Prepared in cooperation with
ALASKA WATER STUDY COMMITTEE
and the STATE OF ALASKA, DEPARTMENT OF
NATURAL RESOURCES, DIVISION OF GEOLOGICAL
AND GEOPHYSICAL SURVEYS

SURFACE WATER

MINIMUM DISCHARGE

Streamflow in the Cook Inlet basin generally is at its annual minimum at the end of winter, from mid-February to mid-April. The greater the distance from the Gulf of Alaska and (or) the higher the elevation, the later the minimum discharge period.

Some of the streams draining the lowlands on the west side of the Kenai Peninsula, on the Anchorage flats, and probably also in the lower Susitna valley have summer minimum discharges that are nearly as low as the winter minimum. The summer minimum discharge usually occurs in late July or August. During an extremely dry summer the summer minimum discharge can be less than the winter minimum discharge.

At the time of minimum discharge, the yield from a basin comes entirely from ground-water storage. The indiscriminate use of all minimum discharge data in developing regional relationships may yield erroneous results. Three examples follow. In the first instance the gaging station is located downstream from a reach in which the stream is losing water to the ground-water system. (Measurements made at such a location indicate less discharge than the basin is yielding.) Two Anchorage area gaging stations, South Fork Campbell Creek near Anchorage and Campbell Creek near Spenard, were excluded from the low-flow regional analysis because of this type of water loss. In the second situation a stream may have a significant portion of its winter discharge continuously stored as ice upstream from the gaging location. The measured discharge at the gage is again significantly less than the basin yield. Caribou Creek near Sutton exemplifies this condition and was excluded from the low-flow regional analysis. In the third condition, man's influence has altered the low-flow pattern. For example, the lowered water table resulting from urban development in the Chester Creek basin in Anchorage has significantly decreased low flows. The gaging stations on Chester Creek were excluded from the low-flow regional analysis for this reason.

In the Cook Inlet basin 30 gaging stations have 10 or more years of low-flow record through the 1976 water year. Ten years was selected as the minimum period of record needed for a frequency analysis of low flows. However, five of the gaging stations could not be used in a low-flow regional analysis because of conditions described above. The minimum discharges for each gaging station for each year for both 7-day and 30-day consecutive periods were tabulated for the frequency analysis. Low-flow frequency curves were obtained for the 25 gaging stations by standard techniques assuming a log-Pearson III distribution and using station skew. For each station six low-flow characteristics were obtained from the frequency analysis. Minimum flows for 7-day and 30-day consecutive periods for 2-, 10-, and 20-year recurrence intervals are tabulated in table 4. Low-flow frequency curves for representative gaging stations are shown in figures 11 and 12.

There is only a slight difference between 7-day and 30-day low-flow characteristics of streams in the study area. Since annual low flow usually occurs near the end of the winter period after a 4- to 6-month recession, the discharge is nearly steady for at least one month. For instance, for the 25 gaging stations used in the regional analysis the 7-day low-flow frequency values are from 0 to 10 percent less than the corresponding 30-day low-flow frequency values, the average being 4 percent less.

Regional low-flow equations were obtained through regression analysis using the gaging station low-flow characteristics and the basin characteristics described in "Annual Discharge". The final regression equations take the form: $M_{d,ri} = aA^b(LP + 1)^c(J + 10)^d$

where

M = dependent variable, the minimum flow

d = number of consecutive days of the minimum flow

ri = recurrence interval, the average number of years between minimum flows less than M.

The reciprocal of the recurrence interval is the probablity in any given year that a d-day low flow will occur that is less than the discharge given. The remaining items in this equation are the same as those described under "Monthly Discharge".

The results of the regression analysis, including the standard error of estimate, are given below. Only the independent variables (basin characteristics) that were statistically significant were used in the final equations.

Dependent Variable $M_{d,ri}$	Regression Constant a	Regression Coefficient b	c	d	Standard Error of Estimate +	−
$M_{7,2}$	0.135	0.98	0.21	0.29	26	21
$M_{7,10}$	.0861	.98	.16	.36	36	26
$M_{7,20}$	.0671	.99	.16	.41	42	29
$M_{30,2}$	.132	.98	.20	.31	27	21
$M_{30,10}$	.0839	.98	.16	.38	36	26
$M_{30,20}$	.0656	.99	.15	.43	41	29

These low-flow characteristics are almost directly proportional to drainage area. The minimum January air temperature is significant, and indicates that minimum unit yield decreases with distance from the Gulf of Alaska and with elevation. The storage in lakes and ponds is also significant because increased storage augments streamflow during low-flow periods.

The generalized variation in $M_{7,10}$ for the Cook Inlet basin is shown on the minimum discharge map. There is a 10 percent probability in any year that the minimum unit yield for 7 consecutive days will be less than the map value. The map was drawn assuming that there was no storage effect from lakes and ponds. A coefficient can be obtained from a graph (fig. 13) to adjust the $M_{7,10}$ discharge values to account for lake and pond storage. The map was based on $M_{7,10}$ values from 25 gaging stations, the low-flow regression relations, and fragmentary low-flow data collected by the U.S. Geological Survey. Low flow is poorly defined on the west side of Cook Inlet, in the Susitna and Matanuska River drainages, and the upper elevations of the mountainous areas.

TABLE 4.—MINIMUM DISCHARGE CHARACTERISTICS (DATA THROUGH 1976 WATER YEAR).

Station number	Station name	Annual low flow, in ft³/s: 7 consecutive days, Recurrence interval, in years: 2	10	20	30 consecutive days, Recurrence interval, in years: 2	10	20	Annual low flow, in (ft³/s)/mi²: 7 consecutive days, Recurrence interval, in years: 2	10	20	30 consecutive days, Recurrence interval, in years: 2	10	20
15239000	Bradley R nr Homer	20.7	19.3	17.7	20.8	19.4	17.9	0.53	0.36	0.33	0.53	0.36	0.33
15240000	Anchor R at Anchor Point	78.5	54.5	47.6	88.7	57.6	49.9	.35	.24	.21	.39	.25	.22
15241600	Ninilchik R at Ninilchik	43.6	35.5	33.7	46.1	37.0	35.0	.33	.27	.26	.35	.28	.27
15242000	Kasilof R nr Kasilof	460	275	260	400	280	265	.62	.37	.35	.65	.38	.36
15244000	Ptarmigan C at Lawing	12.4	9.10	8.35	13.1	9.79	9.01	.38	.28	.26	.40	.30	.28
15246000	Grant C nr Moose Pass	16.7	11.9	10.9	17.6	12.9	12.0	.38	.27	.25	.40	.29	.27
15248000	Trail R nr Lawing	70.1	55.0	52.8	76.2	60.0	58.7	.39	.30	.29	.42	.34	.32
15254000	Crescent C nr Cooper Landing	15.6	11.8	10.8	16.4	12.4	11.4	.49	.37	.34	.52	.39	.36
15258000	Kenai R at Cooper Landing	315	227	213	332	244	231	.50	.36	.34	.52	.38	.36
15260000	Cooper C nr Cooper Landing	14.5	9.39	8.13	15.0	9.72	8.52	.46	.30	.26	.47	.31	.27
15266300	Kenai R at Soldotna	968	754	713	990	763	719	.48	.38	.35	.50	.38	.36
15272550	Glacier C at Girdwood	15.1	13.1	12.5	19.1	13.8	13.3	.29	.21	.20	.31	.22	.21
15273900	SF Campbell C at canyon mouth nr Anchorage	9.64	8.93	8.76	10.1	9.17	8.83	.38	.35	.35	.40	.36	.35
15274000	SF Campbell C nr Anchorage	5.72	3.31	2.78	6.54	4.01	3.41	.19	.11	.09	.22	.13	.11
15274600	Campbell C nr Spenard	5.42	3.45	2.46	10.0	5.78	4.77	.14	.05	.04	.15	.08	.07
15275000	Chester C at Anchorage	8.33	3.05	2.07	9.85	3.98	2.78	.42	.15	.10	.49	.20	.14
15275100	Chester C at Arctic Blvd at Anchorage	7.00	2.65	1.87	8.24	4.10	3.20	.26	.10	.07	.30	.15	.12
15277100	Eagle R at Eagle River	42.5	28.0	24.8	42.6	29.2	26.4	.22	.15	.13	.22	.15	.14
15281000	Knik R nr Palmer	411	298	271	420	310	281	.35	.25	.23	.36	.26	.24
15282000	Caribou C nr Sutton	12.0	0.3	0.0	12.1	1.20	0.49	.04	.00	.00	.04	.00	.00
15284000	Matanuska R at Palmer	439	354	327	455	380	350	.21	.17	.16	.22	.18	.17
15290000	Little Susitna R nr Palmer	19.0	16.4	15.7	19.8	16.8	16.2	.31	.26	.25	.32	.27	.26
15291000	Susitna R nr Denali	182	81.2	57.7	183	81.7	58.4	.19	.09	.06	.19	.09	.06
15291200	Maclaren R nr Paxson	66.8	44.9	40.0	67.5	45.1	40.1	.24	.16	.14	.24	.16	.14
15291500	Susitna R nr Cantwell	608	403	364	612	411	373	.15	.10	.09	.15	.10	.09
15292000	Susitna R at Gold Creek	969	692	636	973	704	651	.16	.11	.10	.16	.11	.11
15292400	Chulitna R nr Talkeetna	906	710	664	920	740	695	.35	.28	.26	.36	.29	.27
15292700	Talkeetna R nr Talkeetna	439	383	376	448	387	379	.22	.19	.19	.22	.19	.19
15294300	Skwentna R nr Skwentna	713	592	570	719	592	570	.32	.26	.25	.32	.26	.25
15294500	Chakachatna R nr Tyonek	395	285	257	407	300	272	.35	.25	.23	.36	.27	.24

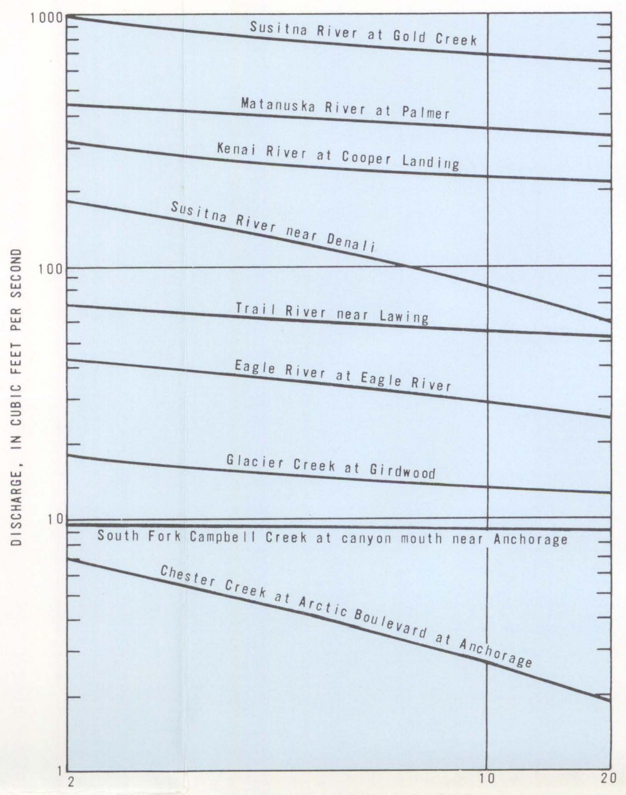


FIGURE 11.—Annual 7-day low-flow frequency curves.

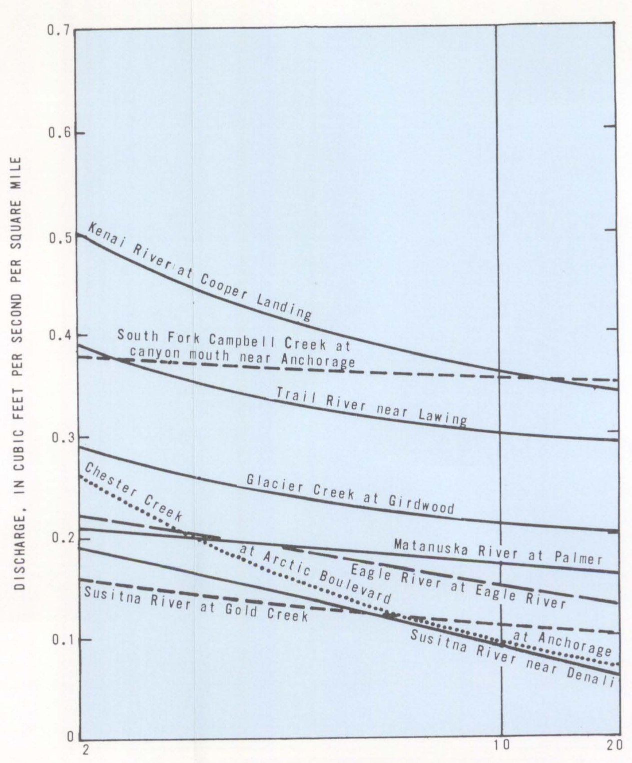


FIGURE 12.—Annual 7-day low-flow frequency curves, expressed as runoff per square mile.

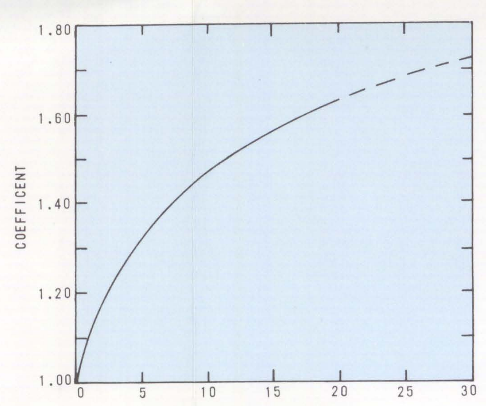
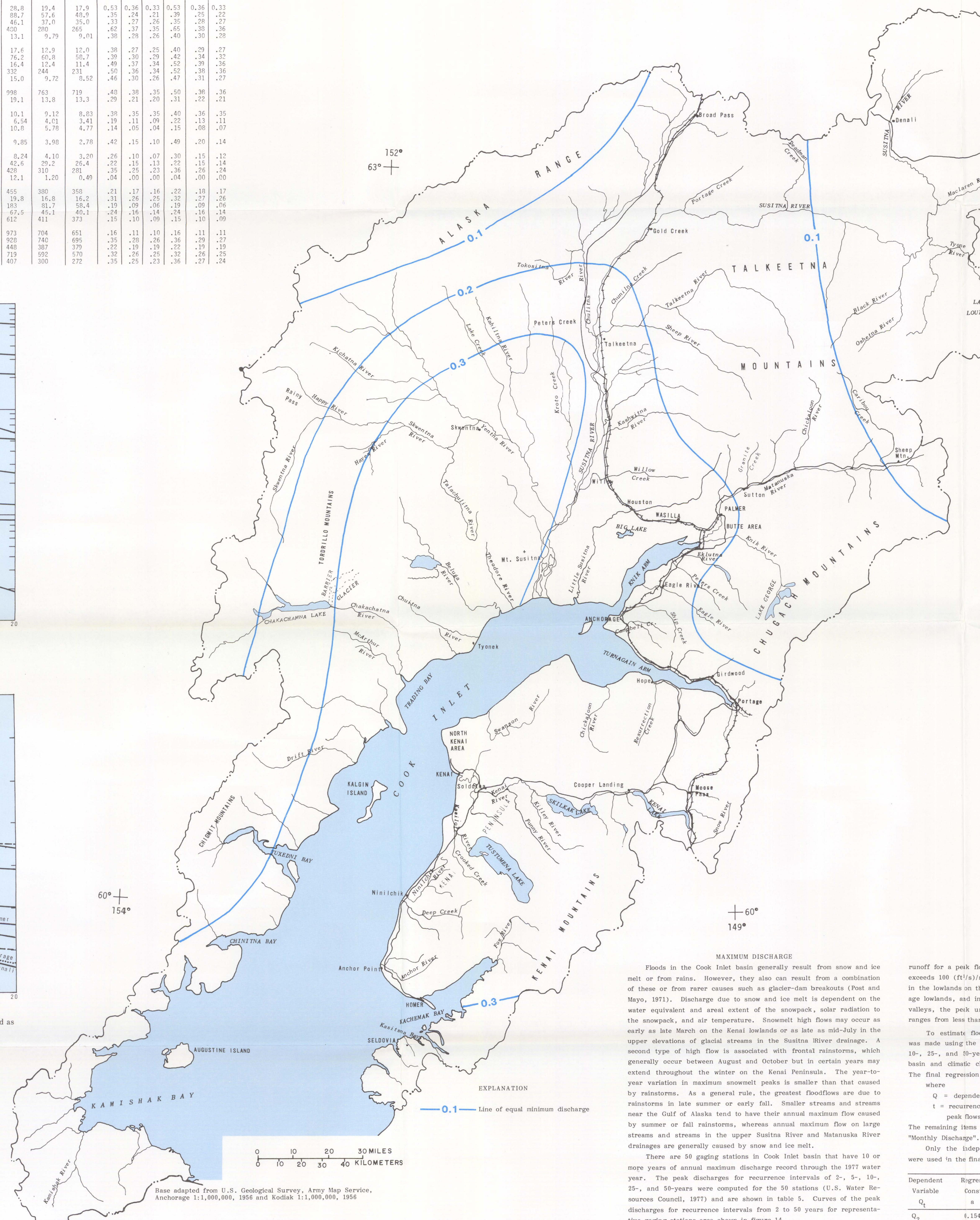


FIGURE 13.—Coefficient used to multiply the $M_{7,10}$ discharge (7-day minimum discharge with a 10-year recurrence interval) from the map to adjust for storage effect of lakes and ponds.



MINIMUM DISCHARGE, $M_{7,10}$ (7-DAY MINIMUM DISCHARGE WITH A 10-YEAR RECURRENCE INTERVAL), IN CUBIC FEET PER SECOND PER SQUARE MILE. (Based on $M_{7,10}$ for 25 gaging stations).

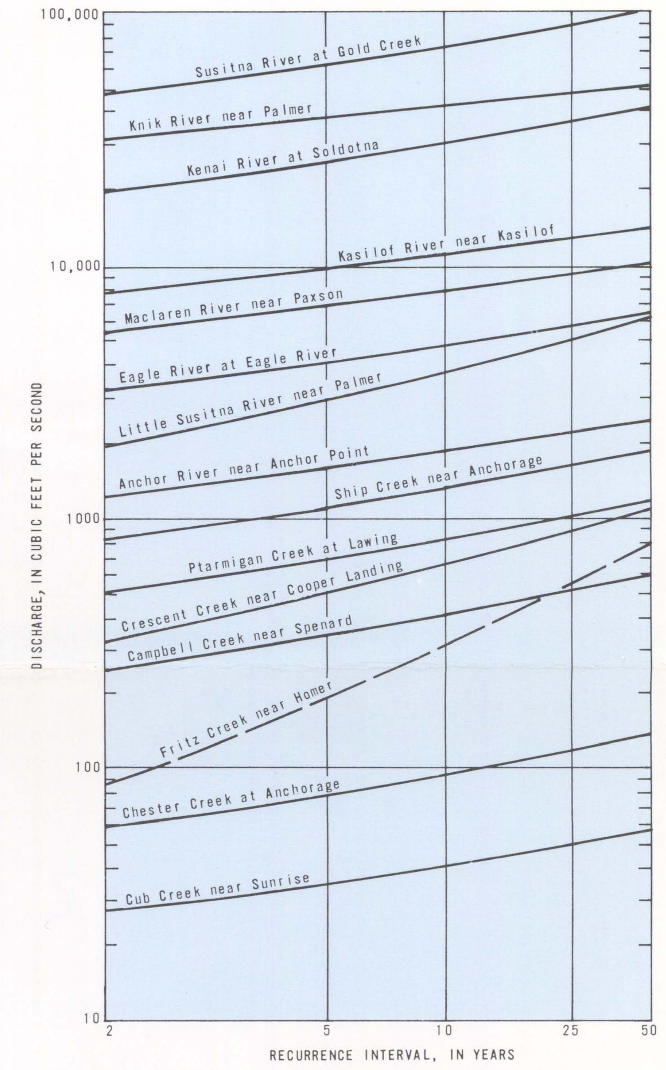


FIGURE 14.—Peak-flow frequency curves.

TABLE 5.—FLOOD FREQUENCY (DATA THROUGH 1977 WATER YEAR).

Station number	Station name	Annual flood discharge, in ft³/s, Recurrence interval, in years: 2	5	10	25	50	Years of record
15239000	Bradley R nr Homer	2,730	4,010	5,010	6,470	7,700	20
15239500	Fritz C nr Homer	86.5	197	318	549	798	15
15239800	Diamond C nr Homer	58.6	88.9	113	150	181	15
15239900	Anchor R nr Anchor Point	1,240	1,590	1,840	2,170	2,440	10
15240000	Anchor R at Anchor Point	1,870	2,350	2,680	3,130	3,470	13
15240500	Cook Inlet tr nr Ninilchik	51.3	76.7	96.8	126	152	12
15241600	Ninilchik R at Ninilchik	598	899	1,140	1,490	1,800	15
15242000	Kasilof R nr Kasilof	7,980	9,850	11,100	12,800	14,100	26
15243950	Porcupine C nr Primrose	720	1,110	1,470	1,890	2,300	15
15244000	Ptarmigan C at Lawing	519	701	835	1,020	1,170	10
15246000	Grant C nr Moose Pass	960	1,350	1,650	2,080	2,430	10
15248000	Trail R nr Lawing	3,560	4,620	5,390	6,420	7,230	26
15250000	Falls C nr Lawing	261	474	669	994	1,300	10
15254000	Crescent C nr Cooper Landing	327	510	660	888	1,090	29
15258000	Kenai R at Cooper Landing	10,800	14,600	17,400	21,300	24,400	31
15260000	Cooper C nr Cooper Landing	293	406	491	610	707	11
15266300	Kenai R at Soldotna	20,000	26,300	30,800	37,000	41,900	13
15266500	Beaver C nr Kenai	130	272	410	684	990	10
15267900	Resurrection C nr Hope	1,250	1,970	2,560	3,460	4,260	10
15269500	Granite C nr Portage	928	1,500	1,970	2,710	3,370	11
15270400	Donaldson C nr Wibel	68.1	104	133	176	213	10
15271000	Cub C nr Sunrise	27.6	36.1	42.2	50.4	56.9	13
15272530	California C at Girdwood	210	410	605	944	1,280	11
15272550	Glacier C at Girdwood	2,410	4,640	6,790	10,600	14,100	13
15273900	SF Campbell C at canyon mouth nr Anchorage	214	299	362	452	526	11
15274000	SF Campbell C nr Anchorage	218	325	414	547	662	25
15274300	NF Campbell C nr Anchorage	62.5	85.4	102	126	145	11
15274600	Campbell C nr Spenard	250	344	414	513	593	12
15274800	SB SF Chester C nr Anchorage	23.1	38.1	50.9	71.0	89.1	10
15275000	Chester C at Anchorage	58.5	79.9	95.6	118	135	18
15275100	Chester C at Arctic Blvd at Anchorage	34.7	110	129	154	175	12
15276000	Ship C nr Anchorage	834	1,120	1,335	1,610	1,840	31
15277100	Eagle R at Eagle River	3,240	4,180	4,850	5,750	6,460	12
15277200	Meadow C at Eagle River	21.5	49.9	81.2	142	208	10
15281000	Knik R nr Palmer	32,500	30,400	42,300	47,200	50,900	12
15282000	Caribou C nr Sutton	4,620	6,010	6,990	8,330	9,380	23
15282400	Puritan C nr Sutton	24.6	49.5	74.3	118	162	14
15284000	Matanuska R at Palmer	23,900	29,000	32,500	36,900	40,300	25
15290000	Little Susitna R nr Palmer	1,970	3,030	3,890	5,190	6,320	29
15291000	Susitna R nr Denali	17,000	21,700	24,900	29,300	32,800	18
15291100	Raft C nr Denali	110	126	136	148	158	15
15291200	Maclaren R nr Paxson	5,600	6,960	7,900	9,130	10,100	20
15291500	Susitna R nr Cantwell	31,800	43,700	52,500	64,900	74,900	12
15292000	Susitna R at Gold Creek	48,500	64,200	75,600	91,000	103,000	28
15292400	Chulitna R nr Talkeetna	38,200	45,900	51,100	57,800	62,900	18
15292700	Talkeetna R nr Talkeetna	28,500	40,000	48,800	61,200	71,500	14
15292800	Montana C nr Montana	3,160	4,440	5,400	6,770	7,890	10
15293000	Caswell C nr Caswell	89.0	143	188	258	321	15
15294300	Skwentna R nr Skwentna	31,900	39,100	44,000	50,400	55,200	18
15294500	Chakachatna R nr Tyonek	15,200	18,300	20,400	23,100	25,100	11

MAXIMUM DISCHARGE

Floods in the Cook Inlet basin generally result from snow and ice melt or from rains. However, they also can result from a combination of these or from rarer causes such as glacier-dam breakouts (Post and Mayo, 1971). Discharge due to snow and ice melt is dependent on the water equivalent and areal extent of the snowpack, solar radiation to the snowpack, and air temperature. Snowmelt high flows may occur as early as late March on the Kenai lowlands or as late as mid-July in the upper elevations of glacial streams in the Susitna River drainage. A second type of high flow is associated with frontal rainstorms, which generally occur between August and October but in certain years may extend throughout the winter on the Kenai Peninsula. The year-to-year variation in maximum snowmelt peaks is smaller than that caused by rainstorms. As a general rule, the greatest floodflows are due to rainstorms in late summer or early fall. Smaller streams and streams near the Gulf of Alaska tend to have their annual maximum flow caused by summer or fall rainstorms, whereas annual maximum flow on large streams and streams in the upper Susitna River and Matanuska River drainages are generally caused by snow and ice melt.

There are 50 gaging stations in Cook Inlet basin that have 10 or more years of annual maximum discharge record through the 1977 water year. The peak discharges for recurrence intervals of 2-, 5-, 10-, 25-, and 50-years were computed for the 50 stations (U.S. Water Resources Council, 1977) and are shown in table 5. Curves of the peak discharges for recurrence intervals from 2 to 50 years for representative gaging stations area shown in figure 14.

The largest flows are associated with the larger drainage systems. However, peak unit runoff (peak discharge divided by drainage area) is greatest on smaller streams in the Kenai Mountains and the windward side of the Chugach Mountains. Records show that the expected unit runoff for a peak flow with a recurrence interval of 50 years generally exceeds 100 $(ft^3/s)/mi^2$ in these areas. In contrast, for small streams in the lowlands on the west side of the Kenai Peninsula, in the Anchorage lowlands, and in the low-lying areas of the Matanuska and Susitna valleys, the peak unit runoff which has a 50-year recurrence interval ranges from less than 10 to about 30 $(ft^3/s)/mi^2$.

To estimate floodflows in ungaged basins, a regression analysis was made using the peak discharges for recurrence intervals of 2-, 5-, 10-, 25-, and 50-years for the 50 Cook Inlet gaging stations and the basin and climatic characteristics as described in "Annual Discharge". The final regression equation takes the form: $Q_t = aA^b(LP + 1)^cP^d$

where

Q = dependent variable, the annual peak discharge in ft^3/s

t = recurrence interval, the average number of years between peak flows greater than Q.

The remaining items in the equation are the same as those described in "Monthly Discharge".

Only the independent variables that were statistically significant were used in the final equations. The results are given below.

Dependent Variable Q_t	Regression Constant a	Regression Coefficient b	c	d	Standard Error of Estimate +	−
Q_2	0.154	0.97	−0.31	1.28	56	36
Q_5	.275	.93	− .31	1.27	51	34
Q_{10}	.385	.90	− .32	1.26	52	34
Q_{25}	.565	.88	− .32	1.26	56	36
Q_{50}	.737	.86	− .33	1.25	61	38

Drainage area and annual precipitation are the most important factors in describing the expected peak discharges. The negative coefficient for lake and pond storage indicates the attenuating effect this storage has on the magnitude of flood discharge. The annual precipitation coefficient remains about constant in the five equations, but the drainage area coefficient decreases for the larger recurrence interval floods. Since the drainage area coefficients are less than 1.0, the peak unit runoff will decrease with an increase in the size of the drainage area for the same frequency flood.

The results of the regression equations were compared to flood frequency curves for each gaging station. The values of peak discharges from the frequency analysis for most gaging stations in the Anchorage area were significantly less than those obtained from the regression equation. For streams in the Anchorage area from Campbell Creek to Eagle River, for which there are records of at least 10 annual maximums, individual station frequency curves are more accurate than the results from the regression equations.

The annual maximum flows on the Knik River resulting from the outbreak of Lake George were not included in this study. Similarly, the August 1971 maximum discharge on the Matanuska River at Palmer which resulted from a breach of a lake outlet in the Granite Creek basin was not included. The August 1971 maximum discharge on the Chakachatna River near Tyonek which resulted from sudden release of water stored in Chakachamna Lake when a portion of the terminus of Barrier Glacier was eroded away was also not included in this study.

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WATER RESOURCES OF THE COOK INLET BASIN, ALASKA

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