Form 9-014

UNITED STATES
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY
WASHINGTON 25, D. C.
[Reports-Open file series]

POTENTIAL WATERPOWER
OF
LAKE CHAKACHAMNA, ALASKA

By

Bruce L. Jackson

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

OPEN FILE

March 1961

U. S. GOVERNMENT PRINTING OFFICE 16—68863-2

U. S. GEOLOGICAL SURVEY.

REPORTS OPEN FILE. NO. 613.

POTENTIAL WATERPOWER

OF

LAKE CHAKACHAMNA, ALASKA

By

Bruce Lawellin Jackson, 1937-

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

OPEN FILE

March 1961

CONTENTS

ILLUSTRATIONS

TABLES

Potential Waterpower of Lake Chakachamna, Alaska

By

Bruce L. Jackson

Abstract

Lake Chakachamna, in view of its area, altitude, and location in a region of high precipitation and runoff, has a large potential power value. The outflow from the lake, based on limited streamflow records, varies from less than 60 cfs to well over 15,000 cfs, with an annual flow in 1960 of 3196 cfs or 2,320,000 acre-feet. With this pronounced variation in flow, regulation by storage is necessary for power development. The requisite storage can be developed by drawing the lake below its natural level. For complete regulation, a drawdown of 78 feet would be required. Regulation of 90 percent of mean flow can be accomplished with a drawdown of 67 feet. Construction of a dam at or near the lake outlet is not considered feasible. The most likely site for a powerhouse appears to be in the McArthur River Valley where a mean head of as much as 1004 feet could be utilized which with a mean flow of 3196 cfs would develop 218,000 kw. The principal market for this power would be the Anchorage and vicinity area and the Kenai Peninsula.

Introduction

Lake Chakachamna is a high mountain glacial lake located in the Alaskan Range some 80 miles west of Anchorage. No roads or passable trails exist into the lake, and at present this area is inaccessible except by air.

Much interest has been shown in recent years concerning the water-power potential of this lake. An underwater contour map of the lake has been made and a gaging station established just below the lake outlet in order to obtain data on storage capacity and runoff characteristics of the lake.

The purpose of this report is to present the data now available and estimate the potential power which could be developed in this region. The plan of development discussed herein is provisional, and is presented as a means of evaluating the potential power.

Maps and aerial photographs

Lake Chakachamna is shown on the following quadrangles:

Tyonek - Reconnaissance series, scale 1:250,000.
CI: 200 feet. 1951.

Tyonek - A-6, A-7, A-8, scale 1:63,360. CI: 100 feet.
(In preparation.)

Lake Chakachamna - Scale 1:24,000. CI: 20 feet, with
underwater contours to a depth of 240 feet.
(In preparation.)

Lake Chakachamna and vicinity is included on the aerial photographs listed below. The films for these are on file with the Geological Survey, Denver Federal Center, Denver, Colorado.

Flight	Altitude	Exposures
M-653	20,000	134, 135, 136, 137
M-222	24,850	5851, 5852, 5853
M-237	24,000	10117, 10118, 10119

Acknowledgments

The Bureau of Reclamation office in Juneau furnished funds for approximately one-half the cost of the field operations.

Previous investigations

The earliest authentic information about this part of Alaska was that obtained by the British navigator, Captain James Cook, who in 1778 discovered the inlet that bears his name. A second British expedition, headed by George Vancouver, returned to the inlet in 1794 for further exploration.

An expedition by J. E. Spurr and W. S. Post traversed west from Cook Inlet across the Alaskan Range to the north of Lake Chakachamna in 1898. In 1902 an expedition conducted by Alfred H. Brooks again went north of Lake Chakachamna and across the Alaskan Range. This expedition was the first into this region but still left the area around Lake Chakachamna unexplored.

In 1927 an exploratory party headed by S. R. Capps traveled from Tyonek, an Indian village on the west shore of Cook Inlet, up the Chakachatna River and across Barrier Glacier into Lake Chakachamna. This party turned north up the Nagishlamina River, across a high mountain pass, and into the Chilligan Valley. The lateness of the season forced them to retrace their steps and leave the upper part of the lake unexplored.

Arthur Johnson made a brief reconnaissance of Lake Chakachamna in 1948, and prepared a report on the potential power available which was placed in open file.

Present investigations

A survey was made of the lake during July and August 1960. A map of the shoreline and underwater contours at 20 foot intervals to a depth of 240 feet was made, and random soundings below the 240 foot depth were made to show the maximum depth of the lake. Topography to 100 feet above lake level was compiled from aerial photographs by the Denver office of the Topographic Division, U. S. Geological Survey. The underwater contouring has been combined with this compilation and the resulting map is now in preparation for publication. This map will be at a scale of 1:24,000 with a 20 foot contour interval. The control for the field mapping and compilation was based on a network of triangulation along the lake established by the Coast and Geodetic Survey. A fathometer was used to obtain the soundings, and spot checks with the tag line showed the accuracy to be quite satisfactory - the difference never being more than 2 feet. The positions of the soundings were

determined by planetable methods from stations along the lake shore, distances being read on a stadia rod mounted in the boat. Two-way radios were used for communication between the planetable and the boat. The use of the fathometer resulted in a time saving of approximately 30-40 percent in the field as compared with soundings made by line-and-weight. All transportation for this survey was by air.

A gaging station was established at the lake outlet in June 1959 by the Geological Survey in cooperation with the Bureau of Reclamation and is still in operation.

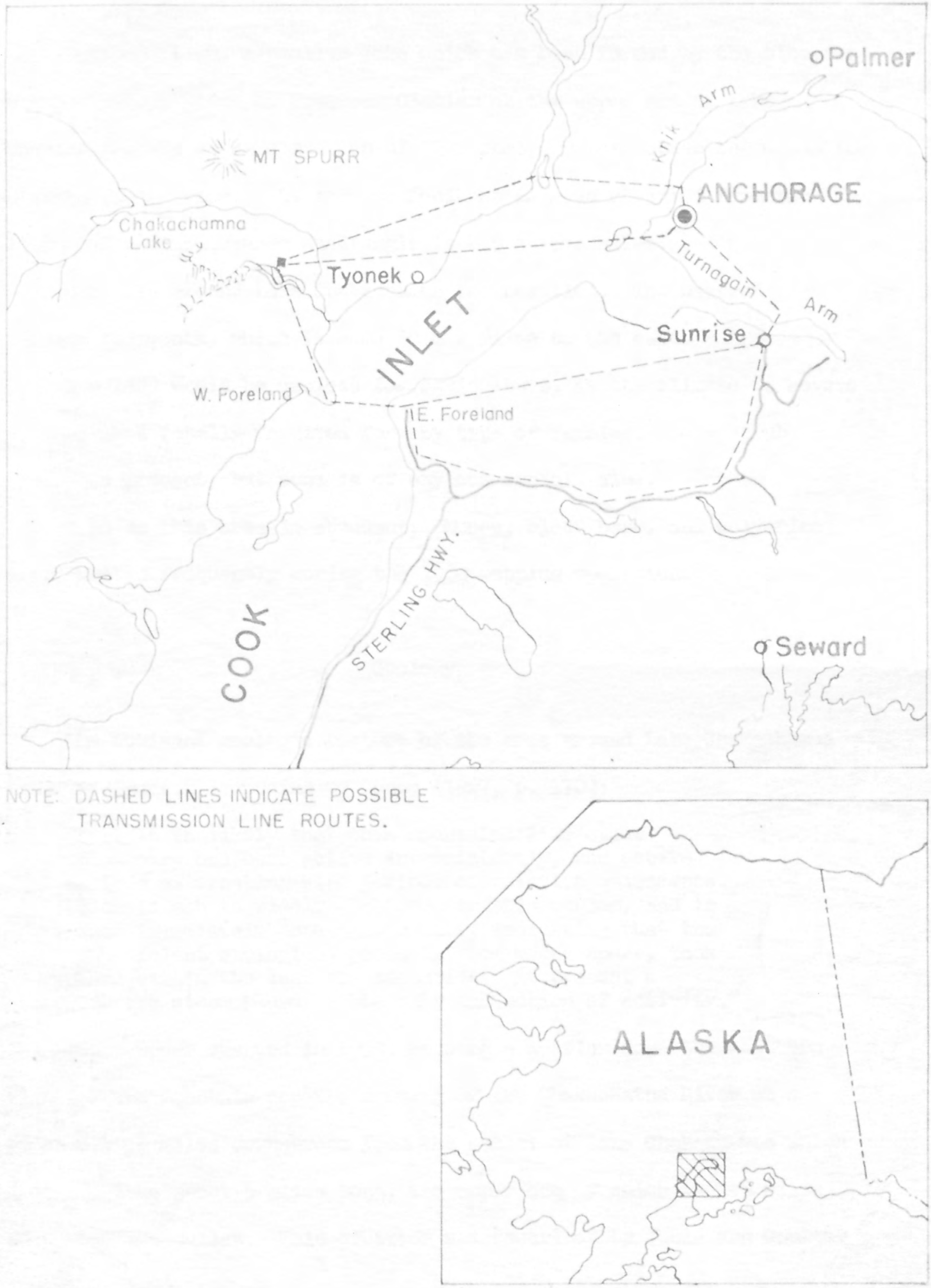
The United States Fish and Wildlife Service had a crew on the lake in July and August 1960 to make studies of the salmon run in this area.

Geography

The outlet of Lake Chakachamna is located 80 miles west of Anchorage at latitude 61°13' N., longitude 152°23' W. (figure 1). The

Figure 1. - Location map.

lake is at elevation 1142 feet, is 15 miles long and an average of 2 miles wide, has an area of 26 square miles, approximately 45 miles of shoreline, and drains an area of 1120 square miles. It lies in a deep east-west oriented glacial valley that has been effectively blocked by Barrier Glacier, which descends the southwest slope of Mount Spurr. High peaks completely surround the lake, and for the most part, the valley walls rise very abruptly from the water's edge.



NOTE: DASHED LINES INDICATE POSSIBLE TRANSMISSION LINE ROUTES.

FIG. 1– LOCATION MAP

Kenibuna Lake, a smaller lake which has been formed by the blocking of the Neacola River by Shamrock Glacier at the upper end of Lake Chakachamna, is at an elevation of 1222 feet, 80 feet above the elevation of Lake Chakachamna. The area of Kenibuna Lake as measured from the 1:250,000 reconnaissance quadrangle is 4.5 square miles.

The area around Lake Chakachamna is unsettled. The nearest village is Tyonek, which is some 38 air miles to the east.

The land would be useless for agriculture, as the climate is severe and the land totally unsuited for any type of farming. Some scrub timber is present, but none is of any commercial value.

Game in this area is abundant. Moose, black bear, and wolverine were spotted frequently during the 1960 mapping operation.

Geology

The dominant geologic feature of the area around Lake Chakachamna is Mount Spurr. According to Capps (1927, p. 170):

> "It is likely that this mountain, like other volcanoes, has been active intermittently, the active periods alternating with periods of relative quiescence. Volcanic ash is widely scattered in this region, and is found immediately beneath the turf, indicating that the last violent explosion, probably from Mount Spurr, took place within the last few centuries. At present a moderate steam plume is the only indication of activity."

Mount Spurr erupted in 1953, causing a mudflow down the southern flank of the mountain and the damming of the Chakachatna River at a point 5 to 6 miles downstream from the outlet of Lake Chakachamna which formed a lake about 5 miles long, the upper end of which is 1.5 miles from the lake outlet. This eruption was described by Juhle and Coulter (1955, p. 199).

A quite noticeable steam plume from Mount Spurr was observed by the field party while encamped on the lake during July and August 1960.

The geologic map of the area included in Geol. Survey Bull. 810-C shows that the dominant rock type is granite intrusive with minor amounts of basaltic intrusives. According to Capps (1927, p. 154):

> "A large part of the area here considered is occupied by granitic rocks that form a notable element of the Alaskan Range from Lake Clark northward to Mount McKinley and beyond. Quite possibly granites of several ages are represented, but in the Mount Spurr region, there is evidence for the belief that the major intrusions took place in late Mesozoic time, although earlier granites are present also."

Lake Chakachamna has been formed by a dam of glacial morainal deposits from the still active Barrier Glacier on the southwestern slope of Mount Spurr. Other deposits in this area are the gravels, sands, and silts of present streams which form river deltas and beach deposits at the entrances of the Nagishlamina, Chilligan, and Neacola Rivers. A large glacial moraine is present at the base of More Glacier.

Aerial photographs of this region show a series of parallel lineaments which trend roughly NW-SE. These features are quite evident in the field, and seem to extend for some distance. They are nearly vertical, and close examination shows severe fracturing and pulverization in the fault or fracture zone. A tunnel from Lake Chakachamna to the McArthur River Valley would roughly parallel the strike of these features.

Factors affecting hydraulic structures

The area around Lake Chakachamna is seismically active, as evidenced by the minor eruption of Mount Spurr in 1953. Large scale faulting and severe jointing give an indication of the instability of the area. The design of all hydraulic structures should recognize the possibility of future distrubances. The topography of the area is such that avalanches are possible, and in the area around the tunnel inlet, appropriate safeguards should be included in the project design.

The streams which feed Lake Chakachamna are all heavily laden with sediment. The sediment is primarily "rock-flour" of glacial origin, and much of it seems to stay in suspension even after it reaches the calm waters of the lake. There are no data available as to the rate of accumulation of sediment in the lake, but the abrupt "leveling off" of the lake bottom at depths below 240 feet seems to indicate a considerable accumulation of sediment. Large deltas have been formed from the stream carried sediments at the entrances of the Nagishlamina, Chilligan, and Neacola Rivers. These deltas form large shallow underwater plains which drop off rather abruptly at varying distances from the shore. There is little likelihood that the sediment accumulation will affect the usable capacity of the lake within the lifetime of any project undertaken here, but the "rock-flour" in suspension may have an abrasive effect on the plant facilities.

There are no temperature data available at or near Lake Chakachamna. If it is assumed that temperatures in this area are

similar to the temperatures at existing stations at roughly the same altitude, an average annual temperature of from 30°F to 40°F may be expected. Icing conditions exist from 7 to 8 months of the year, and hydraulic structures must be designed accordingly.

Water supply

There are no precipitation records available for the area around Lake Chakachamna or the Chakachatna River. Most of the precipitation in the area undoubtedly occurs as snow with consequent low rates of runoff in the late fall and winter months and high runoff rates during the spring and summer months.

Runoff is derived from the melting of snow and glacial ice along with normal rainfall during the summer months. July and August are the months of heaviest runoff. In the water year 1960, 83 percent of the annual runoff occurred in the period June through September, or during 33 percent of the year.

A gaging station designated, "Chakachatna River near Tyonek," was installed on the Chakachatna River in June of 1959, making a record of 16 months available at the end of the 1960 water year. The monthly runoff, in thousands of acre-feet, for this period is tabulated on the following page. The average discharge for the water year 1960 was 3196 cfs or 2,320,000 acre-feet. The equivalent runoff is 39 inches. The maximum mean daily discharge for this period was 8722 cfs on August 28, 1959, the minimum was undetermined because of icing conditions which interfered with gage action, but was probably less than 60 cfs.

Monthly discharge, Chakachatna River
near Tyonek, Alaska

Month	1959 10^3 (ac-ft)	1960 10^3 (ac-ft)	Month	1959 10^3 (ac-ft)	1960 10^3 (ac-ft)
Oct.	---	124	Apr.	---	15
Nov.	---	59	May	---	91
Dec.	---	40	June	457	379
Jan.	---	31	July	676	645
Feb.	---	22	Aug.	674	634
Mar.	---	20	Sept.	343	260

Storage regulation

The capacity of Lake Chakachamna below its normal elevation of 1142 feet is shown in table 1, and graphically in figure 2. The total

Figure 2. - Lake Chakachamna Reservoir Site, Area and Capacity.

capacity between elevations 1142 and 900 is 3,261,000 acre-feet.

A comparison of the monthly flow records of the Kasilof, Iliamna, Newhalen and Susitna Rivers indicates that the flow in these rivers in 1960 was 3 to 4 percent below normal. A correlation of annual flow for these rivers over a 10 year period, 1951-1960, showed little similarity in their records as to the years of high and low flow. For this reason the water year 1960, the only complete year of record, will be the only basis for power estimates.

Table 1. - Area and capacity of Lake Chakachamna

below normal lake elevation.

Altitude (feet)	Area (acres)	Capacity (ac-ft)
1142	16,780	0
1140	16,100	33,000
1120	14, 620	340,000
1100	14,390	630,000
1080	14,170	916,000
1060	13,960	1,197,000
1040	13,740	1,474,000
1020	13,520	1,746,000
1000	13,280	2,014,000
980	12,980	2,277,000
960	12,650	2,533,000
940	12,320	2,783,000
920	11,960	3,026,000
900	11,590	3,261,000

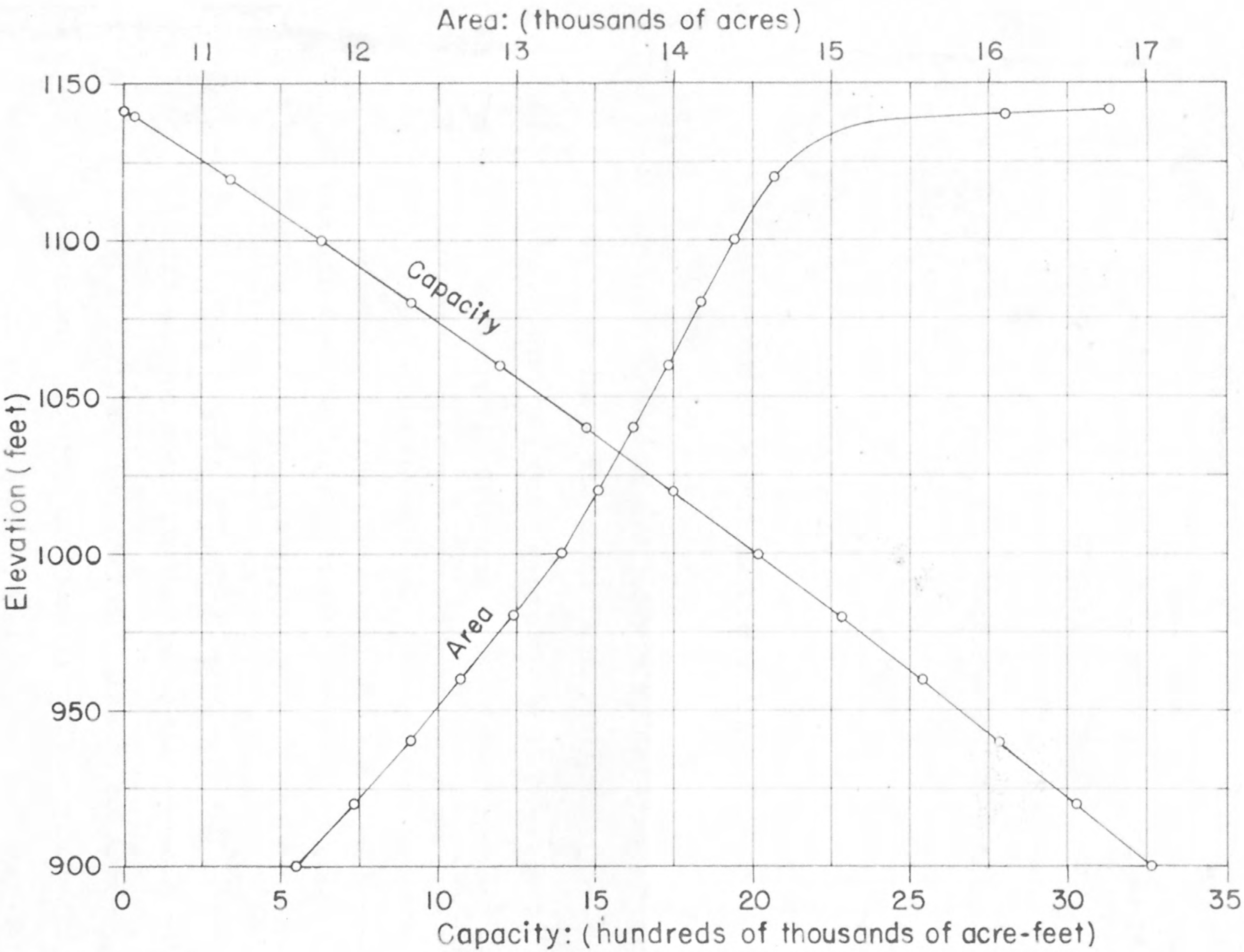


FIG. 2— Lake Chakachamna Reservoir Site, Area and Capacity

A mass diagram based on the 1960 record is shown in figure 3.

Figure 3. - Cumulative monthly discharge (1960).

Regulation of mean annual flow, 3196 cfs, would require a drawdown of 78 feet. A flow of 90 percent of annual, 2876 cfs, would require a drawdown of 67 feet.

For the purposes of this report, power estimates will be made on the basis of mean annual flow.

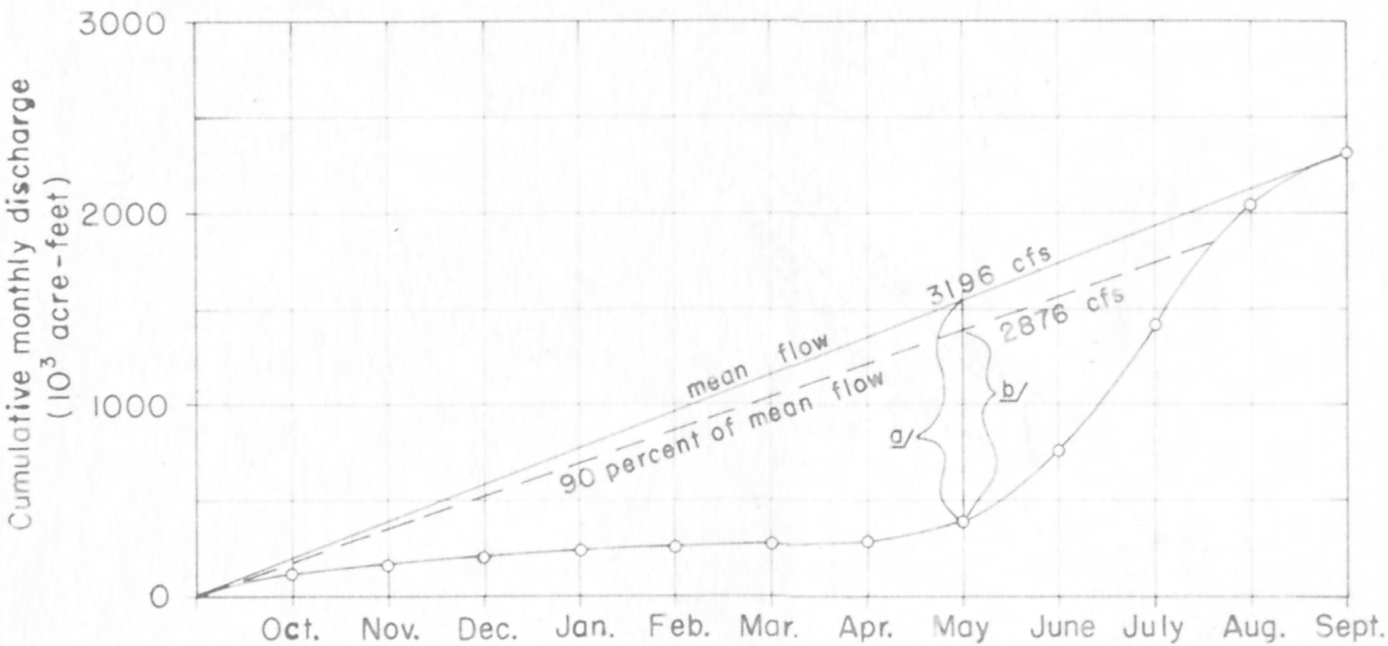
Potential power

All plans of development on Chakachamna Lake will depend on the tapping of the lake at some point below lake level and diversion of the water to a powerhouse site located at some point on the low lying plains to the east or south of the lake. The tunnel intake will probably be located at some point on the south shore, approximately 2000 feet west of the lake outlet (see figure 4). This area is of a favorable rock

Figure 4. - Tunnel routes and powerhouse sites.

type, is uniformly steep, and is the closest such area to the proposed powerhouse sites in the adjacent McArthur River Valley.

Three possible powerhouse sites have been considered at approximate elevations of 100, 200, and 300 feet. The location of the powerhouse will depend on a number of factors, such as topography, geology, and accessibility. The large glacier (lettered G, figure 4) could overrun one of the proposed powerhouse sites if it advanced 2 miles or so from its



a/ Storage necessary to regulate mean flow. (1,143,000 acre feet)

b/ Storage necessary to regulate 90 percent of mean flow. (989,000 acre feet)

FIG. 3 - Cumulative Monthly Discharge, 1960

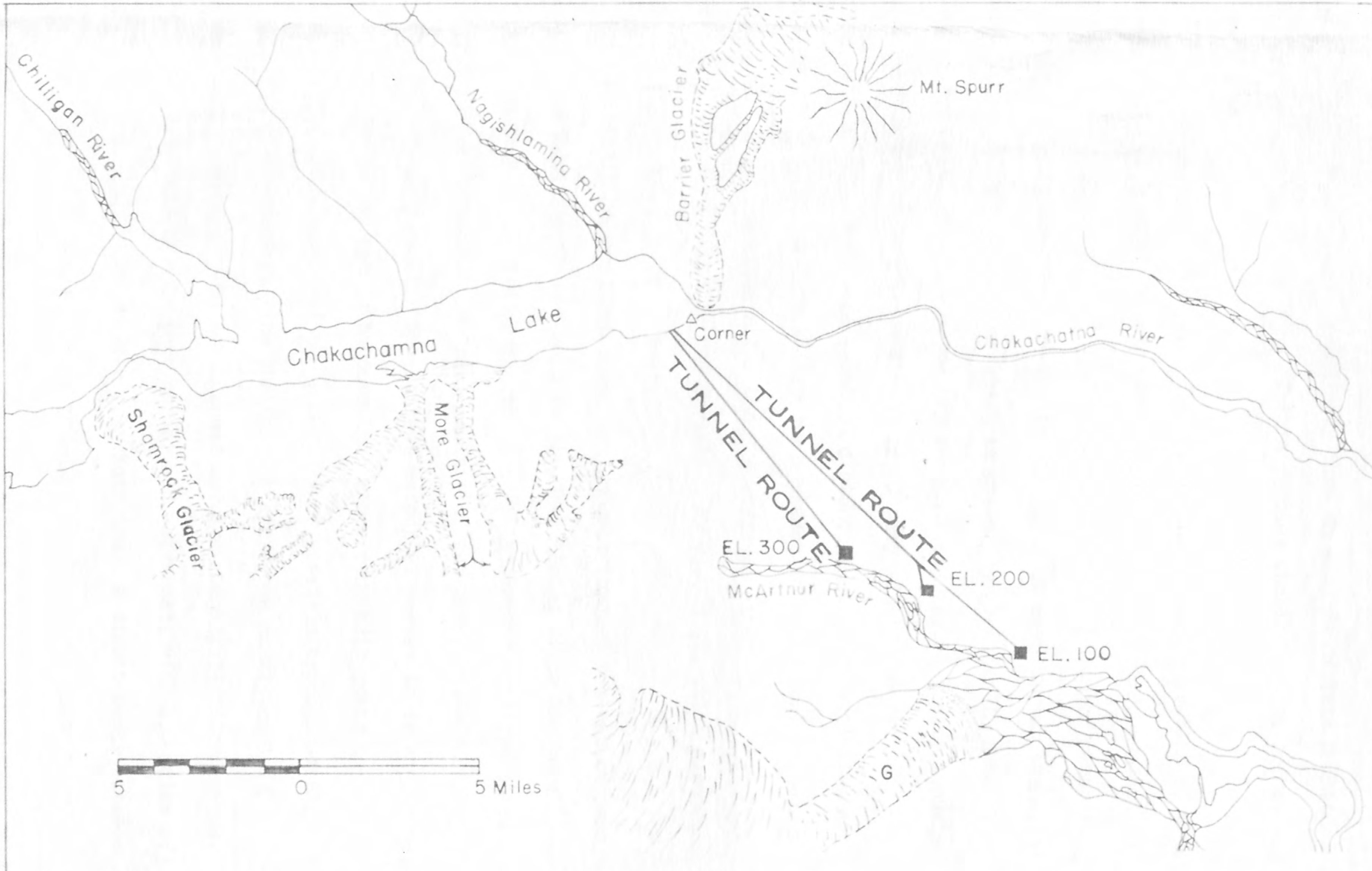


FIG. 4 — TUNNEL ROUTES & POWERHOUSE SITES

present location. It seems unlikely that an advance of this magnitude would take place, but a study of this glacier should be made before any development is undertaken.

With regulated mean flow (3196 cfs), the average elevation of water in the reservoir will be 1104 feet. With regulated flow equivalent to 90 percent of mean flow (2876 cfs), the average elevation of water in the reservoir will be 1110 feet. In all plans of development tunneling will probably be through rock which is primarily granitic in nature. Unless faults or fracture zones are encountered, losses due to leakage and groundwater encroachment should be of very little importance.

Approximate tunnel and penstock distances and power estimates at regulated mean annual flow and flow equivalent to 90 percent of mean annual are shown in table 2 for the 3 powerhouse sites which have been assumed. Power is based on the formula: KW = .068 QH, which assumes an overall efficiency of 80 percent.

Various schemes of waterpower development through the use of dams downstream from Lake Chakachamna on the Chakachatna River has been postulated, but none seem as practicable as the method outlined above.

There is at present no local market for the power which would result from this project. The nearest potential market is in Anchorage, and industry would have to be developed concurrent with power to achieve full utilization of the power. Four possible transmission routes to Anchorage from Lake Chakachamna are shown on figure 1. Skirting Cook Inlet to the north would involve roughly 79 miles across land which is for the most part marshy and unsettled, with 1.8 miles of underwater or suspension cable across Knik Arm. A direct route between

Table 2. - Power estimates and related data

Powerhouse elevation (feet)	Tunnel distance (miles)	Penstock distance (miles)	Total (miles)	Mean annual flow (3196 cfs) a/			90% of mean annual flow (2876 cfs) a/		
				Mean reservoir elevation (feet)	Mean head (feet)	Power KW	Mean reservoir elevation (feet)	Mean head (feet)	Power KW
100	11.5	.7	12.2	1104	1004	218,000	1110	1010	198,000
200	10.0	.3	10.3	1104	904	196,000	1110	910	178,000
300	7.5	.2	7.8	1104	804	175,000	1110	810	158,000

a/ Based on 1960 water year.

the powerhouse and Anchorage via Fire Island would cover 43 miles overland and 34 miles underwater. The two routes to the south are longer, but once across Cook Inlet would be readily accessible from existing roads. A 10 mile crossing of Cook Inlet between East and West Foreland and a 2 mile crossing of Turnagain Arm at Snipers Point would require underwater cable. If the Sterling Highway were followed, the entire route would be approximately 177 miles. A direct route from West Foreland to Sunrise would be 138 miles long.

It is not unreasonable to visualize an underwater cable across Cook Inlet as suggested above. A 16 mile, 138 kv cable between Vancouver Island, B. C. and the Canadian mainland was completed in 1956 and, as far as is known, has proved to be satisfactory.

All estimates of power made in this report are based exclusively on the discharge record for the 1960 water year. The actual discharge over a period of time may very somewhat, but the figures do, at least, indicate the order of magnitude of the power potential of Lake Chakachamna.

Literature cited

Capps, Stephen R., 1927, The Mount Spurr Region, Alaska: U. S. Geol. Survey Bull. 810-C, p. 141-172.

Johnson, Arthur, 1950, Report on reconnaissance of Lake Chakachamna, Alaska: U. S. Geol. Survey open file report no. 14-8.

Juhle, Werner and Coulter, Henry, April 1955, The Mount Spurr Eruption, July 9, 1953: Transactions of the Am. Geophys. Union, vol. 36, no. 2, p. 199.

_______________, November 1956: 138 kv cables for Vancouver Island, Water Power Monthly, p. 437.