ELECTRIC UTILITY SYSTEM

SITKA, ALASKA

ANALYSIS OF

ELECTRIC SYSTEM REQUIREMENTS

CITY AND BOROUGH

of

SITKA, ALASKA

R. W. BECK AND ASSOCIATES

Analytical and Consulting Engineers

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APRIL 1974

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FILE NO. WW-1521-HG1-MX

April 30, 1974

Honorable Members of Assembly
City and Borough of Sitka
Post Office Box 79
Sitka, Alaska 99835

Gentlemen:

Subject: Electric Utility System
Report on System Requirements

We herewith submit a report describing our evaluation of the requirements and potential for development of the municipal electric utility system.

Our investigations show that installation of a third unit at the Blue Lake Hydroelectric Project has technical and economic feasibility, but should not be undertaken until later.

We have determined that future development of the system should be by installation of additional hydroelectric generation. Several hydroelectric sites appear to have technical feasibility but studies to evaluate the site are required to confirm this and to establish firm cost estimates. To meet the projected load, the Green Lake Project is considered to be the most favorable installation and should be brought into service as soon as possible (December 1978). Installation of Unit 3 at the Blue Lake Project should follow the Green Lake development by about five years. The next development would be the Takatz Project with the first unit in late 1986.

In the period prior to the Green Lake Project coming on-line it will be necessary to rely on increased diesel generation. System improvements including oil storage facilities are therefore required.

A significant amount of dependable capacity together with high load factor energy, as well as large amounts of secondary energy, will be available for sale in the early years of the Green Lake Project operation. A contractural commitment to supply maximum amounts of power to the Alaska Lumber & Pulp Company, or other industrial customers, appears to be a prerequisite to financial arrangements for construction.

We consider the future generation sites recommended in the report show sufficient indication of final technical and economic feasibility to warrant the initiation of site evaluation studies. In order to place the Green Lake Project on-line to meet the peak loads in the winter of 1978-1979, the site evaluation should begin in June, 1974. Interim financing will be required to permit the necessary investigation, design, and improvements prior to financing for construction of the Project.

We appreciate the cooperation given us by the City during this phase of our services.

Respectfully submitted,

RW Beck and Associates

CERTIFICATE OF ENGINEER

CITY AND BOROUGH OF SITKA, ALASKA

ANALYSIS OF
ELECTRIC SYSTEM
REQUIREMENTS

The technical material and data contained in this report were prepared under the supervision and direction of the undersigned, whose seals, as professional engineers licensed to practice as such are affixed below.

Richard H. McLemore
Executive Engineer
R. W. BECK AND ASSOCIATES

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Supervising Executive Engineer
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OUTLINE OF REPORT

OUTLINE OF REPORT
(Continued)

OUTLINE OF REPORT
(Continued)

LIST OF TABLES

LIST OF FIGURES

SUMMARY

In order to develop plans for meeting its long-term requirements for generating resources in the most economical and dependable manner, the City of Sitka has begun investigation of potential hydroelectric sites in the area.

This report presents a discussion of the forecast of loads and resources, hydrology and reservoir operation of the Blue Lake Project, potential new sites for hydroelectric development, economic comparisons of alternative plans of development, a proposed program of development and a schedule for such development.

It is determined that installation of a third unit with a capacity of 4,000 kW at the Blue Lake Project is desirable, but should be preceded by installation of a new hydroelectric project since the critical requirement of the City is for additional energy.

Economic comparisons of alternative programs for system development show that a system composed entirely of hydroelectric generating resources has economic feasibility, and sites are available in the general vicinity which show potential of having technical feasibility. The most favorable site for initial development appears to be the Green Lake site.

A proposed schedule of development is included in the report which requires that the Green Lake Project be on-line late in 1978 to meet the peak loads during that winter, and that Unit 3 of the Blue Lake Project be on-line late in 1983. The Takatz Project would be developed to be on-line late in 1986.

Large amounts of power will be available for sale subsequent to development of the Green Lake Project and contractual arrangements for sale of this power should be initiated. Location of new industrial facilities with large load requirements in the area would require an accelerated development of the proposed program. Firm contractual agreements for purchase of power appear to be essential to financing arrangements for construction of the project.

The proposed schedule of development recommends investigations into the Green Lake Site, proceeding with arrangements for financing the investigations, application for FPC license, final feasibility studies, and construction of the Green Lake Project upon determination of final feasibility and financial arrangements. In order to maintain the proposed schedule, investigations of the Green Lake site are to begin in June 1974. Since a large amount of diesel generation will be required prior to completion of the Green Lake Project, installation of oil storage facilities at the diesel plant are recommended to be done immediately.

SECTION I

INTRODUCTION

1. AUTHORIZATION

The work described in this report was authorized by an Agreement for Engineering Services dated December 20, 1973, and which was approved by the City and Borough of Sitka on December 27, 1973. The scope of work to be furnished is described in the Agreement for Engineering Services and is outlined in this report.

2. SCOPE OF SERVICES

The complete scope of work includes the following:

a. Field inspection of the electric system, including the features of the Blue Lake Project which will relate to a future safety inspection for the Federal Power Commission (FPC).

b. A study of the hydrology of the Blue Lake Project including a review of the United States Geological Survey (USGS) gage on Sawmill Creek. The study would also include an analysis of generation and reservoir operation, the use of water by the Alaska Lumber and Pulp Company (ALP), the fish releases and reservoir spillway discharges, and an analysis of the hydraulic characteristics of the power tunnel and penstocks.

c. An analysis of the historic load data, and a preliminary forecast of loads, and establishment of load duration curves for the system.

d. A review of possible methods for increasing the hydroelectric generation during the study period, in the near future (1974-1977), and in the period subsequent to 1980. The short-range methods would include a study of the advisability of installing a third unit at the Blue Lake Project and the desirability of increasing reservoir storage by raising the crest of the dam and spillway. The long-range methods would include preliminary consideration of potential sites for additional hydroelectric generation such as Takatz Lake and Green Lake.

e. Preparation of a schedule for development of resources to meet the forecast load conditions.

f. Preparation of preliminary cost estimates for the potential developments. The estimates would be based on a cost-per kilowatt basis and would be in accordance with previous broad-base estimates by the Alaska Power Administration (APA) and the FPC.

g. Preparation of a report discussing the results of the current investigations.

3. BACKGROUND TO PRESENT STUDY

Since the completion of the Blue Lake Hydroelectric Project in 1961 the water availability at the project had the potential to produce more energy than required by the loads of the City, even during the driest years of the period, but by 1973 the load requirements of the City developed to a magnitude which approached the total firm energy which could be generated at the project. Concurrently, the runoff from the Blue Lake watershed was very low in 1973. The combination of these events has resulted in a severe drawdown of the reservoir, and since it can be anticipated that such drawdowns will occur even under more normal runoff conditions as the load requirements increase, a study of reservoir operating methods to obtain maximum generation from the project is desirable.

During the same period a national shortage of fuel oil occurred and is expected to continue during the foreseeable future. The decreased supply of fuel oil was accompanied by a significant increase in costs. The City has diesel generating units which are more than sufficient to provide the required additional generation for the City, but the cost of such generation will be very high and the uncertain availability of generating fuel will affect the dependability of this generation. As a result it was decided to investigate the feasibility of additional hydroelectric generation for the City.

In the recent decade many studies have been performed for Sitka and other Alaskan cities to compare the economic advantages of single-purpose hydroelectric projects with small diesel units. These studies have usually concluded that the diesel units were more desirable with the prevailing costs at that time and the larger capital investment required for the hydro. This situation has altered significantly at the present time as discussed above, and the City authorized this study to determine the potential for more effective operation of the Blue Lake Project and the desirability of additional hydroelectric installations to meet the increased loads from future development of the electric utility system.

SECTION II

EXISTING SYSTEM

1. GENERAL

Sitka is located on the west coast of Baranof Island approximately 95 miles south-southwest of Juneau and 92 miles west-northwest of Petersburg. Sitka Sound lies to the west of the City and forms a channel directly into the Gulf of Alaska. Eastern Channel is located to the south of the City and forms a channel connection between Sitka Sound and Silver Bay with the mouth of Silver Bay being located about four miles southeast of town.

The powerhouse of the Blue Lake Hydroelectric Project is located near the mouth of Sawmill Creek which flows southwest into Silver Bay at a point about one and one-half miles from the mouth. The powerhouse is about four airline miles east of town and access is by the Sitka Highway. Blue Lake is located about one mile upstream on Sawmill Creek and is about 335 feet higher in elevation. Access to the Blue Lake Dam is from the Sitka Highway by means of a secondary road.

The diesel generating plant is located approximately one mile northwest of city center on a major route of the City's street and road system. A location map of the area is shown in Fig. 1.

2. RESOURCES

a. Blue Lake Hydroelectric Project

The powerhouse installation consists of two Francis turbines mounted horizontally, and connected to individual generators each rated at 3,750 kVA with an 80% power factor. The output at rated capacity is 3,000 kW and the turbines are rated at 5,200 HP with 267 feet net head operating at a speed of 600 rpm. All powerhouse equipment was manufactured by Tokyo Shibaura Electric Company (Toshiba).

Tests were made in January, 1974, by the powerhouse staff and personnel from R. W. Beck and Associates to determine the overload potential of the units. The maximum generator load attained was 4,480 kVA at a power factor of 87% to give an output of 3,900 kW. This output was attained with a net head of approximately 272 feet. This test did not result in excessive temperature rises in either the generators or the transformers, but the tests were restricted at this level due to a 600 Ampere rating of the current transformers.

It is concluded that the two units can be safely operated to produce a dependable capacity of 7,000 kW, with compatible transformers, under the minimum head conditions which will result from rule curve operation of the reservoir during the winter peak period. The dependable capacity of the plant at the minimum reservoir level shown by the rule curve (in May) is considered to be about 5,600 kW. The firm energy content of the reservoir is estimated to be 32,000,000 kWh as discussed later in this report.

b. Diesel Plant

The diesel plant contains four units as follows:

(1) Unit #1 is a Fairbanks Morse prime-mover driving a generator rated at 375 kVA, with a power factor of 80%, 2,400 Volts, at 300 rpm; the dependable capacity is 300 kW.

(2) Unit #2 is a Enterprise prime-mover driving an Electric Machinery generator rated at 625 kVA, with a power factor of 80%, 2,400 Volts, at 900 rpm; the dependable capacity is 500 kW.

(3) Unit #3 is a GMC prime-mover driving a Westinghouse generator rated at 375 kVA, with a power factor of 80%, 2,400 Volts, at 1,200 rpm; the dependable capacity is 300 kW.

(4) Unit #4 is a Fairbanks Morse prime-mover driving a generator rated at 2,500 kVA, with a power factor of 80%, 12,470 Volts, at 720 rpm; the dependable capacity is 2,000 kW.

The diesel plant has a combined capacity of 3,100 kW. Each diesel unit, of course, has its own heat rate, which is inherent with the equipment and which is also affected by the method of operation of that particular unit. An average heat rate for all diesel units of 10,000 BTU per kilowatt-hour has been assumed as being a practical value for the operation as anticipated by this study. A mean value of 140,000 BTU per gallon for No. 2 fuel oil is assumed resulting in the energy output of all diesel units being estimated at 14 kWh per gallon of diesel fuel. With the current cost of diesel fuel of $0.33/gallon the cost of diesel generation is 23.6 mills/kWh, not including the fixed costs of operation and maintenance.

c. Alaska Lumber and Pulp Company (ALP) Thermal Units

ALP has an installation of steam generation with a total capacity of approximately 25,000 kVA. These units are fired by waste materials assisted by oil.

The ALP distribution system is interconnected to the low-voltage cables of the Blue Lake generator step-up transformers. The tie is a double 2/0 copper circuit which has a nominal capacity of 5,000 kVA, however a short section of the tie has a lower capacity which restricts the dependable capacity of the tie to approximately 2,500 kVA. Breakers are provided at each end of the tie which allows power to be transferred in either direction, and makes exchange agreements between ALP and the City possible. An agreement provides for exchanges of energy being repayable in kind on a monthly basis. Any imbalances in energy exchanges are paid at the rate of 10 mills/kWh at the end of each month, with the same rate being applicable to either party to the agreement.

Although the ALP has small amounts of capacity available for export on an emergency basis, it is anticipated that increased loads within its own system will significantly reduce this possibility by the latter part of 1974. The ALP system operates on a high load factor which prevents any large transfer of off-peak energy to the City. The high plant factor indicates essentially continuous operation at close to peak load condition, which would cause any energy transfer to be accompanied by a loss of peak capacity to ALP. Further the excess energy is probably being fired by Bunker C oil which has increased significantly in cost. In addition the system has need of capacitive reactive capability.

3. TRANSMISSION LINES

A 34.5 kV transmission line, approximately five miles long, connects the Blue Lake Substation with the Marine Street Substation which is located near the system load center. The conductor is 2/0 ACSR on wood poles. The ultimate capacity of the line, assuming that the power factor of the system can be improved to about 96%, would be approximately 11,500 kVA, and the line would conduct power at this level with acceptable power losses and voltage drops. The line is considered to have sufficient capacity for installation of a third unit at Blue Lake as originally planned.

4. SUBSTATIONS

a. <u>Blue Lake Substation</u>

This station consists of the step-up transformers for the hydroelectric plant and for power received from ALPC and transmitted to the load center. Three single-phase units, each rated at 2,500 kVA, transform the output from generator voltage at 4160 Volts to transmission line level. The high voltage side has five taps which range from 32.6-kV to 36.2-kV. At present, the transmission level is about 33.5-kV. One spare unit is provided to prevent any extended outage from failure or accident to a transformer unit.

b. <u>Marine Street Substation</u>

This station is located near the system load center and serves to reduce the transmission voltage level to that of the primary feeder lines which operate at 12,470 Volts. Three single-phase units, each rated at 2,500 kVA, and one spare unit, are located in the yard.

c. <u>Diesel Plant Substation</u>

This station contains three single-phase units, each rated at 500-kVA, and provide transformation of voltage from Diesel Units Nos. 1, 2 and 3. The generator outputs are at 2,400 Volts which are stepped-up to primary feeder line level at 12,470 Volts. The generator voltage of Diesel Unit No. 4 is at 12,470 Volts and the generator bus connects directly to the primary feeder line.

5. DISTRIBUTION

The Marine Street Substation supplies four primary feeder lines at 12,470 Volts, three-phase, which are stepped-down to 7,200 Volts for the distribution system. The power factor of the system is low, but it is estimated that approximately 1,000 kVAR of capacitors will increase the power factor to approximately 96% with the present load conditions. The capacitors can be installed in the Marine Street Substation, or individual capacitor banks totaling 1,000 kVAR can be installed in the distribution system. The most desirable location appears to be in the substation since it is near the load center, but this should be confirmed so that installation can proceed according to schedule. The reactive requirement of the system is being supplied by the hydroelectric units at the present time. Improvement of the power factor to about 93% will allow the Blue Lake units to produce power at 3,500 kW each without exceeding the kVA rating of the generators or step-up transformers.

6. HISTORICAL LOADS

Records of historical loads have been maintained by the City and include monthly energy demands and monthly peaks, from which annual energy and peak, as well as annual and monthly system load factors can be obtained.

The annual peak of the system occurs during the winter season, usually in December or January, although the peak has occurred some years in November. Thus the peak load for an individual season could occur in either of two calendar years, and if the annual energy is measured by calendar year, inconsistencies will exist in determination of the system load factor for successive years.

For the purposes of this report loads have been grouped into power years which are assumed to be from July 1 of one year until June 30 of the succeeding year. In this way, the annual peak occurs in mid-year and is clearly defined. A summary of historical loads for Sitka from July 1, 1962 until the present time, which considers the effects of exchanges with ALP, is shown in Table II-1. As shown, during the past decade the system load factor has effectively stabilized at about 55% and this value has been used in forecasting future energy demands. A tabulation of historical monthly energy demands, grouped by power years, is shown in Table II-2. A summary of monthly energy demands expressed as percentages of the annual demand and including monthly load factors is shown in Table II-3.

CITY OF SITKA

SUMMARY OF LOADS

1962 - 1974

Power Year	Peak Capacity kW	Energy 1,000 kW h	Average Capacity kW	Load Factor %
1962-63	--	18,419.2	2,102.6	--
1963-64	5,500	22,220.9	2,536.6	46.1
1964-65	--	24,544.5	2,801.9	--
1965-66	4,950	22,368.4	2,553.5	51.6
1966-67	5,300	22,872.7	2,611.0	49.3
1967-68	5,150	24,658.2	2,814.9	54.7
1968-69	5,300	25,728.1	2,937.0	55.4
1969-70	--	26,640.6	3,041.2	--
1970-71	6,200	28,889.0	3,297.3	53.2
1971-72	6,050	29,979.5	3,422.3	56.6
1972-73	6,400	30,653.7	3,499.3	54.7
1973-74	5,985			

Note: All loads adjusted for transfers to and from ALP

CITY OF SITKA

SYSTEM ENERGY LOADS

1962 - 1974

1,000 kW h

POWER YEAR*	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Annual
1962-63	1,214.0	1,302.1	1,363.7	1,543.6	1,627.0	1,797.1	1,674.8	1,517.5	1,690.8	1,638.2	1,616.8	1,433.6	18,419.2
1963-64	1,505.6	1,632.0	1,703.0	1,898.4	2,007.7	2,087.1	2,102.2	1,936.0	2,045.0	1,891.1	1,834.0	1,578.8	22,220.9
1964-65	1,625.4	1,713.3	1,838.3	1,986.1	2,153.5	2,477.2	2,478.6	2,120.0	2,248.7	2,107.7	2,004.7	1,791.0	24,544.5
1965-66	1,782.9	1,989.6	1,755.2	1,710.3	1,904.5	2,162.5	2,127.6	1,873.6	1,996.9	1,774.1	1,728.5	1,562.7	22,368.4
1966-67	1,446.3	1,642.6	1,735.7	1,911.5	1,987.7	2,197.3	2,201.9	1,952.7	2,256.6	1,976.3	1,881.1	1,683.0	22,872.7
1967-68	1,610.0	1,702.0	1,824.4	2,055.3	2,187.8	2,411.1	2,509.8	2,263.4	2,276.7	2,120.2	1,956.7	1,740.8	24,658.2
1968-69	1,769.9	1,867.9	2,011.8	2,207.1	2,194.8	2,495.2	2,726.1	2,212.3	2,354.6	2,089.9	2,018.5	1,780.0	25,728.1
1969-70	1,972.1	1,973.2	2,085.2	2,247.5	2,335.0	2,482.1	2,612.1	2,205.3	2,377.3	2,248.1	2,190.9	1,911.8	26,640.6
1970-71	2,063.7	2,112.4	2,236.3	2,444.3	2,497.5	2,843.2	2,882.5	2,413.4	2,616.8	2,421.4	2,331.2	2,021.3	28,884.0
1971-72	2,038.8	2,118.4	2,276.1	2,493.4	2,530.0	2,917.4	3,011.4	2,727.6	2,756.5	2,546.4	2,410.3	2,153.2	29,979.5
1972-73	2,108.9	2,168.5	2,383.5	2,268.9	2,694.5	3,030.0	3,055.6	2,702.3	2,864.6	2,569.9	2,526.1	2,280.9	30,653.7
1973-74	2,207.2	2,273.1	2,342.8	2,682.0	2,878.0	2,527.7	2,798.9	2,418.3					

*Example: Power year 1962-63 is from July 1,1962 through June 30,1963.

TABLE II - 2

SUMMARY OF MONTHLY ENERGY LOADS

(Percent of Annual)

	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
1967-68	6.53	6.50	7.40	8.33	8.87	9.78	10.18	9.18	9.23	8.60	7.94	7.06
1968-69	6.88	7.26	7.82	8.58	8.53	9.70	10.60	8.60	9.15	8.12	7.84	6.92
1969-70	7.40	7.41	7.83	8.44	8.76	9.32	9.80	8.28	8.92	8.44	8.22	7.18
1970-71	7.14	7.31	7.74	8.47	8.65	9.84	9.98	8.36	9.06	8.38	8.07	7.00
1971-72	6.80	7.07	7.59	8.32	8.44	9.73	10.05	9.10	9.19	8.49	8.04	7.18
1972-73	6.88	7.07	7.78	7.40	8.79	9.88	9.97	8.82	9.35	8.38	8.24	7.44
Average	6.94	7.17	7.69	8.26	8.67	9.71	10.10	8.72	9.15	8.90	8.06	7.13
Load Factor	64.2	67.7	72.1	67.3	69.2	62.9	65.4	69.6	70.5	65.4	67.4	70.2

TABLE II-3

SECTION III

BLUE LAKE PROJECT

1. LOCATION

The Blue Lake Project is located adjacent to Silver Bay approximately five miles from the system load center by highway. The Sitka Highway follows the shoreline of Silver Bay and extends a short distance beyond Sawmill Cove into which Sawmill Creek discharges. The ALP mill and Blue Lake Project powerhouse are located a short distance upstream of Sawmill Cove. The portion of Sawmill Creek immediately upstream of the powerhouse tailrace is locally referred to as the "Gorge" and is about 1400 feet in length. The dam which impounds Blue Lake is about 6000 feet upstream of the powerhouse tailrace. The general arrangement of the project is shown in Fig. 2.

2. GENERAL DESCRIPTION OF PROJECT

The project consists of a reservoir, concrete arch dam, intake structure, two tunnels which are connected by a steel penstock, powerhouse, substation and transmission line to the load center. It went into operation in 1961.

The reservoir was created by raising Blue Lake to its present level by construction of a concrete arch dam across Sawmill Creek a short distance downstream of the previous natural outlet of Blue Lake. Construction of the dam raised the water surface level from Elev. 205 to Elev. 342 feet (spillway crest level) and provided a total storage volume of 145,000 acre-feet. The surface area of Blue Lake at normal maximum reservoir level (Elev. 342) is 1,225 acres. Operation of the reservoir is described in a subsequent portion of this report.

3. DAM AND SPILLWAY

The dam is a concrete arch structure located in a deep gorge of Sawmill Creek a short distance downstream of the main body of the reservoir. The dam is approximately 225-feet high, has a crest length of 256 feet and a crest width of 8-feet. The sound rock surface in the stream was located approximately 70-feet below the original ground surface so that the low point of the dam is approximately at El. 125. The crest of the dam is at El 351 providing a freeboard of 9 feet from normal maximum reservoir level.

The spillway has an uncontrolled crest located in the center of the concrete arch. The crest includes a downstream extension to provide a flip-bucket effect to discharges. The spillway crest is essentially an ogee-type and has a length of 138.57 feet. Maximum discharge without overtopping the dam is estimated to be approximately 14,000 cfs. Derrick stone and riprap have been placed downstream of the dam to prevent degradation of the stream bed and undercutting of the dam by flow from the spillway.

4. INTAKE

The power intake structure is located several hundred feet from the dam adjacent to the access road on the right abutment. The structure is equipped with a bulkhead gate, a by-pass line and gate, fixed wheel gate, trash racks and air vent. Guides are provided on the abutment slope and the gates are raised by cables connected to a power winch, and are lowered by gravity. The center-line of the intake structure is at Elev. 210 and it is estimated that a submergence of approximately 20 feet will provide an efficient operating level. The proposed drawdown of the reservoir is to El 252 which allows more than adequate submergence.

5. TUNNELS AND PENSTOCKS

a. General

A tunnel (upper tunnel) connects the intake structure to a portal located on the right bank of Sawmill Creek approximately 1800 feet downstream of the dam. A similar portal for a second tunnel (lower tunnel) is located on the left bank of the stream. The portals are connected by a steel penstock which crosses Sawmill Creek and is supported by concrete piers. The lower tunnel has an exit portal near the ALP settling basin and filter plant approximately 300 feet from the powerhouse. Downstream of this portal a steel penstock continues to a manifold with branches for each of the two existing units and a stubbed-off section for the proposed third unit.

b. Tunnels

1. Upper Tunnel

This portion of the power conduit is essentially an 11-foot 6-inch by 11-foot 6-inch unlined horseshoe section approximately 1,535-feet long. Local areas of the tunnel have been provided with concrete lining due to adverse rock conditions, resulting in a 10-foot by 10-foot horseshoe section. A short transition section is provided at the upstream end of this tunnel to connect the major portion of the tunnel to the intake structure.

2. Lower Tunnel

This portion of the power conduit is essentially a 10-foot by 10-foot horseshoe section and is approximately 4995 feet long. Local areas of this tunnel are also provided with concrete lining due to rock conditions at these locations. The lined areas in this tunnel are 7-feet 10-inches by 7-feet 10-inches horseshoe sections. The downstream portal of this tunnel is approximately at El 77.

c. Steel Penstocks

1. Sawmill Creek Crossing

This portion of the power conduit is an 84-inch steel pipe approximately 508-feet long. A 36-inch steel pipe is stubbed-off the penstock near the right-bank portal to allow diversion of water from the penstock into Sawmill Creek, presently being controlled by a badly damaged 12-inch valve. The valve is only partially open at the present time, and due to a significant vibration and leakage problem at the valve, it is deemed prudent not to attempt further operation of the valve until the penstock can be unwatered and a new valve system installed.

2. Downstream Section and Manifold

The section of power conduit downstream of the tunnel portal is again an 84-inch steel pipe which terminates in a manifold. Three 60-inch steel pipe connections are provided to allow individual penstocks into the turbine scroll cases. The connection for the proposed third unit is closed with a blind flange.

A short distance downstream of the tunnel portal the penstock is tapped to divert water for ALP requirements. One 36-inch steel pipe diverts a portion of the water into a forebay area from which it flows by gravity through a settling basin and filter bed and thence is piped by gravity into the mill area. One 16-inch steel pipe diverts additional water, at penstock pressure, into the mill area. A second 16-inch steel pipe is used to provide backwash water for the filter bed. Overflows from the forebay and backwashing operation discharge directly into Sawmill Creek in the "Gorge" portion of the stream.

6. POWERHOUSE

The powerhouse is a conventional indoor reinforced concrete structure housing two generating units. Each unit consists of a Francis turbine, rated at 5,200 hp connected by a horizontal shaft to a generator rated at 3,750 kVA (3,000 kW). The machines operate at a synchronous speed of 600 rpm. The generator output is at 4,160 Volts which is stepped-up to transmission line voltage of 33,500 by three single-phase transformers, each rated at 2,500 kVA, located near the powerhouse structure. The powerhouse tailrace empties into Sawmill Creek approximately 400 feet upstream of the mouth and the tailwater level is controlled by a weir in the tailrace channel.

SECTION IV

HYDROLOGY AND POWER OUTPUT OF BLUE LAKE

1. GENERAL

Average monthly discharge records are available for Sawmill Creek for 28 complete water years. These records were obtained from stream gages installed and operated by the United States Geological Survey (USGS). While the stream gaging was in different locations during the entire period of record, (1921 through 1957) the locations were within a few hundred feet of each other, and the records can effectively be considered as for the same drainage area. The drainage area upstream of the gage is approximately 39.0 square miles, while the drainage area upstream of Blue Lake Dam is approximately 37.0 square miles. The data for complete water years of record converted to monthly runoff in acre-feet, are shown in tabulated form in Table IV-1. As shown in the table the long-term average annual runoff is 351,040 acre-feet and the maximum and minimum annual runoffs are 519,020 acre-feet and 230,140 acre-feet respectively. The average annual runoff during the latest period of record (1946-1957), however, is 320,200 acre-feet and from this the adjusted (for drainage area) average annual discharge of Blue Lake is estimated to be approximately 420 cfs, but reservoir operation and contractual and regulatory water requirements reduce the water available for generation significantly. These items are discussed in detail in subsequent portions of this report.

2. AVAILABILITY OF WATER

Long periods of record for total precipitation are available for stations in Sitka and on Japonski Island. Table IV-2 shows the total precipitation recorded at a station located at the Sitka Observatory from 1950 until the present time. As shown in the table, the average annual precipitation for the period of record is 92.4 inches. If a loss of 10% is assumed for evapo-transpiration and infiltration, the resulting runoff would be approximately 4435 acre-feet per square mile, or about 6.1 cfs per square mile. Based on this precipitation the average annual runoff of Blue Lake would be about 226 cfs, as compared to the 420 cfs estimated from gaged runoffs. This shows that the total precipitation over the Blue Lake drainage basin is about 190% of that gaged in Sitka. This ratio is not unusual in Southeast Alaska where great changes in precipitation occur over relatively small distances and changes in elevation.

3. WATER TO ALP

Water is supplied to the ALP on a contractual basis for operation of the mill. The contract amounts are 35 mgd supplied at El 175, and 15 mgd supplied at penstock pressure. The water is supplied by one 30-inch and two 16-inch lines tapped into the penstock near the downstream portal. The flow from each line is metered and records are available of monthly use by the mill. The last decade of water withdrawals by ALP, expressed in acre-feet per month, is shown in Table IV-3. Calculations for power output of the reservoir are based on ALP utilizing their full allocation of water of 50 mgd (77 cfs) at all times.

4. FISH RELEASES

The FPC license for the Blue Lake Project contains a requirement that a constant release of water be made into Sawmill Creek in the amount of 50 cfs, the release being made at the point where the steel penstock crosses Sawmill Creek. A 36-inch steel pipe branch is located on the right bank of Sawmill Creek. At the present time a 12-inch gate valve is flange mounted on the end of the 36-inch line.

A severe leakage problem exists due to inadequate connections of the valve to the flange and perhaps the flange to the 36-inch pipe. The valve has severe cavitation erosion and vibrates when discharging. At the present time the valve is partially open and is discharging an estimated 20 cfs. The vibration of the valve could lead to structural failure and loss of the valve and it is considered that any attempt now to operate the valve could precipitate this failure. Loss of the valve would result in drawdown of the reservoir to El 206, the invert of the power intake, some 136 feet. Since no back-up valve has been provided, it will be necessary to close the intake gate to de-water the power conduit to replace the damaged valve, which cannot be done until ice has cleared from the reservoir sufficiently to permit a diver to assist in operating the intake gate.

Sitka has filed a request with the FPC for amendment of the license to obtain relief from the mandatory 50 cfs fish release. It is anticipated that if fish releases can be varied throughout the year the total water requirements can be reduced, and sufficient water still be provided for sustaining fish life in the downstream portion (primarily the "Gorge" section) of the stream. A monitoring program is proposed during the forthcoming year to vary the releases and to provide a simultaneous review by the Alaska Department of Fish and Game, and the US Bureau of Sports Fisheries and Wildlife as to the adequacy of stream flows at that time to maintain fish life.

It is anticipated that the intake gate can be operated in late spring this year, and the damaged fish release valve be replaced at that time. Since lead times of one to two years are not unusual in procuring larger regulating valves suitable for flow modulation, (Howell-Bunger) the City has procured a 10-inch globe valve which was readily available, so that replacement can be made expeditiously and thereby remove the danger of loss of reservoir. An 18-inch gate valve has been obtained and will be installed to act as a back-up valve, with operation planned in the open-shut mode only. With the back-up valve, any future replacement of the regulating valve would not require closure of the intake gate. The 18-inch gate valve in combination with the 10-inch globe valve will discharge about 23 cfs during average summer reservoir conditions. To release 50 cfs under minimum reservoir conditions would require replacement of the globe valve with a 14-inch Howell-Bunger valve.

Calculations for power outputs from the project have been based on fish releases of 15 cfs and 50 cfs to provide a range of comparison, since the magnitude of future releases has not yet been established.

5. HYDROELECTRIC GENERATION

As shown in Table IV-1, the minimum water year of record at the gaging station on Sawmill Creek had a runoff of 230,140 acre-feet. This runoff, when adjusted to the Blue Lake drainage basin, represents a corresponding inflow of approximately 220,000 acre-feet into Blue Lake. Under the low-runoff conditions which Sitka is now experiencing, it is considered desirable to establish a rule curve for reservoir operation which will allow complete reservoir recovery on an annual basis. To provide a more realistic basis for this type of operation some adjustments were made to the low-water year of record mentioned above. The monthly and annual inflows assumed for the synthetic minimum-water year are shown in Table IV-4. The table also shows allocations of water for ALP, and fish releases of both 15 cfs and 50 cfs, and provides the basis for annual distribution of power releases and for determination of the firm energy available from rule curve operation. It further shows similar values for an average water year. Table IV-4 shows that in a minimum water year with 50 cfs fish releases the water available for generation is 118,660 acre-feet and with 15 cfs fish releases the value is 144,210 acre-feet, representing some 22% increase in dependable hydroelectric energy. A tabulation of historical energy generation from the project is shown in Table IV-5.

Although some spillway discharges will no doubt occur in wet years, as the system load increases these occurrences will become more infrequent. In years of higher runoff, large amounts of secondary energy can be generated by the existing units, and with installation of a third unit and increase in demand, it is anticipated that the runoff from wet years can be converted into firm energy without provision of additional storage.

Firm energy is defined as the amount of energy which can be obtained on a dependable annual basis, and is based on rule curve operation of the reservoir in a minimum water year. Secondary energy is that available over and above the firm energy in any individual year. The amounts of secondary energy available will, of course, vary from year to year depending on the availability of water in excess of the minimum year runoff.

6. RESERVOIR OPERATION

a. Rule Curve

An area-volume curve of the Blue Lake reservoir is shown in Fig. 3. As shown in the curve the total storage volume is 145,000 acre-feet at normal maximum reservoir El 342 (spillway crest elevation). With the bottom of the storage pool assumed at El 252, the total volume available for regulation of inflow is 86,000 acre-feet.

Traditional reservoir operating practices dictate a residual drawdown in reservoirs during very low water years, with refilling to take place in succeeding wetter years. However, the erratic nature of the past few years of runoff does not appear to be representative of long-term records and it is considered appropriate for Blue Lake to be operated on a rule curve, with annual recovery, at the present time.

The proposed method of operation is shown in Table IV-4, for a minimum water year with both 15 cfs and 50 cfs allocations for fish releases. For comparison an average water year is also shown for each condition. Annual operation by the rule curve will produce a drawdown of approximately 90 feet, to Elev. 252, and will utilize 86,000 acre-feet of storage. A tabulation of rule curve operation is shown in Table IV-6, and is shown graphically in Fig. 4.

b. Firm Energy

The firm energy available from rule curve operation is summarized in Table IV-7 for both 15 cfs and 50 cfs fish releases. A comparison of firm energy available with different fish releases, is shown in Table IV-8. As can be seen, in 1978 the loss of hydrogeneration for a 50 cfs versus a 15 cfs continuous fish release, amounts to a value of about $200,000 annually based on replacement fuel cost for diesel generation. The energy available in an average water year is also shown to provide an estimate of the potential average amount of secondary energy which will be available.

Since required fish releases have not been determined at this time, a value for firm energy from the Blue Lake Project of 32,000,000 kWh has been used in power studies of the system.

SAWMILL CREEK STREAM FLOW RECORDS

RUNOFF IN ACRE-FEET

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
1921	23,000	19,900	5,500	5,520	6,280	3,970	7,560	25,600	57,800	44,600	40,900	47,200	287,830
1922	59,000	15,200	26,600	8,360	2,780	1,520	6,840	30,000	42,000	39,400	41,400	47,100	320,200
1929	46,700	26,400	25,800	22,000	8,000	15,800	11,400	36,900	49,700	46,300	43,300	32,100	364,400
1930	57,100	47,100	15,300	5,090	11,100	8,550	17,400	34.700	45,900	44,200	40,300	47,400	374,140
1931	40,600	33,000	50,300	14,600	19,000	6,520	17,600	38,500	48,100	45,300	44,600	43,500	401,620
1932	54,100	21,100	9,160	14,000	8,460	8,180	17,800	34,200	51,200	44,500	42,000	56,000	360,700
1933	44,700	21,700	8,850	7,870	7,500	3,530	10,000	41,100	42,800	48,800	54,600	26,800	318,250
1934	43,600	49,200	7,620	15,000	20,500	11,100	21,600	35.900	41,500	42,500	51,300	32,500	372,320
1935	50,000	20,100	13,500	8,600	35,800	9,530	13,000	46,700	61,600	60,000	62.800	61,800	443,430
1936	36.900	59,400	43,300	17,100	5,620	21,800	39,400	52,900	70,100	55,200	49,400	67,900	519,020
1937	91,600	101.000	33,800	17,200	8,850	8,610	11,900	30,700	51,200	40,200	58,500	39,400	493,000
1938	74,050	16,100	22,860	13,280	14,880	13,120	10.860	35,880	36,690	35,350	35,210	48,900	357,180
1939	42,040	27,610	24,790	15,910	9,870	8,420	12,150	26,900	46,420	52,890	75,970	60,360	403,330
1940	66,220	29,660	21,040	10,650	9,180	7,990	16,550	29,400	31,800	29,620	45,270	44,950	342,330
1941	39,160	27,700	16,080	11,710	12,630	13,240	19,170	21,950	34,780	33,070	17,440	21,340	262,870
1942	55,430	31.800	7,420	30,620	12,150	7,150	14,610	43,300	32,620	42,160	41,180	41,650	360,090
1946	67,070	18.150	7,870	6,910	3,010	4,500	5,790	39,630	49,130	37,550	34,350	39,590	313,550
1947	46,810	46,190	5,700	10,080	5,480	22,450	17,770	40,970	34,940	28,630	33,950	76,570	369,540
1948	37,140	37,970	13,580	22,260	4,230	3,240	3,660	41,280	46,330	47,730	37,210	72,490	367,120
1949	39,160	50,470	6,850	14,890	4,500	8,030	9,860	34,600	53,920	43,860	38,190	41,280	345,610
1950	59,110	34,830	7,650	3,070	2,500	2,760	4,480	21,750	48,660	49,190	33,990	34,170	302,160
1951	23,510	9,830	3.080	4,560	1,840	2,870	9,640	31,550	46,360	36,530	27,600	32,770	230,140
1952	26,120	18,490	10,180	4,090	3,920	3,600	10,960	32,430	42,290	53,070	35,020	65,220	305,390
1953	63,930	38,870	12,430	6,490	7,480	8,050	12,800	42,010	47,090	39,590	49,640	43,470	371,860
1954	65,160	18,120	18,600	7,100	22,210	3,480	3,840	28,110	44,400	38,200	30,050	44,250	323,520
1955	29,830	32,010	37,600	9,720	8,070	8,690	6,810	19,660	45,330	54,740	43,890	43,340	339,690
1956	32,560	14,760	3,240	1,840	3,650	3,400	9,200	42,770	39,610	45,080	53,750	32,840	282,700
1957	33,290	36,490	32,960	8,760	4,570	3,460	8,090	30,480	40,530	33.380	26,120	39,130	297,260
AVERAGE	48,140	32,260	17,560	11,330	9,430	7,980	12,530	34,640	45,810	43,270	42,430	45,860	351,040

TOTAL PRECIPITATION
GAGE AT SITKA OBSERVATORY

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1950	2.7	4.7	3.6	4.2	4.7	1.1	7.1	7.3	8.6	7.0	3.6	4.9	59.5
1951	5.2	4.4	6.7	8.5	3.1	5.8	2.7	4.3	7.8	7.9	9.4	7.3	73.1
1952	10.0	8.1	6.4	6.8	10.1	2.5	5.2	6.3	17.6	20.1	15.0	5.7	113.8
1953	5.4	11.9	10.3	4.6	2.9	1.8	2.4	8.7	9.6	18.1	8.1	13.3	97.1
1954	4.9	10.7	6.7	4.0	3.1	1.8	3.5	3.3	8.5	10.0	11.6	16.3	84.4
1955	11.2	12.1	13.6	3.2	6.7	3.2	1.9	8.0	8.3	12.9	4.0	5.9	91.0
1956	2.7	8.0	6.3	4.6	8.9	2.3	3.9	13.0	7.6	11.9	14.2	18.2	101.6
1957	3.0	7.5	3.7	7.8	2.2	2.1	4.1	2.8	8.5	9.7	17.8	10.0	79.2
1958	7.2	2.9	4.4	6.3	7.6	3.4	7.4	8.1	10.2	16.6	11.1	11.5	96.7
1959	3.7	9.1	11.7	7.5	4.8	1.5	10.8	9.5	8.5	10.3	14.6	17.9	109.9
1960	6.9	4.0	5.6	5.4	1.4	3.7	4.8	9.3	14.8	19.7	11.0	14.7	101.3
1961	10.0	7.3	6.7	10.7	3.0	6.0	8.2	18.2	10.2	18.6	10.5	9.5	118.9
1962	14.8	1.9	12.6	4.0	3.9	6.0	2.5	8.1	15.4	10.7	10.4	9.1	99.4
1963	15.4	8.4	7.8	5.3	2.6	7.9	3.5	2.7	10.2	14.9	9.8	9.7	98.2
1964	9.9	16.4	11.3	10.1	8.9	3.0	4.7	5.4	4.6	11.3	11.7	7.4	104.7
1965	12.8	7.1	2.8	5.4	6.6	8.6	2.4	6.9	6.0	18.7	5.1	11.5	93.9
1966	5.6	7.0	7.7	5.5	9.8	1.1	4.6	8.6	11.1	20.5	8.7	5.0	95.2
1967	7.9	9.0	3.4	2.9	4.5	2.6	4.7	7.4	16.0	14.1	12.2	6.3	91.0
1968	6.2	5.6	4.9	8.2	2.7	2.2	3.6	3.2	19.3	8.4	11.1	5.8	81.2
1969	2.6	2.2	6.8	2.4	3.2	2.4	10.2	7.5	6.8	6.2	17.2	8.8	76.3
1970	6.3	8.6	7.7	6.9	5.4	4.8	6.0	6.5	16.2	10.7	7.0	8.7	94.8
1971	11.7	7.0	5.2	5.3	6.4	2.4	2.7	4.6	8.8	12.2	8.9	6.9	82.1
1972	7.8	4.6	7.6	6.0	5.6	3.5	2.0	8.5	18.2	18.2	6.2	8.7	96.9
1973	8.1	6.7	6.5	5.0	4.8	2.8	4.4	9.9	6.8	14.7	2.7	5.3	77.7
1974													
Monthly Maximums	15.4	16.4	13.6	10.7	10.1	8.6	10.8	18.2	19.3	20.5	17.8	18.2	
Monthly Minimums	2.6	1.9	2.8	2.4	1.4	1.1	1.9	2.7	4.6	6.2	2.7	4.9	
Maximum Annual	10.0	7.3	6.7	10.7	3.0	6.0	8.2	18.2	10.2	18.6	10.5	9.5	118.9
Minimum Annual	2.7	4.7	3.6	4.2	4.7	1.1	7.1	7.3	8.6	7.0	3.6	4.9	59.5
Average Annual	7.6	7.3	7.1	5.9	5.1	3.4	4.7	7.4	10.8	13.5	10.1	9.5	92.4

TABLE IV-2

BLUE LAKE PROJECT
HISTORICAL WATER USE
ALASKA LUMBER & PULP COMPANY

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1965	4,104	3,577	3,942	3,804	3,914	3,764	3,319	4,028	3,595	4,012	718	3,524	42,301
1966	4,405	3,484	3,902	-	3,478	3,663	3,902	3,736	3,472	3,896	3,936	3,672	41,546
1967	4,138	3,604	4,006	3,696	3,699	3,558	3,997	3,944	3,352	3,982	3,801	4,009	45,789
1968	4,000	3,383	3,638	3,804	3,785	3,555	3,831	4,114	3,196	3,930	3,779	3,874	44,890
1969	3,896	3,509	3,828	3,580	3,380	3,819	4,019	3,970	3,567	3,960	3,855	3,488	44,871
1970	4,390	3,957	4,059	3,970	3,705	3,629	4,510	4,525	4,089	4,752	4,421	4,151	50,158
1971	4,458	4,034	4,445	4,485	4,479	4,307	4,811	4,728	4,212	4,596	4,476	4,666	53,697
1972	4,559	4,350	4,685	4,709	4,541	4,344	4,835	4,688	3,773	4,409	4,485	4,378	53,755
1973	4,310	3,997	4,587	4,375	4,218	4,424	2,999	2,097	2,327	4,786	4,706	4,197	47,023

NOTE: All units are in acre-feet

TABLE IV-3

BLUE LAKE PROJECT

RESERVOIR OPERATION

FISH RELEASE = 15 cfs

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
MINIMUM WATER YEAR													
Inflow	22,600	9,440	2,960	4,380	1,770	1,500	6,570	28,800	40,320	35,070	26,500	31,460	211,370
Water to ALPC	4,774	4,620	4,774	4,774	4,312	4,774	4,620	4,774	4,620	4,774	4,774	4,620	56,120
Fish Release	930	900	930	930	840	930	900	930	900	930	930	900	10,950
Surplus or (Deficit)	16,896	3,920	(2,744)	(1,324)	(3,382)	(4,204)	1,050	23,096	34,800	29,366	20,796	25,940	144,210
Reservoir Storage	6,194	(6,793)	(14,750)	(14,676)	(16,071)	(19,058)	(14,165)	8,614	24,142	19,345	11,216	16,002	-0-
Water for Generation	10,702	10,713	12,006	13,352	12,689	14,854	15,215	14,482	10,658	10,021	9,580	9,938	144,210
Spillway Discharges	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
Power Discharge-cfs	174	180	196	218	228	242	256	236	179	163	156	167	
End of Month Reservoir Storage	145,000	138,207	123,457	108,781	92,710	73,652	59,487	68,101	92,243	111,588	122,804	138,806	Rule Curve
AVERAGE WATER YEAR													
Inflow	56,640	14,590	25,530	8,020	2,670	1,500	6,570	28,800	40,320	37,820	39,740	45,200	307,400
Water to ALPC	4,774	4,620	4,774	4,774	4,312	4,774	4,620	4,774	4,620	4,774	4,774	4,620	56,120
Fish Release	930	900	930	930	840	930	900	930	900	930	930	900	10,950
Surplus or (Deficit)	50,936	9,070	19,826	2,316	(2,482)	(4,204)	1,050	23,096	34,800	32,116	34,036	39,630	240,240
Reservoir Storage	6,194	(6,793)	(4,974)	(22,484)	(18,039)	(19,058)	(14,165)	8,614	24,142	19,345	11,216	16,002	-0-
Water for Generation	24,800	15,863	24,800	24,800	15,557	14,854	15,215	14,482	10,658	12,771	22,820	23,678	220,298
Spillway Discharge	19,942	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	19,942
Power Discharge-cfs	400	266	400	400	278	242	256	236	179	208	372	398	
End of Month Reservoir Storage	145,000	138,207	133,233	110,749	92,710	73,652	59,487	68,101	92,243	111,588	122,804	138,806	

NOTE: All units are in acre-feet, except as noted.

TABLE IV-4
Sheet 1 of 2

BLUE LAKE PROJECT

RESERVOIR OPERATION

FISH RELEASE = 50 cfs

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
MINIMUM WATER YEAR													
Inflow	22,600	9,440	2,960	4,380	1,770	1,500	6,570	28,800	40,320	35,070	26,500	31,460	211,370
Water to ALPC	4,774	4,620	4,774	4,774	4,312	4,774	4,620	4,774	4,620	4,774	4,774	4,620	56,120
Fish Release	3,100	3,000	3,100	3,100	2,800	3,100	3,000	3,100	3,000	3,100	3,100	3,000	36,500
Surplus or (Deficit)	14,726	1,820	(4,914)	(3,494)	(5,342)	(6,374)	(1,050)	20,926	32,700	27,196	18,626	23,840	118,660
Reservoir Storage	6,194	(6,793)	(14,750)	(14,676)	(16,071)	(19,058)	(14,165)	8,614	24,142	19,345	11,216	16,002	-0-
Water for Generation	8,532	8,613	9,836	11,182	10,729	12,684	13,115	12,312	8,558	7,851	7,410	7,838	118,660
Spillway Discharges	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
Power Discharge-cfs	138	144	159	180	192	205	219	199	143	127	120	131	
End of Month Reservoir Storage	145,000	138,207	123,457	108,781	92,710	73,652	59,487	68,101	92,243	111,588	122,804	138,806	Rule Curve
AVERAGE WATER YEAR													
Inflow	56,640	14,590	25,530	8,020	2,670	1,500	6,570	28,800	40,320	37,820	39,740	45,200	307,400
Water to ALPC	4,774	4,620	4,774	4,774	4,312	4,774	4,620	4,774	4,620	4,774	4,774	4,620	56,120
Fish Release	3,100	3,000	3,100	3,100	2,800	3,100	3,000	3,100	3,000	3,100	3,100	3,000	36,500
Surplus or (Deficit)	48,766	6,970	17,656	146	(4,442)	(6,374)	(1,050)	20,926	32,700	29,946	31,866	37,580	214,690
Reservoir Storage	6,194	(6,793)	(7,144)	(22,282)	(16,071)	(19,058)	(14,165)	8,614	24,142	19,345	11,216	16,002	-0-
Water for Generation	24,800	13,763	24,800	22,428	11,629	12,684	13,115	12,312	8,558	10,601	20,650	21,578	196,918
Spillway Discharge	17,772	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	17,772
Power Discharge-cfs	400	229	400	362	208	205	219	199	143	171	333	360	
End of Month Reservoir Storage	145,000	138,207	131,063	108,781	92,710	73,652	59,487	68,101	92,243	111,588	122,804	138,806	

NOTE: All units are in acre-feet, except as noted.

TABLE IV-4
Sheet 2 of 2

BLUE LAKE PROJECT

HISTORICAL ENERGY GENERATION

POWER YEAR	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	TOTAL
1961-62	---	---	---	1544	1596	1733	1722	1512	1691	1533	1459	1250	
1962-63	1302	1407	1460	1596	1701	1796	1722	1554	2367	2489	2300	2237	21,931
1963-64	2268	2415	2331	2561	2562	2573	2699	2405	2615	2657	2699	2436	30,221
1964-65	2279	2468	2478	2646	2772	2076	3087	2657	2562	2468	2363	2516	30,372
1965-66	2331	2289	2394	2594	2384	2523	2562	2279	2478	2268	2174	2100	28,376
1966-67	1922	2174	2205	2447	2489	2668	2825	2279	2539	2531	2384	2184	28,647
1967-68	2079	2205	2373	2636	2646	2594	2856	2489	2583	2468	2195	2006	29,130
1968-69	2027	2121	2237	2699	2541	2699	2888	2510	2468	2310	2247	2027	28,774
1969-70	2100	2195	2415	2457	2478	2657	2762	2500	2552	2384	2426	2184	29,110
1970-71	2310	2363	2447	2646	2709	3077	3151	2625	2877	2678	2615	2247	31,745
1971-72	2394	2447	2573	3024	2951	3161	3266	2972	3035	2814	2709	2573	33,919
1972-73	2457	2457	2709	2268	3018	3204	3284	2901	3107	2794	2762	2335	33,296
1973-74	2454	2529	2633	2932	2983	2836	2312	1817	2620				

Note: All values are in 1,000 kWh.

TABLE IV - 5

BLUE LAKE PROJECT

RULE CURVE OPERATION OF RESERVOIR

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Reservoir Elevation Beginning of Month - Feet	337.0	342.0	336.0	324.0	310.5	294.5	273.5	255.0	266.5	294.0	313.0	323.0
Reservoir Elevation End of Month - Feet	342.0	336.0	324.0	310.5	294.5	273.5	255.0	266.5	294.0	313.0	323.0	337.0
Elevation Change - Feet	+5.0	-6.0	-12.0	-13.5	-16.0	-21.0	-18.5	+11.5	+27.5	+19.0	+10.0	+14.0
Storage Change - Acre-ft.	6,194	-6,793	-14,750	-14,676	-16,071	-19,058	-14,165	8,614	24,142	19,345	11,216	16,002
Cummulative Reservoir Volume-Acre-ft.	145,000	138,207	123,457	108,781	92,710	73,652	59,487	68,101	92,243	111,588	122,804	138,806
Average Reservoir Elevation - Feet	339.5	339.0	330.0	317.3	302.5	285.0	264.3	260.8	280.3	303.5	318.0	330.0
Average Tailwater Elevation - Feet	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
Gross Head-feet	325.5	325.0	316.0	303.3	288.5	271.0	250.3	246.8	266.3	289.5	304.0	316.0

TABLE IV-6

BLUE LAKE PROJECT

AVAILABLE ENERGY WITH RULE CURVE OPERATION

FISH RELEASE = 15 cfs

MINIMUM AND AVERAGE WATER YEARS

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
MINIMUM WATER YEAR													
Power Discharge-cfs	174	180	196	218	228	242	256	236	179	163	156	167	
Average Reservoir Elevation	339.5	339.0	330.0	317.3	302.5	285.0	264.3	260.8	280.3	303.5	318.0	330.0	
Gross Head-Feet	326	325	316	303	289	271	250	247	266	290	304	316	
Head Loss-Feet	17	18	21	26	28	32	36	30	17	14	13	15	
Average Net Generating Head-Feet	309	307	295	277	261	239	214	217	249	276	291	301	
Average Output-kW	3,868	3,976	4,160	4,344	4,281	4,161	3,941	3,684	3,207	3,237	3,266	3,616	3,810
Energy-1,000 kWh	2,878	2,863	3,095	3,232	2,877	3,096	2,838	2,741	2,309	2,408	2,430	2,604	33,371
AVERAGE WATER YEAR													
Power Discharge-cfs	400	266	400	400	278	242	256	236	179	208	372	398	
Average Reservoir Elevation	339.5	339.0	333.0	321.0	303.0	285.0	264.3	260.8	280.3	303.5	318.0	330.0	
Gross Head-feet	326	325	319	307	289	271	250	247	266	290	304	316	
Head Loss-Feet	63	37	63	63	33	32	36	30	17	24	55	62	
Average Net Generating Head-Feet	263	288	256	244	256	239	214	217	249	266	249	254	
Average Output-kW	7,568	5,511	7,367	7,022	5,120	4,161	3,941	3,684	3,207	3,980	6,664	7,273	5,450
Energy-1,000 kWh	5,631	3,968	5,481	5,224	3,441	3,096	2,838	2,741	2,309	2,962	4,958	5,237	47,886
Firm Energy-1,000 kWh	2,878	2,863	3,095	3,232	2,877	3,096	2,838	2,741	2,309	2,408	2,430	2,604	33,371
Secondary Energy-1,000 kWh	2,753	1,105	2,386	1,992	564	-0-	-0-	-0-	-0-	554	2,528	2,633	14,515

TABLE IV-7
Sheet 1 of 2

BLUE LAKE PROJECT

AVAILABLE ENERGY WITH RULE CURVE OPERATION

FISH RELEASE = 50 cfs

MINIMUM AND AVERAGE WATER YEARS

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
MINIMUM WATER YEAR													
Power Discharge-cfs	138	144	159	180	192	205	219	199	143	127	120	131	
Average Reservoir Elevation	339.5	339.0	330.0	317.3	302.5	285.0	264.3	260.8	280.3	303.5	318.0	330.0	
Gross Head-Feet	326	325	316	303	289	271	250	247	266	290	304	316	
Head Loss-Feet	13	14	16	18	20	23	26	21	14	12	11	12	
Average Net Generating Head-Feet	313	311	300	285	279	248	224	226	252	278	293	304	
Average Output-kW	3,107	3,222	3,432	3,691	3,854	3,658	3,529	3,236	2,593	2,540	2,529	2,865	3,177
Energy-1,000 kWh	2,312	2,320	2,553	2,746	2,590	2,722	2,541	2,408	1,867	1,829	1,882	2,063	27,833
AVERAGE WATER YEAR													
Power Discharge-cfs	400	229	400	362	208	205	219	199	143	171	333	360	
Average Reservoir Elevation	339.5	339.0	333.0	320.0	303.0	285.0	264.3	260.8	280.3	303.5	318.0	330.0	
Gross Head-feet	326	325	319	306	289	271	250	247	266	290	304	316	
Head Loss-Feet	63	28	63	53	22	23	26	21	14	17	49	53	
Average Net Generating Head-Feet	263	297	256	253	267	248	224	226	252	273	255	263	
Average Output-kW	7,568	4,893	7,367	6,589	3,995	3,658	3,529	3,236	2,593	3,358	6,109	6,812	
Energy-1,000 kWh	5,631	3,523	5,481	4,902	2,685	2,722	2,541	2,408	1,867	2,498	4,545	4,905	43,708
Firm Energy-1,000 kWh	2,312	2,320	2,553	2,746	2,590	2,722	2,541	2,408	1,867	1,829	1,882	2,063	27,833
Secondary Energy-1,000 kWh	3,319	1,203	2,928	2,156	95	-0-	-0-	-0-	-0-	669	2,663	2,842	15,875

Table IV-8

BLUE LAKE PROJECT
FIRM ENERGY AVAILABLE WITH DIFFERENT FISH RELEASES
(1000 kWh)

Period	Fish Releases 0 cfs	15 cfs	50 cfs
January	3,440	3,232	2,746
February	3,000	2,877	2,590
March	3,256	3,096	2,722
April	2,965	2,838	2,541
May	2,884	2,741	2,408
June	2,498	2,309	1,867
July	2,656	2,408	1,829
August	2,665	2,430	1,882
September	2,836	2,604	2,063
October	3,121	2,878	2,312
November	3,096	2,863	2,320
December	3,327	3,095	2,553
Annual	35,749	33,371	27,833
Comparison	0	-2,378	-7,916
Fuel Oil Required (gallons)	0	169,700	565,400
Estimated Differential Cost of Diesel Generation in 1978	0	+$86,040	+$286,660

SECTION V

POTENTIAL NEW GENERATION

1. BLUE LAKE EXPANSION

a. Description

The ultimate development of the Blue Lake Project was planned as three 3,000 kW units, and the manifold has a branch installed for the third unit which is closed by a blind flange. No provision for expansion has been made at the powerhouse but addition of the third unit would not require significant demolition at the existing structure. The transmission line is adequate for a new unit, but additional transformer capacity would be required.

b. Power Output

As previously discussed, firm energy from the project is considered to be limited to rule curve operation of minimum water years with secondary energy being generated by the installed capacity when excess water is available. As more information relating to reservoir operation becomes available in future years it may be possible to develop firm yield of the reservoir and increase the firm energy with a consequent reduction of secondary energy. At the present time firm energy output cannot be increased by a third unit, but the production of secondary energy can be increased.

Rule curve operation of the reservoir utilizes only about 86,000 acre-feet of the total potential storage of 102,000 acre-feet which is available to El 230, as previously mentioned. This operation provides the maximum amount of firm energy which can be generated, when water available for power usage is allocated in proportion to the historical distribution of monthly energy loads.

Addition of a third unit of 4,000 kW, together with re-rating the existing units at 3,500 kW each, would provide a total installed capacity of 11,000 kW. Based on total average energy production this capacity could be operated at a plant factor of from approximately 45% to 50% depending on the amount of fish releases required. This amount of capacity is needed in the system, and installation will provide better reservoir operation. Since it does not provide additional firm energy, installation of the third unit is included in the proposed program of development following the next major installation.

2. GREEN LAKE PROJECT

a. Description

Green Lake is located approximately 12 miles from Sitka and about 7 miles from Blue Lake at the end of Silver Bay. The lake is a part of the Vodopad River and has formed about 1,500 feet upstream of the mouth. The existing outlet of the lake is a relatively narrow gorge which controls the existing lake level at about El 230.

It is anticipated that raising the lake level to El 420, by means of a concrete arch dam at the present outlet, will provide sufficient reservoir storage for control of the runoff and adequate head to develop economic power from the site. The project was studied by the Alaska Power Administration (APA) in its feasibility investigations of the Takatz Project. A preliminary arrangement of project is shown in Fig. 5, and of the proposed dam in Fig. 6.

A concrete arch dam, approximately 580 feet long along the crest and with a maximum height of 215 feet, will be required to control the reservoir and to provide full regulation of a low water year runoff. A dam of this size would provide a normal maximum reservoir level at El 420, and contain an active storage volume of 112,000 acre-feet. The power conduit is tentatively proposed as a short tunnel 300 feet which would also serve for river diversion during construction. A 78-inch diameter steel penstock approximately 1,300 feet long would be connected to the downstream portal of the tunnel. A surface powerhouse will be constructed at ground level near Silver Bay. It is anticipated that two horizontally-mounted Francis reaction turbines would be installed, each delivering about 11,500 hp at best gate, under average net head, and connected by a horizontal shaft to a generator rated at 9300 kVA with about a 90% power factor (8,300 kW). It is estimated that, including generator, transformer and transmission losses, each unit will deliver 7,500 kW to the load center at peak load conditions, at best-gate operation of the turbines, under winter reservoir levels.

An access road approximately seven miles long will be constructed from Sawmill Cove to the project site as an extension of the existing Sitka Highway. The road will be used for construction and resurfaced with gravel or crushed rock after completion of the project to provide access for maintenance of the transmission line and to the powerhouse. The transmission line will be located along the new road and then follow the route of the existing transmission line to the Marine Street Substation. Transmission line voltage will be at 69 kV and the lines will be carried on wooden frame poles. The capacity of the line will be sufficient to conduct the output of the Green Lake unit, the proposed third unit at the Blue Lake Project and an allowance for emergency capacity provided by ALP generation. Consideration should also be given during design to future connection of additional developments to the lines.

Approximate reservoir area-capacity curves are shown in Fig. 7.

b. Geology

No detailed site geology is available at the present time, but investigations are proposed in this report. It is expected that the general geology will be similar to that at Blue Lake and will prove adequate as an arch dam site. The precipitous terrain in the area indicates that sound rock should be near the ground surface which will reduce construction excavation problems.

c. Hydrology and Power Output

The USGS operated a stream gage on the Vodopad River between 1915-1925 and monthly average runoffs in acre-feet are shown in Table V-1. Significant hydrologic and reservoir operating data have been compiled and are shown in Table V-2.

As shown in the tables the average annual runoff is about 212,400 acre-feet, or approximately 291 cfs. The average annual discharge from the lowest year during the period of record is 236 cfs. The drainage area of Green Lake is approximately 28.9 square miles which produces an annual average runoff of about 7,350 acre-feet per square mile. This is significantly less than the long-term runoff from the Blue Lake drainage basin of 9,844 acre-feet per square mile, which indicates that there may be more firm energy available at the site than estimated from the one decade period of record.

It is anticipated the project can be developed to deliver 15,000 kW of dependable capacity to the load center during periods of peak loads, and will be capable of an output of 52,000,000 kWh of firm energy, or a plant factor of approximately 40%, which is considered appropriate for the system at that time.

This project is considered to have potential feasibility and is included in the proposed program of development.

3. TAKATZ PROJECT

a. Description

Takatz Lake is located approximately 4,000 feet upstream of the mouth of Takatz Creek which flows into Chatham Strait (by way of Takatz Bay) on the eastern shore of Baranof Island. The project would be located about 20 airline miles east of Sitka.

It is anticipated that raising the lake level to El 1040 by construction of a dam at the existing outlet of the lake will provide sufficient storage for regulation of inflow and adequate head to develop the economic potential of the project. A preliminary arrangement of the proposed project is shown in Fig. 8.

A concrete arch dam approximately 200 feet high will be required to control the reservoir and to provide regulation of the annual runoff. A dam of this size would provide a normal maximum reservoir level at El 1040, and contain an active storage volume of 82,400 acre-feet. The power conduit is tentatively proposed as a 6.5-foot by 7.0-foot modified horseshoe tunnel approximately 2,800 feet long with a downstream portal approximately 1,000 feet from the powerhouse. A 72-inch steel penstock would connect the portal to the powerhouse. A surface powerhouse would be constructed at ground level near Takatz Bay. It is anticipated that two Francis turbines would be installed, each delivering about 18,600 hp at best gate, under average net head, and connected to a generator rated at 15,400 kVA, with about a 90% power factor (13,850 kW). It is estimated that, including generator, transformer and transmission losses, each unit will deliver 12,500 kW to the load center at peak load conditions at best-gate operation of the turbines, under winter reservoir levels.

The site was studied in some detail by the APA and was presented in a report entitled "Takatz Creek Project - Alaska" dated 1968. The basic data presented herein was obtained from that report. The reservoir area-capacity curves are shown in Fig. 9.

b. Geology

The APA investigated the geology at the site and concluded that conditions were adequate for construction of a concrete arch dam.

The topography appears to have been greatly influenced by glaciation, probably during Pleistocene Time. Slopes are precipitous and covered by a thin mantle of soil with heavy growths of underbrush.

The bedrock formation at the damsite is a massive quartz diorite which is dense and indurated. The rock is medium-to-coarse grained and is equigranular. This is typical of rocks associated with the Coastal Range Batholith which generally is located along the coast of the mainland of Southeast Alaska. The Coastal Range rocks are considered to be competent foundation materials and if the geology at the site is indeed of that formation, the foundation conditions should be entirely adequate. Further investigations will be required of the site conditions.

c. Hydrology and Power Output

The drainage basin of Takatz Lake has an area of about 10.6 square miles. Stream flow records for 15 complete water years are available at a point on Takatz Creek downstream of the damsite with a drainage area of 17.5 square miles and are listed in Table V-3. The average annual runoff at the gage was 199,800 acre-feet or an average of 11,417 acre-feet per square mile which is significantly higher than either Blue Lake or Green Lake. The annual average precipitation at Baranof Warm Springs, however, is approximately 143 inches which is about 154% of the long-term average at Sitka. The average annual inflow into Takatz Lake is estimated to be about 121,000 acre-feet which would produce an average annual discharge of about 166 cfs.

It is estimated that an average net head of approximately 950 feet can be developed at the site which would produce an average generator output of about 11,080 kW which would deliver approximately 91,200,000 kWh of firm energy to the load center. At 40% plant factor, the peak generator output would be 27,700 kW, which would deliver 25,000 kW of dependable peak capacity to the load center.

Ultimate development of the site could be planned as having two units at 13,850 kW (total 25,000 kW delivered to load center). However, a staged development could be considered, for comparison with the Green Lake Project at the same time period, which would have two units at 7,500 kW each, and with later installation of a third unit at 10,000 kW.

The project appears to be feasible and is included in the proposed program of development.

4. OTHER SITES

a. Major

(1) Baranof Lake Project

A major potential site is located at Baranof Lake, about four miles south of Takatz Lake. The drainage area is larger than Takatz

Lake but the total head which could be economically developed is much less. The APA concluded that bus-bar power from a plant at Baranof Lake would be nearly twice as costly as from Takatz. The site was rejected by comparison with Takatz Lake.

(2) Lake Diana Project

Lake Diana is located about 16.5 miles southeast of Sitka, and has the potential for a high-head development, but only has about 3.5 square miles of drainage area. Development of this site would be costly for the power developed, and is not considered as attractive as Green Lake.

(3) Maksoutof Projects

Two sites are located in the area, but would require about 64 miles of transmission line which would be prohibitive in terms of both cost and reliability.

b. Minor

(1) Cold Storage Lake

This site is located about 10 miles north of Sitka. The drainage area is small and transmission costs would be very high in relation to the capacity which could be developed. The site would not meet long-term requirements of the system and was not considered further.

(2) Hogan Lake

This site, located about 13.5 miles northeast of Sitka, has the same disadvantages as Cold Storage Lake and was rejected for the same reasons.

(3) Indigo Lake

This site has a more favorable geographic location being near (and between) both Blue Lake and Green Lake, but has a drainage area of only 900 acres which is much too small to result in a sufficiently-large development, even with the relatively-high head available.

TABLE V-1

GREEN LAKE OUTLET

RECORDED RUNOFF IN ACRE-FEET

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
1915	-	-	-	-	-	-	-	-	-	-	-	34,100	-
1916	29,900	11,200	7,200	1,400	4,200	2,500	6,900	17,400	33,800	27,400	30,700	33,600	206,200
1917	29,000	12,500	5,900	5,000	6,700	3,100	4,400	19,100	28,300	30,200	32,300	26,900	213,400
1918	40,100	37,800	4,800	7,800	2,200	1,100	4,500	18,200	34,600	36,900	30,100	29,300	247,400
1919	25,800	22,500	11,700	14,200	2,100	900	7,500	15,700	21,300	30,000	27,800	29,800	209,300
1920	24,100	10,800	7,900	13,300	4,800	1,700	2,400	10,600	28,500	27,400	26,900	19,600	178,000
1921	17,300	15,100	4,500	3,900	6,200	3,600	4,100	17,500	32,300	23,800	19,000	24,700	172,000
1922	35,100	9,500	18,000	5,600	2,000	1,700	5,100	21,600	27,700	28,400	30,700	33,900	219,300
1923	15,100	23,800	5,100	1,900	6,100	7,200	13,000	21,000	30,300	24,000	15,400	38,600	201,500
1924	18,000	28,800	11,200	6,000	6,800	5,600	9,500	29,500	40,900	41,400	33,100	41,500	272,500
1925	26,900	17,000	10,000	2,100	1,400	3,100	5,100	29,100	30,900	34,400	24,300	20,200	204,500
Average	26,100	18,900	8,600	6,100	4,300	3,100	6,200	20,000	30,900	30,400	27,000	30,800	212,400

GREEN LAKE PROJECT
ESTIMATE OF FIRM ENERGY

RESERVOIR DATA

Drainage Area - square miles	28.9
Average Runoff - acre feet	212,400
Minimum Runoff - acre feet (estimated)	172,000
Average Annual inflow - cfs	291
Minimum Annual inflow - cfs	236
Normal Maximum Reservoir Elevation - feet	420
Mean High Tide - MSL - feet	12
Gross Head - feet	408

Dependable Capacity (Peak Load Conditions)

Reservoir Elevation - feet	380
Net Head - feet	345
Discharge - cfs (best gate)	653
Turbine Output - hp	23,000
Generator Output - kW	16,600
Capacity at Load Center (on feeder) - kW	15,000

Average Annual Conditions

Maximum Drawdown - feet	120
Average Net Head - feet	352
Average Regulated Discharge (minimum year)- cfs	244
Average Regulated Discharge (average year)- cfs	285
Firm Energy - 1000 kWh (at load center)	52,000
Secondary Energy - 1000 kWh (at load center)	10,000
Average Energy - 1000 kWh (at load center)	62,000

TABLE V-3

TAKATZ CREEK

RECORDED RUNOFF IN ACRE-FEET

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
1951	-	-	-	-	-	-	-	-	-	29,900	19,000	20,000	-
1952	17,800	14,500	3,300	1,200	1,200	1,100	4,800	12,900	23,500	38,500	25,800	37,500	182,100
1953	32,600	17,500	7,100	3,500	3,300	4,200	5,400	22,900	33,000	32,600	28,100	29,000	219,200
1954	40,100	14,500	7,900	3,100	7,000	2,200	2,000	14,600	30,100	26,300	22,000	24,300	194,100
1955	21,100	24,700	13,500	3,900	2,600	2,400	3,200	8,900	22,100	33,900	29,900	27,700	193,900
1956	17,400	6,000	2,300	1,400	1,400	1,500	3,800	16,900	29,900	33,300	37,000	17,800	168,700
1957	16,200	13,300	12,800	4,100	2,200	2,100	3,900	18,500	30,500	27,900	22,400	24,100	178,000
1958	14,400	22,700	4,500	8,000	2,500	3,100	7,000	19,600	31,100	23,300	23,700	16,000	175,900
1959	32,800	13,100	6,800	2,900	2,500	3,900	4,600	17,100	37,100	37,200	28,800	17,800	204,600
1960	16,600	11,100	6,700	3,000	3,700	2,900	5,700	22,900	30,700	38,000	23,500	28,500	193,300
1961	37,500	12,200	12,000	5,200	4,000	5,300	6,400	17,600	42,000	30,900	36,200	21,400	230,700
1962	31,700	7,200	2,800	4,600	2,500	2,300	7,200	9,600	24,300	28,000	29,600	27,600	177,400
1963	33,200	17,600	21,400	12,000	10,900	4,300	5,300	14,900	21,500	21,700	17,300	57,700	237,800
1964	57,700	11,000	13,200	6,300	5,000	3,000	5,400	11,800	37,800	39,699	31,600	19,100	241,500
1965	30,800	11,600	9,200	7,900	2,800	3,600	5,100	8,900	24,600	30,100	20,600	16,600	171,800
Average	28,400	14,300	8,800	4,600	3,800	2,900	5,000	16,000	30,300	31,500	27,400	26,800	199,800

SECTION VI

POWER STUDY

1. GENERAL

A forecast of loads is discussed in this section. Historical loads were used to project annual peak and energy demands to the current year from which the forecast loads were projected. The projection was complicated by power conservation measures which caused reductions from normal demands during the past winter, but it is assumed that load growths will continue in an orderly and progressive manner even though there will be variations from a smooth curve of growth in individual years. The Alaska Power Administration (APA) has estimated that an annual growth rate of 8% per year is appropriate for Southeast Alaska. Based on the analysis of the historical loads in Sitka, the value of 8% is considered reasonable as an average and has been used in this report. This growth rate of course incorporates any larger block loads a number of which are potential as listed in Table VI-7.

2. LOADS

a. Peak Capacity

From historic loads, it was estimated that the normal peak load for the power year 1974-75 would be 6840 kW, and with inclusion of a load growth reserve, the peak load would be 7,114 kW, with a total energy demand of 34,275,300 kWh. These loads were projected at an 8% increase per year to the 1989-90 power year. In that year the peak load will have increased to 22,566 kW, with 108,723,000 kWh of energy being required. A tabulation of forecasted annual loads is shown in Table VI-1, and a peak demand growth curve including reserves, is shown in Fig. 10.

b. Dependable Capacity

Dependable capacity is defined as the capacity which can always be delivered to the load center during a critical period. In this report the critical condition for hydroelectric units is considered to be during the winter season when peak loads occur, with concurrent drawdown of the reservoir to minimum levels for that season. The minimum amount of capacity which can be generated at any time during the critical period for all years is the dependable capacity for that project. Under this definition the delivered capacity during periods of lower loads (off-peak period) could be less than dependable capacity with no detrimental effects. Conversely during most, if not all, of the critical periods during the life of the plant, the delivered capacity would be actually greater than the dependable capacity.

c. System Load Factor

The system load factor expresses the relationship between total energy and peak load in a given time period. For an annual condition the total energy (in kWh) demand for that year is divided by 8,760 hours to determine an average demand (average output when used with resources) in kW for the year. The load factor for the year is the ratio of the average demand to the peak load expressed as a percentage. The annual load factor of the City's system was determined from historical loads to be 55%.

d. Energy

Forecasts of system energy demand were developed from projected peak loads and the system load factor. Monthly energy requirements and peak loads were forecast from the historical values shown in Tables VI-2 and VI-3. The forecast of the monthly energy loads and peak loads is shown in Table VI-4. A growth curve of energy loads is shown in Fig. 11.

e. Load Growth Reserve

Since projections for load growth are usually made in annual increases of finite amounts, a small reserve allowance for load growth during each period is considered to be necessary. For this study a load growth reserve of one-half of the projected annual increase has been included as a part of the annual load forecast for the beginning of that year.

f. Forced Outage Reserve

In order to provide necessary reliability to the system, an adequate amount of reserve capacity is required. For this study the required reserve capacity has been taken as the difference between the required generation (peak loads plus load growth reserve) and the resources, minus the largest individual generating unit. If such a reserve is available, the system can continue to provide reliable power even though a forced outage occurs with the largest unit.

g. Exports

The power requirements of ALP form a potential for Sitka to market power, on a contractual basis. As seen in Figs. 10 and 11, excess capacity and energy will be available in varying amounts in the years subsequent to completion of new hydroelectric generating facilities. No attempt has been made in this report to formulate a fixed amount which might be provided on a long-term contractual basis. If an amount were determined by negotiations with ALP, it appears that reasonable amounts of power could be made available on a firm basis. Exports are a part of system loads and are shown as such in the appropriate tables.

3. FUTURE REQUIREMENTS

a. System in 1974-75

During this period the peak load is forecast to be 7,114-kW with an energy requirement of approximately 34,275,000-kWh. Provision of a forced outage reserve of 3500 kW, to correspond with the largest unit, will increase the required capacity of resources to 10,614 kW. These loads and the resources available to meet the loads are shown in Table VI-5. In this period 3100 kW of diesel capacity and 7000 kW of hydroelectric capacity will be available to meet loads, but the system will have a capacity deficit of 514 kW, including the forced outage reserve requirement.

The Blue Lake Hydroelectric Project will provide firm energy in the amount of 32,000,000 which will require 2,275,000 kWh of generation by diesel units during this period. It is estimated that this amount of diesel generation will require about 162,500 gallons of fuel oil. A load duration curve for this period is shown in Fig. 12.

b. System in 1976-77

During this period the peak load is forecast to be 8,297 kW, with an energy requirement of approximately 39,975,000 kWh. Provision of a forced outage reserve of 3500 kW, again corresponding to the largest unit, will increase the required capacity of resources to 11,797 kW. These loads and the resources available to meet the loads are shown in Table VI-5. In this period 3100 kW of diesel capacity and 7000 kW of hydroelectric capacity will again be available to meet loads, but the capacity deficit of the system will have increased to 1,697 kW, including the forced outage reserve requirement.

The Blue Lake units will again provide firm energy of 32,000,000 kWh, which will require 7,975,000 kWh of generation by diesel units during this period. It is estimated that this amount of diesel generation will require approximately 570,000 gallons of fuel oil. A load duration curve for this period is also shown in Fig. 12.

c. System in 1978-79

During this period the peak load is forecast to be 9,678 kW, with an energy requirement of approximately 46,628,000 kWh. Provision of a forced outage reserve of 3,500 kW, corresponding to the largest unit, will increase the required capacity of resources to 13,178 kW. These loads, and the resources available to meet the loads, are again shown in Table VI-5. In this period 3100 kW of diesel capacity, and 7000 kW of hydroelectric capacity from the Blue Lake Project, will again be available to meet loads, but the capacity deficit of the system will have increased to 3,078 kW, including the forced outage reserve requirement.

If installation of the Green Lake Project proceeds in accordance with the schedule proposed in this report, the two units of the project would be on-line about mid-way through this period to meet the peak load. Table VI-5 does not include the capacity from this project to show the affect of slippage in the schedule so that installation of the units is not completed in time to supply the peak load. The energy available from the project over the latter portion of the period would, of course, eliminate all need of diesel generation subsequent to the on-line date, but in order to show the fuel oil requirements at a period prior to completion of the Green Lake Project, the energy available from the project during the latter portion of the period is not shown in Table VI-5.

The Blue Lake Project will again provide firm energy of 32,000,000 kWh, which will require 14,628 kWh of generation by diesel units during this period. It is estimated that this amount of diesel generation will require approximately 1,045,000 gallons of fuel oil. With the Green Lake units on-line during the last half of the period the fuel oil requirements would be reduced to about one-half of that value. A load duration curve for this period is also shown in Fig. 12.

d. System Subsequent to 1980

A summary of loads and resources for the decade following 1980 is shown in Table VI-6. A brief description of the growth of loads and resources shown in the table is given in the following paragraphs.

In the 1979-80 power year the peak load will have increased to 10,452 kW with an energy requirement of 50,358,000 kWh. With the installation of the larger units at the Green Lake Project, the forced outage reserve requirement will be 7500 kW. It is estimated that there would be 33,642,000 kWh of surplus firm energy available for export during this period. Sale of this amount of energy at unity load factor would require 3840 kW of peak capacity which is also available. The total loads from the above have a peak of 21,792 kW and an energy requirement of 84,000,000 kWh, assuming that the exports can indeed be marketed.

The available resources during this period will still include 3100 kW of diesel capacity and 7000 kW of hydroelectric capacity from the Blue Lake Project. In addition there will be available 15,000 kW of hydroelectric capacity from the Green Lake Project, or a total capacity of 25,100 kW, with firm energy of 84,000,000 kWh. Including the requirements for forced outage reserves, the system will have a surplus capacity of 3208 kW. If it were decided to deactivate the diesel plant at this time the capacity surplus would, of course, be reduced to 108 kW, and a capacity deficit would again exist in the ensuing years until the next hydroelectric unit could be installed. In order to maintain a surplus capacity the diesel units should be maintained until the Blue Lake - Unit #3 goes online which is proposed to occur late in 1983. The diesels are not considered however to provide energy.

In the 1984-85 power year the peak load will have increased to 15,358 kW with an energy requirement of 73,994,000 kWh. The forced outage reserve requirement will again be 7500 kW. During this period it is estimated that there would be 10,006,000 kWh of surplus firm energy available for export. Sale of this energy at unity load factor would require 1142 kW of peak capacity. The total load has a peak of 24,000 kW and an energy requirement of 84,000,000 kWh, again assuming that the exports can be marketed.

The available resources during this period will be entirely hydroelectric, and will consist of 11,000 kW at the Blue Lake Project and 15,000 kW at the Green Lake Project as delivered at the load center. The total available firm energy will again be 84,000,000 kWh again delivered at the load center. Installation of the third unit at the Blue Lake Project will significantly increase the capability of that project to utilize water from high-runoff years for production of secondary energy.

In the 1989-90 power year the peak load will have increased to 22,566 kW with an energy requirement of 108,723,000 kWh. With the installation of the first unit at the Takatz Project which is scheduled to be on-line late in 1988, the forced outage reserve requirement will be 12,500 kW. During this period it is estimated that there would be 30,082,000 kWh of surplus firm energy available for export. Sale of this energy at unity load factor would require 3434 kW of peak capacity. The total loads have a peak of 38,500 kW and an energy requirement of 138,805,000 kWh, again assuming that the exports can be marketed.

The available resources during this period will be 11,000 kW at the Blue Lake Project, 15,000 kW at the Green Lake Project, and 12,500 kW from Unit #1 at the Takatz Project. The firm energy from these projects is estimated to be 175,200,000 kWh. All values are for delivery at the load center.

e. Secondary Energy

All resource values stated above are either dependable capacity or firm energy, which are available at all times. A significant amount of secondary is expected to be available from the hydroelectric projects which would be available for export on "as available" basis, and would permit appreciable savings in fuel oil by ALP. It is anticipated that future hydrological studies will show that the Blue Lake and Green Lake Reservoirs can be operated so as to provide about 10 to 15% additional firm energy, with a consequent reduction of secondary energy.

f. Reserves and Exports

Reserve capacity sufficient to allow the system to meet loads even though the largest unit in the system is forced off-line is an essential requirement for system dependability. If such reserve capacity is not available an outage will cause a blackout of the system and force a serious curtailment of loads when power is restored. This is most significant during an extended outage such as might be caused by a bearing failure or damage to the turbine or generator.

Forced outage reserves in small isolated systems must be equivalent to the capacity of the largest unit in the system, but the incremental cost of installing additional capacity in a unit is usually relatively low. A large reserve capacity requirement however, reduces the amount of power which is available for marketing and a resultant loss of revenue. Interconnected systems often share reserves and thereby reduce the amount of required reserves in each system. Sharing of reserves by Sitka and ALP is possible but is limited by the capacity of the tie line between the mill and Blue Lake powerhouse. With the size of units proposed for the Green Lake Project, the tie is sufficient to allow the Sitka reserves to be reduced by 3750 kW. The amount of reserves furnished Sitka by ALP, must, of course, be considered in marketing negotiations. The ALP reserves can be provided by an allowable curtailment of power to the mill which would range from zero to almost 2900 kW in the period until 1190. A summary of the effect of reserve-sharing on power available for exports is shown in Table VI-8, and can be compared with the exports shown in Table VI-6 in which no sharing is considered. Sharing of reserves will allow a dependable capacity of 4000 kW to be available for export until 1986, when 8,000 kW will be available on a dependable basis. The interconnection will, of course, require improvements at that time. The export capacity would be associated with large amounts of energy which are also shown in Table VI-8.

FORECAST OF LOADS

	(1) Normal Peak kW	(2) Load Growth Reserve kW	Peak Load kW	(3) Energy kWh
1974-75	6,840	274	7,114	34,275,300
1975-76	7,387	296	7,683	37,016,700
1976-77	7,978	319	8,297	39,974,900
1977-78	8,616	345	8,961	43,174,100
1978-79	9,306	372	9,678	46,628,600
1979-80	10,050	402	10,452	50,357,700
1980-81	10,854	435	11,289	54,390,400
1981-82	11,723	469	12,192	58,741,100
1982-83	12,660	507	13,167	63,438,600
1983-84	13,673	547	14,220	68,512,000
1984-85	14,767	591	15,358	73,994,800
1985-86	15,948	638	16,586	79,911,300
1986-87	17,224	689	17,913	86,304,800
1987-88	18,602	744	19,346	93,209,000
1988-89	20,090	804	20,894	100,667,300
1989-90	21,698	868	22,566	108,723,000

(1) Escalated at 8% per year.
(2) Estimated at one half of annual growth.
(3) Based on annual system load factor of 55%.

CITY OF SITKA

SYSTEM ENERGY LOADS

1962 - 1974

1,000 kW h

POWER YEAR*	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Annual
1962-63	1,214.0	1,302.1	1,363.7	1,543.6	1,627.0	1,797.1	1,674.8	1,517.5	1,690.8	1,638.2	1,616.8	1,433.6	18,419.2
1963-64	1,505.6	1,632.0	1,703.0	1,898.4	2,007.7	2,087.1	2,102.2	1,936.0	2,045.0	1,891.1	1,834.0	1,578.8	22,220.9
1964-65	1,625.4	1,713.3	1,838.3	1,986.1	2,153.5	2,477.2	2,478.6	2,120.0	2,248.7	2,107.7	2,004.7	1,791.0	24,544.5
1965-66	1,782.9	1,989.6	1,755.2	1,710.3	1,904.5	2,162.5	2,127.6	1,873.6	1,996.9	1,774.1	1,728.5	1,562.7	22,368.4
1966-67	1,446.3	1,642.6	1,735.7	1,911.5	1,987.7	2,197.3	2,201.9	1,952.7	2,256.6	1,976.3	1,881.1	1,683.0	22,872.7
1967-68	1,610.0	1,702.0	1,824.4	2,055.3	2,187.8	2,411.1	2,509.8	2,263.4	2,276.7	2,120.2	1,956.7	1,740.8	24,658.2
1968-69	1,769.9	1,867.9	2,011.8	2,207.1	2,194.8	2,495.2	2,726.1	2,212.3	2,354.6	2,089.9	2,018.5	1,780.0	25,728.1
1969-70	1,972.1	1,973.2	2,085.2	2,247.5	2,335.0	2,482.1	2,612.1	2,205.3	2,377.3	2,248.1	2,190.9	1,911.8	26,640.6
1970-71	2,063.7	2,112.4	2,236.3	2,444.3	2,497.5	2,843.2	2,882.5	2,413.4	2,616.8	2,421.4	2,331.2	2,021.3	28,884.0
1971-72	2,038.8	2,118.4	2,276.1	2,493.4	2,530.0	2,917.4	3,011.4	2,727.6	2,756.5	2,546.4	2,410.3	2,153.2	29,979.5
1972-73	2,108.9	2,168.5	2,383.5	2,268.9	2,694.5	3,030.0	3,055.6	2,702.3	2,864.6	2,569.9	2,526.1	2,280.9	30,653.7
1973-74	2,207.2	2,273.1	2,342.8	2,682.0	2,878.0	2,527.7	2,798.9	2,418.3					

*Example: Power year 1962-63 is from July 1,1962 through June 30,1963.

TABLE VI-2

SUMMARY OF MONTHLY ENERGY LOADS

(Percent of Annual)

	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
1967-68	6.53	6.50	7.40	8.33	8.87	9.78	10.18	9.18	9.23	8.60	7.94	7.06
1968-69	6.88	7.26	7.82	8.58	8.53	9.70	10.60	8.60	9.15	8.12	7.84	6.92
1969-70	7.40	7.41	7.83	8.44	8.76	9.32	9.80	8.28	8.92	8.44	8.22	7.18
1970-71	7.14	7.31	7.74	8.47	8.65	9.84	9.98	8.36	9.06	8.38	8.07	7.00
1971-72	6.80	7.07	7.59	8.32	8.44	9.73	10.05	9.10	9.19	8.49	8.04	7.18
1972-73	6.88	7.07	7.78	7.40	8.79	9.88	9.97	8.82	9.35	8.38	8.24	7.44
Average	6.94	7.17	7.69	8.26	8.67	9.71	10.10	8.72	9.15	8.90	8.06	7.13
Load Factor	64.2	67.7	72.1	67.3	69.2	62.9	65.4	69.6	70.5	65.4	67.4	70.2

TABLE VI-3

CITY OF SITKA

FORECAST OF LOADS

SUMMARY OF MONTHLY LOADS

	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Annual
ENERGY (1,000 kW h)													
1974-75	2,378.7	2,957.6	2,635.8	2,831.1	2,971.7	3,328.1	3,461.8	2,988.8	3,136.2	2,879.1	2,762.6	2,443.8	34,275.3
1975-76	2,569.0	2,654.1	2,846.6	3,057.6	3,209.4	3,594.3	3,738.7	3,227.9	3,387.0	3,109.4	2,983.5	2,639.3	37,016.7
1976-77	2,774.3	2,866.2	3,074.1	3,301.9	3,465.9	3,881.6	4,037.4	3,485.8	3,657.7	3,357.9	3,222.0	2850.2	39,974.9
1977-78	2,996.3	3,095.6	3,320.1	3,566.2	3,743.2	4,192.2	4,360.6	3,764.8	3,950.4	3,626.6	3,479.0	3,078.3	43.174.1
1978-79	3,236.0	3,343.3	3,585.8	3,851.5	4,042.7	4,527.6	4,709.5	4,066.0	4,266.5	3,916.8	3,758.3	3,324.6	46,628.6
1979-80	3,494.9	3,610.8	3,872.7										
AVERAGE ENERGY (kW)													
1974-75	3,197	3,303	3,661	3,805	4,127	4,473	4,653	4,448	4,215	3,999	3,713	3,394	3,913
1975-76	3,453	3,567	3,954	4,110	4,458	4,831	5,025	4,803	4,552	4,319	4,010	3,666	4,226
1976-77	3,729	3,852	4,270	4,438	4,814	5,217	5,427	5,187	4,916	4,664	4,331	3,959	4,563
1977-78	4,027	4,161	4,611	4,793	5,199	5,635	5,861	5,602	5,310	5,037	4,677	4,275	4,929
1978-79	4,349	4,494	4,980	5,177	5,615	6,085	6,330	6,051	5,735	5.440	5,051	4,618	5,284
1979-80	4,697	4,853	5,379										
PEAK LOAD (kW)													
1974-75	4,980	4,879	5,078	5,654	5,964	7,114	7,114	6,391	6,048	6,048	5,509	4,835	7,114
1975-76	5,379	5,269	5,484	6,107	6,442	7,683	7,683	6,901	6,530	6,530	5,950	5,222	7,683
1976-77	5,808	5,690	5,922	6,594	6,957	8,297	8,297	7,453	7,052	7,052	6,426	5,640	8,297
1977-78	6,273	6,146	6,395	7,122	7,513	8,961	8,961	8,049	7,617	7,617	6,939	6,090	8,961
1978-79	6,774	6,638	6,907	7,692	8,114	9,678	9,678	8,694	8,227	8,227	7,494	6,578	9,678
1979-80	7,226	7,168	7,471										

TABLE VI - 4

SUMMARY OF LOADS AND RESOURCES
1974-1979

	1974-75 Peak kW	1974-75 Energy 1,000 kWh	1976-77 Peak kW	1976-77 Energy 1,000 kWh	1978-79 Peak kW	1978-79 Energy 1,000 kWh
LOADS						
Residential, Commercial and Industrial Loads	6,840	32,955	7,978	38,438	9,306	44,836
Load Growth Reserve	274	1,320	319	1,537	372	1,792
Peak Loads	7,114	34,275	8,297	39,975	9,678	46,628
Exports	-	-	-	-	-	-
Forced Outage Reserve	3,500	-	3,500	-	3,500	-
Total Loads	10,614	34,275	11,797	39,975	13,178	46,628
RESOURCES						
Diesel Unit No. 1	300	1,275	300	1,275	300	1,275
Diesel Unit No. 2	500	-	500	-	500	1,353
Diesel Unit No. 3	300	1,000	300	1,000	300	1,000
Diesel Unit No. 4	2,000	-	2,000	5,700	2,000	11,000
Blue Lake Unit No. 1	3,500	16,000	3,500	16,000	3,500	16,000
Blue Lake Unit No. 2	3,500	16,000	3,500	16,000	3,500	16,000
Total Resources	10,100	34,275	10,100	39,975	10,100	46,628
Surplus or (Deficit)	(514)		(1,697)		(3,078)	

Note:
1. Diesel generation can be reduced by secondary energy from the Blue Lake Project or imports from ALP, when available.
2. Resource values are considered as dependable capacity and firm energy at load center.
3. 1978-79 period does not include Green Lake Project in operation as scheduled to reflect the effect of slippage on the system.

SUMMARY OF LOADS AND RESOURCES
1979-1990

	1979-80		1984-85		1989-90	
	Peak kW	Energy 1,000 kWh	Peak kW	Energy 1,000 kWh	Peak kW	Energy 1,000 kWh
LOADS						
Residential, Commercial and Industrial Loads	10,050	48,421	14,767	71,147	21,698	104,541
Load Growth Reserve	402	1,937	591	2,847	868	4,182
Exports	3,840	33,642	1,142	10,006	3,434	30,082
Peak Loads	14,292	84,000	16,500	84,000	25,451	138,805
Forced Outage Reserve	7,500	-	7,500	-	12,500	-
Total Loads	21,792	84,000	24,000	84,000	38,500	138,805
RESOURCES						
Diesel Unit No. 1	300	-	-	-	-	-
Diesel Unit No. 2	500	-	-	-	-	-
Diesel Unit No. 3	300	-	-	-	-	-
Diesel Unit No. 4	2,000	-	-	-	-	-
Blue Lake Unit No. 1	3,500	16,000	3,500	10,000	3,500	10,000
Blue Lake Unit No. 2	3,500	16,000	3,500	10,000	3,500	10,000
Blue Lake Unit No. 3	-	-	4,000	12,000	4,000	12,000
Green Lake Unit No. 1	7,500	26,000	7,500	26,000	7,500	26,000
Green Lake Unit No. 2	7,500	26,000	7,500	26,000	7,500	26,000
Takatz Bay Unit No. 1	-	-	-	-	12,500	91,200
Takatz Bay Unit No. 2	-	-	-	-	-	-
Total Resources	25,100	84,000	26,000	84,000	38,500	175,200
Surplus or (Deficit)	3,208		2,000		0	36,395

Note: 1. Exports can be increased on "as available" basis by secondary energy from all hydroelectric projects.

2. Resource values are considered as dependable capacity and firm energy at load center.

TABLE VI - 6

ANTICIPATED LOAD INCREASES

Demand in kW

LOAD	POWER YEAR 1973-74	1974-75	1975-76
Meyers Court		100	
Sollars Court	100		
Arrowhead Court	100		
Sitka Seafoods	600		
Public Safety Academy		150	
Sirstad Addition	270		
Berglund Subdivision		225	
Wolf Subdivision			495
High School Addition			145
State Office Building			150
State Health Building			50
U. S. Coast Guard			1,500
U. S. Forest Service	75		
Sheldon Jackson College	75		
TOTALS	1,220	475	2,340

POWER AVAILABLE TO ALP
WITH RESERVE SHARING

	Sitka Reserves kW	ALP Reserves (1) kW	Peak kW	EXPORTS TO ALP Firm Energy 1000 kWh	Secondary Energy (2) 1000 kWh	Average Energy 1000 kWh	Load Factor (3) %
1979-80	3750	0	4000	33,640	1,400	35,040	100
1980-81	3750	789	4000	30,610	4,430	35,040	100
1981-82	3750	1692	4000	25,260	9,780	35,040	100
1982-83 (4)	3750	2667	4000	32,560	2,480	35,040	100
1983-84 (5)	3750	0	4000	27,490	7,550	35,040	100
1984-85	3750	858	4000	22,010	12,000	34,010	97
1985-86	3750	2086	4000	16,090	12,000	28,090	80
1986-87 (6)	6250	0	8000	70,080	0	70,080	100
1987-88	6250	1346	8000	70,080	0	70,080	100
1988-89	6250	2894	8000	70,080	0	70,080	100
1989-90 (7)	6250	0	8000	70,080	0	70,080	100

(1) Curtailment of exports in lieu of reserve sharing.
(2) Based on average water year.
(3) Based on average energy.
(4) Anticipates increase of firm energy by improved reservoir operation.
(5) Blue Lake Unit 3 on-line.
(6) Takatz Unit 1 on-line.
(7) Takatz Unit 2 on-line.

SECTION VII

ESTIMATED CONSTRUCTION COST

1. GENERAL

The cost estimate for Green Lake Project was based on the preliminary arrangement and dimensions. Quantities were established for major civil features to which unit costs were applied, while for equipment and other features costs per kilowatt were used from experience with similar installations and from published information by the FPC and APA. These costs were based on contractor's bid prices, adjusted to a January 1974 level. These costs therefore in general, have built-in escalation which would permit completion of the work in a two-year period, which would correspond to the project being on-line by January, 1976.

Costs for the Blue Lake expansion were estimated based on an overall cost per kW. The costs of the Takatz project is based generally on escalation of that developed by APA, with certain adjustments, to arrive at an overall cost per kW.

Diesel costs are based on a per-kW basis for similar installations in Southeast Alaska.

2. BASIS OF COSTS

a. Direct Construction Cost

This includes the total of all costs directly chargeable to the construction of the project and in essence represents a contractor's bid. State sales taxes are included in this item where appropriate.

Indirect costs are defined as those which are added to the Direct Construction Cost to result in the Total Construction Cost. Indirect costs include an allowance for contingencies, engineering, and escalation where necessary.

b. Contingencies

To allow for unforeseen difficulties during construction and to reflect possible omissions of estimate items, an allowance of 15% for contingencies has been applied to the Direct Construction Cost estimates for hydroelectric installations. For diesel generation an allowance of 10% for contingencies was provided.

c. Engineering and Client Administration

Engineering costs for the project were based on a comparison with actual costs for similar work. This item includes investigations, feasibility and design engineering, field inspection of construction and client administration.

d. Escalation

All preliminary cost estimates for hydro have been considered as a January 1974 bid level which corresponds to completion of the construction by the end of 1975 (2 years construction period). Bid prices for construction anticipated to end at a later time have been escalated from the January 1974 level to the appropriate time of bid for such work. Costs for diesel have been established by escalating from an estimated cost based on in-service in January 1974. A blanket escalation rate of 6% per year for both labor and materials has been assumed for investment costs.

e. Total Construction Cost

This includes the total of all direct construction costs, contingencies, engineering and escalation.

f. Capital Investment Cost

This includes the Total Construction Cost plus interest during construction, and represents the total investment in the project.

g. Bond Issue

This includes the Capital Investment Cost plus costs relating to selling the bond issue. The bond issue amount is considered equal to the capital investment herein for hydroelectric projects, and is the basis for establishing annual costs as discussed in Section VIII. Since the method of financing construction is not yet determined, in this study bond costs are assumed as an addition of 8% to the annual costs. For diesels the capitalized value of the bond costs is estimated as 14% of the total construction cost.

3. CONSTRUCTION COST ESTIMATES

a. Green Lake Project

A cost estimate summary for the proposed development of the Green Lake Project is shown in Table VII-1. The estimated Total Construction Cost for the two unit installation, in-service in January 1976, is equivalent to $1,208/kW delivered to the load center, including roads, substations, and transmission. The estimated Total Construction Cost when escalated to an in-service date in December 1978, is $21,576,900, which is equivalent to $1,438/kW delivered to the load center.

b. Blue Lake Expansion

The Direct Construction Cost for the Blue Lake Expansion is estimated to be $500/kW for entering into service in January 1977, based on judgement developed from experience with projects of similar size in the area. The corresponding Total Construction Cost is equivalent to $661/kW for the third unit being on-line in January 1977, and to $938/kW on-line in December 1983.

c. Takatz Project

Costs for the Takatz Project were estimated at $925/kW based on Direct Construction Cost excluding transmission (not including sales tax), and being in-service in January 1976. This is reasonably compatible with costs derived by the APA, in their 1968 report "Takatz Creek Project, Alaska, January, 1968". The APA costs were adjusted for different project arrangement and schedule, and reescalated from the viewpoint of 1974 experience of cost increases. The estimated Total Construction Cost for the two-unit project, in-service in December 1978, is $37,153,000 which is equivalent to $1486/kW, excluding transmission. A cost estimate summary for the proposed development is shown in Table VII-2.

d. Diesels

The direct construction cost of installing new diesel units is estimated to be $220 per kilowatt for the unit to be in-service in early 1974. This cost, escalated at 6% per year, is used to determine the estimated construction cost for installation of units in future years.

GREEN LAKE PROJECT
COST ESTIMATE SUMMARY

		Bid-date January, 1974	Bid-date (On-line Dec. 1978)
1.	Mobilization	$ 600,000	
2.	Access Road	1,400,000	
3.	Dam and Spillway	5,280,000	
4.	Channel Improvements	150,000	
5.	Diversion Tunnel	450,000	
6.	Penstock	980,000	
7.	Powerhouse	800,000	
8.	Mechanical Equipment	1,310,000	
9.	Electrical Equipment	1,000,000	
10.	Substations	500,000	
11.	Transmission Line	960,000	
	Sub-total	$13,430,000	
	Sales Tax	268,600	
	DIRECT CONSTRUCTION COST	$13,698,600	
	Contingencies	2,054,800	
	Sub-total	$15,753,400	
	Engineering and Client Administration	2,363,000	
	Escalation (1)	-	$ 3,460,500
	TOTAL CONSTRUCTION COST	$18,116,400	$21,576,900
	Installation Cost per kW (2)	$ 1,208	$ 1,438

(1) Escalation at 6% per year

(2) Based on Total Construction Cost, including transmission, and capacity at load center.

TAKATZ PROJECT
COST ESTIMATE SUMMARY

	On-line date January 1976	On-line date December 1978
Estimated Construction Cost-$/kW	$ 925	
ESTIMATED CONSTRUCTION COST	$23,125,000	
Sales Tax	462,500	
DIRECT CONSTRUCTION COST	$23,587,500	
Contingencies	3,538,100	
Sub-total	$27,125,600	
Engineering costs	4,068,800	
Escalation (1)	-	$ 5,958,600
TOTAL CONSTRUCTION COST	$31,194,400	$37,153,000
Installation Cost per kW (2)	$ 1,248	$ 1,486

(1) Escalation at 6% per year

(2) Based on Total Construction Cost, excluding transmission, and capacity at load center.

SECTION VIII

COST OF POWER

1. GENERAL

The only practical alternatives available for future development of the Sitka electric system are installation of additional diesel units or development of new hydroelectric sites. Installation of gas turbines or steam generating units is not appropriate for the loads which the system has at present or in the foreseeable future. The alternative of diesel generation was compared with the development of the Green Lake site and the hydroelectric alternative is more favorable. An additional comparison was made between the Green Lake Project and the Takatz Project, with the Green Lake Project again being the more favorable alternative.

2. ANNUAL COSTS

a. Diesels

New diesel units which would be required were considered as having annual fixed costs established on a capitalized basis and are determined as a percentage of the total bond issue. Fixed costs established in this manner include debt service, O & M, administration, replacements, insurance and taxes and represent a levelized annual cost throughout the life of the units.

An appropriate increase of the Total Construction Cost was determined to include interest during construction, the necessary reserves and other costs to arrive at the estimated bond issue. This increase was determined to be 14% of the Total Construction Cost. The annual fixed cost for new diesel units was estimated to be 13% of the total bond issue, based on a 25-year unit life, 6% interest rate, and one-year construction period. A summary of fixed costs for installation of new diesel units is shown in Table VIII-1.

Variable annual costs are considered as those associated with the generation of energy and which vary as energy production varies. The only variable cost considered in this study is the cost of fuel oil. An estimate of the anticipated costs of fuel oil during the period of time considered in this study is shown in Table VIII-2. The fuel cost has been escalated at 10% annually from the cost of $0.33 per gallon in January 1974.

The annual costs of installing diesel capacity, with the related energy production equivalent to the Green Lake Project, are tabulated in Table VIII-3. This table was based on the diesel capacity going on-line in January 1979, the same proposed schedule as for the Green Lake Project.

b. Green Lake Project

The estimated cost of development of the Green Lake Project resulted in a $1,208/kW value for in-service in January 1976, which escalated is a $1,438/kW value for the proposed on-line date in December 1978. These are total construction costs inclusive of roads, substation and transmission line and are based on capacity delivered to the load center. A summary of construction cost, capital investment cost and annual cost is shown in Table VIII-4.

The Capital Investment Cost was developed by adding the interest prior to and during construction to the Total Construction Cost. The Capital Investment Cost for an on-line date of December 1978 is $23,262,000. The total of all annual costs, fixed and variable, was found to be 7.8% of the Capital Investment Cost, exclusive of bond costs, based on 6% interest bonds. The annual costs include debt service, O & M, administration, replacements, insurance and taxes. Annual costs for the proposed new hydroelectric projects are shown in Table VIII-5 for an on-line date of December 1978 and annual costs in succeeding years for the Green Lake Project are shown in Table VIII-6.

The total annual cost of the project in service in December 1978, is estimated to be $1,966,000 including bond costs, which is equivalent to an annual cost of $131.06 per kW based on capacity delivered at load center.

c. Takatz Project

The cost of development of the Takatz Project is estimated at $1,408/kW value for in-service in January 1976, which escalated is $1,677/kW value for a proposed on-line date in December 1978, for comparison with the Green Lake Project at the same time period. These are Total Construction Costs inclusive of roads, substations and transmission lines, and are based on capacity delivered at the load center. A summary of construction cost, capital investment cost and annual cost is shown in Table VIII-4.

The Capital Investment Cost for an on-line date of December 1978 is $45,480,000. Annual costs were based on the same relationships to the Capital Investment Cost as discussed for the Green Lake Project.

The total annual cost of the project in-service in December 1978, is estimated to be $3,831,200, which is equivalent to an annual cost of $153.25 per kW.

3. COMPARISON OF DIESELS AND GREEN LAKE PROJECT

A comparison was made between the two generating alternatives on the basis of the same installed capacity for each and each generating the same annual amount of firm energy. As shown in Table VIII-3 the estimated annual cost of the diesel alternative is $2,837,800 in 1979 which, due to escalating fuel oil costs, increases to $6,682,600 in 1990.

Although normal annual costs of a hydroelectric project have been assumed as a levelized amount (equivalent to 8.42% of Total Capital Investment) a small percentage of this is subject to escalation. For the purposes of comparison an escalation of 6% per year was applied to 1.38% of the bond issue to reflect increases in salaries during the period of comparison. On this basis, the annual cost of the Green Lake Project was determined to be $1,966,000 in 1979, which escalates to $2,259,700 by 1990.

The comparison between the two alternatives is shown graphically in Fig. 13. The Green Lake Project shows a significant saving over the diesel alternative.

A comparison was also made of the annual costs associated with Sitka continuing with diesel generation solely to meet its load requirements (and not to develop diesel generation of size equal to Green Lake as shown in Fig. 13) as compared to Green Lake, and the result is shown in Fig. 14. As can be seen with continued diesel operation by late 1978 when Green Lake is scheduled to go on-line, annual diesel operating costs would be $270,000 more than annual operating costs for Green Lake. By late 1982, only some four years later the costs of diesel generation would be equal to the total annual costs including debt service, of Green Lake. Whereas the annual cost of the hydro will continue to increase only slightly following this, the diesel costs increase at an astronomical rate.

4. COMPARISON BETWEEN GREEN LAKE AND TAKATZ PROJECTS

The annual cost of the Green Lake Project as shown in Table VIII-6, is based on an installation of 16,600 kW delivering 15,000 kW to the load center and generating firm energy of 52,000,000 kWh annually (about 40% plant factor at load center). Approximately 10,000,000 kWh of secondary energy are expected to be available on an average basis.

As shown in Table VIII-4, the annual cost of the Takatz Project is estimated to be $3,831,200 in December 1978. This cost, however, is based on an installation of 27,700 kW delivering 25,000 kW (in two units) to the load center which would generate firm energy of 91,200,000 kWh annually (about 42% plant factor at load center). For comparison with the Green Lake Project, it is assumed that the Takatz Project will be developed with three units, and that two units of 7,500 kW each will be installed to be in-service in December 1978 with a third unit of 10,000 kW to be installed later. It is estimated that a 3-unit installation will increase the Total Construction Cost of the project by 10% over the 2-unit installation, but will not affect the cost of transmission. It is also estimated the first stage construction would cost about 80% of estimated Total Construction Cost for the ultimate development of the 3-unit plant. The Total Construction Cost for first stage develoment of two 7,500-kW units, on-line in December 1978, is estimated to be $32,694,600, plus cost of transmission of $4,764,100, for a Total Construction Cost of $37,458,700 for the complete first stage installation. This results in an estimated capital investment of $40,642,700 and an estimated annual cost of $3,423,700. This installation would generate about 91,200,000 kWh of firm energy annually. With this level of operation, no secondary energy is expected to be available until installation of the third unit and consequent reduction of the plant factor.

A comparison of the costs of generation for the Takatz and Green Lake Projects is shown in Table VIII-7, and again in Fig. 13 with each project having a capacity of 15,000 kW delivered to load center. This represents staged development of the ultimate capacity of 25,000 kW at Takatz. The Green Lake Project shows a definite economic advantage in cost of power and has significantly less annual cost. Also it is not considered possible to place the Takatz units on-line until December 1979, which would require large additional amounts of diesel generation for the extra year and is a penalty to the Takatz Project. The Green Lake Project is therefore considered to be the more favorable alternative. A comparison of costs is shown in Table VIII-7

A comparison of costs between the Green Lake Project, and the Takatz Project developed to its ultimate installation of 25,000 kW (delivered to load center) is also shown in Table VIII-7. As shown the cost of average energy from the Takatz Project is slightly higher than Green Lake when an allowance is made for the value of the additional 10,000 kW of dependable capacity from the Takatz units. Further, the Takatz Project would require a capital investment (and annual cost) of about twice that required for the development of the Green Lake Project, and it is doubtful that the additional 10,000 kW of dependable capacity could be marketed at that time since only secondary energy would be associated with the additional capacity. In addition, the longer construction time of the Takatz Project requiring additional diesel generation, as mentioned above, makes the Takatz development less attractive. The Green Lake Project is therefore considered to be the most attractive alternative to meet the needs of Sitka at this time. The comparison also shows that ultimate development of the Takatz Project with two 12,500 kW is more desirable than the staged development with two 7,500 kW units initially and 10,000 kW later, considering an on-line date when the additional capacity is needed by the system.

TABLE VIII - 1

FIXED COST OF NEW DIESEL INSTALLATIONS

When Placed In - Service (3)	Direct Construction Cost - $1kW (1)	Contingency and Engineering (2)	Total Construction Cost - $/kW	IDC, Reserve and Cost of Bond (4)	Bond Issue $/kW	Annual Fixed Cost $/kW (5)
Jan. 1974	$220.00	$36.52	$256.52	$35.91	$292.43	$38.02
Jan. 1975	233.20	38.71	271.91	38.07	309.98	40.30
Jan. 1976	247.19	41.03	288.22	40.35	328.57	42.71
Jan. 1977	262.02	43.50	305.52	42.77	348.29	45.28
Jan. 1978	277.74	46.10	323.84	45.34	369.18	47.99
Jan. 1979	294.41	48.87	343.28	48.06	391.34	50.87
Jan. 1980	312.07	51.80	363.87	50.94	414.81	53.93

(1) Escalated at 6% per year.

(2) Contingency estimated at 10%. and engineering estimated at 6%.

(3) Years shown are calendar years with the units shown coming on-line at the beginning of that year. If a unit is completed, for example, late in 1978 to meet the calendar year 1979 loads, (on-line in January 1979) debt service and other annual costs will be payable for the entire year (1979).

(4) Estimated at 14% of Total Construction Cost.

(5) Estimated at 13% of Bond Issue.

ESTIMATED COST OF FUEL FOR DIESEL GENERATION

		Cost per Barrel (42 gallon)	Cost per Gallon	Cost of Power Mills/kWh
Jan.	1974	$13.86	$0.330	23.6
Mid	1974	14.57	0.347	24.8
Mid	1975	16.00	0.381	27.2
Mid	1976	17.60	0.419	29.9
Mid	1977	19.36	0.461	32.9
Mid	1978	21.29	0.507	36.2
Mid	1979	23.44	0.558	39.9
Mid	1980	25.79	0.614	43.9

Assumptions:

(1) Cost of fuel escalated at 10% per year from base price in January 1974.

(2) Average heat rate of diesel units assumed at 10,000 BTU/kWh.

(3) Heat content of diesel fuel assumed at 140,000 BTU/Gallon.

(4) Cost of power in mid-year is assumed for generation during that calendar year.

ANNUAL COST OF POWER
DIESEL UNITS

	Fixed Costs (1)	Variable Costs (2)	Total Annual Cost of Generation	Cost of Power Mills/kWh
1979	$763,000	$2,074,800	$2,837,800	54.6
1980	763,000	2,282,300	3,045,300	58.6
1981	763,000	2,510,500	3,273,500	63.0
1982	763,000	2,761,600	3,524,600	67.8
1983	763,000	3,037,700	3,800,700	73.1
1984	763,000	3,341,500	4,104,500	78.9
1985	763,000	3,675,600	4,438,600	85.4
1986	763,000	4,043,200	4,806,200	92.4
1987	763,000	4,447,500	5,210,500	100.2
1988	763,000	4,892,300	5,655,300	108.8
1989	763,000	5,381,500	6,144,500	118.2
1990	763,000	5,919,600	6,682,600	128.5

(1) - Based on installation of 15,000 kW in diesel capacity, on-line in Januarv 1979, at unit costs shown in Table VIII-1.

(2) - Based on generation of 52,000,000 kWh of firm energy annually at fuel oil costs as shown in Table VIII-2, and escalated at 10% per year subsequent to this period.

TABLE VIII-3

ANNUAL COSTS
NEW HYDROELECTRIC PROJECTS

	GREEN LAKE PROJECT 15,000 kW (4) On-Line Dates		TAKATZ PROJECT 25,000 kW (4) On-Line Dates	
	January 1976	December 1978	January 1976	December 1978
Total Construction Cost-Project	$18,116,400	$21,576,900	$31,194,400	$37,153,000
Total Construction Cost-Transmission	(1)	(1)	4,000,000	4,764,100
TOTAL CONSTRUCTION COST	$18,116,400	$21,576,900	$35,194,400	$41,917,100
Interest prior to and during construction on all bond issues		1,685,100		3,562,900
CAPITAL INVESTMENT COST		$23,262,000		$45,480,000
Installation Cost per kW (2)	$1,208	$1,438	$1,408	$1,677
ANNUAL COST		$1,966,000 (3)		$3,831,200
ANNUAL COST OF CAPACITY-$/kW (5)		$131.06		$153.25

(1) - Included in project costs.
(2) - Based on Total Construction Cost, including transmission, and capacity at load center.
(3) - As detailed in Table VIII-5.
(4) - Delivered at load centers.
(5) - Including transmission and based on capacity delivered at load center.

TABLE VIII-4

TABLE VIII-5

DETAILS OF ANNUAL COSTS
NEW HYDROELECTRIC PROJECTS
ON-LINE DECEMBER 1978

Item	Percentage of Capital Investment	GREEN LAKE Fixed Costs	GREEN LAKE Variable Costs	TAKATZ (2) Fixed Costs	TAKATZ (2) Variable Costs
Capital Investment		($23,261,600)		($40,642,700)	
Debt Service (6% at 47 years) (1)	6.42	1,493,400		2,609,300	
Operation and Maintenance	0.50		$ 116,300		$ 203,200
Additional Operating Expenses	0.28		65,100		113,800
Administrative and General	0.20		46,500		81,300
Insurance	0.10		26,300		40,600
Interim Replacements	0.30		72,800		121,900
Taxes	Nil				
Totals	7.80	$ 1,493,400	327,000	$ 2,609,300	560,800
Subtotal Annual Cost		1,820,400		3,170,100	
Bond costs		$ 145,600 (3)		$ 253,600 (3)	
TOTAL ANNUAL COST		$ 1,966,000		$ 3,423,700	

(1) Based on 50 year bonds with interest prior to and during construction deferred; assume 47 year financing.
(2) Based on first stage development with two 7,500 kW units.
(3) Bond costs estimated at 8% of Subtotal Annual Cost.

GREEN LAKE PROJECT
ANNUAL COST OF POWER
1979 - 90

Year	Fixed Costs (1)	Variable Costs (2)	Total Annual Cost of Generation	Cost of Power Mills/kWh (3)
1979	$ 1,639,000	$ 327,000	$ 1,966,000	31.7
1980	1,639,000	346,600	1,985,600	32.0
1981	1,639,000	367,400	2,006,400	32.4
1982	1,639,000	389,500	2,028,500	32.7
1983	1,639,000	412,800	2,051,800	33.1
1984	1,639,000	437,600	2,076,600	33.5
1985	1,639,000	463,900	2,102,900	33.9
1986	1,639,000	491,700	2,130,700	34.4
1987	1,639,00	521,200	2,160,200	34.8
1988	1,639,000	552,500	2,191,500	35.3
1989	1,639,000	585,600	2,224,600	35.9
1990	1,639,000	620,700	2,259,700	36.4

(1) Debt service based on 6%, 47 year retirement.

(2) Based on cost shown in Table VIII-5, including bond costs, escalated at 6% per year.

(3) Based on total average energy (firm plus secondary).

TABLE VIII-6

COMPARATIVE COSTS OF HYDROELECTRIC GENERATION

	Green Lake Project	Takatz Project (1)	Takatz Project (2)
Capacity-kW	15,000	15,000	25,000
Firm Energy-kWh	52,000,000	91,200,000	91,200,000
Secondary Energy-kWh	10,000,000	0	9,400,000
Total Average Energy	62,000,000	91,200,000	100,600,000
Annual Cost			
(On-line Dec. 1978) (3)	$1,966,000	$3,423,700	3,831,200
Value of Incremental Capacity (4)	0	0	-508,700
Adjusted Annual Cost of Firm Energy	$1,966,000	$3,423,700	3,322,500
Cost of Average Energy-Mills/kWh	31.7	37.5	33.0

(1) - First stage development with two units delivering 15,000 kW at load center.
(2) - Based on ultimate development of site with twounits delivering 25,000 kW at load center.
(3) - It is not considered possible to place either Takatz Project on-line until December, 1979. Costs are shown for economic comparison only.
(4) - Based on equivalent cost of diesel capacity ($50.87 for on-line January 1979).

SECTION IX

PROPOSED PROGRAM OF DEVELOPMENT

1. IMPROVEMENTS CURRENTLY REQUIRED

a. General

An investigation was made of system improvements which should be performed at an early date, but was restricted to generating resources, and was not intended as a review of the distribution system. The improvements discussed herein are therefore related to power delivered to the load center, system dependability and reservoir water storage. Most items are scheduled for this year (1974) and the more important ones are shown in Fig. 15, the Design and Construction Schedule.

b. Tie Line to ALP

The existing tie has the capacity to conduct 5,000 kVA between the ALP distribution and the Blue Lake Project, except for a short section of the line which reduces the capability of the tie significantly. Breakers are in place at each end of the tie sufficient for the 5,000 kVA load. Since it is anticipated that excess capacity of this magnitude will be available from the City's system in the future for export to ALP, it is proposed that the tie line be improved to its full capability.

c. System Power Factor

It is proposed that the system power factor be improved by installing a 1,000 kVAR capacitor bank in the Marine Street Substation. It is anticipated that with the existing magnitude and types of loads in the system the capacitor bank will increase the system power factor to approximately 96%. This improvement will allow the transmission line to conduct approximately 11,000 kW, rather than the 9,000 kW present limitation, without overloading and the existing transformers at Blue Lake Substation and Marine Street Substation would operate at 7,200 kW rather than at the current 6,000 kW rated capacity.

d. Blue Lake Substation

The transformers are sufficient for the existing two units at the project, but have a smaller capability than the transmission line and ultimate installation of the project. It is proposed that when system loads develop to approximately 10,000 kW, three 4,000 kVA, single-phase, transformers be installed and connected to Units 1 and 2, and to the 5,000 kVA tie-line from ALP.

e. Marine Street Substation

This installation is sufficient at the present time, but should be upgraded to conform with the improvements at the Blue Lake Substation at the same time.

f. Fish Release Valves and Monitoring

The valves recently acquired should be installed on the fish release outlet as soon as possible. A stream flow monitoring program, in cooperation with the state and Federal game and fish agencies' personnel, should be developed.

g. Reservoir Level Gage

To provide accurate information as to reservoir levels, a recording, nitrogen-bubbler type level gage should be installed at Blue Lake. The information from the gage should be provided at a read-out point at the control center. This information is essential to successful reservoir management following the rule curve.

h. Pressure Gages in Powerhouse

To provide information for hydrological and power studies, pressure gages which provide more accurate readings should be installed upstream of the scroll-cases of each unit. The existing gages are divided in intervals of 20-feet which allows significant errors between successive readings of different conditions. The existing gages should be replaced by gages divided in intervals of 5-feet, and having an accuracy of plus or minus 0.5%.

i. Oil Storage Facilities

During the next five years, an increasing amount of diesel generation will be required to meet system loads. Normal oil storage facilities should be provided to allow for the delivery date schedule and the possibility of delays in delivery or missed shipments. In addition, it is proposed that a reserve storage tank containing 125,000 gallons of fuel oil should be provided for emergency conditions. It is estimated that this amount of oil would provide approximately 1,750,000 kWh of energy (about one month generation with existing installations).

j. Central Control Station

As diesel generation increases, it will probably be economical to establish a central control station and operate the Blue Lake Project by remote control from that point. Operation of the Green Lake Project is also proposed to be from a central control station. It is anticipated that this method of operation will reduce the annual costs of all installations.

2. FUTURE GENERATION PROGRAM

a. General

The program of development described in this section is proposed to be accomplished during the period 1974 to 1990 inclusive. It is anticipated that during this period the peak load of the system will increase from 7,114 kW to 22,566 kW and the energy requirements will increase from 34,275,300 kWh to 108,723,000 kWh. Including adequate forced outage reserves the required capacity will increase from 10,614 kW in 1974-75, to 38,500 kW in 1989-90.

The proposed program of development will provide Sitka with 32,500 kW of capacity and approximately 144,100,000 kWh of firm energy from new or improved hydro-electric resources through 1990, will allow retirement of all diesel generating units by 1984, provide more economical and reliable generation, and relieve the system from the uncertainty of fuel oil supply. The program will conserve a national resource and eliminate the undesirable environment effects of diesel generation. It is anticipated that, with the

Takatz Project going on-line, the first link in a mini-grid could be established by the connection of Sitka and Baranof Warm Springs with transmission lines.

The proposed program of development of future generation through 1990 follows the schedule in Fig. 15. It consists of the Green Lake Project, followed by expansion of Blue Lake, and the first unit of Takatz.

b. Green Lake Project

Investigations should be undertaken commencing this summer of the Green Lake site. It is proposed that it will be developed to its ultimate installation of two 8,300-kW units as the first phase of new development. The units are scheduled to be placed in service to meet the peak loads in power year 1978-79 (November-December 1978). It is estimated that, including generator, transformer and transmission losses, each unit will deliver 7,500 kW to the load center at peak load conditions, at best-gate operation of the turbines, under winter reservoir levels.

c. Blue Lake Unit 3

While completion of the Green Lake Project will provide sufficient firm energy to meet the requirements of the system for approximately ten years at the forecasted growth rate, additional capacity to meet peaks with adequate reserve allowances, will be required for the 1983-84 winter loads. It is proposed to add a new unit, with an output of 4,000 kW, at the existing Blue Lake Project in late 1983.

d. Takatz Project

The capital investment required for development of the site is high per capita for a city the size of Sitka, primarily due to costs of road and transmission, and it should therefore be deferred in the generating program until the load grows sufficiently to support the investment requirements. This project is therefore scheduled to have the first unit of 12,500 kW in service late in 1986. If large new industrial loads develop in the area as a result of the availability of power and a market is available for the power, the project could be required at an earlier date. Periodic reevaluations of the system load growth should be made to determine when the project will actually be required.

SECTION X

DESIGN AND CONSTRUCTION SCHEDULE

A schedule for investigations, design and construction for system generation through 1990 is shown in Fig. 15. This schedule is for the proposed program of development, which includes initial development of the Green Lake Project with the units coming on-line late in 1978. This is considered to be the earliest possible schedule for the program considering the time required for investigations, FPC licensing, design and construction. The schedule shows the need to begin investigations of the Green Lake Project in the summer of 1974. Subsequent to completion of the Green Lake Project, the Blue Lake Expansion would follow entering into service in 1983, and the Takatz Bay Project in 1986.

Critical dates on the schedule are summarized as follows:

a. Investigate Green Lake site during June - December 1974. Evaluation Report completed by January 1975.

b. Obtain funds for existing system improvements and preparation of Evaluation Report of Green Lake Project in June 1974 ($250,000).

c. Obtain funds for final feasibility investigations and prepare FPC License Application for Green Lake Project in January 1975 ($300,000).

d. Apply for FPC license for Green Lake Project in August 1975.

e. Obtain funds for first stage design, construction of access road, and initial payment on major equipment items of Green Lake Project in January 1976 ($2,000,000).

f. Establish final feasibility of Green Lake Project by March 1976.

g. Begin final design of Green Lake Project in March 1976.

h. Begin construction of access road for Green Lake Project in June 1976.

i. Order major equipment items for Green Lake Project in August 1976.

j. Receive license from FPC for Green Lake Project in November 1976.

k. Sell bonds for financing Green Lake Project in January 1977 ($20,862,000).

l. Begin construction of major works of Green Lake Project in April 1977.

m. Green Lake Project in-service by end of 1978.

n. Complete feasibility report of Blue Lake Expansion by July 1980.

o. Sell bonds for financing Blue Lake Expansion by July 1981.

p. Complete feasibility of Takatz Bay Project by August 1982.

q. Blue Lake Unit 3 in-service in late 1983.

r. Takatz Bay Unit 1 in-service in late 1986.

SECTION XI

CONCLUSIONS AND RECOMMENDATIONS

1. CONCLUSIONS

The following conclusions are made as a result of this study.

a. The generation program for the Sitka Electric Utility System should be directed to development of additional hydroelectric installations, with essentially no diesel generation after 1979 and full retirement of the diesel plant within the next decade.

b. Expansion of the Blue Lake Project by installation of a third generating unit is technically feasible but will not increase the availability of firm energy from the project. It will increase capacity and allow generation of additional amounts of secondary energy and should be brought into service in late 1983.

c. Although the system has a potentially dangerous deficiency in capacity, the more critical condition is lack of sufficient energy to supply the future needs of the City without reliance on the availability of large amounts of diesel fuel oil at high costs.

d. Preliminary studies show that the Green Lake Project will meet the City's power requirements at less cost than any alternative. It should be brought into service as soon as possible; however, the earliest possible on-line date is late 1978.

e. Initial investigations of the Green Lake site must be undertaken this year if the schedule for the proposed program of development is to be maintained.

f. Prior to the Green Lake Project going into operation, over the next 4 to 5 years, it will be necessary to substantially increase operation of the existing diesel plant to meet the City's load. Additional oil storage facilities and other improvements to the system are an immediate requirement.

g. To finance construction of the proposed program will necessitate the City incurring a large financial obligation and will require careful planning. The plans should include alternative bond arrangements and the possibility of shaping the debt service. The possibilities of obtaining financial assistance from state and Federal sources should also be investigated.

2. RECOMMENDATIONS

The following recommendations are submitted:

a. Field investigations and office studies of the Green Lake Project should be performed, commencing in June 1974, so that a project evaluation report can be prepared by January 1975 to firmly establish the project viability prior to proceeding with more detailed and costly investigations. Investigations should continue in 1975 to establish final feasibility including preparation of an application for an FPC License in August, 1975.

b. Construction of an access road to the Green Lake site should begin in the spring of 1976, to allow the construction of the major project works to proceed on schedule.

c. Arrangements for financing the proposed program should be initiated immediately so that funds will be available when required. Funds are estimated to be required on the following schedule:

$250,000 in June 1974 - System improvements and evaluation report of Green Lake Project.

$300,000 in January 1975 - Final Feasibility investigation and preparation of FPC License application for Green Lake Project.

$2,000,000 in January 1976 - First stage design, construction of access roads and initial payment on major equipment items.

$20,862,000 in January 1977 - Bonds for financing construction of Green Lake Project.

d. The possibilities for financing future generation should be pursued with state and Federal agencies, and with the State legislature in combination with other cities in Southeast Alaska to attempt to develop a region-wide basis for hydroelectric project financing.

e. In the interest of avoiding delays in the schedule of the proposed program, information meetings should be scheduled with appropriate local, state and Federal agencies and on the public level, and continued as required.

f. A periodic review and re-evaluation of the system loads should be made, and the program of generation development adjusted accordingly.

g. Improvements to the existing facilities of the City to be initiated immediately should include the following:

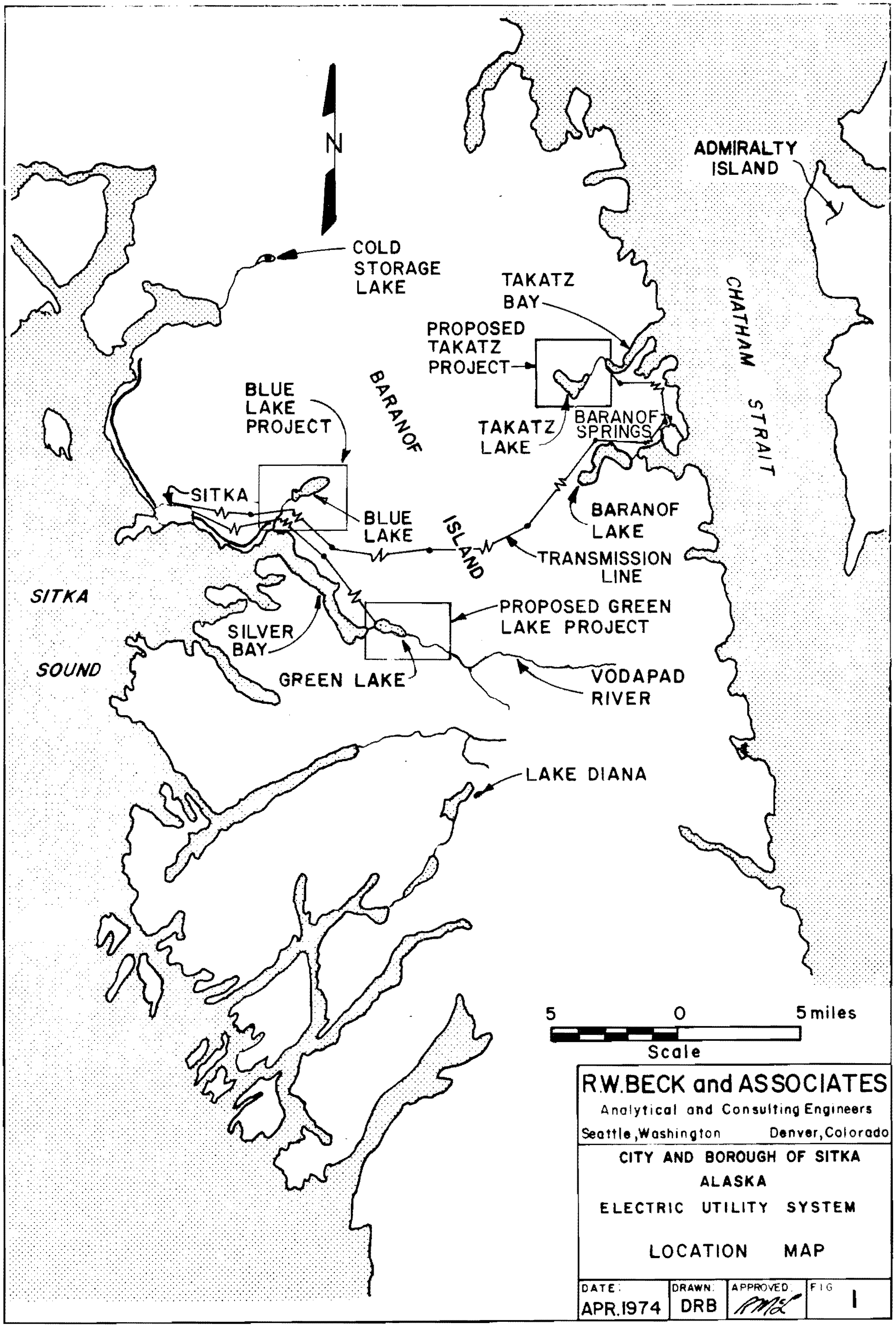
(1) Oil storage tanks and a reserve storage of fuel oil of 125,000 gallons should be provided at the diesel plant. This amount should be in addition to storage for normal operation during the next five years.

(2) The tie line between ALP and the Blue Lake Project should be improved to conduct 5,000 kVA in either direction.

(3) The transformers at Blue Lake Project and Marine Street Substation are inadequate for the combined capacity of the present Blue Lake units and tie-line from ALP, and should be replaced with larger units. The replacement will not be required, however, until about 1979 or until system loads have developed to the level of the combined capacity.

(4) A capacitor bank of 1,000 kVAR should be installed in the Marine Street substation.

(5) Installation of new valves on the fish release pipe should proceed as soon as possible and a program for monitoring release discharges in cooperation with personnel from the Alaska Department of Fish and Game and the U.S. Fisheries and Wildlife Service, should be initiated.



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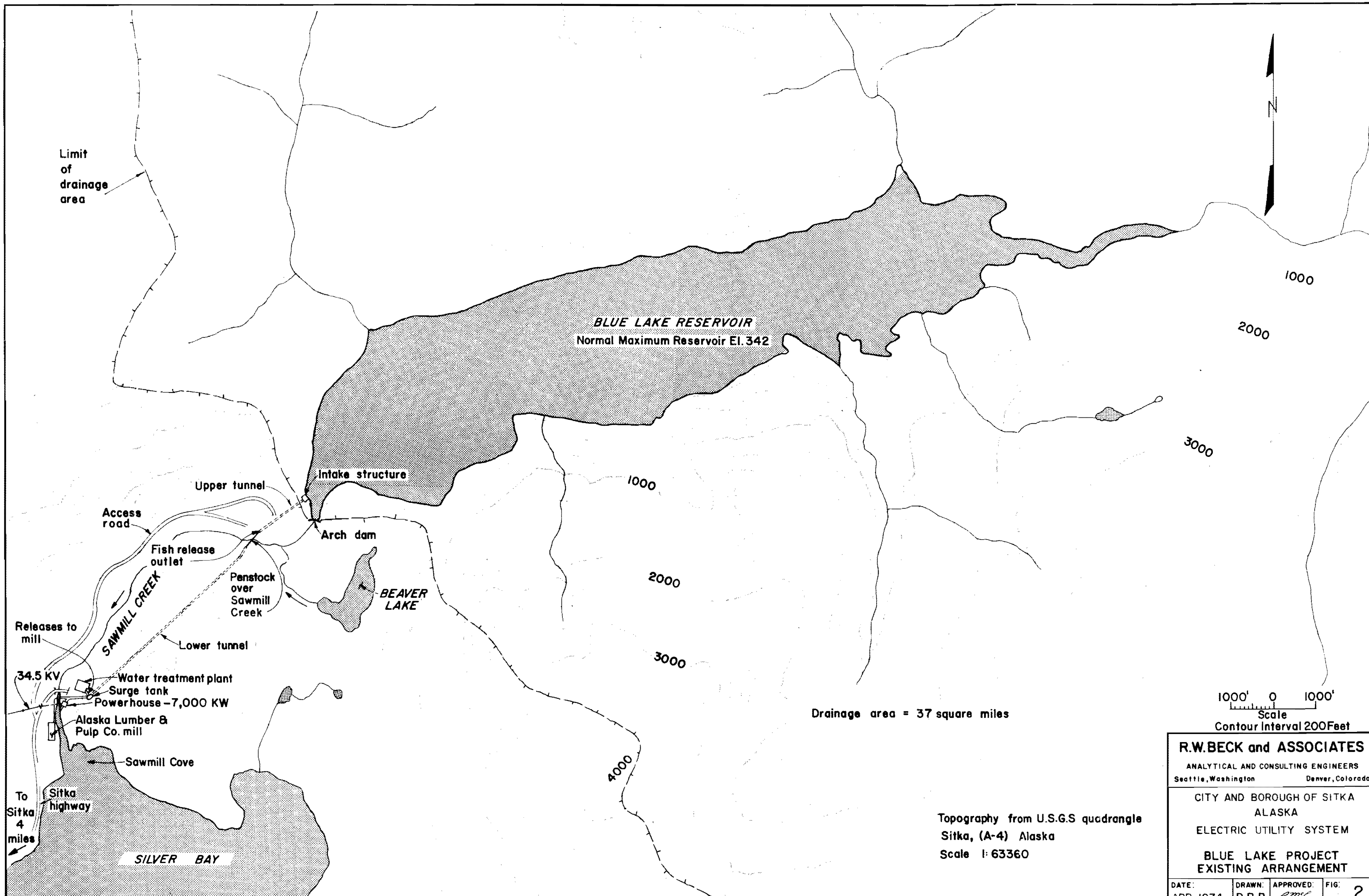
Seattle, Washington Denver, Colorado

CITY AND BOROUGH OF SITKA
ALASKA
ELECTRIC UTILITY SYSTEM

LOCATION MAP

DATE:	DRAWN:	APPROVED:	FIG
APR. 1974	DRB	[signature]	1



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CITY AND BOROUGH OF SITKA
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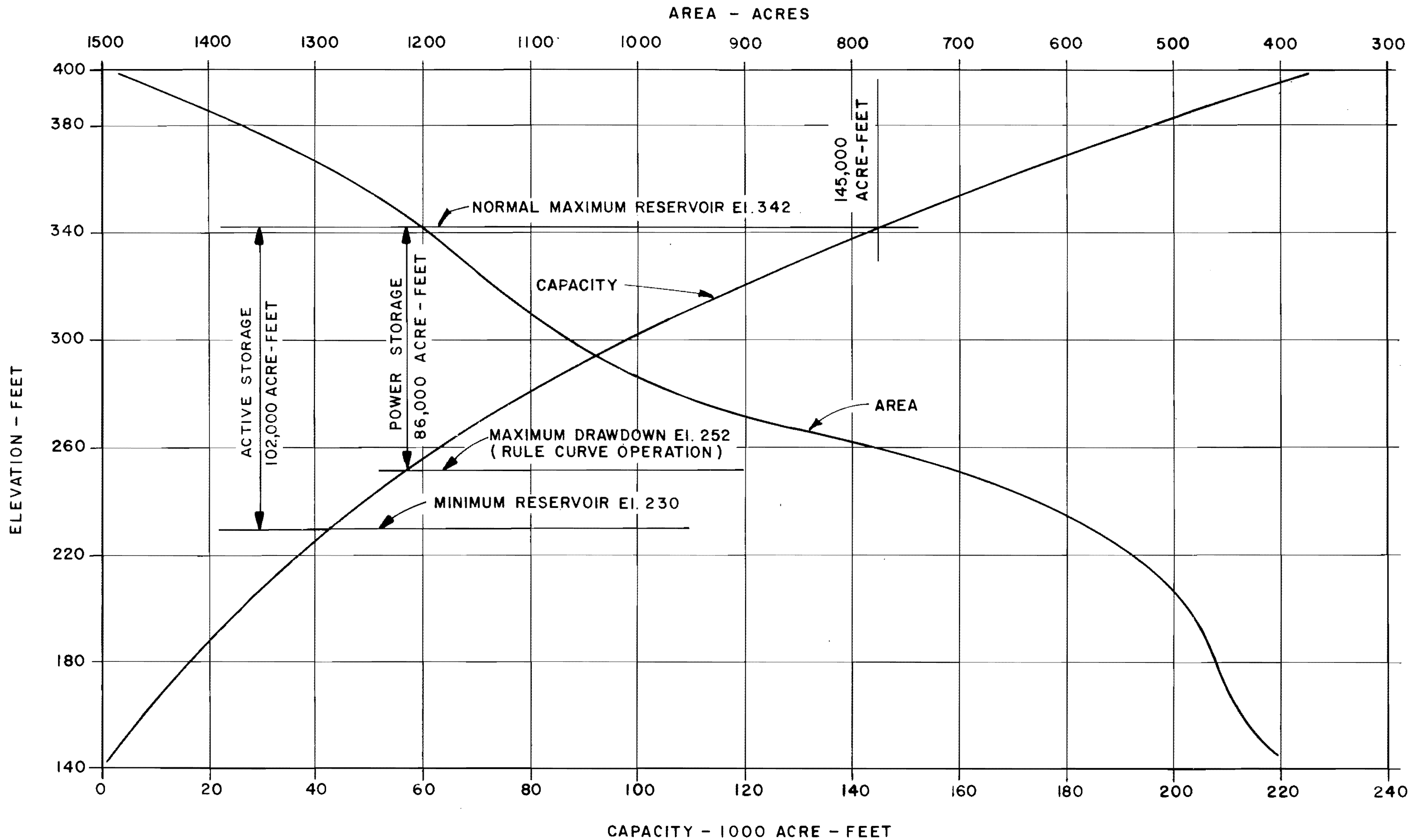
ELECTRIC UTILITY SYSTEM

BLUE LAKE PROJECT
EXISTING ARRANGEMENT

DATE:	DRAWN:	APPROVED:	FIG:
APR. 1974	D.R.B.	R.M.L.	2



NOTES: 1. Power storage determined by rule curve operation of reservoir in minimum water year.

2. Rule curve operation is proposed only during interim period until unit 3 is in-service.

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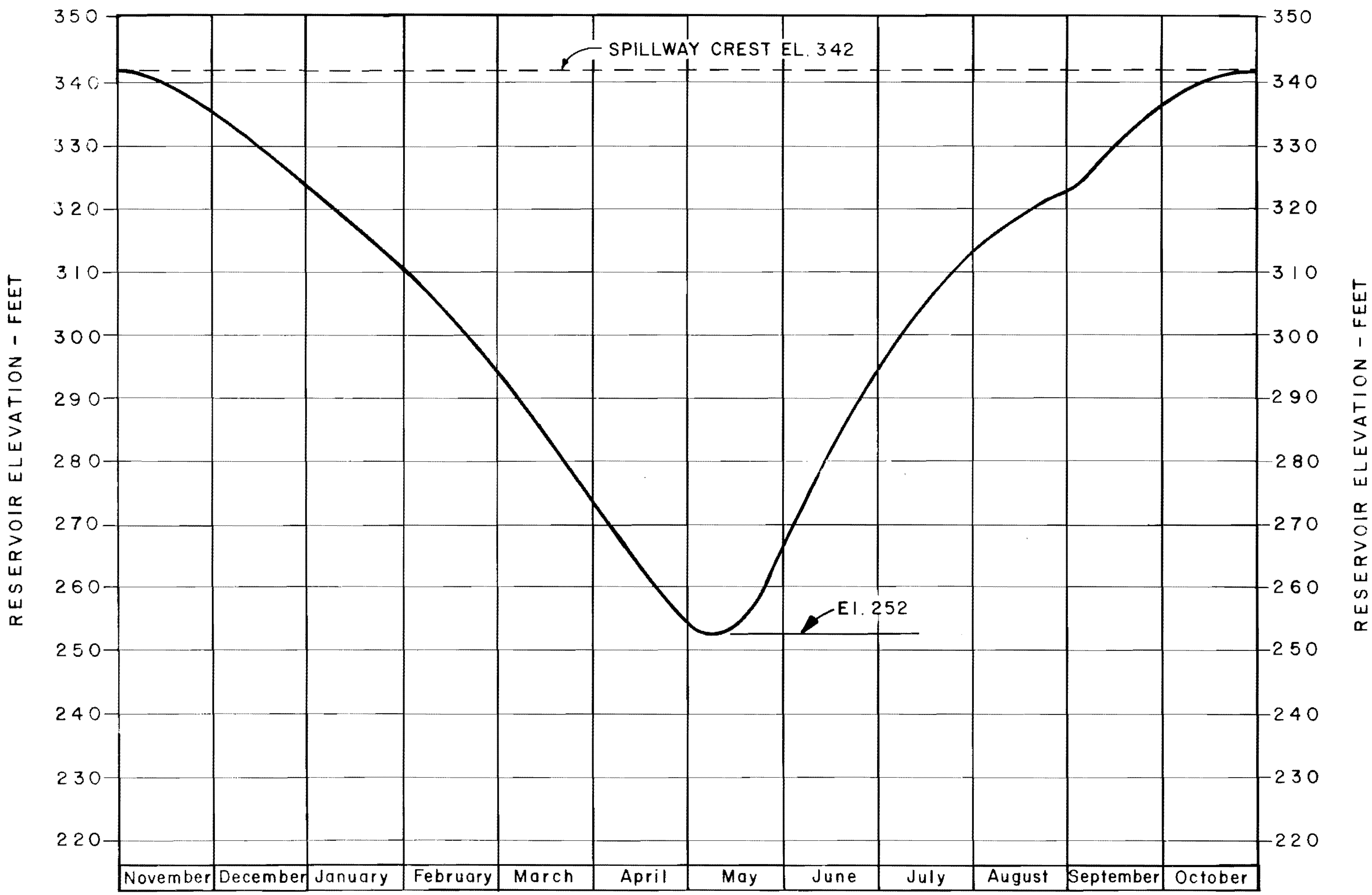
CITY AND BOROUGH OF SITKA ALASKA ELECTRIC UTILITY SYSTEM			
BLUE LAKE RESERVOIR AREA — CAPACITY CURVE			
DATE: APR. 1974	DRAWN DRB	APPROVED	FIG 3



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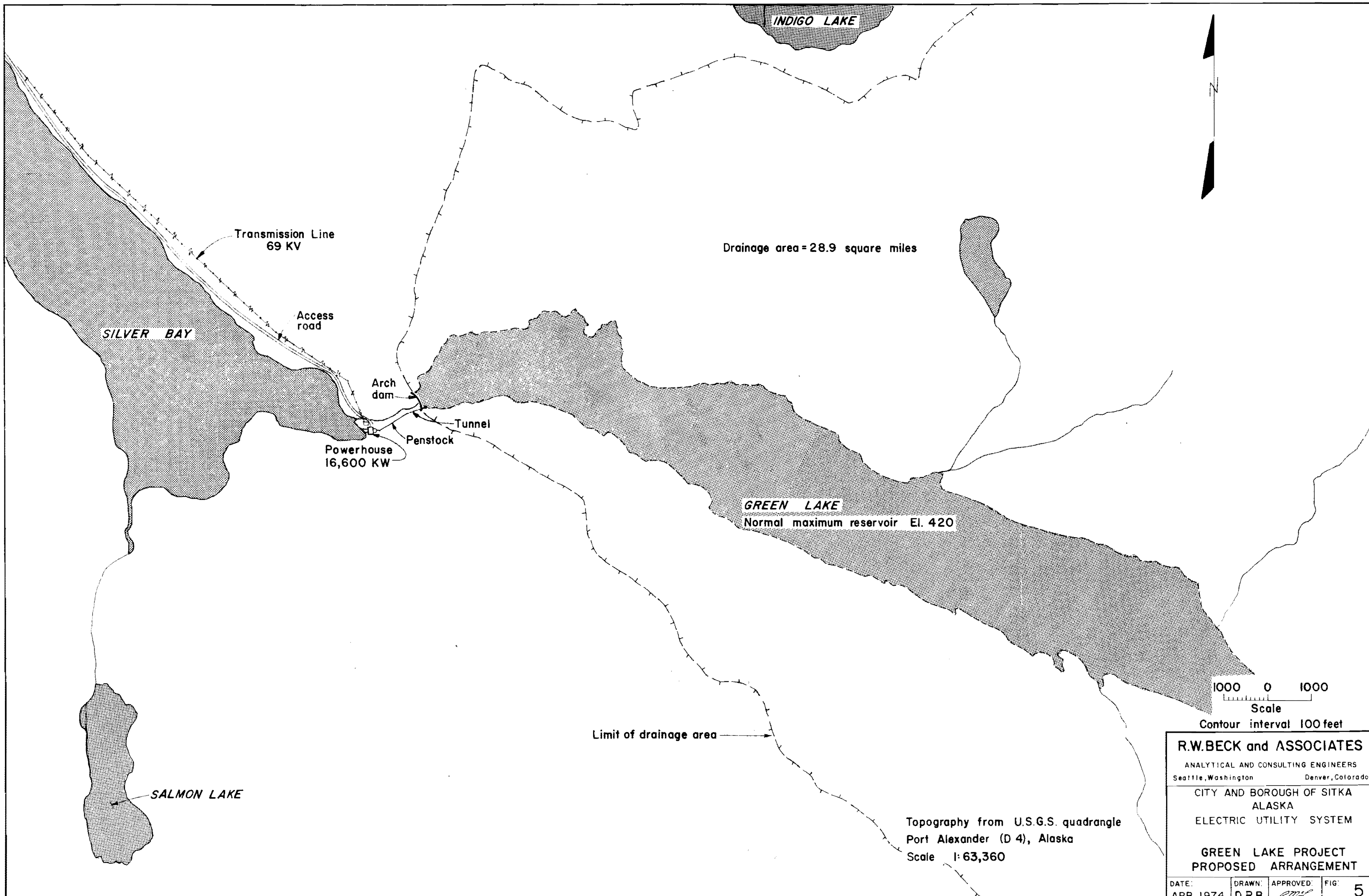
ALASKA
ELECTRIC UTILITY SYSTEM

BLUE LAKE PROJECT
RESERVOIR RULE CURVE

DATE	DRAWN	APPROVED	FIG
APR. 1974	BE	[illegible]	4


INDIGO LAKE
N
Drainage area = 28.9 square miles
Transmission Line
69 KV
Access
road
SILVER BAY
Arch
dam
Tunnel
Penstock
Powerhouse
16,600 KW
GREEN LAKE
Normal maximum reservoir El. 420
1000 0 1000
Scale
Contour interval 100 feet
Limit of drainage area
SALMON LAKE
Topography from U.S.G.S. quadrangle
Port Alexander (D 4), Alaska
Scale 1: 63,360
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Denver, Colorado
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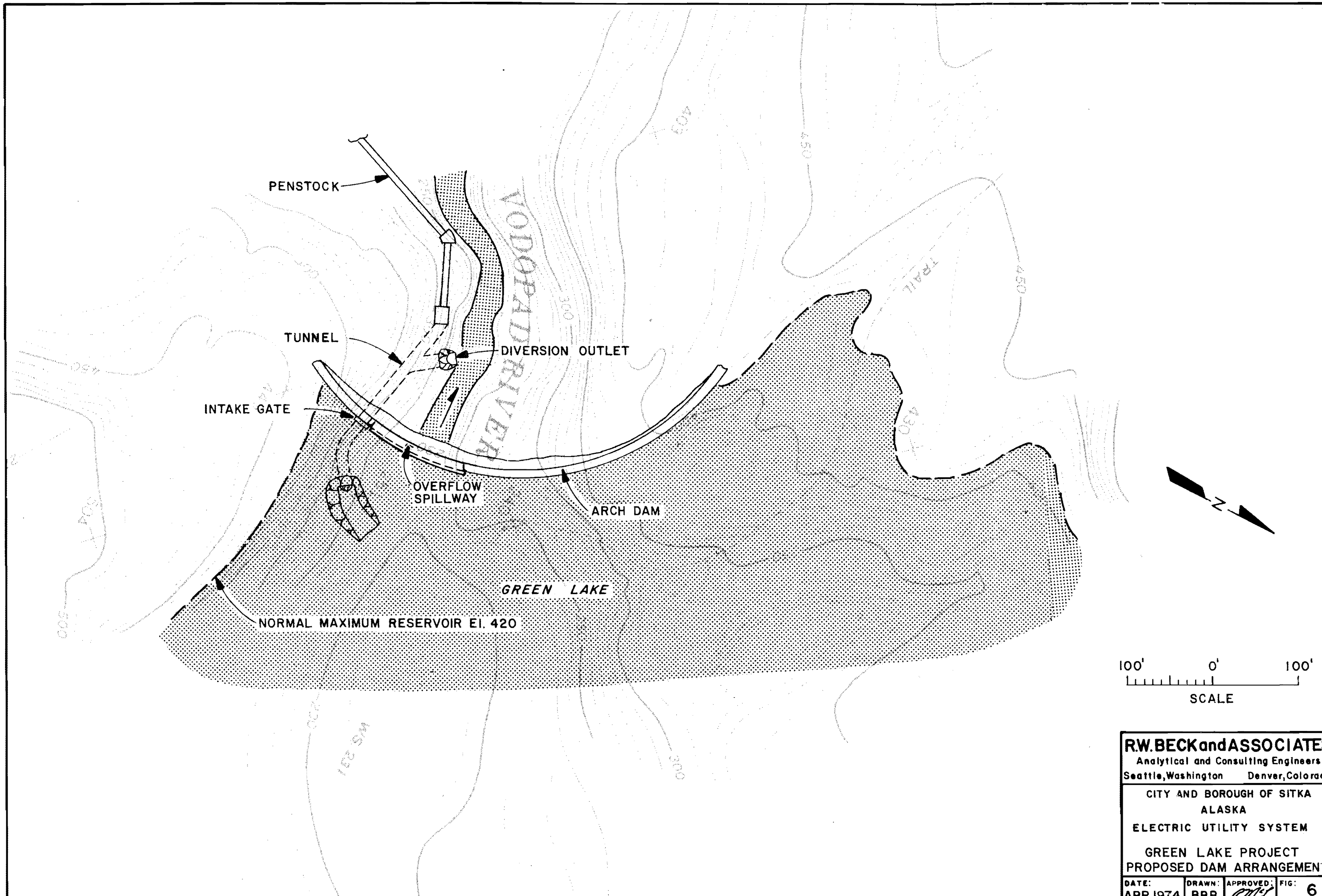
ALASKA
ELECTRIC UTILITY SYSTEM
GREEN LAKE PROJECT
PROPOSED ARRANGEMENT
DATE: APR. 1974
DRAWN: D.R.B.
APPROVED:
FIG: 5



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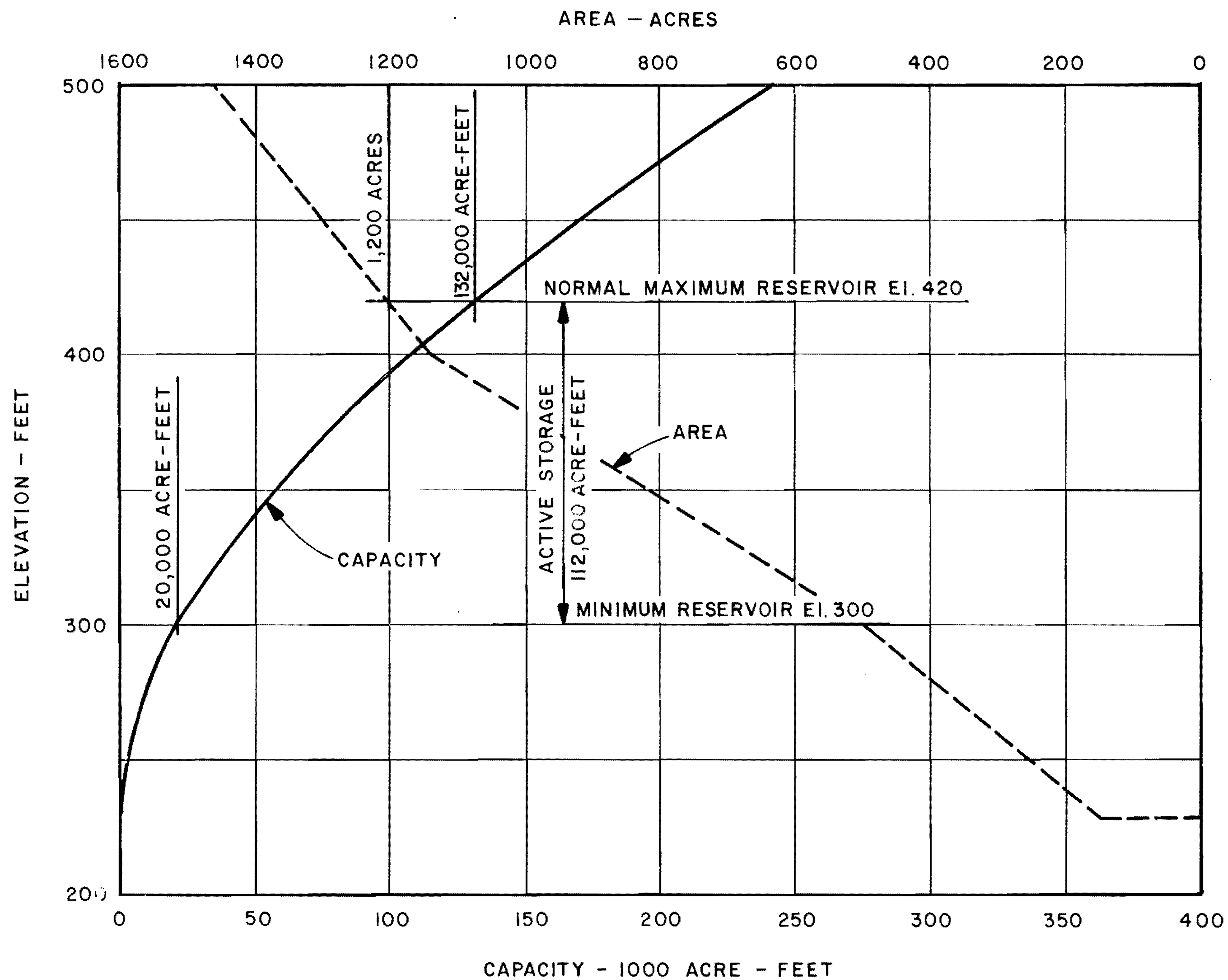
GREEN LAKE PROJECT
PROPOSED DAM ARRANGEMENT

DATE:	DRAWN:	APPROVED:	FIG:
APR. 1974	BBB		6



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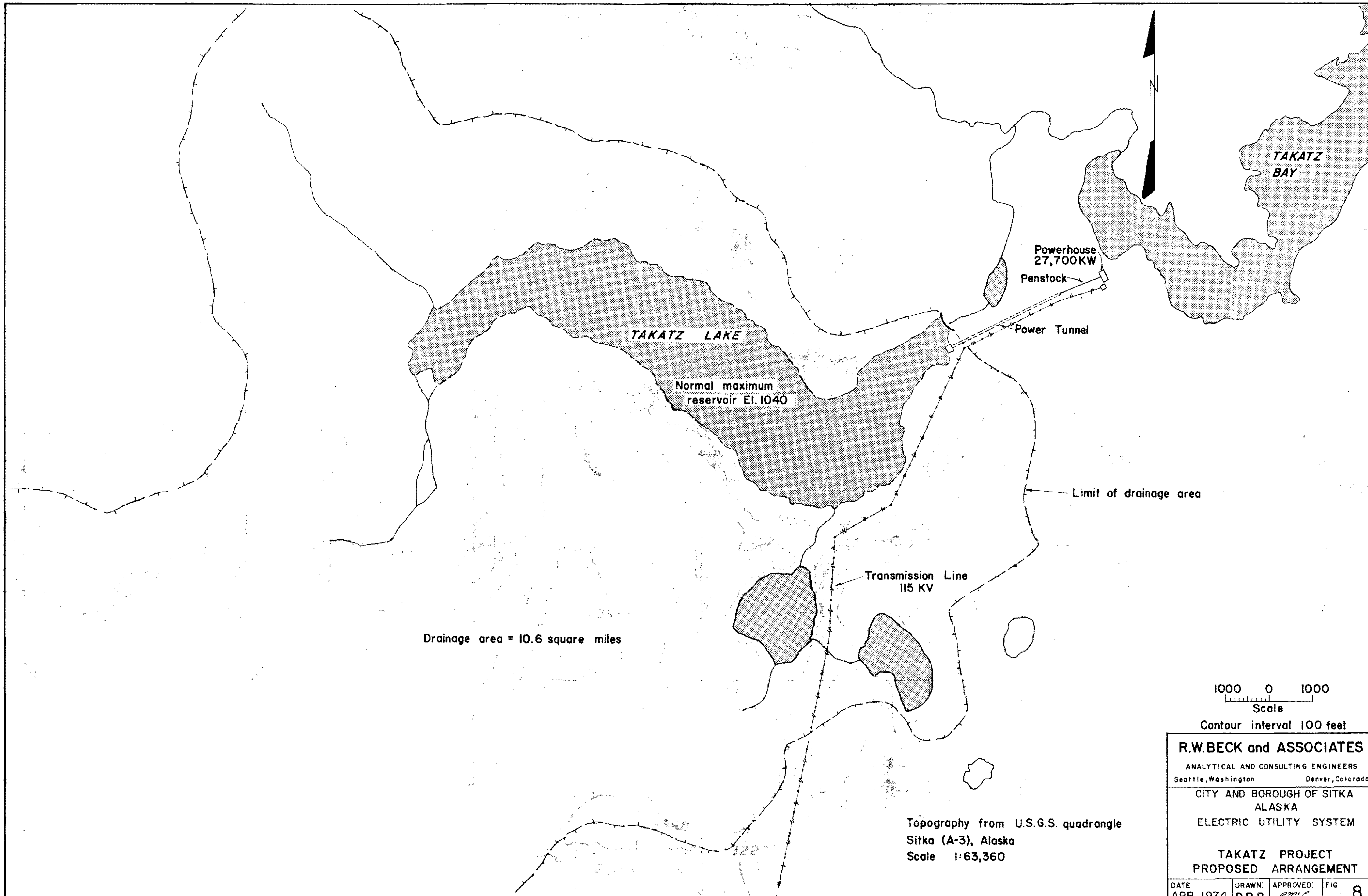
GREEN LAKE RESERVOIR
AREA – CAPACITY CURVES

DATE:	DRAWN	APPROVED:	FIG.
APR. 1974	BBB		7


N
TAKATZ BAY
Powerhouse
27,700KW
Penstock
Power Tunnel
TAKATZ LAKE
Normal maximum
reservoir El. 1040
Limit of drainage area
Transmission Line
115 KV
Drainage area = 10.6 square miles
1000 0 1000
Scale
Contour interval 100 feet
Topography from U.S.G.S. quadrangle
Sitka (A-3), Alaska
Scale 1:63,360
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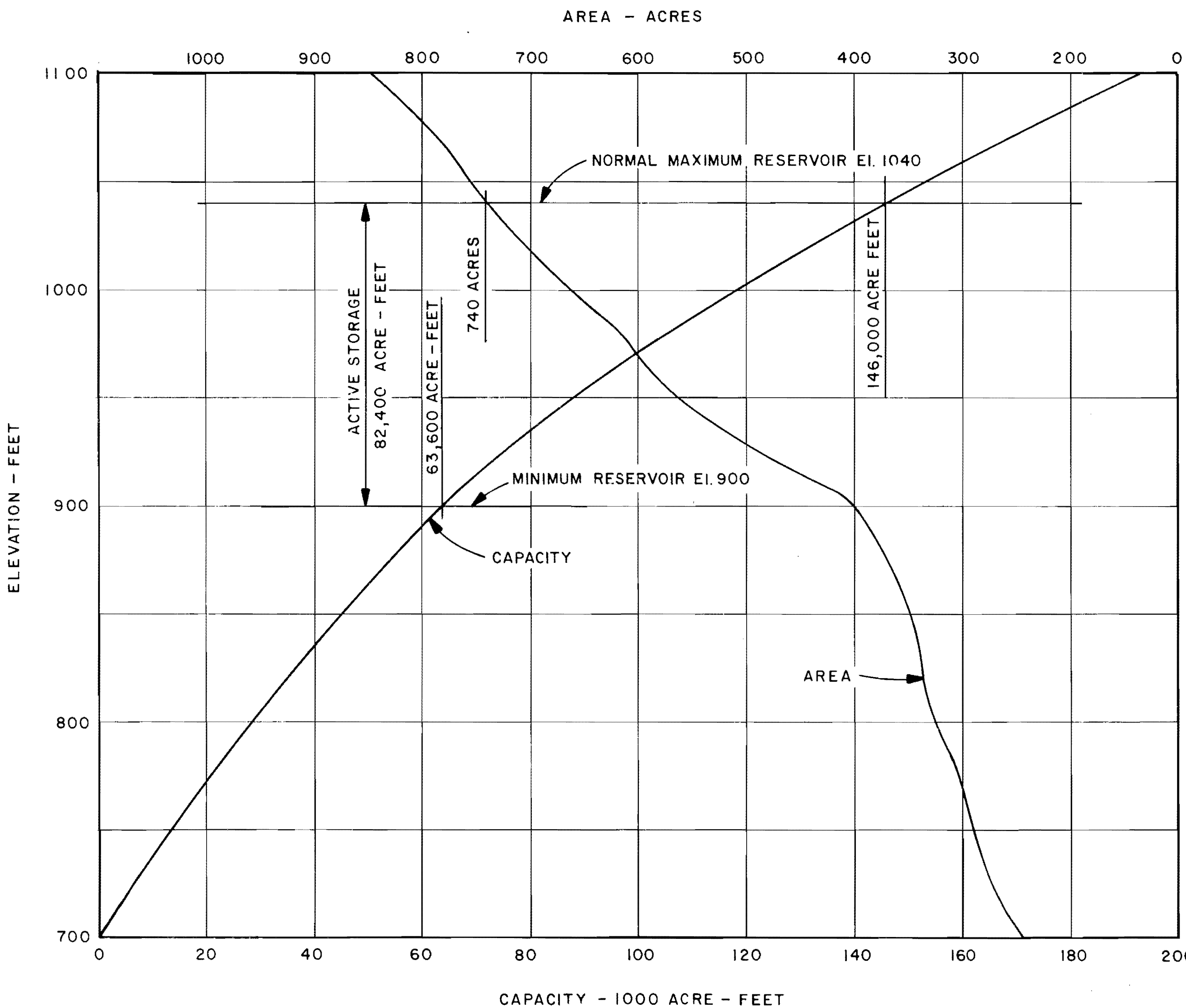
ALASKA
ELECTRIC UTILITY SYSTEM
TAKATZ PROJECT
PROPOSED ARRANGEMENT
DATE: APR. 1974
DRAWN: D.R.B
APPROVED:
FIG: 8



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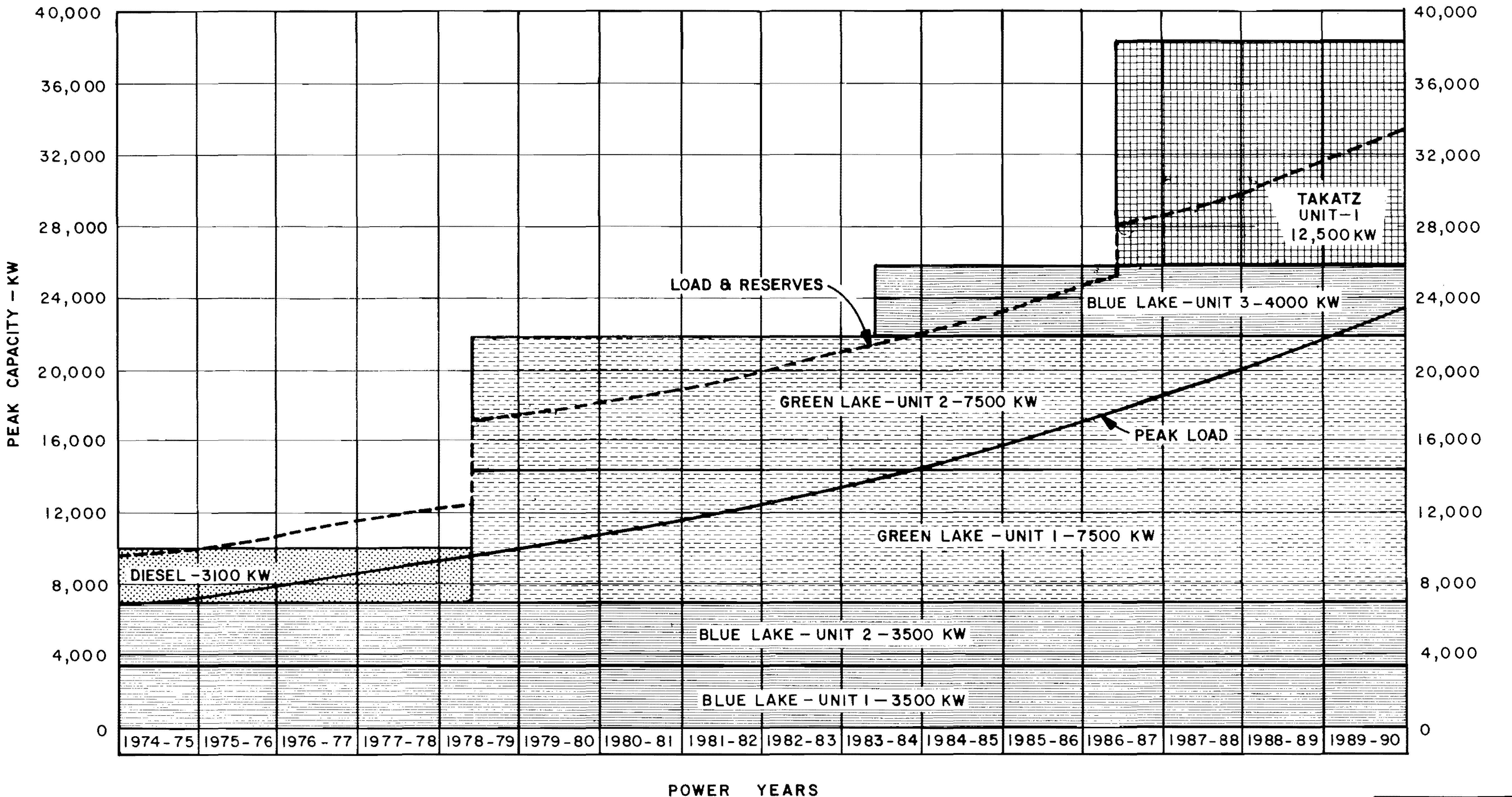
TAKATZ RESERVOIR
AREA - CAPACITY CURVES

DATE:	DRAWN	APPROVED	FIG.
APR. 1974	BBB		9



NOTE: 1. Resource capacity is dependable, delivered at load center.

2. Power years extend from July 1, through June 30.

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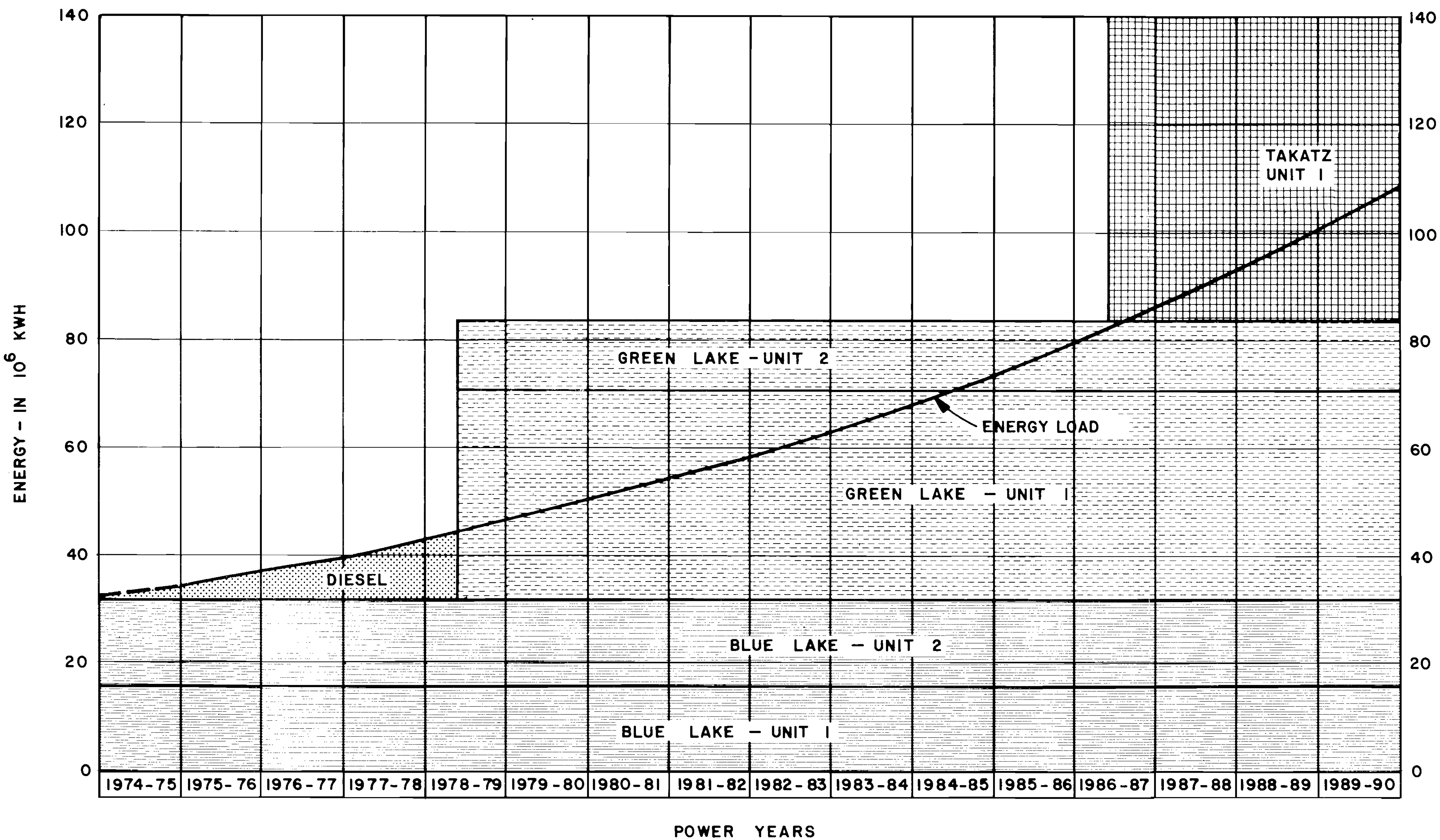
ALASKA
ELECTRIC UTILITY SYSTEM

LOAD GROWTH CURVE
PEAK LOAD

DATE:	DRAWN:	APPROVED:	FIG:
APR. 1974	BBB	[signature]	10



NOTE: 1. Resource capacity is dependable, delivered at load center.

2. Power years extend from July 1, through June 30.

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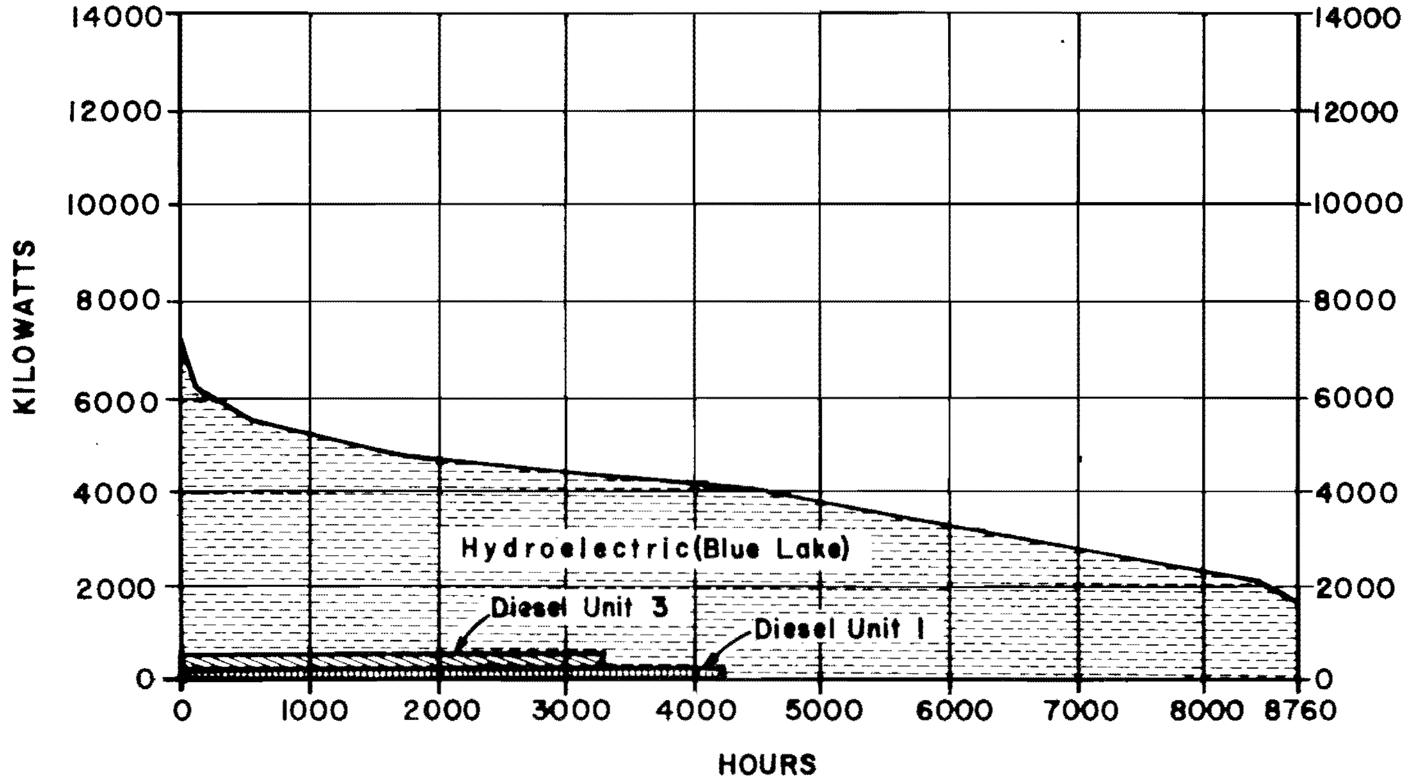
CITY AND BOROUGH OF SITKA
ALASKA
ELECTRIC UTILITY SYSTEM

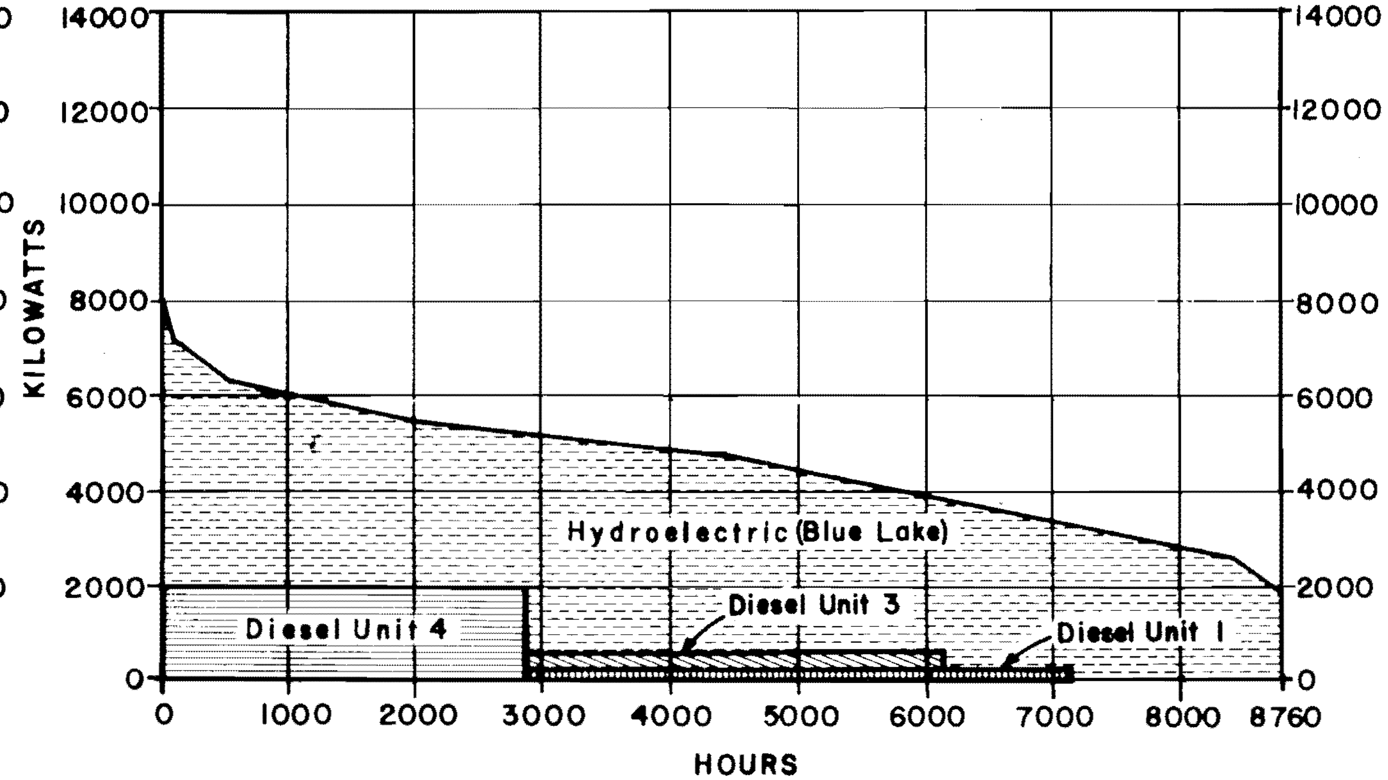
LOAD GROWTH CURVE
ENERGY LOAD

DATE:	DRAWN:	APPROVED:	FIG:
APR. 1974	BBB	[signature]	11

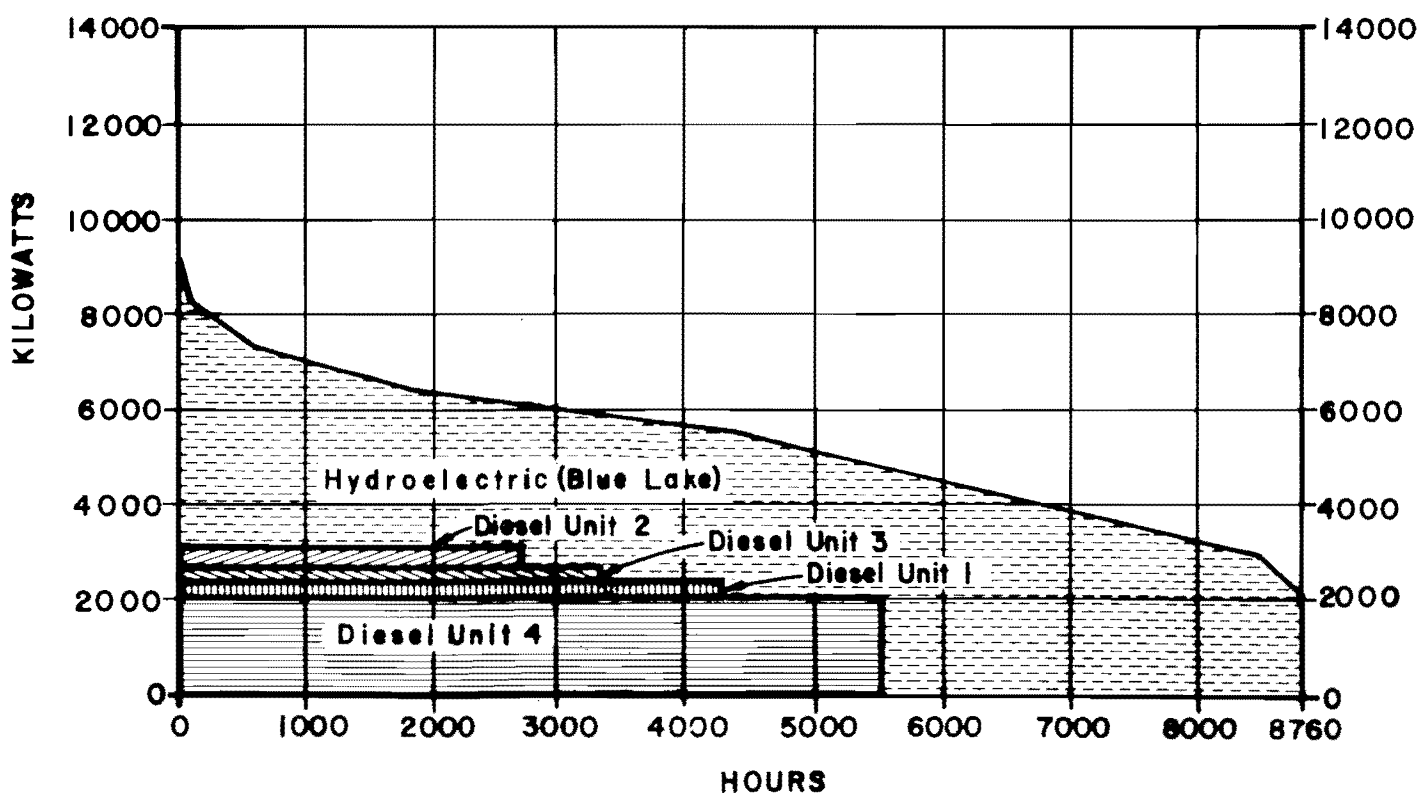
SYSTEM IN 1974-75



SYSTEM IN 1976-77



SYSTEM IN 1978-79



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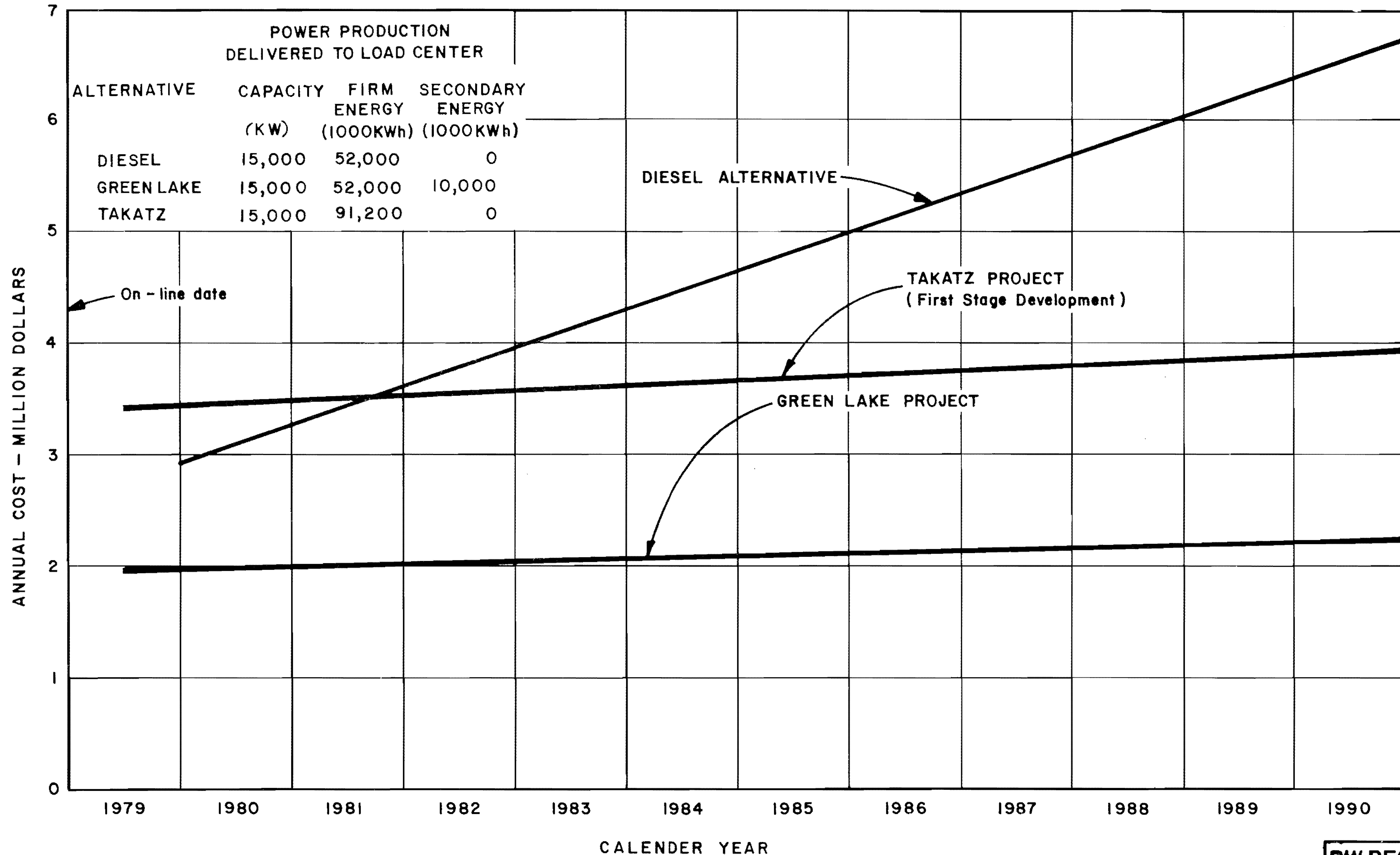
ALASKA
ELECTRIC UTILITY SYSTEM

LOAD DURATION CURVES

DATE:	DRAWN:	APPROVED:	FIG:
APR. 1974	G.L.F.		12



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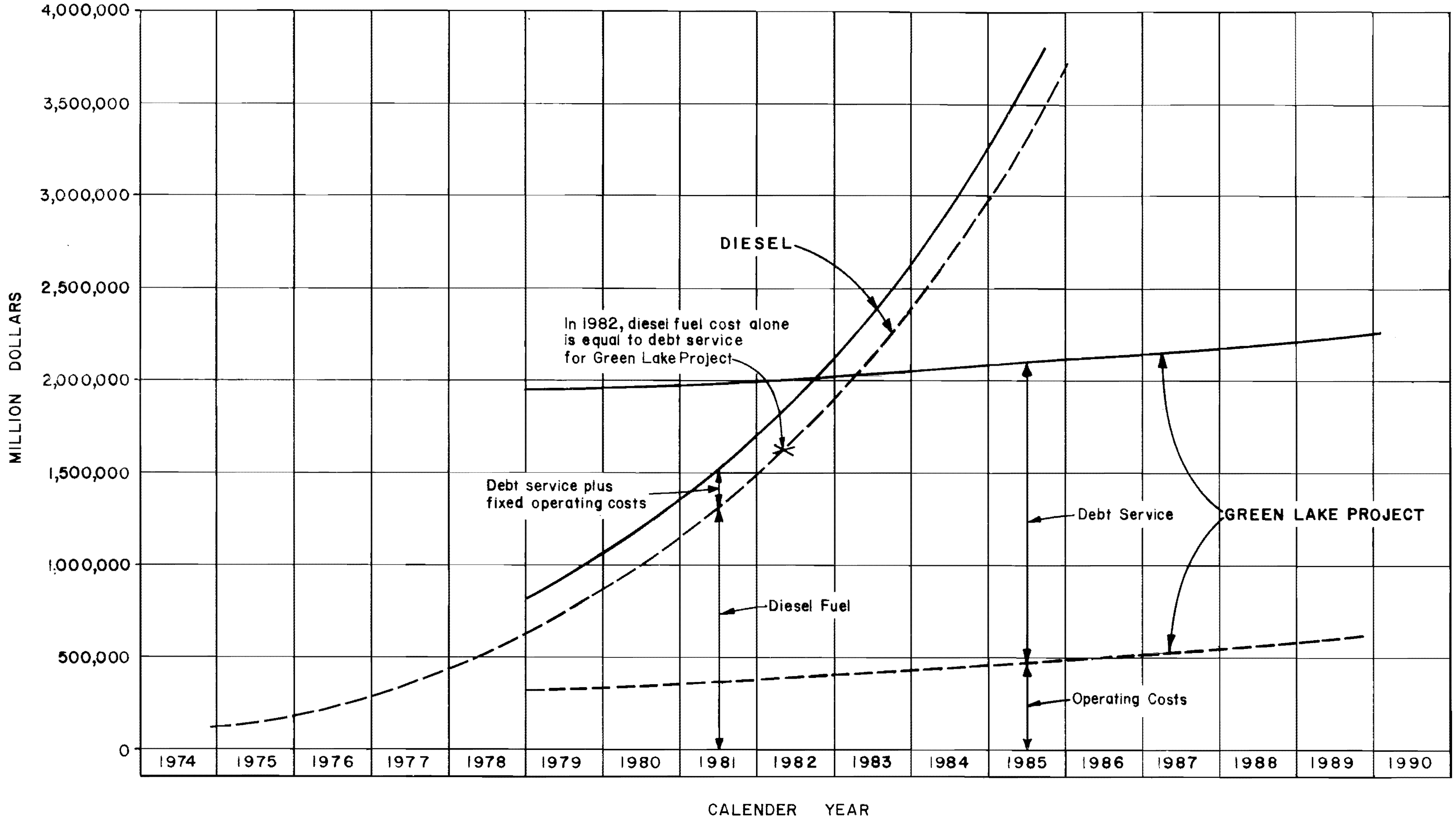
COMPARATIVE COST OF POWER

DATE:	DRAWN:	APPROVED:	FIG:
APR. 1974	BBB	[signature]	13



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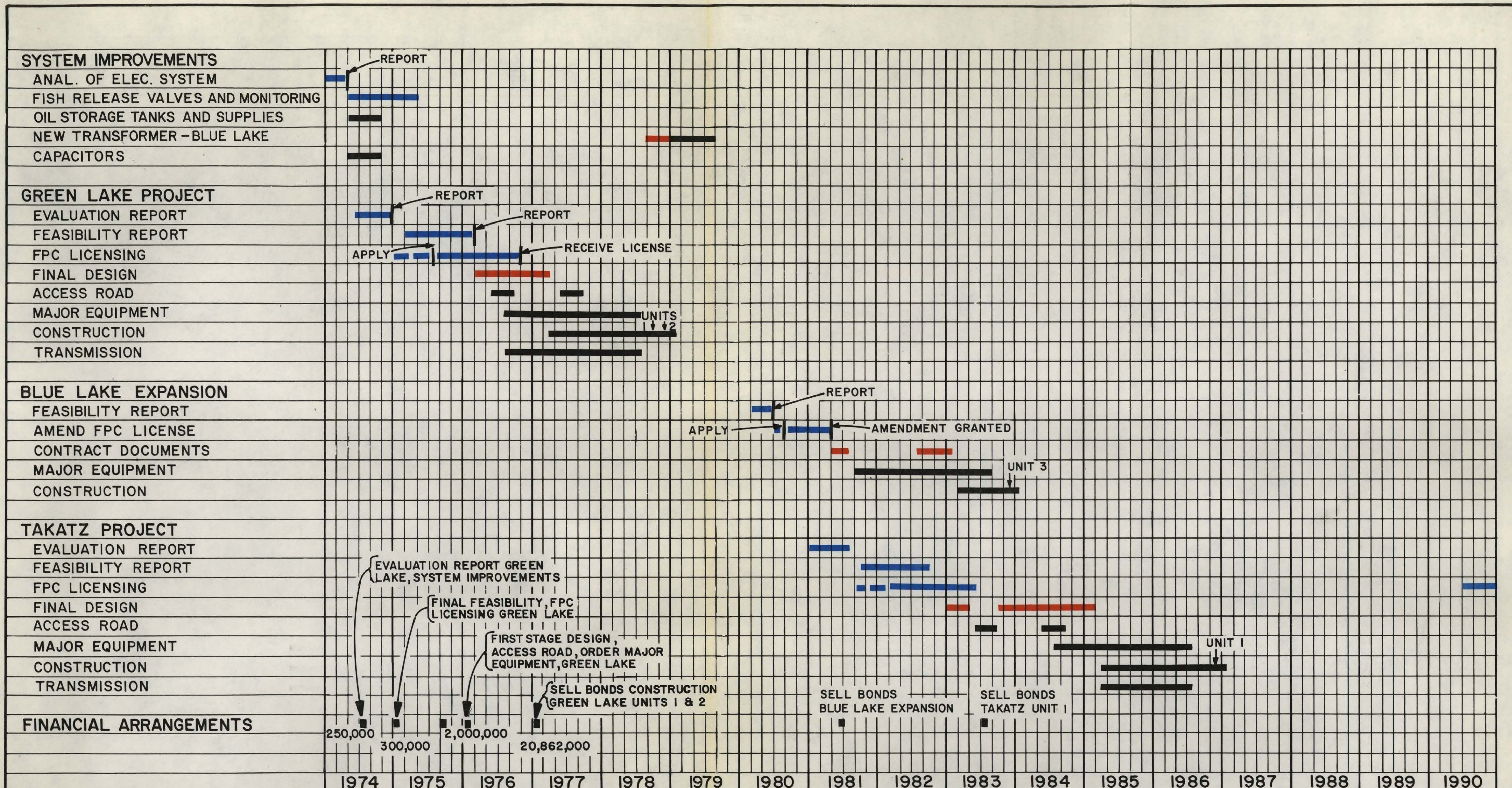
ALASKA
ELECTRIC UTILITY SYSTEM
COST OF CONTINUED
DIESEL GENERATION VS.
GREEN LAKE PROJECT

DATE:	DRAWN:	APPROVED:	FIG:
APR. 1974	EAL	[signature]	14



LEGEND

FEASIBILITY STUDIES	(blue line)
FINAL DESIGN	(red line)
CONSTRUCTION	(black line)

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DESIGN AND CONSTRUCTION SCHEDULE

DATE:	DRAWN:	APPROVED:	FIG:
APR. 1974	BBB	[signature]	15