SR 155

Special Report 155

SPRING BREAKUP OF THE DELTA RIVER, ALASKA

C.W. Slaughter and H.R. Samide

April 1971

CORPS OF ENGINEERS, U.S. ARMY
COLD REGIONS RESEARCH AND ENGINEERING LABORATORY
HANOVER, NEW HAMPSHIRE

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

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PREFACE

This report was prepared by Dr. C.W. Slaughter, Research Hydrologist, and Specialist 5 H.R. Samide, of the Earth Sciences Branch, Research Division, U.S. Army Cold Regions Research and Engineering Laboratory (USA CRREL).

This work was performed under contract with the U.S. Army Arctic Test Center, Fort Greely, Alaska (Reimbursable Order 659-21, 20 June 1966).

Photographic and helicopter support were provided by the U.S. Army Arctic Test Center, through the cooperation of Mr. H.H. Rasche, Chief Scientist; Colonel W.L. Johnston, Deputy Commander; and Lieutenant Colonel A.J. Adams, Director of Logistics.

Dr. Jerry Brown, Earth Sciences Branch, Research Division, USA CRREL, was most helpful in planning and organizing the project. The assistance of Specialist 5 James Riley and Specialist 5 Dwane L. Saboe, USA CRREL, in the field phases of this study was invaluable. Mr. Roy Bates, Snow and Ice Branch, Research Division, USA CRREL, contributed valuable criticism during the preparation of this report.

Manuscript submitted 5 October 1970.

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SPRING BREAKUP OF THE DELTA RIVER, ALASKA

by

C.W. Slaughter and H.R. Samide

Introduction

The Delta River originates in the Tangle Lakes region of the Alaska Range, and flows northward to enter the Tanana River at Big Delta, Alaska. Elevations within the basin are from 1000 to 9000 ft above sea level. Approximately 255 square miles of the 1665 square-mile area of the basin are covered by glaciers. The Delta River, primarily glacially fed, flows in a broad, intensely braided course north (downstream) from Black Rapids Glacier (see basin map, Fig. 1). A description of the physical setting, along with climatic, vegetative, and hydrologic descriptions, is given in Dingman *et al.* (1971).

Conditions on the Delta River during freeze-up in the fall of 1966 were documented by Bilello *et al.* (1967).

The sequence of breakup was observed during periodic ground trips and helicopter flights along the Delta River, Alaska, in the spring of 1967. Photos taken at a number of points along the river and comments on general conditions, along with photo sequences at selected locations, are included in this report. Complete notes and records are available at the Cold Regions Research and Engineering Laboratory (CRREL).

General

The spring ice breakup process has been observed and documented on several arctic and subarctic rivers. As a rule, the breakup being documented has been a relatively rapid, sometimes spectacular, process (in contrast with that of the Delta River, as will be subsequently shown). For example, Williams (1955) described the breakup of the Yukon River at Beaver, Alaska, in the spring of 1950:

> "By 8.30 hr, 14 May, river level had reached 2.35 m .... The river continued to rise rapidly, and just before 10.00 hr, noise caused by grinding ice could be heard as breakup approached Beaver from upstream .... At 10.00 hr ... the river ice in the main channel started to break and move slowly downstream .... Breakup had taken one day to advance from Ft. Yukon to Beaver, a channel distance of about 150 km. The first masses of ice moved were several tens of meters across .... These rammed the banks with terrific force."*

Individual rivers may exhibit markedly different behavior from year to year, as was noted for the Colville River by Walker (1966). Breakup on the Colville River, which flows northward to the Arctic Ocean, occurred concurrently with a continuing rise in discharge in 1962, with consequent rapid removal of ice and little jamming. In 1964 breakup was coupled with a falling discharge,

Figure 1. Delta River drainage basin. (From Dingman et al., 1971.)

leaving much ice stranded on high ground, and a large number of ice jams (and presumably at least localized flooding).

The breakup of the Mackenzie River has been followed for a number of years (MacKay, 1961; MacKay, 1965; Brown, 1957). Even in 1964, when breakup was termed a *placid event* relative to other years, at least two major ice jams formed with ice backed up as far as 15 miles and stage 30 ft above the normal river level (MacKay, 1965).

Similarly, observations on the Meade River indicated that breakup in the spring of 1966 was a rather spectacular event, with rafted ice and repetitive jam formation (Johnson and Kistner, 1967).

Delta River, 1967

No spectacular breakup activity, such as the previously described events, was noted on the Delta River in the spring of 1967. The breakup of this stream, at least in 1967, might be better termed *melt-through*.

Figures A1-A5 (App. A) show sequential changes in the floodplain at selected sites. Locations mentioned are indicated on Figure 1. Figures A6-A15 illustrate reaches of the Delta River at various times of the winter and spring of 1967, as seen on helicopter flights.

Meltwater channels gradually appeared in the icings on the floodplain in late April and May. These often became evident by the collapse of snow and ice bridging an active channel (see Fig. A16). Flow over bottom ice was noted at a few locations in early May, most notably in the vicinity of Donnelly Inn. Flow from the upper basin, which continued throughout the winter, contributed to groundwater storage and to the formation of massive icings on the floodplain such as those seen at Observation Point 9 (Fig. A3). At no time were the amounts of floating ice and snow observed to be very great. Figure A17 shows a near-maximum amount of floating debris for the spring of 1967.

There was open water in the vicinity of Black Rapids throughout the winter. On 10 January 1967 (Fig. A6) an open channel was observed north of Black Rapids on which the sides were caved in, indicating that there had been at least partial bridging of the channel since the previous flight (20 December 1966), at which time the channel had been open. On the 10 January 1967 flight, three to five open channels were noted near Donnelly Inn, disappearing downstream. Open water was also seen both to the west and about 4 miles south of Donnelly Dome. The same or similar open reaches of channel were noted on 30 January, 14 February, 23 March, 28 March, 6 April, 14 April and 19 April.

Open water was observed from Mile 204 to Mile 210, Richardson Highway, on 10 February, and again on 4 April (no trips were made that far south in the intervening period). Open water persisted at the mouth of the Delta River throughout the winter of 1966-67 (Fig. A1). This resulted from groundwater outflow at the mouth.

North (downstream) from Donnelly Dome the floodplain was covered with snow and ice, with no signs of flowing or open water, from about 1 November 1966 through 25 April 1967. A complete traverse was made on foot across the floodplain, about 1 mile upstream from the mouth, on 19 April and again on 25 April. There were no open channels, nor could flowing water be located either by probing or digging pits through the snow. On 29 April 1967 open water was first observed on the lower reaches of the Delta River floodplain. While the channel was not continuously open, flowing water was noted at a great many points between the river mouth and Summit Lake. This was the first day on which it was apparent that flow was continuous from Summit Lake to the Tanana River.

Flow began in Jarvis Creek, which enters the Delta River from the east near Delta Junction, between 1600 hours, 2 May, and 0800 hours, 3 May 1967. As in the Delta River, little floating ice or snow was observed in this stream.

Weather data

Air temperature and degree-day data for two stations in the Delta River Basin are presented in Tables I and II. It is evident that during March and April 1967 recorded air temperatures at both Big Delta and Trims Camp were slightly above normal for the period of record. Precipitation amounts showed no regular deviation from normal monthly amounts during the spring of 1967.

Air temperature has been commonly used as an indication of energy available for snowmelt. As the relation of air temperature (commonly recorded in an instrument shelter at some distance above the snow, and perhaps far removed from the area in question) to snowmelt is not readily derived, temperature data are often converted to a degree-day factor which may be correlated with snowmelt or runoff.

A degree-day may be defined as a departure of 1° (commonly Farenheit) in mean daily temperature from a given base (Garstka *et al.*, 1958). Garstka *et al.* (1958) examined methods of degree-day computation in relation to snowmelt calculations in the Rocky Mountains of Colorado. They showed that the use of daily *maximum* air temperature above a 32°F base is a more appropriate technique to use in snowmelt investigations, as the mean daily temperature can be below 32°F, indicating a negative temperature regime, while maximum temperatures may be well above freezing, producing significant amounts of snowmelt during some parts of the day.

Brown *et al.* (1968) considered that the thaw season at Barrow, Alaska, began with the start of positive degree-day accumulation, based on mean daily temperatures.

Johnson and Kistner (1967) tabulated the positive degree-hours above 0°C, using mean air temperature, in the analysis of conditions during breakup of the Meade River, Alaska. They made no attempt to show a quantitative relation between the degree-hour factor and breakup. On the first day of open water at that site (7 June 1966) the positive temperature accumulation was 17 degree-hours; by the time continuous open water on the Meade River was confirmed (13 June 1966) the positive temperature accumulation was 240 degree-hours.

In the current study, daily temperature data from the Big Delta FAA station and Trims Camp were used in the tabulation of cumulative degree-days above 32°F, using both mean daily and maximum daily temperatures (Tables I and II).

Considering Big Delta data, when mean daily air temperatures were used, positive degree-days were accumulated from the first date of continuous mean daily air temperature above 32°F (25 April 1967). This yielded a positive accumulation of 30 degree-days by 29 April, the first day of continuous open water in the Delta River.

When maximum daily air temperatures were used, positive degree-days were accumulated from the first date of a major series of maximum daily temperatures above 32°F (30 March 1968, the first day of a 12-day "run"). In this case, the positive accumulation was 224 degree-days on 29 April, the first day of continuous open water.

On 3 May 1967, the first day of flow in Jarvis Creek at its mouth, the positive temperature accumulation stood at 91 degree-days, using mean daily temperatures, and 342 degree-days, using maximum daily temperatures.

A similar treatment of temperature data from Trims Camp showed a positive accumulation, from the time of virtually continuous mean daily temperature above 32°F (28 April 1967), of 8 degree-days by 29 April. Use of daily maximum temperatures, beginning with earliest "run" of daily maximum temperatures above freezing (2 April 1967), showed a positive accumulation of 42 degree-days by 29 April 1967.

Table I. Air temperature data and computations, Big Delta FAA Station.

Date	Temp max (°F)	Temp min (°F)	Temp avg (°F)	Degree-days above 32°F base mean daily temp (°F)	Cumulative degree-days above 32°F base mean daily temp (°F)	Degree-days above 32°F base max daily temp (°F)	Cumulative degree-days above 32°F base max daily temp (°F)
15 Mar 67	34	4	19				
	31	1	16				
	25	0	12.5				
	22	−6	8				
	20	1	10.5				
	18	−5	6.5				
	23	3	13				
	15	−10	2.5				
	14	−29	−7.5				
	15	−30	−7.5				
	15	−28	−6.5				
	16	1	8.5				
	23	8	−15.5				
	27	11	19				
	28	11	19.5				
	34	8	21			2	2
31 Mar 67	44	26	35	+3		12	14
1 Apr 67	46	29	37.5	+5.5		14	28
	43	32	37.5	+5.5		11	39
	37	27	32	0		5	44
	43	27	35	+3		11	55
	49	29	39	+7		17	72
	41	25	33	+1		9	81
	41	22	31.5	−0.5		9	90
	33	25	29	−3		1	91
	34	14	24	−8		2	93
	35	12	25.5	−6.5		3	96
	29	20	24.5	−7.5		−3	93
	28	6	17	−15		−4	89
	32	6	19	−13		0	89
	37	12	24.5	−7.5		5	94
15 Apr 67	25	6	15.5	−16.5		−7	87
	33	1	17	−15		1	88
	40	29	34.5	−2.5		8	96
	45	22	33.5	+1.5		13	109
	49	28	38.5	+6.5		17	126
	35	21	28	−4		3	129
	31	20	25.5	−6.5		−1	128
	37	20	28.5	−3.5		5	133
	41	19	30	−2		9	142
	39	22	30.5	−1.5		7	149
	43	25	34	+2	+2	11	160
	50	19	34.5	+2.5	+4.5	18	178
	58	35	46.5	+14.5	+19	26	204
	52	34	43	+11	30	20	224
	60	32	46	+14	44	28	252
30 Apr 67	61	32	46.5	+14.5	58	29	281
1 May 67	62	34	48	+16	74	30	311
	63	31	47	+17	91	31	342
	58	38	48	+16	107	26	368
	59	37	48	+16	123	27	395
5 May 67	43	29	36	+4	127	11	406

Table II. Air temperature data and computations, Trims Camp.

Date	Temp max (°F)	Temp min (°F)	Temp avg (°F)	Degree-days above 32°F base mean daily temp (°F)	Cumulative degree-days above 32°F base mean daily temp (°F)	Degree-days above 32°F base max daily temp (°F)	Cumulative degree-days above 32°F base max daily temp (°F)
15 Mar 67	30	16	23				
	40	19	29.5				
	31	8	19.5				
	21	−16	2.5				
	21	1	11				
	10	0	5				
	15	−8	3.5				
	17	0	8.5				
	10	−10	0				
	5	−10	−2.5				
	7	−20	−6.5				
	12	−8	2				
	18	0	9				
	20	2	11				
	22	2	12				
	25	3	14				
31 Mar 67	28	12	20				
1 Apr 67	30	14	22				
	38	28	33			6	6
	38	14	26			6	12
	33	12	22.5			1	13
	35	28	31.5			3	16
	40	23	31.5			8	24
	38	22	30			6	30
	35	6	20.5			3	33
	30	18	24			−2	31
	30	20	25			−2	29
	28	21	24.5			−4	25
	25	12	18.5			−7	18
	27	−5	11			−5	13
	30	8	19			−2	11
15 Apr 67	28	9	18.5			−4	7
	22	−3	9.5			−10	−3
	28	15	21.5			−4	−7
	38	12	25			6	−1
	40	24	32			8	7
	42	25	33.5			10	17
	30	14	22			−2	15
	29	2	15.5			−3	12
	31	3	17			−1	11
	36	9	22.5			4	15
	34	8	21			2	17
	35	2	18.5			3	20
	40	21	30.5			8	28
	46	34	40	8	8	14	42
	41	33	37	5	13	9	51
30 Apr 67	49	28	38.5	6.5	19.5	17	68
1 May 67	53	25	39	7	26.5	21	89
	52	21	36.5	4.5	31	20	109
	55	27	41	9	40	23	132
	50	26	38	6	46	18	150
5 May 67	48	32	40	8	54	16	166

The preceding discussion is useful primarily for showing that there was a definite positive air temperature regime prior to the appearance of open water in the lower (northern) Delta River floodplain. No correlation can be made of degree-days vs time of breakup without additional knowledge of the conditions and time of open water in the basin during other years.

Date "unsafe for man"

The July issue of *Climatological Data, Alaska* (ESSA) each year lists breakup dates for various Alaskan rivers and lakes. While the Delta River is not included in this summary, Bolio Lake (near Delta Junction) is listed. In 1967, Bolio Lake was noted "unsafe for man" on 1 May; this was 29 days later than the average* date of such condition. The Nenana River, to the northwest, was listed "unsafe for man" on 14 April 1967, and the Nabesna River, to the southwest, on 25 April 1967.

While the criteria for the "unsafe" classification are not given, it is interesting that the Bolio Lake date is only two days later than that of first continuous flow in the Delta River. The two rivers mentioned, both of glacial origin, were shown "unsafe for man" two weeks and one week, respectively, earlier than first day of continuous flow in the Delta River.

The possible relation of degree-day accumulation with the date of the "unsafe for man" classification was investigated for three sites. Temperature records since 1960 from stations associated with Bolio Lake, the Nabesna River, and the Nenana River were treated in the same manner as the 1967 Big Delta and Trims Camp data. Cumulative degree-days, both for mean daily and maximum daily temperatures, were calculated for the date of the "unsafe" classification; results are summarized in Table III. Only the Bolio Lake (Big Delta FAA) data show a consistent positive temperature regime, in terms of mean daily temperature, for the "unsafe for man" date. Data for both the Nabesna and the Nenana Rivers show positive maximum daily temperature regimes for the "unsafe" date.

Table III. Temperature regime for date of "unsafe for man" classification for three sites.

Date "unsafe for man"	*Cumulative degree-days, mean daily temperature (°F)*	*Cumulative degree-days, maximum daily temperature (°F)*
	Bolio Lake (Big Delta FAA)	
24 April 1962	35	221
23 April 1963	16	42
5 May 1964	27	167
9 April 1965	17.5	282
29 April 1967	30	224
	Nenana River (McKinley Park)	
18 April 1961	Not yet positive	52
20 April 1963	Not yet positive	3
1 March 1965	Not yet positive	Not yet positive
29 April 1966	5.5	298
15 April 1967	Not yet positive	85
	Nabesna River (Northway FAA)	
27 April 1963	24.5	185
15 April 1965	2	255
6 April 1966	Not yet positive	140
25 April 1967	Not yet positive	180

*Number of years of record not specified.

The variation in the few years of record analyzed appears to preclude the use of cumulative degree-days, based on either mean daily or maximum daily temperatures, for predicting the date of ice unsafe for man. This is probably due at least in part to the subjective nature of such a classification, as well as to the fact that temperature data at a station do not reflect the thermal regime of the entire basin, or even of the river reach closest to the temperature station. At best, such data can serve as indexes of the thermal regime; in the present case available data do not substantiate even this use.

In the absence of previous observations of spring breakup in the Delta River, and given both the subjective nature of an "unsafe for man" categorization, and the lack of consistency in temperature regime for that date, the relation of date of "unsafe" classification on these other water bodies to spring flow in the Delta River cannot be known. However, it can be hypothesized that flow in the Delta River might begin within one to two weeks of such classification for Bolio Lake, the Nenana River and the Nabesna River.

Summary of action at four ground points

1) *Photo Point 2* (Fig. A2). Through 25 April 1967 the floodplain appeared completely snow and ice covered, with no evidence of open water. On 29 April the snow appeared saturated along the main channel (visual observation), but there was no open water. On 1 May water was flowing in at least three channels; a moderate amount of slush and ice were floating downstream. Flows increased on 2 May, but water levels dropped on 3 May. By 4 May the floodplain was almost entirely snow free. Flow increased through 26 June 1967.

2) *Observation Point 9* (Fig. A3). Observation Point 9 (a local name) looked out over a widespread, massive icing, at least 6 ft thick. On 3 May 1967 (the first date this observation point was used) two channels had cut through the icing; ice blocks were occasionally breaking off and caving into the channel. On 5 and 6 May increased undercutting along the channel edges was evident. By 8 May flow had definitely increased, with increased undercutting of ice. While flow fluctuated and generally increased no major changes occurred until 29 May, when a tributary channel became visible at about the center of the icing. Flow continued to increase, with accelerated disappearance of snow and ice. By 5 June the floodplain had assumed its customary multichanneled appearance, although large areas of snow and ice remained. By 19 June the floodplain was virtually ice free.

3) *Photo Point 6* (Fig. A4). On 19 April most of the floodplain was free of snow, apparently as a result of wind action; channels and depressions were snow filled. Small stretches of open water were noted here as early as 19 April. However, parts of the main channel were still full of ice and snow on 1 May with flow over the ice common. In some reaches this condition persisted through 9 May. By 19 May only ice remnants were left along the edges of the main channel.

4) *Mile 211* (Fig. A5). Open water was observed in the vicinity of Mile 211 on 10 February 1967, and again on 4 April 1967 (no trips were made to that spot in the interim). On 29 April there was open water flowing in the main channel, which was still bridged in many places (indicating that it had been covered by snow and ice at some time). Through cave-ins and melt, the open "leads" were extended until a more-or-less continuous channel existed on 19 May. By 26 May the channel was completely open, with very little floating ice or snow. By 19 June the floodplain was completely free of ice and snow.

Conclusions

Spring breakup on the Delta River in 1967 was a markedly unspectacular event in comparison with the breakup of other arctic and subarctic rivers described in the available literature. Flow continued in the upper reaches of the Delta River throughout the winter; but the lower floodplain was frozen, apparently completely, from about 1 November 1966 to the last week of April 1967.

Channel development in most reaches was predominantly by break-through of snow and ice bridging already flowing water. At a few points flow over bottom ice was observed.

It is thought that the observed breakup of the Delta River was a normal phenomenon, both for the Delta River and for similar braided streams. Holmes and Benninghoff (1957) noted that, in spring of 1957, flow gradually increased in Jarvis Creek from the initial appearance of water at the mouth on 1 May 1957. They also reported that there was very little floating ice in Jarvis Creek that year.

It appears reasonable to expect that widely braided rivers would not experience massive ice jams and sudden rises in water level, such as described for the Yukon and other rivers. The broad floodplain offers few restrictions for floating snow and ice in the channel; minor jams could be readily bypassed by small increases in stage. This situation was observed during freeze-up in October 1966 (Bilello *et al.*, 1968) when floating ice and slush accumulated in a small jam between gages 2 and 3A. A rise in water stage of little more than a foot sufficed to alleviate blockage with water overflowing into an adjacent channel.

Further observation of the sequence of spring flow development on streams such as the Delta River would be necessary to validate these conclusions.

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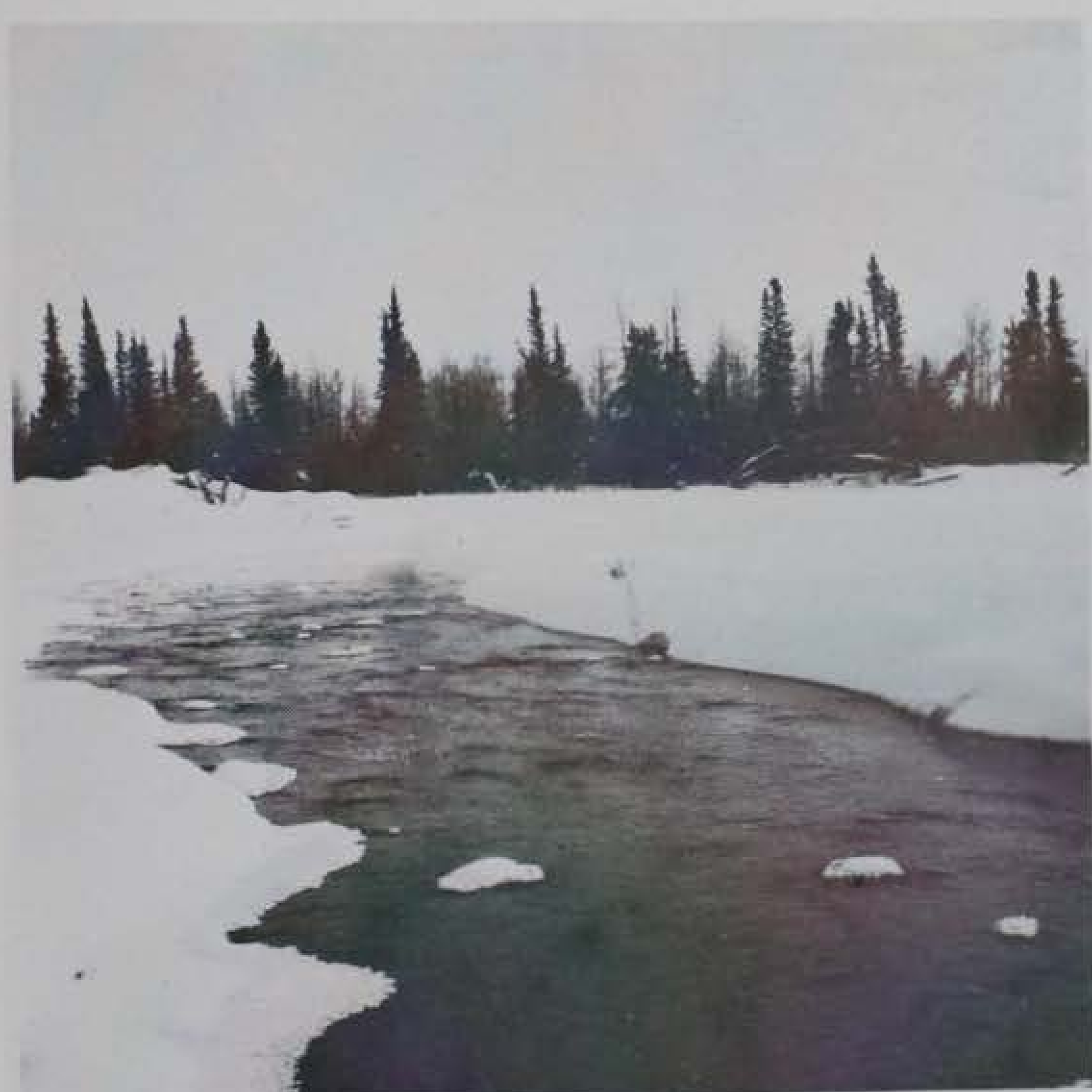
APPENDIX A. SPRING BREAKUP OF THE DELTA RIVER, ALASKA: PHOTOGRAPHIC RECORD

a. 23 December 1966.

b. 13 January 1967.



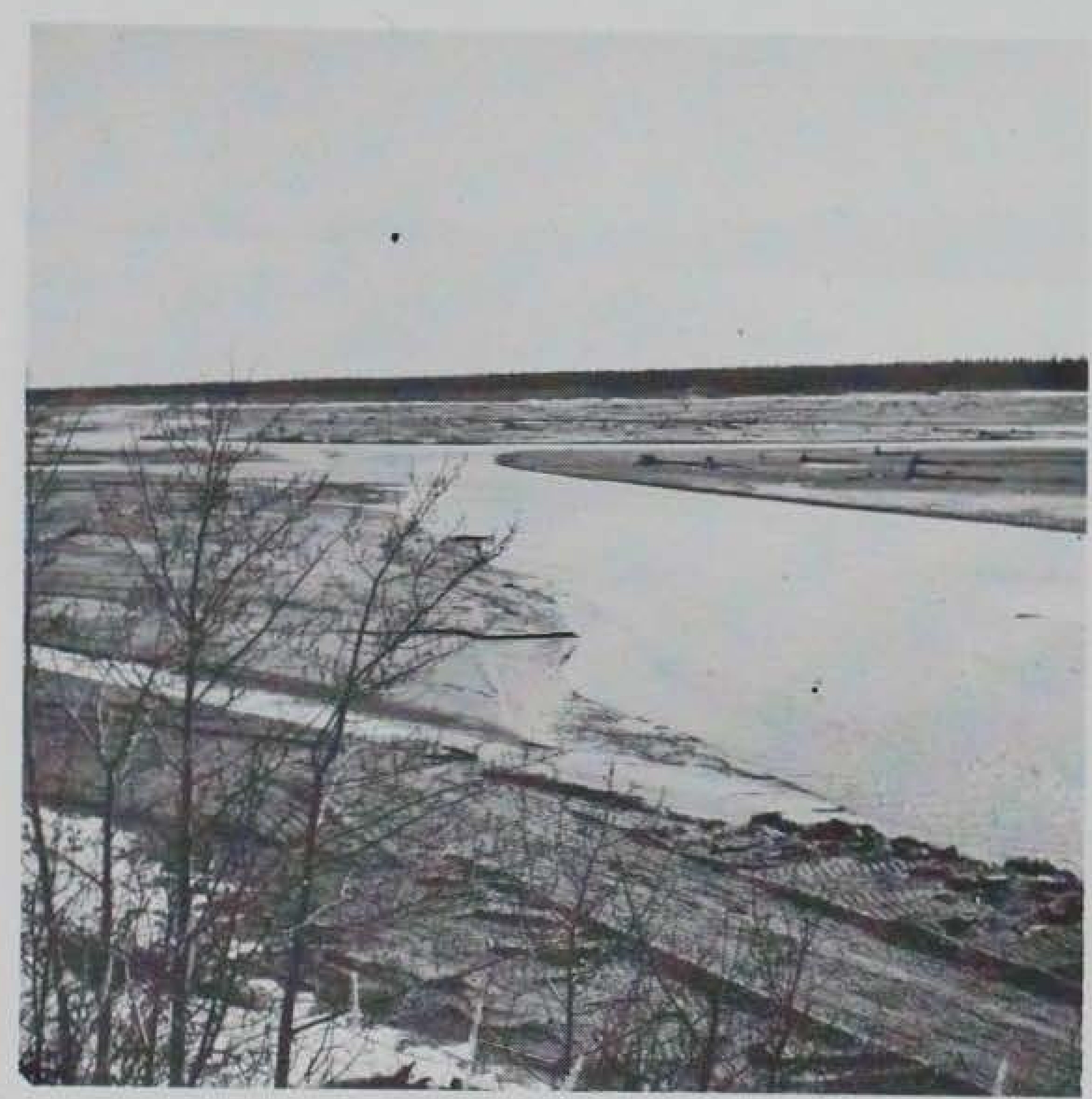
c. 9 February 1967.

d. 17 March 1967.

Figure A1. Open water at mouth of Delta River, winter 1967.

a. *25 April 1967.*

b. *2 May 1967.*



c. *4 May 1967.*

d. *15 May 1967.*

Figure A2. Delta River at Photo Point 2, looking upstream.

a. 3 May 1967, upstream view.

b. 3 May 1967, downstream view.

c. 6 May 1967, downstream view.

d. 8 May 1967, upstream view.

Figure A3. Delta River from Observation Point 9.

e. 8 May 1967, downstream view.

f. 17 May 1967, upstream view.

g. 17 May 1967, downstream view.

Figure A3 (Cont'd). Delta River from Observation Point 9.

h. 29 May 1967, upstream view.

i. 29 May 1967, downstream view.

j. 2 June 1967, upstream view.

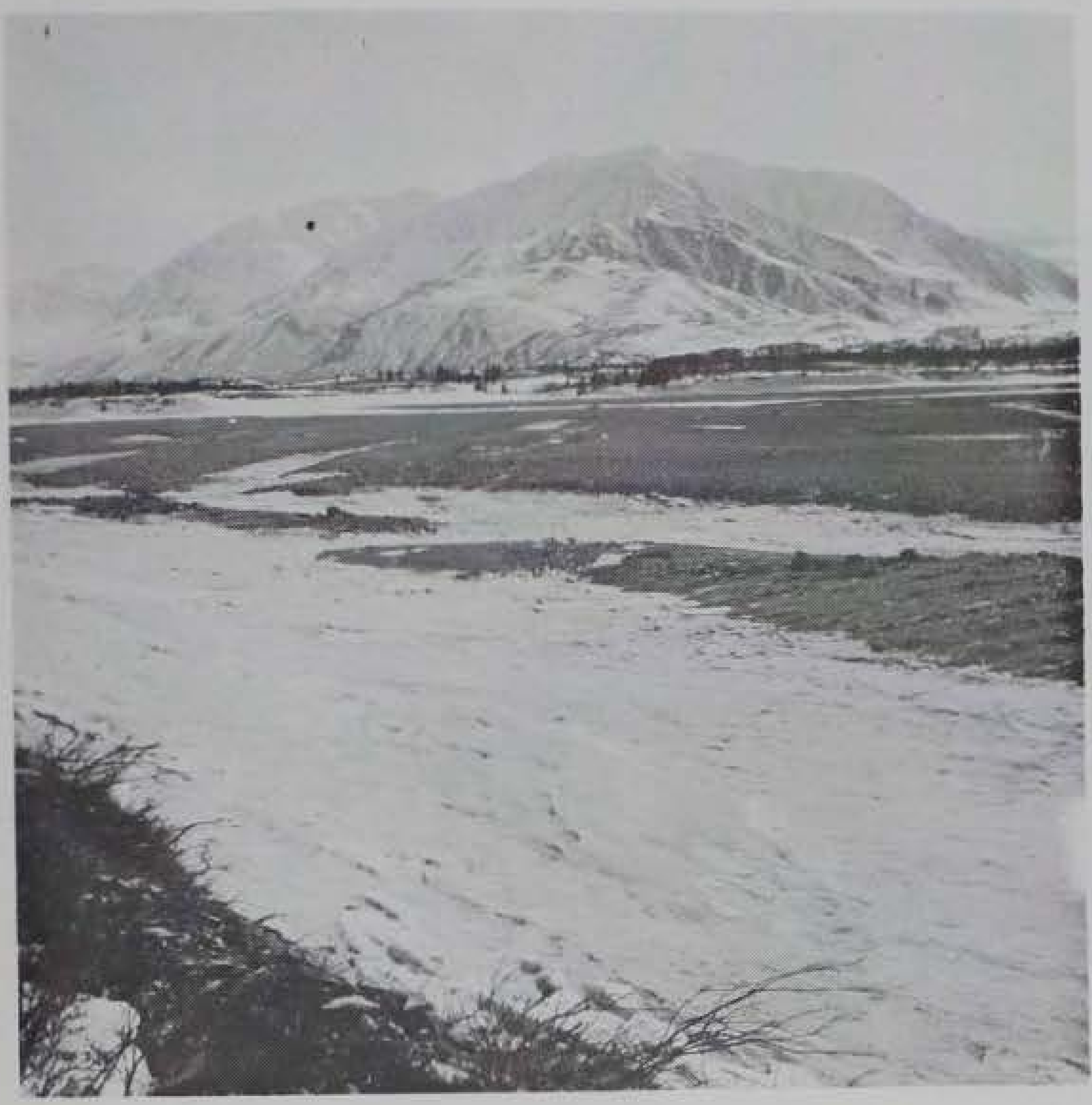
Figure A3 (Cont'd).

k. 2 June 1967, downstream view.

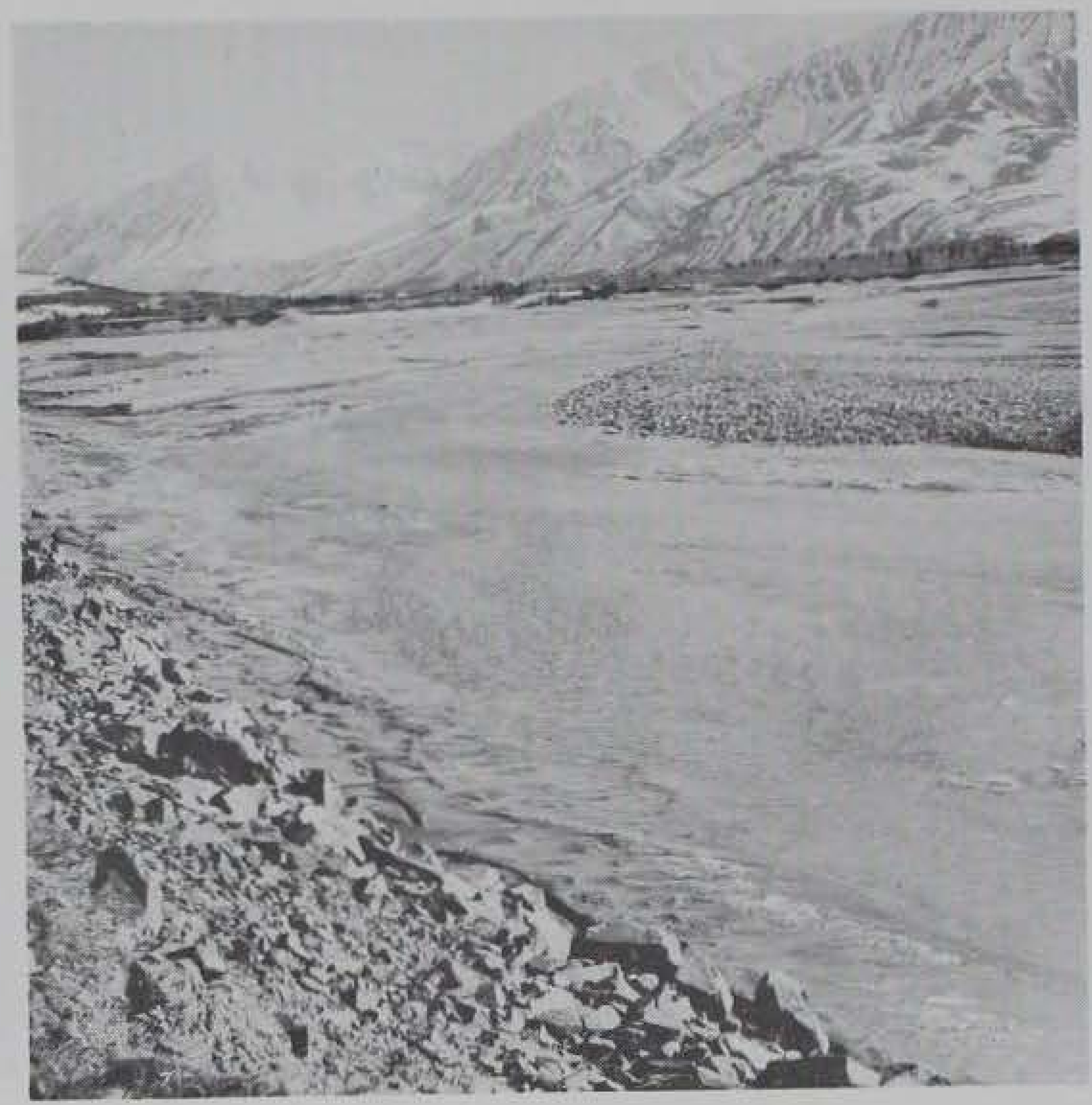
l. 7 June 1967, upstream view.

m. 7 June 1967, downstream view.

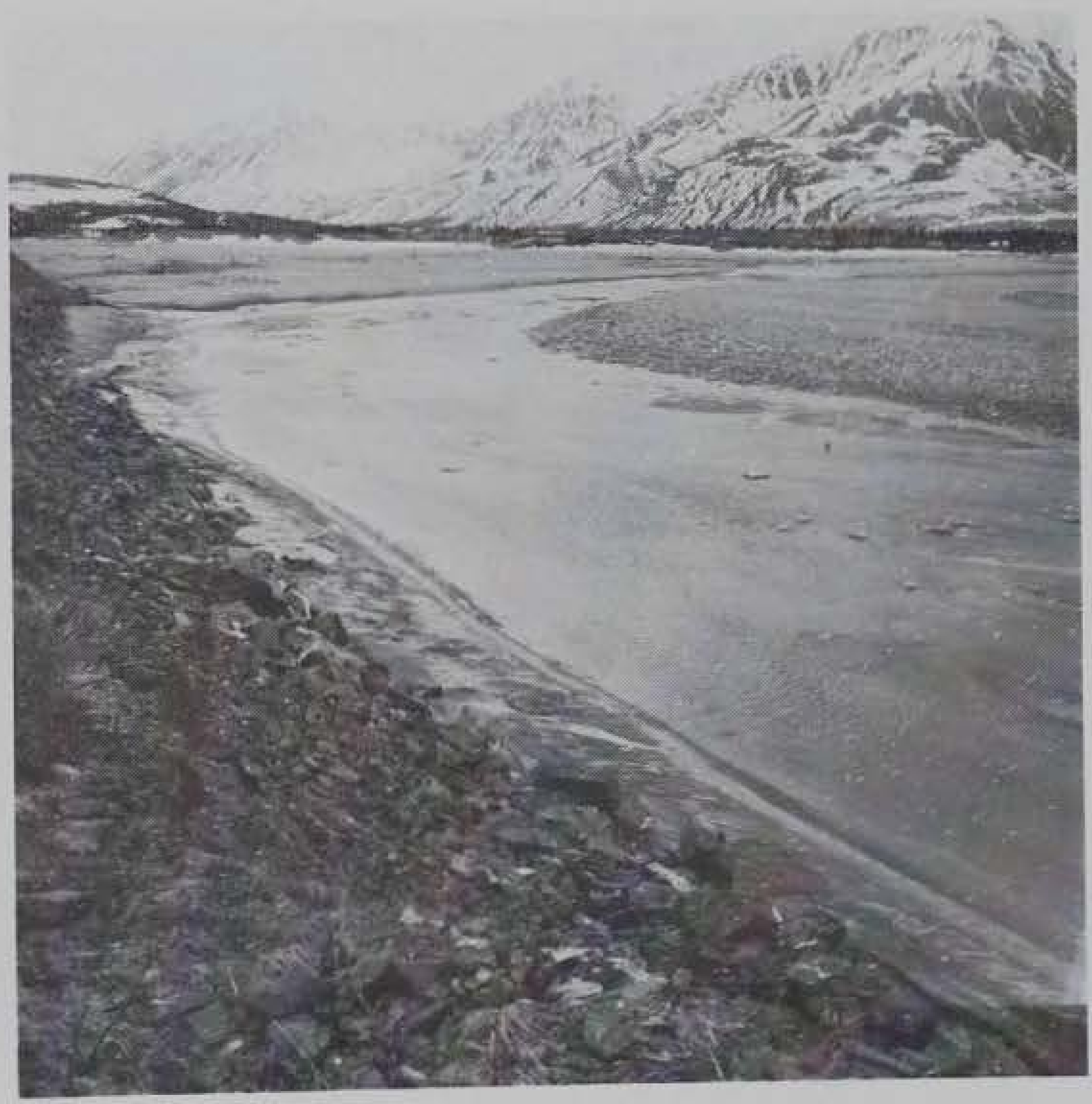
Figure A3 (Cont'd). Delta River from Observation Point 9.



a. *19 April 1967.*

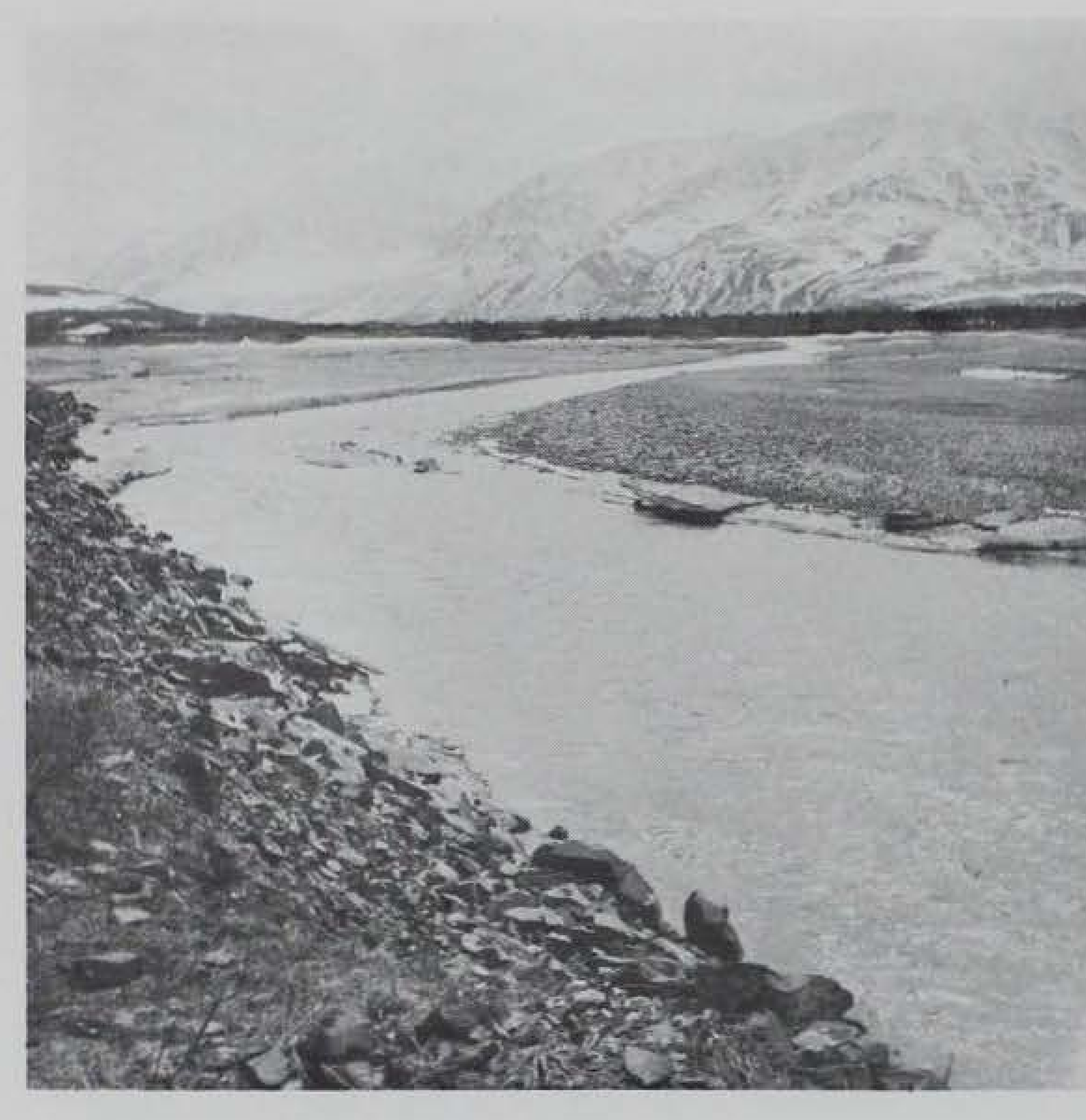


b. *2 May 1967.*



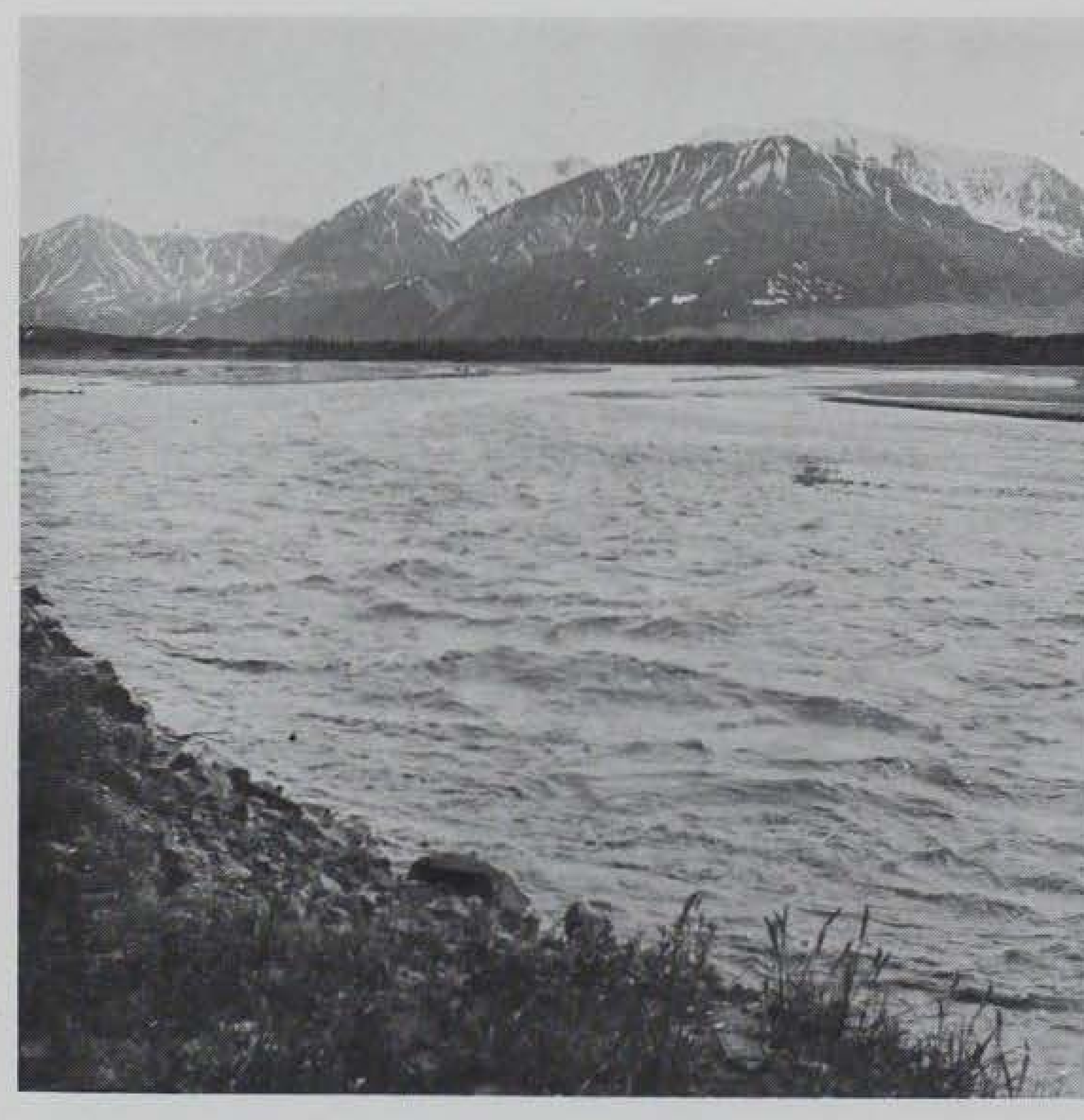
c. *5 May 1967.*

Figure A4. Delta River at Photo Point 6, looking upstream.



d. 19 May 1967.

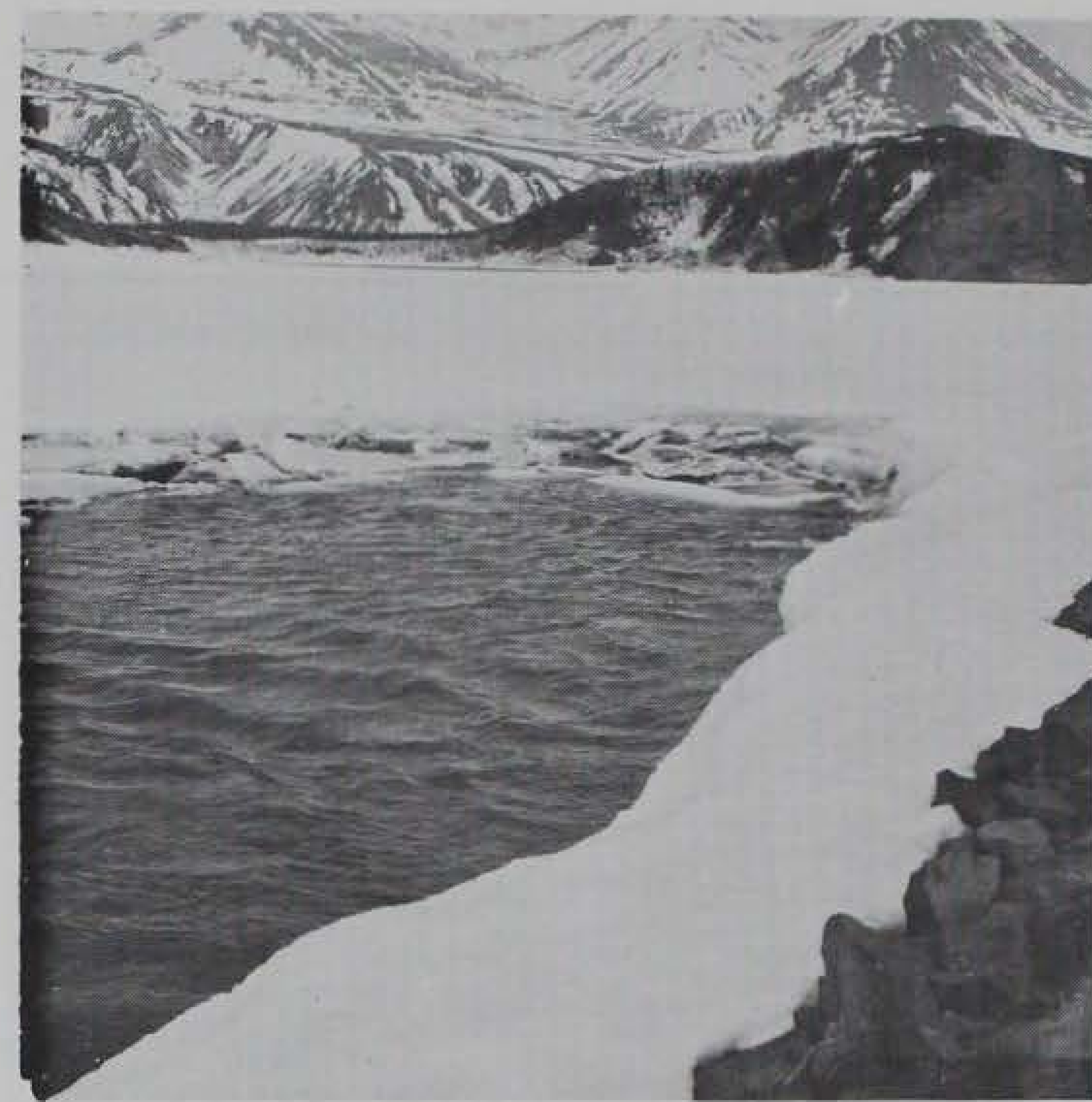
e. 26 May 1967.



f. 19 June 1967.

Figure A4 (Cont'd). Delta River at Photo Point 6, looking upstream.

a. *29 April 1967.*

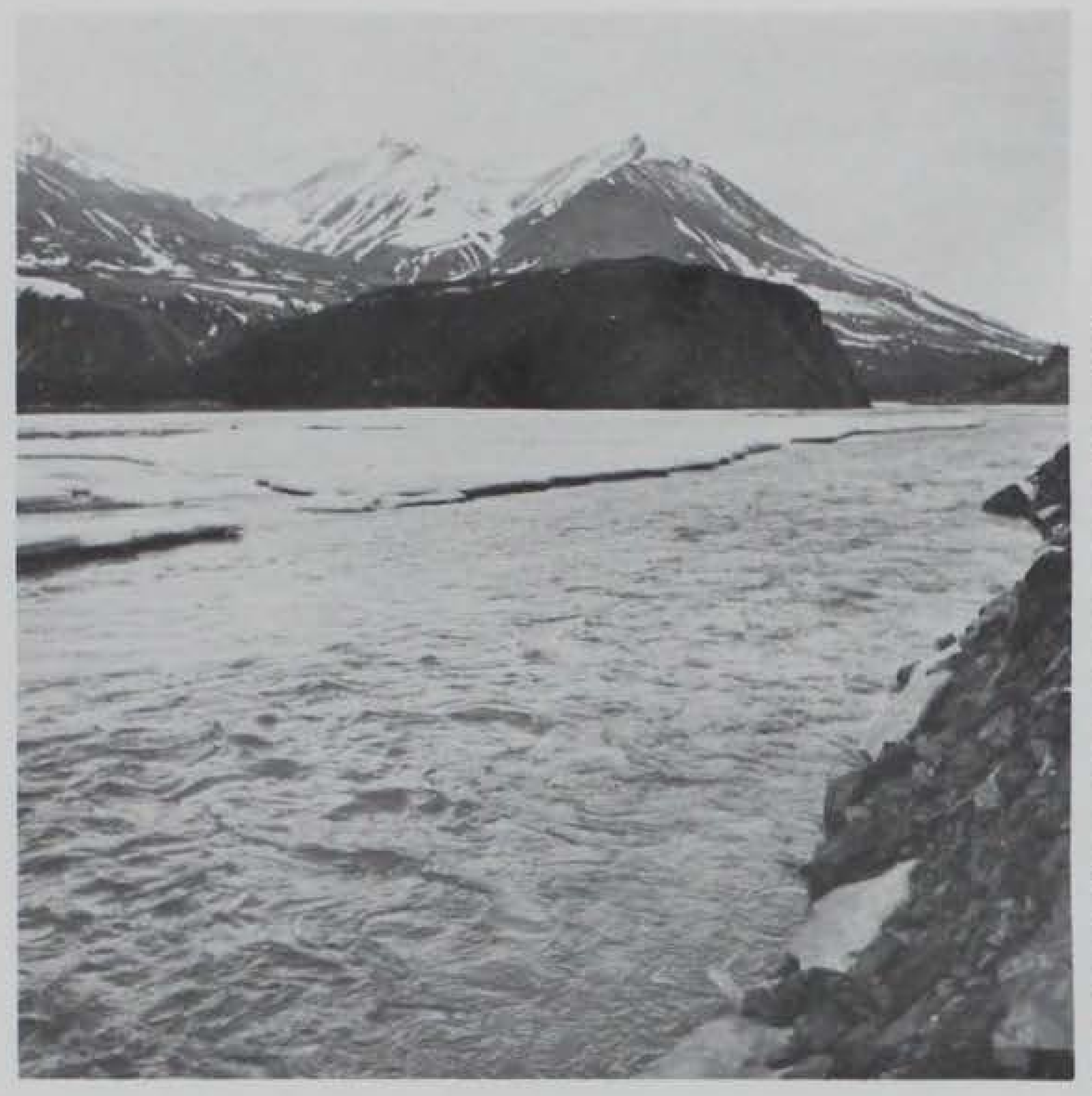


b. *9 May 1967.*

c. *19 May 1967.*

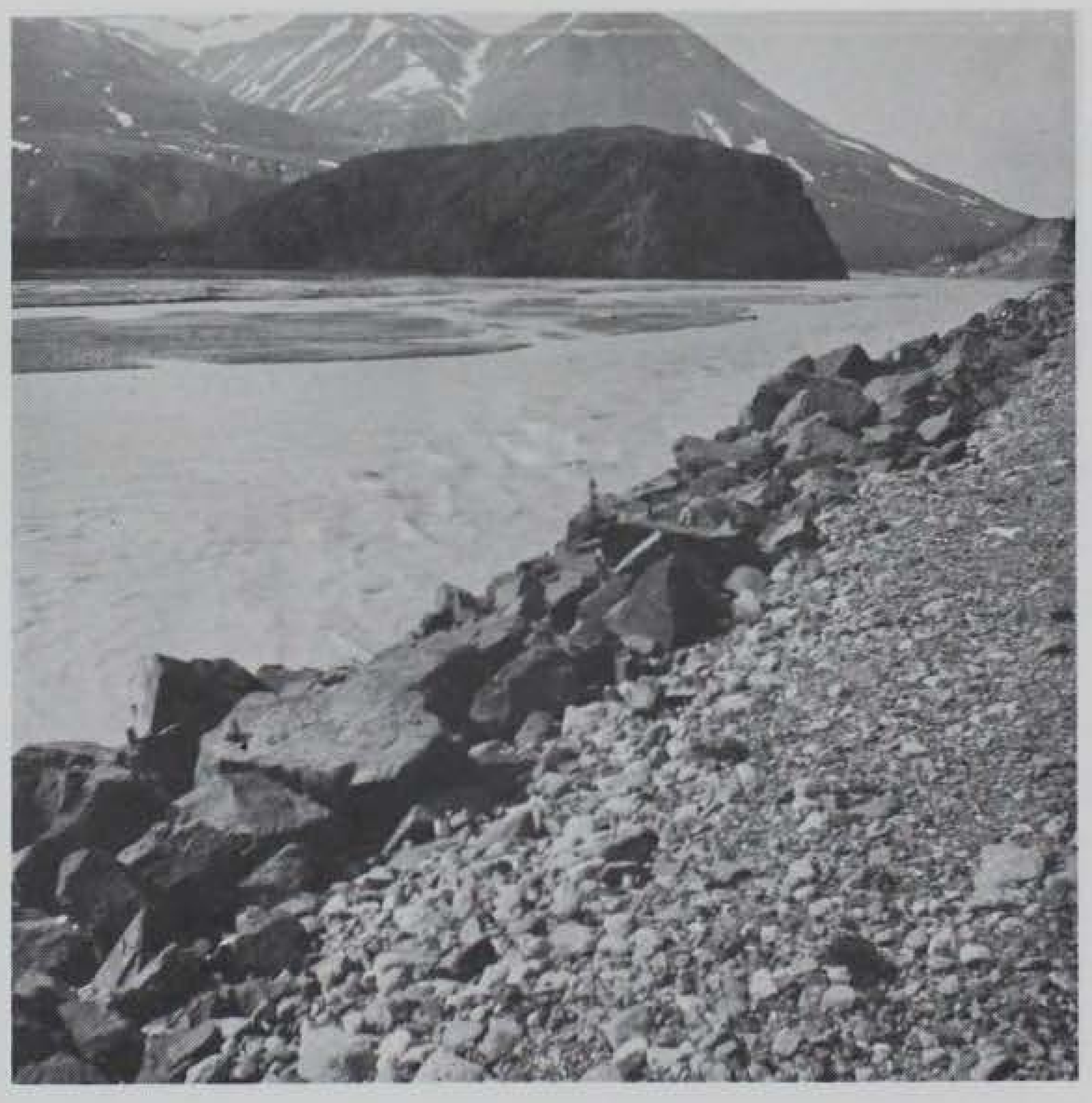
d. *26 May 1967.*

Figure A5. Delta River at Mile 211, looking downstream.



e. 2 June 1967.

f. 5 June 1967.



g. 19 June 1967.

Figure A5 (Cont'd). Delta River at Mile 211, looking downstream.

a. Three miles south of Black Rapids, downstream view.

b. Five miles north of Black Rapids, vertical view.

c. Near Donnelly Inn, downstream view.

d. Near Redeye Site, downstream view.

Figure A6. Delta River, 10 January 1967.

a. *Near Donnelly Inn, downstream view.*

b. *North of Donnelly Inn, downstream view.*

c. *North of Donnelly Dome, eastward view.*

d. *Near Sawmill Range, downstream view.*

e. *Near Gaging Site 2, downstream view.*

Figure A7. Delta River, 30 January 1967.

a. *One mile south of Donnelly Inn, downstream view.*

b. *Near Donnelly Inn, downstream view.*

c. *Five miles south of Donnelly Dome, downstream view.*

d. *Near Gaging Site 2, downstream view.*

Figure A8. Delta River, 14 February 1967.

a. Near Donnelly Inn, downstream view.

b. Four miles south of Donnelly Dome, downstream view.

c. Near Donnelly Dome, downstream view.

d. Vicinity of Observation Point 9, downstream view.

Figure A9. Delta River, 2 March 1967.

a. *Near Donnelly Inn, downstream view.*

b. *North of Donnelly Inn, downstream view.*

c. *Three miles south of Donnelly Dome, downstream view.*

d. *Near Big Delta, downstream view.*

Figure A10. Delta River, 23 March 1967.

a. Near Donnelly Inn, downstream view.

b. North of Donnelly Inn, downstream view.

c. Near Donnelly Dome, downstream view.

d. Near Sawmill Range, downstream view.

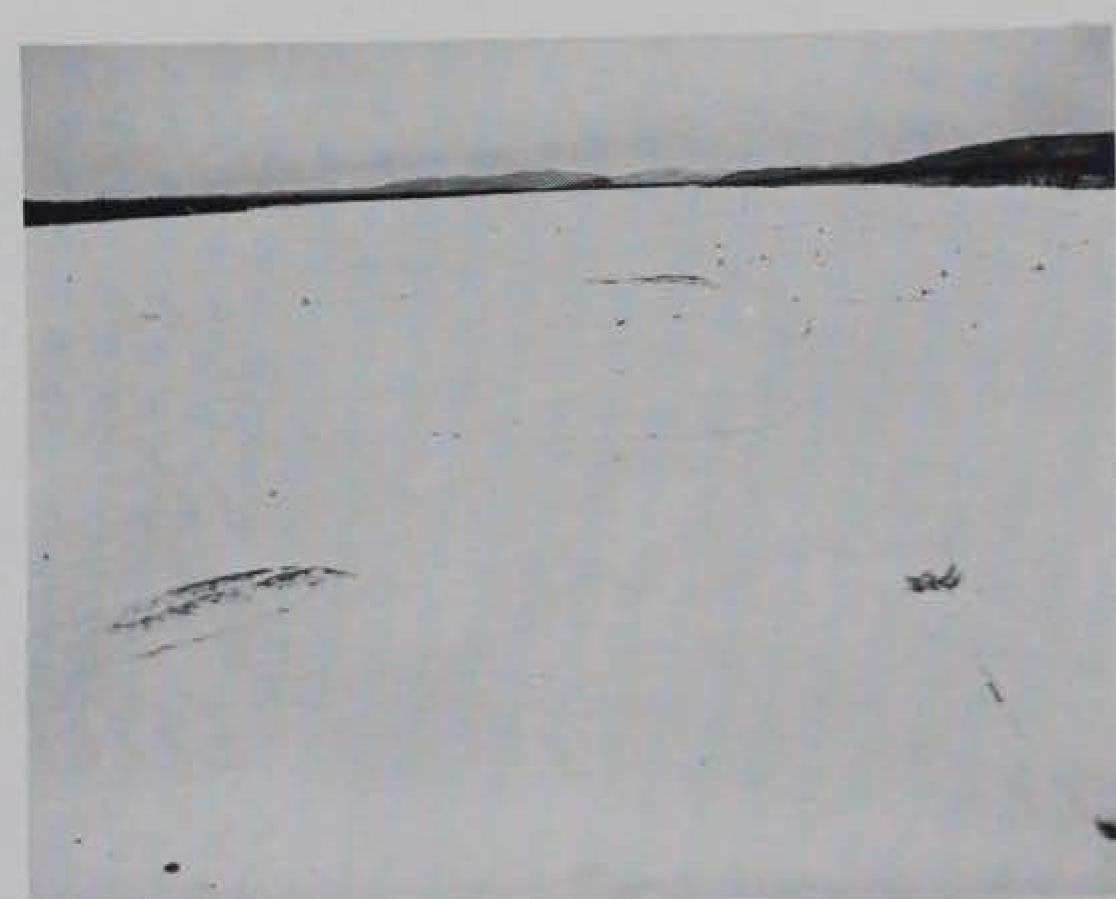
e. Between Big Delta and Delta Junction, downstream view.

Figure A11. Delta River, 6 April 1967.

a. *Near Donnelly Inn, downstream view.*

b. *Four miles north of Donnelly Inn, downstream view.*

c. *Near Sawmill Range, downstream view.*



d. *Between Big Delta and Delta Junction, downstream view.*

Figure A12. Delta River, 14 April 1967.

a. Summit Lake.

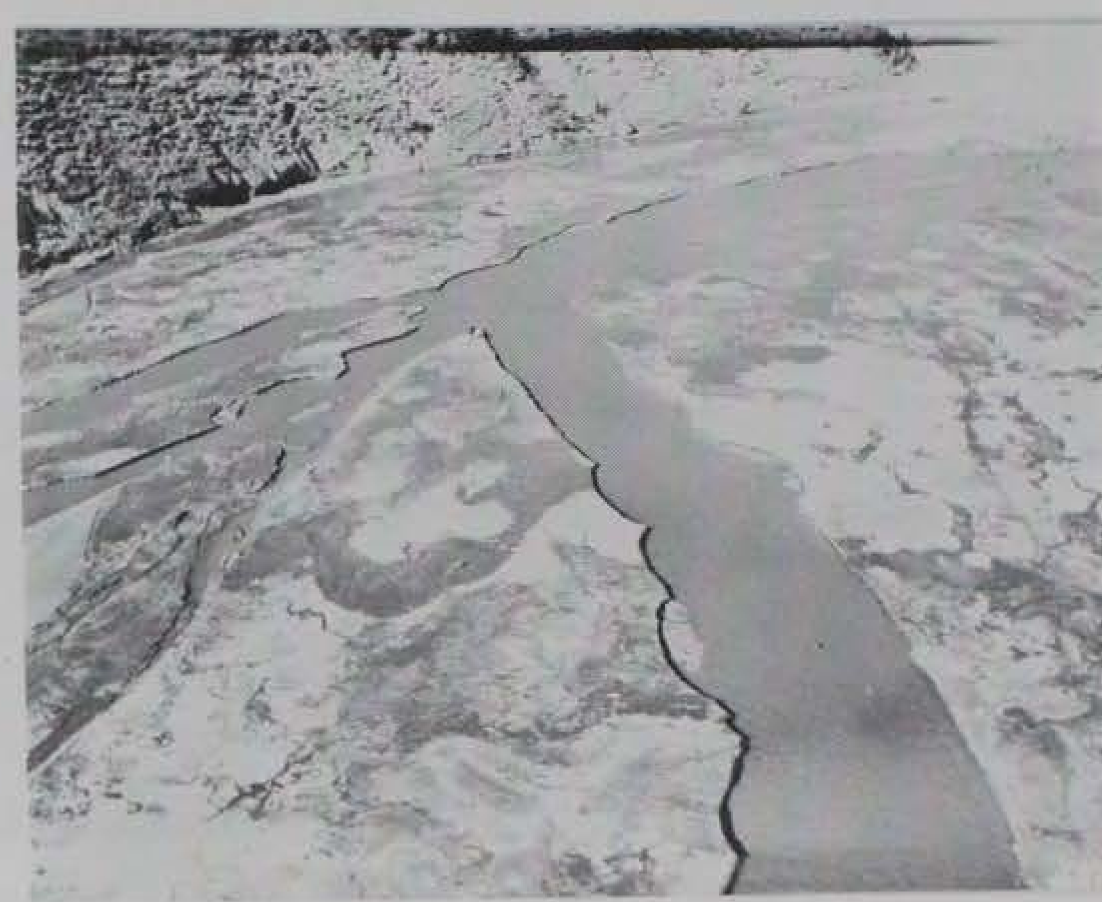
b. Fielding Lake outlet, view north.

c. Junction of Phelan Creek and Delta River.

d. Delta River at Rainbow Mountain, downstream view.

Figure A13. Delta River, 3 May 1967.

e. Near Donnelly Inn, downstream view.



f. West of Donnelly Dome, downstream view.

g. Junction of Delta River and Jarvis Creek.

h. Between Big Delta and Delta Junction, downstream view.

Figure 13 (Cont'd).

a. Near Black Rapids, downstream view.

b. Near Donnelly Inn, downstream view.

c. At Observation Point 9, downstream view.

d. Junction of Jarvis Creek and Delta River.

e. Between Big Delta and Delta Junction, downstream view.

Figure A14. Delta River, 17 May 1967.

a. Near Black Rapids, downstream view.

b. Near Donnelly Inn, downstream view.

c. Downstream view at Observation Point 9.

d. Between Big Delta and Delta Junction, downstream view.

Figure A15. Delta River, 24 May 1967.

Figure A16. Collapse of snow which had bridged flowing water, 29 April 1967.

Figure A17. Snow and ice floating in the main channel, near Photo Point 2, 29 April 1967.

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U.S. Army Cold Regions Research and Engineering Laboratory Hanover, New Hampshire 03755	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

SPRING BREAKUP OF THE DELTA RIVER, ALASKA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

C.W. Slaughter and H.R. Samide

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
April 1971	35	12

8a. CONTRACT OR GRANT NO. b. PROJECT NO. Reimbursable Order 659-21 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Special Report 155 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U.S. Army Arctic Test Center Fort Greely, Alaska

13. ABSTRACT

Spring "breakup" of snow and ice on the Delta River, Alaska, was monitored in 1967. Breakup on this braided river was a relatively calm event, with gradual development of open-water channels from headwaters to mouth. Air temperature data at Big Delta, near the mouth of the river, indicated an accumulation of 30 positive degree-days (^{o}F) above 32^{o}F, using mean daily values, prior to first observation of continuous open water from headwaters to mouth; a corresponding value, but using maximum daily air temperatures, was 224 degree-days (^{o}F). A photographic sequence of breakup at several points along the river is included.

14. Key Words

Delta River, Alaska - Air temperature
Delta River, Alaska - Ice breakup
Delta River, Alaska - Snow breakup
Delta River, Alaska - Spring ice breakup