Floods of August 1967 In East-Central Alaska

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1880-A

Prepared in cooperation with the State of Alaska and agencies of the Federal Government

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By J. M. CHILDERS, J. P. MECKEL, *and* G. S. ANDERSON

With a section on WEATHER FEATURES CONTRIBUTING TO THE FLOODS

By E. D. DIEMER, U.S. WEATHER BUREAU

FLOODS OF 1967 IN THE UNITED STATES

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DEFINITION OF TERMS AND ABBREVIATIONS

The hydrologic terms and abbreviations used in this report are defined as follows:

Acre-foot is the quantity of water required to cover an acre to a depth of 1 foot and is equivalent to 43,560 cubic feet, or 325,851 gallons. The term is usually used in relation to storage and volume of runoff.

Cubic feet per second per square mile (cfs per sq mi) is the average number of cubic feet of water flowing per second from each square mile of area drained, assuming that the runoff is distributed uniformly in time and area.

Cubic foot per second (cfs) is equal to the rate of discharge of a stream whose channel is 1 square foot in cross-sectional area and whose average velocity is 1 foot per second; 1 cfs equals 448.83 gallons per minute. The volume of water represented by a flow of 1 cubic foot per second for 24 hours is equivalent to 86,400 cubic feet, 1.983471 acre-feet, or 646,317 gallons.

Crest-stage station is a particular site where annual flood peak records are collected systematically for use in hydrologic analyses.

Drainage area of a stream at a specified location is that area, measured in a horizontal plane, which is so enclosed by a topographic divide that direct surface runoff from the precipitation would normally drain by gravity into the stream above the specified point. Drainage area is expressed in square miles in this report.

Gaging station is a particular site on a stream where systematic observations of gage height or discharge are obtained. When used in connection with a discharge record, the term is applied only where a continuous record of discharge is obtained.

Runoff is that part of the precipitation that appears in surface streams. When specified in inches, runoff is the depth to which the drainage area would be covered if all the runoff for a given time period were uniformly distributed on its surface.

Stage-discharge relation is the relation between gage height and the rate of flow.

Time of day is expressed in 24-hour time; for example, 12:30 a.m. is 0030, 1:30 p.m. is 1330. All times noted are Alaska standard time, unless stated otherwise.

Transmissibility is the amount of water in gallons per day that would flow through a 1-foot width of the saturated part of the aquifer under a unit hydraulic gradient and prevailing water temperature.

FLOODS OF AUGUST 1967 IN EAST-CENTRAL ALASKA

By J. M. CHILDERS, J. P. MECKEL, and G. S. ANDERSON

ABSTRACT

East-central Alaska had record floods near Fairbanks following extensive rains of August 8–20, 1967. Precipitation during this period totaled as much as 10 inches, which is close to the average annual precipitation for this area.

The most extensive flooding occurred in the White Mountains northeast of Fairbanks and along the major streams draining those mountains. Some of the major streams flooded were the Salcha, Chena, Chatanika, Tolovana, and lower Tanana Rivers, and Birch Creek west of Circle.

Peak discharges on some streams in the flood area were from two to four times the probable 50-year flood. The peak discharge of 74,400 cubic feet per second of the Chena River at Fairbanks, from 1,980 square miles of drainage area, was 2.6 times the 50-year flood.

The rise of ground-water levels in the Tanana River flood plain to the land surface during the flood caused foundation failures and prevented drainage of subsurface structures. Above-normal ground-water levels existed until the middle of September.

Total flood damage was estimated in excess of $85 million. Six lives were reported lost, and about 12,000 persons were evacuated during the flood.

This report has been prepared to furnish hydrologic data for development planning. Included are discussions of antecedent streamflow, meteorology of the storm, descriptions of floods, flood damage, flood frequency, ground-water conditions, and stages and discharges of major streams for August 1967.

INTRODUCTION

The floods of August 1967 in east-Central Alaska and the rare combination of weather conditions that produced them are described in this report. Although the floods were in a sparsely populated area, damage was severe. After the flood, water-level measurements were made periodically to determine the rate of recession of the water table at Fairbanks because of the potential drainage problems associated with the winter freezeup. Some significant reactions of the people in the flooded area are reported. Presented in the report are data in maps, tables, and graphs. Both the data and the data-collection methods are given. The data include comprehensive hydrologic information that should be useful to planners and designers as well as geographers, economists, educators, and others interested in floods.

The floods described in this report occurred on streams in the Yukon River basin between the Alaskan villages of Eagle on the east and Ruby on the west (pl. 1). General location of the 200,000 square miles of the map area is shown on the index map on plate 1. The Yukon River and its major tributaries, the Porcupine, Chandalar, and Tanana Rivers, drain the area from east to west between the Alaska Range on the south and the Brooks Range on the north. Most of the area is uninhabited. Nenana, Fairbanks, Fort Wainwright, Eielson Air Force Base, and Fort Greely, all located along the Tanana River, are the principal communities and have a total population of about 50,000. Scattered along the main rivers are another 2,000 people in small villages. Farming, homesteading, trapping, and gold mining are carried on in the area.

Rainstorms, which began August 8 in the Fairbanks area and continued through August 20, produced heavy precipitation on August 12 and 13 and caused the floods described in this report. Record rainfall was measured at many locations in the area. The storms followed a short generally dry spell during which streams had about seasonal-normal flows.

The heavy rainfall over more than 40,000 square miles surrounding Fairbanks was areally continuous over major stream basins tributary to the Yukon and Tanana Rivers. The resulting storm runoff caused landslides and record floods. Headwater streams overflowed their banks and eroded their channels. Floodwaters exceeded the capacity of main stream channels, and almost entirely inundated flood plains in many valleys. Rivers changed channels, swept away tree-covered terraces, deposited bed material to form new flood plains, and carried trees and debris.

Where man had encroached upon the flood plains or main channels, economic damage occurred. General flooding in Fairbanks and Nenana caused disastrous damage.

The data in this report were collected as part of the cooperative programs between the U.S. Geological Survey and other Federal, State, and Borough agencies. The data were collected and compiled under the supervision of Harry Hulsing, district chief of the Water Resources Division, U.S. Geological Survey, in Alaska. The field surveys and office computations were coordinated by H.F. Matthai, hydraulic specialist.

Cooperation of the State of Alaska Department of Highways, U.S. Weather Bureau, and U.S. Army Corps of Engineers in providing data on precipitation and flood damage as well as other assistance is gratefully acknowledged.

ANTECEDENT STREAMFLOW

Streamflow was high during July with record peak discharges at stream-gaging stations on the Nenana River near both Healy and Rex and on the Teklanika River near Lignite. However, the first week of August was relatively dry throughout east-central Alaska, and streamflow was in the normal range at most gaging stations. The Chena River at Fairbanks had risen to a stage of 6 feet late in July, but then fell during the last part of July and the first week of August to a stage of 3.28 feet on the evening of August 8. Flood stage is 12.8 feet at Fairbanks.

WEATHER FEATURES CONTRIBUTING TO THE FLOODS

By E. D. Diemer, U.S. Weather Bureau

INTRODUCTION

To completely describe the meteorological conditions involved in a rainstorm, it is necessary to describe weather features which occur on various scales. Large-scale phenomena controlling the east-central Alaska flood weather had an areal coverage ranging from the size of Alaska to that of most of the Northern Hemisphere. Such features can be described by using data obtained from the meteorological observation network. Small-scale features are just as significant and may range in size from a few hundred square miles to tens of thousands of square miles. A detailed analysis of rainfall from numerous surface observations combined with radar observations is one approach to describe the small-scale features of rainfall distribution. In general, owing to the lack of observations in the Alaska interior, discussion of small-scale weather phenomena will be limited to areas where small-scale features can be identified.

Two coincident factors are required for precipitation: moisture and upward vertical motion. Extremes of these factors occur as small-scale weather phenomena. The general synoptic patterns of large-scale weather systems, such as extensive high-pressure areas, low-pressure areas, and frontal zones, form an environment which is conducive to the development of the smaller scale features. The smaller features usually play the crucial role in extraordinary events and are actually responsible for much of the weather. This is particularly true for precipitation that may occur in a narrow band of cumulus clouds or that may be associated with a particular orographic feature.

CLIMATOLOGICAL BACKGROUND

A pronounced continental climate covers the area north of the Alaska Range. The heaviest precipitation at Fairbanks is generally from June through September: the average monthly totals are June, 1.39 inches; July, 1.84 inches; August, 2.20 inches; and September, 1.10 inches. In other months, less than 1 inch of precipitation (water equivalent) is received. The normal yearly total is 11.29 inches. Much summer precipitation is of the shower type. Fairbanks has an average of five thunderstorms from June through August, and showers and thunderstorms are quite common throughout the Alaska interior during these months.

Summer precipitation in the interior of Alaska is associated with a marked increase in both moisture and solar radiation. Much of the moisture originates from the Bering Sea and Northwest Pacific Ocean, which warm to 47°F and 51°F, respectively, by August. Surface dewpoints over the Bering Sea in August are in the mid-forties and in the Northwest Pacific reach the upper forties. Surface dewpoints in the forties are not uncommon in the Fairbanks area during July and August. Maximum dewpoints during August 1967 were in the low fifties. Evaporation supplies moisture that is necessary for shower formation, but the amount from this source is too small for consideration in the precipitation amounts recorded during the August flood. Fairbanks has about 22 hours of daylight per day in the latter part of June and about 16 hours during August. Normal daily maximum temperatures for June, July, and August are 71.1°F, 71.7°F and 65.3°F, respectively, with record highs near 80°F. The pronounced surface heating leads to upward vertical motion of the air by decreasing its stability, and thus summer shower activity increases.

Another feature which has a strong influence on summer precipitation is the annual migration of the Arctic Front, which separates the cold dry polar air from the warm moist maritime air of the Gulf of Alaska and Bering Sea. The mean position of the Arctic Front in January is along the North Gulf coast and Aleutian Chain. By July the Arctic Front has moved northward to a mean east-west position near 65° N. latitude, which is about the latitude of Fairbanks and the Chena River basin. A well-developed Arctic Front can increase precipitation along the frontal zone by increasing the upward vertical motion of warm moist air moving northeastward from the Bering Sea. Moist air moving northward from the Gulf of Alaska produces little precipitation at Fairbanks because the moisture is dropped as precipitation during the forced rise over the Alaska Range. Thus a large and continuous moisture supply for Fairbanks must occur as a strong northeastward flow from the Bering Sea area. Moisture from the Bering Sea and the position of the Arctic Front were of major importance among the synoptic features producing the rainfall leading to the Fairbanks flood.

The principal tracks of low-pressure centers are normally from the vicinity of Japan and the Kamchatka Peninsula (U.S.S.R.) northeastward into the Bering Sea. From the Bering Sea the storm tracks turn either eastward north of the Brooks Range into the Beaufort Sea or eastward across central Alaska between the Alaska Range and the Brooks Range. The low-pressure systems affecting Fairbanks during August followed the latter path.

Normal sea level pressures for August indicate that a low-pressure area in the North Bering Sea with northeastward flow across the Bering Sea into central Alaska is the average situation. The low-pressure area and northeastward flow are reflected in the upper airflow: a north-south layer occurs at 10,000 feet near 180° longitude, and southwesterly winds move from the central Bering Sea into central Alaska. The position of the trough and winds coincides with the principal storm tracks.

SYNOPTIC FEATURES

Rainfall started about August 8 and continued until about August 20 over a wide area in east-central Alaska. Figure 1 is an isohyetal map showing the distribution of rainfall during August. The area covered by heavy rainfall is enclosed by the 3-inch isohyetal and includes the lower Tanana River basin and adjacent basins to the north draining into the Yukon River.

August precipitation data for locations in east-central Alaska are given in table 1. Figure 1 shows the locations where the precipitation data were collected. U.S. Weather Bureau gages are in valleys and thus did not record the greater amounts of rain that fell in the mountains. Rainfall as high as 10 inches was unofficially reported in the Chatanika River basin 60 miles northeast of Fairbanks. For most of August the rainfall occurred during the same period over widely scattered locations. Figure 2 shows cumulative daily rainfall at Clear Airport, Nenana, and Chena Hot Springs from August 8–19. Clear Airport and Chena Hot Springs are about 100 miles

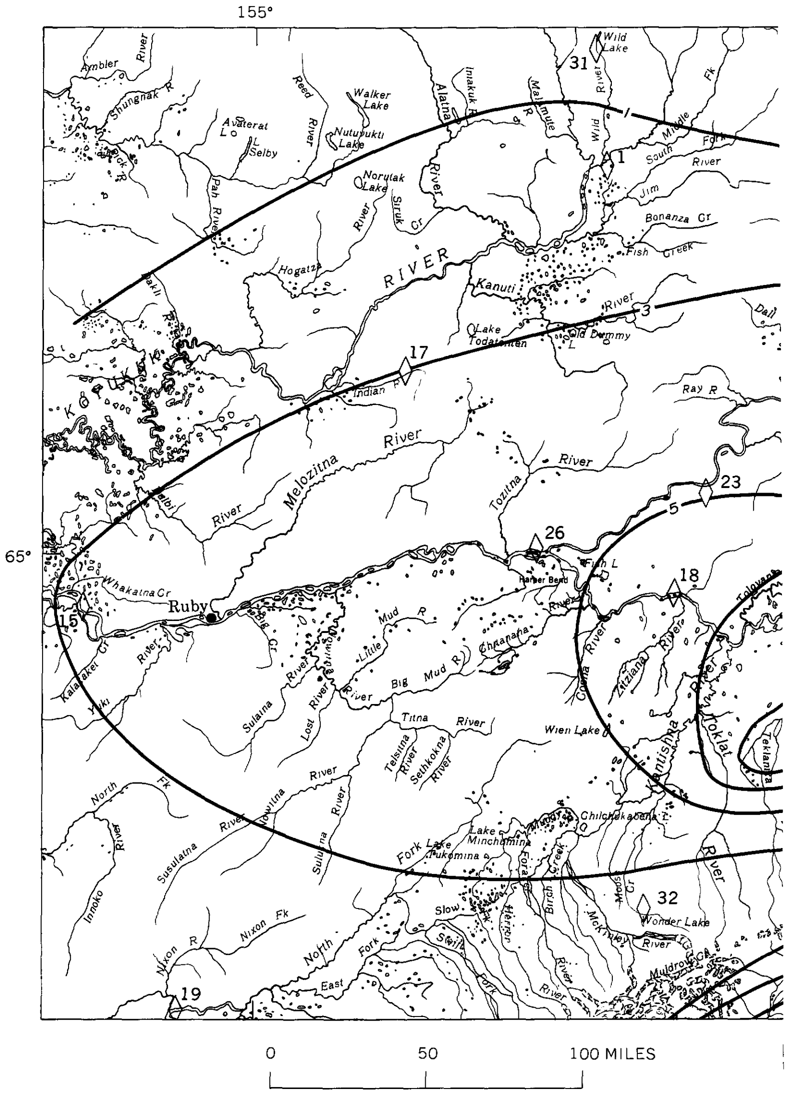
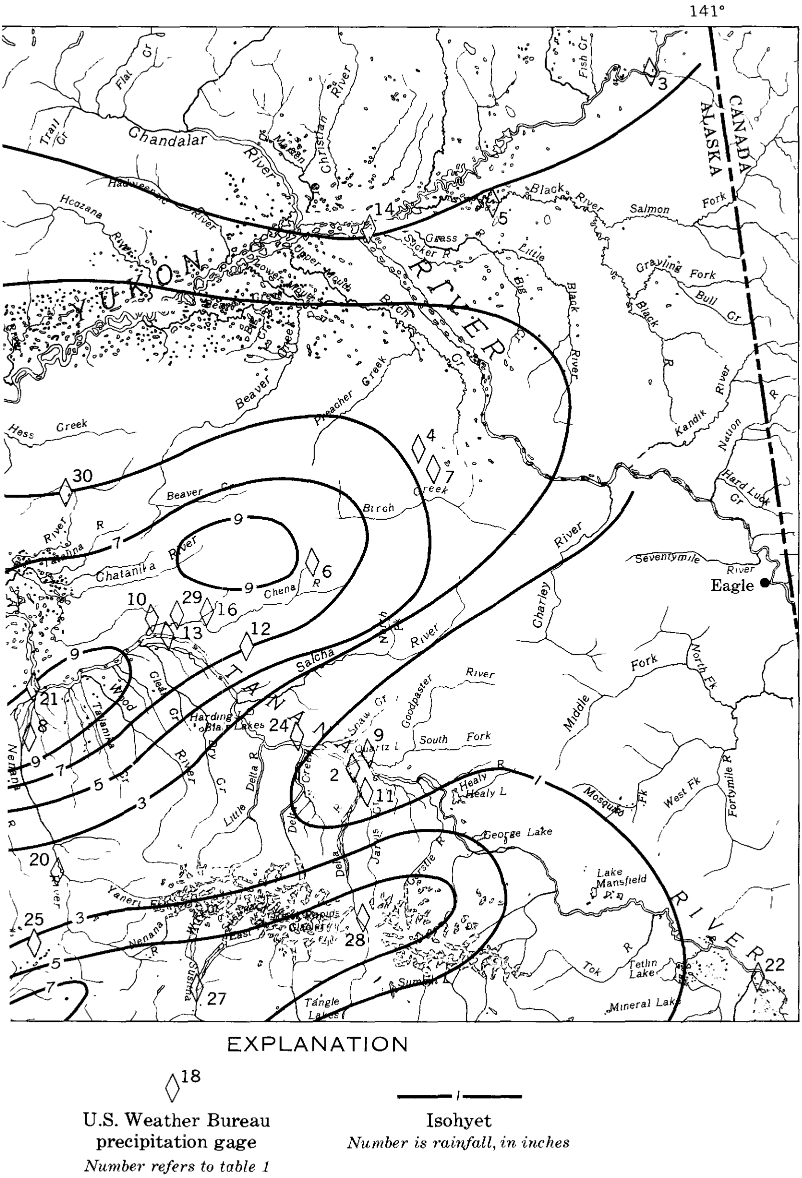


Figure 1.—Total rainfall distribution

apart. The cumulative daily rainfall curves at the three stations are very similar and indicate the general nature of this storm. Maximum daily rainfall of the storm period occurred on either August 12 or 13 at half of the locations given in table 1. Eight of the Weather



for August 1967, east-central Alaska.

Bureau stations reported an excess of 3 inches for the day of heaviest rainfall.

At the Fairbanks Airport, 6.15 inches of rain fell during the period August 8–15. The severity of the storms can be illustrated by

TABLE 1.—*Precipitation, in inches, during August 1967 in east-central Alaska*
[Adapted from U.S. Weather Bureau (1952)]

No. (fig. 1)	U.S. Weather Bureau station	Monthly total	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Bettles FAA Airport	2.17	Trace							Trace	0.18	0.24	0.22	0.12		0.14	0.01
2	Big Delta FAA	1.56	0.24			Trace				0.12	.09	.09	.04	.42	0.03	.02	Trace
3	Canyon Village	1.72	.69							.01	.03	.27	.04	.49	.03		
4	Central No. 2	5.70	.23	0.09							.60			1.17	1.32	.73	.33
5	Chalkyitsik	1.37	.06							.09	.08	.33	.01	.59		.02	.03
6	Chena Hot Springs	7.74	.06	.02			0.05			.23	.50	.42	.18	3.13	1.50	.63	.34
7	Circle Hot Springs	5.75	.06	Trace							.34	.02	.01	1.66	1.62	.84	.17
8	Clear Airport	10.06	Trace					Trace				1.00	.70	1.70	4.58	1.20	.33
9	Clearwater	2.37	.02	.15						.05	.10	.05		.65	.15	.15	
10	College Mag Obsy	7.36	.08	.05							.50	.21	.05	2.25	2.51	.65	.49
11	Delta Junction	2.48	.17	.05		Trace				.28	.09	.06	Trace	.48	.11	.10	Trace
12	Eielson	7.47	.09			0.02				Trace	.68	.29	.65	3.61	1.42	.38	.05
13	Fairbanks WB Airport	6.20	.02							.02	.56	.05	.87	3.42	.69	.47	.07
14	Fort Yukon	.35	.01									.10	.10			.05	.02
15	Galena	4.70			0.01				0.04			.01	.83	1.40	.49	.32	.18
16	Gilmore Creek	9.49	.09	.11							.67	.32	.04	3.38	2.80	.75	.70
17	Indian Mountain	3.44				Trace				.11	.16	.04	.41	.86	.02	.25	.11
18	Manley Hot Springs	6.89	.19								.08	.02	.14	3.33	.48	.54	.58
19	McGarth WB Airport	3.41	.07		Trace		Trace			Trace		.05	.07	.33	.22	.70	.41
20	McKinley Park	3.45	.26								.41	.25		1.86	.02	.32	.05
21	Nenana FAA	8.26	.08							.07	1.01	.06	.52	3.04	2.22	.80	.10
22	Northway FAA AP	1.85	.03			Trace		Trace		.28		.01	.07	Trace	.09	Trace	
23	Rampart No. 2	6.08	.02								.28	.11	.98	2.00	.39	.32	.26
24	Richardson	2.87		.10							.15	.08	.14	1.07	.28	.36	.08
25	Summit FAA	3.52	.34	.12	.01	Trace				.30	.30	.48	.16	.18	.47	.28	.03
26	Tanana FAA	5.06	.02			Trace					.15	.10	.44	1.96	.13	.36	.07
27	The Gracious House	7.54	1.63			.05		0.02	.05	.02	.53	.75	.34	.50	1.08	.77	.77
28	Trims Camp	9.16	.85	.67			Trace				.37	.35	.40	.73	2.44	.91	.29
29	University Exp. Sta.	6.57	.06								.50	.19	.17	3.28	1.15	.63	.31
30	West Fork	4.52	.54	Trace					.05		.28	.11	.21	1.78	.44	.35	.27
31	Wild Lake No. 2	2.00									.29	.17	.01				
32	Wonder Lake	3.81	.63								.37	.36	.08	.49	.87	.30	.31

No. (fig. 1)	U.S. Weather Bureau station	Monthly total	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	Bettles FAA Airport	2.17	0.40	0.48	0.03	Trace	Trace		Trace	0.13	0.08		0.08	0.04	0.01			0.01
2	Big Delta FAA	1.56				Trace	Trace	0.25	0.12	Trace			Trace	.12	.02			
3	Canyon Village	1.72	Trace			Trace	0.06	.04				0.06					Trace	
4	Central No. 2	5.70	.02	.04	.04	0.10		.04	.02			.64	.01	.03			0.02	.27
5	Chalkyitsik	1.37	Trace	.08	Trace	Trace						.08						
6	Chena Hot Springs	7.74	Trace			.27	Trace	Trace	.17	Trace	.03			.13	Trace		Trace	.08
7	Circle Hot Springs	5.75	.01	Trace		.19	Trace				.27	Trace	.03	Trace	.01		.25	.27
8	Clear Airport	10.06	.05			.04			.30					.16	Trace			
9	Clearwater	2.37					.15	.05	.25	.40				.20				
10	College Mag Obsy	7.36	.03	Trace		Trace					.06			.44	.04			
11	Delta Junction	2.48					.07	Trace	.79	Trace			Trace	.09	.03		Trace	.16
12	Eielson	7.47	.02	Trace	.02	.02		.22	Trace	Trace			Trace	Trace	Trace	Trace	Trace	Trace
13	Fairbanks WB Airport	6.20	Trace			Trace		Trace	.01		.01		.01	Trace		Trace		Trace
14	Fort Yukon	.35										.06	.01					
15	Galena	4.70	.01	.40		.18			Trace	.10	.45	.18	.10	Trace			Trace	Trace
16	Gilmore Creek	9.49					.14		.15	.09	.08			.12	.05			
17	Indian Mountain	3.44	.59	.37	.22			.04	.02		.03			.08	.09			.04
18	Manley Hot Springs	6.89	.63	.04	.15		.03			.30	.03			.06			.24	.05
19	McGrath WB Airport	3.41	.18	.41	.10	.18	.07	.49	.01	.01		Trace	.08			Trace	.03	
20	McKinley Park	3.45	.01	.01		.05	.04						.05	.12				
21	Nenana FAA	8.26			Trace	.04		.01	.02	.03			.26	Trace				
22	Northway FAA AP	1.85			Trace	Trace	.90	.16	.09	.03			.06	Trace			.01	.12
23	Rampart No. 2	6.08	.38	.02	.02	Trace				.22	.08						.80	.20
24	Richardson	2.87	Trace			.07		Trace	.54	Trace				Trace	Trace		Trace	Trace
25	Summit FAA	3.52	.23	.04	Trace	.09	Trace	.10	.13	.22	Trace	Trace	.04	Trace		Trace	Trace	
26	Tanana FAA	5.06	.69	.24	.03	Trace	Trace		.49	Trace	.03		.04	Trace			.31	
27	The Gracious House	7.54	.25			.15	.02			Trace		.30	.05			0.08	.18	
28	Trims Camp	9.16	.15	.31	.04	.03	.10	.13	.06	.09	.18	.09	.08	.06	.04	.03	.76	
29	University Exp. Sta	6.57	Trace	Trace					Trace	Trace	Trace		.09	.19	Trace	Trace		
30	West Fork	4.52	.29		Trace								.05	.01			.14	
31	Wild Lake No. 2	2.00	.25		.81					.20	.22	.02		.03				
32	Wonder Lake	3.81	Trace		Trace	.07	Trace	.03	.11	.03		.11	.05	Trace			Trace	

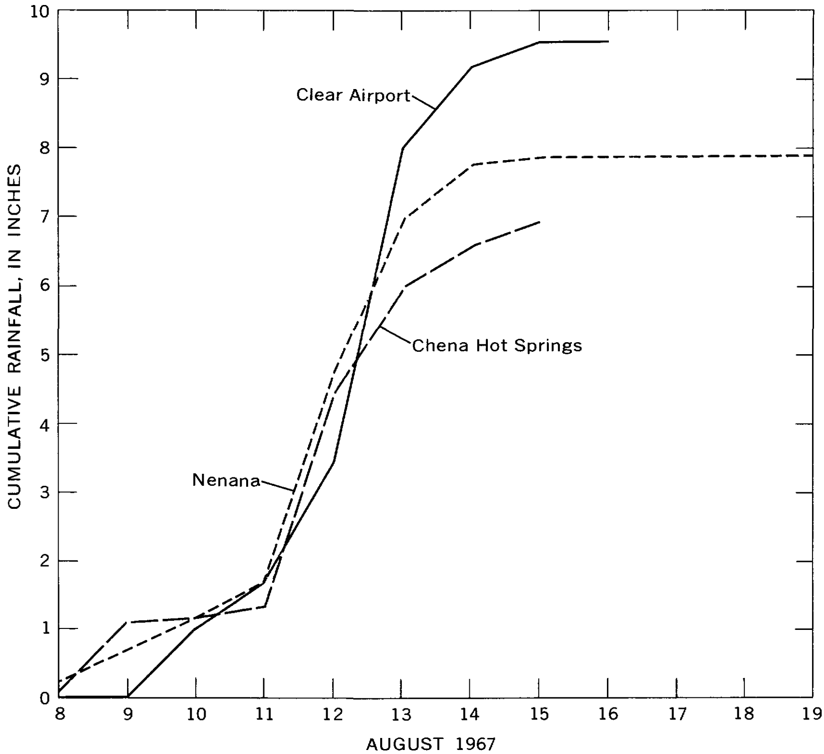


FIGURE 2.—Cumulative daily rainfall at Clear Airport, Nenana, and Chena Hot Springs, August 8–19.

several comparisons. The August 1967 rainstorm was the heaviest since records began in 1929 and exceeded the previous maximum amount by 31 percent. The storm precipitation of 6.15 inches is over half the normal annual precipitation at the airport. Comparison with the previous record storm, that of August 1930, is as follows:

	August 1930	*August 1967*
Total storm precipitation	4.69	6.15
Maximum daily precipitation	2.33	3.42

A series of storm systems accounted for such an extended period of rain. Thus, it is convenient to consider the rain period in four sections: the period prior to August 8, the period of August 8–11, the heavy rain of August 12, and the period of August 13–20.

CONDITIONS PRIOR TO AUGUST 8

The Weather Bureau airport station at Fairbanks recorded a total of 1.13 inches of precipitation during the month of June, 0.26

inches below normal. During July, precipitation was 1.50 inches above normal, and the total precipitation recorded was 3.34 inches. Of this total, 1.27 inches fell on July 24; this was the last heavy rain of the month. For the 14-day period July 25 through August 7, 0.39 inches of rain fell at Fairbanks, but of this amount only 0.02 inches fell during the first week of August.

Similar conditions prevailed upstream in the Chena River basin, judging from the precipitation record at Chena Hot Springs, the only observation station near the headwaters of the Chena River. Both the 1.46 inches of precipitation recorded during June and the 3.68 inches recorded during July are about one-third of an inch higher than the amounts recorded at Fairbanks. These are not significant differences considering that the usual amounts of precipitation differ and that Chena Hot Springs is at a higher elevation where the effects of nearby mountains are greater. On July 24, Chena Hot Springs received 0.54 inches of rain, compared with 1.27 inches at Fairbanks. During the 14-day period July 25 through August 7, 0.83 inches of rain fell at Chena Hot Springs, but only 0.13 inches of this amount fell during the first week in August. In general, conditions prior to August 8 were about normal.

CONDITIONS AUGUST 8–11

Rainfall of direct consequence to the flood began on August 8. Figure 3 presents the isohyets of total precipitation August 8 to 11, inclusive. The isohyets are a gross depiction of the rainfall distribution because there are only 32 precipitation records in about 80,000 square miles and these are in valleys or at mountain passes. During August 9, 10, and 11, the Chena River basin received about 1.5 inches of rain.

Two features of particular interest affected the rainstorms. The first feature was a tropical storm named Typhoon Hope, which had moved into midlatitudes and had become an extratropical low-pressure center near 40° N. latitude, 175° E. longitude, about 700 miles south of the Aleutian Islands, at 1800Z on August 9. (1800Z is 1800 hours Greenwich time, which is equivalent to 0800 hours Alaska standard time.) Typhoon Hope continued northward and by 1800Z on August 11 had formed the deep low-pressure system northwest of Shemya. Figure 4 shows the synoptic patterns at 1800Z on August 11.

The second feature was the Arctic Front in central Alaska near 65° N. latitude. A low-pressure center just west of Fairbanks at 1800Z on August 9 influenced the Fairbanks weather until about

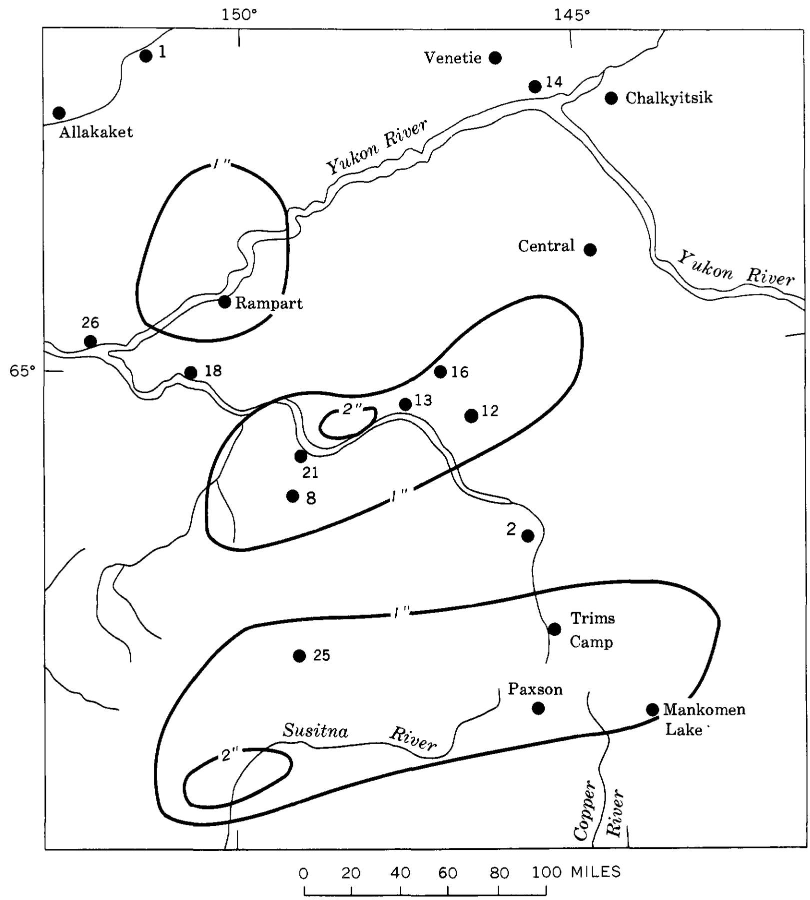


FIGURE 3.—Isohyets of total rainfall distribution, August 8–11. Numbered points are U.S. Weather Bureau precipitation gages identified in table 1.

0000Z August 11. By this time it had moved eastward into the Northwest Territories (Canada) near the mouth of the Mackenzie River, and the Arctic Front had moved to the south of Fairbanks. At about 0600Z on August 11 an open wave, or small low-pressure center, had formed on the Arctic Front south of Fairbanks causing the front to again move northward. Referring to figure 4, the effect on the front can be seen just north of Fairbanks. Another low-pressure center had moved eastward along the Arctic Front from 178° E. longitude to the North Bering Sea west of Nome. Note that the deep low pressure northwest of Shemya had set up a long south-west fetch for the Fairbanks area. Strong low-level winds began a renewed influx of moisture to central Alaska. The low pressure

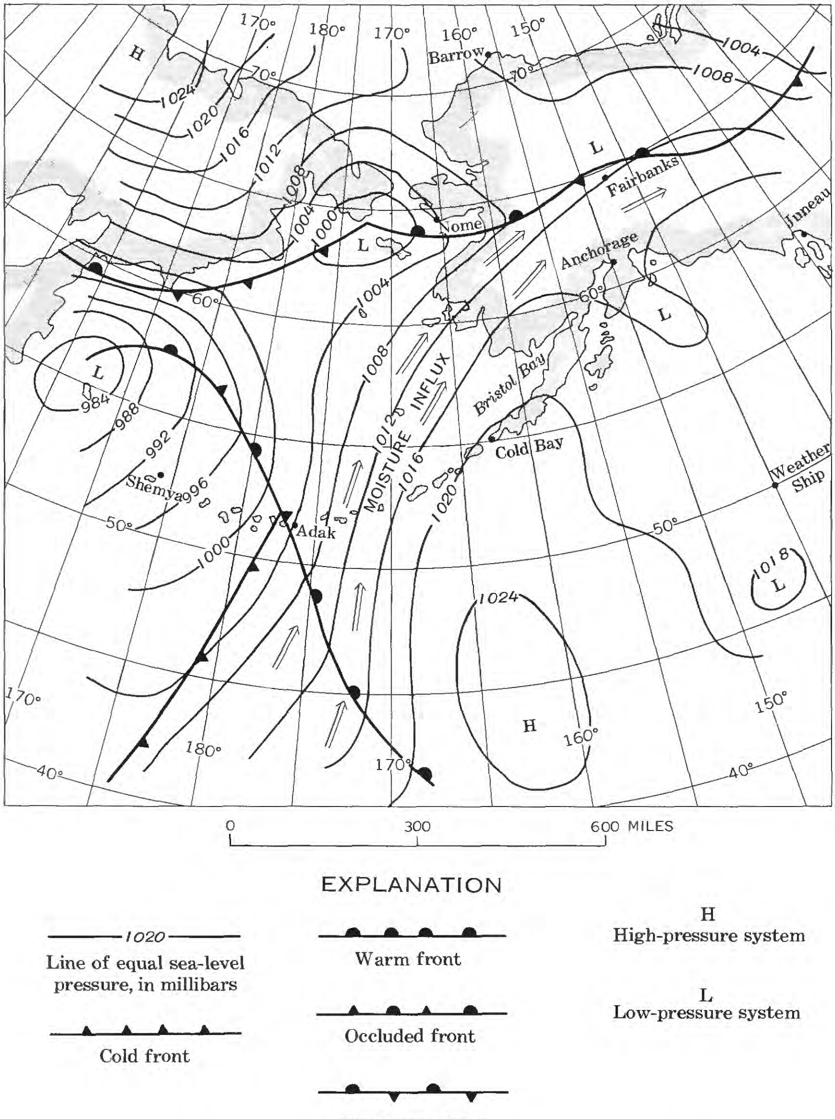


FIGURE 4.—Surface weather chart, 1800Z, August 11.

west of Nome continued rapidly eastward providing the vertical motion necessary for precipitation. About this time the low pressure in the Bering Sea, formed by the extratropical storm, began to play an important role in the Fairbanks and Chena River basin rainfall.

CONDITIONS AUGUST 12

Rain began falling again at Fairbanks about midafternoon on August 11 and continued until the early morning of August 15. On August 12 the heaviest rain fell: 3.42 inches at the Weather Bureau airport station at Fairbanks and 3.13 inches at Chena Hot Springs. Figure 5 depicts the isohyets for August 12. The 3-inch isohyet encloses an area about 180 miles long and 40 miles wide. The eastern extent of the 2-inch and the 3-inch isohyets was not defined, but was positioned to coincide with observed high water or flood conditions of the streams in that area.

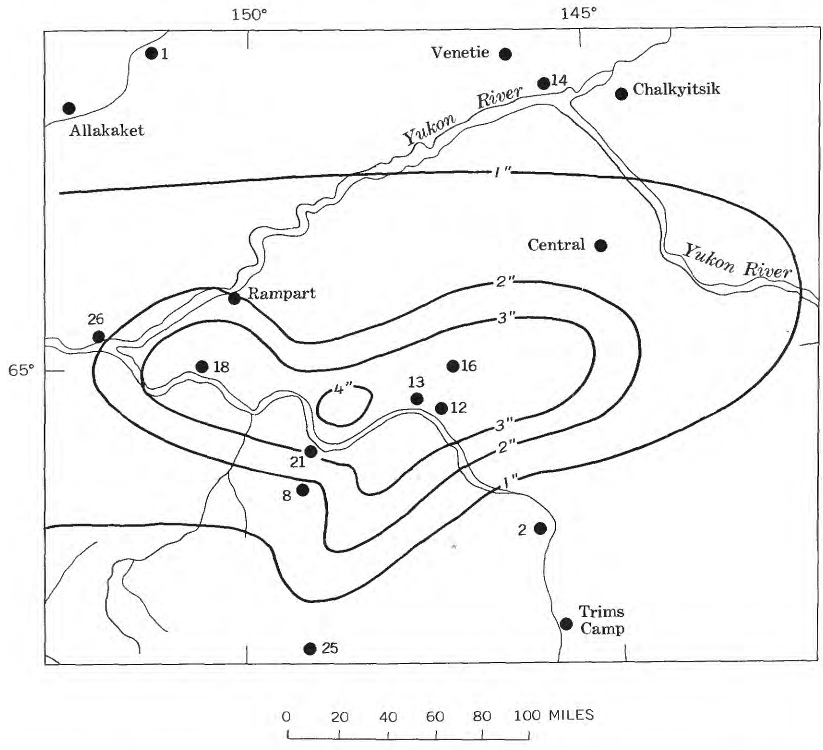


FIGURE 5.—Isohyets of total rainfall distribution, August 12. Numbered points are U.S. Weather Bureau precipitation gages identified in table 1.

There is a strong similarity between the weather systems that affected east-central Alaska, especially that of August 12, and a synoptic situation which leads to squall-line formation in the Great Plains of the United States. Strong low-level winds provided an intrusion of warm moist air, and a cross current of strong upper winds existed across the Arctic Front. Weak lows or open waves were moving along the frontal system. The degree of instability characteristic of a Great Plains squall line was lacking; however, the cumulus development must have been considerable to produce the rainfall amounts observed.

The low west of Nome moved rapidly eastward and decreased in intensity. By 1200Z on August 12 the remainder of this low appeared as just an open wave on the Arctic Front northeast of Fairbanks.

The frontal system in the Bering Sea began rapid eastward movement forming another low on the Arctic Front in the vicinity of Norton Sound south of Nome. The parent low remained north of Shemya.

By 1800Z on August 12 (fig. 6) this low had crossed Norton Sound and was about 250 miles west of Fairbanks. Moisture influx remained strong at low levels with the long southwest fetch extending from Fairbanks to the North Pacific south of Shemya, a distance of about 2,000 miles. At 0600Z August 13 (2000 hours August 12 local time) the low had passed Fairbanks and merged with the general trough of low pressure extending from Fairbanks eastward into Canada. The strong southwest flow of moist air continued into the Fairbanks area. The Arctic Front remained in almost the same position just to the north of Fairbanks. The parent low north of Shemya had decreased in intensity and began moving along the Arctic Front toward central Alaska.

CONDITIONS AUGUST 13–20

At 0000Z August 14 the Shemya low had moved to a position southwest of Norton Sound, and another low had formed in the Bristol Bay area (northeast of Cold Bay). By 1200Z August 14 (fig. 7) a series of low-pressure centers was evident. The Bristol Bay low extended northward from Cook Inlet (south of Anchorage) as a trough line, and the low to the north had moved into Norton Sound. An extensive area of low pressure in the South Bering Sea just to the north of the Aleutian Chain had become well formed.

At 0000Z August 15 several waves were still active along the Arctic Front. The last of these was located in eastern Norton Sound.

The low-pressure area moving into Bristol Bay continued eastward into southwestern Alaska. This was the last low-pressure system of this series of storms. Figure 8 shows the eastward movement of this low-pressure system. By 0000Z August 15 the winds at Fairbanks became southerly, a direction which is not conducive

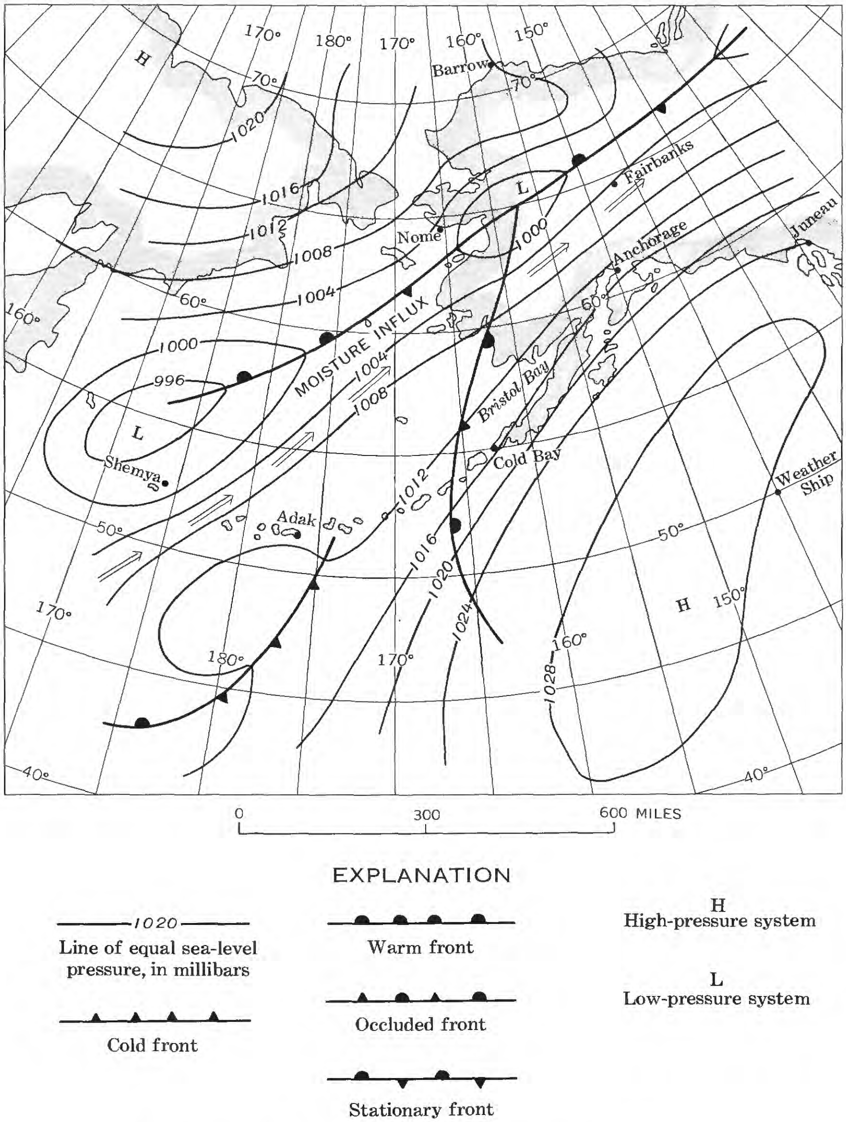


FIGURE 6.—Surface weather chart, 1800Z, August 12.

to precipitation at Fairbanks. Significant precipitation at Fairbanks ended early in the morning of August 15.

Precipitation during this period was highly variable, as indicated by the isohyets in figure 9. Several large centers stand out: Gilmore Creek, 4.39 inches; Clear, 6.46 inches; Trims Camp, 4.96 inches; and the area north of Talkeetna, 7.18 inches.

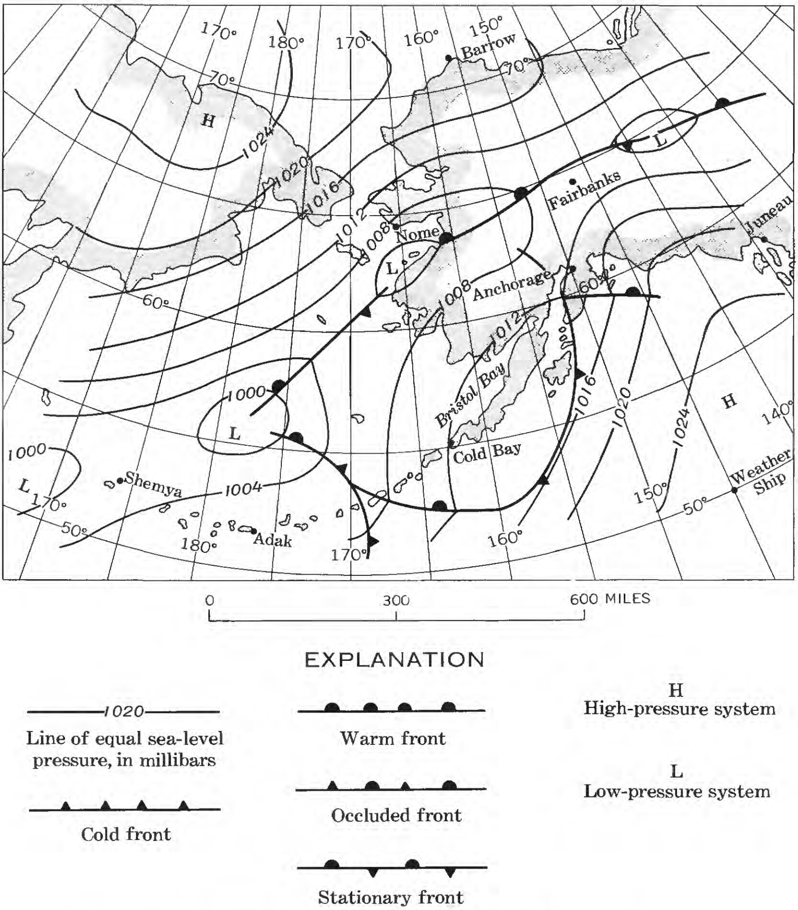


FIGURE 7.—Surface weather chart, 1200Z, August 14.

STORM SEQUENCE

One of the extraordinary aspects of the weather associated with the August 1967 floods in east-central Alaska was the rapid sequence of storms which traversed the area. Normally, low-pressure centers do not move through a specific area with such rapid succession. Also, when the interval between storms is brief, storm intensity usually decreases with succeeding storms of a series. This was not the case during August 1967, because on about August 12 the storm track into east-central Alaska changed from west to southwest as extratropical storm Typhoon Hope developed a deep low-pressure center in the Bering Sea. This change provided a new source of low-pressure centers and maintained the moisture influx to the Fairbanks area.

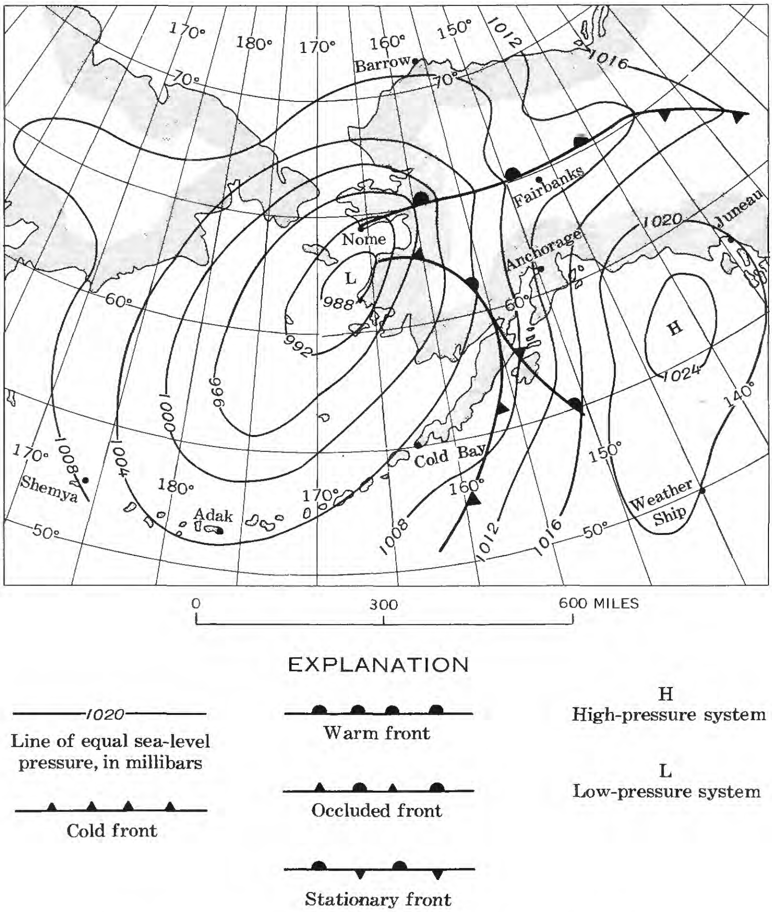


FIGURE 8.—Surface weather chart, 0600Z, August 16.

All the meteorological conditions required for rain were present over east-central Alaska during each storm passage; therefore, each storm dropped its maximum precipitation in the same general area. A small change in the development and movement of the low-pressure centers could have placed the vertical motion out of phase with the main moisture supply. For example, a slight shift in the low-level winds from the Bering Sea could have moved the moisture several hundred miles from east-central Alaska, or a slight fluctuation in the Arctic Front could have moved the area of maximum precipitation north or south.

Many floods, especially on small streams and rivers, result from exceptionally heavy rainfall from one storm. The August 1967 floods in east-central Alaska, however, resulted from an accumulation of rainfall events from a rapid sequence of storms over about a week's period. Only one of these rain periods, August 12, produced exceptionally heavy precipitation.

DESCRIPTION OF FLOODS

The rare storm conditions described in the previous section caused widespread flooding. The floods were the highest known in many locations, and damage was great even though most of the area is virtually uninhabited. The severest flooding was along the lower courses of large streams, but some small streams at higher elevations also had severe floods. The flood-area boundary shown on

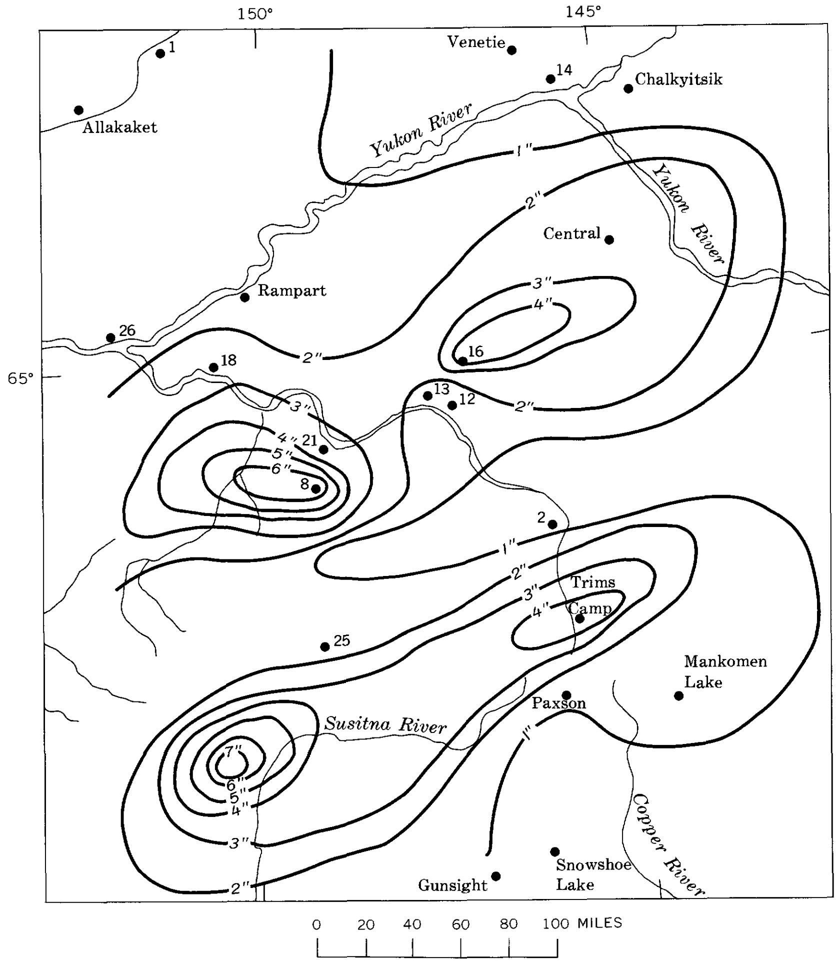


FIGURE 9.—Isohyets of total rainfall distribution, August 13–20. Numbered points are U.S. Weather Bureau precipitation gages identified in table 1.

plate 1 was drawn after consideration of several factors: (1) streamflow and rainfall records, (2) postflood aerial reconnaissance, (3) damage to culture, (4) interviews with observers, (5) flood-frequency relations, and (6) hydrologic inference.

The floods followed a period of normal streamflow. Comparison of hydrographs for different locations gives some indication of the similarity in flooding throughout the area. The hydrographs of the Yukon River are presented in downstream order. Each gaged tributary of the Yukon River along the way was considered, again in downstream order. Also shown on each hydrograph is the previous peak discharge of record and its date of occurrence to aid in establishing the relative size of the floods.

Hydrographs of the Yukon River (fig. 10) at Eagle (sta. 1), Rampart (sta. 10), and Ruby (sta. 47) indicated that the storm

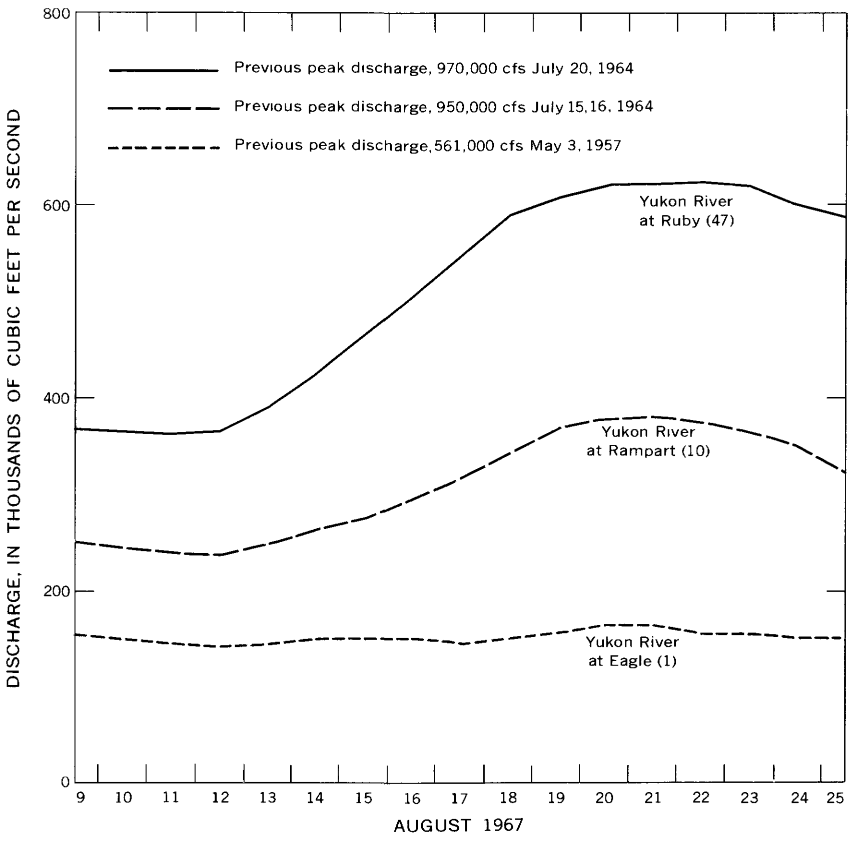


FIGURE 10.—Discharge at selected gaging stations on the Yukon River, August 9–25. Numbers in parentheses refer to those in table 7 and plate 1.

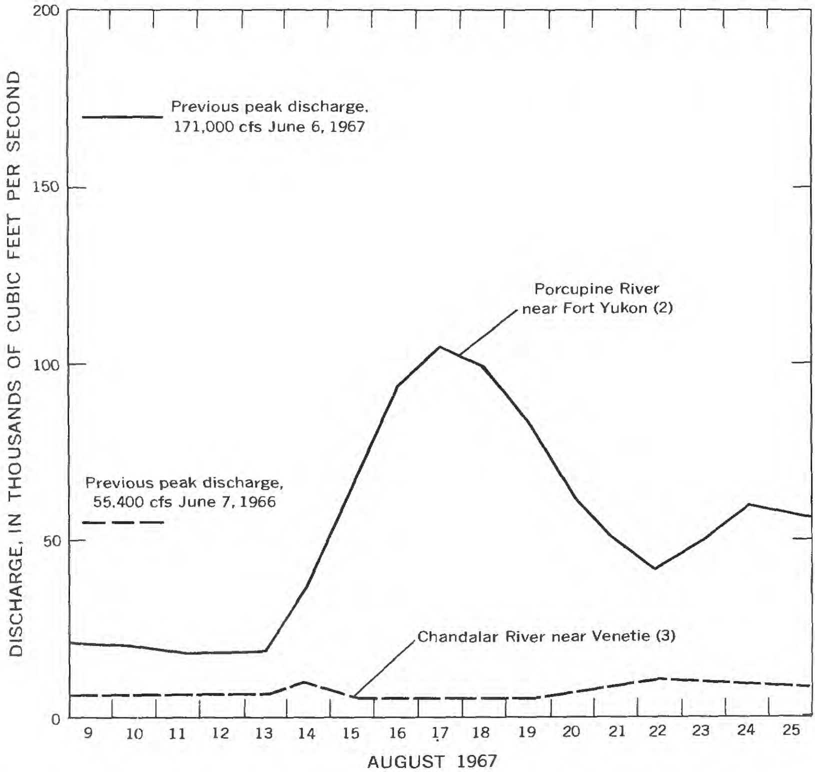


FIGURE 11.—Discharge at selected gaging stations on Yukon River tributaries, August 9–25. Numbers in parentheses refer to those in table 7 and plate 1.

runoff occurred downstream from Eagle. The Yukon River at Rampart is downstream from several tributary streams draining the northeastern part of the flood area. Hydrographs for the Porcupine River near Fort Yukon and the Chandalar River near Venetie (fig. 11) indicate little or no flooding on the Chandalar and only medium-high water on the Porcupine.

The rise of 142,000 cfs, a 60-percent increase in discharge, for the Yukon River at Rampart is the result of high water and flooding on tributaries above Rampart. Damage along Birch Creek near Circle and reports of boat travelers support this conclusion. Figure 12 shows the U.S. Geological Survey stream-gaging station at Boulder Creek near Central (sta. 6) in the Birch Creek drainage basin after the flood. The bridge supporting the gaging station was moved more than a foot and tilted, and the bridge opening was choked with boulders and debris. The gage which was in the main stream

FIGURE 12.—U.S. Geological Survey gaging station on Boulder Creek near Central after flood of August 13. Photograph by U.S. Geological Survey.

before the flood was out of the stream after the flood. At the Steese Highway crossing of Birch Creek near Circle, about 1 mile of roadway was inundated up to 5 feet in depth, and the peak discharge of the creek was 84,000 cfs.

The rise of 261,000 cfs, a 72-percent increase in discharge on the Yukon River at Ruby (fig. 10), was partly the result of record flooding of the Tanana River, the major tributary between Rampart and Ruby. The Tanana River near Tanacross discharge hydrograph (fig. 13) indicates that no extensive flooding occurred in the upper Tanana River basin. But downstream, the Tanana River at Big Delta peaked on August 17 or 18 at a discharge estimated to be in excess of 60,000 cfs. This peak discharge probably resulted from flooding in the Goodpaster River basin.

Upstream from Fairbanks along the Tanana River, the Richardson Highway was washed out at Little Salcha River, and about half a mile of approach roadway was washed away at the Salcha River bridge. The peak discharge of 97,000 cfs on the Salcha River near Salchaket (fig. 14) was measured by indirect methods at a site 8

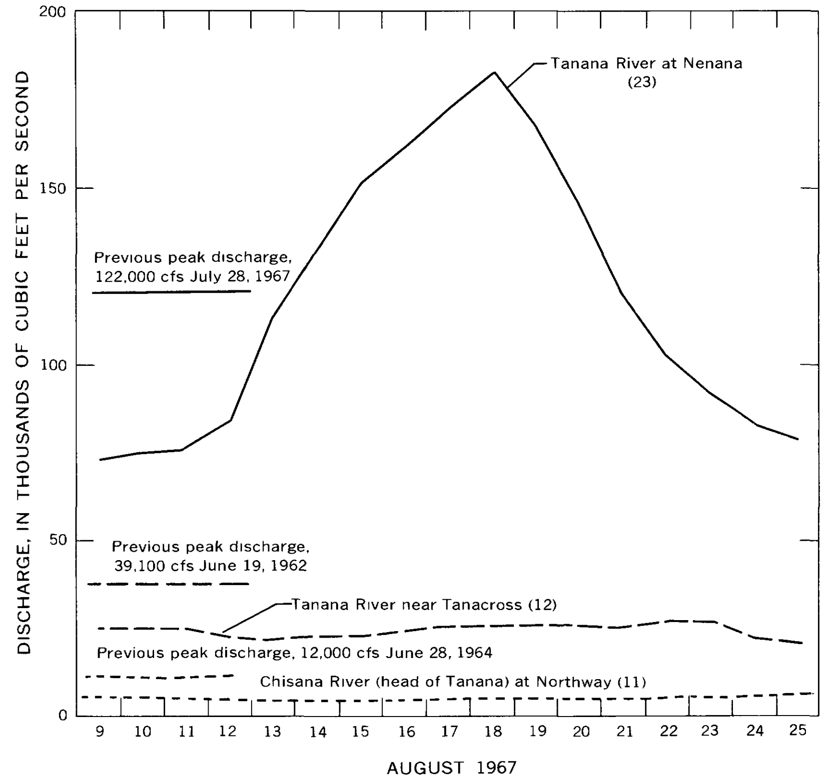


FIGURE 13.—Discharge hydrographs at selected gaging stations on Tanana River, August 9–25. Numbers in parentheses refer to those in table 7 and plate 1.

miles upstream from the gaging station. Visual evidence of extensive flooding was obtained by flying over the Salcha River basin.

In the Chena River basin along the Chena River upstream from Fairbanks, storm runoff caused numerous slides on headwater hillsides, washed out roads and tree-covered terraces, and inundated most of the flood plain. The Corps of Engineers' stream-gaging station on the Chena River 40 miles upstream from Fairbanks was completely destroyed by the flood. Figures 15 and 16 show landslides in the upper Chena River basin. Figures 17–19 show damage to the Chena Hot Springs Road. A resident on the Chena River 35 miles upstream from Fairbanks reported the flood peak occurred there between 1600 and 1800 hours, August 13.

The hydrograph for Little Chena River near Fairbanks (fig. 14) shows that the peak discharge was 17,000 cfs on August 13 at the U.S. Geological Survey stream-gaging station at the Chena Hot

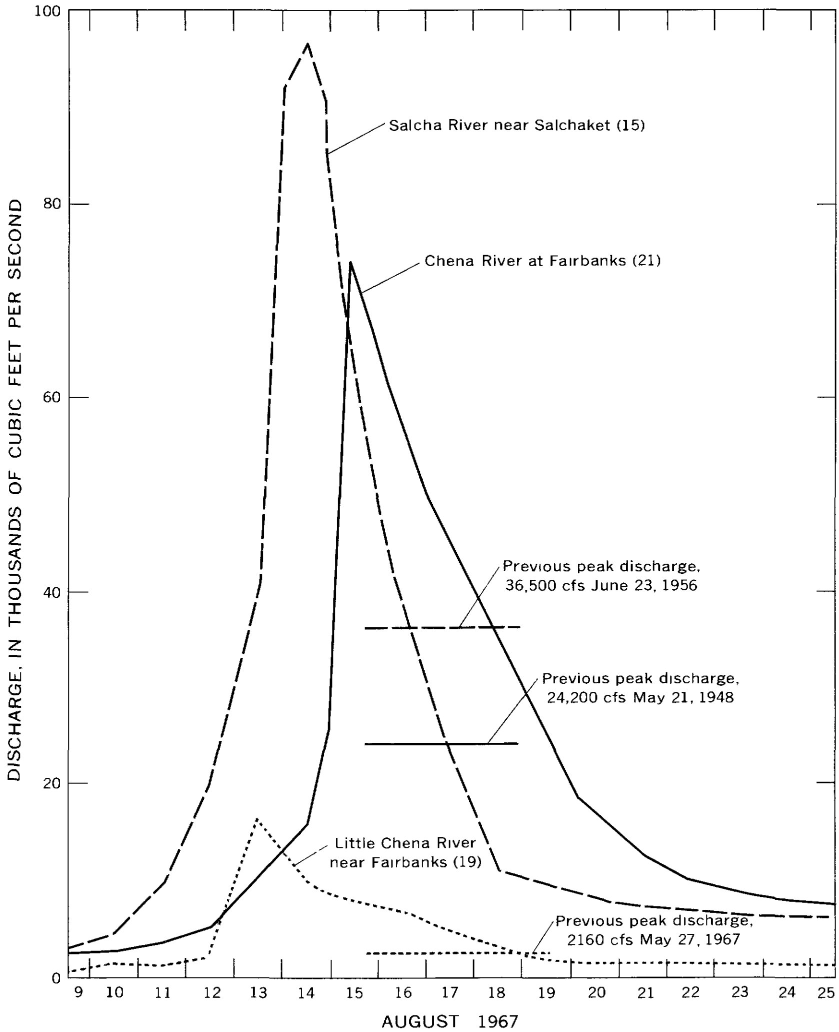


FIGURE 14.—Discharge hydrographs at selected gaging stations on Tanana River tributaries, August 9–25. Numbers in parentheses refer to those in table 7 and plate 1.

Springs Road crossing. Figure 20 shows flooding conditions near the site. After the picture was taken, the roadway was washed out, and the channel was scoured and widened so that it was completely changed below the bridge.

The peak discharge of 74,400 cfs on the Chena River at Fairbanks (fig. 14) on August 15, 1967, was more than three times the previous maximum discharge of record, 24,200 cfs on May 21, 1948.

FIGURE 15.—Landslides in upper Chena River basin. Photograph by U.S. Army Corps of Engineers.

About 95 percent of Fairbanks was flooded; water was up to 5 feet deep in places. The extent of inundation is shown on plate 2. About 12,000 inhabitants in the Fairbanks area were evacuated, and six deaths were reported. Urban Fairbanks and nearby Fort Wainwright were damaged seriously. Houses and other structures were surrounded by water. Runoff from the Chena River and adjacent streams caused the flood along the lower Tanana River from above Fairbanks to the mouth of the Tanana River. However, flow from the Tanana River probably did not contribute to flooding in the Chena River valley. Floodmark elevations throughout the Fairbanks area indicate a general downward slope to the Tanana River. Figures 21 through 23 show flood conditions in the Fairbanks area on August 15 at about the time of the crest.

Flood damage was also found along the Tanana River below Fairbanks. Figure 13, the hydrograph for the Tanana River at Nenana, shows the comparative size of the peak discharge. On August 13, 1967, the Tanana River topped its banks at Nenana and continued rising. Overbank flooding averaging 6 feet deep throughout the town forced total evacuation of the 300 residents, and the

FIGURE 16.—Landslide in upper Chena River basin. Photograph by U.S. Army Corps of Engineers.

river was over its banks in town for 10 days. Figure 24 shows flood conditions there on August 15. The discharge of 186,000 cfs at gage height 18.90 feet on August 18 is the maximum of record.

The Nenana River, which joins the Tanana River at Nenana, reached a peak discharge of 31,100 cfs (fig. 25) on August 12 at Healy. This flood followed a peak discharge of 46,800 cfs in July 1967, which is the highest in 17 years of record at Healy. Evidence of flooding was found at some highway crossings of small streams tributary to the Nenana River. Birch Creek near Rex had a peak discharge of 464 cfs from a drainage area of 4.10 square miles.

The Chatanika River valley was severely flooded. Mr. Warren J. Fyton of Chatanika reported that the rain started Friday, August 11, and was heavy and continuous through August 12 with high winds; the Chatanika River peaked about 2400 hours Sunday, August 13, at Chatanika. The Steese Highway was extensively damaged by flooding. Overbank flood discharge swept away bridge approaches, scoured roadway shoulders, and cut new channels. In the headwaters of the Chatanika River, highway bridges and culverts were damaged by overtopping, washouts, and scour fill of

FIGURE 17.—Road washout along Chena Hot Springs Road. Photograph by U.S. Geological Survey.

bridge openings. Hillsides were slashed by slides. The 5-foot-high crest-stage gage on Idaho Creek near Miller House in the upper Chatanika River basin was completely buried by flood-deposited cobbles, boulders, and gravel. Peak discharge was 626 cfs, or 118 cfs per square mile, on Idaho Creek near Miller House sometime during the period August 12–13.

Tolovana River flooding contributed to the Tanana River flood below Nenana. Overbank flooding with depths up to 4 feet occurred near the Elliott Highway crossing of the Tolovana River. A riverside campground at Tolovana River bridge was practically washed out by the flood. Similar damage was found at Tatalina River and Chatanika River crossings on the Elliott Highway. The West Fork Tolovana River at West Fork and a Tolovana River tributary near Livengood had only small rises, as these streams were on the west edge of the area of major flooding.

PEAK DISCHARGES AND FLOOD-CREST PROFILES

A considerable time lag separated the heaviest rainfall on August 12 from the time of the peak discharge, particularly on the

FIGURE 18.—Flood damage on Chena Hot Springs Road. Photograph by U.S. Army Corps of Engineers.

larger streams. The flood-peak discharges generally occurred on August 13 or 14 on the smaller streams and on August 15 or later on the larger streams. The following table illustrates the relation between drainage area size and date of the peak:

Stream	*Drainage area (sq mi)*	*Date of peak in August 1967*
Little Chena River near Fairbanks	356	13
Chena River above Little Chena River near Eielson Air Force Base	1,370	13 or 14
Chena River at Fairbanks	1,980	15
Tanana River at Nenana	[1] 27,500	18
Yukon River at Ruby	[1] 259,000	22

[1] Only part of area contributed to flood runoff.

Some of the time lag was caused by the floodflow-retardation effects of overbank or flood-plain storage. Flood-plain storage also reduced the peak discharge of the Chena River from 105,000 cfs at the upstream site near Eielson Air Force Base to 74,400 cfs at Fairbanks. This reduction occurred even though the Little Chena

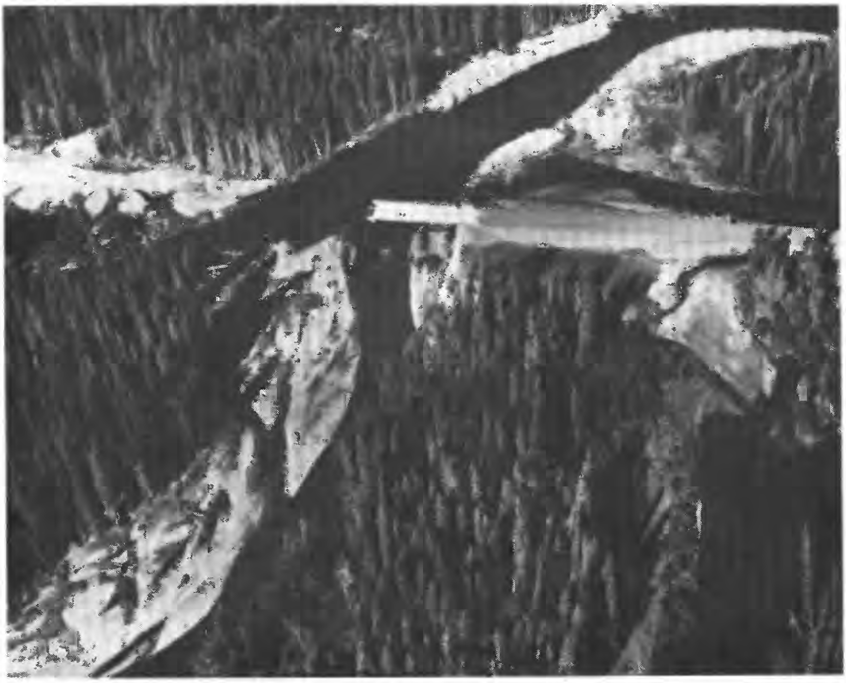


FIGURE 19.—Flood damage on Chena Hot Springs Road. Photograph by U.S. Army Corps of Engineers.

River, which enters between these two places, contributed considerable floodflow (peak discharge of 17,000 cfs).

The overbank flooding phenomenon may be visualized by looking at the flood map (pl. 2) and the cross-section plot (fig. 26). The flooding of the Chena River at Fairbanks is best described as a flowing lake which extended upstream and downstream from Fairbanks for several miles. Overbank flow at the gaging station accounted for 47,600 cfs of the total 74,400 cfs at the peak. Mean velocity of the overbank flow was 1.61 feet per second, as compared with a mean velocity of 4.48 feet per second in the main channel. As increasing amounts of the total discharge are carried on the flood plain, the overall mean velocity is reduced, and the movement of flood crest is retarded. The overbank flooding thus increases the duration of the floodflow and reduces the peak discharge as the flow moves downstream.

The Tanana River peaked at Fairbanks about 0100 hours August 16. Flooding of the Salcha River and other tributaries contributed to the flood on the Tanana River at Fairbanks and downstream.

FIGURE 20.—Little Chena River flood at Chena Hot Springs Road. Photograph by Fairbanks News-Miner.

The crest on the Tanana River at Fairbanks is shown in figure 27. Downstream at Nenana the peak occurred on August 18. Figure 27 shows the comparative hydrographs of river stage and the progression of the flood peak downstream from the Chena River at Fairbanks to the Tanana River at Nenana.

Peak discharge during the floods was measured at 51 sites, most near existing roads. Review of these measurements discloses information about comparative flood magnitudes within the area. Table 2 shows unit peak discharge as measured at selected sites along the major streams draining the area. From this table it

TABLE 2.—*Unit peak discharge, in cubic feet per second, per square mile*

Stream	*Headwater*	*Midcourse*	*Lower course*
Birch Creek	74		39
Salcha River			45
Chena River		76	38
Chatanika River	118	80	47
Tolovana River		86	
Average	96	81	42

FIGURE 21.—Chena River flood around Fairbanks International Airport, August 15. Photograph by U.S. Army Corps of Engineers.

appears that headwater tributaries at higher elevations yielded the highest runoff rates. Runoff rates were reduced slightly after concentration of floodwaters in major channels. In the lower courses of major streams, after flood-plain storage became effective, unit runoff rates were reduced to about half those in the headwaters. Small tributaries at lower elevations yielded runoff rates ranging from 11 to 63 cfs per square mile.

Profiles of the August 1967 flood crests on the Chena and Tanana Rivers at Fairbanks are shown in figures 28 and 29. The May 21, 1948, flood-crest profile for the Chena River is also shown for comparison. The baselines to establish distances for the flood profiles were arbitrarily drawn and are shown in figure 30 as lines *B–B′* and *C–C′*. The baselines have also been drawn on the flood map of Fairbanks (pl. 2). Elevations of high-water marks left by the flood of August 1967 have been plotted on the flood map (pl. 2) and are the basis for the flood profiles. The profile stationing for a specific point can be obtained from a projection perpendicular to the baseline.

FIGURE 22.—Chena River flood in downtown Fairbanks, August 15. Photograph by U.S. Army Corps of Engineers.

Profiles of floods are a reflection of the capacity of the main channel, the degree to which bridge openings are obstructed, and the extent of man's encroachment on the flood plain. The profile in figure 28 is smooth with only minor breaks in slope. This smooth profile indicates that bridges and other structures were not serious obstructions to the floodflow at Fairbanks.

FLOOD DAMAGE

Though the floods of August 1967 in east-central Alaska were generally in uninhabited and undeveloped areas, the resultant damage was extremely great. Fairbanks and Nenana are the only nonmilitary communities in the flooded area with populations exceeding 300. Both were declared national disaster areas. Information furnished by the U.S. Army Corps of Engineers (1968) shows that nonmilitary improvements valued at $180 million and affected by flooding in the Fairbanks area sustained about $84 million flood damage. Nenana, which had $27 million of improvements affected by flooding, sustained about $1 million flood dam-

FIGURE 23.—Chena River flood at Fairbanks, August 15. Photograph by U.S. Army Corps of Engineers.

age. Damage to rural areas and improvements including highways and the Alaska Railroad was estimated at $7 million.

In Fairbanks, where the most damage occurred, the flood was a threat to survival. Fairbanks is on the flood plain of the Chena and Tanana Rivers. The Chena River bisects the city, which crowds up to the riverbanks with expensive commercial and residential buildings. Because the Chena River rose rapidly, quickly inundating the occupied flood plain to unprecedented depths, unprepared residents were not able to comprehend their plight. Many first concerned themselves with basements. They piled belongings on tables or other furniture, working frantically to save their possessions from the silty floodwater. They soon realized the hopelessness of their efforts and began carrying things up to the main floor of their houses. Then again, they soon watched the floodwater rise rapidly up to windowsill height, floating bureaus, refrigerators, and other objects so that they toppled. Need for evacuation then became urgent, and it was discovered that only boats or helicopters could be used because depths of inundation and current velocities

FIGURE 24.—Tanana River flood at Nenana, August 15. Photograph by Alaska Railroad.

were too great for cars or wading. People moved to rooftops and multistoried buildings to await evacuation.

Data were inadequate to predict an accurate forecast of the flood crest. That some people suffered loss because of their reliance on the forecast can be illustrated by the following account.

A man and his family lived in a basement apartment in the northeast section of Fairbanks. They helped the landlord build dikes with sandbags and loose dirt. By 2400 hours August 14, the predicted time of the crest, the water was still confined to the street, and the family went peacefully to bed. Several hours later, they were awakened by the sound of water running down the basement stairway. With a few of their possessions, the family was soon driving away through deep water seeking an exit from town, but the exits were blocked by stalled vehicles. The man then tried to find a high spot to park his car, but it also stalled. They waited on top of their car until someone in a boat came by, but only the wife and two children could be taken toward the north side of town. They later found their way to the University of Alaska campus, which stands on a hill about 3 miles northwest of Fair-

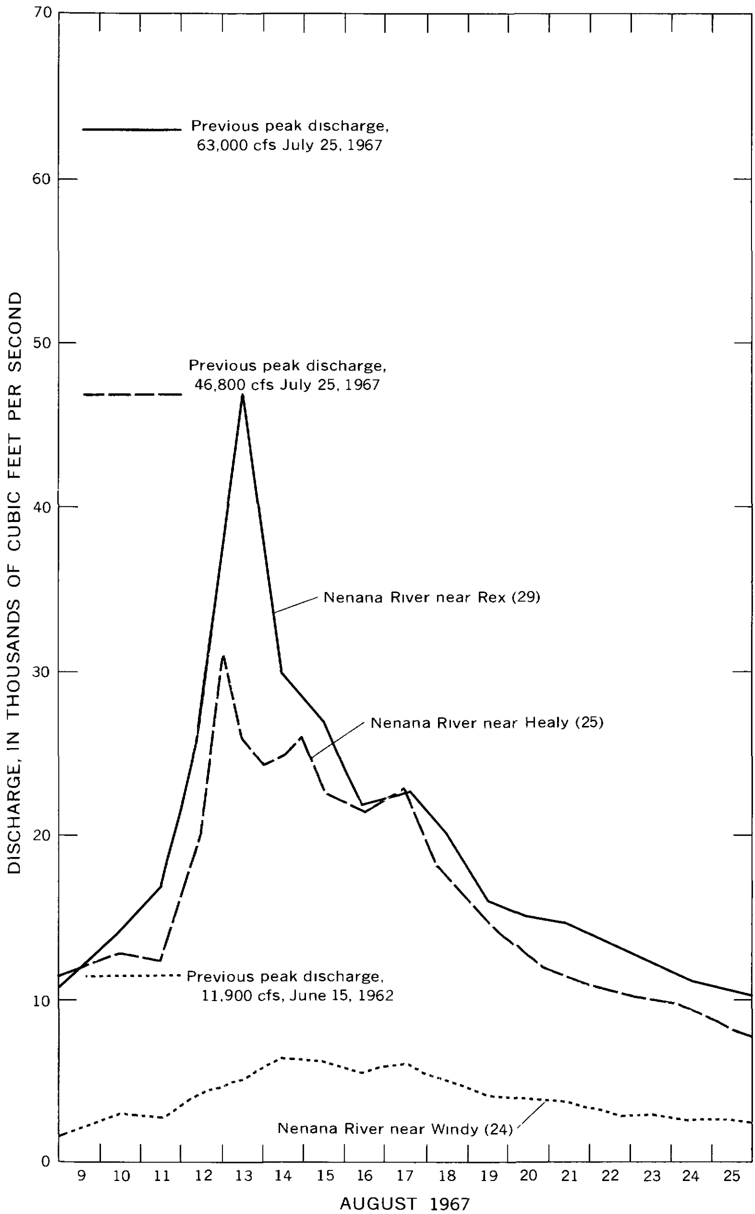


FIGURE 25.—Discharge at selected gaging stations on Nenana River, August 9–25. Numbers in parentheses conform with those in table 7 and figure 1.

banks. Later the man was rescued and was taken to the south end of town. Several days passed before the family was reunited.

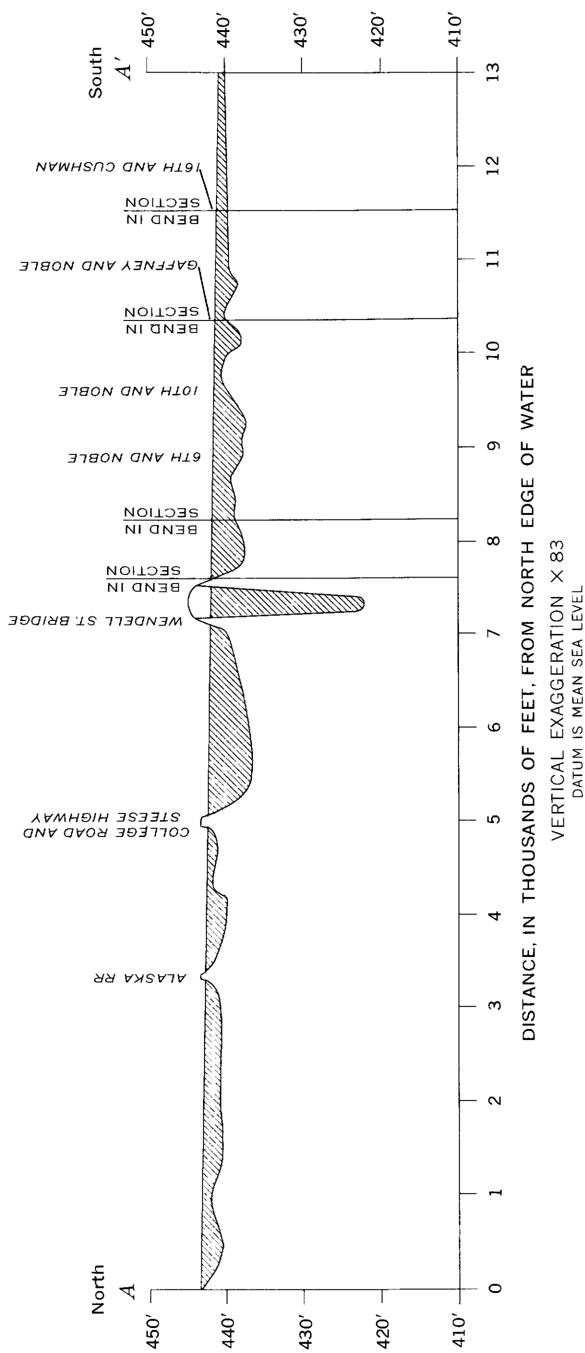


FIGURE 26.—Cross section of Chena River flood plain at Fairbanks showing water-surface elevation, August 15. See figure 30 for location.

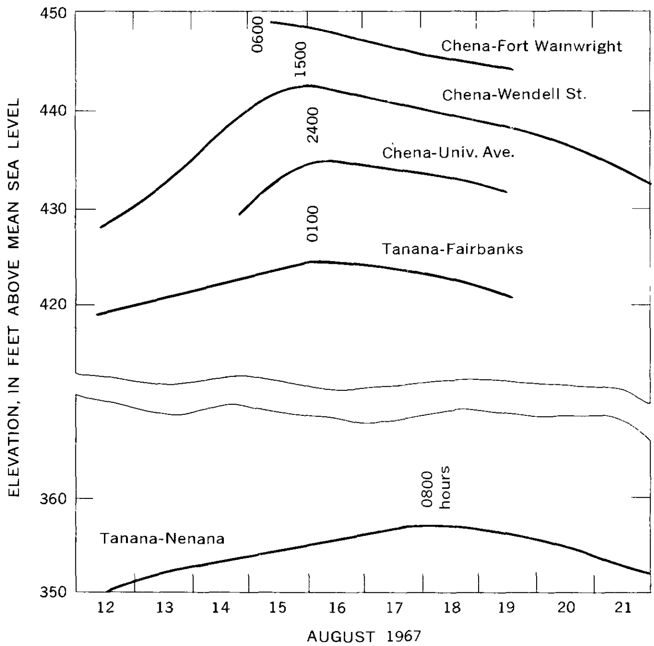


FIGURE 27.—Flood-stage hydrographs for Chena and Tanana Rivers at Fairbanks and Nenana, August 12–21.

Certainly the large number of private boats in Fairbanks prevented a larger loss of life than the three reported drownings. Fairbanks was fortunate, too, that a large number of tracked vehicles, trucks, and helicopters were available from nearby Fort Wainwright and Eielson Air Force Base and were used in rescue operations.

Damage-survey teams later found saturated underground electrical installations, silt-clogged sewers, undermined and caved building foundations, imploded basement walls and floor slabs, saturated and warped wood-frame buildings, eroded road subgrades and bridge abutments, well-water pollution, collapsed cesspools, inundated automobiles, saturated business inventory, deposition of silt in yards, and many other kinds of damage.

Foundation failures were the most costly damage related to the high ground-water table. Most failures were caused by too early pumping of basements, before the ground water had lowered sufficiently to reduce hydrostatic loading on the basement walls and floor slabs. Some of the larger buildings had structural damage resulting from settlement due to loss of bearing capacity in the wetted soils.

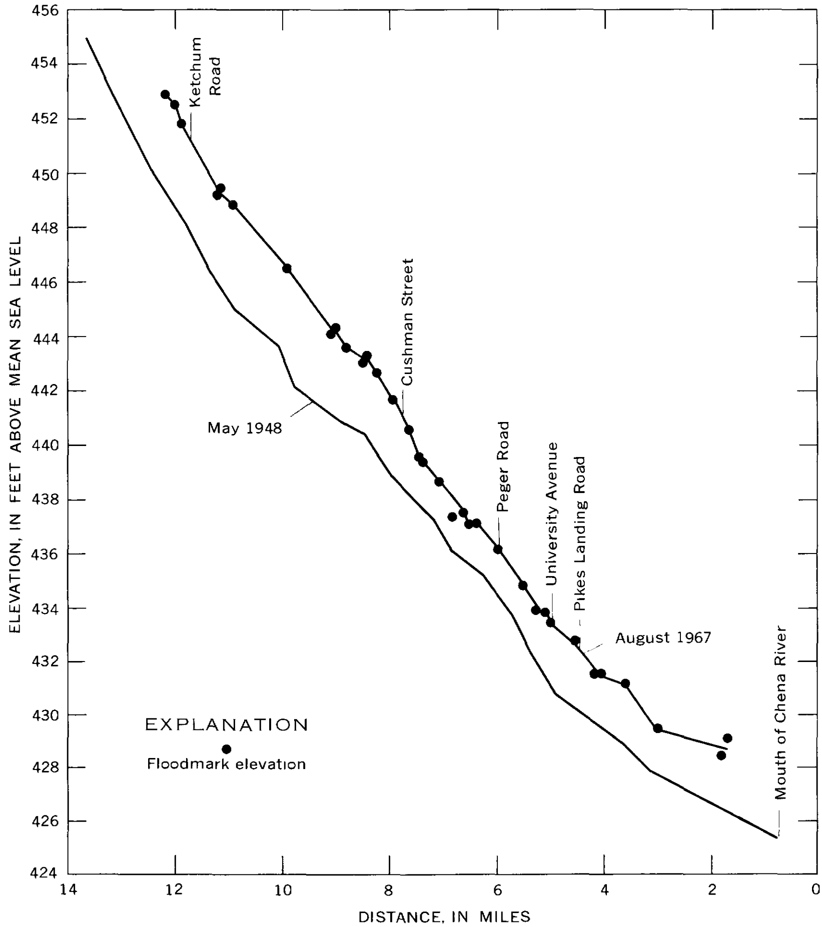


FIGURE 28.—Flood-crest profiles of Chena River at Fairbanks, 1948 and 1967 (1948 profile adapted from U.S. Army Corps of Engineers data).

The Fairbanks municipal water-supply system remained usable through the flood; the system never lost its pressure. As many as 6,500 people were evacuated to the University of Alaska campus. There a determined effort by a crowd of refugee volunteers saved an electrical power and heat-generating plant owned by the University. This plant, which is at the toe of the University hill and on the flood plain, was diked off from the floodwater by handwork which continued for most of one night. Fuel oil and gasoline tanks popped out of the ground or were emptied when the fuel floated on the floodwater. The floodwater surface was covered in places

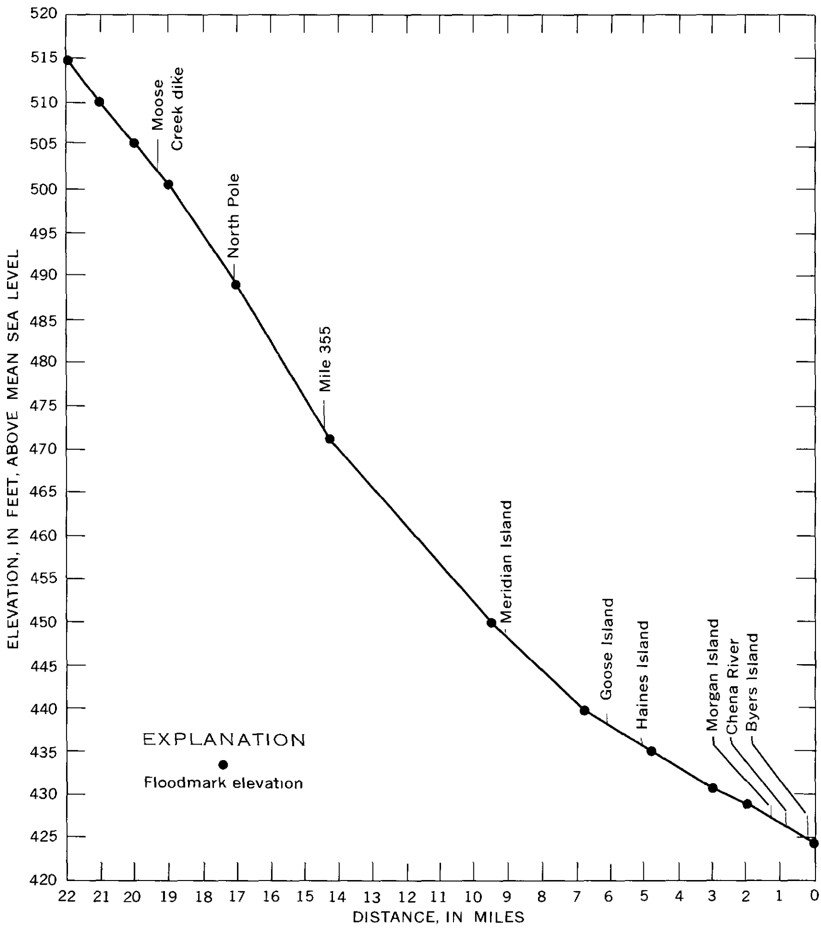


FIGURE 29.—Flood-crest profile of Tanana River near Fairbanks, August 15.

by films of oil and gasoline. Fire was a serious threat, but fortunately, only a few small fires occurred.

The Chena River was above flood stage for a week, and some low-lying areas required an additional week or more to be drained of floodwater. Residents then faced the difficult task of cleaning up and preparing for the harsh winter season. For weeks the streets were piled with flood-destroyed possessions and business stocks awaiting cleanup truck crews. This was a time of hard work, but universally high spirits characterized the hardy people of Fairbanks. When winter arrived, they were prepared.

The situation at Nenana was much the same. The community of Nenana occupies a small area on the Tanana River flood plain.

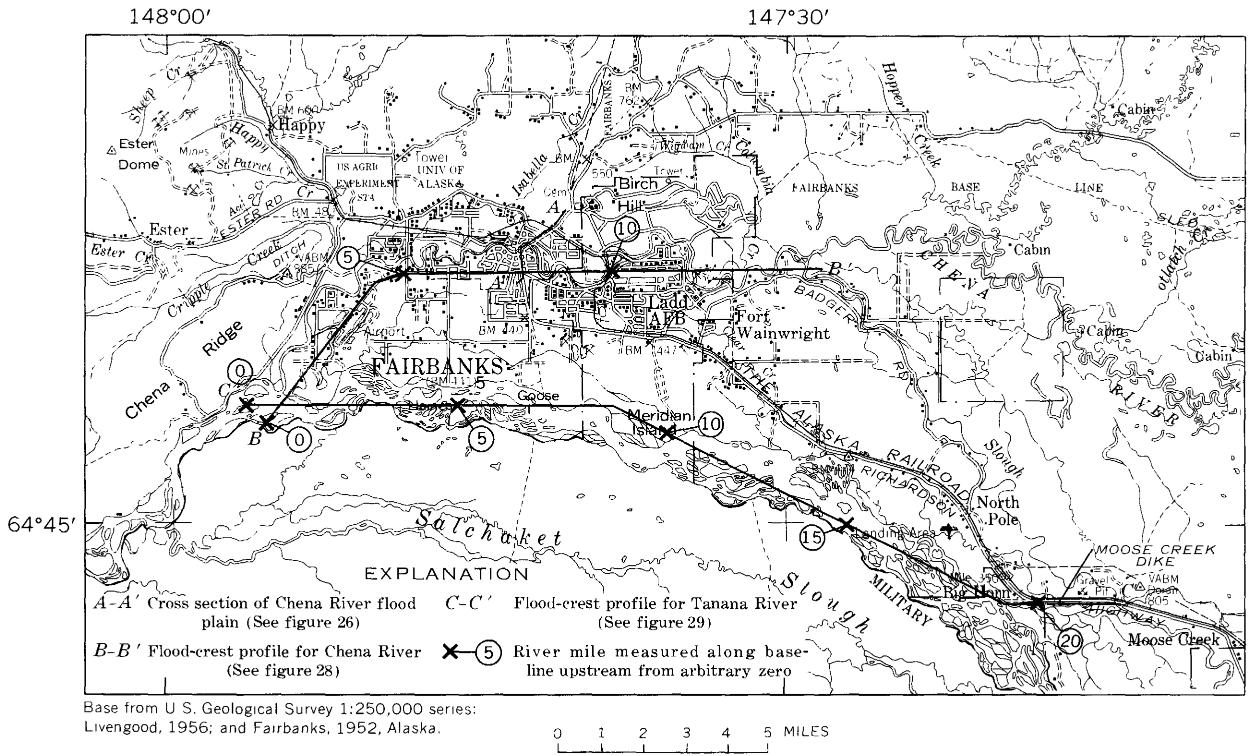


FIGURE 30.—Index to location of cross section and profiles.

The August 1967 flood on the Tanana River inundated Nenana for 10 days to an average depth of 6 feet. The entire town was evacuated.

Flood damage at Fairbanks and Nenana is summarized in tables 3 and 4, respectively.

TABLE 3.—*Summary of flood damage at Fairbanks*
[Information furnished by U.S. Army Corps of Engineers, 1968]

Category	Total
Private and commercial sector	$75,230,000
Utilities	1,633,000
Public buildings	1,680,000
Transportation	529,000
Debris cleanup	1,037,000
Miscellaneous	4,000,000
Total	84,109,000

TABLE 4.—*Summary of flood damage at Nenana*
[Information furnished by U.S. Army Corps of Engineers, 1968]

Category	Total
Residential buildings	$346,000
Business buildings	160,000
Business loss	90,000
Municipal building	62,000
Tax-exempt building	19,000
School	200,000
Street damage	3,000
Cleanup	90,000
Relief and rescue work	30,000
Total	1,000,000

FLOOD FREQUENCY

The probable-return frequency (recurrence interval) for a flood of a specific magnitude can be determined by analysis of flood records for gaging stations. Regional flood characteristics are derived from a statistical study of flood experience on a number of streams. The reliability of calculated return frequencies may vary with the areal coverage and number of years of flood records on which they are based. Generally, in Alaska, a fair degree of confidence is indicated for recurrence intervals as great as 50 years; extension of curves beyond that period is not recommended. A flood having a recurrence interval of 50 years will be exceeded once in 50 years, on an average; in other words, it has a 2-percent chance of occurring in any year.

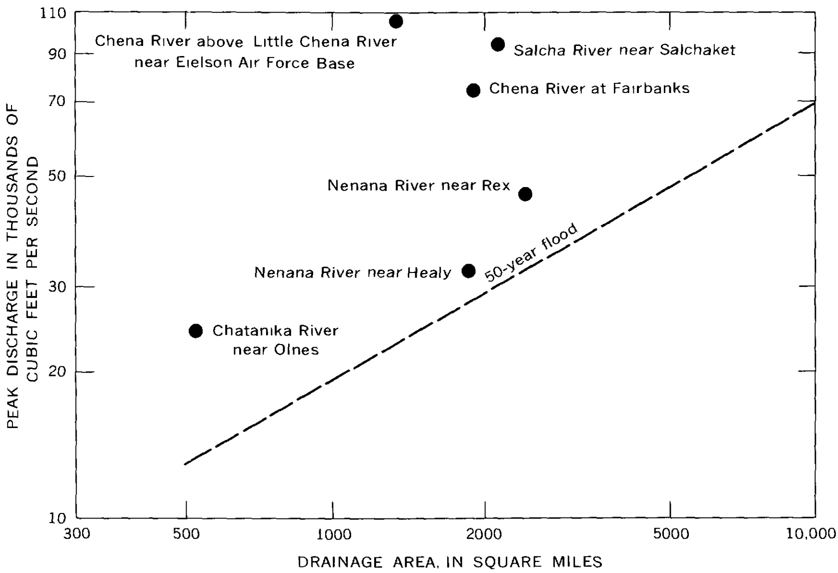


FIGURE 31.—Relation of August 1967 floods to 50-year floods in Tanana River basin.

Comparison of the peak discharge for a given flood with the probable 50–year flood provides an approximate measure of the severity of the flood. The floods of August 1967 were exceptionally high, particularly on the major streams draining the mountains north and east of Fairbanks.

Figure 31 shows the relation between the August 1967 floods and the 50-year floods for drainage areas in the Tanana River basin. The 50–year flood curve was defined by Berwick, Childers, and Kuentzel (1964, p. 11) for sites having drainage areas ranging from 500 to 10,000 square miles. Gaging-station records were insufficient or completely lacking to define flood-frequency characteristics for drainage basins smaller than 500 square miles or larger than 10,000 square miles in the Tanana River basin. For these reasons any extrapolation of the relation is not recommended. The length of individual gaging-station records used to define the flood-frequency characteristics was so short that definition of probability beyond the 50-year recurrence interval is not recommended. For the area north of the Tanana River basin, flood-frequency characteristics are not defined.

The peak discharge on the Chena River above Little Chena River was 105,000 cfs, which is more than four times the 50–year flood. The peak discharge of the Chena River at Fairbanks was 74,400 cfs, which is 2.6 times the 50-year flood.

Birch Creek, northeast of the Tanana River basin, is in a region where flood-frequency relations have not been defined. Assuming that the relation is similar to that in the Tanana River basin, the peak discharge of 84,000 cfs at Birch Creek near Circle is probably three times the magnitude of the 50-year flood. Floods greater than 50-year floods occurred over a wide area, but not at all points within that area.

Frequency of floods on small basins (those under 500 sq mi) is not known. In the headwaters of some major streams north and east of Fairbanks, numerous landslides indicate that small basins in higher elevations had exceptionally high floods during this storm.

EFFECT OF FLOOD ON GROUND-WATER CONDITIONS IN THE FAIRBANKS AREA

The flood-plain alluvium of the Tanana River valley consists of alternating lenses of sand, gravel, and silt (table 5). The alluv-

TABLE 5.—*Logs of selected test borings*
[Well numbers refer to those in table 6]

Constituent	Thickness (ft)	Depth (ft)
Well 1		
Sandy gravel, brown	3	3
Sand, fine, brown	5	8
Sand, fine to medium, brown	5	13
Sandy gravel, gray	5	18
Well 10		
Sandy silt	5	5
Sand, very fine	2	7
Sand, very fine, and gravel	14.5	21.5
Well 15		
Silt	3	3
Sand, fine	11	14
Permafrost at 14 feet	----	----
Well 22		
Road fill	3	3
Silt and silty gravel	5	8
Sandy gravel	15	23
Well 27		
Silt and sand, fine	8	8
Sand and gravel, medium	7	15
Permafrost at 15 feet	----	----
Well 30		
Silt	1	1
Gravel	.5	1.5
Silt, sand, and gravel	17	18.5
Sand and gravel	9	27.5
Well 34		
Road fill	2	2
Sandy silt and peat	6	8
Sand, very fine, and gravel	13.5	21.5
Well 36		
Silt	2	2
Sandy silt	6	8
Sand, very fine	4	12
Sand, very fine, and gravel	2	14
Sand, very fine	1	15
Permafrost at 15 feet	----	----
Well 37		
Silt, brown	3	3
Silty sand, fine, brown	5	8
Silty sand, brown	5	13
Sand, fine to medium, brown	5	18
Sand, medium to coarse, brown, and gravel	5	23

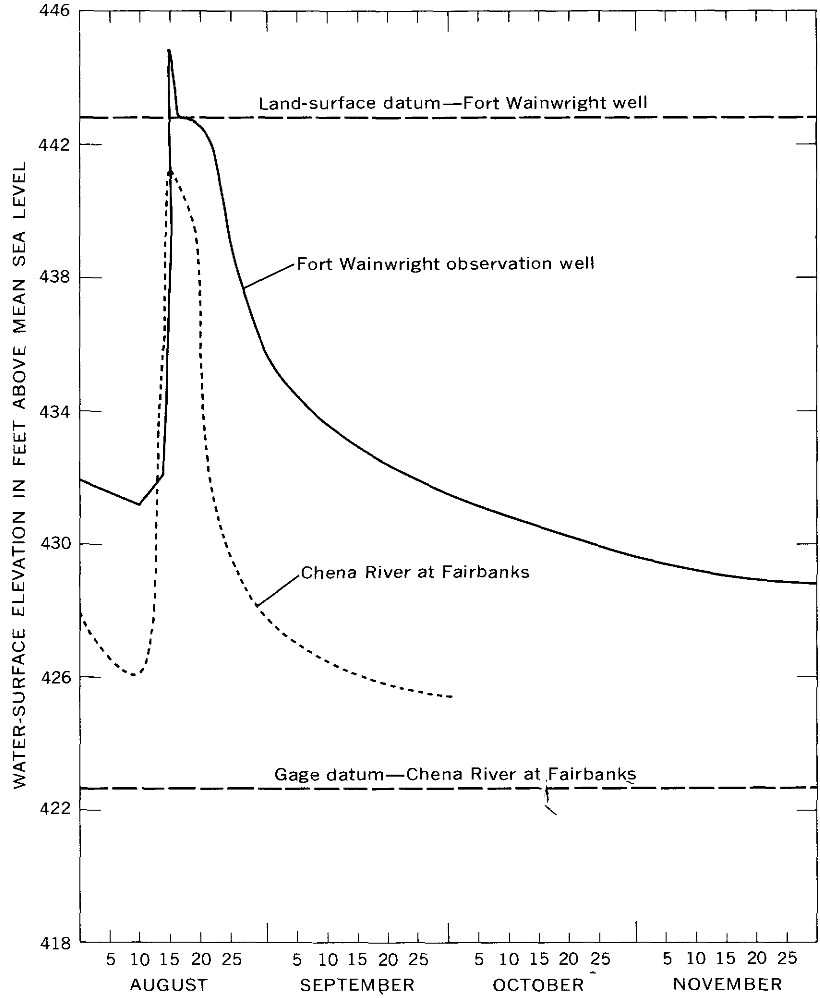


FIGURE 32.—Stage of Chena River at Wendell Street Bridge at Fairbanks related to observation well at Fort Wainwright.

ium is covered by swale and slough deposits of organic silt and silty sand ranging in thickness from 6 inches to about 15 feet. Permafrost is discontinuous beneath the flood plain; in many places it is absent, and in other places it extends from near the surface to depths of more than 200 feet.

Ground water in the alluvium occurs under water-table conditions. Depth to water ranges from about 1–20 feet below land surface. During 3 years of continuous record at Fort Wainwright, depth to water was approximately 14 feet.

The permeability of the alluvial sediments is high. Attempts to

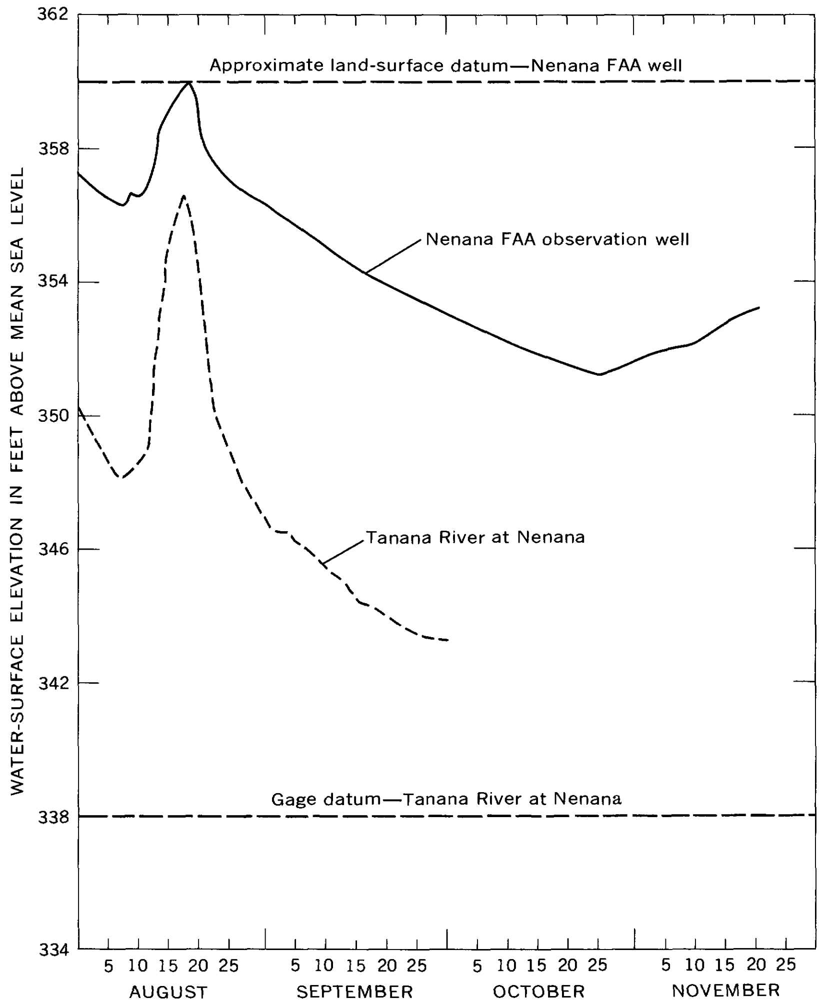


FIGURE 33.—Stage of Tanana River at Nenana related to Federal Aviation Administration observation well near Nenana.

measure transmissibility have been unsuccessful, mainly owing to the high permeability and lenticularity of the sediments (Cederstrom, 1963, p. 45). Transmissibility may be as high as several hundred thousand gallons per day per foot.

Water from wells less than 40 feet deep in the flood plain is commonly of poor quality. Iron is the most undesirable constituent, and hardness generally is high.

The ground-water level in Fairbanks rose almost as fast as the stage of the Chena River (fig. 32), and the ground-water level in Nenana rose almost as fast as the stage of the Tanana River (fig. 33). At the time of overbank flow, and consequent flood-plain inundation, ground water was at, or very near, the surface. As the floodwater receded, the ground-water level lowered at a rate similar to that of the river (figs. 32, 33). Subsurface drainage was most restricted in areas underlain by surficial silt deposits or by permafrost at shallow depth.

Average rates of ground-water decline in Fairbanks were 0.28 feet per day from August 16 to August 31, 0.14 feet per day from September 1 to September 16, and 0.09 feet per day from September 16 to October 1. Recession hydrographs for selected wells are shown in figure 34.

At the beginning of September, the major directions of ground-water flow were northwesterly from the Tanana River and southeasterly from the hills north of Fairbanks (fig. 35). The ground

TABLE 6.—*Record of test borings and quality of water*

Well (figs. 35, 36)	Depth of well below land surface (ft)	Measuring point		Depth to water level below measuring point (ft)	Date of measurement (1967)	Quality of water		
		Distance above land surface (ft)	Elevation above mean sea level (ft)			Temperature (°C)	Specific conductance (micromhos at 25°C)	Iron (mg/l)
1	18	0	431.34	4.26	9–1	2	635	5.32
2	42.5	0	430.04	6.19	9–1	2	464	11.61
3	12	1.4	432.17	7.40	9–1	7	456	2.39
4	23	1.5	430.61	7.89	9–1	3	398	3.58
5	23	1.0	430.87	8.55	9–1	2	352	4.80
6	21.5	4.0	435.10	13.26	9–1	2	284	6.64
7	15	1.5	432.89	6.85	9–1	2	928	10.39
8	26	2.0	432.24	8.37	9–1	1	339	3.75
9	14	1.0	430.76	3.30	9–1	2	383	1.76
10	21.5	3.0	432.90	5.49	9–1	2	337	8.35
11	26.5	2.5	431.40	3.40	9–1	2	400	4.99
12	24	3.5	432.29	5.05	9–1	1	504	8.26
13	26.5	3.0	433.96	8.48	9–1	2	514	8.26
14	26.5	2.5	429.34	6.53	9–1	1	332	8.22
15	14	1.0	426.31	3.46	9–1	6	411	2.82
16	26.5	3.0	431.40	8.82	9–1	3	370	8.39
17	36.5	2.5	426.38	4.90	9–1	1	361	8.41
18	8	3.5	435.65	4.09	9–1	------	------	------
19	18	1.5	433.71	4.10	9–1	------	395	8.26
20	23	1.5	435.50	4.98	9–1	------	352	8.84
21	18	0	434.20	3.17	9–1	4	611	8.82
22	23	2.0	435.67	7.97	9–1	1	437	3.43
23	18	1.5	436.50	4.39	9–1	2	542	8.90
24	23	1.0	436.42	8.82	9–1	2	325	8.98
25	18	0.5	436.28	6.78	9–1	3	650	1.00
26	23	3.5	438.08	6.56	9–1	------	867	8.77
27	15	2.5	434.18	3.21	9–1	1	361	7.15
28	25	2.0	436.01	2.95	9–1	2	398	8.59
29	23	1.5	438.37	7.10	9–1	2	495	8.82
30	27.5	1.0	438.39	6.60	9–1	1	712	3.11
31	24	2.5	441.58	10.59	9–1	2	559	8.59
32	25.5	2.0	441.17	5.76	9–1	1	341	8.65
33	15.5	2.0	438.51	2.57	9–1	------	------	------
34	21.5	4.5	442.11	5.58	9–1	3	395	8.94
35	21.5	2.5	443.27	6.72	9–1	7	260	3.02
36	15	1.5	439.49	5.96	9–1	4	792	2.70
37	23	1.0	436.09	4.43	9–1	3	535	8.94
38	13	1.0	437.52	4.75	9–1	------	1,110	8.57
39	18	0	------	7.47	9–2	1	438	8.47
40	21.5	3.0	446.26	6.14	9–2	1	427	8.80
41	118	1.5	444.31	8.70	9–1	------	------	------

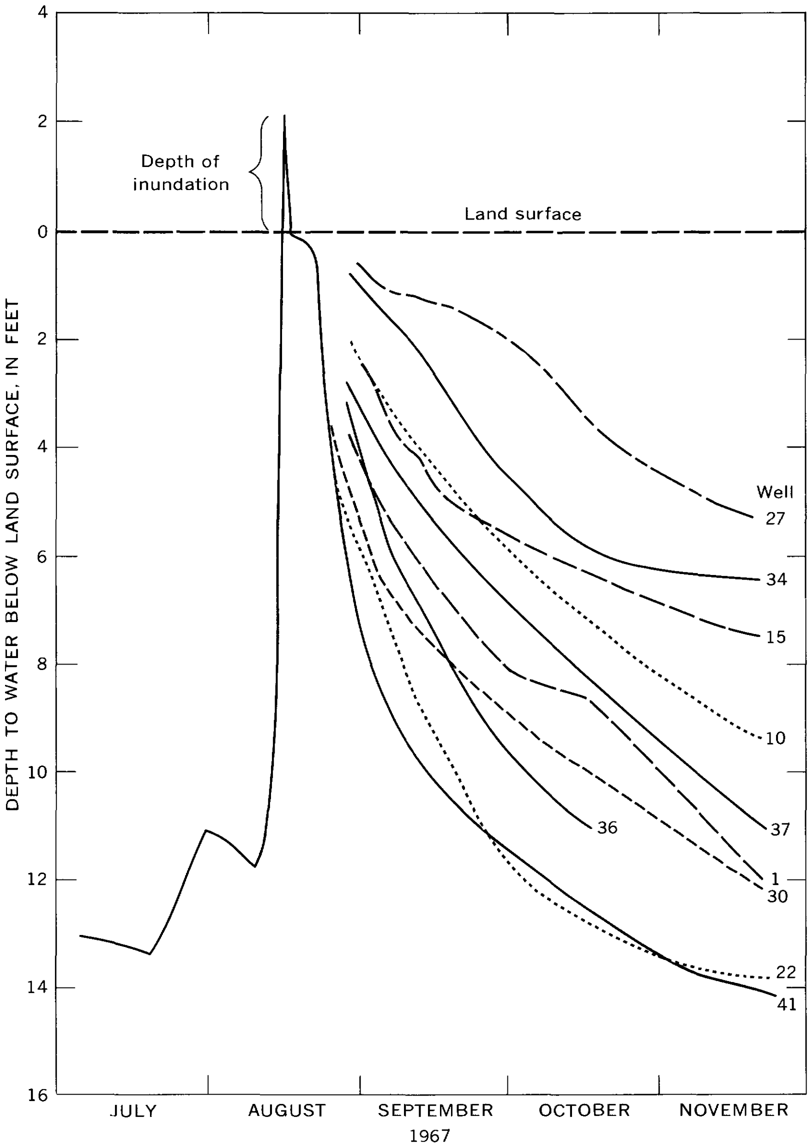


FIGURE 34.—Selected ground-water recession curves in Fairbanks area. Numbers refer to those in table 6.

water was discharged to the Chena River and the topographic low area between the Chena and Tanana Rivers. A ground-water mound was formed south of, and parallel to, the road from Fairbanks to the airport. Damage and inconvenience caused by the

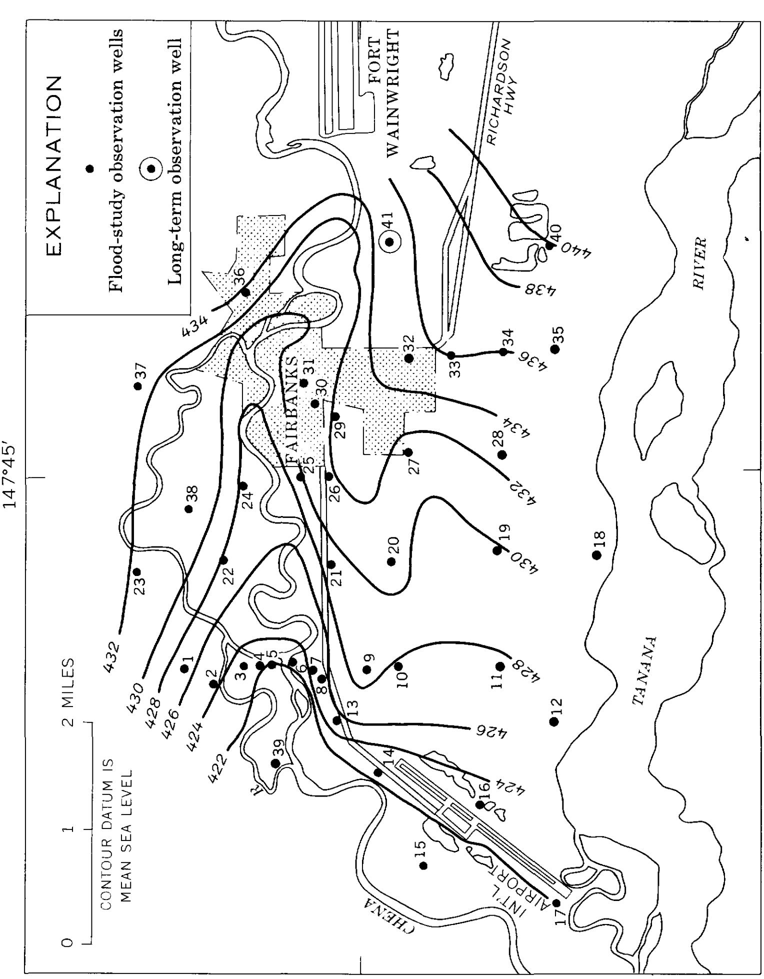


FIGURE 35.—Elevation of water table, in feet, September 1. Well numbers refer to those in table 6.

high-water table were most intense in the area of the ground-water mound; some basements could not be pumped dry until September 15. The water level in the Fort Wainwright observation well (well 41, fig. 34) had returned to seasonal normal by mid-November, and figure 36 shows the ground-water flow pattern at that time.

Bacteriological contamination of shallow domestic wells was reported to be a result of the flooding. However, the meager pre-flood data indicate there was little change in the mineral character of the shallow ground water. Water samples taken after the flood showed conductivity and iron content (table 6) similar to pre-flood conditions. These data seem to indicate that the low-mineralized surface water entering the flood-plain aquifer did not significantly flush or dilute the more highly mineralized ground water.

PLANNING FOR FUTURE FLOODS

The floods of August 1967 in east-central Alaska demonstrated the need to plan for future floods. Although Fairbanks, Nenana, and other communities affected by the floods have histories of damaging floods, few people were adequately prepared for this one. Severe structural damage and huge losses of personal possessions revealed the vulnerability of the communities to floods. Structural designs—residential, commercial, and public utility—were inadequate in various ways. Knowledge of flood inundation probability was lacking, and even immediate flood forecasting was dependent on guessing. All these inadequacies are now considered essential subjects in planning for future floods.

People at Fairbanks intend to continue inhabiting the flood plain as before, and increased construction is likely there. Building designers should consider flood probability and then design buildings to cope with whatever size flood they choose. Landfill to raise structures above depths of inundation is one method of coping with floods, and floodproofing structures is another. Flood-plain zoning might be used to guide future construction. Plans by the U.S. Army Corps of Engineers (1968) for flood-control projects are scheduled for early approval. A currently proposed plan features a levee system along the Tanana River and reservoir storage on the Chena and Little Chena Rivers. This plan would provide protection for Fairbanks from a design flood of 250,000 cfs on the Tanana River and 85,000 cfs under present conditions on the Chena River.

A flood of much smaller magnitude than the proposed project

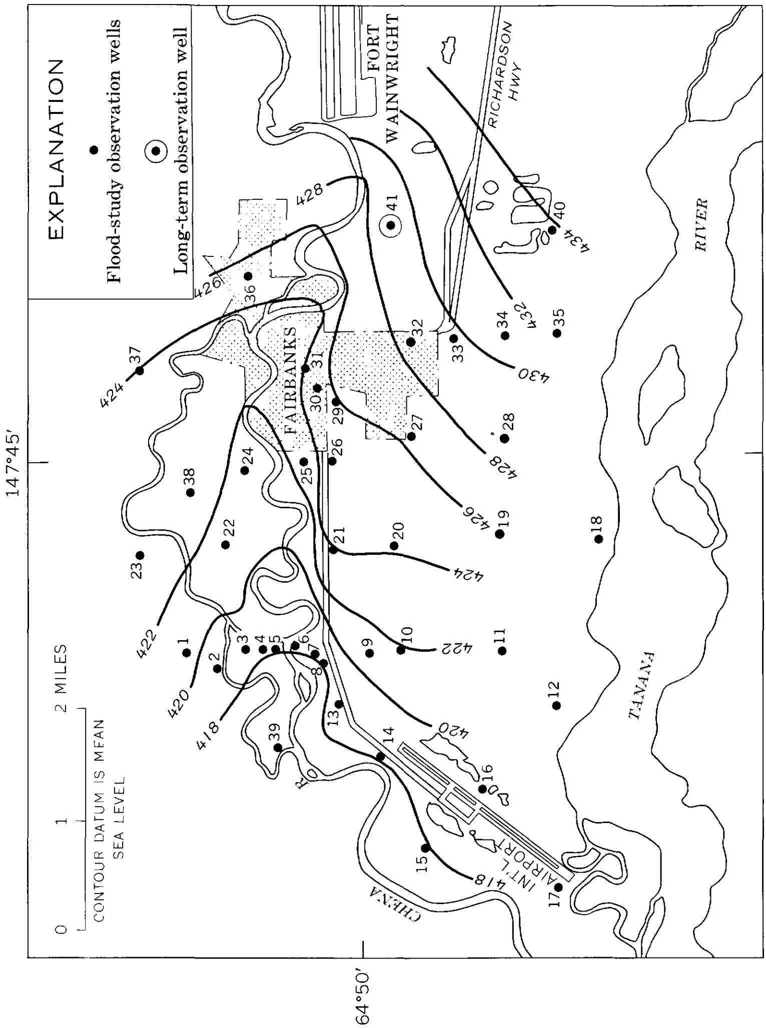


FIGURE 36.—Elevation of water table, in feet, November 21. Well numbers refer to those in table 6.

design flood could cause a high ground-water table in flood-plain deposits and damage to underground structures and facilities. Further, flood-control structures that confine high water within the channels of the Chena and Tanana Rivers would not completely inhibit the rise of ground water in flood-plain deposits.

The future design of foundations of structures subject to high water-table conditions should allow for decrease in bearing capacity. The rates of ground-water recession after the 1967 flood would not necessarily apply to future flood conditions, but should provide some basis for planning the pumping of inundated basements.

Although the community of Nenana considered relocation to higher ground at a different site in the vicinity, the citizens decided to remain at the present site. Residents of Nenana are inured to flood hardships and apparently prefer flooding at times to giving up their community and way of life. The U.S. Army Corps of Engineers (1968) proposed a solution to Nenana's flood problem and certain other socioeconomic problems. The proposal requires coordinated participation by several agencies in a joint flood-protection urban-development plan. Under the plan, the Corps of Engineers would build a landfill. The fill would accommodate a reconstructed town at the present site with room for expansion. The Department of Housing and Urban Development and other agencies would then undertake an urban renewal project on top of the landfill.

Many residents of Fairbanks expressed concern because they were not warned of the 1967 flood beforehand. They felt that at least some government agency or official should have been able to warn the community in time to save personal possessions and to allow orderly evacuation to safety. Few had more regrets at being unable to provide such warning than those in government who might have been expected to do so. The fact is that sufficient data did not exist to make this warning possible. An adequate warning system for a flood of this magnitude did not exist prior to the flood at Fairbanks. But with the flood came a keen public awareness of the importance of such a warning system. As a result, three agencies (the U.S. Weather Bureau, which is the official flood-forecast agency of the Federal Government; the U.S. Army Corps of Engineers, which is responsible for providing flood control; and the U.S. Geological Survey, which is the water-resources information agency) agreed to undertake construction and operation of a flood-warning system for the Fairbanks and Nenana areas. Six river-gaging stations were constructed to provide instantaneous information to a flood-forecast center. This system should make possible reliable flood warning at Fairbanks and Nenana in time to minimize personal losses. The system began operation before the 1968 flood season.

The flood behavior of streams in east-central Alaska is poorly understood. Not only is knowledge of flood probability at stream sites in the area indefinite, but the hydraulic response of stream channels, including flood plains, to given flood discharges is not well known. It is in this area of study that the Geological Survey in cooperation with the Corps of Engineers and the State of Alaska, Department of Highways, is working to improve understanding. An initial attempt to define flood probability in east-central Alaska (Berwick and others, 1964, p. 11) was based on short records at seven stream-gaging stations in the area.

Recognizing the lack of flood information and the importance of such information to design engineers, the State of Alaska, Department of Highways, joined the Geological Survey in 1963 in a cooperative program to obtain a record of annual peak discharges at a network of sites throughout the State including 36 in east-central Alaska. When a statistically reliable period of record is available at these sites, a thorough analysis should improve understanding of regional flood-frequency relations.

The floods at Fairbanks provided Geological Survey engineers with an opportunity to document the effects of flooding throughout the occupied flood plain. The result is a flood inundation map and an accompanying description of this rare flood (Childers and Meckel, 1967). The information therein should be useful for any planning and design in the area. A copy of the flood map is enclosed as plate 1 in this report.

The disastrous nature of this flood, even though in a sparsely inhabited area, points to the urgency for flood planning. The potential for disaster is present in flood plains not only along the Chena and Tanana Rivers but also along any stream.

Valuable information for flood-plain planning is available in publications of the U.S. Government. One publication (Bue, 1967) gives information on the nature of flood problems and describes flood-plain regulation as a means of solution. Another publication (Wiitala and others, 1961) is a flood-plain planning manual and was prepared cooperatively by the U.S. Geological Survey and the Commonwealth of Pennsylvania to help planners solve flood problems.

DATA COLLECTION METHODS

Discharge records at gaging stations are determined by the measurements of stage and discharge, which enable definition of a stage-discharge relation. The record of stage is generally obtained by a continuous water-stage recorder or by a local observer. The stage-discharge relation or rating, from which discharge can be calculated for any given stage, is usually defined by current-meter measurements made throughout the range in stage experienced.

Because flood stages occur infrequently, the stage-discharge relation may have to be extended above the highest current-meter measurement. Short extensions can be based upon logarithmic plotting, velocity-area studies, or the use of other hydraulic or hydrologic principles. When rare flood stages occur, it may be impossible to obtain current-meter measurements at some sites because of washouts, floating debris, and very short duration of peak flow.

At sites where the maximum discharge was not defined by current-meter measurements or a short extension of the stage-discharge relation, it was determined by slope-area, contracted-opening, culvert, or other types of indirect measurements. They are indirect because channel geometry and high-water profiles are obtained by field surveys subsequent to the passage of the peak discharge. Indirect measurement methods used by the Geological Survey are described by Benson and Dalrymple (1967); Dalrymple and Benson (1967); Bodhaine (1968); and Matthai (1968).

Some stage data were obtained by persons inadvertently stranded in flooded areas. A Fairbanks resident, John Huber, only vaguely familiar with the value of flood-stage data, was stranded at the Salcha River near Salchaket gaging station. The water-stage recorder had been removed from the site by the Geological Survey personnel during the rising stage to prevent its loss. John Huber obtained frequent stage measurements of the Salcha River during the rise, crest, and recession until he was able to continue his journey to Fairbanks. These invaluable data were corrected to gage datum and used to formulate the discharge hydrograph for the Salcha River.

Forty exploratory wells were augered by two Geological Survey auger rigs. The wells were cased with 2–inch pipe and were screened. All wells were augered below the anticipated normal water table and finished in a relatively permeable aquifer. The lithology of all the auger wells was logged, and water-quality samples were taken from the developed wells. Water-level measurements commenced upon completion of the wells, and the frequency of measurement decreased as the water receded. Elevation of the measuring point was determined by direct leveling. Continuous water-level measurements are obtained from wells at Fort Wainwright near Fairbanks and at the Federal Aviation Administration near Nenana.

SUMMARY OF PEAK STAGES AND DISCHARGES

Maximum floodflows at stream-gaging stations and other sites on streams in the area covered by this report are summarized in table 7. The reference number is the same as that designating the site in figure 1 and will aid in identifying the location at which discharge was determined. As an added means of identification, each gaging station and partial-record station is listed with its permanent station number in the same downstream order used in the annual streamflow reports of the Geological Survey. No distinction is made between partial-record stations and continuous-record gaging stations. Numbers are not consecutive, as gaps were left in the series to allow for numbering of new stations that may be established.

In table 7, under "Period of Record," is shown the period of known floods prior to August 1967. This period does not necessarily correspond to that in which continuous records of discharge were obtained, and for some stations the record extends back to an earlier date. More than one period of known floods is shown for some stations. If the maximum flood previously known occurred during 1967, the month is also shown in the "Year" column.

EXPLANATION OF STATION DATA

The following station data give detailed information on stage and discharge at 47 stream-gaging stations, crest-stage stations, and miscellaneous sites during the floods of August 1967. Much of the information is in addition to records usually published in annual streamflow reports of the Geological Survey.

The stations are numbered and arranged in downstream order along the main stem, and all stations on a tributary are inserted in corresponding order following the order in which the tributaries enter the main stream. The first part of the reference number preceding the name of the gaging station is the same as that used on plate 1 and will aid in locating the site.

In general, the station data consist of a description of the station, a table showing daily mean discharge for August 1967, and for a few stations, a table of stage and discharge.

The description of the gaging station includes location, datum, and type of gage; area of drainage basin; details of gage-height and discharge records; and miscellaneous remarks. The section on discharge record briefly explains methods used to define the

TABLE 7.—*Summary of flood stages and discharges in Yukon River basin*

No.	Permanent station	Stream and place of determination	Drainage area (sq mi)	Period of record	Maximum flood previously known: Year	Gage height (ft)	Discharge: Cfs	Discharge: Cfs per sq mi	Maximum during August 1967: Day	Gage height (ft)	Discharge: Cfs	Discharge: Cfs per sq mi
1	15–3560	Yukon River at Eagle	113,500	1911–13, 1950–67	1957	33.01	561,000	4.9	3	18.6	206,000	1.8
2	3890	Porcupine River near Fort Yukon	29,500	1962–67	June 1967	27.12	171,000	5.8	17	22.67	107,000	3.6
3	3895	Chandalar River near Venetie	9,330	1963–67	1966	19.08	55,400	5.9	3	14.77	12,900	1.4
4	3939	North Fork Twelvemile Creek near Miller House	23.2	1963–67	1966	11.16	110	4.7	14	14.40	1,710	73.7
5	4385	Bedrock Creek near Miller House	9.94	1964–67	1964	15.25	267	26.8	14	15.73	422	42.5
6	4398	Boulder Creek near Central	31.5	1963–67	1964	12.70	707	22.4	13	7.5	1,150	36.5
7	----	Big Mosquito Creek near Central	3.51	-------	----	-----	------	----	13	-----	142	40.5
8	----	Quartz Creek near Central	17.2	-------	------	-----	------	----	13	-----	375	21.8
9	4460	Birch Creek near Circle	2,150	-------	------	-----	------	----	14	-----	84,000	39.1
10	4680	Yukon River at Rampart	199,400	1955–67	1964	-----	950,000	4.8	21	30.6	380,000	1.9
11	4700	Chisana River at Northway Junction	3,280	1949–67	1964	13.18	[1]12,000	3.7	1	10.07	6,710	2.0
12	4760	Tanana River near Tanacross	8,550	1953–67	1962	11.65	39,100	4.6	9	9.75	28,400	3.3
13	4780	Tanana River at Big Delta	13,500	1948–52, 1953–57	1949	23.57	62,800	4.6	17 or 18	-----	60,000+	----
14	4800	Banner Creek at Richardson	20.2	1963–67	1966	13.55	732	36.2	13	12.15	352	17.4
15	4840	Salcha River near Salchaket	2,170	1948–67	1956	16.13	36,500	16.8	14	20.50	97,000	44.7
16	----	Little Salcha River near Salchaket	67.4	-------	------	-----	------	----	13	-----	1,900	28.2
17	----	Potlatch Creek near Two Rivers	3.49	-------	------	-----	------	----	12	-----	40	11.5
18	----	Chena River above Little Chena River near Eielson Air Force Base	1,370	-------	------	-----	------	----	13 or 14	-----	105,000	76.6
19	5110	Little Chena River near Fairbanks	356	1967	May 1967	21.35	2,160	6.1	13	31.95	17,000	47.7
20	----	Steele Creek near Fairbanks	10.7	-------	------	-----	------	----	12	-----	340	31.8
21	5140	Chena River at Fairbanks	1,980	1947–67	1948	[2]14.17	24,200	12.2	15	18.82	74,400	37.6
22	----	Isabella Creek near Fairbanks	4.56	-------	------	-----	------	----	12	-----	160	35.1
23	5155	Tanana River at Nenana	27,500	1962–67	July 1967	15.0	122,000	4.4	18	18.90	186,000	6.8
24	5160	Nenana River near Windy	710	1950–56, 1958–67	1962	9.84	11,900	16.8	14	6.68	6,880	9.7
25	5180	Nenana River near Healy	1,910	1950–67	July 1967	13.40	46,800	24.5	12	11.65	31,100	16.3
26	5181	Little Panguingue Creek near Lignite	3.44	1965–67	1965	13.5	119	34.6	12	14.13	151	44.2
27	5182	Rock Creek near Ferry	8.17	1964–67	1965	11.34	([3])	----	12	17.40	515	63.0
28	5182.5	Birch Creek near Rex	4.10	1964–67	1965	11.43	183	44.6	12	14.74	464	113
29	5183	Nenana River near Rex	2,450	1964–67	July 1967	14.85	63,000	25.7	13	13.7	46,900	19.1
30	5183.5	Teklanika River near Lignite	489	1964–67	July 1967	12.51	33,100	67.7	13	10.17	16,400	33.5
31	5184	Tanana River tributary near Nenana	.58	1965–67	May 1967	12.01	17.7	30.5	12 or 13	11.26	7.8	13.4
32	----	Tolovana River near Livengood	140	-------	------	-----	------	----	12 or 13	-----	12,000	85.7
33	5190	Bridge Creek near Livengood	12.6	1963–67	1964	17.41	1,070	85.0	12 or 13	17.65	788	62.5
34	----	West Fork Tolovana River near Livengood	291	-------	------	-----	------	----	13	-----	2,290	7.9
35	5192	Tolovana River tributary near Livengood	7.81	1964–67	1964	12.58	137	17.5	13	9.26	42.8	5.5
36	5200	Idaho Creek near Miller House	5.31	1963–67	1964	16.0	813	65.4	12–14	[2]28.96	626	118

TABLE 7.—*Summary of flood stages and discharges in Yukon River basin*—Continued

No.	Permanent station	Stream and place of determination	Drainage area (sq mi)	Period of record	Maximum flood previously known: Year	Gage height (ft)	Discharge: Cfs	Cfs per sq mi	Maximum during August 1967: Day	Gage height (ft)	Discharge: Cfs	Cfs per sq mi
37	15-5300	Faith Creek near Chena Hot Springs	61.1	1863-67	1964	11.65	(3)	----	14	15.15	4,950	81.0
38	----	Chatanika River near Chatanika	244	-------	------	-----	------	----	13	-----	19,600	80.3
39	----	Chatanika River near Olnes	528	-------	------	-----	------	----	13-14	-----	25,000	47.3
40	----	Rose Creek near Fox	2.00	-------	------	-----	------	----	13	-----	104	52.0
41	----	Little Goldstream Creek near Nenana	40.8	-------	------	-----	------	----	12-14	-----	1,490	36.5
42	----	Tatalina River near Livengood	80.8	-------	------	-----	------	----	12-14	-----	3,560	44.1
43	5416	Globe Creek near Livengood	26.3	1964-67	July 1967	12.06	284	10.8	12	16.0	(3)	----
44	5416.5	Globe Creek tributary near Livengood	9.01	1963-67	1966	11.77	187	20.7	12	15.35	490	56.3
45	5418	Washington Creek near Fox	46.7	1963-67	1964	14.25	(3)	----	14	18.29	2,500	53.5
46	5646	Melozitna River near Ruby	2,693	1961-67	1962	9.40	28,200	10.5	17	8.69	24,000	8.9
47	5648	Yukon River at Ruby	259,000	1956-67	1964	(3)	970,000	3.7	22	27.6	624,000	2.4

[1]Observed.
[2]Datum change.
[3]Not determined.

stage-discharge relation over the range of stage that occurred during the floods, special methods used to obtain discharge, and conditions that may have affected the stage-discharge relation. Maximum stage and discharge are given for August 1967 and for the period of previous record.

The table of daily mean discharges gives data for August 1967. The period of daily discharge was chosen to show the relation of flood discharges to discharges of the preceding and the following periods. The table also shows monthly mean discharge and the volume of runoff, in inches and acre-feet, from the drainage area.

The table of stage and discharge at indicated times gives sufficient data so that hydrographs of stage and discharge can be drawn. The period of time covered is from prior to the start of the major rise to an arbitrary cutoff point on the recession and is not the same for all stations.

STATION DATA

YUKON RIVER BASIN

(1) 15–3560. YUKON RIVER AT EAGLE, ALASKA

Location.—Lat 64°47'30", long 141°12'00", on left bank at Eagle, 0.125 mile upstream from Mission Creek, 1.1 miles downstream from Castalia Creek, and 11 miles downstream from the Canadian boundary.

Drainage area.—113,500 sq mi, approximately.

Gage-height record.—Portable manometer read once daily. Elevation of gage is 750 ft (from topographic map).

Discharge record.—Stage-discharge relation defined by current-meter measurements.

Maxima.—August 1967: Discharge, 206,000 cfs Aug. 3 (gage height 18.6 ft).
1911–13, 1950 to July 1967: Discharge, 561,000 cfs May 30, 1957 (gage height, 33.01 ft, present datum), from rating curve extended above 250,000 cfs by logarithmic plotting.

[Mean discharge, in cubic feet per second, August 1967]

Day	Discharge	Day	Discharge	Day	Discharge
1	189,000	11	145,000	21	165,000
2	200,000	12	142,000	22	156,000
3	206,000	13	145,000	23	156,000
4	200,000	14	150,000	24	151,000
5	195,000	15	151,000	25	151,000
6	190,000	16	151,000	26	146,000
7	166,000	17	148,000	27	142,000
8	166,000	18	150,000	28	138,000
9	156,000	19	157,000	29	136,000
10	150,000	20	166,000	30	127,000
				31	125,000

Monthly mean discharge, in cubic feet per second	158,600
Runoff, in inches	1.61
Runoff, in acre-feet	9,750,000

(2) 15–3890. PORCUPINE RIVER NEAR FORT YUKON, ALASKA

Location.—Lat 66°59′35″, long 143°07′45″, on right bank 2,300 ft upstream from John Herberts village and 65 miles northeast of Fort Yukon.

Drainage area.—29,500 sq mi, approximately.

Gage-height record.—Water-stage recorder graph. Elevation of gage is 520 ft (from topographic map).

Discharge record.—Stage-discharge relation defined by current-meter measurements.

Maxima.—August 1967: Discharge, 107,000 cfs 1000 hours Aug. 17 (gage height, 22.67 ft).

1964 to July 1967: Discharge, 171,000 cfs June 6, 1967 (gage height, 27.12 ft).

[Mean discharge, in cubic feet per second, August 1967]

Day	Discharge	Day	Discharge	Day	Discharge
1	23,300	11	18,500	21	49,400
2	27,300	12	17,900	22	42,400
3	27,100	13	19,200	23	50,300
4	28,200	14	36,700	24	60,300
5	31,100	15	65,700	25	56,900
6	30,300	16	92,900	26	47,800
7	26,800	17	106,000	27	40,000
8	24,100	18	99,400	28	34,200
9	21,900	19	84,800	29	30,300
10	20,100	20	64,300	30	27,400
				31	25,400

Monthly mean discharge, in cubic feet per second	42,890
Runoff, in inches	1.95
Runoff, in acre-feet	2,637,000

(3) 15–3895. CHANDALAR RIVER NEAR VENETIE

Location.—Lat 67°06′00″, long 147°10′30″, on right bank 2 miles downstream from East Fork and 21.5 northwest of Venetie.

Drainage area.—9,330 sq mi, approximately.

Gage-height record.—Water-stage recorder graph. Elevation of gage is 750 ft (from topographic map).

Discharge record.—Stage-discharge relation defined by current-meter measurements.

Maxima.—August 1967: Discharge, 12,900 cfs 1500 hours, Aug. 3 (gage height, 14.77 ft, not peak of year).

1963 to July 1967: Discharge, 55,400 cfs about June 7, 1966 (gage height, 19.08 ft).

[Mean discharge, in cubic feet per second, August 1967]

Day	Discharge	Day	Discharge	Day	Discharge
1	5,510	11	5,580	21	7,890
2	8,810	12	5,820	22	10,200
3	12,300	13	5,760	23	9,640
4	10,600	14	8,930	24	8,650
5	7,930	15	4,850	25	8,250
6	6,600	16	4,460	26	9,100
7	6,100	17	4,350	27	9,500
8	6,000	18	4,610	28	8,930
9	5,820	19	4,970	29	8,130
10	5,720	20	6,600	30	7,410
				31	6,740

Monthly mean discharge, in cubic feet per second	7,283
Runoff, in inches	0.90
Rinof, in acre-feet	447,800

(4) 15–3939. NORTH FORK TWELVEMILE CREEK NEAR MILLER HOUSE, ALASKA

[Crest-stage station]

Location.—Lat 64°24′00″, long 145°44′20″, on right bank at mile 93.5 Steese Highway, and 17.5 miles southwest of Miller House.

Drainage area.—23.2 sq mi.

Gage-height record.—Crest stages only. Elevation of gage is 2,000 ft (from topographic map).

Discharge record.—Stage-discharge relation is defined by current-meter measurements below 40 cfs and by slope-area measurement at 1,710 cfs.

Maxima.—August 1967: Discharge, 1,710 cfs Aug. 14 (gage height, 14.40 ft, from high-water profile), by slope-area measurement.

1963 to July 1967: Discharge recorded, 110 cfs June 1966 (gage height, 11.16 ft).

(5) 15–4385. BEDROCK CREEK NEAR MILLER HOUSE, ALASKA

[Crest-stage station]

Location.—Lat 65°33′25″, long 145°05′15″, on left bank at mile 119 Steese Highway, and 8 miles west of Central.

Drainage area.—9.94 sq mi.

Gage-height record.—Crest stages only. Datum of gage is 1,427.65 ft above mean sea level.

Discharge record.—Stage-discharge relation defined by current-meter measurements below 40 cfs and by flow-through-culvert measurements above 260 cfs.

Maxima.—August 1967: Discharge, 422 cfs Aug. 14 (gage height, 15.73 ft, from high-water profile), by flow-through-culvert and flow-over-road measurements.

1964 to July 1967: Discharge, 267 cfs 1964 (gage height, 15.25 ft), by flow-through-culvert and flow-over-road measurements.

(6) 15–4398. BOULDER CREEK NEAR CENTRAL, ALASKA

Location.—Lat 65°34′10″, long 144°52′50″, in SW¼ sec. 29, T. 9 N., R. 14 E., on right downstream wingwall of bridge, at mile 125.3 on Steese Highway, 2.3 miles west of Central.

Drainage area.—31.5 sq mi.

Gage-height record.—Water-stage recorder graph and crest-stage gage, except Aug. 13–31, when graph was reconstructed from high-water marks. Elevation of gage is 1,060 ft (from topographic map).

Discharge record.—Stage-discharge relation defined by current-meter measurements below 70 cfs, by contracted-opening measurement at 707 cfs, and by slope-area measurement at 1,150 cfs.

Maxima.—August 1967: Discharge, 1,150 cfs Aug. 13 (gage height, 7.5 ft on crest-stage gage), by slope-area measurement.

1963 to July 1967: Discharge, 707 cfs July 1964 (gage height, 12.70 ft, site and datum then in use).

[Mean discharge, in cubic feet per second, August 1967]

Day	Discharge	Day	Discharge	Day	Discharge
1	7.7	11	16	21	85
2	6.9	12	216	22	70
3	5.6	13	600	23	55
4	5.1	14	500	24	50
5	4.0	15	300	25	45
6	3.8	16	250	26	40
7	3.4	17	200	27	35
8	3.0	18	160	28	32
9	3.8	19	130	29	28
10	7.2	20	100	30	26
				31	23

Monthly mean discharge, in cubic feet per second	97.1
Runoff, in inches	3.56
Runoff, in acre-feet	5,970

(7) BIG MOSQUITO CREEK NEAR CENTRAL, ALASKA
[Miscellaneous site]

Location.—Lat 65°36′10″, long 144°34′10″, in sec. 14, T. 9 N., R. 15 E., downstream from Steese Highway, 7 miles east of Central.

Drainage area.—3.51 sq mi.

Maximum.—August 1967: Discharge, 142 cfs Aug. 13, by slope-area measurement.

(8) QUARTZ CREEK NEAR CENTRAL, ALASKA
[Miscellaneous site]

Location.—Lat 65°37′30″, long 114°29′00″, in sec. 7, T. 9 N., R. 16 E., at bridge on Steese Highway, 1 mile above mouth, 10 miles east of Central, and 19 miles southwest of Circle.

Drainage area.—17.2 sq mi.

Maximum.—August 1967: Discharge, 375 cfs Aug. 13, by flow-through-culvert measurement.

(9) 15–4460. BIRCH CREEK NEAR CIRCLE, ALASKA
[Miscellaneous site]

Location.—Lat 65°43′, long 144°20′, at bridge on Steese Highway, 11 miles southwest of Circle.

Drainage area.—2,150 sq mi.

Maximum.—August 1967: Discharge, 84,000 cfs Aug. 14, total of contracted-opening and slope-conveyance measurements.

(10) 15–4680. YUKON RIVER AT RAMPART, ALASKA

Location.—Lat 65°30′25″, long 150°10′15″, on left bank at Rampart, 0.8 mile downstream from Squaw Creek, 1.25 miles downstream from Minook Creek, and 3½ miles upstream from Russian Creek.

Drainage area.—199,400 sq mi, approximately.

Gage-height record.—Staff gage read twice daily. Elevation of gage is 300 ft (from topographic map).

Discharge record.—Stage-discharge relation defined by current-meter measurements.

Maxima.—August 1967: Discharge, 380,000 cfs 0800 hours Aug. 21 (gage height, 30.6 ft).

1955 to July 1967: Discharge observed, 950,000 cfs June 15, 16, 1964; maximum gage height, 58.69 ft May 16, 1963, from floodmarks (ice jam).

[Mean discharge, in cubic feet per second, August 1967]

Day	Discharge	Day	Discharge	Day	Discharge
1	236,000	11	240,000	21	380,000
2	236,000	12	238,000	22	374,000
3	240,000	13	249,000	23	364,000
4	240,000	14	265,000	24	350,000
5	243,000	15	277,000	25	322,000
6	254,000	16	294,000	26	300,000
7	256,000	17	318,000	27	290,000
8	254,000	18	342,000	28	283,000
9	250,000	19	368,000	29	277,000
10	247,000	20	378,000	30	270,000
				31	261,000

Monthly mean discharge, in cubic feet per second	286,400
Runoff, in inches	1.66
Runoff, in acre-feet	17,610,000

(11) 15–4700. CHISANA RIVER AT NORTHWAY JUNCTION, ALASKA

Location.—Lat 63°00′25″, long 141°48′20″, near left bank on downstream side of bridge on highway from Northway Junction to Northway, 0.3 mile southwest of Northway Junction and 4 miles upstream from Nabesna River.

Drainage area.—3,280 sq mi, approximately.

Gage-height record.—Wire-weight gage read once daily. Datum of gage is 1,682.85 ft above mean sea level.

Discharge record.—Stage-discharge relation defined by current-meter measurements.

Maxima.—August 1967: Discharge, 6,710 cfs Aug. 1 (gage height, 10.07 ft).

1949 to July 1967: Discharge observed, 12,000 cfs June 28, 1964 (gage height, 13.18 ft).

[Mean discharge, in cubic feet per second, August 1967]

Day	Discharge	Day	Discharge	Day	Discharge
1	6,710	11	6,330	21	6,080
2	6,570	12	6,070	22	6,070
3	6,320	13	5,650	23	6,190
4	6,010	14	5,490	24	6,460
5	5,830	15	5,630	25	6,520
6	5,940	16	5,830	26	6,420
7	6,040	17	5,970	27	6,010
8	6,080	18	6,180	28	5,550
9	6,180	19	6,150	29	5,260
10	6,460	20	6,040	30	5,060
				31	4,950

Monthly mean discharge, in cubic feet per second	6,002
Runoff, in inches	2.11
Runoff, in acre-feet	369,000

(12) 15–4760. TANANA RIVER NEAR TANACROSS, ALASKA

Location.—Lat 63°23′20″, long 143°44′45″, on right bank 0.25 mile downstream from unnamed tributary, 0.25 mile north of Cathedral Rapids, 9 miles upstream from Robertson River, and 13 miles west of Tanacross.

Drainage area.—8,550 sq mi, approximately.

Gage-height record.—Water-stage recorder graph. Datum of gage is 1, 489.58 ft above mean sea level.

Discharge record.—Stage-discharge relation defined by current-meter measurements.

Maxima.—August 1967: Discharge, 28,400 cfs 0400 hours Aug. 9 (gage height, 9.75 ft).

1953 to July 1967: Discharge, 39,100 cfs June 19, 1962 (gage height, 11.65 ft).

[Mean discharge, in cubic feet per second, August 1967]

Day	Discharge	Day	Discharge	Day	Discharge
1	24,200	11	25,300	21	25,400
2	24,600	12	22,600	22	27,000
3	24,900	13	21,800	23	26,400
4	23,500	14	22,300	24	22,900
5	23,200	15	22,800	25	21,800
6	24,200	16	24,600	26	20,300
7	25,700	17	25,6C0	27	19,100
8	27,100	18	26,200	28	17,900
9	27,600	19	27,200	29	16,800
10	26,400	20	27,100	30	16,100
				31	15,700

Monthly mean discharge, in cubic feet per second	23,430
Runoff, in inches	3.16
Runoff, in acre-feet	1,441,000

(13) 15–4780. TANANA RIVER AT BIG DELTA, ALASKA

[Discontinued station]

Location.—Lat 64°09′25″, long 145°51′00″, on line between sec. 6 and 7, T. 9 S., R. 10 E., at bridge on Richardson Highway, 0.5 mile northwest of Big Delta.

Drainage area.—13,500 sq mi.

Maxima.—August 1967: Discharge, over 60,000 cfs Aug. 17 or 18 estimated from current-meter measurement at 49,500 cfs and high-water marks.

1948–52, 1953–57: Discharge observed, 62,800 cfs July 29, 1949 (gage height, 23.57).

(14) 15–4800. BANNER CREEK AT RICHARDSON, ALASKA

[Crest-stage station]

Location.—Lat 64°17′25″, long 146°21′00″, on right bank in SW¼ sec. 22, T. 7 S., R. 7 E., at mile 295.4 Richardson Highway, and 0.4 mile northwest of Richardson.

Drainage area.—20.2 sq mi.

Gage-height record.—Crest stages only. Elevation of gage is 880 ft (from topographic map).

Discharge record.—Stage-discharge relation defined by current-meter measurements from 6 cfs to 36 cfs and by slope-area measurement at 352 cfs.

Maxima.—August 1967: Discharge, 352 cfs Aug. 13 (gage height, 12.15 ft), by slope-area measurement.

1963 to July 1967: Discharge, 732 cfs in 1966 (gage height, 13.55 ft, possible ice effect).

(15) 15–4840. SALCHA RIVER NEAR SALCHAKET, ALASKA

Location.—Lat 64°28′15″, long 146°55′45″, in sec. 22, T. 5 S., R. 4 E., near center of span on downstream side of bridge pier on Richardson Highway, 0.5 mile east of Aurora Lodge, 2 miles upstream from mouth, and 6 miles southeast of Salchaket.

Drainage area.—2,170 sq mi, approximately.

Gage-height record.—Wire-weight gage read at least twice daily, except Aug. 1–12. Datum of gage is 631.85 ft above mean sea level.

Discharge record.—Stage-discharge relation defined by current-meter measurements, below 16,000 cfs, and by slope-area and slope-conveyance measurement at 97,000 cfs.

Maxima.—August 1967: Discharge, 97,000 cfs 0800 hours Aug. 14 (gage height, 20.50 ft).

1948 to July 1967: Discharge, 36,500 cfs June 23, 1956 (gage height, 16.13 ft), from rating curve extended above 16,000 cfs by logarithmic plotting.

[Mean daily discharge, in cubic feet per second, August 1967]

Day	Discharge	Day	Discharge	Day	Discharge
1	4,400	11	9,000	21	7,560
2	4,000	12	20,000	22	6,990
3	3,700	13	40,900	23	6,480
4	3,400	14	94,100	24	6,180
5	3,200	15	63,000	25	5,880
6	3,100	16	38,300	26	5,310
7	3,000	17	23,200	27	4,920
8	3,000	18	11,200	28	4,680
9	3,000	19	9,600	29	4,460
10	4,500	20	8,320	30	4,200
				31	4,130

Monthly mean discharge, in cubic feet per second	13,350
Runoff, in inches	7.09
Runoff, in acre-feet	820,600

[Gage height, in feet, and discharge, in cubic feet per second, at indicated time, 1967]

Date	Hour	Gage height	Discharge	Date	Hour	Gage height	Discharge	Date	Hour	Gage height	Discharge
Aug. 13	1800	17.2	54,000	Aug. 14	1800	20.1	91,400	Aug. 15	1800	17.4	56,000
	2400	20.1	91,400		2400	19.4	81,600		2400	16.7	49,000
14	0600	20.4	95,600	15	0600	18.7	71,800	16	0600	16.0	42,000
	0800	20.50	97,000		1200	18.0	63,000		1200	15.7	39,000
	1200	20.5	97,000								

(16) LITTLE SALCHA RIVER NEAR SALCHAKET, ALASKA

[Miscellaneous site]

Location.—Lat 64°30′50″, long 146°58′10″, in sec. 4, T. 5 S., R. 4 E., at Richardson Highway bridge 3 miles southeast of Salchaket and 3.5 miles northwest of Aurora Lodge.

Drainage area.—67.4 sq mi.

Maximum.—August 1967: Discharge, 1,900 cfs Aug. 13, by contracted-opening measurement.

(17) POTLATCH CREEK NEAR TWO RIVERS, ALASKA

[Miscellaneous site]

Location.—Lat 64°52′14″, long 147°03′00″, in NE¼SW¼ sec. 36, T. 1 N., R. 3 E., at mile 18 on Chena Hot Springs Road crossing 0.6 mile west of Two Rivers School 12 miles northeast of North Pole.

Drainage area.— 3.49 sq mi.

Maximum.—August 1967: Discharge, 40 cfs Aug. 12, by flow-through-culvert measurement.

(18) CHENA RIVER ABOVE LITTLE CHENA RIVER NEAR EIELSON AIR FORCE BASE, ALASKA

[Miscellaneous site]

Location.—Lat 64°50′45″, long 146°57′55″, in sec. 9, T. 1 S., R. 4 E., at abandoned bridge 12 miles north of Eielson Air Force Base and 15 miles upstream from Little Chena River.

Drainage area.—1,370 sq mi.

Maximum.—August 1967: Discharge, 105,000 cfs Aug. 13 or 14, by slope-area, slope-conveyance, and other indirect methods.

(19) 15–5110. LITTLE CHENA RIVER NEAR FAIRBANKS, ALASKA

Location.—Lat 64°53′10″, long 147°14′50″, in NE¼ sec. 25, T. 1 N., R. 2 E., on left bank attached to downstream face of abutment of bridge at mile 12 on Chena Hot Springs Road, 14 miles northeast of Fairbanks.

Drainage area.—356 sq mi.

Gage-height record.— Water-stage recorder graph. Elevation of gage is 490 ft (from topographic map).

Discharge record.—Stage-discharge relation defined by current-meter measurements below 3,000 cfs and contracted-opening and flow-over-road measurement at 17,000 cfs.

Maxima.—August 1967: Discharge 17,000 cfs 1200 hours Aug. 13 (gage height, 31.7 ft).

1966 to July 1967: Discharge 2,160 cfs May 27, 1967 (gage height, 21.35 ft).

[Mean discharge, in cubic feet per second, August 1967]

Day	Discharge	Day	Discharge	Day	Discharge
1	563	11	685	21	1,500
2	548	12	1,940	22	1,300
3	492	13	12,000	23	1,200
4	452	14	10,000	24	1,100
5	424	15	8,000	25	1,000
6	396	16	6,500	26	950
7	371	17	5,000	27	850
8	353	18	3,000	28	800
9	457	19	2,000	29	750
10	706	20	1,800	30	720
				31	700

Monthly mean discharge, in cubic feet per second	2,147
Runoff, in inches	6.95
Runoff, in acre-feet	132,000

[Gage height, in feet, and discharge, in cubic feet per second, at indicated time, 1967]

Date	Hour	Gage height	Discharge	Date	Hour	Gage height	Discharge	Date	Hour	Gage height	Discharge
Aug. 8	Day	12.78	353	Aug. 12	0400	15.22	753	Aug. 12	2000	25.7	3,230
9	1200	13.32	435		0800	16.40	973		2200	26.5	3,500
	2400	14.37	609		1000	17.70	1,250		2400	27.4	3,880
10	1200	15.07	728		1200	20.00	1,780	13	0400	29.0	5,300
	2400	14.97	711		1400	22.00	2,260		0800	31.1	12,000
11	1200	14.82	685		1600	23.70	2,680		1100	31.7	15,200
	1800	14.74	672		1800	24.9	3,000		1200	31.95	17,000
	2400	14.83	687						1400	31.8	15,900
									2400	31.3	13,000

(20) STEELE CREEK NEAR FAIRBANKS, ALASKA

[Miscellaneous site]

Location.—Lat 64°57'12", long 147°29'12", on line between sec. 23 and 26, T. 1 N., R. 1 E., at Chena Hot Springs Road crossing 7.5 miles northeast of Fairbanks.

Drainage area.—10.7 sq mi.

Maximum.—August 1967: Discharge, 340 cfs Aug. 12, by flow-through-culvert measurement.

(21) 15–5140. CHENA RIVER AT FAIRBANKS, ALASKA

Location.—Lat 64°50'50", long 147°42'20", in NW¼ sec. 11, T. 1 S., R. 1 W., near center of span on downstream side of bridge on Steese Highway (U.S. Highway 97) in Fairbanks, 0.15 miles upstream from Noyes Slough, 11 miles downstream from Chena Slough.

Drainage area.—1,980 sq mi, approximately.

Gage-height record.—Wire-weight gage read twice daily. Datum of gage is 422.92 ft above mean sea level.

Discharge record.—Stage-discharge relation defined by current-meter measurements.

Maxima.—August 1967: Discharge, 74,400 cfs 1400 hours Aug. 15 (gage height 18.82 ft).

1947 to July 1967: Discharge 24,200 cfs May 21, 1948 (gage height, 14.17 ft, site and datum then in use, from graph based on gage readings).

[Mean discharge, in cubic feet per second, August 1967]

Day	Discharge	Day	Discharge	Day	Discharge
1	4,680	11	3,780	21	12,800
2	4,210	12	5,170	22	10,300
3	3,920	13	10,700	23	8,940
4	3,640	14	20,500	24	8,120
5	3,360	15	64,600	25	7,550
6	3,120	16	57,600	26	7,030
7	2,950	17	46,600	27	6,470
8	2,790	18	36,100	28	5,990
9	2,740	19	25,500	29	5,720
10	3,020	20	18,000	30	5,480
				31	5,270

Monthly mean discharge, in cubic feet per second	13,100
Runoff, in inches	7.64
Runoff, in acre-feet	806,600

[Gage height, in feet, and discharge, in cubic feet per second, at indicated time, 1967]

Date	Hour	Gage height	Discharge	Date	Hour	Gage height	Discharge	Date	Hour	Gage height	Discharge
Aug. 12	1200	5.08	4,880	Aug. 16	0600	18.41	60,800	Aug. 19	1800	15.43	22,600
	2400	6.64	6,980		1200	18.29	57,800		2400	14.90	20,700
13	0600	8.50	9,700		1800	18.13	54,000	20	1200	13.67	17,700
	1200	9.22	10,800		2400	17.95	50,400		2400	12.00	15,300
	1800	9.92	11,900	17	0600	17.85	48,600	21	1200	10.50	12,800
	2400	11.16	13,700		1200	17.73	46,500		2400	9.60	11,400
14	0600	12.72	16,500		1800	17.58	44,000	22	1200	8.90	10,000
	1200	13.97	15,200		2400	17.43	41,600		2400	8.40	9,550
	1800	15.46	22,700	18	0600	17.24	38,900	23	1200	8.11	9,120
	2400	16.97	35,200		1200	17.04	36,100		2400	7.64	8,380
15	0600	18.20	55,500		1800	16.75	32,600	24	1200	7.39	8,040
	1200	18.82	74,400		2400	16.59	30,900		2400	7.15	7,690
	1400	18.82	74,400	19	0600	16.30	28,100	25	1200	7.00	7,480
	1800	18.77	72,300		1200	15.95	25,400	26	1200	6.56	6,860
	2400	18.56	64,800								

(22) ISABELLA CREEK NEAR FAIRBANKS, ALASKA

[Miscellaneous site]

Location.—Lat 64°53′10″, long 147°40′30″ in SW¼NW¼ sec. 25, T. 1 N., R. 1 W., culvert on Farmers Loop Road, about 2½ miles upstream from Chena River, and 3 miles northeast of Fairbanks Post Office.

Drainage area.—4.56 sq mi.

Maximum.—August 1967: Discharge, 160 cfs Aug. 12, from flow-through-culvert measurement.

(23) 15–5155. TANANA RIVER AT NENANA, ALASKA

Location.—Lat 64°34′05″, long 149°04′20″, NW¼ sec. 13, T. 4 S., R. 8 W., near the right bank, on downstream side of Alaska Railroad bridge at Nenana, and 0.8 mile upstream from Nenana River.

Drainage area.—27,500 sq mi, approximately.

Gage-height record.—Wire-weight gage read twice daily. Datum of gage is 338.50 ft above mean sea level.

Discharge record.—Stage-discharge relation defined by current-meter measurements.

Maxima.— August 1967: Discharge, 186,000 cfs 0800 hours Aug. 18 (gage height, 18.90 ft).

1962 to July 1967: Discharge, 122,00 cfs July 28, 1967 (gage height, 15.00 ft).

[Mean discharge, in cubic feet per second, August 1967]

Day	Discharge	Day	Discharge	Day	Discharge
1	89,000	11	76,000	21	121,000
2	86,500	12	84,000	22	103,000
3	83,000	13	115,000	23	91,800
4	80,000	14	133,000	24	85,000
5	75,000	15	152,000	25	80,500
6	72,500	16	162,000	26	76,500
7	70,500	17	173,000	27	71,500
8	70,500	18	183,000	28	66,000
9	72,500	19	168,000	29	64,000
10	74,500	20	145,000	30	61,500
				31	58,600

Monthly mean discharge, in cubic feet per second	98,210
Runoff, in inches	4.12
Runoff, in acre-feet	6,038,000

(24) 15–5160. NENANA RIVER NEAR WINDY, ALASKA

Location.—Lat 63°27′15″, long 148°48′10″, on left pier under bridge on Denali Highway, 0.75 mile upstream from Jack River, 1 mile southeast of Windy railroad station, and 2 miles downstream from Schist Creek.

Drainage area.—710 sq mi, approximately.

Gage-height record.—Water-stage recorder graph. Elevation of gage is 2,100 ft (from topographic map).

Discharge record.—Stage-discharge relation defined by current-meter measurements.

Maxima.—August 1967: Discharge, 6,880 cfs 2400 hours Aug. 14 (gage height 6.68 ft).

1950–56. 1958 to July 1967: Discharge, 11,900 cfs June 15, 1962 (gage height, 9.84 ft); maximum gage height, 10.20 ft May or June from floodmarks (backwater from ice).

[Mean discharge, in cubic feet per second, August 1967]

Day	Discharge	Day	Discharge	Day	Discharge
1	2,970	11	3,220	21	3,440
2	3,120	12	4,480	22	3,140
3	2,710	13	5,620	23	2,870
4	2,430	14	6,630	24	2,780
5	2,220	15	6,550	25	2,610
6	2,140	16	5,770	26	2,430
7	2,080	17	5,830	27	2,390
8	2,060	18	4,910	28	2,220
9	2,380	19	4,180	29	2,040
10	2,900	20	3,690	30	1,990
				31	1,960

Monthly mean discharge, in cubic feet per second	3,347
Runoff, in inches	5.43
Runoff, in acre-feet	205,800

[Gage height, in feet, and discharge, in cubic feet per second, at indicated time, 1967]

Date	Hour	Gage height	Discharge	Date	Hour	Gage height	Discharge	Date	Hour	Gage height	Discharge
Aug. 11..	2400	4.44	3,030	Aug. 13..	2000	5.94	5,450	Aug. 16..	1200	6.01	5,580
12..	0600	4.89	3,680		2400	6.15	5,840		1800	6.03	5,620
	1200	5.65	4,930	14..	0600	6.53	6,590		2400	6.18	5,900
	1800	5.85	5,290		1200	6.62	6,770	17..	0600	6.23	6,000
	2400	5.92	5,420		1800	6.60	6,730		0900	6.24	6,020
13..	0600	6.10	5,750		2400	6.68	6,880		1800	6.07	5,690
	1200	6.05	5,660	15..	1200	6.53	6,590		2400	5.91	5,400
	1800	5.95	5,470		2400	6.30	6.130	18..	1200	5.64	4,910

(25) 15–5180. NENANA RIVER NEAR HEALY, ALASKA

Location.—Lat 63°50′40″, long 148°56′35″, in W½ sec. 28, T. 12 S., R. 7 W., on left bank 0.5 mile upstream from Healy Creek, 1.1 miles southeast of Healy, and 1.2 miles upstream from railroad bridge.

Drainage area.—1,910 sq mi, approximately.

Gage-height record.—Wire-weight gate read once daily. Datum of gage is 1,207.22 ft above mean sea level.

Discharge record.—Stage-discharge relation defined by current-meter measurements.

Maxima.—August 1967: Discharge, 31,100 cfs 2400 hours Aug. 12 (gage height, 11.65 ft, from high-water marks).

1950 to July 1967: Discharge, 46,800 cfs July 25, 1967 (gage height, 13.40 ft, from high-water marks).

[Mean discharge, in cubic feet per second, August 1967]

Day	Discharge	Day	Discharge	Day	Discharge
1	11,800	11	12,500	21	11,500
2	13,300	12	20,900	22	10,300
3	11,600	13	26,500	23	9,780
4	11,300	14	25,000	24	9,300
5	10,700	15	23,000	25	7,980
6	10,800	16	22,000	26	7,950
7	10,700	17	23,100	27	7,200
8	10,700	18	18,100	28	7,320
9	11,600	19	14,500	29	7,120
10	12,800	20	12,500	30	7,080
				31	6,950

Monthly mean discharge, in cubic feet per second	13,090
Runoff, in inches	7.90
Runoff, in acre-feet	805,100

[Gage height, in feet, and discharge, in cubic feet per second, at indicated time, 1967]

Date	Hour	Gage height	Discharge	Date	Hour	Gage height	Discharge	Date	Hour	Gage height	Discharge
Aug. 10..	1200	8.40	12,800	Aug. 12..	0800	9.30	16,700	Aug. 13..	1800	10.75	24,800
	2000	8.52	13,300		1200	10.00	20,300		2400	10.67	24,300
	2400	8.50	13,200		1600	10.70	24,500	14..	1200	10.77	24,900
11..	0600	8.42	12,900		2000	11.30	28,600		2400	10.95	26,200
	1800	8.20	12,000		2400	11.65	31,100				
	2400	8.25	12,200	13..	0600	11.22	28,000				
12..	0400	8.55	13,400		1200	10.92	25,900				

(26) 15–5181. LITTLE PANGUINGUE CREEK NEAR LIGNITE, ALASKA

[Crest-stage station]

Location.—Lat 63°56′25″, long 149°06′40″, on right bank in NW¼ sec. 27, T. 11 S., R. 8 W., on Anchorage-Fairbanks Highway, and 3 miles northwest of Lignite.

Drainage area.—3.44 sq mi.

Gage-height record.—Crest stages only. Elevation of gage is 1,350 ft (from topographic map).

Discharge record.—Stage-discharge relation defined by current-meter measurements below 3.0 cfs and by flow-through-culvert measurement at 151 cfs.

Maxima.—August 1967. Discharge, 151 cfs Aug. 12 (gage height, 14.13 ft, from high-water marks), by flow-through-culvert measurement.

1965 to July 1967: Discharge, 119 cfs June 13, 1965 (gage height, 13.5 ft), by flow-through-culvert measurement.

(27) 15–5182. ROCK CREEK NEAR FERRY, ALASKA

[Crest-stage station]

Location.—Lat 64°01′55″, long 149°08′35″, on right bank in SW¼ sec. 21, T. 10 S., R. 8 W., on Anchorage-Fairbanks Highway, 0.25 mile upstream from mouth, and 1½ miles northwest of Ferry.

Drainage area.—8.17 sq mi.

Gage-height record.—Crest stages only. Elevation of gage is 1,000 ft (from topographic map).

Discharge record.—Stage-discharge relation defined by current-meter measurements below 100 cfs and by slope-area measurement at 515 cfs.

Maxima.—August 1967: Discharge, 515 cfs Aug. 12 (gage height, 17.40 ft, from high-water marks), by slope-area measurement.

1964 to July 1967: Discharge, not determined (gage height, 11.34 ft, June 13, 1965).

(28) 15–5182.5 BIRCH CREEK NEAR REX, ALASKA

[Crest-stage station]

Location.—Lat 64°10′35″, long 149°17′30″, on left bank in SW¼ sec. 35, T. 8 S., R. 9 W., on Anchorage-Fairbanks Highway, and 4.2 miles north of Rex.

Drainage area.—4.10 sq mi.

Gage-height record.—Crest stages only. Elevation of gage is 850 ft (from topographic map).

Discharge record.—Stage-discharge relation defined by current-meter measurements and by flow-through-culvert measurements at 183 and 464 cfs.

Maxima.—August 1967: Discharge 464 cfs Aug. 12 (gage height, 14.74 ft), by flow-through-culvert measurement.

1964 to July 1967: Discharge, 183 cfs June 13, 1965 (gage height, 11.43 ft), by flow-through-culvert measurement.

(29) 15–5183. NENANA RIVER NEAR REX, ALASKA

Location.—Lat 64°13′05″, long 149°16′40″, in S½ sec. 14, T. 8 S., R. 9 W., on right bank, about 250 ft downstream from highway bridge crossing, 1.3 miles southwest of Rex and 24.4 miles southwest of Nenana.

Drainage area.— 2,450 sq mi.

Gage-height record.—Water-stage recorder graph and wire-weight gage read twice daily. Elevation of gage is 690 ft (from topographic map).

Discharge record.—Stage-discharge relation defined by current-meter measurements.

Maxima.—August 1967: Discharge, 46,900 cfs Aug. 13 (gage height, 13.7 ft).

1964 to July 1967: Discharge 63,000 cfs July 25, 1967 (gage height, 14.85 ft).

[Mean discharge, in cubic feet per second, August 1967]

Day	Discharge	Day	Discharge	Day	Discharge
1	13,200	11	17,300	21	14,300
2	13,400	12	27,200	22	13,500
3	12,700	13	37,200	23	12,600
4	11,700	14	30,300	24	11,200
5	10,700	15	27,100	25	10,700
6	11,000	16	22,300	26	11,000
7	10,900	17	22,900	27	10,200
8	10,800	18	20,100	28	9,000
9	11,300	19	15,700	29	7,180
10	14,300	20	14,800	30	8,900
				31	9,450

Monthly mean discharge, in cubic feet per second	15,260
Runoff, in inches	7.18
Runoff, in acre-feet	938,000

(30) 15–5183.5. TEKLANIKA RIVER NEAR LIGNITE, ALASKA

Location.—Lat 63°55′10″, long 149°29′50″, in NW¼ sec. 34, T. 11 S., R. 10 W., on left bank 0.4 mile downstream from confluence with Savage River and 14.5 miles west of Lignite.

Drainage area.—489 sq mi.

Gage-height record.—Water-stage recorder graph. Elevation of gage is 1,550 ft (from topographic map).

Discharge record.—Stage-discharge relation defined by current-meter measurements.

Maxima.—August 1967: Discharge, 16,400 cfs 0700 hours Aug. 13 (gage height, 10.17 ft).

1964 to July 1967: Discharge, 33,100 cfs July 25, 1967 (gage height, 12.51 ft, from high-water marks), from rating curve extended above 3,000 cfs by logarithmic plotting.

[Mean discharge, in cubic feet per second, August 1967]

Day	Discharge	Day	Discharge	Day	Discharge
1	2,700	11	2,160	21	2,210
2	2,300	12	7,800	22	1,950
3	2,080	13	13,000	23	1,950
4	2,000	14	7,070	24	1,870
5	1,900	15	4,700	25	1,630
6	1,800	16	3,840	26	1,590
7	1,800	17	4,060	27	1,600
8	1,780	18	3,410	28	1,460
9	2,530	19	2,770	29	1,420
10	2,620	20	2,250	30	1,520

Monthly mean discharge, in cubic feet per second	2,943
Runoff, in inches	6.92
Runoff, in acre-feet	181,000

[Gage height, in feet, and discharge, in cubic feet per second, at indicated time, 1967]

Date	Hour	Gage height	Dis-charge	Date	Hour	Gage height	Dis-charge	Date	Hour	Gage height	Dis-charge
Aug. 11	1200	5.85	1,960	Aug. 12	2000	9.28	12,300	Aug. 14	0200	8.94	9,600
	1800	5.85	1,960		2400	9.40	12,900		0800	8.46	7,680
	2400	6.05	2,350	13	0400	9.63	13,400		1200	8.11	6,480
12	0600	6.72	3,900		0700	10.17	16,400		1800	7.98	6,070
	0800	7.12	4,910		1300	9.75	14,000		2400	7.90	5,810
	1000	7.65	6,580		2100	8.90	14,800	15	1200	7.57	5,800
	1300	8.45	9,200		2300	8.81	14,400		2400	7.42	5,200
	1800	9.02	11,500		2400	8.83	14,400				

(31) 15–5184. TANANA RIVER TRIBUTARY NEAR NENANA, ALASKA

[Crest-stage station]

Location.—Lat 64°38′27″, long 149°00′34″, on right bank in NW¼ sec. 20, T. 3 S., R. 7 W., on Nenana Road, and 7.4 miles northeast of Nenana.

Drainage area.—0.58 sq mi.

Gage-height record.—Crest stages only. Elevation of gage is 450 ft (from topographic map).

Discharge record.—Stage-discharge relation defined by current-meter measurements and by flow-through-culvert measurements at 7.8 and 17.7 cfs.

Maxima.—August 1967: Discharge, 7.8 cfs Aug. 12 or 13 (gage height, 11.26 ft), by flow-through-culvert measurement.

1965 to July 1967: Discharge, 17.7 cfs May 1967 (gage height, 12.01 ft).

(32) TOLOVANA RIVER NEAR LIVENGOOD, ALASKA

[Miscellaneous site]

Location.—Lat 65°28′20″, long 148°15′50″, 0.1 mile upstream from bridge on Elliott Highway, and 8.8 miles southeast of Livengood.

Drainage area.— 140 sq mi.

Maximum.—August 1967: Discharge, 12,000 cfs Aug. 12 or 13 by slope-conveyance measurement.

(33) 15–5190. BRIDGE CREEK NEAR LIVENGOOD, ALASKA

[Crest-stage station]

Location.—Lat 65°27′50″, long 148°15′10″, on left bank at mile 56 Elliott Highway, and 9.5 miles southeast of Livengood.

Drainage area.—12.6 sq mi.

Gage-height record.—Crest stages only. Elevation of gage is 670 ft (from topographic map).

Discharge record.—Stage-discharge relation defined by current-meter measurements below 90 cfs and by flow-through-culvert measurements above 750 cfs.

Maxima.—August 1967: Discharge, 788 cfs. Aug. 12 or 13 (gage height, 17.65 ft, from high-water marks).

1963 to July 1967: Discharge, 1,070 cfs July 31, 1964 (gage height, 17.41 ft).

(34) WEST FORK TOLOVANA RIVER NEAR LIVENGOOD, ALASKA

[Miscellaneous site]

Location.—Lat 65°28′05″, long 148°38′35″, just below bridge on Elliott Highway, 1 mile upstream from Tolovana River, and 5 miles southwest of Livengood.

Drainage area.—291 sq mi.

Maximum.—August 1967: Discharge, 2,290 cfs Aug. 13, by slope-area measurement.

(35) 15–5192. TOLOVANA RIVER TRIBUTARY NEAR LIVENGOOD, ALASKA

[Crest-stage station]

Location.—Lat 65°23′00″, long 148°56′30″, on right bank on Elliott Highway, and 16 miles southwest of Livengood.

Drainage area.—7.81 sq mi.

Gage-height record.—Crest stages only. Elevation of gage is 750 ft. (from topographic map).

Discharge record.—Stage-discharge relation defined by current-meter measurements and flow-through-culvert measurements at 42.8 and 137 cfs.

Maxima.—August 1967: Discharge, 42.8 cfs Aug. 13 (gage height, 9.26 ft at gage), by flow-through-culvert measurement.

1964 to July 1967: Discharge, 137 cfs Aug. 1964 (gage height, 12.58 ft), by flow-through-culvert measurement.

(36) 15–5200. IDAHO CREEK NEAR MILLER HOUSE, ALASKA

[Crest-stage station]

Location.—Lat 65°21′15″, long 146°09′35″, on right bank at mile 79 Steese Highway, and 30 miles southwest of Miller House.

Drainage area.—5.31 sq mi.

Gage-height record.—Crest stages only. Elevation of gage is 1,938 ft (from U.S. Coast and Geodetic Survey).

Discharge record.—Stage-discharge relation defined by current-meter measurements below 35 cfs, by slope-area measurement at 626 cfs, and by flow-through-culvert and flow-over-road measurement at 813 cfs.

Maxima.—August 1967: Discharge, 626 cfs Aug. 12-14 (gage height, 28.96 ft), by slope-area measurement.

1963 to July 1967: Discharge, 813 cfs Aug. 20, 1964 (gage height 16.0 ft, datum then in use), by flow-through-culvert and flow-over-road measurement.

(37) 15–5300. FAITH CREEK NEAR CHENA HOT SPRINGS, ALASKA

[Crest-stage station]

Location.—Lat 65°17′30″, long 146°22′50″, on right bank on mile 69 Steese Highway, 19 miles northwest of Chena Hot Springs, and 34.5 miles northeast of Chatanika.

Drainage area.—61.1 sq mi.

Gage-height record.—Crest stages only. Elevation of gage is 1,450 ft (from topographic map).

Discharge record.—Stage-discharge relation defined by current-meter measurements below 150 cfs and by slope-area measurement at 4,950 cfs.

Maxima.—August 1967: Discharge, 4,950 cfs Aug. 14 (gage height, 15.15 ft, from high water marks), by slope-area measurement.

1963 to July 1967: Discharge, not determined, (gage height, 11.65 ft July 1964, possible ice effect).

(38) CHATANIKA RIVER NEAR CHATANIKA, ALASKA

[Miscellaneous site]

Location.—Lat 65°14′, long 146°52′ in about sec. 10, T. 5 N., R. 4 E., at mile 51 on the Steese Highway, 22 miles east of Chatanika.

Drainage area.—244 sq mi.

Maximum.—August 1967: Discharge, 19,600 cfs Aug. 13, by slope-area measurement.

(39) CHATANIKA RIVER NEAR OLNES, ALASKA

[Miscellaneous site]

Location.—Lat 65°05′20″, long 147°43′00″, 0.3 mile upstream from Elliott Highway bridge 1.6 miles northwest of Olnes.

Drainage area.—528 sq mi.

Maximum.—August 1967: Discharge, 25,000 cfs Aug. 13 or 14, by slope-conveyance measurement.

(40) ROSE CREEK NEAR FOX, ALASKA

[Miscellaneous site]

Location.—Lat 64°58′23″, long 147°30′50″, in NE¼ sec. 27, T. 2 N., R. 1 E., 500 ft upstream from road crossing 0.1 mile south of NASA guard shack and 3.2 miles northeast of Fox.

Drainage area.—2.00 sq mi.

Maximum.—August 1967: Discharge, 104 cfs Aug. 13, by slope-area measurement.

(41) LITTLE GOLDSTREAM CREEK NEAR NENANA, ALASKA

[Miscellaneous site]

Location.—Lat 64°40′00″, long 148°56′40″, at bridge on Nenana Road, and 8.5 miles northeast of Nenana.

Drainage area.—40.8 sq mi.

Maximum.—August 1967: Discharge, 1,490 cfs Aug. 12–14, by contracted-opening measurement.

(42) TATALINA RIVER NEAR LIVENGOOD, ALASKA

[Miscellaneous site]

Location.—Lat 65°19′45″, long 148°18′25″, just above right bank tributary above bridge at about mile 45 on Elliott Highway, about 15 miles southeast of Livengood, and about 35 miles northeast of confluence with Chatanika and Tolovana Rivers.

Drainage area.—80.8 sq mi.

Maximum.—August 1967: Discharge, 3,560 cfs Aug. 12–14, by slope-area measurement.

(43) 15–5416. GLOBE CREEK NEAR LIVENGOOD, ALASKA

[Crest-stage station]

Location.—Lat 65°17′05″, long 148°08′05″, on right bank at mile 38 Elliott Highway, 9 miles upsteam from mouth, and 19 miles southeast of Livengood.

Drainage area.—26.3 sq mi.

Gage-height record.—Crest stages only. Elevation of gage is 675 ft (from topographic map).

Discharge record.—Stage-discharge relation defined by current-meter measurements.

Maxima.—August 1967: Discharge, not determined, Aug. 12 (gage height, about 16.0 ft).

1964 to July 1967: Discharge, 284 cfs July 25, 1967 (gage height, 12.06 ft), by current-meter measurement.

(44) 15–5416.5. GLOBE CREEK TRIBUTARY NEAR LIVENGOOD, ALASKA

[Crest-stage station]

Location.—Lat 65°16′30″, long 148°07′00″, on right bank at mile 37 Elliott Highway, 1 mile upstream from mouth, and 20 miles southeast of Livengood.

Drainage area.—9.01 sq mi.

Gage-height record.—Crest stages only. Elevation of gage is 750 ft (from topographic map).

Discharge record.—Stage-discharge relation defined by current-meter measurements below 100 cfs and by flow-through-culvert measurement at 490 cfs.

Maxima.—August 1967: Discharge, 490 cfs Aug. 12 (gage height, 15.35 ft, from crest-gage reading and from high-water marks), by flow-through-culvert measurement.

1963 to July 1967: Discharge, 187 cfs in 1965 (gage height, 11.77 ft).

(45) 15–5418. WASHINGTON CREEK NEAR FOX, ALASKA

[Crest-stage station]

Location.—Lat 65°09′05″, long 147°51′15″, on right bank at mile 18.2 Elliott Highway, and 15 miles northwest of Fox.

Drainage area.—46.7 sq mi.

Gage-height record.—Crest stages only. Elevation of gage is 870 ft (from topographic map).

Discharge record.—Stage-discharge relation defined by current-meter measurements below 100 cfs and by contracted-opening, flow-over-road and critical depth flow measurements at 2,500 cfs.

Maxima.—August 1967: Discharge, 2,500 cfs Aug. 14 (gage height, 18.29 ft, from high-water marks).

1963 to July 1967: Discharge, not determined (gage height, 14.25 ft June 1964).

(46) 15–5646. MELOZITNA RIVER NEAR RUBY, ALASKA

Location.—Lat 64°47′35″, long 155°33′20″, on left bank 2.9 miles downstream from Grayling Creek, 4.2 miles northwest of Ruby, and 6.5 miles upstream from mouth.

Drainage area.—2,693 sq mi.

Gage-height record.—Digital-recorder tape punched at 15-minute intervals. Elevation of gage is 190 ft (from topographic map).

Discharge record.—Stage-discharge relation defined by current-meter measurements.

Maxima.—August 1967: Discharge, 24,000 cfs 1100 hours Aug. 17 (gage height, 8.69 ft).

1961 to July 1967: Discharge, 28,200 cfs Sept. 3, 1962 (gage height, 9.40 ft); maximum gage height, 13.97 ft May or June 1964, and about June 1, 1965, from floodmark (ice jam).

[Mean discharge, in cubic feet per second, August 1967]

Day	Discharge	Day	Discharge	Day	Discharge
1	3,000	11	4,000	21	15,600
2	3,800	12	5,000	22	14,800
3	3,600	13	7,000	23	13,500
4	3,400	14	10,000	24	12,200
5	3,000	15	16,000	25	10,600
6	2,800	16	21,000	26	9,430
7	2,600	17	23,000	27	9,020
8	2,400	18	22,500	28	8,470
9	2,200	19	18,700	29	7,860
10	3,800	20	16,500	30	7,300
				31	6,810

Monthly mean discharge, in cubic feet per second	9,325
Runoff, in inches	3.99
Runoff, in acre-feet	573,400

(47) 15–5648. YUKON RIVER AT RUBY, ALASKA

Location.—Lat 64°44′25″, long 155°29′55″, on left bank at Ruby, 300 ft downstream from Ruby Creek, 2 miles downstream from Melozitna River, and 2¼ miles upstream from Ruby Slough.

Drainage area.—259,000 sq. mi, approximately.

Gage-height record.—Staff gage read twice daily. Elevation of gage is 150 ft (from topographic map).

Discharge record.—Stage-discharge relation defined by current-meter measurements.

Maxima.—August 1967: Discharge, 624,000 cfs 0800 hours Aug. 22 (gage height, 27.6 ft).

1956 to July 1967: Discharge observed, 970,000 cfs June 20, 1964; maximum gage height, 31.91 ft probably May 20 or 21, 1963, from floodmarks (ice jam).

[Mean discharge, in cubic feet per second, August 1967]

Day	Discharge	Day	Discharge	Day	Discharge
1	411,000	11	363,000	21	620,000
2	402,000	12	366,000	22	624,000
3	390,000	13	390,000	23	620,000
4	387,000	14	423,000	24	600,000
5	384,000	15	464,000	25	588,000
6	378,000	16	506,000	26	560,000
7	375,000	17	544,000	27	513,000
8	372,000	18	588,000	28	499,000
9	369,000	19	608,000	29	467,000
10	366,000	20	620,000	30	432,000
				31	414,000

Monthly mean discharge, in cubic feet per second	472,000
Runoff, in inches	2.10
Runoff, in acre-feet	29,040,000

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