440.	1968
JAN	821.	1961	349.	1959
FEB	628.	1961	381.	1971
MAR	572.	1965	360.	1971
APR	985.	1964	465.	1972
MAY	6019.	1960	1007.	1966
JUN	17247.	1964	5415.	1965
JUL	15616.	1956	10340.	1959
AUG	15729.	1971	4992.	1959
SEP	8966.	1951	2123.	1969

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
4815.	1957	2562.	1969

15290000 LITTLE SUSITNA RIVER NEAR PALMER, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
OCT	442.	1965	1	30.	1956	28	118.
NOV	140.	1970	1	18.	1958	27	57.
DEC	60.	1972	1	9.	1961	26	36.
JAN	100.	1961	13	16.	1959	16	28.
FEB	31.	1957	1	10.	1955	1	22.
MAR	30.	1965	27	8.	1957	11	18.
APR	72.	1953	30	8.	1956	1	21.
MAY	1510.	1974	30	12.	1955	1	199.
JUN	2810.	1949	21	90.	1971	1	675.
JUL	2080.	1967	20	167.	1958	15	516.
AUG	5040.	1971	10	102.	1974	25	444.
SEP	1880.	1957	19	57.	1969	30	284.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
5040.	1971	8.	1957	202.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
OCT	210.	1972	51.	1968
NOV	81.	1957	24.	1968
DEC	47.	1965	17.	1954
JAN	54.	1961	17.	1959
FEB	29.	1968	14.	1952
MAR	28.	1968	10.	1956
APR	34.	1965	10.	1955
MAY	395.	1974	53.	1971
JUN	1176.	1949	289.	1959
JUL	1047.	1963	240.	1958
AUG	909.	1971	169.	1969
SEP	606.	1965	82.	1969

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
316.	1949	96.	1959

15292000 SUSITNA RIVER AT GOLD CREEK, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
OCT	20100.	1949	1	1500.	1950	31	5688.
NOV	5300.	1957	1	950.	1969	25	2473.
DEC	4400.	1957	5	800.	1968	25	1765.
JAN	2600.	1958	6	700.	1969	14	1444.
FEB	2200.	1972	1	75.	1969	28	1204.
MAR	2100.	1961	16	660.	1950	11	1076.
APR	3700.	1953	26	700.	1974	1	1342.
MAY	55500.	1972	31	900.	1964	1	13533.
JUN	85900.	1964	7	10000.	1971	1	27986.
JUL	50000.	1967	21	11800.	1969	28	24079.
AUG	77700.	1971	10	5280.	1969	29	22087.
SEP	41000.	1959	1	3710.	1969	30	13786.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
85900.	1964	75.	1969	9761.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
OCT	8212.	1957	3124.	1969
NOV	3954.	1957	1215.	1969
DEC	3264.	1957	866.	1969
JAN	2452.	1961	724.	1969
FEB	2028.	1972	699.	1969
MAR	1900.	1968	713.	1964
APR	2650.	1961	745.	1964
MAY	21887.	1972	3745.	1971
JUN	50577.	1964	15503.	1969
JUL	34400.	1963	16103.	1969
AUG	32623.	1967	8879.	1969
SEP	21243.	1951	5093.	1969

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
11566.	1962	5595.	1969

152945-CHAKACHATNA RIVER NEAR TYONEK, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
OCT	9240.	1955	1	1000.	1971	27	2458.
NOV	2590.	1969	1	802.	1959	25	1236.
DEC	1300.	1969	1	590.	1959	16	813.
JAN	990.	1961	25	438.	1963	31	613.
FEB	890.	1961	6	360.	1960	16	515.
MAR	678.	1961	1	320.	1960	16	445.
APR	1000.	1971	29	240.	1960	16	441.
MAY	5980.	1960	31	310.	1964	1	1042.
JUN	19000.	1971	27	1000.	1955	1	5736.
JUL	19800.	1971	15	4430.	1955	1	12018.
AUG	90000.	1971	11	4390.	1959	31	12976.
SEP	14000.	1965	16	2010.	1960	29	6054.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
90000.	1971	240.	1960	3545.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
OCT	4072.	1965	1351.	1971
NOV	1822.	1969	902.	1971
DEC	1007.	1963	650.	1965
JAN	817.	1961	480.	1966
FEB	780.	1961	381.	1960
MAR	550.	1970	325.	1960
APR	692.	1971	250.	1960
MAY	2381.	1971	471.	1964
JUN	10933.	1971	2114.	1965
JUL	14472.	1971	9960.	1970
AUG	16714.	1971	8416.	1969
SEP	10255.	1965	3347.	1969

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
4558.	1971	3106.	1970

15295700 TERROR RIVER AT MOUTH NEAR KODIAK, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
MAR	394.	1965	23	19.	1967	1	69.
APR	237.	1965	10	24.	1966	1	94.
MAY	1430.	1965	30	60.	1968	1	351.
JUN	1820.	1964	16	290.	1967	30	774.
JUL	1850.	1968	23	96.	1967	30	490.
AUG	2010.	1964	13	85.	1967	3	357.
SEP	2500.	1966	26	111.	1968	2	435.
OCT	2600.	1965	2	77.	1965	31	277.
NOV	482.	1967	3	47.	1965	22	115.
DEC	500.	1967	25	34.	1964	30	75.
JAN	245.	1966	26	24.	1967	31	60.
FEB	320.	1968	12	19.	1967	23	62.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
2600.	1965	19.	1967	277.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
MAR	164.	1965	27.	1966
APR	134.	1965	72.	1964
MAY	528.	1968	200.	1965
JUN	1055.	1966	553.	1967
JUL	625.	1965	194.	1967
AUG	533.	1964	243.	1967
SEP	708.	1967	249.	1964
OCT	327.	1965	251.	1967
NOV	210.	1967	67.	1965
DEC	154.	1967	48.	1965
JAN	75.	1966	39.	1967
FEB	142.	1968	27.	1967

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
280.	1967	257.	1966

15296000 UGANIK RIVER NEAR KODIAK, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
OCT	8180.	1952	3	120.	1973	29	676.
NOV	9130.	1954	2	76.	1965	17	534.
DEC	2920.	1963	21	65.	1955	31	259.
JAN	4110.	1963	22	50.	1967	31	226.
FEB	1100.	1968	27	30.	1972	23	159.
MAR	2150.	1965	23	24.	1972	10	158.
APR	1440.	1953	30	30.	1972	1	231.
MAY	3420.	1961	31	130.	1952	1	844.
JUN	5540.	1969	8	493.	1955	6	1734.
JUL	5050.	1968	23	230.	1967	30	1351.
AUG	7480.	1963	30	198.	1967	3	827.
SEP	5530.	1966	27	164.	1952	20	797.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
9130.	1954	24.	1972	653.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
OCT	2106.	1969	162.	1973
NOV	1378.	1959	100.	1973
DEC	620.	1969	82.	1973
JAN	1108.	1963	53.	1956
FEB	442.	1968	48.	1972
MAR	631.	1965	26.	1972
APR	383.	1953	69.	1972
MAY	1396.	1960	473.	1971
JUN	2885.	1969	1034.	1952
JUL	2426.	1971	457.	1967
AUG	1308.	1971	394.	1957
SEP	1523.	1957	254.	1954

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
882.	1960	438.	1952

15297200 MYRTLE CREEK NEAR KODIAK, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
JUN	877.	1969	8	13.	1968	22	42.
JUL	333.	1971	19	2.	1963	24	35.
AUG	429.	1966	21	1.	1963	14	37.
SEP	722.	1969	14	8.	1968	1	62.
OCT	396.	1968	2	7.	1973	16	47.
NOV	254.	1967	1	4.	1965	21	38.
DEC	450.	1969	5	2.	1968	16	32.
JAN	250.	1965	20	2.	1969	1	21.
FEB	346.	1968	29	2.	1969	1	28.
MAR	330.	1965	8	1.	1972	3	25.
APR	257.	1966	26	2.	1972	1	32.
MAY	443.	1971	31	12.	1972	1	74.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
877.	1969	1.	1963	43.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
JUN	175.	1969	15.	1963
JUL	87.	1971	8.	1967
AUG	72.	1967	7.	1969
SEP	107.	1969	30.	1968
OCT	120.	1969	20.	1973
NOV	63.	1972	11.	1973
DEC	112.	1969	3.	1968
JAN	48.	1965	2.	1969
FEB	79.	1968	2.	1969
MAR	108.	1965	1.	1972
APR	47.	1969	4.	1972
MAY	102.	1973	39.	1964

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
67.	1970	34.	1964

15300500 KVICHAK RIVER AT IGUIGIG, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
AUG	35000.	1967	30	14600.	1974	1	22388.
SEP	43000.	1967	21	16000.	1974	1	25194.
OCT	66000.	1967	4	18400.	1973	30	31426.
NOV	36200.	1967	1	15000.	1973	27	24926.
DEC	32000.	1967	12	12600.	1973	30	20405.
JAN	21600.	1968	1	9000.	1969	23	14619.
FEB	17000.	1972	1	7500.	1969	23	12474.
MAR	14400.	1970	14	7000.	1969	5	11049.
APR	13800.	1970	1	6400.	1969	21	11269.
MAY	15000.	1972	26	7000.	1969	1	10810.
JUN	20400.	1972	30	9000.	1969	1	13742.
JUL	25800.	1972	31	12000.	1974	1	18153.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
66000.	1967	6400.	1969	18144.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
AUG	28677.	1967	15248.	1974
SEP	40367.	1967	17237.	1974
OCT	47994.	1967	20432.	1973
NOV	30620.	1967	16523.	1973
DEC	26665.	1967	14103.	1973
JAN	18781.	1968	9726.	1969
FEB	15207.	1972	8143.	1969
MAR	14000.	1972	7065.	1969
APR	13080.	1970	6740.	1969
MAY	14032.	1972	7371.	1969
JUN	17873.	1972	10983.	1974
JUL	23694.	1972	13555.	1974

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
23268.	1968	13420.	1974

1530200 NUYAKUK RIVER NEAR DILLINGHAM, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
OCT	19900.	1955	1	2000.	1958	31	5055.
NOV	12000.	1959	1	2100.	1953	21	4642.
DEC	7250.	1957	2	1700.	1957	25	2974.
JAN	3400.	1957	1	1300.	1954	16	2253.
FEB	3200.	1953	1	1200.	1954	15	1859.
MAR	3570.	1953	8	1000.	1954	16	1653.
APR	2300.	1955	1	770.	1950	15	1571.
MAY	13400.	1950	31	960.	1950	1	3555.
JUN	29900.	1959	20	3590.	1955	1	14638.
JUL	26100.	1958	1	4700.	1957	31	13259.
AUG	20300.	1971	1	3500.	1957	23	8112.
SEP	22900.	1955	26	4100.	1957	1	7827.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
29900.	1959	770.	1950	58[illegible].

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
OCT	11523.	1955	3815.	1958
NOV	8886.	1957	2570.	1958
DEC	4887.	1957	1348.	1953
JAN	3176.	1951	1397.	1954
FEB	3200.	1953	1252.	1954
MAR	3041.	1953	1097.	1954
APR	2300.	1955	800.	1950
MAY	5890.	1951	1719.	1954
JUN	23293.	1959	10361.	1954
JUL	21852.	1958	5794.	1954
AUG	13834.	1971	3855.	1957
SEP	14373.	1955	5271.	1959

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
7948.	1958	4235.	1954

15303000 WOOD RIVER NEAR ALEKNAGIK, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
OCT	16200.	1955	1	2800.	1957	25	[illegible]
NOV	10200.	1969	1	2200.	1957	26	[illegible]
DEC	7830.	1957	1	1300.	1955	30	[illegible]
JAN	5400.	1970	1	800.	1957	28	[illegible]
FEB	4400.	1953	1	700.	1957	13	[illegible]
MAR	3600.	1953	8	700.	1957	1	1527.
APR	3250.	1955	26	700.	1957	1	[illegible]
MAY	11900.	1965	31	990.	1956	1	[illegible]
JUN	23300.	1959	22	2000.	1956	1	[illegible]
JUL	16800.	1959	1	3680.	1958	28	[illegible]
AUG	8270.	1960	15	2720.	1959	29	[illegible]
SEP	17500.	1955	26	2940.	1959	5	[illegible]

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
23300.	1959	700.	1957	[illegible]

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
OCT	9855.	1966	3396.	1959
NOV	8225.	1957	2500.	1967
DEC	5337.	1969	1600.	1955
JAN	4187.	1970	969.	1957
FEB	3451.	1963	727.	1957
MAR	3129.	1953	700.	1957
APR	2939.	1955	785.	1950
MAY	5595.	1960	990.	1956
JUN	18393.	1955	8003.	1959
JUL	13080.	1958	5046.	1958
AUG	7508.	1960	4245.	1969
SEP	9517.	1965	3912.	1957

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
6054.	1958	3495.	1958

15304000 KUSKOKWIM RIVER AT CROOKED CREEK, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
OCT	172000.	1955	1	18000.	1953	31	[illegible]
NOV	37000.	1957	1	12000.	1956	16	2[illegible]252.
DEC	25000.	1957	1	10000.	1955	1	14357.
JAN	19000.	1962	1	8400.	1956	1	12559.
FEB	14000.	1955	1	6900.	1955	1	11[illegible]18.
MAR	19000.	1957	1	6100.	1956	1	1[illegible]195.
APR	50000.	1957	16	7000.	1955	1	12755.
MAY	260000.	1957	7	10000.	1951	1	[illegible]1761.
JUN	391000.	1964	5	28000.	1954	22	[illegible]7573.
JUL	154000.	1957	28	30200.	1954	1	69596.
AUG	302000.	1963	28	33100.	1959	17	[illegible]
SEP	234000.	1963	1	25800.	1968	26	7131[illegible].

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
391000.	1964	6100.	1956	436[illegible]6.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
OCT	74903.	1955	25625.	1953
NOV	34500.	1957	14000.	1956
DEC	25000.	1961	10000.	1955
JAN	19000.	1962	8400.	1956
FEB	14000.	1955	6900.	1955
MAR	19000.	1957	6100.	1956
APR	41000.	1967	8600.	1953
MAY	161658.	1957	22129.	1964
JUN	235057.	1964	33890.	1954
JUL	115677.	1953	44055.	1954
AUG	159761.	1963	41842.	1957
SEP	114770.	1961	31790.	1968

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
62116.	1963	32178.	1959

15564800 YUKON RIVER AT RUBY, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
OCT	330000.	1955	1	67000.	1959	31	151270.
NOV	120000.	1957	1	41000.	1959	16	69494.
DEC	76000.	1957	1	31000.	1957	15	44453.
JAN	51000.	1958	1	29000.	1959	1	36323.
FEB	37000.	1952	1	23000.	1955	1	29915.
MAR	33000.	1955	1	17000.	1959	1	25916.
APR	40000.	1959	30	17000.	1959	1	27556.
MAY	800000.	1971	21	25000.	1972	1	229753.
JUN	959000.	1964	18	332.	1957	29	457437.
JUL	705000.	1954	1	262.	1959	31	292546.
AUG	524000.	1957	22	190000.	1956	31	317155.
SEP	498000.	1952	5	142000.	1958	30	244235.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
959000.	1954	262.	1959	161120.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
OCT	199613.	1953	99323.	1958
NOV	98000.	1962	47000.	1953
DEC	54225.	1957	32935.	1959
JAN	50000.	1952	29000.	1965
FEB	37000.	1962	23000.	1965
MAR	33000.	1965	17000.	1959
APR	34000.	1965	18500.	1959
MAY	389710.	1971	104677.	1954
JUN	865099.	1954	517.	1957
JUL	548516.	1954	323.	1959
AUG	472355.	1957	225581.	1956
SEP	370033.	1952	168857.	1955

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
227211.	1962	116756.	1959

15712000 KUZITRIN RIVER NEAR NOME, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
AUG	10000.	1955	8	305.	1971	15	1253.
SEP	8930.	1955	10	200.	1970	30	1444.
OCT	2310.	1954	8	130.	1970	30	713.
NOV	750.	1972	1	40.	1957	29	253.
DEC	300.	1972	1	10.	1957	26	177.
JAN	160.	1973	1	2.	1954	21	53.
FEB	120.	1973	1	1.	1971	28	35.
MAR	100.	1973	1	10.	1972	1	57.
APR	100.	1959	30	1.	1955	23	33.
MAY	30000.	1957	23	1.	1954	1	3169.
JUN	40000.	1971	3	310.	1970	30	5334.
JUL	4040.	1965	19	290.	1970	5	112[illegible].

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
40000.	1971	1.	1971	1454.

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
AUG	4125.	1955	350.	1971
SEP	4154.	1955	381.	1959
OCT	1355.	1965	187.	1970
NOV	448.	1972	83.	1957
DEC	212.	1972	23.	1957
JAN	142.	1973	10.	1958
FEB	108.	1973	2.	1955
MAR	85.	1973	10.	1972
APR	80.	1973	1.	1955
MAY	8252.	1957	212.	1954
JUN	11793.	1971	912.	1970
JUL	1871.	1957	345.	1970

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
2258.	1955	675.	1959

15744000 KOBUK RIVER AT AMBLER, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
JUL	65500.	1957	21	3300.	1959	9	16446.
AUG	90400.	1973	22	5600.	1958	31	17852.
SEP	53500.	1955	10	4000.	1958	29	13831.
OCT	32100.	1955	1	2200.	1970	30	9271.
NOV	5500.	1973	1	1600.	1970	25	3528.
DEC	3400.	1972	1	1100.	1970	25	2041.
JAN	2600.	1973	1	900.	1959	21	1515.
FEB	2200.	1973	1	800.	1959	15	1256.
MAR	1800.	1973	1	800.	1957	1	1155.
APR	3400.	1959	30	700.	1957	1	1154.
MAY	95000.	1971	29	900.	1971	1	15824.
JUN	94000.	1958	13	4800.	1959	30	34775.

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
95000.	1971	700.	1957	[illegible]

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
JUL	30977.	1957	5236.	1959
AUG	39752.	1973	8119.	1971
SEP	33253.	1955	4967.	1958
OCT	18584.	1955	2974.	1970
NOV	5000.	1955	1850.	1970
DEC	3052.	1972	1297.	1970
JAN	2426.	1973	931.	1959
FEB	2057.	1973	827.	1959
MAR	1753.	1973	800.	1957
APR	1550.	1973	900.	1971
MAY	30242.	1973	3945.	1966
JUN	51310.	1958	7810.	1959

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
12615.	1958	5502.	1970

15896000 KUPARUK RIVER NEAR DEADHORSE, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
MAY	7200.	1971	31	10.	1972	1	[illegible]
JUN	78000.	1973	8	330.	1971	30	[illegible]
JUL	3700.	1973	25	213.	1971	9	821.
AUG	6040.	1972	28	200.	1974	12	[illegible]
SEP	5040.	1972	4	20.	1974	30	[illegible]
OCT	500.	1972	1	20.	1973	21	[illegible]
NOV	300.	1972	1	15.	1973	1	74.
DEC	30.	1972	1	10.	1973	1	17.
JAN	10.	1972	1	10.	1972	1	[illegible]
FEB	10.	1972	1	10.	1972	1	[illegible]
MAR	10.	1972	1	10.	1972	1	[illegible]
APR	10.	1972	1	10.	1972	1	[illegible]

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
78000.	1973	10.	1972	[illegible]

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
MAY	7200.	1971	10.	1972
JUN	17884.	1971	5592.	1974
JUL	1392.	1973	300.	1971
AUG	2641.	1972	425.	1971
SEP	2733.	1972	192.	1974
OCT	406.	1972	52.	1973
NOV	174.	1972	15.	1973
DEC	23.	1972	10.	1973
JAN	10.	1972	10.	1972
FEB	10.	1972	10.	1972
MAR	10.	1972	10.	1972
APR	10.	1972	10.	1972

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
1721.	1972	1592.	1973

15910000 SAGAVANIRKTOK RIVER NEAR SAGWON, ALASKA

***** MEAN DAILY FLOW BY MONTH *****

MONTH	MAXIMUM	YEAR	DAY	MINIMUM	YEAR	DAY	AVERAGE
AUG	25200.	1974	10	1300.	1971	31	[illegible]
SEP	6050.	1972	1	450.	1970	30	[illegible]
OCT	900.	1972	1	92.	1973	31	[illegible]
NOV	500.	1972	1	14.	1973	30	[illegible]
DEC	100.	1970	1	3.	1973	29	27.
JAN	20.	1973	1	2.	1974	5	5.
FEB	11.	1973	1	2.	1972	1	[illegible]
MAR	10.	1973	1	2.	1971	1	[illegible]
APR	11.	1973	1	2.	1971	1	6.
MAY	15000.	1972	31	2.	1971	1	[illegible]
JUN	20000.	1972	1	1500.	1971	15	7311.
JUL	18400.	1973	24	1750.	1971	3	[illegible]

***** YEARLY FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR	AVERAGE
25200.	1974	2.	1974	[illegible]

***** MEAN MONTHLY FLOW DATA *****

MONTH	MAXIMUM	YEAR	MINIMUM	YEAR
AUG	6731.	1974	2585.	1971
SEP	2271.	1972	792.	1971
OCT	690.	1972	245.	1971
NOV	273.	1972	40.	1973
DEC	59.	1972	7.	1973
JAN	15.	1973	2.	1974
FEB	10.	1973	2.	1972
MAR	10.	1973	2.	1971
APR	10.	1973	2.	1971
MAY	2954.	1974	186.	1971
JUN	9051.	1972	5683.	1973
JUL	7154.	1973	4006.	1974

***** MEAN ANNUAL FLOW DATA *****

MAXIMUM	YEAR	MINIMUM	YEAR
1945.	1973	1497.	1971