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Preliminary report on the waterpower resources of Snow River, Nellie Juan Lake and Lost Lake, Kenai Peninsula, Alaska

By

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This preliminary report is distributed without editorial and technical review for conformity with official standards and nomenclature.

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By Vernon C. Indermuhle

Summary

The three basins discussed in this report lie in the eastern part of the Kenai Peninsula. Detailed topographic surveys and geológic reconnaissances have been made by the Geological Survey between 1955 and 1959 and quadrangle maps compiled from aerial photographs cover all of the basins on a scale of one inch to the mile.

No streamflow measurements have been made on the Snow or Nellie Juan Rivers and only one complete year of record has been obtained for Lost Creek. The Snow River runoff was estimated as the difference between the recorded flow at the outlet of Kenai Lake and the recorded and estimated flows from several areas tributary to the lake downstream from the Snow River. Because of the proximity and similarity of the Snow and Nellie Juan basins, the runoff of Nellie Juan was estimated to be similar to that of the Snow River. Lost Creek runoff was estimated by comparisons of the one yéar record with runoff from Grant Creek basin. The estimates are intended to be conservative.

Because of low flows during the winter months storage would be required for substantial utilization of the runoff to provide dependable power. Sufficient storage capacity could be developed at all sites for regulation of at least 90 percent of the expected runoff, on a schedule of uniform monthly releases.

At the Snow River site a dam 328 feet high and auxiliary dams in two saddle areas would be necessary to develop the potential power. Conveyance by a waterway system for 2.3 miles to the powerhouse would develop 740 feet of head and provide for generation of 32,000 kw, 100 percent of the time. Abnormal floods due to releases from natural storage have been reported on this river but without direct evidence. If there is a possibility that such floods can occur, it would be of primary importance to consider larger spillway systems than would be needed to provide for floods due to storm runoff alone. The Snow River damsite is only a few miles from an existing highway and railroad.

Development of the Nellie Juan Lake site could be accomplished by construction of a dam 95 feet high at the lake outlet and an auxiliary structure at a saddle area. The water would be conveyed by a two-mile waterway to the powerhouse thereby developing 514 feet of head. This would provide for generation of 7,300 kw, 100 percent of the time. A relatively small amount of construction near the upper end of the lake would increase the drainage area 3.9 square miles, thereby increasing the plant output 11 percent. The Nellie Juan damsite is 15 miles from the existing highway and railroad, hence the cost of construction of an access road and transmission line might be a substantial part of the plant cost.

Lost Lake project, the smallest of the three considered, could be developed by a dam 68 feet high and conveyance by pipeline and penstock two and a half miles to the powerhouse. This would utilize 1,537 feet of head and provide for generation of 2,900 kw, 100 percent of the time.

The Lost Lake area is within two miles of an existing highway and railroad, and access by tractor trail probably is feasible.

Alternative plans of development have been considered and illustrated for all three projects.

Introduction

Purpose and scope.--The primary purpose of this report is to give a preliminary estimate of the hydroelectric potential of the Snow River, Nellie Juan Lake, and Lost Lake basins to aid in classifying lands in the areas as to their waterpower values. Pertinent conditions and features which may determine the character of developments are described.

General plans of development are shown for each basin as a means of determining the potential power. These plans give a rough approximation of the amount of construction that may be involved but cost analysis is beyond the scope of this report. The plans presented herein are not intended as models of development, but merely a means of making reasonably accurate power estimates.

The possible effects of sedimentation, floods, and ice are mentioned, but no attempt is made to accurately analyze these effects.

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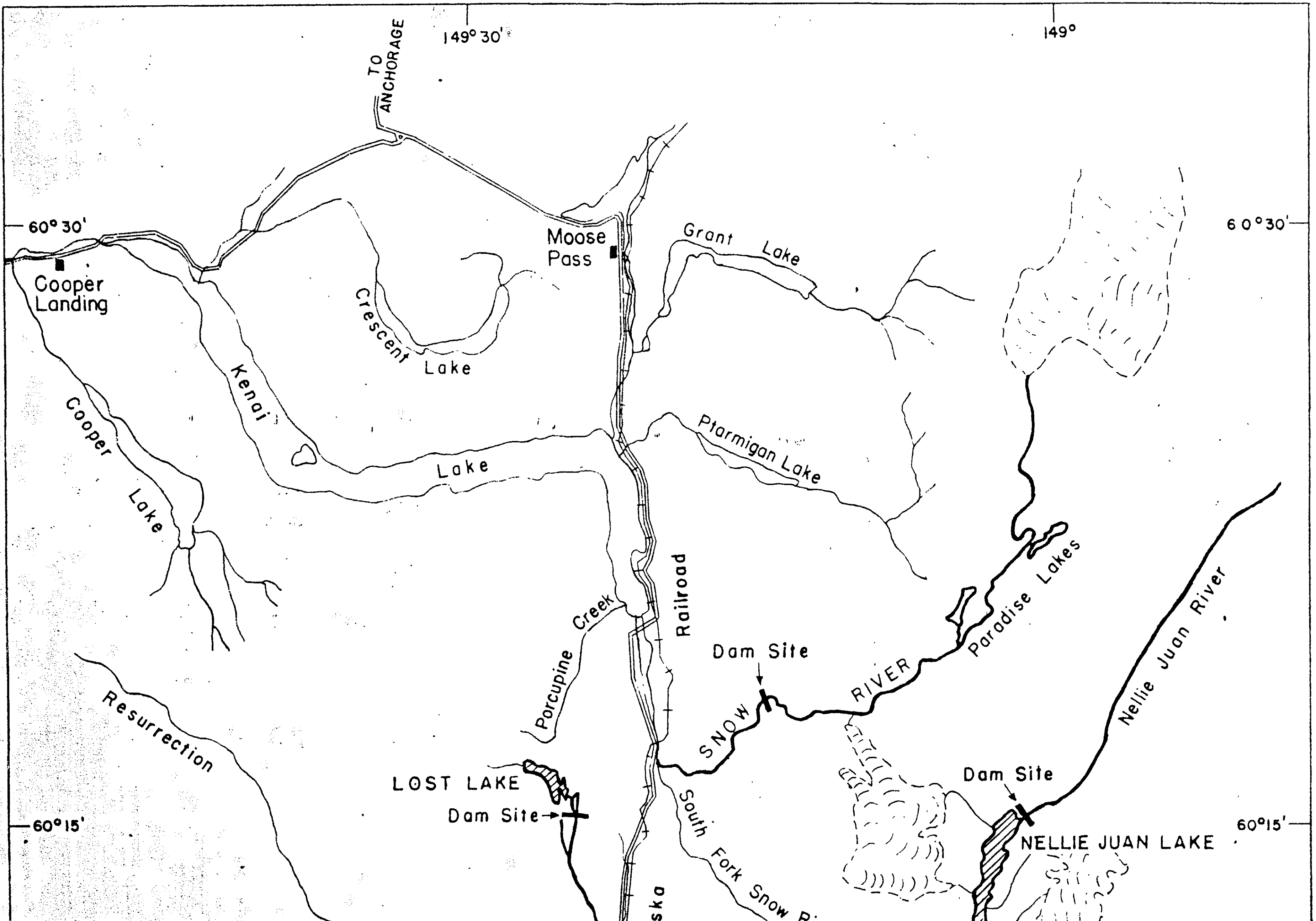


149° 30'
149°
60° 30'
6 0° 30'
60° 15'
60° 15'
TO ANCHORAGE
Moose Pass
Cooper Landing
Grant Lake
Crescent Lake
Kenai Lake
Cooper Lake
Ptarmigan Lake
Paradise Lakes
Nellie Juan River
Porcupine Creek
Railroad
Dam Site
SNOW RIVER
Resurrection
LOST LAKE
Dam Site
Dam Site
NELLIE JUAN LAKE
South Fork Snow Ri
ska

Previous investigations and reports.--Hubbell and Waller Engineering Corp., Seattle, Washington retained by the city of Seward, made an investigation in 1935 and submitted a report and plans for development. An application was made by the city of Seward, Alaska in 1936 to the Federal Power Commission for a permit on Lost Creek and Upper and Lower Lost Lakes. This permit, Federal Power Project No. 1316, was surrendered on May 24, 1938.

Acknowledgments.--Acknowledgment is due Hubbell and Waller Engineering Corporation, Seattle, Washington, and Alex Petrovich, Mayor and Acting City Manager, Seward, Alaska, for making available the report on the investigation of the hydroelectric possibilities of Lost Lake.

G. E. Mitchell, Assistant Regional Forester, U. S. Forest Service, Juneau, Alaska; and R. H. Anderson, General Manager, The Alaska Railroad, Anchorage, Alaska supplied information concerning reports on abnormal floods of the Snow River.

C. E. Watson, State Climatologist, U. S. Weather Bureau, Anchorage, Alaska furnished information regarding climatic conditions in the Gulf Coast and Cook Inlet areas.

General discussion.--The three basins considered in this report are located in the southeast part of the Kenai Peninsula within a 30 mile radius of the city of Seward (fig. 1).

Figure 1. - Location map.

There are few, if any, inhabitants within any of the areas, and so there is little direct knowledge concerning the climatic conditions.

Estimates of the runoff were made on the basis of streamflow records for nearby basins and climatic records obtained at various stations on the Kenai Peninsula.

The power possibilities of the basins are discussed on the basis of regulated flow only. Power estimates were made on the basis of 80 percent and 90 percent regulation of the expected runoff. If and when these projects are developed, it may be desirable to provide a greater or lesser amount of regulation.

Maps and aerial photographs.--The three drainage basins are shown on the following quadrangle maps:

Seward: Reconnaissance series, scale 1:250,000, contour interval 200 feet.

Seward: A-6, A-7, B-6, B-7, and C-6, scale 1:63,360, contour interval 100 feet.

The reservoir areas and damsites on Snow River, Nellie Juan Lake, and Lost Lake are shown on the following standard river survey maps:

Plan and profile, Snow River, Alaska, damsite. Scale 1:24,000, contour interval 20 feet on land, 5 feet on water surface; damsite scale 1:2,400, contour interval 10 feet on land, 1 foot on water surface.

Plan, Nellie Juan Lake, Miscellaneous Damsites, Kenai Peninsula, Alaska. Scale 1:24,000, contour interval 20 feet on land, 5 feet on water surface; damsite scale 1:4800, contour interval 10 feet on land, 1 foot on water surface.

Plan, Lost Lake near Seward, Alaska, damsites. Scale 1:24,000, contour interval 20 and 100 feet; damsite scale 1:4800, contour interval 10 feet on land, 1 foot on water surface.

These maps are included as Plates I, II, and III respectively, in this report.

Aerial photographs used in compilation of of the topographic maps are on file with the Geological Survey, Denver Federal Center, Denver, Colorado.

Geography and topographic features

Snow River basin.--The Snow River flows in a southwesterly direction, about 18 miles from a glacier at its headwaters, then north about 4 miles, to its mouth at Kenai Lake approximately 25 miles north of Seward. It is crossed by the Alaska Railroad and the Seward-Anchorage highway near Kenai Lake. The South Fork of the Snow River converges with the main river about two and a half miles from its mouth.

From a point 4 miles below the headwaters glacier, the river flows through Paradise Valley, which is about 17 miles long and has an average width of about half a mile. Two lakes located in this valley are called Upper Paradise Lake and Lower Paradise Lake. Their surface areas are 206 and 158 acres respectively. In addition, there are several ponds in the valley. Views of the headquarters glacier and the upper part of Paradise Valley are shown in figures 2 and 3.

Figure 2. - Aerial view downvalley from above glacier at the head of Snow River.

Figure 3. - Glacier at head of Snow River.

Figure 2. - Aerial view downvalley from above glacier at the head of Snow River.

Figure 3. - Glacier at head of Snow River.

The Snow River enters a narrow canyon at the downstream end of Paradise Valley, where construction of a high dam would provide sufficient storage capacity in the valley for either complete or partial control of the river.

The basin varies in altitude from 436 feet at its mouth on Kenai Lake to peaks over 5,500 feet. Numerous glaciers are located in the basin, the glacier area being 52 square miles or 31 percent of the basin area of 166 square miles.

The basin contains very little timber, although there are some spruce and mountain hemlock in Paradise Valley and on the lower slopes. Vegetation on the higher slopes is limited to low shrubs and grasses, or is lacking.

Paradise Valley and the damsite areas can be reached by trail from the Seward-Anchorage highway. Float equipped aircraft can land on the lakes in the valley, or small land airplanes can land on some of the river gravel bars.

Nellie Juan River basin.--Nellie Juan Lake is located in the eastern part of the Kenai Peninsula approximately 15 miles east and slightly north of the town of Seward and about 12 miles southeast of Kenai Lake.

The lake extends 3.8 miles in a north-south direction and varies in width from about three-tenths to eight-tenths of a mile. The lake has a surface area of 1,130 acres and is at an altitude of 1,189 feet.

It is bounded mostly by steep slopes on the west, whereas the east side is lower, more broken country. The valley upstream from the lake is filled with glacial deposits which form a delta about eight-tenths of a mile wide, extending one and a half miles upstream from the lake.

A large part of the potential storage capacity of the lake is in this valley. Several alluvial fans are located around the perimeter of the lake.

The lake is drained by the Nellie Juan River which flows northeastward to its outlet in Kings Bay on the Port Nellie Juan arm of Prince William Sound. The stream falls about 450 feet in the first two miles below the lake outlet beyond which the gradient becomes relatively flat.

The lake drainage basin covers an area of 35.3 square miles ranging from an altitude of 1,189 feet at the lake surface to peaks higher than 5,500 feet. There are several large glaciers in the basin, the total glacier area being approximately 9.4 square miles or 27 percent of the total area.

The entire lake basin is practically void of trees, containing only a few scattered scrub spruce and mountain hemlock. Alluvial fans extending into the lake are covered with grasses and shrubs. Vegetation on the higher slopes is limited to low shrubs and grasses, or is completely lacking.

There are no known trails leading into the area. The lake is about 15 miles from the Seward-Anchorage highway and can be reached on foot but the trek is hampered by many glacier stream crossings. The area can best be reached by float equipped aircraft.

Lost Lake basin.--Lost Lake is located approximately 11 miles north of Seward and two and a half miles west of the Seward-Anchorage highway. It is drained by Lost Creek which runs in a southerly direction to its confluence with Salmon Creek six and a half miles north of Seward.

Two lakes in the basin are known as Lost Lake and Lower Lost Lake. Their surface areas are 370 and 38 acres respectively. Lower Lost Lake at an altitude of 1,899 feet is 21 feet lower and about three-tenths of a mile southeast of the larger lake.

The basin area draining into the lakes is 5.6 square miles. There are glaciers in the surrounding area but few, if any, in the drainage basin.

The altitude of the basin varies from 1,899 feet at the lower lake to peaks higher than 5,000 feet. The average altitude of the basin is about 2,600 feet.

Most of the area is barren and rocky, with vegetation being limited to low brush, grass, and a few scrub spruce and mountain hemlock.

Lost Lake can be reached by trail from the Seward-Anchorage highway and it may be accessible to four wheel drive vehicles. However, it is most easily reached by float equipped aircraft.

Geology

Geologic investigations have been made of the powersites in the three basins under consideration. Reports, as listed below, have been prepared but as yet have not been published nor released to open file. The comments relating to geology for the various sites have been extracted from these reports.

Geologic investigations of powersites on Bradley, Halibut, Snow, and Anchor Rivers, Kenai Peninsula, Alaska by K. S. Soward, June 1958.

(Note: The section on Bradley Lake has been prepared and submitted for publication as a bulletin chapter.)

Geologic reconnaissance of the Nellie Juan damsite and reservoir area, Kenai Peninsula, Alaska by D. L. Gaskill and R. G. Wayland, 1959.

Geologic reconnaissance of the Lost Lakes damsites and reservoir area, Kenai Peninsula, Alaska by D. L. Gaskill and R. G. Wayland, 1959.

Climate

General.--So far as known no climatic records have been obtained in any of the three basins of concern. However, records have been maintained at Seward since 1908 and at Whittier since 1942.

Table 1 is a summary of the records at Seward and shows indices of wetness for individual years.

The mean annual precipitation at Seward is 66.8 inches for 39 water years, and a comparison of overlapping records indicates that the corresponding mean at Whittier might be roughly 177 inches. This large difference in annual precipitation seems to indicate that there is a definite increase in precipitation to the northeast of Seward. The large amount of glacier area substantiates this supposition and indicates that most of the precipitation falls in the form of snow.

Table 1. - Precipitation and indices of wetness at Seward, Alaska

Water year	Recorded (inches)	Percent of mean	Water year	Recorded (inches)	Percent of mean
1909	67.8	100	1941	88.8	133
1910	48.7	73	1942	74.1	111
1913	66.2	99	1943	52.7	79
1914	56.2	84	1944	101.4	152
1915	80.8	121	1945	74.5	111
1916	56.0	84	1946	58.2	87
1919	80.4	120	1947	65.0	97
1920	45.0	67	1948	67.9	101
1921	57.5	86	1949	58.3	87
1922	58.2	87	1950	63.3	95
1923	69.4	104	1951	47.0	70
1924	98.8	148	1952	42.8	64
1930	66.8	100	1953	100.8	151
1931	87.3	131	1954	51.7	77
1933	52.8	79	1955	63.3	95
1934	70.0	105	1956	48.1	72
1935	89.2	133	1957	45.0	67
1936	57.6	86	1958	87.4	131
1937	70.1	105	1959	49.4	74
1940	87.2	130	Mean	66.8	100

The mean annual precipitation, 1948-59, was 90 percent of the mean for 39 years of record between 1909 and 1959.

Distribution of annual precipitation.--The monthly distribution of the precipitation at Seward, and percent of mean annual total, for the period of record to 1959 is shown in the following tabulation:

Mean monthly precipitation in inches

and percent of mean annual

Month	Pcpt. (inches)	Percent of mean annual	Month	Pcpt. (inches)	Percent of mean annual
Jan.	5.25	7.89	July	3.01	4.52
Feb.	5.35	8.04	Aug.	6.01	9.04
Mar.	3.72	5.59	Sept.	9.43	14.17
Apr.	4.14	6.23	Oct.	10.34	15.55
May	3.51	5.28	Nov.	7.14	10.72
June	2.26	3.40	Dec.	6.37	9.57
			Annual	66.53	100.00

The seasonal distribution at Whittier is very nearly the same as at Seward, so it appears that the distribution in the mountain areas between the two stations probably is closely similar.

Approximately 40 percent of the precipitation occurs during the months of September, October and November.

Temperatures.--The mean annual temperature at Seward was 39.4°F for 16 water years, and by way of comparison it was 38.9°F at Whittier for the corresponding period. Minimum temperatures of about -20°F were recorded at the two stations during this period.

The stations at Seward and Whittier are located at or near sea level whereas the three basins discussed herein have average altitudes of over 2,000 feet. It is possible that minimum temperatures in the basins are several degrees lower than at Seward or Whittier. The mean monthly temperatures probably are below freezing from November to April.

Water supply

Runoff records.--No runoff records are available for the Snow River or Nellie Juan basins, and only a short one for the Lost Creek basin.

Runoff records for the Kenai River at Cooper Landing, near the outlet of Kenai Lake, and for stream basins comprising about 40 percent of the total drainage area of Kenai Lake are available.

The following records were considered in preparation of this report.

Station	Drainage area square miles	Period of record 1/
Kenai River at Cooper Landing	642 2/	Oct. 1947 to Sept. 1959
Trail River near Lawing	181	Oct. 1947 to Sept. 1959
Grant Creek near Moose Pass	44.2	Oct. 1947 to Sept. 1958
Ptarmigan Creek at Lawing	32.6	Oct. 1947 to Sept. 1958
Cooper Creek near Cooper Landing	31.8	Aug. 1949 to July 1959 3/
Crescent Creek near Cooper Landing	31.7	July 1949 to Sept. 1959
Lost Creek near Seward	7.96	Aug. 1948 to Mar. 1950 4/

See footnotes on the following page.

1/ 1957 to 1959 records are provisional.

2/ Changed from 634 square miles as published in water-supply papers after a revised interpretation of the drainage area boundary. The change is too small to justify revision of the water-supply papers, but is appreciable in the Snow River portion of the Kenai River basin.

3/ Affected by storage regulation after July 1959.

4/ Not a continuous record.

In 1960 the Geological Survey and the Corps of Engineers, U. S. Army, planned to start a cooperative program of stream gaging for both the Snow River and Nellie Juan River. Plans were being made to install the gages in 1961.

Estimate of Snow River runoff.--The Kenai Lake drainage basin, including the Snow River basin, has an area of about 642 square miles. (A precise determination cannot be made because glaciers extend across the drainage boundary in places.) Available streamflow records cover approximately 245 square miles of this area between the Snow River and Cooper Landing. The Snow River basin covers an area of 166 square miles, thus leaving about 230 square miles of ungaged area in downstream tributaries above Cooper Landing. This area can be broken down as follows.

Description	Area, sq. mi.	Basis of unit runoff estimates
Kenai Lake surface area	21.3	Equal to Cooper Creek
Falls Creek	15.0	Average of Grant Creek and Ptarmigan Creek
Victor Creek, Rocky Creek and small unnamed drainages between Ptarmigan and Snow River	18.0	Same as Falls Creek
Porcupine Creek, Meadow Creek, Ship Creek and small adjacent drainages	50.6	Average of Grant Creek and Cooper Creek
Shackleford Creek and adjacent small drainages to the southeast	20.0	Equal to Cooper Creek
Quartz Creek and remaining area	76.3	Equal to Crescent Creek
Schliter Creek, Dry Creek and unnamed drainages between Crescent and Kenai Lakes	29.6	Equal to Crescent Creek

An estimate of the runoff from the ungaged area, excluding the Snow River basin, was made by assuming relationships with adjacent basins as indicated in the above table. By subtracting the sums of the gaged runoff and estimates of the ungaged runoff of tributaries from the discharge of Kenai River at Cooper Landing, estimates of the Snow River runoff were obtained. Table 2 shows the results of these estimates on an annual and monthly basis for all months (excluding the period November through May, which is shown as one value) from October 1947 through September 1959. Some of the monthly figures may be in considerable error because of errors in estimated areal distribution in ungaged basins. However, on an annual basis these errors probably tend to be compensating. The mean annual runoff as determined by this analysis is 81.2 inches. For the corresponding period the precipitation records at Seward show a mean of 60.4 inches which is approximately 90 percent of the 39-year mean at this station. Adjusting the Snow River runoff by a proportional amount indicates that the long-term annual runoff may average about 90 inches.

Mean runoff of 90 inches very likely is less than the mean runoff above the damsite at Mile 4.8, for two reasons. First, the estimate was made on the basin as a whole, whereas the precipitation and unit runoff in the higher and more easterly parts of the basin undoubtedly are greater than in the lower portion of the basin. Second, it is felt that the estimates of the ungaged runoff from tributary basins downstream from the Snow River, if in error, are overestimated and, therefore, that Snow River runoff may be somewhat underestimated.

Table 2. - Estimates[1] of the monthly and annual runoff of Snow River at mouth, in thousands of acre-feet

Water year	Oct.	Nov. May	June	July	Aug.	Sept.	Total
1948	60.0	51.7	106.0	215.5	163.4	82.6	679.2
1949	52.6	83.5	94.8	157.9	168.8	175.8	733.4
1950	187.0	28.6	110.5	155.0	211.3	111.7	804.1
1951	8.4	14.7	66.9	195.3	164.0	173.1	622.4
1952	3.4	173.8	57.3	169.3	149.1	76.2	629.1
1953	62.5	75.8	226.8	182.2	195.2	105.1	847.6
1954	58.7	156.2	88.4	148.6	168.2	74.5	694.5
1955	38.2	41.9	52.9	177.1	140.2	94.1	544.4
1956	7.0	27.1	57.2	135.7	204.8	82.3	514.1
1957	131.4	33.1	105.6	159.4	206.2	326.3	962.0
1958	92.9	168.5	144.3	208.5	220.1	43.9	878.2
1959	130.7	77.5	146.4	146.4	164.3	58.4	723.7

1/ Some of the monthly figures may be in considerable error because of variations in areal runoff distribution on the estimated basins.

Estimate of runoff from Nellie Juan Lake basin.--The analysis of the Snow River runoff on the preceding pages provides a basis for predicting the runoff from the Nellie Juan Lake basin. The two basins are separated by only one ridge and have many similar characteristics. Table 3 shows a comparison of the altitude distribution for the two basins. The distribution for the Lost Lake basin also is included in this table. The mean altitude of Nellie Juan Lake and Snow River basins are practically the same, being 2,620 feet and 2,600 feet respectively.

The vegetative conditions probably are somewhat different, principally because of the larger area at lower elevations in the Snow River basin. This lower part of the basin undoubtedly contains more vegetation thereby increasing the evapotranspiration losses of the basin as a whole.

For purposes of estimating the power potential of the Nellie Juan Lake basin, the runoff per unit area was assumed to be the same as that of the Snow River basin, or 90 inches per year. This possibly is a conservative estimate because of the location, vegetative conditions, and higher elevations of the Nellie Juan Lake basin.

It seems reasonable to assume the monthly distribution of the runoff to be somewhat similar to the distribution shown for the Snow River in Table 2. However, Nellie Juan Lake with a surface area of 1,130 acres or 5 percent of the area of the basin undoubtedly has some regulating effect on the monthly flows.

Table 3. - Altitude distribution

Snow River, Nellie Juan Lake and Lost Lake basins

	Snow River basin (includes So. Fork) Drainage area 166 sq mi		Nellie Juan Lake basin Drainage area 35.3 sq mi		Lost Lake basin Drainage area 5.6 sq mi	
Altitude below	Area (sq mi)	Percent of total area	Area (sq mi)	Percent of total area	Area (sq mi)	Percent of total area
1,000 ft	17.8	11	0	0	0	0
2,000 ft	62.8	38	13.3	35	2.5	45
3,000 ft	96.6	58	20.9	59	5.2	93
4,000 ft	128.4	77	30.8	87	5.5	98
Mean altitude		2,600 ft.		2,620 ft.		2,100 ft.

Estimate of Lost Lake runoff.--A gage located 4.9 miles downstream from Lower Lost Lake was maintained and operated by the Geological Survey during the period 1948-1950. Remarks in Water-Supply Paper 1372 state that the records are poor. A continuous record was obtained from August 1948 through March 1950.

During the 1949 water year, a runoff of 69.3 inches was measured at this station. Estimates of the monthly runoff in other years were based on the records for Grant Creek near Moose Pass. The Grant Creek basin is about 15 miles northeast of Lost Lake. The estimates between 1948 and and 1959 together with the records, August 1948 to March 1950, are listed in Table 4.

The precipitation at Seward during the 12 year period, 1948-59, was 90 percent of the mean for the 39 year period of record. By comparison the long-term mean annual runoff of Lost Creek is estimated to be about 76 inches.

Hubble and Waller Engineering Corporation (1935) state that during a flood in September and October 1935, the level of Lower Lost Lake rose 5 feet and the discharge at the lake outlet was estimated as reaching a maximum of more than 1,500 cfs. (A number of discharge measurements and estimates were made by engineers of this corporation in the fall of 1935.)

Table 4. - Estimates and records of the monthly and annual runoff of Lost Creek near Seward in hundreds of acre-feet 1/

Water year	O	N	D	J	F	M	A	M	J	J	A	S	Annual
1948	2.96	2.24	0.86	0.15	0.06	0.08	0.28	4.18	11.12	5.72	1.71	1.66	31.02
1949	2.92	1.01	0.19	0.07	0.03	0.07	0.18	2.35	9.27	4.86	2.65	5.78	29.38
1950	1.96	2.32	0.48	0	0	0	0.26	2.02	10.10	5.35	2.96	4.04	29.49
1951	1.14	0.37	0.15	0.09	0.04	0.06	0.29	2.12	7.37	5.32	2.31	6.21	25.47
1952	0.99	0.58	0.22	0.09	0.04	0.07	0.15	1.13	8.48	5.87	2.67	3.29	23.58
1953	3.79	2.96	0.92	0.27	0.11	0.14	0.64	4.80	21.00	7.30	3.15	3.61	48.69
1954	2.88	0.78	0.29	0.15	0.09	0.13	0.31	2.96	9.25	4.31	2.36	2.40	25.91
1955	1.89	1.64	0.38	0.19	0.06	0.09	0.19	1.23	6.58	6.60	2.50	3.26	24.61
1956	0.92	0.47	0.18	0.09	0.05	0.07	0.23	2.07	6.08	4.84	2.79	2.56	20.35
1957	0.73	0.63	0.38	0.10	0.05	0.09	0.30	2.83	10.15	3.68	2.27	6.75	27.96
1958	2.33	1.81	0.42	0.21	0.07	0.12	0.69	2.91	12.10	4.62	2.57	1.85	29.70
1959	1.76	0.73	0.28	0.12	0.06	0.10	0.41	3.67	12.50	5.03	2.48	2.69	29.83
Mean	2.02	1.30	0.40	0.13	0.06	0.09	0.33	2.69	10.33	5.29	2.54	3.68	28.83

1/ Figures for the period August 1948 to March 1950 rounded from published records; other figures were estimated from records of Grant Creek and the monthly relationship during period of overlapping records.

Variation of annual runoff.--During the period 1948 to 1959 it was determined from the estimates that the annual runoff of the Snow River ranged from 71 percent to 134 percent of the mean for that period, whereas precipitation at Seward ranged from 71 percent to 167 percent of the corresponding mean. The runoff from this basin and the Nellie Juan Lake basin in many years has little direct relationship with the amount of annual precipitation. As an illustration, the 1957 runoff, which was the high of the 12-year period of estimates, was 134 percent of the mean, whereas precipitation at Seward was only 74 percent of the mean and the second lowest amount of the 12-year period.

The equalizing effect of snow and ice storage is shown by the characteristics of annual runoff from several of the basins in this area in relation to the characteristics of annual precipitation at Seward. These are tabulated as follows:

Water years 1948-59 Station	Variability of annual runoff: Range (% of mean)	Variability of annual runoff: Standard deviation (% of mean)	Variability of annual precipitation, Seward: Range (% of mean)	Variability of annual precipitation, Seward: Standard deviation (% of mean)
Snow River	+34, -29	17.6	+67, -29	28.3
Kenai River at Cooper Landing	+42, -22	17.0	+67, -29	28.3
Cooper Creek	+67, -33	26.9	+67, -29	28.3
Crescent Creek	+68, -31	25.8	+67, -29	28.3
Trail River	+43, -21	15.8	+67, -29	28.3
Lost Creek	+69, -30	23.2	+67, -29	28.3

The annual runoff variability in percent of the mean annual runoff of Cooper, Crescent, and Lost Creeks is somewhat similar to that of the annual precipitation at Seward. This would seem to indicate that the natural storage of these basins is small, a circumstance that may be substantiated by the absence of any appreciable amount of glacier area in these basins. The somewhate consistent nature of the difference for Trail River, Snow River and Kenai River indicates that natural storage had an appreciable effect - reducing the range of runoff and the standard deviation considerably. However, the figures for Kenai River are undoubtedly a reflection of the Snow and Trail River basins which comprise approximately 55 percent of the Kenai drainage and contribute an even larger part of the runoff. The upper Trail River and Snow River basins are in high glacier areas where a considerable amount of natural storage would be expected. During the wet years the cool, cloudy weather would tend to inhibit the normal melting of the snow and ice, an effect which together with the greater duration of the heavier snow packs would tend to increase the amount to be carried over into other years.

The annual variation during future periods probably will be similar to that shown because the period, 1948-59, includes the driest and the second wettest year of record for the 39-year period of record at Seward.

Because of its relative location and many similar characteristics, the Nellie Juan basin can be expected to be similar to the Snow River basin in its annual variation of runoff.

Seasonal variation of runoff.--Table 5 shows the seasonal distribution of several streams in the Kenai Lake area. The figures shown for Snow River were computed from the estimates made for that basin.

Because of the similar characteristics, runoff from the Nellie Juan Lake basin probably is similar to that of the Snow River in seasonal distribution.

Table 5. - Average seasonal distribution of runoff from some Kenai Peninsula basins

Percentage of annual runoff

Basin	Oct.	Nov.	Dec.	Jan to May	June	July	Aug.	Sept.	Annual
Snow River 1/	9.6	(		10.8)	14.6	23.8	25.0	16.3	100
Trail River 2/	7.1	4.6	2.5	11.9	18.5	23.0	19.5	12.9	100
Cooper Crk. 3/	9.3	7.9	3.8	15.7	19.9	19.5	13.0*	10.9*	100
Crescent Crk. 3/	9.5	8.5	4.4	17.9	20.9	17.5	11.0	10.4	100

1/ Average figures computed from runoff estimates 1948-59.

2/ Average figures computed from recorded runoff 1948-59.

3/ Average figures computed from recorded runoff 1950-59.

* Runoff for 1959 estimated.

Runoff increases substantially during May and June with peak discharges usually occurring during July and August, primarily as a result of heavy runoff from snow melt. High flows are generally sustained by heavy fall rains through September, usually through October and occasionally through November. From December through April runoff is very low, and probably consists of occasional small amounts of snow melt or rain, with some ground-water return.

Undeveloped powersites

Factors that would affect the operation of powerplants.--

Sedimentation.--During the field surveys on Nellie Juan Lake and Snow River, it was noted that both streams carried considerable bedloads and suspended sediment which evidently is a result of glacial erosion.

On the Snow River this sedimentation is particularly noticeable near the junction of the South Fork and the main channel where it has been necessary for the Alaska Railroad to move considerable quantities of this material for protection of a railroad bridge.

If a reservoir were developed in Paradise Valley on the Snow River or at Nellie Juan Lake, a certain amount of this material would undoubtedly be deposited in the reservoirs. This would eventually decrease the storage capacity but it would probably be many years before it would be a serious threat. However, this should be taken into consideration and a suitable safety factor included in the original design. It is beyond the scope of this report to attempt an estimate of the rate at which this sedimentation would occur.

At the upper end of Nellie Juan Lake there is evidence of much material being deposited during high water periods. This material consists of boulders and gravel, grading down to the finer materials. The lake discharge was noted as being a slate color which seemed to indicate that the suspended material was mostly glacial flour.

Suspended material passing through the hydraulic structures and machinery would cause some additional wear, but this problem would be relatively minor.

Lost Creek basin contains little, if any, glacier area, hence the sedimentation problems would be minor.

Floods.--It has been reported by the Forest Service, the Geological Survey, and local residents that Kenai Lake is subject to abrup rises of several feet. The common conjecture is that the origin of these rises are glacier lakes in the Snow River basin. A recording gage was installed on Kenai Lake at the ranger station on November 15, 1933. Following is an excerpt from a descritpion of this gage by W. M. Sherman, Forest Ranger:

> "Floods: 'High water marks are evident all along the lake shore. This lake is subjected to large floods caused by glacier lakes breaking loose, it having been known to rise 4 feet in 3 hours'."

Since such a rise corresponds to a mean discharge of more than 200,000 cfs, it seems probable that the account is exaggerated or mistaken. However, in the Seward (B-6) quadrangle there is a sink area which may be the source of infrequent large floods. This evidently contains a glacial lake draining under a glacier to the Snow River. It is conceivable that this lake could be dammed by glacial action until the water pressure caused a break in the barrier. If this should occur, the water might be released abruptly through channels under the glacier, thereby creating flood conditions in the Snow River area and a corresponding rise of Kenai Lake water surface.

There is no conclusive evidence, however, that any recorded rises of Kenai Lake or the Kenai River resulted from abrupt releases from natural storage. It is quite possible that all of the recorded rises were due to normal runoff from heavy storms occurring in the mountainous regions of the upper Snow River basin. Comparisons of the runoff from nearby basins and the estimates of Snow River runoff indicate the mountainous areas of the Snow River are subjected to heavy storms which bypass the other basins. Because of the remoteness of the area and lack of inhabitants, it is probable that this condition could exist and be unknown to residents of the Kenai Lake area.

Analysis of the recorded rises and available climatic records at nearby stations (Seward, Moose Pass and Portage) show that there were definite increases in precipitation and temperature rises during the periods preceding and during the occurrence of several of the rises. Moreover, records of the Alaska Railroad do not disclose that any rises of the Snow River observed in connection with the design, operation, and maintenance of the railroad were of an unusual nature. (Preliminary surveys for a predecessor railroad were made in 1902 and construction of a section from Seward across the Kenai Peninsula was started in 1903. This was taken over by the government in 1915.[1/])

1/ Geology of the Alaska Railroad Region, Geological Survey Bulletin 907, 1940.

Nevertheless, in any plan of development on this stream the possibility of the occurrence of abnormal surges should be taken into consideration.

Ice on the reservoirs.--The reservoirs would be frozen over during the winter months, which would be the normal periods of drawdown. It would be necessary to take into consideration the protection of the dam and intake structures from icing and damage by ice from the spring breakup.

If storage were provided for a high degree of regulation, spill would probably occur only in the late summer after melting of ice, therefore, ice from the breakup would probably present no spillway problems.

Earthquakes.--The Kenai mountains are known to be in a strongly seismic area. Therefore, it would be necessary to design earthquake resistant structures for any projects in these basins.

Methods for appraisal of power.--The estimates were made by use of the formula $P = 0.068\ Q\ H$, where: P = power in kilowatts; Q = flow in cubic feet per second; H = mean gross head. Use of this formula assumes an overall efficiency of 80 percent and does not take into consideration the friction losses occurring in the tunnels or conduits.

Snow River.--

Reservoir and damsites.--The proposed damsite (see Plate I in pocket) is located between river mile 4.8 and 4.9, as measured upstream from the Alaska Railroad bridge. The site is topographically favorable for a dam. The river altitude is about 965 feet. At altitudes of 1300 and 1250 feet, the canyon widths are 1000 and 900 feet respectively. There are two saddles that must be considered along with this damsite. One of these is located about a mile southeast of the damsite at an altitude of 1205 feet. The other is located about 1100 feet north-northwest of the damsite at an altitude of 1235 feet. Dikes or dams across these saddles would be necessary for reservoir flow lines exceeding their controlling altitudes.

Geologic conditions at the damsite are favorable for the construction of a concrete or rock-fill dam to a height of 1300 feet, the maximum considered in the field investigation. The rocks at the damsite are well-indurated, interbedded slates, argillites, and graywackes in an estimated ratio of 70 percent argillaceous to 30 percent arenaceous. The fabric of the rock is impermeable, but minor seepage might take place along joints and fractures. Cement grouting of the rock should reduce water losses to a negligible amount. The overall feasibility of the site may be primarily dependent on the permeability of the material underlying the saddle area 1 mile southeast of the damsite.

The reservoir site is the Paradise Valley which extends northeast from the damsite some 17 miles, averaging about half a mile in width. The stream has a relatively flat gradient in this valley as shown on the profile (see Plate I). Soward (1958) found that the reservoir area probably is underlain by interbedded slate and graywacke covered by gravel, sand, and possibly till at many places in the valley bottom and that no appreciable seepage losses would occur except possibly at the saddle area 1 mile southeast of the damsite.

The potential reservoir capacities and corresponding surface areas are listed in Table 6, following this page.

Table 6. - Snow River reservoir, areas and capacities (Damsite at mile 4.8)

Altitude feet	Area acres	Capacity acre-feet
965 1/	0	0
980	6	40
1,000	18	280
1,020	31	770
1,040	38	1,500
1,060	54	2,400
1,080	126	4,200
1,100	572	11,200
1,120	796	24,800
1,140	993	42,800
1,160	1,420	67,000
1,180	2,160	103,000
1,200	3,010	154,000
1,220	3,890	223,000
1,240	4,340	306,000
1,260	4,770	397,000
1,280	5,180	497,000
1,300	5,700	605,000

1/ River surface at damsite.

Inflow.--The average estimated annual inflow to the reservoir is about 504,000 acre-feet or an average of about 700 cfs based on the estimate of 90 inches on the 104.5 square miles above the damsite. This probably is an underestimate since it is based on the assumption that the runoff is uniform throughout the basin, whereas it probably is heaviest in the upper part. Evaporation losses from the surface of the reservoir to be created may be equivalent to as much as an inch and a half on the basin area above the damsite. Since the error in the estimated runoff undoubtedly is large with respect to this amount, and since it probably is negative, no allowance was made for evaporation in the computation of reservoir schedules.

Storage requirements.--As shown by the indices of wetness of Table 1, page 13, precipitation at Seward (and probably in this basin) during the 12 years, 1948-59, was about 90 percent of the long term mean. Storage requirements were computed on basis of the monthly estimates of the basin for this period. (Estimates shown in Table 2.)

The usable storage capacities required to provide regulated flows equivalent to 90 percent and 80 percent of the longtime estimated mean flow would be 523,000 acre-feet and 295,000 acre-feet respectively. These regulated flows would be 627 and 547 cfs.

Potential power.--Power development would be accomplished by the construction of a dam at mile 4.8, conveying the water from the resulting reservoir by a tunnel about 1.9 miles in length and a penstock

0.4 miles long to a powerhouse at altitude 500 feet. The powerhouse would be located about three-tenths mile east-northeast of where the Paradise Valley trail leaves the railroad (see Seward B-7 quadrangle). The estimated power along with related data is shown in the following tabulation.

Estimated power and related data

	With regulated flow 90% of mean	With regulated flow 80% of mean
Required storage capacity, acre-feet a/	523,000	295,000
Maximum reservoir altitude, feet	1,293	1,247
Minimum reservoir altitude, feet	1,140	1,140
Height of dam, feet	328	283
Mean reservoir altitude, feet	1,240	1,211
Mean gross head, feet	740	711
Mean flow, cfs	627	547
Power, kilowatts	31,600	26,400

a/ Capacity above altitude 1,140, the proposed minimum reservoir level.

Construction of this project would be facilitated by its location in respect to existing transportation facilities. Access to the damsite could be had by construction of two and a half to 3 miles of road from the Seward-Anchorage highway. The Alaska Railroad parallels the highway in this area. The powerhouse site is within easy access from both the highway and railroad.

Spillways.--A spillway or spillway system of sufficient size would be necessary to pass any flood which may occur. Soward (1958), on the basis of his examination of the damsite, states that a discharge of as much as 200,000 cfs could probably be passed by the combination of spillways over the dam and through the small saddle 1,000 to 1,400 feet north of the river at the damsite. His study shows another possible spillway site through the saddle about 1 mile southeast of the damsite. However, a decision as to this site cannot be made until subsurface geologic investigations are made.

Locations at which power could be used.--The primary market for a block of power this large in the foreseeable future would be in the Anchorage area about 110 miles to the northwest. This plant could easily be interconnected with Cooper Lake project, now under construction, and the proposed Ptarmigan and Grant Lakes development. The Cooper Lake project includes plans for transmission lines to the western Kenai Peninsula area and Anchorage.

Nellie Juan Lake.--

Reservoir and damsite.--The canyon at the lake outlet appears topographically suitable for a dam to about altitude 1,300 feet or 110 feet above the lake surface. However, development above an altitude of 1,255 feet would require a dike in a bypass area about 1,600 feet north of the lake outlet. The exact location of a dike probably would be dependent upon the height of development. Two possible dike locations are near the ponds at altitudes 1,254 and 1,244 feet (see Plate II). Development to altitude 1,280 feet would necessitate a dam at the lake outlet about 680 feet long and a dike 600 to 1,000 feet long in the bypass area.

The bedrock exposures in the Nellie Juan Lake damsite area consist of generally thick to massive beds of graywacke interbedded with a somewhat smaller volume of dense, tight, quartzitic slate. The beds are isoclinally folded, strike parallel to the general course of the Nellie Juan River, and everywhere dip at a near-vertical to vertical angle. The rock fabric is relatively impermeable and insoluble, but the rocks are broken by numerous fractures and shear clevage planes. A lineament, adjacent to the damsite area on the east side, indicates the proximity of a possible major fault zone. The damsite abutments are characterized by bedrock exposures with very little overburden.

General views of Nellie Juan Lake are shown in figures 4 and 5.

Figure 4. - View of Nellie Juan Lake showing the Nellie Juan River in foreground.
Figure 5. - View of Nellie Juan Lake from left abutment of damsite.

Figure 4. - View of Nellie Juan Lake showing Nellie Juan River in foreground.

Figure 5. - View of Nellie Juan Lake from left abutment of damsite.

Diversion possibilities.--A low saddle area at an altitude of 1,314 feet about a mile and a half south of the lake separates Nellie Juan Lake and Day Harbor drainage. By diversion of the two streams draining to the south in this area (see Seward A-6 quadrangle), the area tributary to the lake could be increased by about 3.9 square miles or 11 percent. Diversion could be accomplished by excavation of a channel about half a mile in length to the northwest. It might be necessary to construct a short training wall or dike near the point of diversion. Excavation of the channel would be largely or entirely through deposits of glacial debris.

Another possible diversion exists near the headwaters of the South Fork of the Snow River. A large glacier is located at the drainage divide, with drainage into both basins. (This is shown on the map of the Seward (A-6) quadrangle.) By means of a dike and excavation of glacial debris this drainage could possibly be diverted entirely to Nellie Juan Lake, thereby tapping a drainage area of approximately 2.3 square miles or 6.5 percent of that of Nellie Juan Lake. However, this diversion may be impractical because the glacier terminus is in the divide and constant movement of glacial debris would no doubt necessitate constant maintenance work on the diversion works.

The diversion and drainage areas as listed may be somewhat in error because of the inexact method of dividing glacier drainage by surface topography which may not reflect the drainage pattern under the glacier.

Inflow.--The drainage basin area above the damsite, according to the surface boundary is 35.3 square miles. If the average annual inflow is equivalent to the estimated 90 inches on the basin, it is about 169,000 acre-feet. Because the tapping of the additional 3.9 square miles of drainage area as previously described would entail relatively little construction, it is probable that this would be favorably considered in any development. Therefore, preliminary estimates of this report are based on the runoff from 39.2 square miles or a long-term average water supply of 188,000 acre-feet per year.

Storage requirements.--Assuming the seasonal and annual runoff variation to be similar to the Snow River, about 196,000 acre-feet of storage would be required for regulation of 90 percent of the runoff. This would provide for a uniform release of about 235 cfs.

On the same basis, it is estimated that only 111,000 acre-feet of storage would be required for 80 percent regulation of the expected runoff. This degree of regulation would provide for a uniform release of about 204 cfs.

The potential reservoir capacities and corresponding surface areas are shown in Table 7 following this page.

Table 7. - Nellie Juan Lake reservoir, areas and capacities

Altitude feet	Area acres	Capacity (acre-feet) Below lake surface	Above lake surface
1,080	650	97,000	
1,100	762	82,800	
1,120	844	66,800	
1,140	917	49,200	
1,160	987	30,100	
1,180	1,050	9,800	
1,189 1/	1,130	0	0
1,200	1,470		14,300
1,220	1,880		47,700
1,240	2,230		88,800
1,260	2,420		135,000
1,280	2,610		186,000
1,300	2,780		239,000

1/ Lake surface.

Potential power.--The development of power would be accomplished by utilizing the lake as a storage reservoir and conveying the water from it to a powerhouse located about 2 miles downstream at an altitude of 730 feet (see fig. 6). This location takes advantage of the concen-

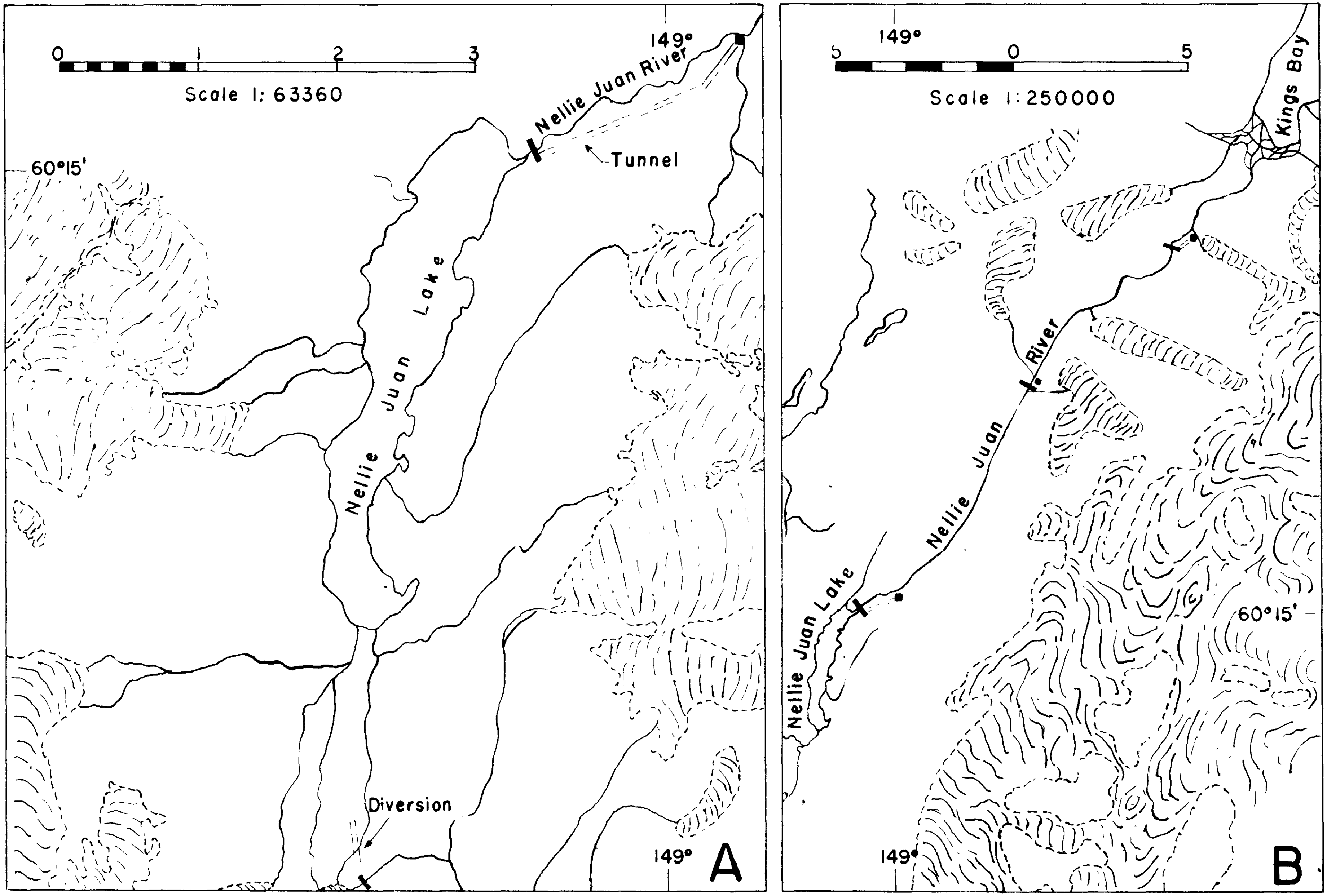
Figure 6. - Illustrative plans of development, Nellie Juan basin.

trated fall in this section of the river. The required storage would be developed by the construction of a dam at or near the lake outlet to raise the lake above its natural level or by a combination of a dam and drawing the lake to some point below its natural level. The underwater topography near the lake outlet is, however, not particularly favorable for underwater construction. With a drawdown of 49 feet, down to an altitude of 1140 feet, the intake structure would be about 700 feet from the lake outlet. The estimated power for 2 degrees of regulation and 2 methods of development for each, along with related data is shown in the following tabulation.

Estimated power and related data

	With regulated flow 90 percent of mean		With regulated flow 80 percent of mean	
	With dam only	With dam and drawdown	With dam only	With dam and drawdown
Required storage capacity, ac-ft	196,000	196,000	111,000	111,000
Maximum reservoir altitude, feet	1,284	1,265	1,250	1,227
Minimum reservoir altitude, feet	1,189	1,140	1,189	1,140
Height of dam, feet	95	76	61	39
Drawdown, feet	--	49	--	49
Mean reservoir altitude, feet	1,244	1,221	1,224	1,193
Mean gross head, feet	514	491	494	466
Mean flow, cfs	235	235	204	204
Power, kilowatts	8,210	7,850	6,850	6,420

Figure 6



Illustrative plans of development, Nellie Juan Basin "A" As described in this report ▮ Dam

The Nellie Juan River falls 730 feet between the proposed powerhouse location and its mouth on Kings Bay. If the lake project were developed, it would provide a regulated release which could be utilized by construction of an additional powerplant or plants on the lower reaches of the river. Considerably more water would be available at these downstream locations because of the increased drainage area. Extensive glaciers on both sides of the valley downstream from the lake suggest that the precipitation and runoff must be very heavy. From the available map coverage the topography appears suitable for dams at several down river sites for concentration of head and some additional storage. The overall potential power of the Nellie Juan River thus may be very much greater than that of the first stage - possibly as much as 30,000 or 40,000 kw. (The Corps of Engineers in a rough preliminary estimate given in a written communication estimates that prime power of as much as 55,000 kw might be developed from the lake to tidewater.)

Investigation of possible sites on the river downstream from an altitude of 730 feet may reveal that a desirable pool level of the second stage might be higher than 730 feet. The location of a powerhouse at that level, as suggested herein, is for illustrative purposes only.

Spillway.--If a dam were constructed at the lake outlet, it would be necessary to provide a spillway capable of passing any flood which may occur. The saddle areas on the damsite could be used as natural spillway sites for development above an altitude of 1,250 feet.

Locations at which power may be used.--If this plant were developed, the power would probably be used at Anchorage and in the Kenai Peninsula area. The Nellie Juan plant could be interconnected with the existing and proposed networks.

The most attractive transmission line route from Nellie Juan powerplant is along the west shore of the lake and through the low pass separating the lake and South Fork Snow River drainages, then along the South Fork to the Seward-Anchorage Highway. This distance is about 17 miles.

Lost Lake dam and reservoir sites.--Two damsites and the reservoir site in the Lost Lake area were surveyed and maps published in 1957 by the Geological Survey (see Plate III).

One damsite is located near the outlet of Lost Lake and the other is near the outlet of Lower Lost Lake (see figs. 7, 8, 9, 10). Both

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Figure 7. - Outlet of Lost Lake.
8. - View looking downstream, Lost Lake damsite.
9. - View looking downstream, Lower Lost Lake damsite showing right abutment face.
10. - Lower Lost Lake from below outlet.

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sites appear topographically suitable for low, short dams. However, any development at either damsite above an altitude of 1,950 feet would necessitate construction of a dike in the saddle area about 2,000 feet southwest of the outlet of Lost Lake.

Gaskill and Wayland (1959), after a geologic reconnaissance of the area, found Lost Lake damsite to have bedrock foundation material suitable for a rock-fill or concrete dam, whereas the Lower Lost Lake site may be more susceptible to foundation failure due to strike direction. This and other pertinent geologic features are described in their report.

Figure 7. - Outlet of Lost Lake.

Figure 8. - View looking downstream, Lost Lake damsite.

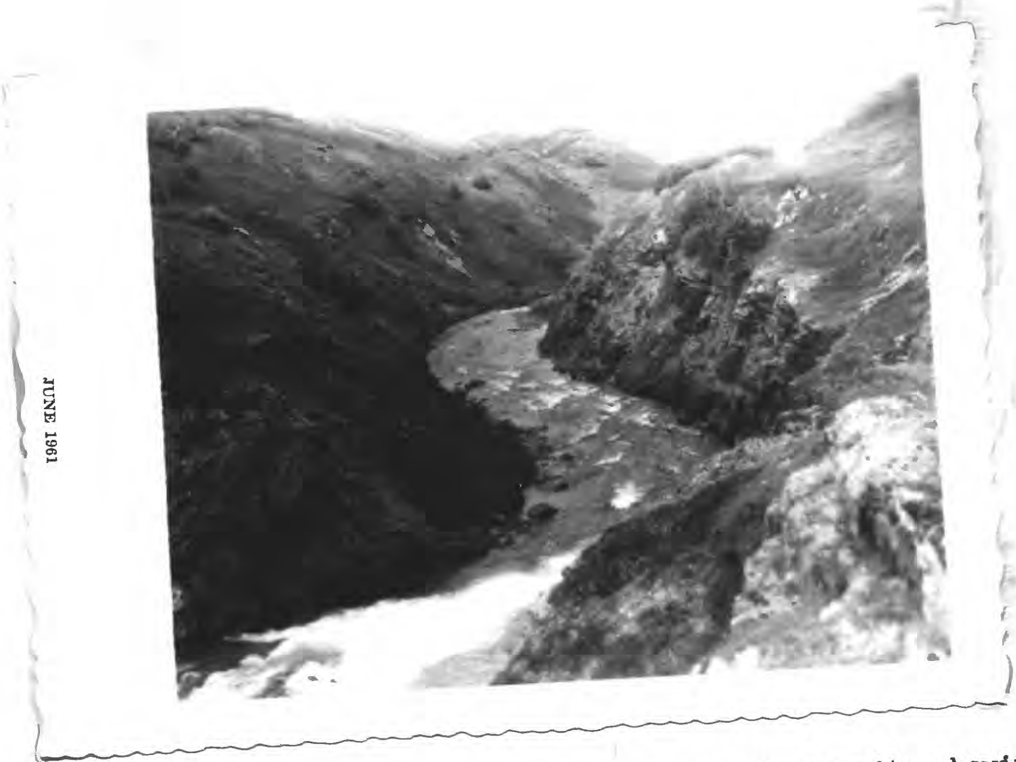


Figure 9. - View looking downstream, Lower Lost Lake damsite showing right abutment face.

Figure 10. - Lower Lost Lake from below outlet.

Diversion possibility.--Porcupine Creek, which originates about a mile and a half northwest of Lost Lake parallels the Lost Lake drainage for about two miles, the lower half a mile in a deep gorge, then makes a right angle turn to the north and flows to its outlet at Kenai Lake. About a square mile of this drainage basin could be made tributary to Lost Lake, thereby increasing the drainage area and water supply by about 18 percent. The topography of this area is shown on the Seward (B-7) quadrangle map.

Diversion of this stream could be accomplished by a diversion dam and conveyance of the water by open channel or pipeline for about a quarter of a mile or to a point where natural drains into Lost Lake could be utilized. Waterways designed for a maximum of 25 cfs would probably be large enough to convey all but the extreme floods. Excavation in this area may be difficult because the dividing ridge is formed largely of massive graywacke beds (Gaskill and Wayland, 1959).

Because of the usual decrease in unit cost as the size of a small project increases, this diversion may be favorably considered in any development plans.

Inflow.--The drainage basin areas above the upper and lower damsites are 4.9 and 5.6 square miles, respectively. The average expected annual inflow above the lower damsite is about 20,300 acre-feet or 28.0 cfs, if it is equivalent to the estimated 68.1 inches on the drainage area of 5.6 square miles. Diversion of Porcupine Creek would increase the expected annual runoff to about 23,900 acre-feet or 33.1 cfs. Estimates of storage requirements and regulated flows do not take this diversion into account, except as noted hereinafter.

Storage requirements.--The reservoir area includes both Lost Lake and Lower Lost Lake. The potential reservoir capacities and corresponding surface areas are shown in Tables 8 and 9 following this page.

By use of the runoff estimates for the period 1948-1959, it was determined from an operation schedule that about 21,770 acre-feet of storage would provide 100 percent regulation of the runoff above the Lower Lost Lake damsite. Since the mean precipitation at Seward during the corresponding period was 90 percent of the mean for the 39 year period of record, it is estimated that the storage capacity required for 100 percent regulation of the runoff during this period (1948-1959) would provide for only about 90 percent regulation of the expected longtime annual runoff. With storage capacity of 21,770 acre-feet, a uniform release of about 28 cfs could be maintained.

For 80 percent regulation of the long term annual runoff, storage requirements would be reduced by approximately 36.5 percent or to 13,800 acre-feet. This would provide a uniform release of about 25 cfs. This lesser degree of regulation may be considered desirable because of decreased construction costs.

Table 8. - Areas and capacities above Lost Lake Damsite

Altitude feet	Area acres	Capacity (acre-feet) Below lake surface	Above lake surface
1,820	56	21,300	
1,840	130	19,500	
1,860	171	16,400	
1,880	241	12,300	
1,900	310	6,800	
1,910 1/	-	-	
1,920 2/	370	0	0
1,940	517		8,800
1,960	653		20,500

1/ Water surface at damsite.

2/ Lost Lake surface.

Table 9. - Areas and capacities above Lower Lost Lake Damsite

(without drawdown below surface of Lost Lake)

Altitude feet	Area acres	Capacity (acre-feet)
1,885 1/	0	0
1,899 2/	38	-
1,900	81	60
1,920	113	2,000
1,920	483 3/	-
1,940	653	13,400
1,960	843	26,300

1/ Water surface at damsite.

2/ Lower Lost Lake surface.

3/ Includes surface area of Lost Lake.

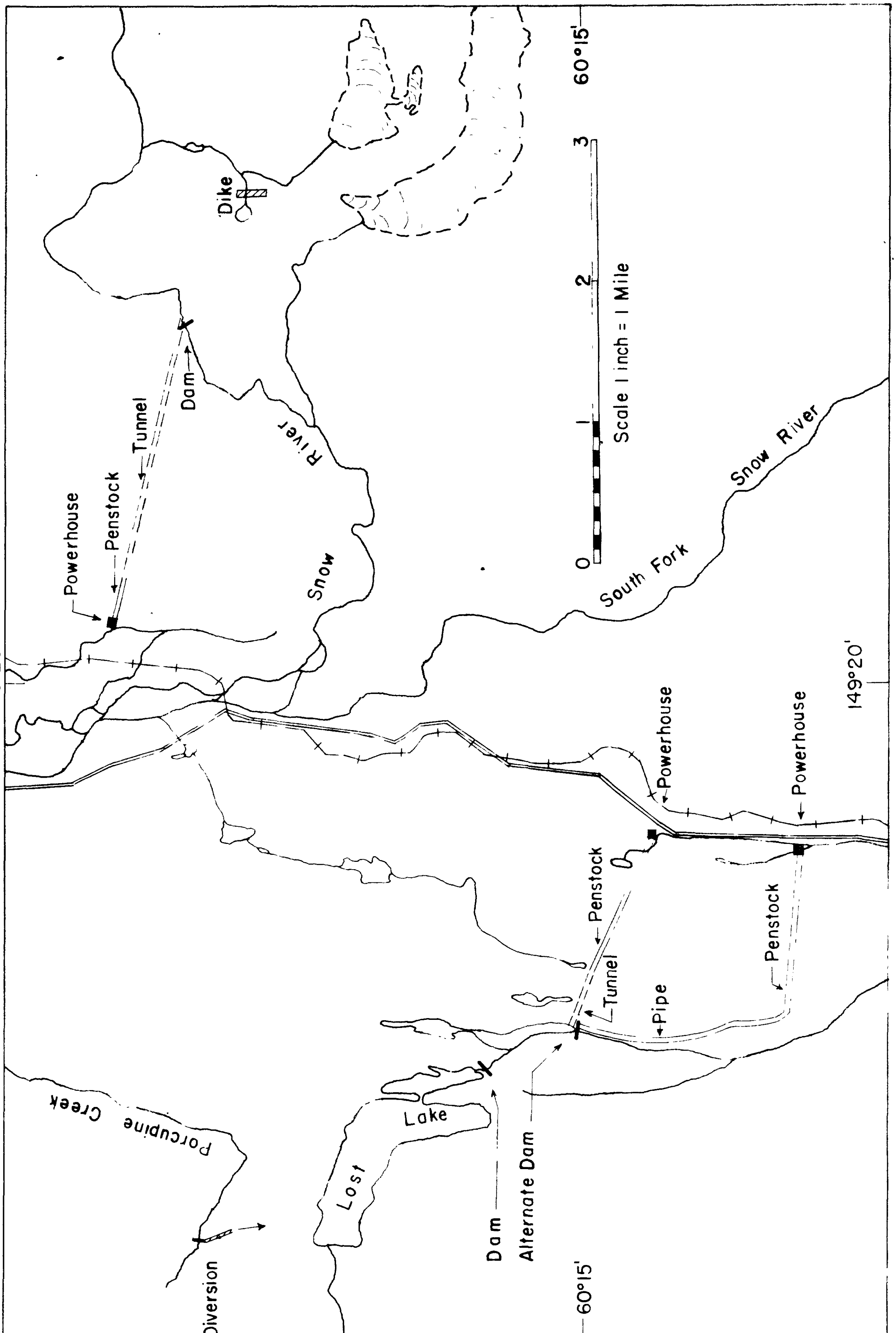
Illustrative plans of development and estimated power.--Powerhouse locations and waterway routes are shown on figure 11. Waterway route

Figure 11. - Illustrative plans of development, Lost Lake and Snow River powersites.

number one leads to a powerhouse location at an altitude of about 500 feet near the Seward-Anchorage Highway. The discharge would be into Grouse Creek. The total waterway length would be about one and a half miles, and the waterway would consist of a half a mile of tunnel and a mile of penstock. A pond at an altitude of 1,838 feet near the outlet of the tunnel could be used as a forebay, as was proposed in the plan of Hubbell and Waller Engineering Corp. (1935). Since this would sacrifice nearly a hundred feet of the available head, it was not considered for purposes of this report. If an unlined tunnel of minimum practical size is feasible, water under pressure could be conveyed through it in a pipeline; otherwise, a lined tunnel could be operated under pressure.

The alternate route, number two, figure 11, leading to a powerhouse location at an altitude of of 400 feet near the Seward-Anchorage Highway would require two and a half miles of waterway. The water would be conveyed by pipeline along Lost Creek for approximately a mile and a half, then eastward a mile by penstock to the powerhouse and discharged into Grouse Creek. This route, although a mile longer than route number one, may be the more feasible because there would be no tunnel construction, and 100 feet of additional head would be developed.

Figure 11



Illustrative plans of development Lost Lake and Snow River power sites

The power estimates shown below, except as noted, were computed assuming the powerhouse at an altitude of 400 feet and without the Porcupine Creek diversion.

Development in one of the alternative plans listed below would utilize 10 feet of the underwater storage capacity of Lost Lake. This would necessitate excavation of the creek channel for a distance of about 600 feet below the lake outlet and a minor amount of excavation at the saddle area located in the narrow constriction of the lake. The field surveys showed the minimum lake depth at the constriction to be about 3 feet.

The power possibilities and related factors are summarized as follows:

	Plan A	Plan B	Plan C	Plan D
Controlled flow (% of mean flow)	90	90	80	80
Controlled flow (cfs)	24.6	28.0	21.8	25.0
Mean head (feet)	1,500	1,537	1,500	1,531
Storage capacity (acre-feet)	19,000	21,770	12,200	13,800
Height of dam (feet)	42	68	36	56
Operating range (alt in feet)	(1,951 (1,910	(1,953 (1,900	(1,945 (1,920	(1,941 (1,900
Continuous power (kw)	2,510	2,920	2,220	2,600

Plan A, dam at upper site and 10-foot drawdown of Lost Lake.
Plan B, dam at lower site.
Plan C, dam at upper site.
Plan D, dam at lower site.

The foregoing estimates feature regulation of runoff from the Lost Lake basin alone. With the estimated diversion from Porcupine Creek, and with a dam at the lower site the power possibilities and related factors for 2 degrees of regulation would be as follows:

	Plan E	Plan F
Controlled flow (% of mean)	90	80
Controlled flow (cfs)	33.1	29.4
Mean head (feet)	1,539	1,533
Storage capacity (acre-feet)	25,600	16,300
Height of dam (feet)	74	60
Operating range (alt in feet)	(1,959 (1,899	(1,945 (1,899
Continuous power (kw)	3,460	3,060

The power estimates shown above do not take into consideration the additional evaporation losses that would occur as a result of the increased water surface area. However, if this evaporation were as much as 24 inches per year it would be only about 2 percent of the estimated average annual inflow, which is small in relation to the probable error of the estimates. It should be noticed, however, that in operation schedules for 100 percent utilization over many years, such as from 1948 to 1959, cumulative evaporation losses might be equivalent to a substantial portion of the reservoir capacity.

Spillways.--This basin is subject to heavy floods such as occurred during September and October 1935 (Hubbell and Waller, 1935). The discharge, as measured at the lake outlet increased from 25 cfs to over 1,500 cfs during an eight day period of heavy rainfall.

If the project were developed with a dam at the Lower Lake site, a spillway could be built to divert the water through the saddle area about 400 feet west of the lake outlet. Another saddle area bout 2,000 feet southwest of the upper damsite could be utilized as a spillway for all illustrative plans of development. This would divert floods and spill into the west branch of Lost Creek. Spillways could also be developed over the dams or on the damsite abutments. Wayland and Gaskill (1959) state that with the probable exception of abutment-spill sites at the lower lake damsite, these areas would need little or no protection from water erosion.

Locations at which power could be used.--Power generated by this project could be substantially utilized at Seward which is now served by diesel electric plants. Any excess could be distributed by interconnected systems to other parts of the Kenai Peninsula and Anchorage.