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WATER RESOURCES DATA OF THE SEWARD AREA, ALASKA

U.S.Geological Survey Water Resources Investigations 79-11

Prepared in cooperation with the
City of Seward
Kenai Peninsula Borough
Alaska Department of Natural Resources
Division of Geological and Geophysical Surveys

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16. Abstracts

Seward obtains a water supply of about 2 million gallons per day primarily from Marathon Springs and the Fort Raymond well field. The springs have supplied up to 800 gallons per minute, and the city's deep wells currently have a combined capacity of about 3,000 gallons per minute. Fresh water is abundant in the area; future public supplies could be derived from both shallow and deep ground water and from stream impoundment with diversion. High deep-aquifer transmissivity at the Fort Raymond well field indicates that additional wells could be developed there. Water quality is generally not a problem for public consumption. A flood potential exists along several streams having broad alluvial fans.

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1979

UNITED STATES DEPARTMENT OF THE INTERIOR

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INCH-POUND UNITS AND SI UNITS EQUIVALENTS

Multiply inch-pound unit	By	To obtain SI unit
Length		Length
inch (in.)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
Area		Area
square mile (mi^2)	2.590	square kilometer (km^2)
Rate		Rate
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
million gallons per day (Mgal/d)	90.85	liter per second (L/s)
Transmissivity		Transmissivity
foot squared per day (ft^2/d)	0.09290	meter squared per day (m^2/d)

ABSTRACT

Favorable geohydrologic conditions in the Seward area provide several choices for developing additional water supplies. Abundant stream runoff and the prospects for expanded well-field development in the Jap Creek alluvial fan, as well as other similar fans, allow a selection of future water sources based on factors other than the availability of the natural resource. Although water in both streams and deep aquifers is of good potable quality, ground water has the inherent advantages of being free of suspended sediment, of being warmer during winter months, and of being less vulnerable to pollution. Shallow infiltration galleries constructed along the alluvial-fan reaches of some streams should provide large volumes of water for public supply.

A potential exists at Seward for serious flooding of the alluvial fans by the major streams, for coastal flooding by bay waters resulting from storm-driven waves or tsunamis, and for pollution of shallow ground water by onsite sewage disposal.

INTRODUCTION

Seward lies at the head of Resurrection Bay on the Gulf of Alaska (fig. 1), and is a major Alaskan seaport and the southern terminus of the Alaska Railroad. In 1975 Seward had an estimated population of 2,000 (Arctic Environmental Engineers, 1975). The principal industries are commercial fishing, seafood processing, transportation, tourism and timber processing. The city is the closest major port to the postulated outer-continental-shelf petroleum basins in the Gulf of Alaska and southern Cook Inlet. It is anticipated that Seward will soon be heavily stressing its present water-supply system and will have to construct additional supply facilities to support increased industrial activities.

The U.S. Geological Survey (referred to as the Survey hereafter) has collected water-resources data in the Seward area at various times since 1947. Intensive geologic and engineering investigations were also made after the 1964 earthquake (Lemke, 1967). The purpose of this report is to compile those hydrologic data and review the present development and use of Seward's water resources, and to describe alternative sources and methods for further development of supplies.

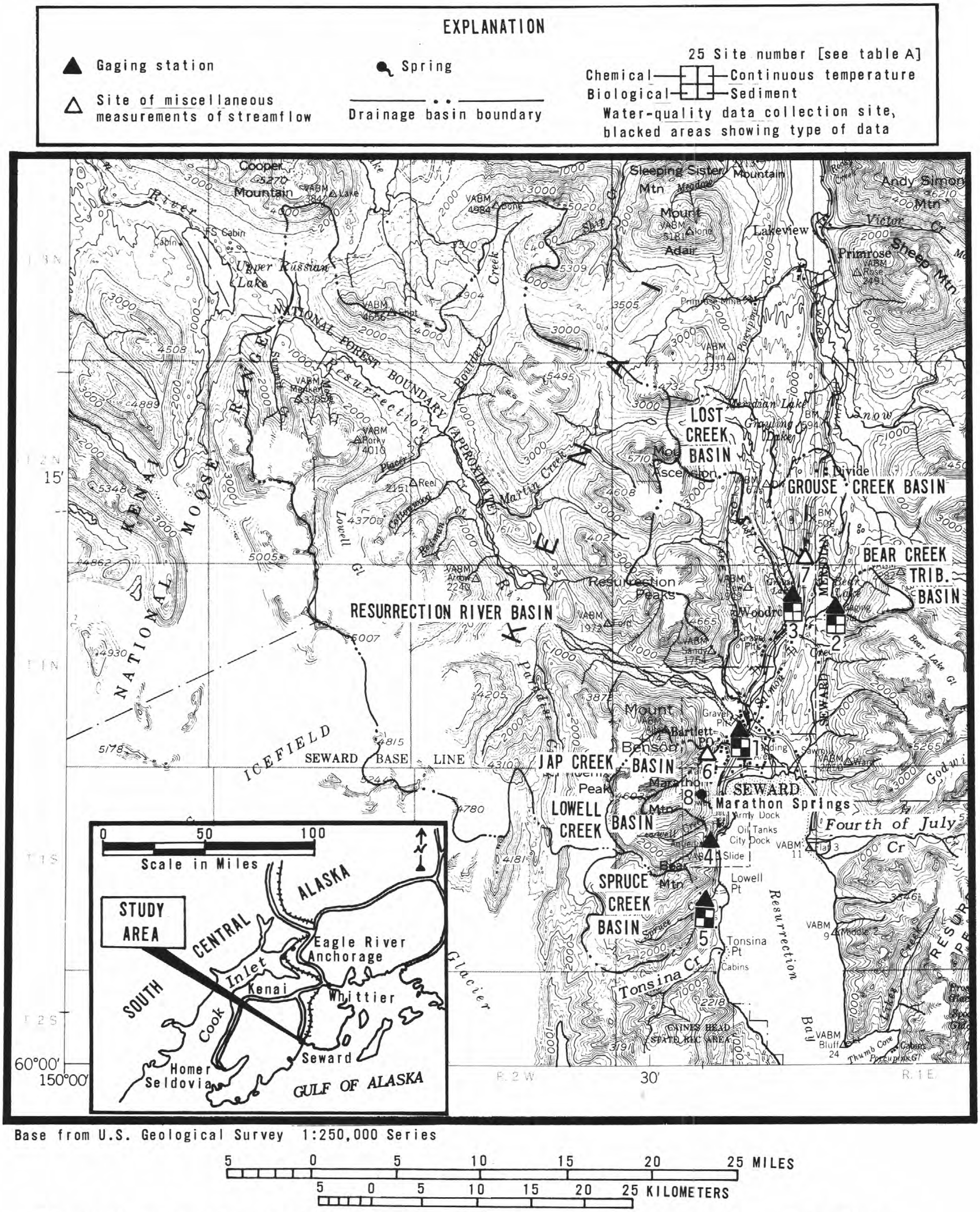
Wells are referred in this report by the Survey's unique five-digit numbers listed in an Alaska register, abbreviated AKRG. These numbers are cross-referenced to Alaska local well numbers (township, range and section system) in table 1.

The authors thank the well drillers who have made their logs available for this report. Also, we are grateful for the construction information for the new city wells supplied by Arctic Environmental Engineers.

HYDROLOGIC SETTING

Seward has a maritime climate, characterized by cool summers and mild winters. Windy or foggy weather is common because of the influence of the steep, rugged Kenai Mountains surrounding Seward on three sides and perennially ice-free Resurrection Bay to the south. Average annual precipitation at Seward is 63 inches (in.) (U.S. Department of Commerce, NOAA, 1977). This amount includes the water equivalent of 85 in. of snow. On the average the smallest amount of precipitation (2.3 in.) falls in June, while the greatest amount (10.0 in.) falls in October. Mean annual air temperature is $4^{o}C$, and average monthly temperatures are below freezing from November through March (U.S. Department of Commerce, unpublished climatological data summary, 1969).

The City of Seward lies in a deeply eroded glacial valley of the Kenai Mountains. Pleistocene glaciers scoured the Resurrection River valley and deep fiord that is now Resurrection Bay. The rugged Kenai Mountains, which rise abruptly to altitudes of 4,000-5,000 feet (ft) on either side of Resurrection Bay, have been dissected by side-valley



Base from U.S. Geological Survey 1:250,000 Series

Figure 1.--Location of Seward and nearby surface-water data-collection sites.

Table 1.--*Summary of data for wells in the Seward area.*

Alaska register number AKRG	Alaska local well number						Owner (original)	Depth of well (feet)*	Well finish (feet below land surface)	Casing diameter (inches)
	BQ	T	R	Sec	¼'s	Seq				
10778	SB	001	001	34	CADA	1	City of Seward			8
10779	SB	001	001	34	CADB	1	City of Seward	162?		8
10780	SB	001	001	34	CADB	2	City of Seward	185 D	173-183 SC	12
10781	SB	001	001	34	CADC	1	City of Seward			8
10782	SB	001	001	34	CADC	2	City of Seward	141 D	SC	8
10783	SC	001	001	09	DBCA	1	City of Seward	32.5 D	25-32 PF	8
10915	SB	001	001	12	DBDD	1	Kenai Lumber Co.	45 D	38-43 SC	6
10918	SB	001	001	27	AACD	1	Horton's Seafood	36		4
10943	SB	001	001	01	CDCA	1	Richard R. Ronne	32	32 OE	2
10944	SB	001	001	12	DBDD	2	Kenai Lumber Co.	35		6
10945	SB	001	001	12	DBBB	1	Murawsky	40		6
10946	SB	001	001	14	ACCA	1	Pete Kesselring	40		4
10947	SB	001	001	14	ADDB	1	F.H. Appleton	50		6
10948	SB	001	001	14	AAAB	1	Walter Bryan	40		6
10949	SB	001	001	14	DCDC	1	Irwin Metcalf	52		4
10950	SB	001	001	27	AABB	1	R.A. Gillespie	50		4
10952	SC	001	001	01	DADB	1	Shannon & Wilson	83 BD		6
10953	SC	001	001	02	BAAD	1	Shannon & Wilson	226 D		
10954	SC	001	001	03	ACBB	1	Shannon & Wilson	189.5 D		
10955	SC	001	001	03	ABDC	1	Shannon & Wilson	165 D		
10956	SC	001	001	03	ACBA	1	Shannon & Wilson	176.5 D		6

B = drilled into bedrock C = chemical analysis given in table 2
D = driller's log given in table B OE = open-ended casing
PF = perforated casing SC = screen finish UG = uncased hole
? = Questionable depth

Well production data			Static water level (feet below land surface)	Altitude at well (feet above mean sea level)	Year well drilled	Remarks
Yield (gal/min)	Drawdown (feet)	Test duration (hours)				
			20	34		Casing damaged by 1964 earthquake; C
557	7	20	21	41		Casing damaged by 1964 earthquake; C
850	38	22	20	41	1964	C
552		19	21	45		Casing damaged by 1964 earthquake
			20	46	1964	Water-level recorder installed in 1976
230	13	4.5	8	235	1961	Lowell Canyon no. 4
10	<1	2	8	250	1972	
			20	100	1954	C
			12	320	1950	
			22	250	1946	
			14	320	1959	
				150	1958	
			28	125	1955	
			24	140	1943	
			26	110	1962	
			30	95	1956	
			7	14	1964	Owner's no. S-103
2			flowing	10	1964	Owner's no. S-104
30			flowing	15	1964	Owner's no. S-101
25			+5	11	1964	Owner's no. S-102
100			+13	14	1964	Owner's no. S-107; C

Table 1.--*Summary of data for wells in the Seward area--continued.*

Alaska register number AKRG	Alaska local well number BQ T R Sec ¼'s Seq	Owner (original)	Dept of well (feet)*	Well finish (feet below land surface)	Casing diameter (inches)
10957	SC 001 001 09 DBCA 2	City of Seward	40	35-40 SC	8
10958	SC 001 001 09 DBCA 3	City of Seward	40	34-39 SC	8
10959	SC 001 001 09 DBCA 4	City of Seward	39	34-39 SC	8
10960	SC 001 001 09 DABC 1	City of Seward	17.5 BD		
10961	SC 001 001 09 ADDD 1	City of Seward	123 BD	113-123 SC	8
10962	SC 001 001 10 CADB 1	Shannon & Wilson	333 D		
10963	SC 001 001 10 BDAC 1	Shannon & Wilson	482 D		8 & 6
10964	SC 001 001 10 BABB 1	Shannon & Wilson	313 D		6
10965	SB 001 001 34 CADA 2	City of Seward	248?	SC	12
10966	SB 001 001 34 CADC 3	City of Seward	232?	SC	12
11235	SB 001 001 34 CACD 1	City of Seward	200	200 OE	6
11317	SB 001 001 34 CACD 2	City of Seward	206 D	170-197 SC	12
11361	SB 001 001 23 BDCC 1	Exxon	201 BD	42-201 UC	6

B = drilled into bedrock C = chemical analysis given in table 2
D = driller's log given in table B OE = open-ended casing
PF = perforated casing SC = screen finish UC = uncased hole
? = Questionable depth

Well production data			Static water level (feet below land surface)	Altitude at well (feet above mean sea level)	Year well drilled	Remarks
Yield (gal/min)	Drawdown (feet)	Test duration (hours)				
265	13	24	8	235	1964	Lowell Canyon no. 1
250	11	28	12	235	1964	Lowell Canyon no. 2
250	7	21	12	235	1964	Lowell Canyon no. 3
				188	1962	Lowell Canyon test hole 3
73	2.5	18	96	124	1961	At Hospital. Prior to 1965 well was 78 ft deep; C
				20	1964	Owner's no. S-100
			9	13	1964	Owner's no. S-105
48			12	12	1964	Owner's no. S-106
495				35	1964	
467		24		43	1964	Primary supply well; C
400			34	64	1977	Test well for production well no. 4
2070	80	12	40	70	1977	Production well no. 4
1+			10	100	1976	

glaciers and streams tributary to the main Resurrection River valley. These tributary streams have steep gradients and have deposited alluvial fans along the flanks of the mountains near Seward.

The Kenai Mountains are composed of metamorphic rock, namely graywacke and phyllite, which contain intrusions of igneous rocks (Lemke, 1967). Continual uplift and erosion of the mountains has filled the valley bottoms with unconsolidated sediments. Unconsolidated glacial and fluvial deposits now overlie bedrock nearly everywhere in the study area, except on the steep high-altitude slopes near Seward. The unconsolidated surficial deposits were mapped as five units: glacial deposits, alluvial fan and fan-delta deposits, valley alluvium, intertidal deposits, and landslide deposits (Lemke, 1967, and fig. 2). Fine-grained marine sediments are not exposed at the surface but have been identified in wells and test borings (Shannon and Wilson, Inc., 1964). The marine sediments intertongue with alluvial fan, fan-delta and valley allvium deposits.

WATER AVAILABILITY

Surface Water

The Resurrection River, which originates in glaciers and ice fields of the Kenai Mountains, is the major surface-water drainage system of the Seward area. The river flows in a U-shaped glacial valley along its lower course, where a braided channel pattern has developed, and has formed a delta at the head of Resurrection Bay.

Other significant streams in the Seward area (fig. 1) are Lowell Creek, which forms the alluvial fan on which Seward was founded; Jap Creek, which has formed a similar alluvial fan at the edge of Resurrection River flood plain; Spruce and Tonsina Creeks, both to the south of Seward; and Fourth of July Creek, across the bay from the city.

A compilation of Seward-area streamflow data collected by the Survey, including a monthly summary of data for continuous record sites, is presented in table A at the back of this report.

Ground Water

The locations of wells and test holes in the Seward area for which Survey information is available are shown in figure 3. A summary of data for these sites is included in table 1, and available driller's logs are given in table B.

Bedrock--Little hydrologic information is available concerning bedrock in the Seward area. The bedrock that forms the valley walls west of Seward probably extends beneath the fan deposits of Lowell Creek at about the same slope as above the fan, 30° to 40°. Bedrock probably lies more than 1,000 ft beneath most of the fan at the bay's edge (Lemke, 1967). A ridge of bedrock crops out at the north edge of the city. Bedrock was reached at about 113 ft in a water well drilled at the apex of Lowell Creek fan (well 10961, table 1). No hydrologic data were reported for the bedrock penetrated in that well.

Well 11361, located about 4 miles (mi) north of Seward in the valley floor, penetrated bedrock from 42 to 201 ft below land surface. This open-hole interval yielded just over 1 gallon per minute (gal/min) from fractures, mostly below 157 ft. The mineralogic composition of the rock was not recorded. Although fractured bedrock undoubtedly contains some water, the inherent hydraulic properties of typical Seward-area bedrock (graywacke and phyllite) severely limit the potential for successful development of any appreciable yield.

Unconsolidated deposits--Ground water occurs under both water-table (unconfined) and artesian (confined) conditions in unconsolidated deposits at the head of Resurrection Bay and in the mountain-front alluvial fans. Appreciable recharge to the shallow ground-water body occurs from streamflow losses through sand and gravel deposits of alluvial fans. During most winters, periods of no flow occur at the Survey's gaging station on Spruce Creek, 2 mi south of the city. However, some surface-water flow must occur upstream, and is subsequently lost to the ground-water system before reaching the gage. Winter visits to the gage in 1968, 1969, 1970, 1972, and 1975 found that all streamflow measured at the gage [as much as 15 cubic feet per second (ft^3/s)] infiltrated into the streambed in the downstream reach. Significant recharge probably occurs also from rainfall and snowmelt infiltration in the upper part of Resurrection River valley.

Because of the diversion of Lowell Creek in the early 1940's to eliminate a flood threat to the City of Seward, the creek no longer is a major source of recharge. Thus, ground-water levels (pressure heads) in the lower parts of the fan probably are not as high as they were before the creek was diverted. In test borings made along the Seward waterfront after the 1964 earthquake, water levels were approximately at sea level (about 10 ft below land surface) and fluctuated with the tide (Shannon and Wilson, Inc., 1964).

The water-level record from well 10782 in the Fort Raymond well field shows that in water-year 1977 the local ground-water system was recharged largely in late fall and early winter (fig. 4). Ground-water levels and streamflow responded quickly to most precipitation events throughout the year. However, ground-water levels, as represented by the 141-ft deep well, were not responsive to increasing streamflow (as indexed by the Spruce Creek hydrograph) caused by snowmelt in June and July when rainfall was low. Ground-water recharge from stream-channel losses may attain a maximum rate at relatively low stream discharges as allowed by conditions at the channel bed. The low ground-water levels during June and July 1977 may reflect a lack of aquifer recharge by direct infiltration of precipitation. Additional considerations are that channel losses in Jap Creek may not be as great as in Spruce Creek, or perhaps

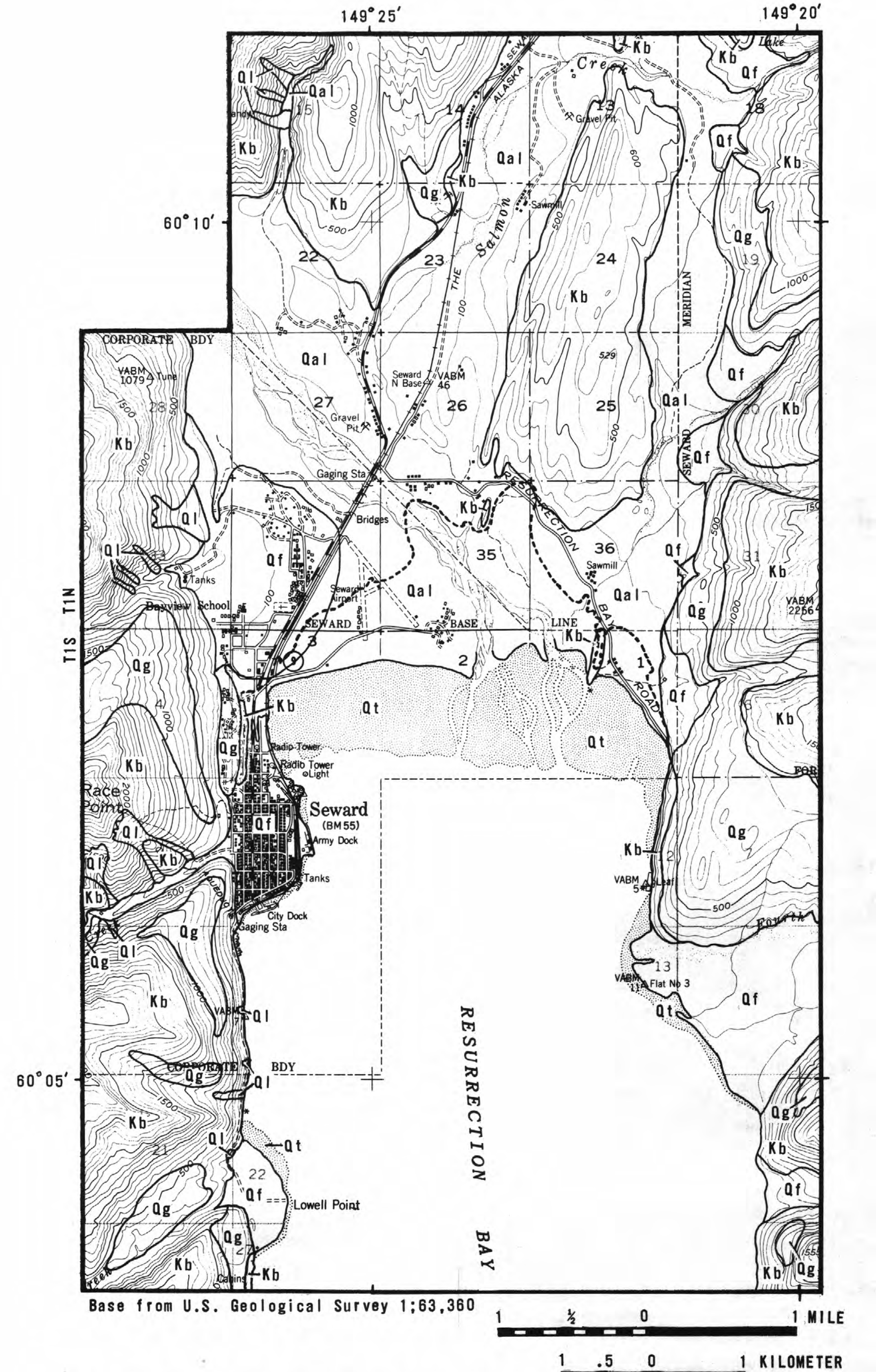


Figure 2.--Geologic map of the Seward area (modified from Lemke, 1967--USGS Prof. Paper 542-E; section of plate I).

EXPLANATION FOR FIGURE 2

Pleistocene and Holocene — Mostly contemporaneous — QUATERNARY

Ql

Landslide deposits

Mostly rockslide or debris-flow fragments and talus deposits that have moved by earthquake shaking. Include some preearthquake slide material

Qt

Intertidal deposits

Mostly silt, sand, and fine gravel constituting beach, deltaic, and estuarine sediments deposited on intertidal flats

Qal

Valley alluvium

Chiefly sand, fine to medium gravel; minor silt and cobbles; underlies valley floor of Resurrection River and larger tributaries

Qf

Alluvial-fan and fan-delta deposits

Chiefly loose sand, gravel, and silt; lesser amounts of cobbles and boulders; deposited as broad fans at the mouths of larger tributary valleys. Probably include drift, mudflows, and landslide deposits in some small poorly exposed fanlike features near mouths of smaller tributaries

Qg

Glacial deposits

Mostly till constituting morainal deposits and consisting predominantly of silt and sand with lesser amounts of gravel, cobbles, and boulders. Include some stratified ice-contact deposits, minor glacial outwash deposits, and small outcrops of bedrock

Upper Cretaceous — CRETACEOUS

Kb

Bedrock

Chiefly graywacke and phyllite; a few conglomeratic beds; includes small or thin deposits of drift

Contact

Dashed where approximately located; short dashed where inferred

Maximum runup of earthquake-induced sea waves

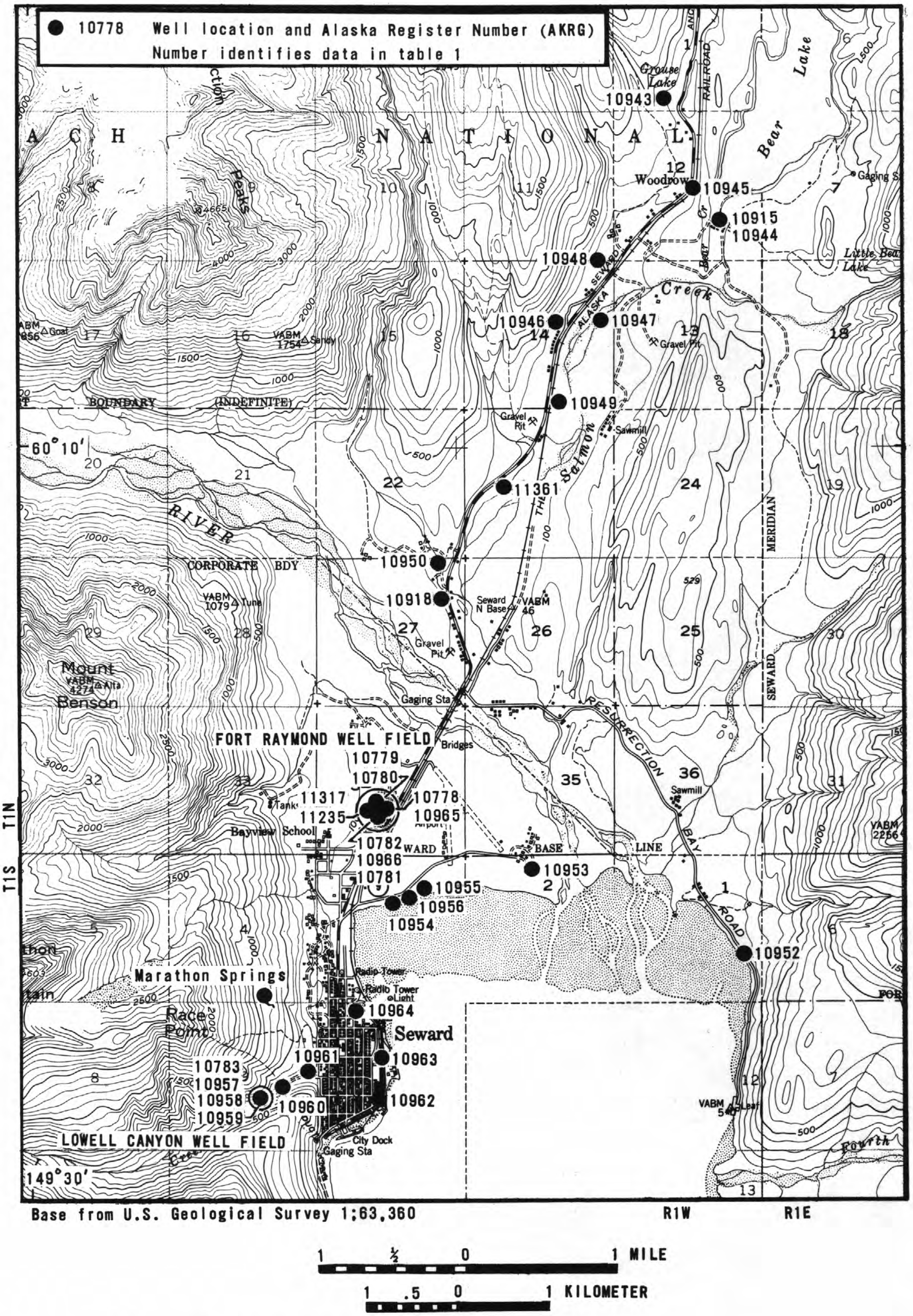


Figure 3.--Well locations in the Seward area.

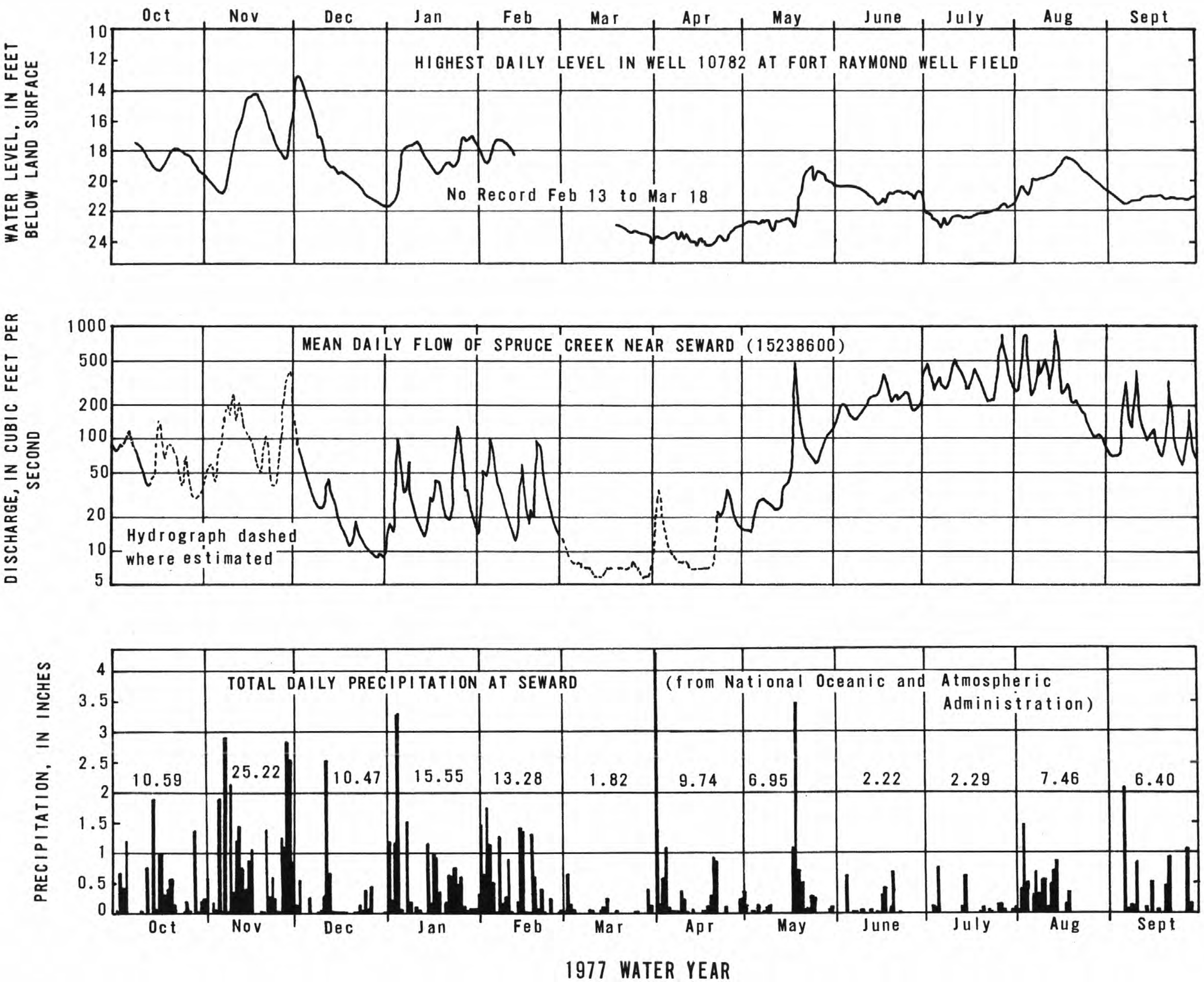


Figure 4.--Relation of precipitation, streamflow and ground-water levels in the Seward area.

the water-level observation well is too far from Jap Creek channel to be significantly influenced by streamflow losses. At this time the hydrologic factors controlling aquifer recharge are not completely understood.

Ground water is discharged from the unconsolidated aquifers by pumping, springs, seepage to streams, and submarine discharge to Resurrection Bay. Marathon Springs (fig. 3), which essentially is one point of discharge from a morainal ridge that forms a bench on the side of Marathon Mountain, presumably derives its water from a shallow-seated ground-water body whose recharge is closely related to the infiltration of precipitation upgradient from the spring outlet. The spring is used as a public water supply during summer months, but its flow decreases with the onset of subfreezing temperatures until it virtually ceases. The developed yield of Marathon Springs and major wells is discussed in the report under "Present Water Supply and Use".

Ground water is also discharged at numerous seeps and springs on the Resurrection River flood plain. Close to their tidewater mouths, streams regain some flow previously lost to ground water in their alluvial fans. The amount of return flow is unknown, as is the rate of ground-water movement from aquifers that discharge into the bay below sea level.

WATER QUALITY

The chemical composition of surface water and ground water in the Seward area can be characterized as dilute calcium-bicarbonate water. Dissolved solids concentrations range from 22 to 99 milligrams per liter (mg/L) in surface water and from 68 to 267 mg/L in the few analyses of ground water made by the Survey. Iron concentrations in some shallow ground waters exceed 1 mg/L and may make the water unsuitable for some purposes; the concentration was 17 mg/L in water from one well. Concentrations of the major chemical constituents and the physical characteristics of water sampled from wells and from streams are given in tables 2 and C, respectively.

Glacier-fed streams usually carry a relatively high concentration of suspended sediment, except during winter periods, as compared to nonglacial streams. Large glaciated areas are present in the Resurrection River drainage, and glaciers also occur in the Lowell Creek and Spruce Creek basins. Some suspended-sediment data for these streams are presented in table D.

PRESENT WATER SUPPLY AND USE

The public water supply at Seward is presently (1978) obtained from three sources: the Fort Raymond well field, the Lowell Canyon well field, and Marathon Springs. Private domestic supplies in areas not served by the municipal system are obtained principally from shallow wells.

Table 2.--*Major chemical constituents and physical characteristics of ground water.*

Parameter Sampling date	(units)	Well Number (AKRG) 10778 Feb. 1, 1954	10780 June 13, 1969	10783 Aug. 19, 1961	10918 Aug. 5, 1966	10956 Aug. 14, 1964	10961 Aug. 19, 1961	10966 Aug. 13, 1966	Marathon Springs* Aug. 19, 1961
Well opening	(ft below surface)	--	173-183	25-32	36	176.5	123	232?	0
Specific cond.	(μmhos @ 25°C)	222	133	116	138	250	217	245	123
Temperature	(°C)	--	--	--	5.0	--	--	5.0	3.0
Color	(platinum cobalt units)	--	0	0	--	--	0	10	0
Hardness, Ca-Mg	(mg/L)	106	60	52	--	98	86	64	53
Non-carbonate hardness	(mg/L)	0	15	13	--	--	14	15	10
Dissolved calcium	(mg/L)	32	23	19	--	30	27	20	20
Dissolved magnesium	(mg/L)	6.2	0.8	1.0	--	5.6	4.5	3.4	0.7
Dissolved sodium	(mg/L)	5.2	2.2	1.5	--	--	9.6	2.4	2.0
Dissolved potasium	(mg/L)	1.9	0.4	0.2	--	--	0.8	0.0	0.3
Bicarbonate	(mg/L)	138	55	47	--	--	88	60	53
Dissolved sulfate	(mg/L)	4.0	14	15	--	--	16	16	14
Dissolved chloride	(mg/L)	3.0	2.1	2.0	--	34	15	4.5	2.0
Dissolved fluoride	(mg/L)	--	0.1	0.0	--	--	0.0	0.1	0.0
Dissolved silica	(mg/L)	46	4.9	5.3	--	--	6.8	4.9	5.5
Total dissolved solids	(mg/L)	167	77	68	--	--	123	83	71
Dissolved nitrate, as NO_3	(mg/L)	0.30	2.6	1.0	--	--	0.50	1.3	0.70
Dissolved nitrate, as N	(mg/L)	0.07	0.59	0.23	--	--	0.12	0.30	0.16
Arsenic	(μg/L)	--	0	--	--	--	--	--	--
Iron	(μg/L)	17,000[t]	80[d]	20[d]	--	--	20[d]	400[d]	20[d]
Manganese	(μg/L)	390[d]	0[d]	0[d]	--	--	0[d]	--	0

* = spring discharge not measured on this data. (See measurements on p. 17)
t = total concentration
d = dissolved concentration

The Fort Raymond well field was originally developed by the U.S. Army in 1940, and prior to the 1964 earthquake the city acquired the three production wells. However, their casings were damaged beyond repair by the earthquake, and consequently, a new well about 200 ft in depth was drilled near each original production well. These new wells have a combined yield of about 1,500 gal/min, and presently are Seward's most reliable water source. The capacity will double when a newly completed production well (No. 11317) is joined to the existing water system.

Analyses of drawdown data from two pumping tests conducted by the City of Seward in 1977 indicate a pumped aquifer transmissivity in the range of 10,000 to 20,000 feet squared per day (ft^2/d). Greater refinement of transmissivity was not possible because of data interpretation problems caused by variable pumping rates, small drawdown in observation wells (the measurement of which was greatly complicated by externally-induced fluctuations), and relatively short duration of test pumping. Storage coefficients of the aquifer were calculated to fall in the order of 0.001 to 0.01 — these figures support data obtained during drilling of the wells that indicate that aquifer water is partially confined under pressure. Also, the shapes of drawdown and recovery curves suggest a stratified aquifer system that contains lenses of low permeability which retard the vertical flow of water induced by pumping. However, vertical leakage of water into the major aquifer 180 ft below land surface was sufficiently great that observed drawdowns within the well-field area during the pumping tests were substantially less than those expected for typical confined aquifers with the above transmissivity.

One year of continuous water-level record (fig. 4) at well 10782 indicates no sustained water-level decline has been caused by pumping at rates approaching 1,500 gal/min at times. Drawdown at this well, 85 ft east of the main production well (No. 10966), has remained less than 1 ft. On December 14, 1977, the new production well (No. 11317) was test pumped for 12 hours at an average rate of 2,070 gal/min, causing a drawdown of 1.4 ft in observation well 10782, about 415 ft away. Drawdown data of this test confirm that the well-field aquifer is capable of supporting several high-yield (1,000 to 3,000 gal/min) production wells.

Four wells, ranging in depth from 33 to 40 ft, were drilled in Lowell Creek canyon in 1961. Originally, three of these wells provided a combined flow 400 to 600 gal/min. However, this well field has not been dependable during late winter, and recent well failures have caused strong reliance to be placed on the Fort Raymond wells (Richard Lohman, Seward City Engineer, written commun., 1976). The unconsolidated sediments in the Lowell Creek canyon are thin and occupy a small area; thus, they provide only a small ground-water reservoir. Recharge to this aquifer occurs principally through the stream channel and, consequently, a significant reduction of flow in Lowell Creek occurs during the winter.

Marathon Springs was first developed as a water supply between the years 1904 and 1906 (Tryck, Nyman, and Assoc., 1961). The spring originates at the base of a moraine on the side of Mount Marathon (fig. 3). The surfacing water flows about one-fourth mile along a morainal bench on the side of the mountain and cascades over the escarpment of the bench to the collection point. The spring currently supplies as much as 800 gal/min (Arctic Environmental Engineers, 1975), but is generally capable of supplying greater quantities between May and October. However, there is little flow during winter months, and most emerging water freezes within a short distance after surfacing. The Survey measured flows of 265 and 495 gal/min in late 1972 at the source of the spring. (See table A.)

In addition to the three currently used municipal sources, the City of Seward has previously used streamflow diversions from Jap Creek and an unnamed tributary to the boat harbor lagoon (locally referred to as Rudolph, Scheffler, or Dairy Creek).

City records on the historic use of water by Seward were summarized by Arctic Environmental Engineers (1975). The city measured instantaneous flow at the pumphouses and recorded these figures as the average flow for one to several days. Total pumpage reached a maximum of about 2.5 million gallons per day (Mgal/d) in 1971, but was reduced significantly in 1973 when meters were installed at fish canneries, the area's major water users.

WATER-RELATED PROBLEMS

A potential for ground-water pollution is posed by the naturally high ground-water table in the Seward area, particularly along the flood plains of Resurrection River and Salmon Creek. This environmental condition, combined with the potential for leakage from sewer lines and seepage from septic-tank systems in areas not served by sewers, creates a likelihood for pollutants to enter the ground-water system. Also, there is no treatment of sewage by the city, and wastes are discharged directly into Resurrection Bay. The discharge of seafood-processing wastes to the bay is also a potential source of pollution.

Damaging floods have occurred in the past on Resurrection River and in the Salmon Creek valley (U.S. Army Corps of Engineers, 1975). In their report the Corps presents detailed maps showing the areas that might be inundated by floods of 100- and 500-year recurrence intervals in the Resurrection River and Salmon Creek drainages near Seward. Not surprisingly, the report indicates that larger floods than those in recent times are possible. The extent of potential property damage and the danger to lives would, of course, increase with increasing development in the flood plains of the streams unless preventative measures were taken.

A prior field reconnaissance by the Survey, described in a report published in 1975, delineated flood-prone areas (fig. 5) that extend beyond the map boundaries of the Corps of Engineers' report cited above. The Corps' maps should be utilized for design purposes as they resulted from actual field surveying. However, the potential of possible flooding on the Jap Creek fan should be considered as depicted in figure 5.

The Survey report points out that additional hazards are posed by potential snow and debris slides in the steep mountainous headwater areas of Lowell and Jap Creeks. Such events could temporarily impound water and lead to flooding of the downstream alluvial fan. In August 1966, a release of water impounded by a debris slide caused the reservoir level behind the diversion dam on Lowell Creek to rise within 2 ft of the dam's crest.

A flood-frequency analysis, showing recurrence interval versus discharge, is presented for Lost Creek and Spruce Creek (fig. 6). Annual maximum discharges determined at the respective gaging stations were analyzed using a log-Pearson type III distribution and a skew of 0.20 (R. D. Lamke, written commun., 1978). Although the drainage areas of basins above the gaging stations are similar, flood discharges for Spruce Creek are about four to five times greater than for Lost Creek. This difference is due in part to the storage effect of a sizeable lake in the headwaters of Lost Creek. Some difference in precipitation and runoff patterns must also exist owing to differences between basins with respect to proximity to the bay (fig. 1).

There is also a potential for minor coastal flooding from storm-driven waves at Seward. Major damage from tsunamis, such as those that followed the 1964 earthquake (Lemke, 1967), is also possible (fig. 2).

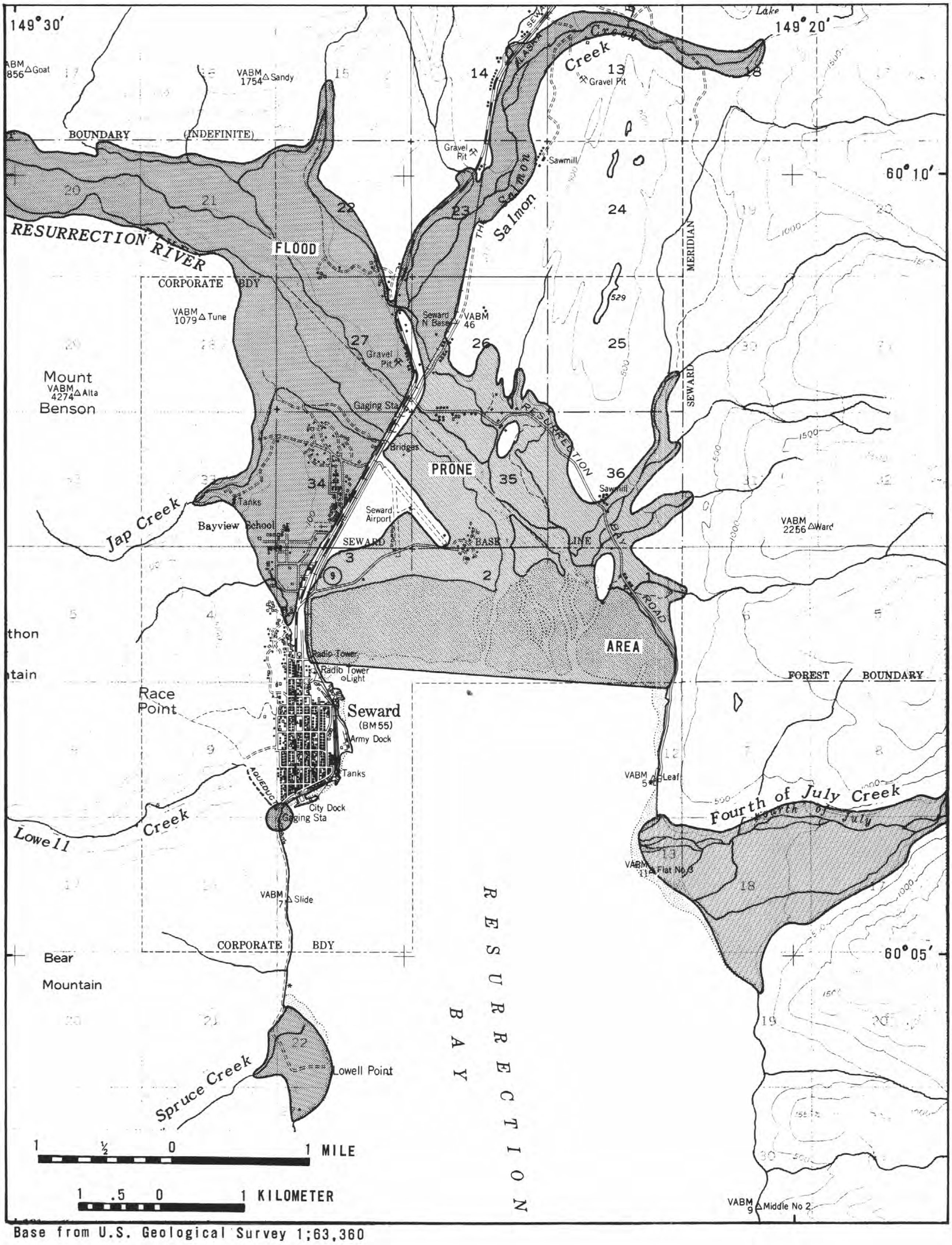
CONSIDERATIONS FOR WATER-SUPPLY DEVELOPMENT

Both surface water and ground water are abundant in the Seward area. Thus, the choice of which source to develop will probably depend on the economics of water collection, treatment and distribution. Because it is readily available and visible, surface water has been the choice for water supply in many rural Alaskan communities. However, ground water offers these important advantages:

(1) It is not subject to freezing as are Marathon Springs and surface-water sources.

(2) On an annual basis, ground water is usually of more uniform qualilty and temperature and is not as vulnerable to pollution as is surface water.

(3) Ground water is free of suspended sediment that is present at least part of the year in glacier-fed streams, such as Resurrection River.



Base from U.S. Geological Survey 1;63,360

Figure 5.--Flood prone areas at Seward (U.S. Geol. Survey, 1975).

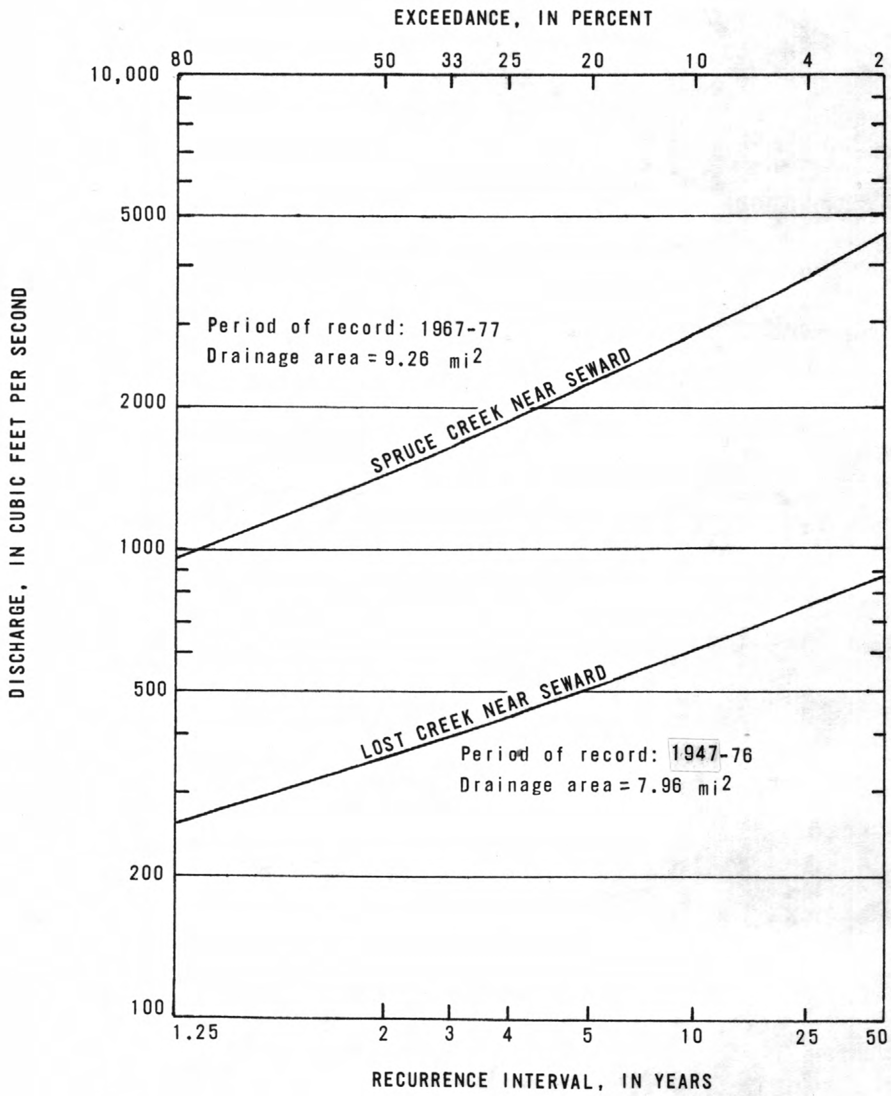


Figure 6.--Flood-frequency curves computed from annual maximum discharges (see table A).

In addition to the ground water already developed in Jap Creek fan, several other areas near Seward appear promising for ground-water development. The Resurrection River valley alluvium, the alluvial fans of Spruce Creek and Fourth of July Creek, and other areas on the Jap Creek fan besides the present well field probably have saturated sediments that are sufficiently thick and permeable to support the required yield of city production wells.

The rapid movement of water from streams into the ground-water body in unconsolidated fan deposits near Seward offers an alternative method of developing ground water. Infiltration galleries, utilizing large-diameter perforated collector pipes and installed either vertically or horizontally in alluvial deposits (Feulner, 1964), could be used to develop water supplies from shallow aquifers along the losing reaches of Jap, Lowell, or Spruce Creeks. Ground water collected in this way generally requires treatment for bacterial contamination similar to that required for surface water.

The water resources of the Seward area have a potentially high value for fish propagation (E. T. McHenry, Alaska Department of Fish and Game, oral commun., 1977). Additional fish spawning and rearing areas could be developed on the Resurrection River flood plain through planned mining of gravel in areas where the water table is shallow. Pits could be excavated deep enough to prevent winter fish kill by freezing, and channels could be constructed so as to connect the pits to an active stream channel. The channels could be designed as ground-water drains which would maintain relatively uniform winter flow and temperature. Additional data may be required to locate areas where the seasonal fluctuation of the water table is small and the sediments have the necessary permeability to provide the flow required for fish culturing.

SUMMARY

* Seward has climatic and geologic conditions that provide abundant surface-water and ground-water resources. The water is generally of drinking-water quality except for suspended sediment in glacier-fed streams and iron in shallow ground water in some areas.

* Several potential water-related problems exist; namely, ground-water pollution by onsite sewage disposal in areas of high water table, flooding along several rivers (particularily those where snow and debris slides in the steep mountain drainages occasionally occur), and coastal flooding from storm-driven waves and tsunamis.

* The city water supply is presently (1978) obtained from three sources: the Fort Raymond and Lowell Canyon well fields and Marathon Springs.

* The Fort Raymond well field is the most dependable of the three sources. The Jap Creek alluvial-fan aquifer is capable of supporting additional production wells.

* Other water-supply sources that could be developed are: (1) sand and gravel aquifers in the alluvial fan areas of several creeks, (2) stream diversions with adequate reservoir impoundment, and (3) shallow infiltration galleries along the alluvial-fan reaches of Jap Creek, Lowell Creek or Spruce Creek. Selection of which source to utilize will depend largely on the economics of water collection, treatment, and distribution.

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SUPPLEMENTAL DATA

Table A.--*Discharge data for selected Seward area streams.*

Map No.	Station number or latitude-longitude	Name	Period of record	Page
		Continuous record stations		
1*+	15237700	Resurrection R nr Seward	1964-68	25
2*	15237800	Bear Cr Trib nr Seward	1966-68	26
3*	15238000	Lost Cr nr Seward	1948-50	27
4	15238500	Lowell Cr at Seward	1965-68	28
5*+	15238600	Spruce Cr nr Seward	1967-	29
		Miscellaneous measurement sites		
6	60°07'59"149°27'23"	Jap Cr nr Seward	1972	30
7	60°12'40"149°22'06"	Grouse Cr nr Seward	1969	30
8	60°06'46"149°27'18"	Marathon Springs	1972	30

* data included in table C
\+ data included in table D

Table A.--*Discharge data for selected Seward area streams*--Continued.

15237700 Resurrection River near Seward.

LOCATION.--Lat 60°08'34", long 149°24'58", in SE¼ sec.27, T.1 N., R.1 W., on left channel on downstream side of Alaska Railroad bridge near right bank, 0.8 mile upstream from Salmon Creek, and 2.5 miles northeast of Seward. (See fig. 1, map no. 1.)

BASIN CHARACTERISTICS.--Drainage area, 169 mi^2; main-channel slope, 38.5 ft/mi; stream length, 23.5 mi; area of lakes and ponds, 0 percent; mean elevation, 2270 ft; glacier area, 22 percent.

PERIOD OF RECORD.--October 1964 to June 1968.

GAGE.--Nonrecording gage. Altitude of gage is 20 ft, from topographic map. Prior to June 11, 1965, water-stage recorder 13 ft upstream at same datum.

EXTREMES.-- Period of record: Maximum discharge, 18,900 ft^3/s about August 21, 1966 (gage height, 10.68 ft, from floodmarks); minimum daily, 60 ft^3/s March 11-22, 1966.

Monthly and yearly mean discharge, (ft^3/s)

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	The year
1965	1,178	680	265	179	124	220	338	764	2,179	3,294	2,439	2,409	1,178
1966	850	182	119	95.2	96.1	68.2	98.2	351	1,830	2,568	4,271	5,745	1,360
1967	1,179	370	175	130	115	103	119	673	1,866	2,529	3,221	4,140	1,223
1968	662	685	384	295	321	216	163	886	2,268	---	---	---	---

Water year	Annual maximum discharge			Annual minimum discharge	
	Discharge (ft^3/s)	Gage height (ft)	Date	Discharge (ft^3/s)	Date
1965	6,660	8.20	Sept. 23, 1965	102	Feb. 27, 1965
1966	18,900	10.68	Aug. 21, 1966	60	Mar. 11-22, 1966
1967	18,000	10.51	Sept. 18, 1967	99	Apr. 6, 1967

Table A.--*Discharge data for selected Seward area streams*--Continued.

15237800 Bear Creek Tributary near Seward

LOCATION.--Lat 60°11'35", long 149°20'20", in NE¼ sec.7, T.1 N., R.1 E., on right bank, 0.3 mile upstream from Bear Lake, and 7 miles northeast of Seward. (See fig. 1, map no. 2.)

DRAINAGE AREA.--1.63 square miles (mi^2)

PERIOD OF RECORD.--October 1966 to September 1968.

GAGE.--Water-stage recorder. Altitude of gage is 400 ft, from topographic map.

EXTREMES.--Period of record: Maximum discharge, 134 ft^3/s September 7, 1967 (gage height, 4.11 ft); minimum, 1.8 ft^3/s April 16-21, 1968.

Monthly and yearly mean discharge, (ft^3/s)

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	The year
1967	13.0	6.27	4.57	2.97	2.83	2.73	2.57	9.95	13.9	13.9	18.4	25.2	9.72
1968	12.8	10.7	7.09	4.55	4.82	5.38	2.31	11.4	12.2	15.5	14.6	5.65	8.96

Water year	Annual maximum discharge			Annual minimum discharge	
	Discharge (ft^3/s)	Gage height (ft)	Date	Discharge (ft^3/s)	Date
1967	134	4.11	Sept. 7, 1967	2.1	Jan. 20, 1966
1968	44	3.43	Aug. 20, 1968	1.8	Apr. 16-21, 1968

Table A.--*Discharge data for selected Seward area streams*-- Continued.

15238000 Lost Creek near Seward

LOCATION.--Lat 60°11'50", long 149°22'30", in NW¼ sec.12, T.1 N., R.1 W., on left bank 0.2 mile upstream from unnamed tributary, 4.9 miles downstream from outlet of lower Lost Lake, and 6.5 miles northeast of Seward. (See fig. 1, map no. 3.)

BASIN CHARACTERISTICS.--Drainage area, 7.96 mi^2; main-channel slope, 246 ft/mi; stream length, 8.1 mi; area of lakes and ponds, 7 percent; mean elevation, 2210 ft; glacier area, 0 percent.

PERIOD OF RECORD.--August 1948 to March 1950. Annual maximums, water years 1963-72, 1976.

GAGE.--Nonrecording gage. Crest-stage gage only May 1963 to October 1972. Altitude of gage is 300 ft, from topographic map.

EXTREMES.--Maximum discharge, 920 ft^3/s September 20, 1976, determined from slope-area computation using high-water marks (gage height, 12.33 ft; no flow for many days most years.

Monthly and yearly mean discharge, (ft^3/s)

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	The year
1948	---	---	---	---	---	---	---	---	---	---	27.8	27.8	---
1949	47.5	17.0	3.06	1.16	.536	1.19	3.00	38.2	156	79.1	43.1	97.1	40.6
1950	31.9	39.0	7.74	0	0	0	---	---	---	---	---	---	---

Water year	Annual maximum discharge		
	Discharge (ft^3/s)	Gage height (ft)	Date
1949	280	*1.35	Sept. 27, 1949
1963	250	10.70	July, 1963
1964	310	11.17	June, 1964
1965	240	10.99	Sept. 23, 1965
1966	300	11.13	Aug. 21, 1966
1967	530	11.57	Sept. 1967
1968	224	10.53	June 20, 1968
1969	400	11.34	June 1969
1970	619	11.68	Oct. 11, 1970
1971	350	10.80	Oct. 31, 1971
1972	370	10.30	Sept. 3, 1972
1976	**920	12.30	Sept. 20, 1976

*this gage datum not continued
**determined from slope-area computation

See fig. 6 for flood-frequency curve.

Miscellaneous measurements			
Date	Discharge (ft^3/s)	Date	Discharge (ft^3/s)
Aug. 21, 1947	16.8	Aug. 3, 1967	53.7
Aug. 25, 1947	54.0	Sept. 8, 1967	248
Feb. 16, 1948	0	Oct. 18, 1967	22.6
Oct. 4, 1950	24.0	June 20, 1968	244
Nov. 9, 1950	0	Aug. 3, 1968	29.4
Jan. 30, 1951	0	Oct. 24, 1968	8.0
Mar. 30, 1951	0	May 6, 1969	4.4
May 31, 1951	69.1	July 29, 1969	34.4
July 6, 1951	134	Sept. 11, 1969	15.9
July 24, 1951	36.4	Oct. 11, 1969	619
Aug. 25, 1951	26.4	June 23, 1970	201
May 31, 1963	227	Aug. 10, 1970	100
July 11, 1963	100	Nov. 11, 1970	49.0
Sept. 30, 1963	59.4	May 12, 1971	0
June 3, 1964	103	Nov. 12, 1971	7.8
June 20, 1964	194	May 23, 1972	12.8
Sept. 28, 1965	100	July 11, 1972	142
June 10, 1966	196	Sept. 1, 1972	32.1
July 16, 1966	65.6	Sept. 26, 1972	20.5
Sept. 22, 1966	107		

Table A.--*Discharge data for selected Seward area streams*--Continued.

15238500 Lowell Creek at Seward

LOCATION.--Lat 60°05'55", long 149°26'35", on left bank near mouth of diversion aqueduct, and at south edge of Seward. (See fig. 1, map no. 4.)

DRAINAGE AREA.--4.02 mi^2.

PERIOD OF RECORD.--May 1965 to September 1968.

GAGE.--Water-stage recorder. Altitude of gage is 5 ft, from topographic map.

EXTREMES.--Discharges represent entire flow of creek above diversion dam as measured just downstream of waters exit from diversion tunnel, constructed in the 1940's. Low-flow may be affected by ground-water pumpage from the basin above diversion dam. Discharge measurements at this site since gage was discontinued September 1968, are as follows: April 25, 1972, 3.6 ft^3/s and November 28, 1972, 11 ft^3/s.

Monthly and yearly mean discharge, (ft^3/s)

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	The year
1965	---	---	---	---	---	---	---	21.5	53.0	75.0	69.2	83.1	---
1966	55.1	12.9	3.84	1.67	2.96	1.81	6.44	17.5	44.6	64.9	139	169	43.5
1967	68.2	19.0	9.34	6.69	3.62	3.50	8.79	42.9	55.9	60.7	99.8	137	43.1
1968	40.7	37.6	16.3	9.55	10.6	10.1	5.99	35.9	59.9	61.7	46.1	31.1	30.5

	Annual maximum discharge			Annual minimum discharge	
Water year	Discharge (ft^3/s)	Gage height (ft)	Date	Discharge (ft^3/s)	Date
1966	1,200	---	Aug. 21, 1966	1.0	Jan. 2-4, 6, 7, 1966
1967	410	5.45	Sept. 26, 1967	3.5	Feb. 5 to Apr. 1, 1967
1968	140	3.65	Nov. 3, 1967	4.2	Apr. 15-16, 1968

Table A.--*Discharge data for selected Seward area streams*--Continued.

15238600 Spruce Creek near Seward

LOCATION.--Lat 60°04'10", long 149°27'08", on left bank, 0.7 mile upstream from Resurrection Bay, and 2.4 miles south of Seward. (See fig. 1, map no. 5.)

BASIN CHARACTERISTICS.--Drainage area, 9.26 mi^2; main-channel slope, 507 ft/mi; stream length, 5.5 mi; area of lakes and ponds 0 percent; mean elevation, 1990 ft; glacier area, 8 percent.

PERIOD OF RECORD.--September 1967 to current year.

GAGE.--Water-stage recorder. Altitude of gage is 75 ft, from topographic map.

EXTREMES.--Maximum discharge, 2,720 ft^3/s October 11, 1969 (gage height, 8.53 ft), from rating curve extended above 900 ft^3/s on basis of slope-area determination of peak flow; no flow for many days most years. Flood of August 21, 1966 reached a stage of 10.1 ft, from floodmarks (discharge, 3,980 ft^3/s).

Monthly and yearly mean discharge, (ft^3/s)

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	The year
1967	---	---	---	---	---	---	---	---	---	---	---	351	---
1968	41.0	57.9	14.4	10.2	10.5	8.55	4.51	100	171	132	72.5	55.9	56.6
1969	47.7	17.6	5.42	1.16	1.00	.19	35.6	74.1	298	137	56.9	56.2	60.9
1970	333	62.6	51.1	15.1	31.2	15.3	15.1	54.8	186	213	218	96.4	108.0
1971	68.7	59.8	12.0	6.28	2.39	0	1.27	30.6	142	234	169	82.5	67.8
1972	59.1	11.9	4.03	1.34	0	0	.12	44.4	116	152	116	188	57.7
1973	90.4	17.4	5.24	1.15	0	0	9.58	51.4	146	190	117	117	62.5
1974	37.9	9.4	4.02	.65	0	0	4.70	65.0	161	110	77.2	220	57.6
1975	104	46.9	17.1	9.19	3.64	.23	1.62	59.2	193	227	86.1	220	80.8
1976	111	12.6	4.61	2.94	1.45	0	8.73	34.6	224	176	131	273	81.5
1977	68.6	129	33.5	37.8	37.6	7.3	14.7	70.8	240	371	323	139	123
Ave.	96.1	51.4	15.1	8.58	8.78	3.16	9.59	58.5	188	194	137	164	75.6

Water year	Annual maximum discharge			Annual minimum discharge	
	Discharge (ft^3/s)	Gage height (ft)	Date	Discharge (ft^3/s)	Date
1968	614	5.99	Nov. 3, 1967	3.3	Apr. 18-19, 1968
1969	1,070	6.70	June 17, 1969	0	Mar. 1-25, 1969
1970	2,200	8.53	Oct. 11, 1969	10	Many days, Jan. to Apr. 1970
1971	580	5.72	Oct. 31, 1970	0	Mar. 1 to Apr. 4, 1971
1972	1,680	7.83	Sept. 3, 1972	0	Feb. 1 to Apr. 24, 1972
1973	1,120	6.77	Oct. 16, 1972	0	Jan. 23 to Apr. 3, 1973
1974	1,900	8.10	Sept. 20, 1974	0	Jan. 13 to Apr. 11, 1974
1975	1,160	7.13	Sept. 10, 1975	0	Mar. 6 to Apr. 15, 1975
1976	2,770	9.49	Sept. 20, 1976	0	Feb. 24 to Apr. 11, 1976
1977	1,510	7.68	Aug. 14, 1977	6.0	Mar. 11-14, 27-29, 1977

See fig. 6 for flood-frequency curve.

Table A.--*Discharge data for selected Seward area streams* --Continued.

Miscellaneous Measurements Sites

Stream	Location	Drainage Area (mi^2)	Date Measured	Discharge (ft^3/s)
Jap C nr Seward	Lat 60°07'59", long 149°27'23" nr canyon mouth and 1.8 miles northeast of Seward. (See fig. 1, map no. 6.)	3.05	Nov. 29, 1972	6.8
Grouse C nr Seward	Lat 60°12'40", long 149°22'06", in NE¼ sec.1, T.1 N., R.1 W., at bridge on Seward-Anchorage highway and 7.5 miles northeast of Seward. (See fig. 1, map no. 7.)	5.32	May 23, 1969	80.5
Marathon Springs	Lat 60°06'46", long 149°27'18", at spring, 0.7 mile upstream fromm Resurrection Bay, and 0.6 mile northeast of Seward. (See fig. 1, map no. 8.)	--	Sept. 26, 1972 Nov. 29, 1972	1.1 .59

Table B.--*Drillers' logs of wells in the Seward area.*

Well: 10780 (SB00100134CADB2)
Owner: City of Seward
Driller: Clemenson Drilling Co.

Material	Thickness (feet)	Depth (feet)
Gravel, sandy	20	20
Clay, gravelly	15	35
Clay, sandy	10	45
Gravel, clayey	7	52
Gravel, sandy; water-bearing	6	58
Gravel, clayey	2	60
Gravel, silty, sandy; water-bearing	5	65
Gravel, clayey	30	95
Gravel, sandy; water-bearing	5	100
Clay, gravelly	15	115
Silt, sandy, clayey	5	120
Sand, silty, sandy; water-bearing.	5	125
Sand, gravelly; water-bearing	5	130
Gravel, clayey	15	145
No record	25	170
Sand, silty	5	175
Sand, gravelly; water-bearing	5	180
Sand, silty, gravelly	3	183
Sand	2	185

Well: 10782 (SB00100134CADC2)
Owner: City of Seward
Driller: Clemenson Drilling Co.

No record	32	32
Sand, gravelly	6	38
Sand and gravel, silty	4	42
Sand, gravelly	16	58
Sand, gravelly, silty	4	62
Sand, gravelly	39	101
Sand, gravelly, silty	6	107
Sand, gravelly	12	119
Sand and gravel, silty	4	123
Sand, gravelly	7	130
Sand, gravelly, silty	11	141

Table B.--*Drillers' logs of wells in the Seward area*.--Continued.

Well: 10783 (SC00100109DBCA1)
Owner: City of Seward
Driller: Western Drilling Co.

Material	Thickness (feet)	Depth (feet)
Shale, black	13	13
Boulders	4	17
Shale, black	2	19
Boulders, small; water-bearing	3	22
Shale, black	2	24
Till, gray; water-bearing	3	27
Gravel and boulders, some black sand	2	29
Boulder	1	30
Boulders, black sand; water-bearing	2.5	32.5

Well: 10915 (SB00100112DBDD1)
Owner: Kenai Lumber Co.
Driller: Frank Kraxberger

Material	Thickness (feet)	Depth (feet)
Gravel fill	2	2
Mud	10	12
Sand and gravel	25	37
Sand; water-bearing	8	45

Well: 10952 (SC00100101DADB1)
Owner: Shannon and Wilson

Material	Thickness (feet)	Depth (feet)
Sand and gravel	15	15
Silt, sandy, organic	2	17
Sand and gravel	51	68
Phyllite bedrock	15	83

Well: 10953 (SC00100102BAAD1)
Owner: Shannon and Wilson

Material	Thickness (feet)	Depth (feet)
Sand and gravel	35	35
Sand, fine to very fine, alternating with clayey to fine sandy-silt zones	85	120
Sand and gravel	106	226

Table B.--*Drillers' logs of wells in the Seward area.*--Continued.

Well: 10954 (SC00100103ACBB1)
Owner: Shannon and Wilson

Material	Thickness (feet)	Depth (feet)
Sand and gravel	6	6
Clay, peat, and wood	2	8
Sand and gravel	32	40
Sand, black, silty, fine	4	44
Sand and gravel, some slightly clayey silt	10	54
Sand, black, silty, medium to fine	6	60
Silt, black, organic, slightly clayey, some sand and gravel, trace of shells	30	90
Sand, black, silty, fine, trace of coarse sand and shells	38	128
Sand, gray-brown-green silty, fine, with coarse sand and gravel, trace organics	28	156
Sand and gravel	33.5	189.5

Well: 10955 (SC00100103ABCD1)
Owner: Shannon and Wilson

Material	Thickness (feet)	Depth (feet)
Sand and gravel	39	39
Sand, black, silty, fine to very fine, trace of shells, few seams of slightly clayey silt	96	135
Sand and gravel	30	165

Well: 10956 (SC00100103ACBA1)
Owner: Shannon and Wilson

Material	Thickness (feet)	Depth (feet)
Sand and gravel fill	8	8
Peat	1	9
Sand and gravel	33	42
Silt, black, organic, fine, sandy, alternating with medium to fine sand, some gravel, trace of shells	98	140
Sand and gravel	36.5	176.5

Table B.--*Drillers' logs of wells in the Seward area.*--Continued.

Well: 10960 (SC00100109DABC1)
Owner: City of Seward
Driller: Western Drilling Co.

Material	Thickness (feet)	Depth (feet)
Shale and boulders................	9	9
Shale, gravelly..................	5	14
Boulders.........................	1	15
Shale and gravel; water-bearing...	3	17.5
Bedrock..........................		17.5

Well: 10961 (SC00100109ADDD1)
Owner: Seward Hospital
Driller: Corps of Engineers

Gravel, silty, sandy, black, a few small boulders..................	20	20
Boulders.........................	5	25
Gravel, silty, sandy, numerous boulders.......................	38	63
Boulders.........................	4	67
Gravel, silty, sandy, boulders.....	3	70
Boulders.........................	2	72
Sand, gravelly, black............	6	78
Gravel, silty, sandy, boulders....	12	90
Sand, silty; water-bearing........	2	92
Silt, gravelly...................	2	94
Sand, gravelly; water-bearing.....	2	96
Gravel, silty, small boulders.....	2	98
Sand, gravelly; water-bearing.....	6	104
Sand, silty, gravelly, occasional boulders.......................	2	106
Sand, gravelly, silty............	1	107
Clay, gravelly...................	2	109
Sand, gravelly; water-bearing.....	3	112
Gravel, silty....................	2	114
Boulders with sand and gravel; water-bearing..................	4	118
Rock, highly weathered and fractured, sand and silt in fractures; water-bearing........	5	123

Table B.--*Drillers' logs of wells in the Seward area.*--Continued.

Well: 10962 (SC00100110CADB1)
Owner: Shannon and Wilson

Material	Thickness (feet)	Depth (feet)
Sand and gravel fill..............	4	4
Sand, silty.......................	2	6
Sand and gravel...................	286	292
Silt, gray-black, clayey, sand and gravel, thinly stratified, thin layer of black organic silt, trace of shells...........	14	306
Sand and gravel...................	27	333

Well: 10963 (SC00100110BDAC1)
Owner: Shannon and Wilson

Material	Thickness (feet)	Depth (feet)
Sand and gravel...................	25	25
Sand, medium to fine, silt, clayey silt, sand and gravel, some thinly laminated zones..........	27	52
Sand and gravel, occasional stringers of stratified gray-yellow silt, black organic silt, fine black sand.....................	148	200
Sand and gravel...................	98	298
Silt, slightly organic, clayey, silty, coarse to fine sand lenses..........................	14	312
Sand and gravel...................	170	482

Well: 10964 (SC00100110BABB1)
Owner: Shannon and Wilson

Material	Thickness (feet)	Depth (feet)
Sand and gravel...................	80	80
Sand, black, medium, sand and gravel, clayey to sandy silt....	25	105
Silt, gray-black, clayey, trace of shells and organics, some thin sand and gravel stringers.......	145	250
Silt, gray-black, sandy to slightly clayey silt, trace of shells and organics, some sand zones..........................	63	313

Table B.--*Drillers' logs of wells in the Seward area*.--Continued.

Well: 11317 (SB00100134CAD2)
Owner: City of Seward
Driller: Western States Associates

Material	Thickness (feet)	Depth (feet)
Silt and gravel	81	81
Gravel, coarse to fine, sand	37	118
Gravel and sand, with clay	4	122
Gravel and sand; water-bearing	4	126
Gravel, sandy with clay	25	151
Clay, with gravel seams; not water-bearing	19	170
Sand, fine; water-bearing	8	178
Sand and gravel; water-bearing	13	191
Sand and gravel, very silty; not water-bearing	2	193
Sand and gravel; water-bearing	7	200
Clay, with gravel; not water-bearing	6	206

Well: 11361 (SB00100123BDCC1)
Owner: Exxon
Driller: C. H. Self

Material	Thickness (feet)	Depth (feet)
Clay and gravel	35	35
Gravel, sand and clay	7	42
Bedrock, small amounts of water entering hole at 157 and 178 feet	159	201

Table C.--*Major chemical constituents and physical characteristics of Seward area streams.*

15237700 - RESURRECTION R AT SEWARD AK

WATER QUALITY DATA

DATE	TIME	INSTANTANEOUS DISCHARGE (CFS)	SPECIFIC CONDUCTANCE (MICROMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	COLOR (PLATINUM-COBALT UNITS)	HARDNESS (CA,MG) (MG/L)	NONCARBONATE HARDNESS (MG/L)	DISSOLVED CALCIUM (CA) (MG/L)	DISSOLVED MAGNESIUM (MG) (MG/L)	DISSOLVED SODIUM (NA) (MG/L)	DISSOLVED SODIUM PLUS POTASSIUM (MG/L)
APR , 1952 22...	1200	--	158	7.2	3.5	5	72	13	26	1.7	--	4.8
MAY 20...	1800	--	149	7.4	6.0	10	73	12	26	2.0	--	5.2
JUN 19...	2100	--	137	7.4	6.0	5	66	13	24	1.6	--	4.1
JUL 24...	1400	--	80	6.9	--	5	40	7	13	1.8	1.1	--
AUG 21...	1700	--	82	--	9.0	5	42	9	15	1.2	.9	--
SEP 16...	1800	--	159	7.2	6.5	5	80	23	25	4.1	2.5	--
AUG , 1953 01...	1530	--	83	6.1	6.5	5	38	4	14	.8	1.2	--
SEP , 1955 08...	--	--	109	6.7	--	--	48	8	18	.7	1.5	--
MAY , 1956 01...	--	--	137	7.7	--	0	62	10	23	1.2	3.0	--
JUL 03...	1500	--	106	7.8	--	5	46	4	17	1.0	2.1	--
OCT , 1957 03...	1100	--	131	6.6	4.5	5	63	15	21	2.6	2.0	--
NOV 06...	0835	--	121	7.4	3.5	5	56	8	20	1.3	2.0	--
DEC 11...	0945	--	152	7.4	1.0	0	72	10	26	1.8	2.6	--
JAN , 1958 22...	0845	--	150	7.5	.0	0	71	10	25	2.1	2.5	--
FEB 18...	1715	--	148	7.0	--	5	70	13	22	3.5	2.4	--
MAY 21...	0830	--	129	7.3	4.5	0	65	12	22	2.5	2.9	--
JUL 16...	0830	--	102	6.6	4.5	10	48	10	17	1.2	1.4	--
AUG 20...	1925	--	95	6.9	7.0	30	46	9	14	2.8	1.4	--
SEP , 1965 28...	1315	2270	104	8.0	5.0	10	48	5	19	.1	4.8	--
AUG , 1967 03...	1355	2660	83	7.2	8.0	0	38	7	14	1.0	1.5	--
SEP 09...	--	2800	101	7.2	5.5	0	50	10	17	1.3	1.5	--
OCT 17...	1142	781	140	7.7	4.0	5	65	12	23	1.3	1.8	--
NOV 16...	1520	522	145	7.6	4.0	0	69	13	25	1.5	1.9	--
FEB , 1968 14...	1430	292	137	7.8	1.5	0	60	12	20	1.1	2.5	--
APR 17...	1800	169	155	7.0	1.5	5	68	9	25	1.4	1.8	--

Table C.--*Major chemical constituents and physical characteristics of Seward area streams*--Continued.

15237700 - RESURRECTION R AT SEWARD AK

WATER QUALITY DATA

DATE	DIS-SOLVED PO-TAS-SIUM (K) (MG/L)	BICAR-BONATE (HCO3) (MG/L)	CAR-BONATE (CO3) (MG/L)	DIS-SOLVED SULFATE (SO4) (MG/L)	DIS-SOLVED CHLO-RIDE (CL) (MG/L)	DIS-SOLVED FLUO-RIDE (F) (MG/L)	DIS-SOLVED SILICA (SIO2) (MG/L)	DIS-SOLVED SOLIDS (SUM OF CONSTI-TUENTS) (MG/L)	DIS-SOLVED NITRATE (N) (MG/L)	IRON (FE) (UG/L)	MAN-GANESE (MN) (UG/L)
APR , 1952											
22...	--	72	0	15	5.0	.0	4.9	94	.16	50	--
MAY											
20...	--	74	0	17	3.8	.0	4.4	96	.16	70	--
JUN											
19...	--	65	0	15	4.2	.0	3.9	86	.18	90	--
JUL											
24...	.4	40	0	12	1.0	.1	4.9	54	.05	40	--
AUG											
21...	.6	40	0	9.5	1.0	.0	8.0	57	.14	60	--
SEP											
16...	.8	70	0	23	3.5	.1	4.5	99	.27	0	--
AUG , 1953											
01...	.5	41	0	6.7	1.2	.0	3.5	49	.11	40	--
SEP , 1955											
08...	.4	49	0	12	1.5	.0	5.0	64	.14	0	0
MAY , 1956											
01...	.8	63	0	11	1.8	.1	4.3	77	.25	0	10
JUL											
03...	.4	51	0	8.8	2.8	.0	6.2	64	.14	0	0
OCT , 1957											
03...	.7	59	0	13	2.5	.1	3.8	75	.14	30	0
NOV											
06...	.3	59	0	10	1.5	.0	8.1	73	.27	40	0
DEC											
11...	.7	76	0	14	2.5	.0	4.5	90	.18	30	0
JAN , 1958											
22...	.4	74	0	12	4.0	.0	5.8	89	.14	190	0
FEB											
18...	.4	70	0	11	3.5	.0	5.6	84	.25	30	10
MAY											
21...	.4	65	0	14	4.0	.0	4.7	83	.18	70	0
JUL											
16...	.5	46	0	10	3.0	.0	4.0	60	.05	50	0
AUG											
20...	.9	46	0	9.0	2.5	.2	3.3	57	.05	50	10
SEP , 1965											
28...	.8	53	0	9.1	1.8	.1	4.3	66	.07	20	--
AUG , 1967											
03...	.3	38	0	8.0	.4	.1	2.2	48	.32	630	--
SEP											
09...	.7	49	--	9.0	2.5	.1	4.0	52	--	260	--
OCT											
17...	.3	65	0	14	2.8	.1	4.2	81	.36	220	--
NOV											
16...	.5	68	0	15	2.5	.0	3.8	85	.29	60	--
FEB , 1968											
14...	.3	58	0	14	3.2	.0	4.8	75	.14	240	--
APR											
17...	.6	72	0	11	2.8	.1	3.8	83	.16	280	--

Table C.--*Major chemical constituents and physical characteristics of Seward area streams*--Continued.

15238000 - LOST C NR SEWARD AK

WATER QUALITY DATA

DATE	TIME	INSTANTANEOUS DISCHARGE (CFS)	SPECIFIC CONDUCTANCE (MICROMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	COLOR (PLATINUM-COBALT UNITS)	HARDNESS (CA,MG) (MG/L)	NONCARBONATE HARDNESS (MG/L)	DISSOLVED CALCIUM (CA) (MG/L)	DISSOLVED MAGNESIUM (MG) (MG/L)	DISSOLVED SODIUM (NA) (MG/L)	DISSOLVED SODIUM PLUS POTASSIUM (MG/L)
JUL , 1950												
05...	--	121	48	7.5	6.5	10	19	3	6.7	.5	--	2.9
OCT												
04...	--	24	71	6.6	6.5	5	30	10	11	.7	--	1.8
NOV , 1971												
12...	1530	7.8	71	7.2	.0	0	33	13	12	.7	1.1	--

15238600 - SPRUCE C NR SEWARD AK

WATER QUALITY DATA

DATE	TIME	INSTANTANEOUS DISCHARGE (CFS)	SPECIFIC CONDUCTANCE (MICROMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	COLOR (PLATINUM-COBALT UNITS)	HARDNESS (CA,MG) (MG/L)	NONCARBONATE HARDNESS (MG/L)	DISSOLVED CALCIUM (CA) (MG/L)	DISSOLVED MAGNESIUM (MG) (MG/L)	DISSOLVED SODIUM (NA) (MG/L)	DISSOLVED POTASSIUM (K) (MG/L)
FEB , 1968												
13...	1620	16	76	7.3	1.0	0	31	8	12	.3	1.1	.0
JUN												
20...	1027	190	52	7.1	4.0	0	22	6	8.4	.3	.9	.0
AUG												
23...	1000	54	58	7.5	6.5	0	24	6	9.4	.2	.9	.0
OCT												
24...	--	19	73	7.9	3.5	5	31	9	12	.4	1.6	.1
JAN , 1969												
17...	1000	1.0	86	7.5	.0	5	34	10	13	.5	1.5	.0
MAY												
06...	1320	15	83	7.7	3.0	0	34	9	13	.5	1.9	.2
JUN												
25...	2105	358	41	7.4	3.0	10	16	3	6.0	.2	.8	.2
JUL												
29...	1800	103	48	7.4	6.0	10	21	6	8.0	.1	.8	1.1
MAR , 1970												
02...	1640	13	103	7.6	1.0	0	41	17	15	.6	2.0	1.4
MAY												
05...	1715	12	76	7.7	2.0	5	30	7	9.8	.4	1.8	.1
JUN												
23...	--	182	55	7.4	4.5	0	22	6	8.2	.4	1.3	.1
AUG												
10...	1100	175	49	6.4	4.5	10	20	8	7.8	.2	1.1	.1
SEP												
21...	1300	47	61	6.6	3.0	0	27	8	10	.4	1.2	.1
NOV												
10...	1430	74	61	7.4	3.0	5	24	8	9.4	.3	1.4	.2
DEC												
23...	0930	7.0	78	7.4	1.0	0	34	8	13	.5	1.6	.1

Table C.--*Major chemical constituents and physical characteristics of Seward area streams*--Continued.

DATE	DIS-SOLVED PO-TAS-SIUM (K) (MG/L)	BICAR-BONATE (HCO3) (MG/L)	CAR-BONATE (CO3) (MG/L)	DIS-SOLVED SULFATE (SO4) (MG/L)	DIS-SOLVED CHLO-RIDE (CL) (MG/L)	DIS-SOLVED FLUO-RIDE (F) (MG/L)	DIS-SOLVED SILICA (SIO2) (MG/L)	DIS-SOLVED SOLIDS (SUM OF CONSTI-TUENTS) (MG/L)	DIS-SOLVED NITRATE (N) (MG/L)	DIS-SOLVED IRON (FE) (UG/L)	IRON (FE) (UG/L)	DIS-SOLVED MAN-GANESE (MN) (UG/L)
JUL , 1950												
05...	--	19	0	7.1	1.0	.2	3.0	31	.05	--	10	--
OCT												
04...	--	24	0	11	1.5	--	4.1	43	.29	--	10	--
NOV , 1971												
12...	.2	25	0	12	1.0	.0	2.9	43	.20	40	--	10

DATE	BICAR-BONATE (HCO3) (MG/L)	CAR-BONATE (CO3) (MG/L)	DIS-SOLVED SULFATE (SO4) (MG/L)	DIS-SOLVED CHLO-RIDE (CL) (MG/L)	DIS-SOLVED FLUO-RIDE (F) (MG/L)	DIS-SOLVED SILICA (SIO2) (MG/L)	DIS-SOLVED SOLIDS (SUM OF CONSTI-TUENTS) (MG/L)	DIS-SOLVED NITRATE (N) (MG/L)	DIS-SOLVED IRON (FE) (UG/L)	IRON (FE) (UG/L)	DIS-SOLVED MAN-GANESE (MN) (UG/L)	MAN-GANESE (MN) (UG/L)
FEB , 1968												
13...	28	0	7.5	.7	.0	3.1	40	.25	--	240	--	--
JUN												
20...	20	0	6.4	.4	.1	2.2	29	.00	--	250	--	--
AUG												
23...	22	0	7.7	.6	.0	2.6	32	.05	--	340	--	--
OCT												
24...	27	0	8.5	.2	.4	3.0	40	.11	--	--	--	0
JAN , 1969												
17...	30	0	12	.7	.0	2.6	46	.23	--	30	--	--
MAY												
06...	30	0	9.1	2.5	.3	1.3	46	.38	--	180	--	--
JUN												
25...	16	0	4.6	.4	.3	1.9	22	.05	--	0	--	--
JUL												
29...	18	0	6.8	.7	.2	2.0	29	.02	--	10	--	110
MAR , 1970												
02...	29	0	8.3	10	.0	2.4	54	.11	--	0	--	0
MAY												
05...	28	0	7.7	1.4	.1	2.0	39	.20	--	1400	--	0
JUN												
23...	20	0	6.5	2.1	.0	2.2	32	.09	--	30	--	0
AUG												
10...	15	0	8.6	1.0	.1	1.3	28	.00	--	30	--	30
SEP												
21...	23	0	7.2	1.0	.0	2.3	33	.00	--	0	--	0
NOV												
10...	20	0	5.8	1.8	.3	2.8	33	.27	30	--	20	--
DEC												
23...	32	0	8.9	.5	.1	2.8	44	.20	30	--	10	--

Table C.--*Major chemical constituents and physical characteristics of Seward area streams*--Continued.

601125149220000 - BEAR LK NR SEWARD AK

WATER QUALITY DATA

DATE	TIME	SAMPLING DEPTH (FT)	SPECIFIC CONDUCTANCE (MICROMHOS)	TEMPERATURE (DEG C)	COLOR (PLATINUM-COBALT UNITS)	HARDNESS (CA,MG) (MG/L)	NONCARBONATE HARDNESS (MG/L)	DISSOLVED CALCIUM (CA) (MG/L)	DISSOLVED MAGNESIUM (MG) (MG/L)	DISSOLVED SODIUM (NA) (MG/L)
JUN , 1975										
04...	1300	.0	92	5.0	7	43	10	17	.2	2.7

DATE	DISSOLVED POTASSIUM (K) (MG/L)	BICARBONATE (HCO3) (MG/L)	DISSOLVED SULFATE (SO4) (MG/L)	DISSOLVED CHLORIDE (CL) (MG/L)	DISSOLVED FLUORIDE (F) (MG/L)	DISSOLVED SILICA (SIO2) (MG/L)	DISSOLVED SOLIDS (RESIDUE AT 180 C) (MG/L)	DISSOLVED SOLIDS (SUM OF CONSTITUENTS) (MG/L)	TOTAL NITRITE PLUS NITRATE (N) (MG/L)	DISSOLVED NITRITE PLUS NITRATE (N) (MG/L)
JUN , 1975										
04...	.9	40	7.0	4.0	.0	4.7	56	56	.05	.02

DATE	TOTAL AMMONIA NITROGEN (N) (MG/L)	TOTAL ORGANIC NITROGEN (N) (MG/L)	TOTAL KJELDAHL NITROGEN (N) (MG/L)	TOTAL NITROGEN (N) (MG/L)	TOTAL PHOSPHORUS (P) (MG/L)	DISSOLVED ORTHO. PHOSPHORUS (P) (MG/L)	TOTAL BORON (B) (UG/L)	DISSOLVED IRON (FE) (UG/L)	DISSOLVED MANGANESE (MN) (UG/L)	TOTAL ORGANIC CARBON (C) (MG/L)
JUN , 1975										
04...	.00	.05	.05	.10	.01	.00	170	40	30	7.2

15237800 - BEAR C TR NR SEWARD AK

WATER QUALITY DATA

DATE	TIME	INSTANTANEOUS DISCHARGE (CFS)	SPECIFIC CONDUCTANCE (MICROMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	COLOR (PLATINUM-COBALT UNITS)	HARDNESS (CA,MG) (MG/L)	NONCARBONATE HARDNESS (MG/L)	DISSOLVED CALCIUM (CA) (MG/L)	DISSOLVED MAGNESIUM (MG) (MG/L)	DISSOLVED SODIUM (NA) (MG/L)
FEB , 1968											
14...	1150	4.5	142	7.7	1.5	0	64	10	24	.8	1.4

DATE	DISSOLVED POTASSIUM (K) (MG/L)	BICARBONATE (HCO3) (MG/L)	CARBONATE (CO3) (MG/L)	DISSOLVED SULFATE (SO4) (MG/L)	DISSOLVED CHLORIDE (CL) (MG/L)	DISSOLVED FLUORIDE (F) (MG/L)	DISSOLVED SILICA (SIO2) (MG/L)	DISSOLVED SOLIDS (SUM OF CONSTITUENTS) (MG/L)	DISSOLVED NITRATE (N) (MG/L)	IRON (FE) (UG/L)
FEB , 1968										
14...	.8	66	0	13	.0	.1	6.5	80	.25	20

Table D.--*Suspended-sediment data for Seward area streams.*

15237700 - RESURRECTION R AT SEWARD AK

WATER QUALITY DATA

DATE	TIME	INSTAN-TANEOUS DIS-CHARGE (CFS)	TEMPER-ATURE (DEG C)	SUS-PENDED SEDI-MENT (MG/L)	SUS-PENDED SEDI-MENT DIS-CHARGE (T/DAY)	SUS. SED. FALL DIAM. % FINER THAN .002 MM	SUS. SED. FALL DIAM. % FINER THAN .004 MM	SUS. SED. FALL DIAM. % FINER THAN .008 MM	SUS. SED. FALL DIAM. % FINER THAN .016 MM	SUS. SED. FALL DIAM. % FINER THAN .031 MM
JUL , 1959										
22...	1115	2070	5.5	300	1680	--	--	--	--	--
APR , 1965										
16...	1525	275	4.0	12	8.9	--	--	--	--	--
JUN										
20...	1005	1660	6.0	30	134	--	--	--	--	--
JUL										
24...	1045	2300	5.5	97	602	--	37	49	52	58
AUG										
29...	1450	1230	9.5	42	139	--	--	--	--	--
SEP										
28...	1308	2270	5.0	350	2150	21	26	33	38	43
DEC										
17...	1240	114	.0	67	21	--	--	--	--	--
APR , 1966										
05...	0935	107	3.0	14	4.0	--	--	--	--	--
JUN										
10...	1810	2310	9.0	237	1480	2	4	12	18	25
JUL										
16...	1100	2890	--	322	2510	24	34	42	50	56
AUG										
20...	1400	2250	9.0	157	954	--	--	--	--	--
23...	1200	7790	5.0	1120	23600	22	34	44	51	59
NOV										
11...	1000	395	1.0	10	11	--	--	--	--	--
JAN , 1967										
16...	1532	128	1.0	8	2.8	--	--	--	--	--
APR										
06...	1200	99	5.5	8	2.1	--	--	--	--	--
JUN										
15...	1045	2180	5.5	172	1010	30	40	48	53	58
AUG										
03...	1407	2660	8.0	396	2840	16	24	31	38	43
SEP										
09...	1030	2800	5.5	529	4000	--	--	--	--	--
OCT										
17...	1142	781	4.0	9	19	--	--	--	--	--
NOV										
16...	1520	522	4.0	6	8.5	--	--	--	--	--
FEB , 1968										
14...	1430	292	1.5	12	9.5	--	--	--	--	--
APR										
17...	1800	169	1.5	5	2.3	--	--	--	--	--

Table D.--*Suspended-sediment data for Seward area streams*--Continued.

15237700 - RESURRECTION R AT SEWARD AK

WATER QUALITY DATA

DATE	SUS. SED. FALL DIAM. % FINER THAN .062 MM	SUS. SED. FALL DIAM. % FINER THAN .125 MM	SUS. SED. FALL DIAM. % FINER THAN .250 MM	SUS. SED. FALL DIAM. % FINER THAN .500 MM	SUS. SED. FALL DIAM. % FINER THAN 1.00 MM	SUS. SED. SIEVE DIAM. % FINER THAN .062 MM	SUS. SED. SIEVE DIAM. % FINER THAN .125 MM	SUS. SED. SIEVE DIAM. % FINER THAN .250 MM	SUS. SED. SIEVE DIAM. % FINER THAN .500 MM	SUS. SED. SIEVE DIAM. % FINER THAN 1.00 MM
JUL , 1959										
22...	--	--	--	--	--	47	54	68	87	100
APR , 1965										
16...	--	--	--	--	--	--	--	--	--	--
JUN										
20...	--	--	--	--	--	--	--	--	--	--
JUL										
24...	64	71	79	94	100	--	--	--	--	--
AUG										
29...	52	59	67	85	100	--	--	--	--	--
SEP										
28...	50	61	73	88	97	--	--	--	--	--
DEC										
17...	--	--	--	--	--	--	--	--	--	--
APR , 1966										
05...	--	--	--	--	--	--	--	--	--	--
JUN										
10...	44	58	82	93	100	--	--	--	--	--
JUL										
16...	60	66	77	91	98	--	--	--	--	--
AUG										
20...	50	58	75	95	100	--	--	--	--	--
23...	65	73	87	98	100	--	--	--	--	--
NOV										
11...	--	--	--	--	--	--	--	--	--	--
JAN , 1967										
16...	--	--	--	--	--	--	--	--	--	--
APR										
06...	--	--	--	--	--	--	--	--	--	--
JUN										
15...	63	68	76	96	100	--	--	--	--	--
AUG										
03...	48	56	64	91	100	--	--	--	--	--
SEP										
09...	27	33	48	72	82	--	--	--	--	--
OCT										
17...	--	--	--	--	--	--	--	--	--	--
NOV										
16...	--	--	--	--	--	--	--	--	--	--
FEB , 1968										
14...	--	--	--	--	--	--	--	--	--	--
APR										
17...	--	--	--	--	--	--	--	--	--	--

Table D.--*Suspended-sediment data for Seward area streams*--Continued.

15238600 - SPRUCE C NR SEWARD AK

WATER QUALITY DATA

DATE	TIME	INSTAN-TANEOUS DIS-CHARGE (CFS)	TEMPER-ATURE (DEG C)	TUR-BID-ITY (JTU)	SUS-PENDED SEDI-MENT (MG/L)	SUS-PENDED SEDI-MENT DIS-CHARGE (T/DAY)	SUS. SED. FALL DIAM. % FINER THAN .002 MM	SUS. SED. FALL DIAM. % FINER THAN .004 MM
JUN , 1968								
20...	1012	190	4.0	--	4	2.1	--	--
AUG								
03...	0945	63	5.0	--	3	.51	--	--
23...	0956	54	6.5	--	2	.29	--	--
OCT								
24...	0930	19	3.5	--	2	.10	--	--
MAY , 1969								
06...	1320	15	3.0	--	0	.00	--	--
JUL								
29...	1800	103	6.0	--	1	.28	--	--
MAR , 1970								
02...	1640	13	1.0	--	0	.00	--	--
MAY								
05...	1730	12	2.0	--	0	.00	--	--
JUN								
23...	1415	182	4.5	--	1	.49	--	--
AUG								
10...	1100	175	4.5	--	2	.94	--	--
SEP								
21...	1700	47	3.0	--	5	.63	--	--
NOV								
10...	1430	74	3.0	--	1	.20	--	--
DEC								
23...	0930	7.0	1.0	--	1	.02	--	--
MAY , 1971								
12...	1700	14	1.0	--	1	.04	--	--
JUL								
02...	1130	134	3.5	--	1	.36	--	--
AUG								
10...	0945	200	4.0	--	3	1.6	--	--
OCT								
07...	1000	62	3.0	--	2	.33	--	--
NOV								
03...	1230	14	1.5	--	1	.04	--	--
MAY , 1972								
23...	1830	32	1.5	--	1	.09	--	--
JUL								
11...	1000	143	5.0	--	3	1.2	--	--
AUG								
31...	1100	163	6.0	--	5	2.2	--	--
SEP								
27...	1100	32	4.0	--	0	.00	--	--
NOV								
28...	1500	12	2.0	1	1	.03	--	--
SEP , 1974								
20...	1730	1150	7.0	90	528	1640	10	15

Table D.--*Suspended-sediment data for Seward area streams*--Continued.

15238600 - SPRUCE C NR SEWARD AK

WATER QUALITY DATA

DATE	SUS. SED. FALL DIAM. % FINER THAN .008 MM	SUS. SED. FALL DIAM. % FINER THAN .016 MM	SUS. SED. FALL DIAM. % FINER THAN .031 MM	SUS. SED. SIEVE DIAM. % FINER THAN .062 MM	SUS. SED. SIEVE DIAM. % FINER THAN .125 MM	SUS. SED. SIEVE DIAM. % FINER THAN .250 MM	SUS. SED. SIEVE DIAM. % FINER THAN .500 MM	SUS. SED. SIEVE DIAM. % FINER THAN 1.00 MM
JUN , 1968								
20...	--	--	--	--	--	--	--	--
AUG								
03...	--	--	--	--	--	--	--	--
23...	--	--	--	--	--	--	--	--
OCT								
24...	--	--	--	--	--	--	--	--
MAY , 1969								
06...	--	--	--	--	--	--	--	--
JUL								
29...	--	--	--	--	--	--	--	--
MAR , 1970								
02...	--	--	--	--	--	--	--	--
MAY								
05...	--	--	--	--	--	--	--	--
JUN								
23...	--	--	--	--	--	--	--	--
AUG								
10...	--	--	--	--	--	--	--	--
SEP								
21...	--	--	--	--	--	--	--	--
NOV								
10...	--	--	--	--	--	--	--	--
DEC								
23...	--	--	--	--	--	--	--	--
MAY , 1971								
12...	--	--	--	--	--	--	--	--
JUL								
02...	--	--	--	--	--	--	--	--
AUG								
10...	--	--	--	--	--	--	--	--
OCT								
07...	--	--	--	--	--	--	--	--
NOV								
03...	--	--	--	--	--	--	--	--
MAY , 1972								
23...	--	--	--	--	--	--	--	--
JUL								
11...	--	--	--	--	--	--	--	--
AUG								
31...	--	--	--	--	--	--	--	--
SEP								
27...	--	--	--	--	--	--	--	--
NOV								
28...	--	--	--	--	--	--	--	--
SEP , 1974								
20...	19	24	29	34	39	47	59	77