FEASIBILITY ASSESSMENT

HYDROPOWER DEVELOPMENT AT GRANT LAKE

Prepared for

City of Seward, Alaska

CH2M HILL

APRIL, 1980

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STATE OF ALASKA

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PREFACE

This report was prepared in fulfillment of the contract dated September 10, 1979, between the City of Seward, Alaska, and CH2M HILL Engineering of Alaska, Inc. The agreement was executed by the City of Seward to meet its requirements under the Contract for Services dated July 18, 1979, with the State of Alaska Department of Community and Regional Affairs.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The basic intent of a feasibility study of this type is to determine if the project is sound enough to take the next step in project development: preparation of a Federal Energy Regulatory Commission (FERC) license. Sufficient evidence has been presented to justify taking that step on the Grant Lake Hydropower project.

It should be pointed out that, while the Grant Lake development presents a definite economic benefit to Sewards' future energy costs, the project does not generate enough energy to meet Seward's complete future electric needs. Energy from additional sources will still be required. The other factor to be considered is that Seward has historically enjoyed low cost energy made possible through transmission interties to south central Alaska energy sources. These energy sources will undoubtedly become more expensive in the future making renewable energy sources such as the Grant Lake project more desirable.

In the preferred alternative, a 68-foot-high dam at the outlet of Grant Lake was selected to provide 78,000 acre-feet of storage for power generation. A small saddle dam would also be required. A 1/2-mile-long pipeline/penstock would be required to deliver the water to the powerhouse sited on Upper Trail Lake. Its cost, added to the cost of other required project features, makes the Grant Lake project a relatively expensive one.

A 7.3-MW powerhouse is proposed, equipped with two equal turbine/generator units and having an expected average annual energy of 27.3 million kWh. A 4.0-MW powerhouse with a single turbine generator was also considered in an attempt to reduce capital costs. This smaller powerhouse has an expected average annual energy of 26.1 million kWh. The final installed capacity of the project is to be determined during the FERC license application effort.

The total cost of the bond issue required for the project is $23,870,000, which, over a 30-year period at an interest rate of 8-1/2 percent, requires a debt service payment of $2,221,000 per year. Operation and maintenance and other annual costs bring the total annual cost to $2,363,000. This cost, when compared to the expected average annual energy of 27.3 million kWh, yields a unit cost for energy of 87 mills (in 1984 dollars) for the first year of operation (1984).

Unit energy costs for the preferred Grant Lake hydropower alternative and the two principal alternative electric power sources available to Seward are shown in the following figure. The Grant Lake project energy costs are compared to the costs of a Bradley Lake hydropower project and purchased power from the Chugach Electric Association (CEA). Two curves are shown for CEA power purchases. The first curve is based on CH2M HILL projected annual 2 percent real and 5 percent real above the general inflation rate price escalation rates for CEA purchasers' power. The second is based upon price escalation rates for CEA as estimated and described in a Homer Research Agency report assessing the effects of the Pacific LNG project on the regional electric power prices.

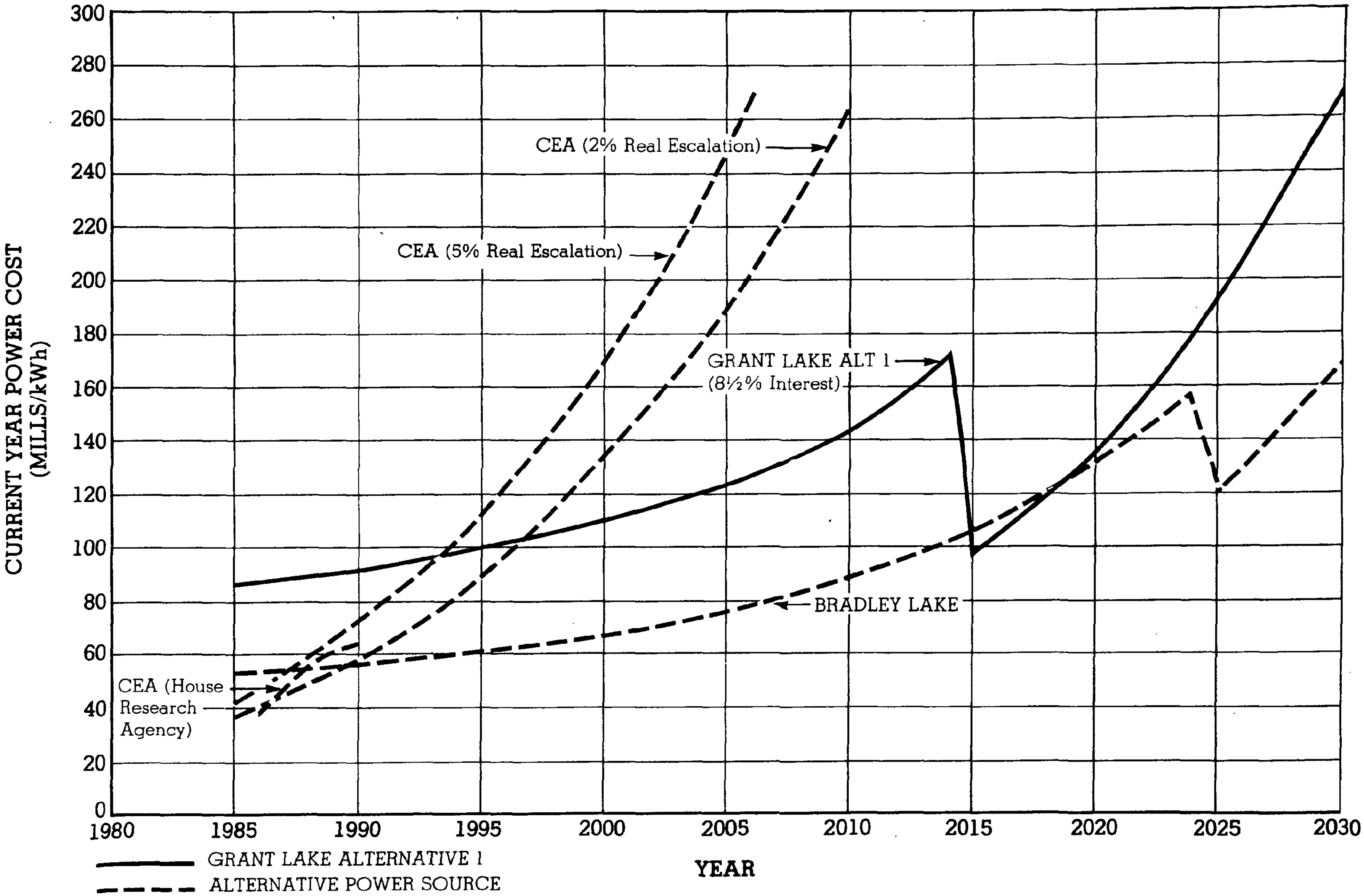
This high initial cost for energy is normal for hydropower projects. A present value benefit-cost comparison is required to measure the true economic value of the project. The benefits chosen for this analysis included three different rates of price escalation for power purchased from fossil-generated sources and one rate from the proposed Bradley Lake project. The benefit-cost analysis showed that, when compared to power purchased from fossil-generated sources (mostly gas or coal generated), the Grant Lake project is economically feasible. When Grant Lake is compared to the Bradley Lake project as documented in the most recent reports, Bradley Lake is more cost-effective due mostly to the economies of scale that favor the larger (70 to 100 MW) Bradley Lake project. The final cost and availability to the City of Seward of Bradley Lake power is not known.

RECOMMENDATIONS

It is recommended that the City of Seward vigorously pursue development of the Grant Lake hydropower project. The next step in the development process is to prepare an application for a FERC license. A detailed work plan for that effort should be prepared and should include further environmental studies and engineering predesign of the project.

The best approach to obtain the funds for the FERC license effort for Grant Lake may be by soliciting the advice and financial support of the Alaska Power Authority. The City should seek review and endorsement of the project feasibility work to date from the APA and consider plans the APA might wish to propose.

It is further recommended that the city develop a long-term power plan to meet the projected energy needs. This plan would be extremely helpful in making decisions about whether to develop the Grant Lake project, to rely on purchased power, to invest in a portion of other new generation. This plan should involve a critical review of proposed alternative energy sources to determine their expected cost and availability to the city. In the meantime the city should continue its efforts to secure a short-term, 5- to 10-year contract for purchased power.



NOTE: Initial investment amortization period is 30 years (Grant Lake Alternative) and 40 years (Bradley Lake Alternative).

ESTIMATED POWER COSTS FOR GRANT LAKE ALTERNATIVE 1, AND ALTERNATIVE POWER SOURCES

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Chapter 1
INTRODUCTION

The purpose of this study was to determine the feasibility of developing hydropower for the City of Seward. Several potential hydropower sites were investigated at the reconnaissance level. As a result of the reconnaissance-level screening, a single site was selected for assessment of its environmental, economic, and financial feasibility. The intent of this approach was to enable the earliest possible development of one site that will assist the city in meeting its future electrical demands.

The study began with an investigation of the city's anticipated power needs in light of historical demand and projections of future economic growth. Because the city is connected to the regional power grid, the availability and expected future cost of purchased power from regional power sources were investigated. The results of this study are reported in Chapter 2.

A preliminary reconnaissance was then conducted for the numerous hydropower sites that were studied. Cost curves and unit cost methods were used to identify which site should be selected for the feasibility-level investigation. Environmental factors associated with each proposed site were also identified and discussed at a meeting with concerned agencies and environmental groups (Appendix A). The reconnaissance investigations and environmental meeting led to the designation of Grant Lake as the preferred hydropower site, which the city should pursue first. Chapter 3 summarizes the results of this preliminary reconnaissance.

A feasibility-level investigation was then conducted to determine the power potential of the Grant Lake site. This investigation included a study of climate and hydrology, followed by selection of the type and location of appropriate system components such as the dam, penstocks, and turbine/generators.

The results of the power potential investigation are presented in Chapter 4. Alternative system layouts and capacities were assessed, and operations studies were performed to determine the estimated capacity and energy for the alternative layouts. A preliminary layout of the proposed alternatives at the preferred site was prepared showing the size and location of principal system components. Chapter 5 presents the results of this investigation.

Environmental and institutional considerations associated with the development of Grant Lake were identified. This effort included a description of the environmental setting and expected project impacts. Potential mitigation measures were also identified in Chapter 6.

The economic and financial feasibility of the Grant Lake Project was determined. The estimated project cost was compared with the expected project benefits. The benefits were measured in terms of the value of the energy produced; this value is based on the cost of alternative purchased power. The potential sources of project financing were then identified. Chapter 7 discusses these findings in detail.

Finally, a plan for project implementation was prepared. The implementation plan identifies required permits and approvals and gives a detailed project schedule to ensure timely development of the project. Chapter 8 presents this plan.

Chapter 2
SEWARD POWER NEEDS AND SUPPLY SOURCES

The electric power requirements of the City of Seward will grow in response to population increases and economic development. The city's load will double and could possibly triple over the next 10 years. The city will be responsible for meeting these, increasing electric power demands by residential, commercial, and industrial customers. The additional capacity and energy that must be acquired to meet the expected load will come from either wholesale power purchases or city owned generation.

For planning purposes, Seward should expect to have, in 1985, a peak capacity requirement of 11,300 kW and an annual energy requirement of 52,000 MWh. By 1990, Seward should expect to have a peak capacity requirement of 14,000 to 15,000 kW and an annual energy requirement of 68,000 MWh.

The projected electric power requirements of the city are described in Figures 2-1 and 2-2. This load growth forecast is based on population and economic development growth projections. Also described are alternative sources of electric power that could be used by Seward to meet these load growth requirements. The economic characteristics of these alternative sources are used later in this report to determine the economic feasibility of any future hydropower project(s) constructed and operated by Seward.

PROJECTED ELECTRIC POWER REQUIREMENTS

A peakload and electrical energy growth forecast was prepared for use in evaluating future energy source alternatives for the City of Seward. The peakload growth forecast indicates the city's future capacity requirements, and the energy growth forecast indicates its future energy requirements. To allow for several possible growth rates, both high and low projections were calculated for population and electric load growth. An average of the high and low projections serves as the most probable (medium) projection.

The energy requirement projections in this report are based on an evaluation of Seward's economy, population trends, and energy use trends. The peakload projections were calculated using the energy requirement projections and an assumed average annual load factor of 55 percent. To facilitate the calculations, the rate schedule classifications were reduced to five customer classes: residential, commercial, power and government (city, State, and Federal), Seward water system, and city street lighting. Appendix A contains a detailed description of the economic development and population growth projections, forecasting methodology, and electric power requirement projections.

Economic Development and Population Projections

Seward's economic growth will depend on a number of factors. The city's assets include available land for industrial and residential growth, an ice-free harbor, good deepwater port facilities, and transportation links to Anchorage by air, rail, and highway.

The city's economy is expected to continue its relatively rapid growth of recent years. A proposed shipbuilding and repair facility is expected to have a major impact on the local economy. Other potential resource development activities include bottomfish processing, construction of the Alcan pipeline, Outer Continental Shelf development, and wood processing. The economy will continue to grow, to some extent, in response to increasing tourism and government employment.

High and low population projections were developed for the Seward electric system service area (Table 2-1). These values were developed using baseline projections from the August 1979 City of Seward Land Use Plan (Ref. 8). The plan's projected growth rates of 3 and 5 percent were used to arrive at low and high base populations. These base figures were then adjusted for major industrial developments that would significantly affect population growth. The service area encompasses all of the City of Seward and an estimated 734 residents (in 1978) outside the city.

Table 2-1
POPULATION PROJECTIONS FOR
SEWARD ELECTRIC SYSTEM SERVICE AREA

	Population		
	1980	1985	1990
Low Projection	3,130	4,000	4,560
High Projection	3,270	4,680	5,790

Projected Peakload and Energy Requirements

High and low peakload and energy projections were calculated to reflect the economic forecasts and the high and low population forecasts. The average of these extremes was also calculated and is considered to be the most likely to occur in the future. The projected peakload and energy requirements are shown in Figures 2-1 and 2-2.

In developing the energy and peakload forecasts, residential customers were calculated by dividing the population by the estimated persons per household. The remaining four customer classes were calculated on the basis of their historical ratios to the number of residential customers. The average consumption for residential electric heat was estimated at 32.2 megawatt-hours (MWh) annually per customer by using a sample of customer bills from Homer Electric Company in Homer, Alaska. Weather data for Seward and Homer show that although Seward experiences slightly more extreme temperatures, the average annual heating degree days are about the same. The average use per customer for residential nonheating loads and all other class loads was projected at slightly below the average annual growth rates over the last 4 years. The reason for selecting a lower-than-historical rate is an anticipated increase in conservation. Industrial loads were adjusted to reflect the economic projections described above.

During the forecast period of 1979 to 1990, the existing total energy requirements of 26,883 MWh are projected to increase to 57,400 MWh in the low projection and 78,800 MWh in the high projection. The energy requirements will increase more rapidly in the initial years of the forecast period because of large increases in industrial loads and the beginning of a higher incidence of electric residential home heating.

From 1978 to 1990, the peakload requirements will increase by an amount ranging from 6,900 kW (low projection) to 11,308 kW (high projection). Because the peakload was derived from the energy requirement projections by using a constant load factor, the largest increases also will occur in the early years.

ALTERNATIVE POWER SOURCES

Alternative sources of electric power will be available to the City of Seward in future years. The cost to Seward of generating or purchasing electric power produced by these alternative sources was used later in this study to determine the economic feasibility of the proposed hydropower projects. The purpose of this study was not to assess the overall attractiveness of the alternative energy sources, but rather to compare the costs of proposed hydropower projects to the costs of these alternative sources.

Nonconventional sources of electric power, such as wind, geothermal, and tidal power, were not examined in this

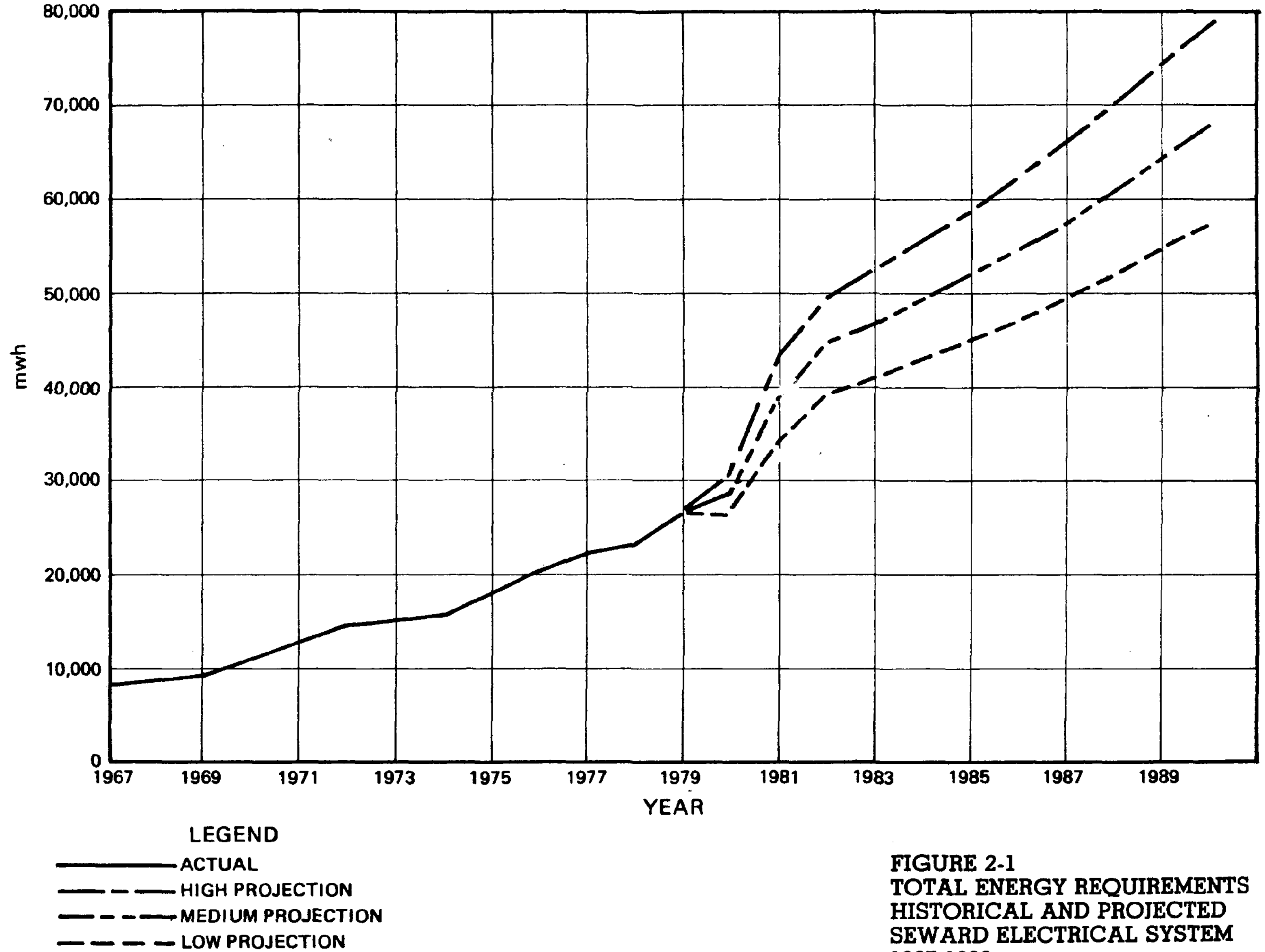


FIGURE 2-1
TOTAL ENERGY REQUIREMENTS
HISTORICAL AND PROJECTED
SEWARD ELECTRICAL SYSTEM
1967-1990

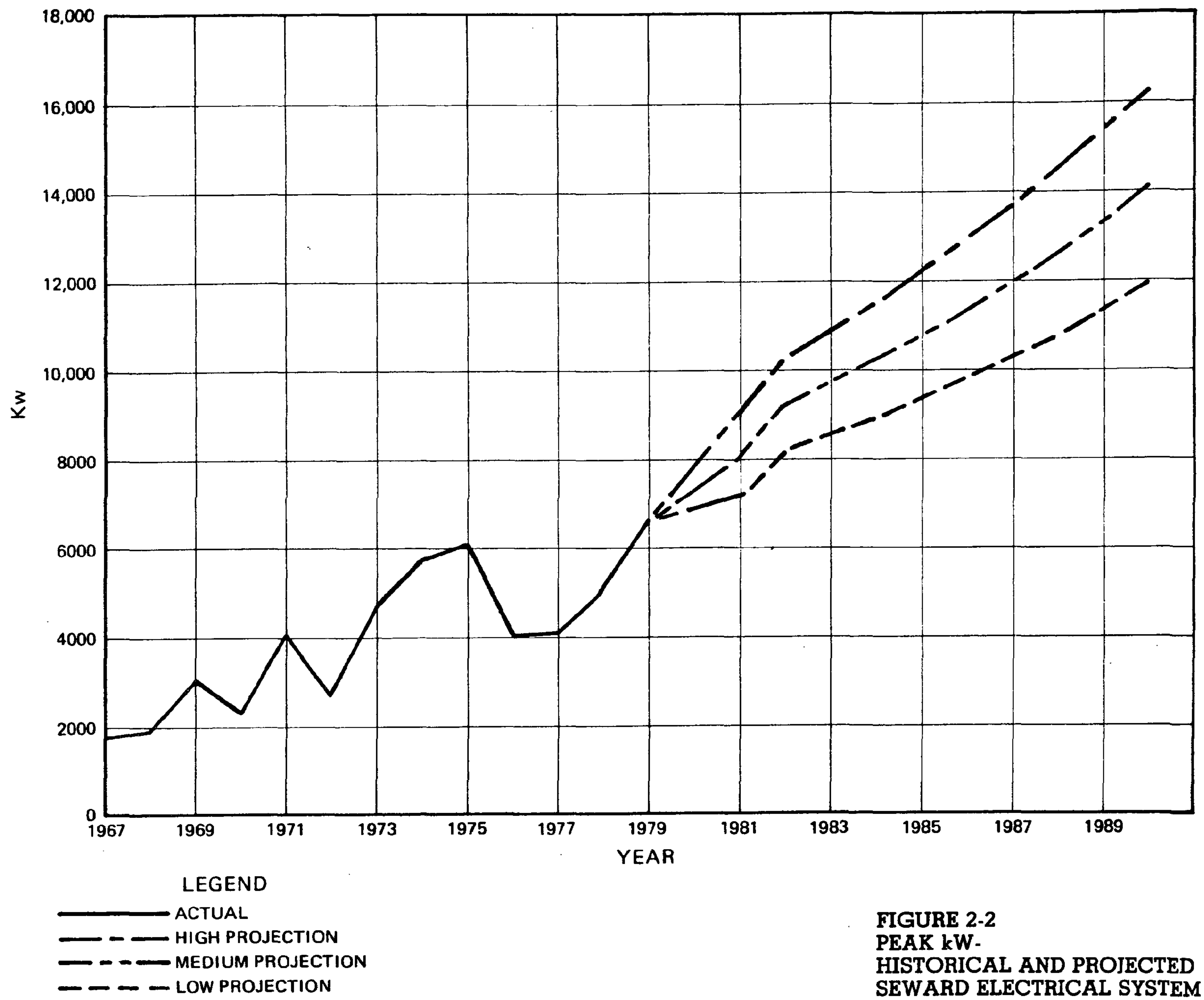


FIGURE 2-2
PEAK kW-
HISTORICAL AND PROJECTED
SEWARD ELECTRICAL SYSTEM
1967-1990

study. These sources were excluded because of technological uncertainties and a lack of information needed to establish their role as energy generation sources in Alaska. These sources are also expected to be far more expensive than the conventional technologies. Nuclear power was not included because it was determined to be at least as expensive as coal-fired alternatives and is laden with economic, financial, and institutional uncertainties.

The City of Seward currently purchases electric power from Chugach Electric Association (CEA) without a formal contract. To insure a firm source, Seward is presently negotiating a wholesale power purchase contract (interruptible power) with the Anchorage Municipal Light and Power Company. The Anchorage contract is dependent on a wheeling contract from CEA.

CEA owns and operates the Knik Arm Steam Electric Generating Plant with an installed capacity of 14.5 MW, a hydroelectric generating plant at Cooper Lake with an installed capacity of 15 MW, and 13 gas turbine power-generating units with a total installed capacity of about 425 MW. The total 1978 nameplate capacity for all CEA generation was about 454.5 MW. In 1978, CEA sold for resale almost 477,000,000 kWh of electric power to other utilities at an average price of 13 mills per kWh. According to CEA's annual report to the Federal Energy Regulatory Commission (FERC), it sold 23,155,200 kWh in 1978 to the City of Seward at an average price of 14 mills per kWh.

The principal alternatives available to meet the City of Seward's future electric power requirements are: (1) purchase electric power from electric utility companies, (2) participate in the development and operation of a major power generation project, and (3) generate electric power using Seward-owned power generation facilities. Potential power sources within these alternatives are:

1. Purchase of electric power

   - Chugach Electric Association
   - Anchorage Municipal Light and Power
   - Other electric utility companies

2. Participation in a major power generation project

   - Susitna hydropower project
   - Beluga coal-fired project
   - Bradley Lake hydropower project

3. Seward-owned generation projects

   - Diesel power generation
   - Hydropower projects
   - Other power generation projects

These alternatives are analyzed below.

Purchase of Electric Power

Chugach Electric Association

Electric power could continue to be purchased from CEA. The City of Seward is currently negotiating to purchase firm power from CEA under a new contractual agreement. Power would be priced using a one-component rate at approximately 21 to 23 mills per kWh. This price would increase over time subject to price escalation clause adjustments. Even though CEA has long-term, low-cost, fixed-price purchase contracts for much of its natural gas supply, electric power prices are still expected to increase in response to higher generation costs as new capacity becomes operational. If the present contracts for gas do not produce enough gas to meet the growing load, additional gas or substitute fuels would be even more expensive.

Electric power prices to the City of Seward are expected to increase by approximately 0 to 5 percent per year above inflation as a result of limitations currently being placed on the use of natural gas and oil as fuel. Because use of natural gas and oil is discouraged, if not prohibited, by the Fuel Use Act of 1978 and subsequent regulations of the Department of Energy, high-cost coal-fired and hydropower plants appear to be the only alternatives available for new generation. Because Seward is not considered a preference customer of CEA, the city will probably be required to pay much of the cost of converting and acquiring new and costly non-natural-gas-fired generating capacity. In effect, Seward will probably not obtain the full averaging benefit when purchasing CEA power even though CEA will be mixing low-cost existing capacity with higher cost new capacity.

The purchase price for power sold by CEA under the proposed contract with Seward is expected to be about 22 mills per kWh in 1980. It is anticipated that in 1985 the price will be 22 to 28 mills per kWh (1980 price levels). Purchase price escalation rates after 1985 are expected to be 0 to 5 percent above an assumed general inflation rate of 7 percent per year, for a total escalation rate of 7 to 12 percent per year. These energy prices include transmission costs to Seward.

Anchorage Municipal Light and Power Company

The City of Seward is considering a proposed contract with Anchorage Municipal Light and Power Company. Under the contract, Seward would buy interruptible power from Anchorage at a current cost of about 17 mills per kWh (1980 price levels) plus a "wheeling" charge for transmitting the power over CEA lines. Presently, there is no agreement between the City and CEA for wheeling power. The City is negotiating and has requested CEA to allow wheeling.

Anchorage Municipal Light and Power Company could be considered an immediate source of interruptible power. For this reason, it cannot be considered as an alternative to a hydropower project that is owned by Seward and that can be relied on for "firm" power. Should the City enter into a power contract with Anchorage Municipal Light and Power Company, consideration should be given to becoming a minority partner in any future investment of new generation sources.

Other Electric Utility Companies

Electric power could be purchased from other electric utility companies. One such company might be the Alaska Power Administration (APA). Because of a lack of information establishing the utilities that will be servicing the region and their future generating equipment, these alternative electric power sources cannot be characterized at this time.

Participation In Major Power Generation Project

Proposed Susitna Hydropower Project

Seward could participate in the development and operation of the proposed Susitna hydropower project and thereby obtain power from it. This facility is expected to become operational in 1994. The capacity and energy that could be made available to the City of Seward are unknown.

As in most electric power generating projects that will not become operational for many years, there is much uncertainty about the cost of electric power generated from this project. The APA estimates that in 1994 the project's electric power costs will be 47 mills per kWh (October 1978 prices) or 54 mills per kWh (1980 prices). After 1994 it can be expected that power costs will increase at rates considerably less than the inflation rate. These power costs include the transmission expenses to Anchorage only.

Proposed Beluga Coal-Fired Project

Seward could participate in the development and operation of the proposed Beluga coal-fired thermal electric power project(s) and thus obtain power from it. This facility is expected to become operational in the mid-1980's. The capacity and energy that could be made available to the City of Seward are unknown.

There is considerable uncertainty about the cost of electric power generated from the Beluga project. The APA estimates that in 1985 the project's power costs will be 52 to 64 mills per kWh (October 1978 prices) or 60 to 74 mills per kWh (1980 prices). Anchorage Municipal Light and Power Company estimates the power costs to be 52 mills in 1986 (1986 prices) or 34 mills per kWh in 1985 (1980 prices). After the project becomes operational in 1985, it can be expected that project power costs will increase at rates less than the inflation rate. These power costs include transmission expenses to Anchorage only.

Proposed Bradley Lake Hydropower Project

Seward could participate in the development and operation of the proposed Bradley Lake hydropower project and obtain power from it. The facility is expected to become operational in the mid-1980's. The capacity and energy that could be made available to the City of Seward are unknown.

As in the previous two projects, the cost for power from the Bradley Lake project is uncertain. The APA estimates that the project's power costs in 1985 will be 44 mills per kWh (1985 prices) or 34 mills per kWh (1980 prices). Anchorage Municipal Light and Power estimates the power costs to be 35 to 60 mills per kWh in 1986 (1986 prices) or 23 to 40 mills per kWh in 1985 (1980 prices). After 1985, the projected date for completion of the project, power costs can be expected to increase at rates considerably less than the inflation rate. These power costs include transmission expense to Anchorage only.

Seward-Owned Generation Projects

5,500-kW Diesel Standby Generating Plant

The City of Seward currently owns and operates a diesel-fired, 5,500-kW standby power generating plant. Because of the high cost of diesel fuel required for operation of this plant, it is used only when the power supply from CEA is interrupted or when necessary to maintain a reasonable voltage levels within the system. Prohibitively high diesel fuel oil costs result in this electric power source being used for emergency situations only. The expense of this plant is estimated to be 105 mills per kWh (1980 prices).

Hydropower Projects

A city-owned hydropower project(s) is an alternative electric power source. The energy cost for electricity generated from such a source is developed in the following chapters in this report. Power from a Seward hydropower project would be transmitted by construction of a new transmission line.

Other Seward-Owned Power Generation Projects

No other Seward-owned power generation projects can be identified as potentially feasible electric power sources available before 1990. Natural-gas- and oil-fired generation cannot be considered as alternative power sources because of severe Federal restrictions placed on use of these fuels. A Seward-owned coal-fired power generation facility would not be economically viable to construct and operate. To meet the needs of Seward alone, such a facility would be very small compared to conventional coal-fired units and would be costly on a per-unit basis.

Summary of Alternative Energy Sources

The alternative electric power sources available to the City of Seward are summarized in Table 2-2. Although there is considerable uncertainty regarding the costs of electric power generated from these alternative energy sources, these figures are the best available and were used in the economic and financial feasibility analysis described in Chapter 7.

Table 2-2
ALTERNATIVE ELECTRIC POWER SOURCES

Project Title	Owner	Type/Fuel	Purchase Participate Own	Installed Capacity (MW)	Year Available	1980 Energy Cost (1980 mills/kWh)	1985 Energy Cost[a] (1980 mills/kWh)
--	Chugach Electric	Primarily natural gas	Purchase	454.5	Present	21-23	28
--	Anchorage[b] Municipal Light and Power	--	Purchase	--	Present	17 (interruptible power)	NA
Susitna[b]	--	Hydropower	Participate	1,500-1,600	1993-1995	Not applicable	54
Beluga[b]	--	Coal-fired	Participate	200-500	1985-1986	Not applicable	34-74
Bradley Lake[b]	--	Hydropower	Participate	80-100	1985-1986	Not applicable	23-40
Seward Diesel	City of Seward	Diesel-fired	Own	5.5	Present	100+	100+

[a]Basis for energy cost comparisons.

[b]Transmission expense from Anchorage to Seward not included in energy cost estimates.

Chapter 3
PRELIMINARY RECONNAISSANCE

Several potential hydroelectric sites near the City of Seward have been investigated at various levels of detail over the last 30 years. Only one site, Cooper Lake, has actually been developed. The intent of the preliminary reconnaissance portion (Chapter 3) of this study was to gather data on the previously studied hydropower developments near Seward and determine which project is most desirable for development by the city. The remainder of this report presents a feasibility assessment of the preferred site recommended in this chapter. A list of all previous studies is contained in the References of this report.

PREVIOUSLY STUDIED PROJECTS

Two recently completed studies reviewed the hydroelectric options available to the city. CH2M HILL's Reconnaissance Study of Hydroelectric Power Alternatives (Ref. 10) investigated four hydroelectric sites that could be developed by the city. CH2M HILL's Reconnaissance Feasibility Study, Hydroelectric Potential on Lowell Creek (Ref. 11) looked at three potential low-head sites that could be developed by the city.

The conclusion of the reconnaissance study was that both Grant and Crescent Lakes could be economically developed for hydropower generation, but that Grant Lake was the preferred site because less environmental impact was expected. Sites on the Resurrection and Snow Rivers were considered infeasible due to excessive environmental impacts.

None of the three alternatives considered on Lowell Creek proved to be feasible as a result of the intermittent flow of the creek and the low heads that were proposed. A storage project on Lowell Creek was not considered feasible because of the site's characteristics and proximity to the city.

From these recently completed studies and a review of earlier reports, it was determined that four potential hydropower projects should be considered for this preliminary reconnaissance. These projects are at:

- Crescent Lake
- Grant Lake
- Ptarmigan Lake
- Grant/Ptarmigan Lakes

All four projects were studied in the 1950's and 60's (Ref. 26), and all the projects were granted preliminary permits by the Federal Power Commission (now FERC).

EVALUATION OF ALTERNATIVE PROJECTS

Environmental Feasibility

From the earlier studies and again from the more recent studies, all four projects appeared to be technically and economically feasible. As a result, the environmental feasibility of all four projects was assessed at a screening level. A meeting with environmental agencies and concerned citizen groups was held on October 3, 1979, to explain the development concept for each project and to determine which project would have the least environmental impact. The results of that meeting and a list of attendees is contained in Appendix A.

It was the consensus of all the meeting participants that the environmental impact of the Crescent Lake project would be extreme. Impacts on Ptarmigan Lake would be less severe, and the Grant Lake project would have the least environmental impact.

As a result of that meeting, it was decided that Crescent Lake should be dropped from consideration at this time. However, the environmental factors alone could not be used to determine whether Grant Lake, Ptarmigan Lake, or the Grant/Ptarmigan project is most desirable.

Cost Comparison

To evaluate which of the three remaining projects should be studied at the feasibility level, a reconnaissance-level cost comparison was made. The costs and benefits prepared for this reconnaissance assessment should be considered rough estimates prepared primarily to direct the efforts of the remainder of the feasibility assessment.

This comparison was begun by performing a preliminary assessment of the costs and benefits of the Grant/Ptarmigan project. This project is the most comprehensive of the three and includes all the features of the remaining two. The Grant/Ptarmigan project involves the connection of Grant Lake, Ptarmigan Lake, and Falls Creek by tunnels or pipelines. As shown in Figure 3-1, this concept would require either 3.5 miles of tunnel, 5.0 miles of pipeline, or a combination of 1.2 miles of tunnel and 2.2 miles of pipeline.

The primary benefits associated with the Grant/Ptarmigan project came from the addition of Falls Creek water to the system and the consolidation of all generation in one powerhouse. Approximately 7,000,000 kWh could be generated with the additional water from Falls Creek; at 4¢ per kWh, this is worth $280,000 per year. At 7 percent interest over a period of 50 years, the additional energy would be worth

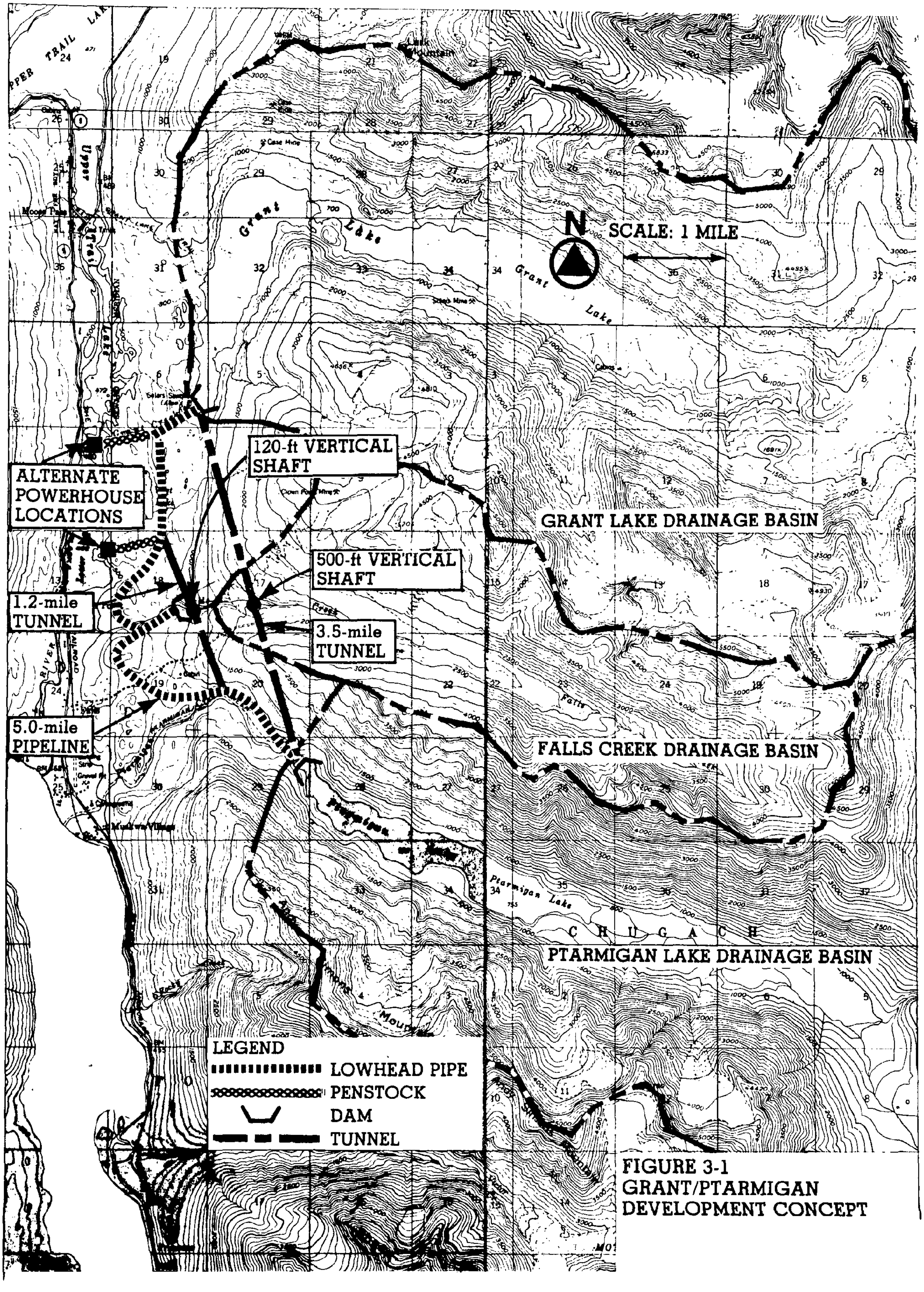


FIGURE 3-1
GRANT/PTARMIGAN
DEVELOPMENT CONCEPT

$3.9 million. The consolidation of the generation in one powerhouse was estimated to be worth $500,000. The combined benefit of the Grant/Ptarmigan project would, therefore, be $4.4 million in 1980 dollars.

The cost of the required pipeline and tunnel for Grant/Ptarmigan is estimated to be $1.6 million and $7.9 million per mile, respectively. For the three alternative routes, the least-cost route, consisting of pipeline only, would cost in excess of $8 million, or almost twice the estimated benefit. Thus, the combination of Grant and Ptarmigan Lakes does not appear feasible because of the high cost of the required pipeline.

It is possible, as shown in Figure 3-2, to divert the Falls Creek water to either Grant Lake or the Ptarmigan Lake penstock. The cost for such a diversion is $3.5 million to Grant Lake and $2.4 million to the Ptarmigan penstock. Compared to the estimated $3.9 million benefit, either of these concepts appears worthwhile.

The Grant Lake project, with diversion of Falls Creek water into Grant Lake, is the most desirable of the three alternatives and was selected for the feasibility study. This project would have the fewest environmental impacts, and it would generate more energy than the Ptarmigan Lake project.

The Ptarmigan Lake project should be considered in the future for development, but it is unlikely that the project could include a powerhouse on Kenai Lake. The reason for this is that the lower few miles of Ptarmigan Creek are a very productive salmon spawning area. The Ptarmigan Lake project would have to provide instream flow maintenance for this reach, so that most of the flow in the stream would not be available for power generation.

An alternative method of developing the Ptarmigan Lake project would be to site the powerhouse on Ptarmigan Creek above the salmon spawning areas. This would allow for the majority of the streamflow to pass through the powerhouse and generate energy, although the available head would be reduced. This method could actually enhance the salmon resources by guaranteeing minimum flows.

The diversion of Falls Creek water into such a Ptarmigan Lake project would, however, pose environmental problems. The temperature of the Falls Creek water is apparently too cold to support salmon rearing, as shown by the fact that salmon do not currently use Falls Creek for a spawning area. The diversion of Falls Creek water into Grant Lake is not expected to cause as great a problem because the cold Falls Creek water will either mix with the water in Grant Lake water or travel as a density current to the bottom of the very deep lake.

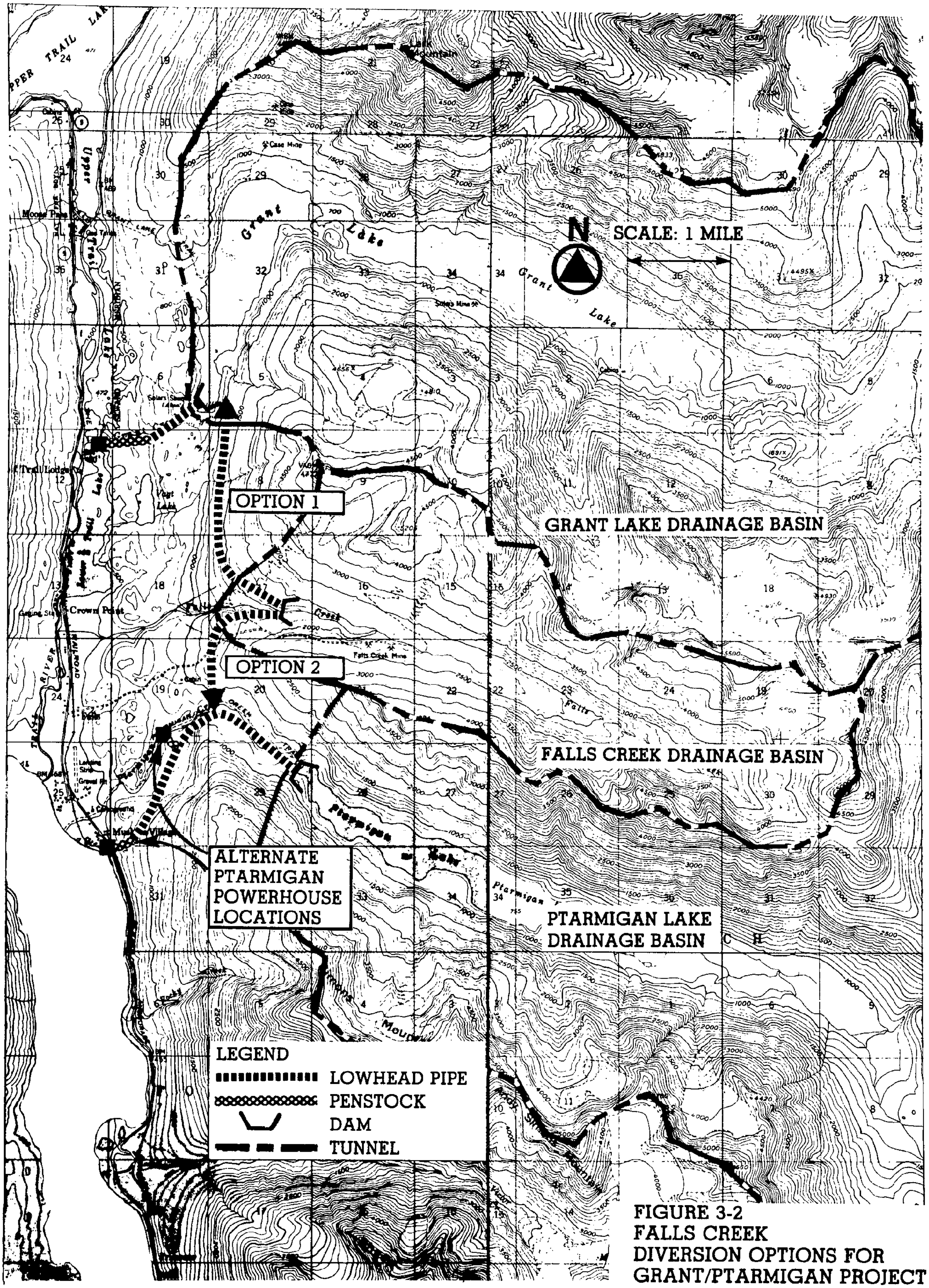


FIGURE 3-2
FALLS CREEK
DIVERSION OPTIONS FOR
GRANT/PTARMIGAN PROJECT

The results of the preliminary reconnaissance are:

- The Grant Lake project, with a diversion from Falls Creek, is the preferred alternative and, as such, it should be the subject of the feasibility study.

- The Crescent Lake project does not seem to be developable at this time because of environmental factors.

- The Grant/Ptarmigan project is not and probably will never be as desirable as developing Grant Lake and Ptarmigan Lake separately.

- The Ptarmigan Lake project, with a powerhouse on Ptarmigan Creek and with proper operations to enhance the salmon fishery, should be investigated in the future at the feasibility level.

The remainder of this report (Chapter 4 through 8) deals only with the preferred alternative, Grant Lake with the option of the diversion from Falls Creek.

Chapter 4
POWER POTENTIAL OF GRANT LAKE/FALLS CREEK

CLIMATE AND HYDROLOGY

The Grant Lake basin and surrounding area is in a transition zone between continental and maritime climates. The maritime influence supplies relatively large quantities of moist air and moderating temperatures. The effects of the mountains on the weather cause localized areas of heavier than average precipitation. The influence of continental climate can cause extreme cold temperatures. Considerable variability in precipitation can be expected throughout the area, depending principally on elevation. Numerous glaciers exist at the higher elevations, indicating long-term heavy snowfall and cold temperatures.

Temperature

The average temperature recorded at Moose Pass, 2 miles west of Grant Lake, is 34.8 degrees F, with extremes of 90 degrees F and -48 degrees F. In comparison, the average temperature recorded at Seward, approximately 30 miles south of Grant Lake, is 39.6 degrees F, with extremes of 98 degrees F and -20 degrees F. Temperatures in the Grant and Falls Creek basins will, at the lower elevations, be close to those recorded at Moose Pass and Seward; at the higher elevations, temperatures will be colder. Because both basins run east-west, extensive portions of the basins are either on north- or south-facing slopes. Considerable temperature variations can be expected between these, with south-facing slopes being much warmer. This effect is significant in the spring and early summer and causes rapid snowmelt on south-facing slopes.

Precipitation

The mean annual precipitation recorded at Seward is 63 inches and at Moose Pass, 33 inches. Recorded flows on Grant Creek show a basin average runoff of 60 inches. Similar amounts can be expected in the Falls Creek basin. Although Moose Pass is close to these drainage basins, it is at a much lower altitude and between several significant peaks; consequently, it receives much less precipitation. The wettest months in this area are in late summer and early fall. The driest months are in late spring and early summer.

Drainage Basins

Grant Creek

Grant Creek has a drainage area of approximately 44.5 square miles at its mouth (see Figure 4-1). The outlet of Grant Lake, 1.1 miles upstream from the mouth of Grant Creek, has a drainage area of 43.5 square miles. The majority of the drainage basin rises from Grant Lake at elevation 700 feet to a maximum elevation of 5,883 feet. The mean elevation is 2,900 feet. Flow is generally from east to west. Grant Creek has a gradient of 207 feet per mile. Several creeks flow into Grant Lake, the steepest having a gradient of over 2,500 feet per mile. Grant Lake has a surface area of 2.5 square miles, 5.5 percent of the total basin area. U.S. Geological Survey (USGS) maps show several glaciers within the Grant Creek basin with a total area of 5.3 square miles, or 12 percent of the basin area. A USGS open file report indicates 18 percent glacial coverage (Ref. 26).

Falls Creek

Falls Creek has a drainage of 11.9 square miles at its mouth (see Figure 4-1). At the 1,000-foot level, the drainage area is 11.1 square miles. The drainage basin rises from Trail River at elevation 457 feet to a maximum elevation of 5,800 feet The mean elevation is 3,480 feet. The flow is generally from the east to the west. Falls Creek has an average gradient of 477 feet per mile. There are no lakes within the drainage basin. USGS maps show that the Falls Creek basin has three glaciers, with a total area of 0.5 square mile (4 percent of the basin area). The USGS open file report indicates 6-percent glacial coverage (Ref. 26).

Streamflow Records

Grant Creek was gaged for 11 years at a location 0.3 mile upstream from the mouth of Grant Creek. This record is the primary source of hydrologic data for the Grant Creek basin. Because the gage is downstream from Grant Lake, the gage data reflect natural evaporation in the lake. Continuous gage records are not available for Falls Creek.

The gages used in this study are listed in Table 4-1. No manmade regulation except the Cooper Lake project on the Kenai River affects these records.

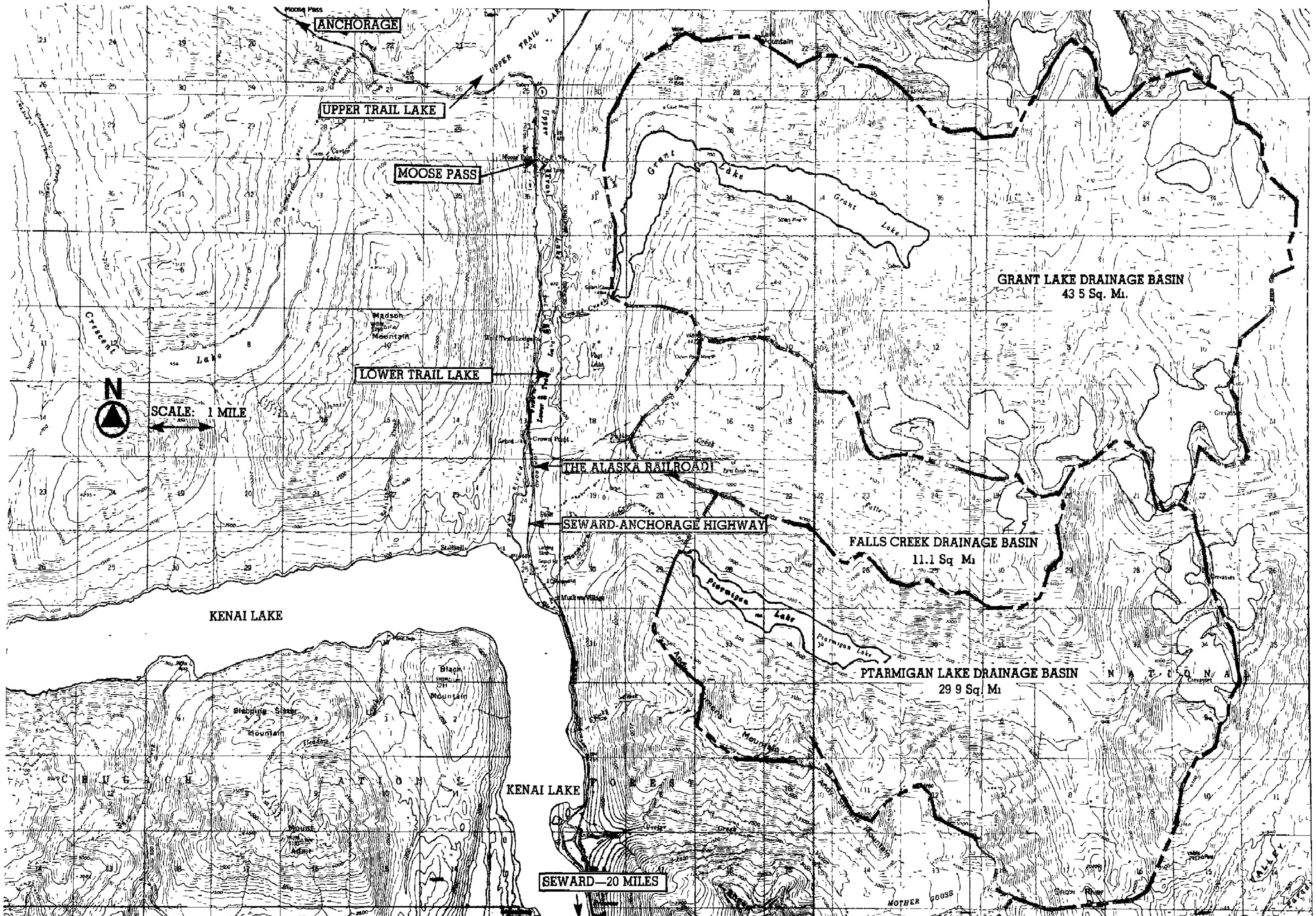


FIGURE 4-1
GRANT LAKE, FALLS CREEK, AND PTARMIGAN LAKE DRAINAGE BASINS

Table 4-1

AREA STREAM GAGES

Name	USGS No.	Drainage Area at Gage (sq mi)	Period of Record Water Year
Grant Creek	2460	44.2	1948-1958
Trail River	2480	181.0	1948-1974
Ptarmigan Creek	2440	32.6	1948-1958
Crescent Creek	2540	31.7	1950-1966
Kenai River	2580	634.0	1948-current

STREAMFLOW CHARACTERISTICS

For the 11 years of record on Grant Creek, water year 1952 had the least annual flow, 162 cubic feet per second (cfs); 1953 had the most, 304 cfs; and 1958 had the average annual flow, 190 cfs. The hydrographs for these water years are shown in Figure 4-2.

The use of the streamflow data from nearby gaged streams (Table 4-1) allowed an extension of the data for Grant Creek. A Corps of Engineers' computer model, HEC-4 Monthly Streamflow Simulation, (Ref. 14) was used for this analysis. A total of 31 years of monthly data for Grant Creek, 11 recorded and 20 reconstituted by correlation, yielded an average annual flow of 190 cfs, with a high of 304 cfs and a low of 140 cfs. The correlation was very good with most of the months of record. The annual and monthly flow duration curves for the Grant Creek gage are shown in Figure 4-3.

Additional hydrologic analysis of the Kenai River flows is recommended for future studies. Jokulhlaups (the Icelandic term for glacier outburst floods) on the Snow River cause significant floods on the Kenai River. These peak flows are the result of the sudden release of 2 to 3 years of storage within the Snow River glacier. This effect was not considered in the feasibility study and could slightly affect the expected energy output from Grant Lake, because the flow records for Grant Lake were extended based on correlation with the Kenai River gage.

Peak flood frequency data were calculated using the Log-Pearson type III method on the recorded peak flows of Grant Creek. Because only 11 years of record are available, the estimated recurrence interval of floods is reliable only to about the 25-year flood. Table 4-2 shows the peak flows and their associated recurrence intervals.

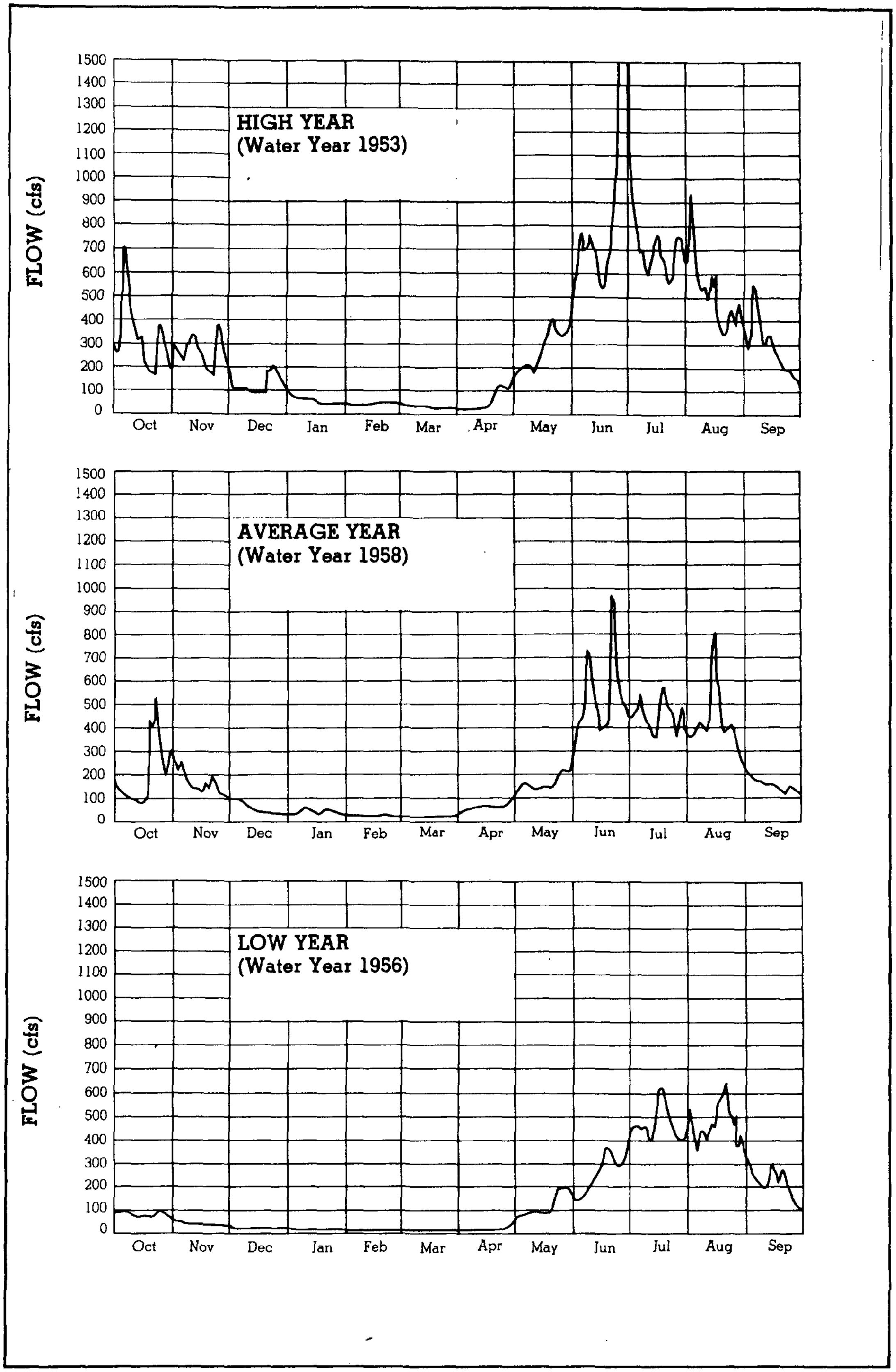


FIGURE 4-2
HYDROGRAPHS OF GRANT CREEK
AVERAGE DAILY FLOW

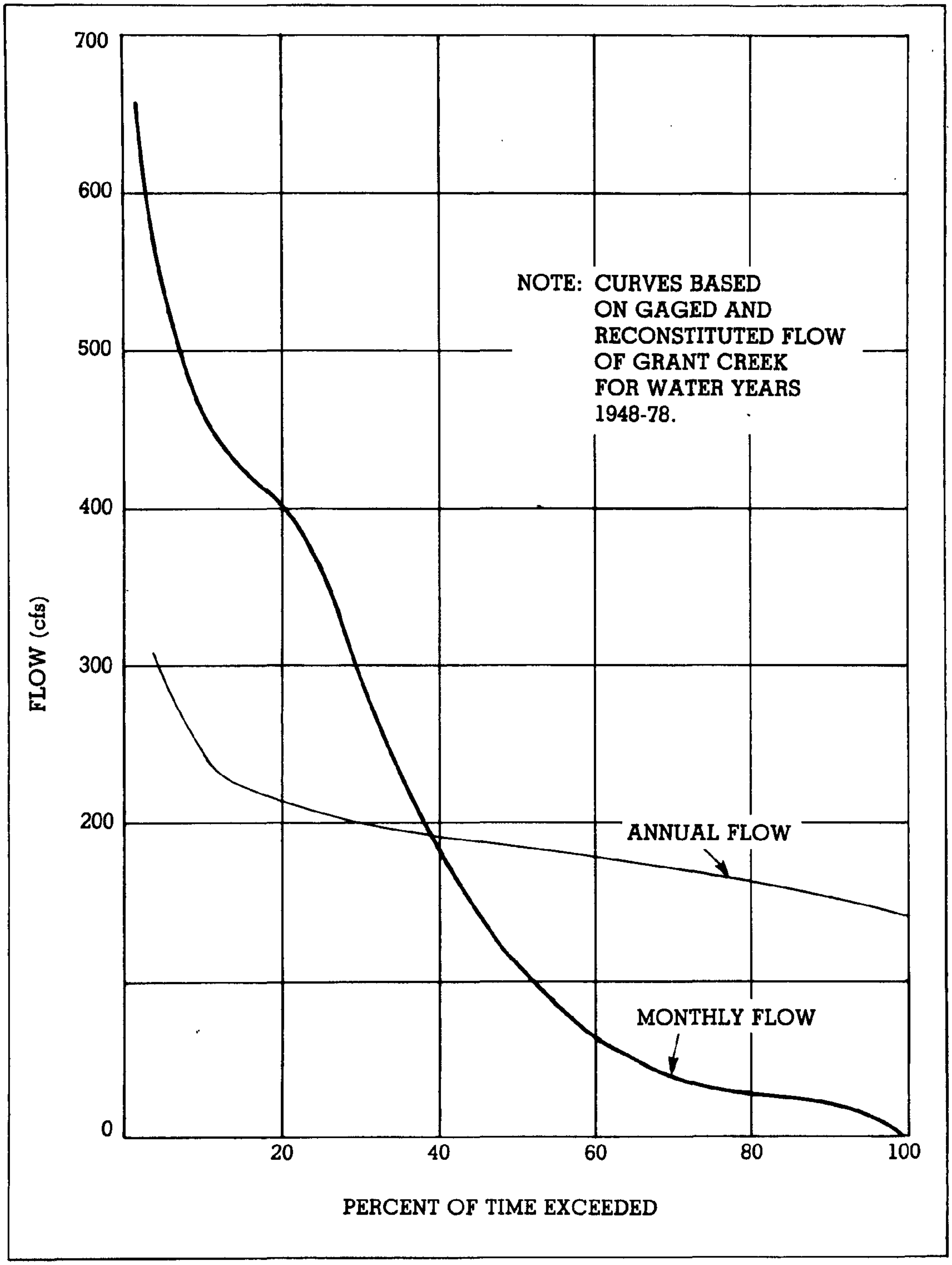


FIGURE 4-3
GRANT CREEK
FLOW DURATION CURVES

Table 4-2
GRANT CREEK FLOOD FREQUENCY DATA

Recurrence Interval (years)	Peak Flow (cfs)
2	850
5	1,190
10	1,500
25	2,000
50*	2,500
100*	3,050

NOTE: Data from USGS Gage 2460; period of record is 1948-58.

*Peak flow estimates at these recurrence intervals are not considered reliable because of the short period of record.

For Falls Creek, 11 years of monthly flow data were calculated by averaging the yields of Grant Creek and Ptarmigan Creek for each month of recorded streamflows. The HEC-4 model was used to reconstitute, by correlation, 31 years of data for Falls Creek. This correlation was very good. Flood flows were not calculated for Falls Creek because individual peak events have not been recorded and the level of effort for a regional analysis was not warranted for this study.

Reconstituted mean monthly flows calculated from the data are presented in Table 4-3 for Grant and Falls Creeks.

Table 4-3
MEAN MONTHLY FLOWS FOR GRANT CREEK AND FALLS CREEK

	Mean Monthly Flow (cfs)												Mean Annual Flow (cfs)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Grant Creek	167	113	58	35	33	25	32	164	431	503	403	306	190
Falls Creek	41	29	16	9	8	6	8	39	101	116	96	76	45

EXPECTED ENERGY AND CAPACITY

Project Components

A detailed description of four alternative ways to develop Grant Lake is given in Chapter 5. The components of the four alternatives are briefly described below to provide a basis for determining the project energy and capacity.

Reservoir

The surface area of Grant Lake is equal to 5.6 percent of the lake's total contributing drainage area. This characteristic allows for development of considerable reservoir storage by constructing a relatively small dam. The volume and area curves for the Grant Lake reservoir are shown in Figure 4-4. The shapes of these curves reflect the steep shoreline of the lake.

The mean annual flow of 190 cfs (approximately 139,000 acre-feet) is distributed throughout the year as shown in the hydrographs in Figure 4-2. By routing the monthly inflow, for several different water years, it was determined that 78,000 acre-feet of storage will provide 100 percent regulation of the runoff in average years. A dam at the outlet of Grant Lake was considered the most desirable method of obtaining the required storage. A lake tap concept in which the storage would be obtained below the natural level of Grant Lake was considered but not used. The lake tap would be more costly to construct, and it would result in lower operating heads and thus less energy.

The required storage can be obtained by a 78-foot-high dam with an ungated spillway crest at elevation 750. The crest of the dam would be at elevation 768. The centerline of the intake to the penstock would be at elevation 690; this would allow the reservoir to be drawn down to elevation 700. The forebay elevations for power generation would, therefore, range between a minimum of 700 and a maximum of 750. During floods in extremely wet years, the spillway would be used to pass excess flows. Forebay elevations during these periods would range between 750 and 765, the maximum elevation during the probable maximum flood.

Penstock

The flow capacity of the penstock was set equal to 380 cfs, twice the mean annual flow of Grant Creek. The reason for this flow figure is that the reservoir provides enough storage to allow for a constant year-round draw of 190 cfs. With a desired 50-percent plant factor, the penstock will sometimes be required to deliver 380 cfs.

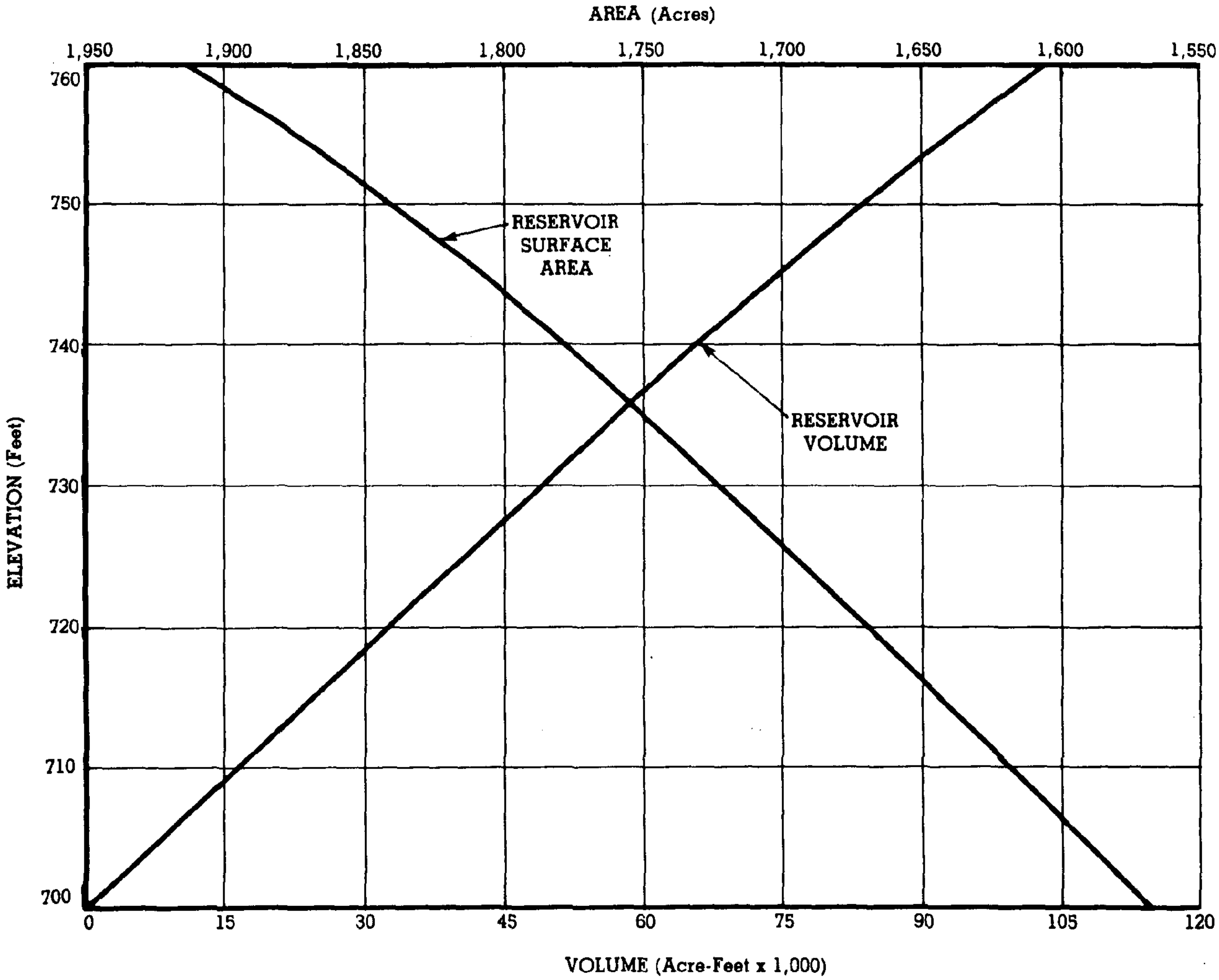


FIGURE 4-4
GRANT LAKE RESERVOIR VOLUME
AND SURFACE AREA CURVES

From the dimensions and alignment of the penstock for each of four alternative powerhouse locations, head losses were calculated over a full range of flow conditions.

Tailrace Elevations

The four alternative powerhouses do not discharge to the same body of water. Table 4-4 shows the body of water to which each powerhouse discharges and the average range of tailrace elevations used for this study. In future studies, these elevations will have to be refined by field observation and measurements.

Table 4-4
CHARACTERISTICS OF
GRANT LAKE ALTERNATIVES

	Alternative			
	1	2	3	4
Discharges to:	Upper Trail Lake	Upper Trail Lake	Grant Creek	Upper Trail Lake
Forebay Elevation (ft)				
Maximum	750	750	750	750
Minimum	700	700	700	700
Tailrace Elevation (ft)				
Maximum	472	472	520	468
Minimum	468	468	520	464
Gross Head (ft)				
Maximum	282	282	230	286
Minimum	228	228	180	232
Full Gate Flow (cfs)				
2 Units @ 190 cfs each	380	380	380	380
Head Loss @ Fullgate Flow (ft)	19	27	23	35
Maximum Net Head @ Fullgate Flow (ft)	263	255	207	251
Turbine/Generator Capacity at Fullgate and Maximum Head (assumed 86-percent overall efficiency, kW)				
Each unit	3,640	3,530	2,870	3,480
Both units	7,280	7,060	5,740	6,960

The water surface elevation in the tailrace of each alternative powerhouse had to be approximated. The elevations for both Upper and Lower Trail Lakes in July of 1950 were noted on the USGS topographic map of Grant Lake (Appendix B). The rating curve for the USGS stream gage on the Trail River just below Lower Trail Lake was also used.

Both Upper and Lower Trail Lakes were assumed to fluctuate 2 feet above and below the elevations given in the USGS maps. The 100-year flood level for both lakes was assumed to be 4 feet above the recorded elevation. Powerhouse 3 was sited on Grant Creek to maintain near-normal flows in Grant Creek for fish maintenance. The tailrace elevation for this alternative was assumed to be constant for all flows.

Installed Capacity

The proposed Grant Lake Reservoir, with 78,000 acre-feet of storage, provides many options for installed capacity of the powerhouse. Under current power market conditions in the area, there is no premium placed on peak power at the wholesale level. The city pays only for the total amount of energy used, not for the rate of use. Under these market conditions the installed capacity of the powerhouse would normally be determined on the basis of energy production rather than peaking capability.

The location of the city on the regional grid and the harsh terrain over which the transmission lines are routed require that, at certain times, Grant Lake act as a backup for the city. As a result, it was determined that two equal-sized turbine/generator units, each with a fullgate flow capacity of 190 cfs, should be installed. No attempt was made to place an economic value on this added capacity or to optimize it with regard to energy production. The main thrust of this study was to determine which powerhouse location was preferred rather than to perform a detailed optimization of the installed capacity. The fullgate capacity of each alternative is given in Table 4-4.

System Operations and Expected Energy

System Operations

The combination of reservoir storage and powerhouse capacity provides for a great deal of flexibility in the operation of the Grant Lake hydropower project. Under average water year conditions, the project could be operated strictly as a base load plant, with use of only one unit at full gate 24 hours a day for the whole year. In contrast, under the same conditions the plant could be operated at full capacity for a 12-hour period each day. In an emergency when regional power is not available, the plant could be operated at full capacity for extended periods until regional power is restored.

To estimate the average annual energy avilable from each of four alternatives, operations studies were conducted. These studies were performed on the U.S. Army Corps of Engineers computer program HEC-3 (Ref. 13), a program that performs reservoir system analysis based on monthly flow data.

The 31 years of actual and reconstituted monthly flows for Grant and Falls Creeks were used in the operations studies. The operational constraints imposed on the model are in the form of maximum flow releases for power at prescribed elevations. The intent is to keep the reservoir as high as possible to maximize head and thus energy. However, keeping the reservoir too high will force spills to occur during high-flow years. The operation policy used for this study is shown in Table 4-5.

Table 4-5
POWER OPERATION POLICY

Reservoir Surface Elevation (feet)	Average Daily Power Flow (cfs)	Comment
700	0	Reservoir empty
705	75	Minimal flow to build head
710	150	Increase flow
720-740	170	Mean annual flow
Above 740	380	Avoid spill

Figure 4-5 shows how the discharge and lake level of Grant Lake would change during project operation in an average water year. The preproject discharges are also shown for comparison. Under natural conditions Grant Lake fluctuates between elevations 696 and 701.

The above operation policy is only one way to operate the project. Under this policy the reservoir level is kept fairly high and very few spills occur, even during extremely high flow years. Future operation studies should include the consideration of higher minimum storage elevations and higher dam crests to maximize head and still try to minimize spills. It can be seen in Figure 4-5 that during the average year neither the full storage capacity nor the full plant capacity was actually stressed.

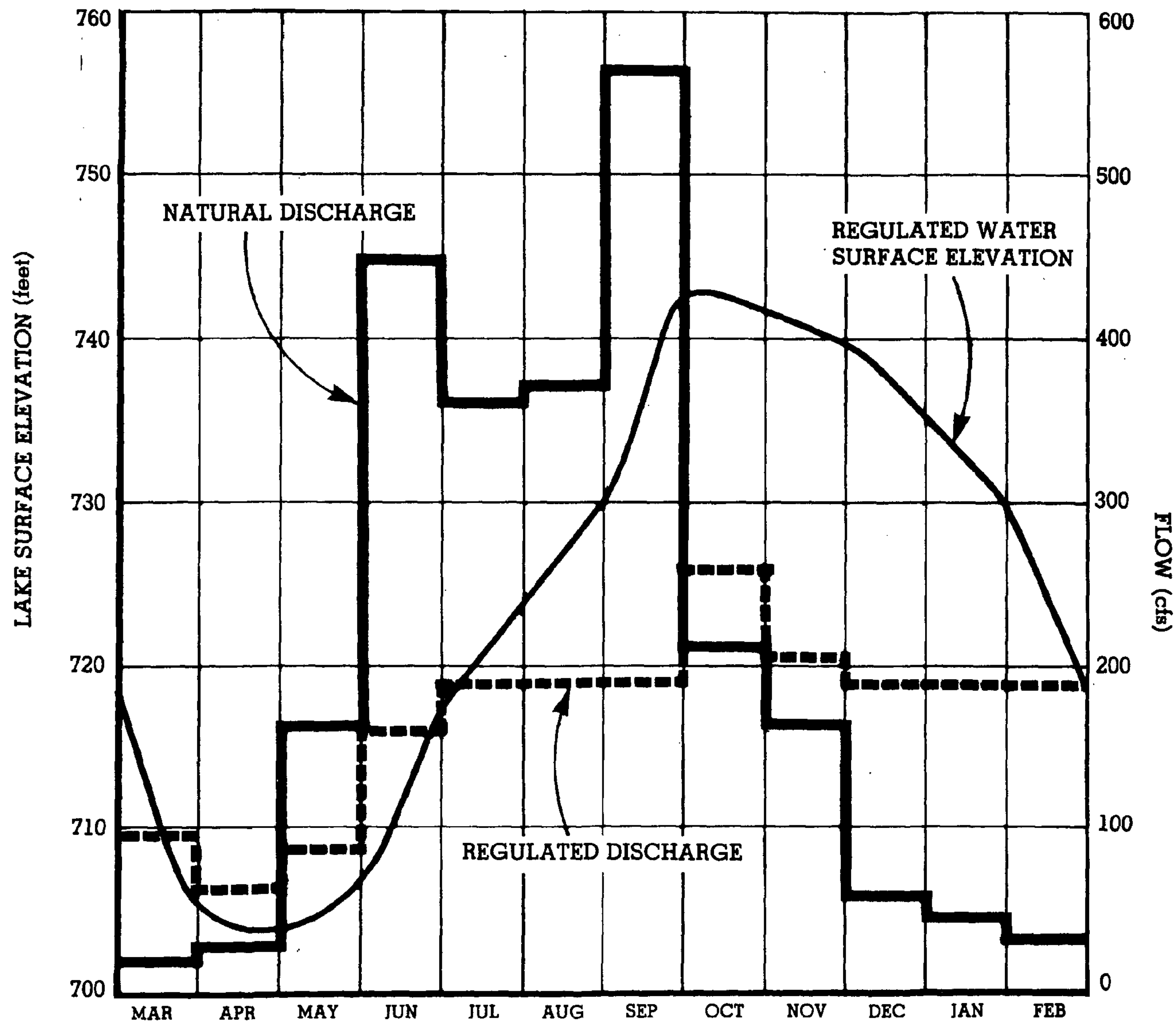


FIGURE 4-5
HYDROGRAPHS OF GRANT LAKE DISCHARGE
AND WATER SURFACE ELEVATION

Expected Energy

The expected energy production from the four alternative powerhouses was calculated as part of the HEC-3 operation studies. In addition, the expected energy from the addition of the Falls Creek diversion was calculated.

The energy was calculated assuming an overall efficiency of 86 percent at the bus bar. A reduction of 5 percent was applied to account for transmision line losses between the powerplant and the city's meter at the Seward-Anchorage Highway near Falls Creek. Table 4-6 shows the expected energy production.

Table 4-6
EXPECTED ENERGY PRODUCTION

Alternative	Annual Energy (million kWh) Average	Maximum	Minimum
No. 1			
Without Falls Creek	27.3	39.3	18.9
With Falls Creek	32.8	45.8	24.4
No. 2			
Without Falls Creek	26.3	38.6	18.2
With Falls Creek	31.8	44.9	23.7
No. 3			
Without Falls Creek	21.0	31.4	14.3
With Falls Creek	25.6	36.6	18.7
No. 4			
Without Falls Creek	26.0	38.3	17.9
With Falls Creek	31.4	44.6	23.3

Note: Energy delivered at the City of Seward's meter at the Seward-Anchorage Highway near Falls Creek.

Chapter 5
PROJECT DESCRIPTION OF GRANT LAKE/FALLS CREEK

Feasibility-level designs for four alternative ways of developing the Grant Lake hydropower project are presented in this chapter. Feasibility-level designs are necessary to identify potential problems in development of the project, generally identify and describe the needed project components, and establish a technical basis for developing the cost estimates needed in assessing project feasibility.

The project area is shown in Figure 5-1.

BASES FOR FEASIBILITY-LEVEL DESIGNS

Topographic Data

Because Grant Lake was identified in previous studies as a potential site for hydroelectric development, the mapping done for the earlier studies is adequate for the purposes of this study. Thus, no surveys were conducted and no maps were prepared for this study. Any subsequent detailed project studies will require refined mapping and surveying at the selected site. The topographic maps used in this study include:

- Seward Alaska, at a scale of 1:250,000 with a contour interval of 200 feet, published by U.S. Geological Survey
- U.S. Geological Survey quadrangle sheets Seward (B-6), and Seward (B-7), at a scale of 1:63,360 with a contour interval of 100 feet.
- Grant Creek and Grant Lake, Alaska, at various scales, prepared by the U.S. Geological Survey, 1951. (Prepared especially because Grant Lake was identified as a potential hydropower site. This map is reproduced in Appendix B.)

Geologic Conditions

Geologic investigations were conducted consisting of a 1-day site visit and a review of the geologic literature for the area. The remainder of this section briefly summarizes geologic conditions of the project site. Additional geologic detail is provided in Appendix C.

Geology. The project area is located in the Border Ranges geologic province of Alaska. All of the project facilities are underlain by rocks of the Valdez Group. The Valdez Group consists of interbedded graywacke sandstone and shale

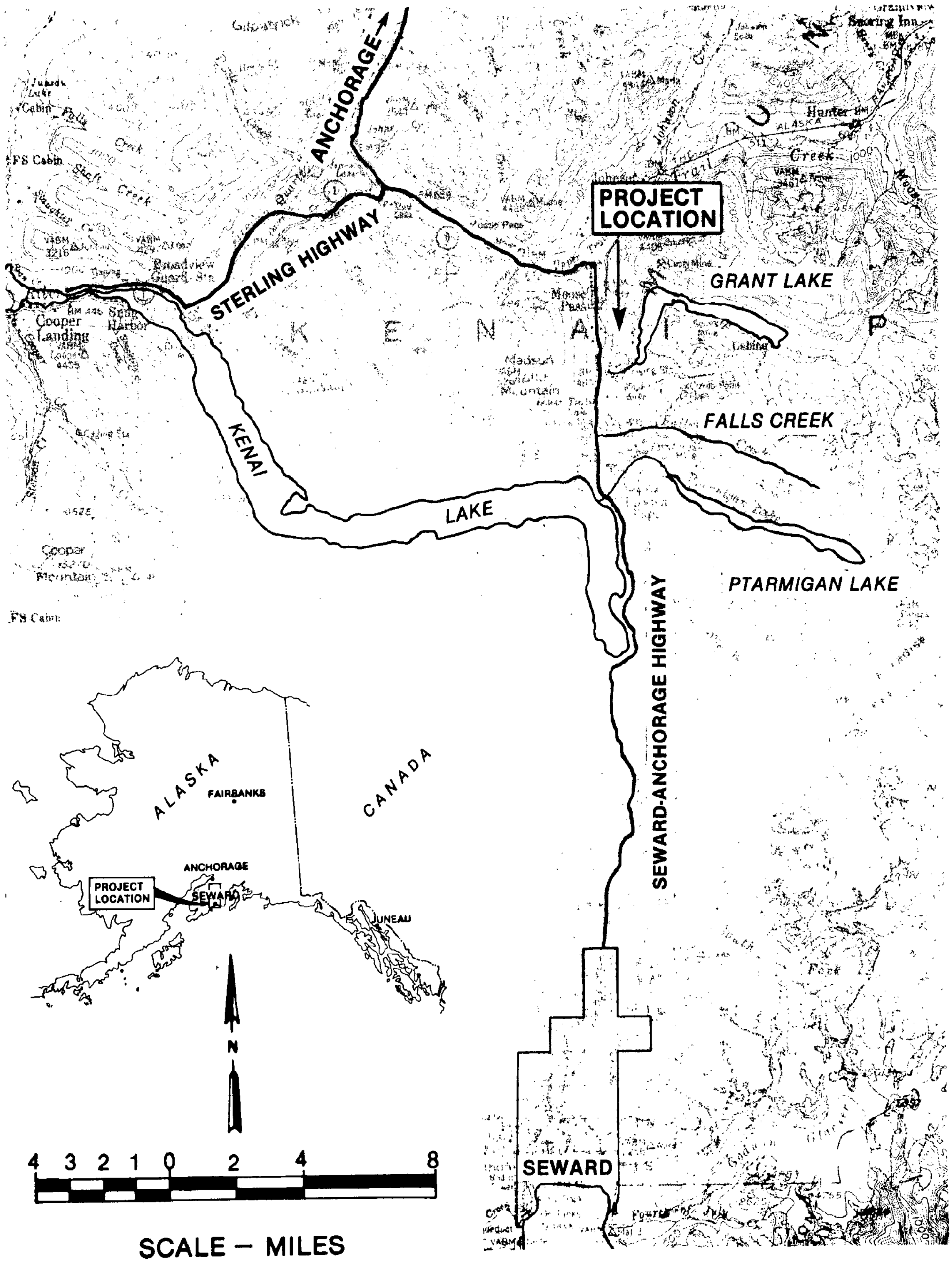


FIGURE 5-1
VICINITY MAP

that has been slightly metamorphosed, producing foliation in the sandstones and converting the shale into slates. The metamorphism was associated with deformation that folded the rocks to a steep dip in the project area.

Glaciation has produced the steep walled, U-shaped valleys that contain Grant and Upper and Lower Trail Lakes. The retreat of the glaciers to higher elevations has left occasional moraine and till deposits.

The sandstone found at the site is hard, fine- to medium-grained rock, moderately jointed, of probably average permeability. The slate is hard and thin-bedded and breaks along cleavage planes parallel to the bedding. The bedding strikes north and dips 40 to 50 degrees to the east.

Geologic maps and high-altitude NASA color infrared aerial photographs reveal east-west faults and linear features. Further study is needed to establish the nature of these linear features and the seismic activity of the faults.

Engineering Considerations. The dam would be placed on the sandstone bedrock; this should provide a good foundation having no visible signs of weak or compressible layers. The orientation of the bedding is favorable and excessive seepage is not expected to be a problem. A fault has been mapped on the south abutment; the activity and character of this fault requires further investigation.

An unlined open-cut rock spillway through the left abutment should be resistant to water flow.

The northern-most and preferred pipeline-penstock route would be along a linear feature that might be a fault. A saddle dam would also be on this linear feature. Further investigation of this site will be required.

There are no fine-grained soils available for earth dam construction. Rock removed from the required excavations should produce satisfactory rockfill. Rockfill embankments with an upstream membrane of concrete should provide satisfactory dams for the main and saddle dams.

Seismicity. Since 1964, 271 earthquakes with a Richter magnitude greater than 4 have occurred within about 90 miles of the site. Included in this figure is the 1964 Good Friday earthquake of magnitude 8.4, which was centered in Prince William Sound.

Strong earthquake motions could occur in the area, and designs would have to provide for bedrock accelerations of up to about 0.4 g's.

A potential hazard exists if, during an earthquake, a fault ruptures or moves under either the main dam or saddle dam. The activity of these faults must be assessed, but our current belief is that these faults are probably not active and should not be considered as affecting the project feasibility unless later evidence indicates otherwise.

Suitability of the Site. Generally, the site appears geologically suitable for the planned development. Further investigations will be necessary to confirm geologic conditions. These investigations should include:

- Test drilling at the dam sites and powerhouse
- Investigations of faults at proposed structures
- Evaluation of reservoir shoreline stability during earthquakes
- Further evaluation of seismic activity
- Exploration along planned roads and pipelines

Hydrologic Studies

In addition to the hydrologic and power operation studies presented in Chapter 4, an approximate probable maximum flood (PMF) was calculated for the Grant Lake drainage basin by using standard hydrologic techniques. An inflow PMF peak of 84,000 cfs was calculated. Routing the inflow PMF through Grant Lake for various widths of the spillway gave a curve of maximum lake level versus spillway width.

For an uncontrolled rock spillway with the crest at elevation 750 (see Chapter 4), the width of the spillway was chosen to give a safe routing for the PMF and to provide the proper volume of rock for the construction of the main dam. These requirements resulted in selection of a 125-foot-wide spillway that would give a maximum water surface elevation of 765 and an outflow discharge of 19,200 cfs.

Major Project Components

The basic size of the project components was established from the hydrologic and power generation studies described in Chapter 4. The hydrologic and power studies resulted in a spillway crest set at elevation 750 to provide 78,000 acre-feet of storage between that level and elevation 700.

In addition, the selected project capacity established a flow requirement of 380 cubic feet per second to be delivered to the powerhouse.

The following are the major project components that were established:

- Main dam 78 feet high, proposed as a rockfill dam with the upstream concrete membrane located at the outlet of Grant Lake

- 30-foot-high saddle dam, proposed as a rockfill dam with an upstream concrete membrane situated on the topographic saddle near Portage Trail

- An unregulated rock-cut overflow spillway with a crest elevation of 750

- A low-pressure, 7-foot-diameter steel pipe and intake to deliver 380 cfs from the lake to the surge tank. The route would be across the low area between Grant Lake and Upper Trail Lake (see Figure 5-2)

- A surge tank structure at the end of the low-pressure pipe

- An exposed 5.5-foot-diameter steel penstock leading from the surge tank to a bifurcation just outside the powerhouse

- Concrete powerhouse structure to house two turbine/generator units and appurtenant equipment

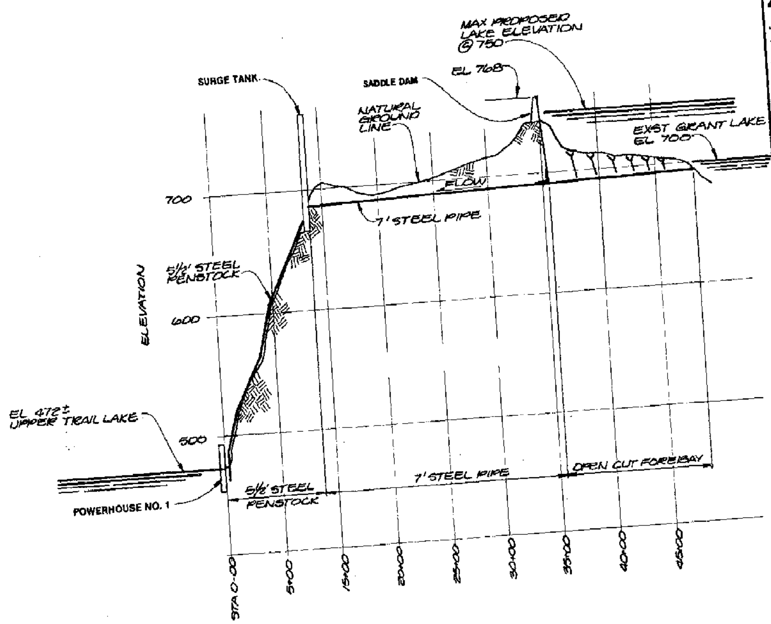
- Related access roads

- 69-kV transmission line from the powerhouse to the City of Seward's Falls Creek metering point

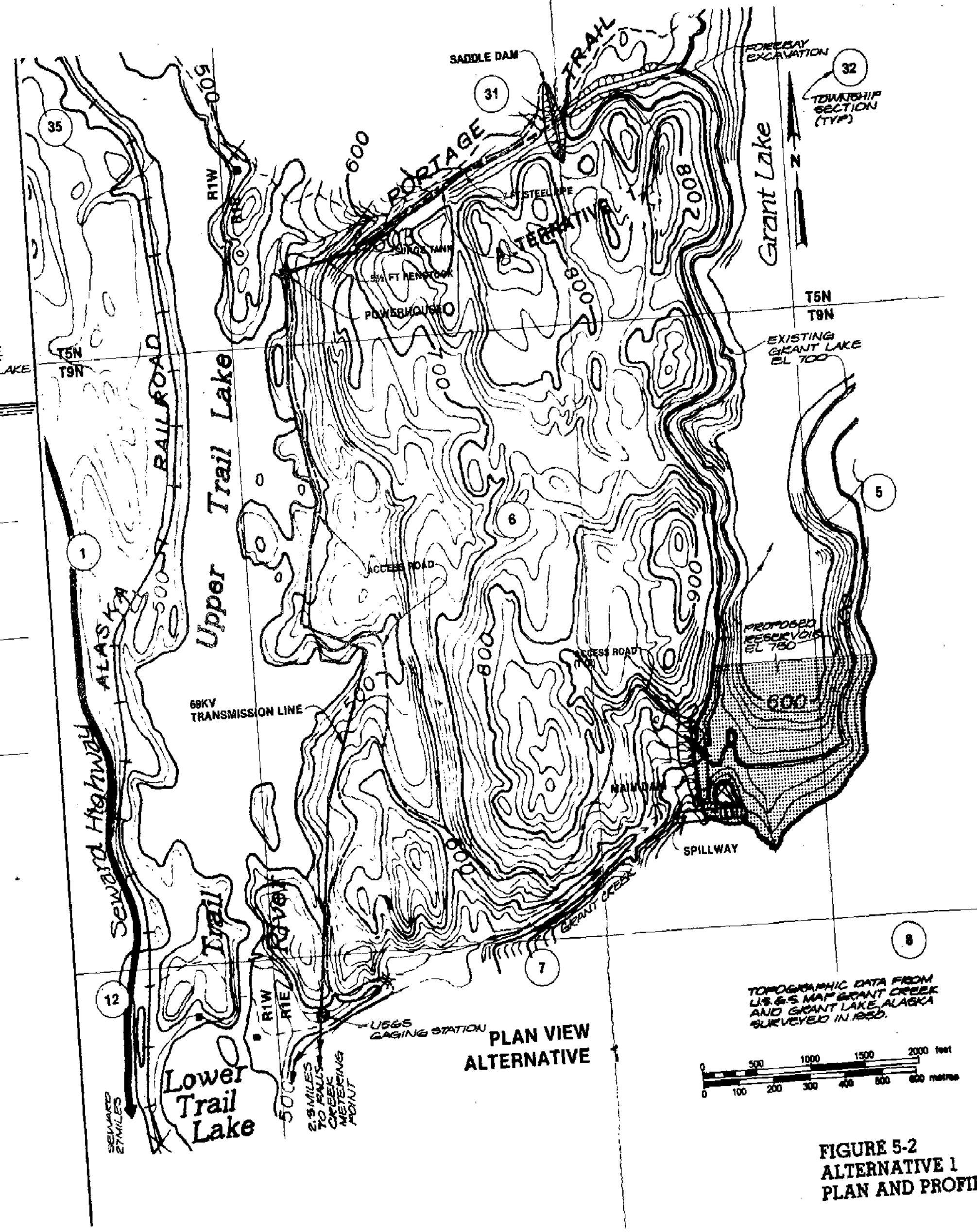
ALTERNATIVE PROJECT CONFIGURATIONS

An evaluation of the topography of the area between Grant Lake and the Upper and Lower Trail Lakes resulted in development of four alternative project configurations. For each of the alternatives, the sizes and locations of the main dam, saddle dam, and spillway remained unchanged. However, the alignment of the water conveyance system and the location of the powerhouse vary for each alternative. The plans and profiles of the four alternatives are shown in Figures 5-2 through 5-4.

Falls Creek, situated south of Grant Lake, has the potential for providing added flow to the project. A diversion system was developed for transferring water from the creek to Grant Lake. As shown in Figure 5-5, this diversion system is comprised of a 15-foot-high gravity concrete diversion



PROFILE
ALTERNATIVE 1
SCALE: AS SHOWN

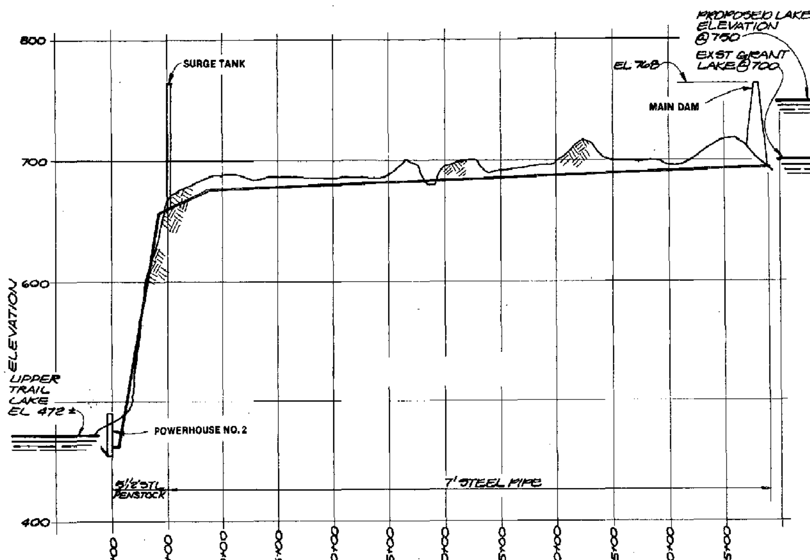


PLAN VIEW
ALTERNATIVE 1

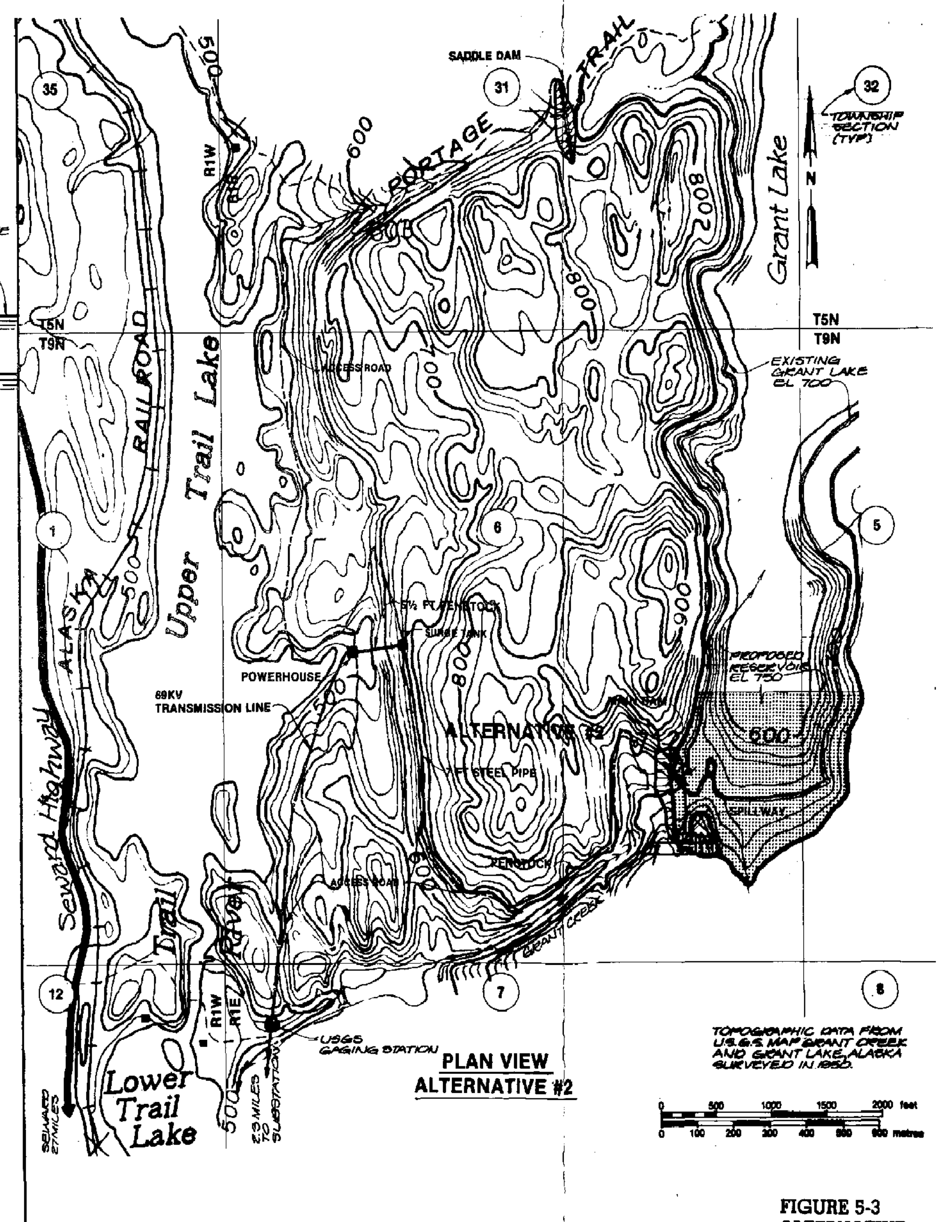
TOPOGRAPHIC DATA FROM U.S.G.S MAP GRANT CREEK AND GRANT LAKE, ALASKA SURVEYED IN 1950.

0 500 1000 1500 2000 feet
0 100 200 300 400 500 600 metres

FIGURE 5-2
ALTERNATIVE 1
PLAN AND PROFILE



PROFILE
ALTERNATIVE 2
SCALE: AS SHOWN



PLAN VIEW
ALTERNATIVE #2

FIGURE 5-3
ALTERNATIVE 2
PLAN AND PROFILE

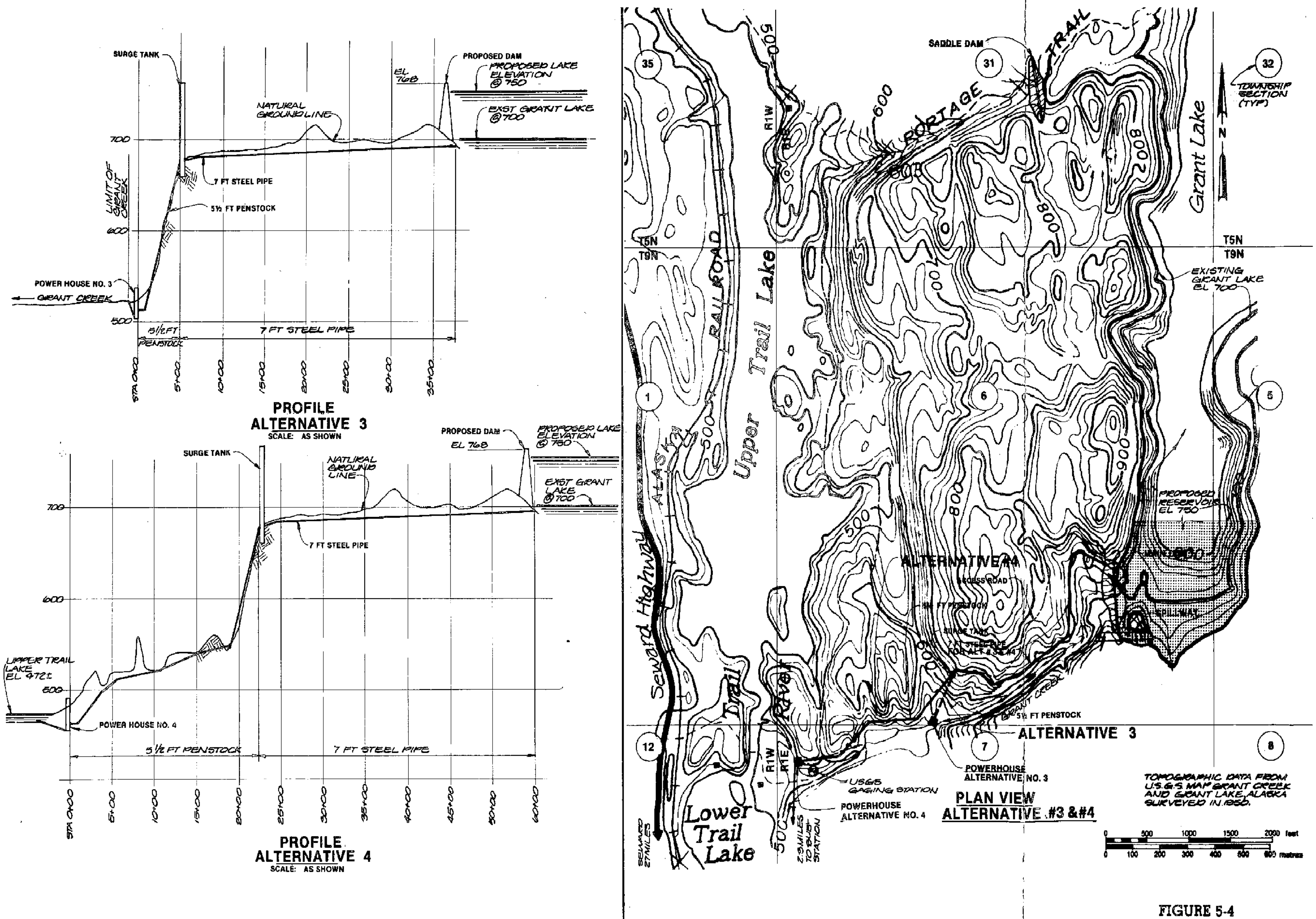


FIGURE 5-4
ALTERNATIVES 3 AND 4
PLAN AND PROFILE

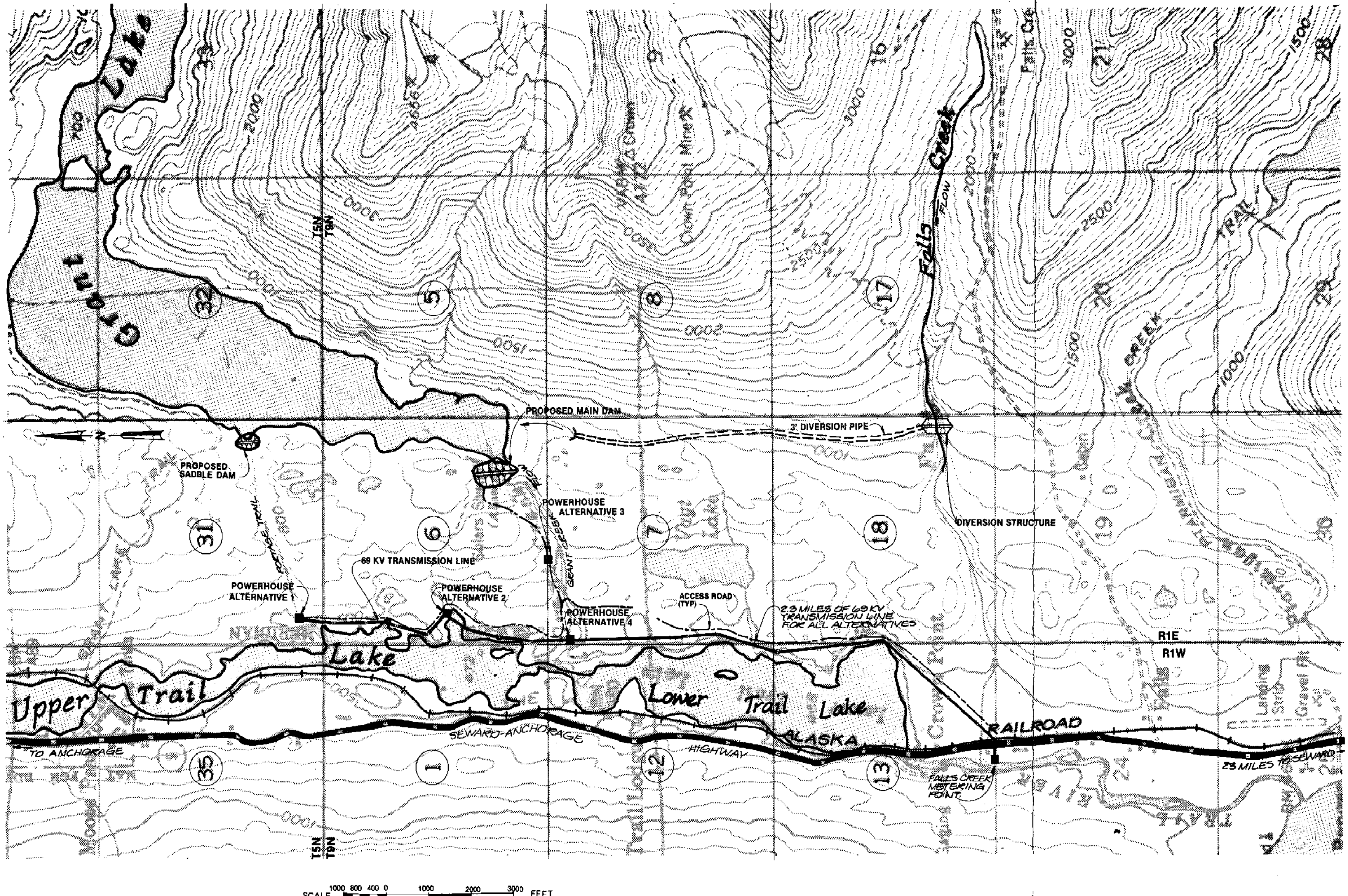


FIGURE 5-5
TRANSMISSION LINE ROUTE AND
FALLS CREEK DIVERSION SYSTEM

structure and an exposed steel pipe 3 feet in diameter. This system would provide a maximum discharge of 120 cfs from Falls Creek to Grant Lake and is expected to add 26,000 acre-feet of water to the Grant Lake project during an average year. All four Grant Lake alternatives were studied with and without the Falls Creek diversion as an option.

FORMULATION OF PROJECT FACILITIES

Main and Saddle Dam

Two of the major components of this project are the main dam and the saddle dam. Alternative types of structures for these dams were considered at the outlet of Grant Lake. The concrete gravity type dam and concrete arch were determined to be technically feasible, but they would be very expensive because the cross section of the valley at the dam site is wide and the cost of concrete in the area is high. After careful analysis of available material at the site, a rockfill dam with a concrete upstream membrane was selected. A concrete membrane was selected because fine core material is not available near the site.

The height of the main dam was selected to provide the storage required for power production and the freeboard needed to safely pass the PMF. The maximum water level was established at elevation 750. Te crest of the dam was set at elevation 768 to provide 3 feet of freeboard during the PMF. Details of the dam and spillway are shown in Figure 5-6. The saddle dam would prevent the overflow of water to a low point in the hills between Grant and Upper Trail Lakes. The crest of the saddle dam would be at elevation 768, and the cross section of the saddle dam would be similar to that of the main dam.

Overflow Spillway

An overflow-type spillway would be excavated in rock and would have a trapazoidal control section at crest elevation 750, as shown in Figure 5-6. The spillway would to be located on the left abutment of the dam. The deep cut for the spillway was designed to provide adequate passage of the PMF, and to provide enough rockfill material to be used in construction of the main dam.

The spillway section would require presplitting, but no concrete lining would be needed.

Low-Pressure Pipe

The major difference among the four alternatives is the length of the water conveyance system required to deliver water to the respective powerhouses. All four alternatives require an intake and some length of low-pressure pipe for water conveyance. All four intakes are basically the same in that they must operate under as much as 60 feet of head as well as be free from maintenance problems associated with intakes in cold regions.

The low-pressure pipes, as with all water conveyance components, were sized to accommodate a maximum flow of 380 cfs. A 7-foot-diameter steel pipe, either buried or supported above ground on saddles, was selected for all four alternatives. The lengths and routes of the low-pressure pipes can be seen in Figures 5-2 through 5-4.

Because of the length of these low-pressure pipes, this component of the water conveyance system would be very expensive. The 7-foot-diameter pipe costs $400 per linear foot if it is above ground and $700 per linear foot if it is in a rock-cut trench. Because of the high cost for this single component, the possibility of using a tunnel for the water conveyance in alternative 2 was considered (Figure 5-3).

For a tunnel in alternative 2 to be competitive with the short length of low-pressure pipe required for alternative 1, it would have to cost between $600 and $800 per linear foot. Normal costs for tunnels of this type range between $1,500 and $2,000 per linear foot. Therefore, tunnels were not considered feasible for this project.

Surge Tanks

The low-pressure pipe in all four alternatives would terminate in a surge tank structure. The surge tank was provided to protect the pipes from large surge pressures when the turbines start, stop, or change power output and to provide proper speed regulation of the turbines and generators. For the purposes of this study, a simple surge tank was provided above the powerhouse. The location of the surge tank is shown on Figures 5-2 through 5-4 for the various alternatives.

Penstock

Flow from the surge tank would descend rapidly to the powerhouse by way of an aboveground steel penstock. A single 5.5-foot-diameter steel penstock leads to a bifurcation just before the powerhouse. The bifurcation divides the flow into two 3.5-foot penstocks that lead to each of two turbines in the powerhouse. The penstock between the turbines and the surge tank would be required to transmit the full surge pressures to the surge tank and has been designed accordingly.

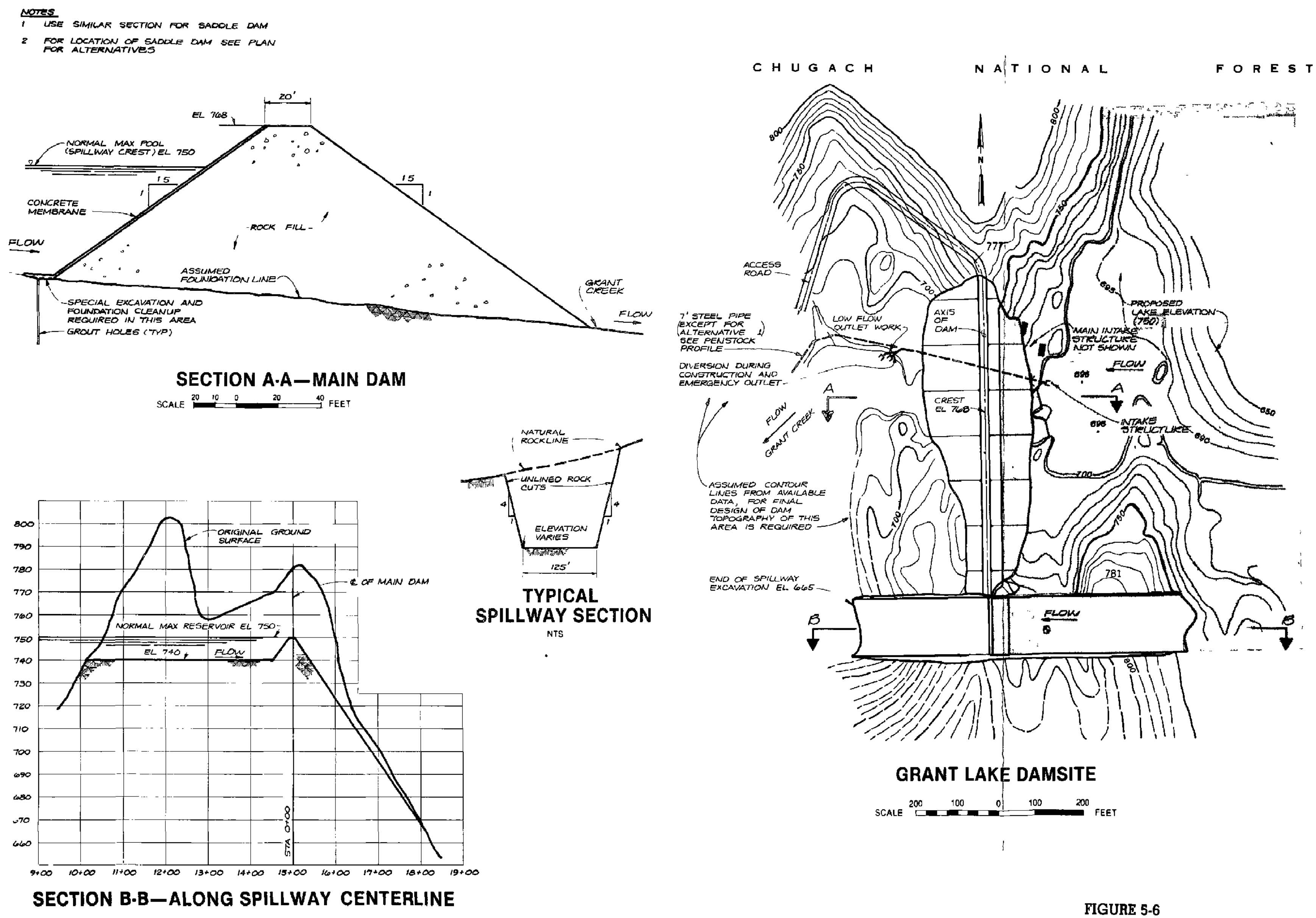


FIGURE 5-6
DETAIL OF DAM AND SPILLWAY

Concrete Powerhouse

A concrete powerhouse to house two equal turbine/generators is common to all four alternatives. A typical plan, section, and single-line electrical diagram for the powerhouse is shown in Figures 5-7 through 5-9. As shown in Table 4-4, each of the alternative powerhouses has a different installed capacity for its turbine/generator sets. This results in different energy-producing capabilities because of differences in conveyance system head losses and tailrace elevations.

These differences are indicative of the relative merits of each alternative site for power generation. For example, the powerhouse for alternative 3 was sited on Grant Creek to determine the feasibility of maintaining fish flows in Grant Creek. The difference in energy produced between alternative 1 and alternative 3 was 6.3 million kWh. At a reasonable cost of energy of 5¢ per kWh, that energy loss equates to an annual loss in power revenue of $315,000.

To avoid ice problems in the tailrace area, a deep setting of the draft tube was selected for all the alternatives. The floor of the powerhouse was established 1 foot above the estimated 100-year flood level. The turbine, valve chamber, and draft tube excavations are as shown in Figure 5-8.

The office space inside the powerhouse would be isolated, and attention was given to possible use of the erection bay area for the winter parking of snow-clearing equipment. A 20-ton overhead crane was provided for erection and maintenance of the powerhouse equipment. Two 3.5-foot guard valves would be installed in the valve chamber inside the powerhouse. The bifurcation would be located outside the powerhouse and would be embedded in a concrete anchor block.

The proposed powerhouse configuration is subject to change when more detailed site data are available. Surveying and drilling need to be accomplished before these concepts can be made final. The powerhouse site for all four alternatives was assumed to have the topographic and geologic characteristics shown in Figure 5-8.

Access Roads

All major project components need to be accessible by roads for both construction and maintenance reasons. In addition to the local access roads between the dams and powerhouses, access to the general site area needs to be established. Currently, only the Alaska Railroad bridges Trail Lake near the site. Use of this crossing was not considered appropriate. The portion of the Trail River between Upper and Lower Trail Lakes adjacent to the mouth of Grant Creek was considered the best place to provide a new bridge. However, at the request of the City of Seward, this concept was also discarded. Instead, an all-land route running east of Lower Trail Lake from the Crown Point area was suggested. As shown in Figure 5-5, this route is considerably longer than bridging the Trail River and connecting to the Seward Anchorage Highway at that point.

There are two reasons for using the longer route. First, the city requested that a 69-kV transmission line be used to connect to their Falls Creek metering point located near the intersection of the Seward Anchorage Highway and Falls Creek. This would preclude having to connect to or rebuild the CEA 25-kV line directly across the Trail River from Grant Creek. The longer access road would also act as the transmission line right-of-way.

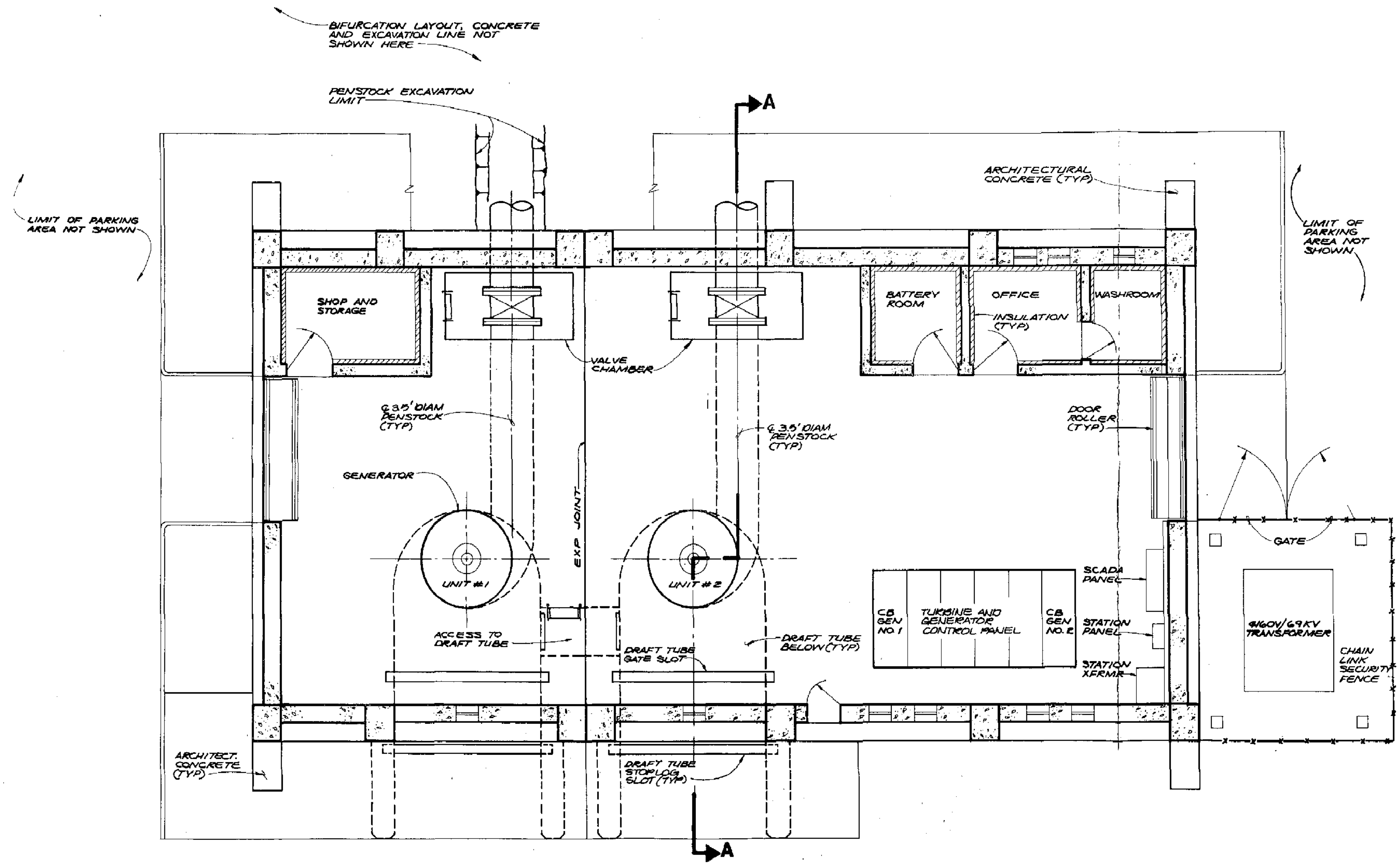
The second reason for the longer access route was to open up the area east of Lower Trail Lake to recreational development. No dollar benefit was assigned to that function for the access road, but a high cost will obviously be paid in comparison with the shorter route. The detailed alignment and potential cost sharing for the access road will be investigated in future studies.

Transmission Lines

As mentioned above, the city requested that the Grant Lake project be connected to their own transmission lines at the Falls Creek metering point. To accomplish this, a 69-kV transmission line was routed to that point from each alternative powerhouse, as shown in Figure 5-5. A schematic of the transmision line is shown in Figure 5-9.

COST ESTIMATES

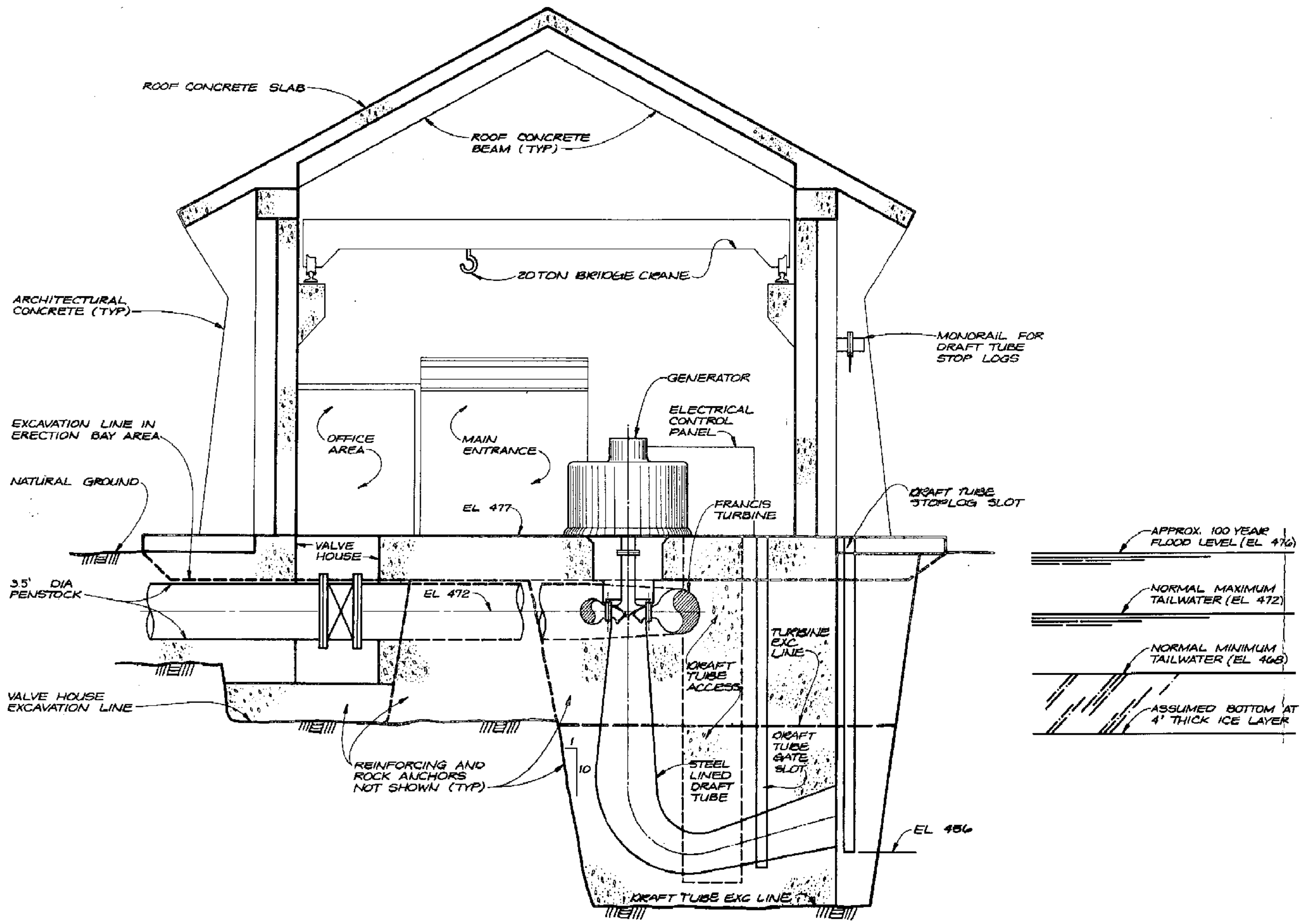
To determine the feasibility-level cost estimates for each alternative, conceptual engineering designs were developed for major project components such as the main dam, saddle dam, spillway, water conveyance system, powerhouse, transmission lines, and access roads. The alignment and major details of these structures have been presented in this chapter. Manufacturers' quotes were obtained for the turbine/generators and for other major equipment items. The summary of project costs is presented in Table 5-1, as is the expected energy production and installed capacity for each alternative. The unit cost for installed capacity is shown at the bottom of Table 5-1. These costs are relatively high because of the high cost of the water conveyance system, access roads, and transmission.



GENERATOR FLOOR-PLAN VIEW ELEVATION 477
FOR ALTERNATIVES 1 THROUGH 4

SCALE: 4' 2' 0' 4' 8' 12' FEET

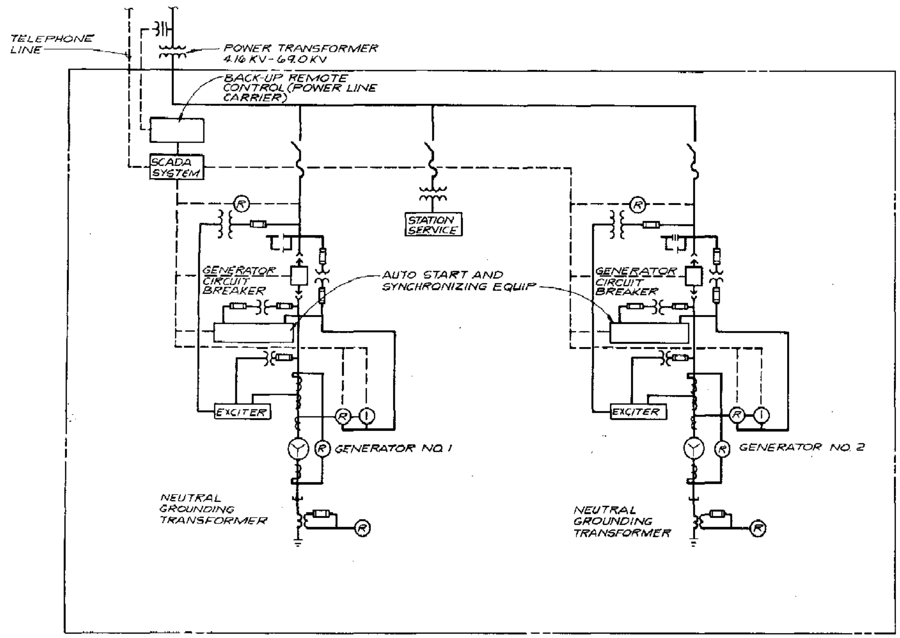
FIGURE 5-7
POWERHOUSE FLOOR PLAN



CROSS SECTION THROUGH CENTERLINE OF PENSTOCK AND TURBINE ALTERNATIVES 1, 2 AND 4

SCALE: 4' 2' 0' 4' 8' 12' FEET

FIGURE 5-8
POWERHOUSE CROSS SECTION
ALTERNATIVES 1, 2, AND 4



SINGLE LINE DIAGRAM FOR GRANT LAKE POWERHOUSE

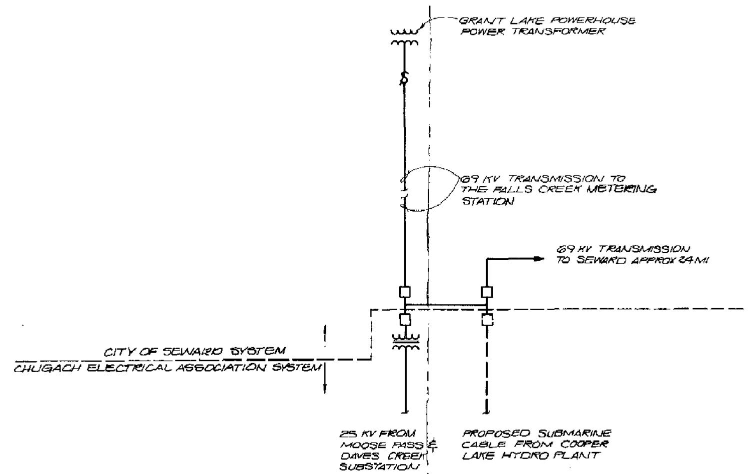
NTS

LEGEND

Ⓡ PROTECTIVE RELAYS

Ⓘ INSTRUMENTS

SCADA = SUPERVISORY CONTROL AND DATA AQUISITION



GRANT LAKE TRANSMISSION SYSTEM

NTS

FIGURE 5-9
POWERHOUSE SINGLE-LINE DIAGRAM
GRANT LAKE PROJECT
TRANSMISSION SYSTEM

It can be seen from Table 5-1 that alternative 1 is by far the most desirable alternative because of its low total cost, low unit cost per installed kW, and high energy production. As a result, alternative 1 is the preferred alternative for the development of Grant Lake.

All of the proposed alternatives are considered to be technically feasible at this level of study.

As will be shown in Chapter 7, the cost of alternative 1 equates to a first-year energy cost of 87 mills/kWh (in 1984 prices). This is higher than the cost of energy would be from alternative power sources at that time. Consequently, the effect of reducing the installed capacity of alternative 1 was investigated.

If the alternative 1 powerhouse is reduced from 7.3 MW in two equal turbine/generator units to 4.0 MW in a single turbine/generator unit, the capital cost would be reduced from $15,187,000 to $12,451,000.

This 4.0 MW capacity powerhouse would produce 26.1 million kWh per year, which is only 4 percent less energy than produced by the 7.3 MW powerhouse. The plant factor of 43 percent for the 7.6 MW powerhouse would increase to 74 percent for the 4.0 MW powerhouse. The 4.0 MW powerhouse option would yield a first-year energy cost of 74 mills/kWh (in 1984 prices).

The final determination of the exact installed capacity for the project will be performed as part of the FERC license application effort. This determination will have to be based on the benefits of installing extra capacity at Grant Lake. These benefits will be difficult to evaluate because currently there are no charges for capacity on the wholesale market in Alaska.

Table 5-1
FEASIBILITY-LEVEL COST ESTIMATES

FERC Acct. No.	Account Description	Alternative 1		Alternative 2		Alternative 3		Alternative 4	
		Without Diversion	With Diversion	Without Diversion	With Diversion	Without Diversion	With Diversion	Without Diversion	With Diversion
	Hydroelectric Plant Accounts								
330	Land and land rights	0	0	0	0	0	0	0	
331	Structures and improvements (powerhouse)	$ 686,000	$ 686,000	$ 710,000	$ 710,000	$ 728,000	$ 728,000	$ 730,000	$ 730,000
332	Reservoirs, dams, and waterways	5,037,000	7,437,000	6,441,000	8,841,000	5,796,000	8,196,000	6,352,000	8,752,000
333	Waterwheels, turbines, and generators	2,538,000	2,538,000	2,474,000	2,474,000	2,098,000	2,098,000	2,418,000	2,418,000
334	Accessory electrical equipment	146,000	146,000	146,000	146,000	146,000	146,000	146,000	146,000
335	Miscellaneous powerplant equipment	119,000	119,000	119,000	119,000	119,000	119,000	119,000	119,000
336	Roads, railroads, and bridges	792,000	792,000	792,000	792,000	792,000	792,000	792,000	792,000
	Transmission Line Accounts								
350	Land and land rights	0	0	0	0	0	0	0	0
352	Structure and improvement	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
353	Station equipment (substation)	142,000	142,000	142,000	142,000	142,000	142,000	142,000	142,000
355	Poles and fixtures	582,000	582,000	459,000	459,000	369,000	369,000	257,000	257,000
356	Overhead conductors and devices	378,000	378,000	298,000	298,000	240,000	240,000	167,000	167,000
397	Communication equipment	135,000	135,000	135,000	135,000	135,000	135,000	135,000	135,000
	Subtotal	$10,565,000	$12,965,000	$11,726,000	$14,126,000	$10,575,000	$12,975,000	$11,268,000	$13,668,000
	Contingency (25%)	2,641,000	3,241,000	2,931,000	3,531,000	2,644,000	3,244,000	2,817,000	3,417,000
	Subtotal	$13,206,000	$16,206,000	$14,657,000	$17,657,000	$13,219,000	$16,219,000	$14,085,000	$17,085,000
	Engineering, Legal, and Adminstrative (15%)	1,981,000	2,431,000	2,198,000	2,648,000	1,983,000	2,433,000	2,112,000	2,562,000
	Total Construction Cost	$15,187,000	$18,637,000	$16,855,000	$20,305,000	$15,202,000	$18,652,000	$16,197,000	$19,647,000
	Annual Energy Production (kWh/yr)	27,300,000	32,800,000	26,300,000	31,800,000	21,000,000	25,600,000	26,000,000	31,400,000
	Plant Capacity (kW)	7,280	7,280	7,060	7,060	5,740	5,740	6,960	6,960
	Construction Cost/kW	2,023	2,497	2,592	3,081	3,051	3,652	2,780	3,276

NOTE: All costs in January 1980 dollars.

Chapter 6
ENVIRONMENTAL SETTING, IMPACTS, AND MITIGATION FOR GRANT LAKE/FALLS CREEK

This chapter contains a discussion of environmental settings and probable environmental impacts associated with the proposed Grant Lake project. The evaluation is based on existing reports, contacts with agency staff, and generally available knowledge on the kind of impacts likely to occur with hydropower developments. Possible measures to mitigate adverse effects are suggested. Site-specific information was available from previously published reports by the U.S. Fish and Wildlife Service and the U.S. Forest Service, U.S. Geological Survey (USGS) topographic maps, and aerial photographs, and site visits by CH2M HILL personnel.

Descriptions of the proposed alternatives for the development of Grant Lake and Falls Creek are contained in Chapters 4 and 7. The project components as described in Chapter 7 will be addressed individually wherever appropriate in the ensuing sections.

GEOLOGY, TOPOGRAPHY, SEISMICITY, AND SOILS

Setting

An analysis of existing geologic, topographic, and soil conditions is presented in Appendix C.

Although a design-level seismic evaluation has not yet been made, the project area is known to be tectonically active, and large earthquakes have occurred nearby. The epicenter of the 1964 earthquake, Richter magnitude 8.6, was located about 63 miles northeast of Grant Lake.

Avalanche danger is said to be extreme on the ridges along the northern side of Grant Lake and the eastern side of the lower basin of Grant Lake. Unconsolidated glacial deposits are present on some of the hillsides and could be involved in a debris flow, particularly during earthquakes.

Grant Lake, which is fed by numerous glacial streams, has a normal water surface elevation of 700 feet above mean sea level. An island and neck at a right angle bend separate the lake into two basins. The upper basin, 3.5 miles long and 0.5 mile wide, is confined between steep slopes and, at its upper end, by a flat-bottomed valley. The lower basin of the lake, 1.5 miles long and 0.5 mile wide, is flanked by a mountain rising nearly 4,000 feet from its eastern edge and a low divide to the west.

Originating from Grant Lake, Grant Creek flows approximately 1 mile in a southwesterly direction and discharges into a short section of the Trail River between Upper and Lower Trail Lakes.

Falls Creek is 8 miles in length with only short lateral tributaries. It drains the precipitous country between the Ptarmigan and Grant Lake watersheds and empties into Trail River south of Lower Trail Lake.

Impacts

The proposed Grant Lake dams, alternative penstock routes, and powerhouses will not affect the geology or seismic conditions in that area.

Construction of access roads, the penstock, and Falls Creek pipeline will cause changes to topography of the area. Excavation will be required at the Grant Lake outlet dam site.

A saddle dam will be required midway along the western side of Grant Lake. Access roads to this might may cross environmentally sensitive terrain.

The possibility of avalanche-induced waves in Grant Lake has been considered. However, the lake would probably be frozen during most periods of high avalanche danger.

Mitigation

All project components should be designed to acceptable engineering standards to accommodate existing geologic and seismic site conditions. Access roads and pipeline and transmission routes should be designed so that topographic disturbances are minimized. The spillway should be designed to pass an avalanche-induced wave, thus avoiding possible damage to the dam.

CLIMATE, HYDROLOGY, AND WATER QUALITY

Setting

A thorough analysis of climatic and hydrologic data is presented in Chapter 2.

Grant Lake is fed by glacial waters, causing moderate to heavy turbidity of lake waters. These glacial waters are warmed as they pool in Grant Lake. However, the very fine glacial flour remains in suspension, causing Grant Creek to be a glacially turbid stream. Temperatures recorded at Grant Creek tend to be warmer than at Falls Creek (Table 6-1).

Table 6-1

TEMPERATURES OF GRANT LAKE AND GRANT CREEK

	Temperature (°F)					
	Lower Grant Creek			Surface, Grant Lake Outlet		
Date	Water	Air	Time	Water	Air	Time
7/10/59	53	64	1830			
7/23/59	52	52	1500			
8/05/59	52	50	2000			
9/11/59	49	54	1045			
9/17/59	51	60	1330			
10/07/59	40		1315			
10/09/59				42		
11/03/59	40	36	1400			
2/04/60	33	38	1100			
3/11/60	32	26	1100			
4/21/60	35	35	1330			
6/08/60	46	60	1500			
6/17/60	53	64	1645	53	67	1515
7/07/60	49	59	1115			
7/08/60				52		2000
7/10/60				54		2000
7/11/60	56	68	1130			
7/20/60	52	58	0700	55	69	1100
7/29/60	49	58	1500			
8/08/60	52	59	1345	52	56	1900
8/13/60	51	57	1415			
8/18/60	52	54	1200			
9/01/60	50	46				
9/14/60	49	48	1130			
10/16/60	42	36	1800	44	46	1330
10/26/60				41	41	1500
10/27/60	42	40	1400			

Source: U.S. Fish and Wildlife Service, 1961 (Ref. 19).

Falls Creek water originates mostly from snowmelt because there are few glaciers in the Falls Creek basin and is clear and cold (Table 6-2).

Chemical analyses are available for Grant Creek during 1950 through 1958 and for Falls Creek during 1956. These data are presented in Table 6-3.

Table 6-2
TEMPERATURE FOR LOWER FALLS CREEK

Date	Temperature (°F)		
	Water	Air	Time
11/03/59	32.5		1445
6/08/60	41	51	1630
6/14/60	42	55	1800
6/15/60	45	59	1745
7/12/60	46	64	1845
7/16/79	47	64	1545
7/19/60	47	64	1745
7/20/60	41	54	0715
7/26/60	42	53	2100
8/04/60	42	51	1130
8/05/60	45	54	
8/13/60	44	56	1345
8/17/60	45	59	
9/01/60	42	45	1845
9/14/60	41	48	
10/16/60	36	34	1745

Source: U.S. Fish and Wildlife Service, 1961 (Ref. 19).

Impacts

Fluctuations in the surface elevation of Grant Lake will result in changes in the surface area ranging from the existing 1,570 acres at elevation 700 to a maximum of 1,845 acres at elevation 750. Under alternatives 1, 2, and 4, Grant Creek would be dried up except during times of spillway flows. Under alternative 3, Grant Creek would be dry above the powerhouse situated approximately 1/2 mile upstream from Trail Lake.

Increased siltation in Grant and Falls Creeks can be expected to occur during the construction period. However, seasonal high runoff will flush this material downstream to lower Trail Lake.

Because Falls Creek contains colder water, diverting it into Grant Lake would slightly decrease the water temperature in Grant Lake. Under alternative 3, water in the lower segment of Grant Creek might become somewhat warmer in winter and colder in summer. This could affect the timing of the life cycle of the salmon that spawn in Grant Creek.

Table 6-3
CHEMICAL ANALYSES OF GRANT CREEK AND FALLS CREEK
CONCENTRATION (ppm)

Date of Collection	Mean Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_2)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved Solids	Hardness as $CaCO_2$: Calcium, Magnesium	Hardness as $CaCO_2$: Non-carbonate	Specific Conductance (micromhos at 25°C)	pH	Color
Grant Creek																		
7/05/50	497	4.9	.04	11.0	1.7	1.2		30	9.5	1.0		1.4	46	34	10	70.8	7.1	5
10/07/50	139	5.3	.08	10.0	0.9	1.7		26	8.2	0.8		1.8	42	29	7	66.5	7.0	5
1/30/51	19	4.2	.05	10.0	0.9	3.1		28	8.2	1.2		2.6	44	29	6	75.9	7.2	6
4/16/53	26	3.4	.02	11.0	1.2	1.8	0.9	29	12.0	1.5	0.1	1.1	47	32	8	74.8	7.2	3
1/21/55	50	3.9	.04	11.0	1.1	0.5	0.6	30	12.0	0.3	0.1	0.2	45	32	7	73.0	7.0	
5/01/56	20	4.0	.00	11.0	0.5	1.0	1.0	29	9.2	0.0	0.1	1.0	42	30	6	72.0	7.4	0
5/30/56	157	3.3	.00	11.0	0.3	0.7	0.5	28	6.7	0.2	0.0	0.6	37	29	6	67.0	7.0	8
7/03/56	460	4.9	.00	11.0	0.5	1.2	0.4	26	8.0	0.2	0.0	1.2	40	30	8	73.0	7.0	0
10/03/57	143	3.2	.06	9.1	2.4	0.9	0.8	27	9.5	0.5	0.0	0.8	40	32	10	65.0	7.0	10
12/11/57	61	3.3	.08	9.9	1.2	1.3	1.3	28	7.0	2.0	0.1	0.9	41	29	6	70.0	6.7	0
1/22/58	51	4.7	.02	11.0	1.5	1.1	0.7	32	9.0	1.0	0.0	0.9	46	33	7	75.0	7.2	0
2/19/58	30	4.4	.02	10.0	1.8	0.9	0.6	32	8.0	1.0	0.0	1.2	44	32	6	76.0	7.2	0
5/21/58	156	3.6	.07	10.0	2.1	0.8	0.6	27	9.0	2.0	0.0	0.8	42	34	12	81.0	6.4	0
7/16/58	393	3.7	.03	11.0	1.0	0.7	0.6	25	10.0	2.0	0.1	0.9	42	32	11	71.0	6.3	5
8/21/58	390	3.2	.05	10.0	1.6	0.6	0.7	29	9.0	0.5	0.1	0.3	40	32	8	73.0	6.8	10
Falls Creek																		
5/1/56				14.0	0.9	1.7	0.6	32	11.0	1.0				39	12	94.0	7.0	
7/3/56				7.9	0.5	1.1	0.8	19	6.5	1.0				22	6	91.0	6.6	

Source: U.S. Geological Survey. 1950–1958 (Ref. 27).

Nitrogen supersaturation and siltation during operation of the Grant Lake project are not expected to be a problem.

Mitigation

Minimization of turbidity and siltation should be planned for during construction. If alternative 3 is selected, design plans could include methods to control the temperature of water discharged from Grant Lake so that it does not vary significantly from the original natural temperature. Further study of the feasibility of water temperature control might be desirable.

VEGETATION

Setting

Spruce, birch, cottonwood, aspen, and willow occur along Grant and Falls Creeks. However, both creeks flow through steep rock-walled canyons with little vegetation directly adjacent to the streambeds.

According to a U.S. Fish and Wildlife Service report, aquatic plants in Grant Lake include two species of green filamentous algae, brown algae, *Myriophyllum*, cattail, and two species of *Equisetum* (Ref. 19).

Impacts

Up to 275 acres of vegetation surrounding Grant Lake will be inundated to an elevation of 50 feet up the bank from the existing lake edge. Major vegetation within this area will be removed prior to initiation of water holding operations.

Vegetation along the access road, penstock, pipeline route, and transmission line corridors will be removed during construction. Those routes will be maintained free of vegetation for the life of the project.

Mitigation

Careful design of access roads can minimize the extent of vegetation removal required.

FISH

Setting

No sport fish have been found to inhabit Grant Lake, although cottids and sticklebacks are present.

Stream surveys that ranged between 1/4 and 3/4 mile from the mouth of Grant Creek were made for various years between 1954 and 1978. The results are presented in Table 6-4. According to U.S. Fish and Wildlife Service reports, during the early 1950's sockeye salmon were predominant (Ref. 19). For example, 42 live and three dead sockeyes were counted in 1954. In 1962, 324 sockeyes and two king salmon were counted. According to Alaska Department of Fish and Game (personal communication), between 1976 and 1978 only a few sockeyes and kings were counted. Difficulty in making accurate fish counts was encountered because of glacial turbidity.

The U.S. Fish and Wildlife Service counted fish fry in Grant Creek between July 1959 and January 1961 (Ref. 19). King salmon, coho salmon, Dolly Varden, and sculpin (*Cottus aleuticus* Gilbert) were taken during various months.

Falls Creek is small and swift, and apparently has an insignificant fish population. Falls above the lower mile of the creek preclude migration of anadromous fish. Although the lower mile of Falls Creek appears to possess salmon spawning potential, no salmon were seen during checks made in the late summer of 1959 and 1960. The cold temperature of this stream is thought to be a major factor limiting salmon spawning.

The U.S. Fish and Wildlife Service sampled Falls Creek for fry during the summer and fall of 1960 (Ref. 19). King salmon were caught during August, September, and October within 200 yards from the mouth. Dolly Varden were taken within one mile of the Falls Creek outlet. Sculpin (*Cottus aleuticus* Gilbert and *C. cognatus* Richardson) were taken in August.

Impacts

Under alternatives 1, 2, and 4, Grant Creek would be dewatered, eliminating the aquatic habitat.

Under alternative 3 streamflows would be maintained in the lower 1/2 mile of Grant Creek.

The flow in Falls Creek would be maintained annually at its winter low-flow level downstream from the diversion structure, thus minimizing the aquatic habitat.

Mitigation

A detailed study of the resident and anadromous fishery resources in Grant and Falls Creek is needed. An alternative to maintaining streamflows in Grant Creek may be to provide for enhancement of another fishery located in some other area.

Table 6-4
GRANT CREEK STREAM SURVEYS

Date	Distance Surveyed (miles)	Counts: Sockeye Alive	Counts: Sockeye Dead	Counts: Kings Alive	Counts: Kings Dead	Method	Remarks	Source of Information
8/27/54	3/4	42	3	5	1	ground	Glacial water	Cook Inlet Management Reports (FWS)
7/06/57	3/4	0	0	0	0	"		"
7/21/57	3/4	0	0	0	0	"		"
8/02/57	3/4	0	0	3	0	"		"
8/26/57	1/2	0	0	8	3	"		"
unknown	unknown	0	0	28		"	Stream glacial	"
7/23/59						"	No fish taken in net set overnight	RBS Surveys
8/06/59						"	1 king salmon in net; no salmon seen in stream but water turbid	"
8/07/59						"	7 sockeye salmon in overnight gillnet set	"
8/29/59						"	1 sockeye salmon in overnight net set; dockeye salmon numerous but turbidity prevented counting	"
9/11/59						"	No salmon seen but conditions for observation poor	"
9/17/79						"	No salmon taken in overnight net set	"
10/07/59						"	No salmon seen	"
8/4/60						"	No salmon seen	"
8/13/60						"	Sockeye seen but turbidity prevented counting	"
8/17/60				1	0	"	A number of sockeyes seen	"
8/18/60						"	10 sockeyes in overnight gillnet set; 1 female spawned out, the rest ripe	"
8/24/60						aerial	A few salmon seen but turbidity prevented counting	"
9/02/60						ground	5 sockeye salmon in overnight net set	"
10/21/60						ground	Nothing taken in net set	"
1962	1/4*		324	2				Soldotna Office ADF&G
1963	1/4	41	33					"
1976	1/4						Too turbid to see anything	"
1977	1/4	4	1					"
1978	1/4	0	5					"

Sources: U.S. Fish and Wildlife Service, 1961 (Ref. 19).
Alaska Department of Fish and Game, Soldotna offices (personel communication).

*Spawning takes place only in lower 1/4 mile of Grant Creek.

WILDLIFE

Setting

The area surrounding Grant Lake is a fall and winter range for moose. Alaska Department of Fish and Game moose counts for the Grant Lake/Trail Lake area showed 101 moose in 1965 and 114 moose in 1966 (personal communication). However, it has been estimated that the existing moose population might actually be half that level because of a low rate of calf survival experienced during the early 1970's.

The Grant Lake area is also an important wintering area for goats and sheep. During winter 1979, counts made by the Alaska Department of Fish and Game showed 45 goats and 17 sheep inhabiting the ridge north of Grant Lake (personal communication).

Information on other animals inhabiting the Grant Lake area has been obtained from the 1961 U.S. Fish and Wildlife study (Ref. 19). Waterfowl use Grant Lake for nesting and molting. Other animals found throughout the area include black and grizzly bears, coyote, lynx, mink, beaver, marten, weasel, and wolverine. Small game includes ptarmigan, spruce grouse, and snowshoe hare. Aquatic insects identified at the mouth of streams flowing into Grant Lake included two species of caddis fly, three species of stone fly, black fly, two species of snails, and *Planaria*.

Impacts

Effects on wildlife will occur as a result of changes in streamflows and riparian vegetation. It is estimated that approximately half of the available wildlife habitat at the eastern end of Grant Lake, particularly moose browse, will be inundated.

Some fur and small game animal habitat will be inundated by raising the level of Grant Lake. Habitat might be changed by the diversion of Falls Creek.

Five areas totaling 659 acres adjacent to Grant Lake have been identified by the U.S. Forest Service as burn sites during 1983 under the Chugach Moose-Fire Management Program (Ref. 20). The island between the upper and lower basin of Grant Lake will be the only designated burn area that would be totally inundated. The other four burn areas rise along the mountains to elevations of between 1,500 and 2,400 feet.

Mountain goats and sheep are not expected to be directly affected by fluctuations in the Grant Lake reservoir because they graze primarily at higher elevations. However, the

Alaska Department of Fish and Game and the U.S. Forest Service have begun a 5-year research project on goats and sheep in the vicinity of Grant Lake. This study will determine the effect of the proposed U.S. Forest Service moose burn program on goat and sheep populations.

The Alaska Department of Fish and Game is concerned that increases in human activity, including big game hunting, will occur at Grant Lake because of the improved visibility and access. This may result in the dispersal of moose, sheep, and goats from that area.

Mitigation

Further information should be obtained from the U.S. Forest Service and Alaska Department of Fish and Game to determine if the raised water level will significantly affect their moose burn program and research project. An alternative might be to institute a cooperative program with the U.S. Forest Service to enhance moose habitat in areas other than Grant Lake.

LAND STATUS

Setting

All of the land to be occupied by the proposed project is located in the Chugach National Forest. The U.S. Forest Service administers activities on these lands and is responsible for developing land use policies.

Some of the Federal land has been selected by the State of Alaska, but will not be conveyed until the D-2 lands issue is resolved by the U.S. Congress. This could take anywhere from 1 to 5 years. State-selected lands are shown in Figure 6-1.

A large percentage of the state-selected lands have also been nominated for conveyance to the Kenai Peninsula Borough. Transfer of the land to Borough ownership is likely to occur about 5 months following its conveyance to the State. However, easements of from 50 to 200 feet will be retained by the State along all waterways.

The U.S. Forest Service is in the process of completing its Roadless Area Review Evaluation (RARE II) for national forest lands in Southcentral Alaska. The area surrounding Grant Lake and Falls Creek is likely to receive a non-wilderness designation as a result of this planning study. Hydroelectric development will probably be listed as a potential use. The RARE II designations and a draft EIS are scheduled to be published in July 1980.

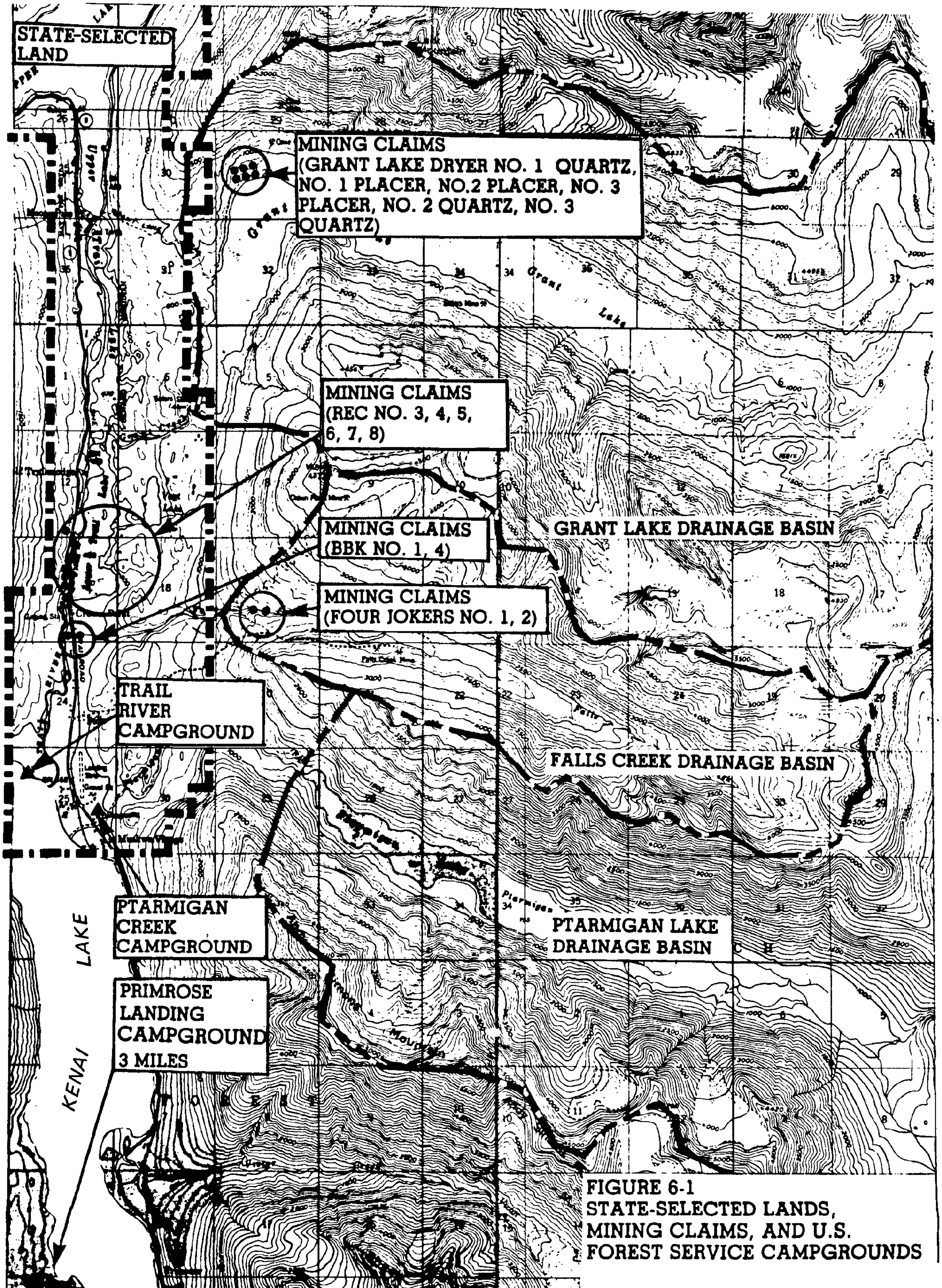


FIGURE 6-1
STATE-SELECTED LANDS, MINING CLAIMS, AND U.S. FOREST SERVICE CAMPGROUNDS

Both the State and the Borough have initiated planning studies that may affect the area. The Alaska Division of Lands is preparing land use recommendations for all state lands within the Borough. The Kenai Peninsula Borough, in turn, is establishing planning goals for Borough-nominated lands. An advisory planning commission was established in Moose Pass to help formulate those goals.

There are a number of mining claims being worked along Grant Lake and Falls Creek. Four claims that would be affected by the Falls Creek diversion have been identified. Two of these are near the outlet of Falls Creek, the other two are approximately 2 miles upstream (Figure 6-1). Six mine claims are located at the northwest corner of Grant Lake. The claimant is applying for patents on three of these.

Private land holdings in the Grant Lake-Falls Creek area include a 5-acre tract and house along Grant Creek owned by Jack Warner of Seward.

Impacts

Land will be required for dam sites on Grant Lake and Falls Creek and for a pipeline, penstock, and powerhouse. Access to this area will cross Federal lands and, after anticipated land transactions take place, State and Borough lands.

The proposed Grant Lake dam sites, penstock routes, and powerhouse sites are located on state-selected land. An access road and transmission line corridor on state-selected land which parallels the eastern side of Lower Trail Lake at about 500 feet elevation has been proposed. The Falls Creek diversion pipeline will be near the boundary between Chugach National Forest and state-selected lands.

Safety regulations could preclude future home construction in the flood plain downstream from the Grant Lake dam site. Access easements through private land might be required for the Falls Creek pipeline development.

LAND USE, RECREATION, AND SCENIC ENVIRONMENT

Setting

Grant Lake experiences little recreational use. No road access to Grant Lake exists. An old Forest Service trail from Moose Pass into Grant Lake is shown on maps, but has not been maintained. However, goats are hunted along the ridge north of Grant Lake.

The U.S. Forest Service is in the process of cataloging Federal land according to its scenic value along the designated visual corridor which parallels the Seward-Anchorage Highway. Areas surrounding Grant Lake and the eastern portion of Falls Creek have been identified according to sensitivity to change, relative distance from the highway, and proposed management programs.

According to National Forest Landscape Management criteria, lands surrounding Grant Lake have been designated primarily as average sensitivity requiring partial retention (Ref. 19). Land in the vicinity of Falls Creek has been identified as more sensitive with interspersed areas of distinctive scenery.

Retention has been determined to be the appropriate management policy.

The U.S. Forest Service provided usage information for several campgrounds in the Grant Lake area (personal communication). Visitation data by category of general camping, auto, trailer, and tent camping and picnicking are shown for each campground in Table 6-5. The Ptarmigan Creek and Trail River campgrounds are both situated on the northeastern corner of Kenai Lake approximately four miles southwest of Grant Lake (Figure 6-1). The total visitor days for fiscal year 1978 were 10,800 at Trail River and 7,100 at Ptarmigan Creek. This increased in 1979 to 12,100 and 7,800 visitor days at Trail River and Ptarmigan Creek Campgrounds, respectively. Primrose Landing Campground is located approximately 8-1/2 miles southwest of Grant Lake at the southwestern corner of Kenai Lake (Figure 6-1). Visitation at Primrose Landing increased from 5,000 days logged in 1978 to 5,700 days in 1979.

Table 6-5
CAMPGROUND VISITATION

CAMPING	Trail River FY 78* (Visitor Days)	Trail River FY 79* (Visitor Days)	Ptarmigan Creek FY 78* (Visitor Days)	Ptarmigan Creek FY 79* (Visitor Days)	Primrose Landing FY 78* (Visitor Days)	Primrose Landing FY 79* (Visitor Days)
General	7,000	8,000	500	500	500	600
Auto	1,000	1,100	2,000	2,200	1,000	1,100
Trailer	1,300	1,400	4,000	4,400	1,500	1,700
Tent	500	500	100	100	500	600
Picnicking	1,000	1,100	500	600	1,500	1,700
Total	10,800	12,100	7,100	7,800	5,000	5,700

Source: U.S. Forest Service (personal communication).

* FY78 refers to the Fiscal Year from September 1, 1977 through September 1, 1978; FY79 is September 1, 1978 through September 1, 1979.

Land uses need to be compatible with Federal, State, and local policies and with permit requirements. The policies currently being formulated are expected to be favorable toward hydroelectric power development.

Impact

Recreational opportunities around Grant Lake will increase if access roads for construction are subsequently maintained and opened to the public. Activities might be expected to include hiking, picnicking, hunting, skiing, and snowmobiling. Development of a picnic area or campground would provide further opportunities.

The Grant Lake reservoir will be drawn down during late winter and early spring. This could create the unsightly appearance of a "bathtub ring" often associated with hydropower reservoirs. However, unfavorable impacts on recreation use are expected to be minimal since Grant Lake is typically covered with snow during winter and early spring and few, if any, people are in that area.

Scenery viewed from the highway in the direction of Grant Lake is not expected to change significantly. The proposed dams on Grant Lake will be screened from highway view by a low ridge. The penstock will probably be hidden from roadside view by existing trees and undergrowth, but the Falls Creek pipeline may be visible.

Visual intrusion of the proposed power transmission and access corridor which parallels Lower Trail Lake will be minimal because of existing vegetative cover. Very little additional visual impact from transmission lines south of Trail Lake is anticipated if the lines are placed within the existing power transmission corridor.

SOCIOECONOMIC CONDITIONS

Setting

The project area is served by the Seward-Anchorage Highway and the Alaska Railroad, both of which cross the lower section of Falls Creek and lie within 1/4 mile of the mouth of Grant Creek. The few residents near the project live along the Seward-Anchorage Highway. Commercial development in the Grant and Falls Creek drainages has been limited to a few mines, several of which are active.

The two communities closest to Grant Lake are Seward, located about 30 miles to the south via the Seward-Anchorage Highway, and Moose Pass, situated across upper Trail Lake approximately 2 miles northwest of the Grant Lake outlet.

The 1980 population of Seward is estimated at 2,300. Major contributors to the local economy include fishing and fish processing, port and transportation services, wood processing, and educational and health care institutions. Other sources of economic activity have been tourist related retail services, port activity related to construction of the Alaska pipeline, and services to offshore oil and gas development.

Total employment in the Seward labor market averaged about 1,325 in both 1977 and 1978. The unemployment rate was about 14 percent in 1977 and 16 percent in 1978. The seasonal variation in unemployment is significant; it decreased from 19 percent in January 1979 to about 11 percent in April 1979.

The town of Moose Pass had an estimated population of 268 in 1978. Most of the residents have year-round jobs with either the State or Federal governments or in small business firms. The Alaska Railroad and the Seward Highway connect at Moose Pass, which serves as a freight transfer point for goods shipped to points on the Kenai Peninsula not served by rail.

Several old mine buildings exist within the inundation zone at the northwest corner of Grant Lake.

Impacts

During the 1982-1983 construction season, approximately 30 to 50 workers will be employed on the project. An estimated 70 percent of these will be semi-skilled and general labor and 30 percent will be specialized technicians. Part of this construction work force could be hired from the Seward-Moose Pass or Kenai-Soldotna areas. Other workers may be hired from Anchorage. A work force of this size may affect the local economies by creating demand for additional services and temporary housing. Alternatively, little local economic impact would occur if workers were hired primarily out of the Anchorage area. A much smaller portion of wages would be spent in local communities with more spending occurring in Anchorage. The origin of construction workers will be determined by the contractor selected to build the proposed facilities.

If the Grant Lake hydropower project is constructed, it would provide Seward residents with lower cost power than would be available from other sources (see Chapters 5 and 7).

Elimination or damage of as-yet undiscovered historical or archeological sites may occur during construction and flooding. A preconstruction cultural resources survey is recommended in order to determine whether any significant historical or archeological sites would be affected.

SUMMARY AND CONCLUSIONS

The proposed project would have impacts on several areas of the environment, but none is expected to be significant enough to preclude project development. The main impacts are expected to be:

- Moose, sheep, and goats could be displaced as a result of increased human activity during and after project development
- Aquatic life, including fish, would be affected in Grant Lake, Grant Creek, and Falls Creek as a result of lowered water temperatures in Grant Lake, dewatering of Grant Creek, and reduction of the flow in Falls Creek
- The lake surface elevation would rise 50 feet and fluctuate by this amount, leaving a visible barren ring around the lake
- Vegetation would be permanently removed from the existing lakeshore and from the routes of access roads, the penstock, pipelines, and transmission lines
- Home construction downstream from the lake could be precluded for safety reasons
- Local communities could be affected by the construction labor force

Further study is needed to determine the design level earthquake. Water temperature control in the lake and streams could also be studied as part of a more detailed assessment of fish in Grant and Falls Creeks. The U.S. Forest Service should be contacted to determine if raising the lake level would affect the moose burn program. Finally, a cultural resources survey should be conducted before construction to determine whether any archeological or historical resources would be affected.

Chapter 7
ECONOMIC AND FINANCIAL ANALYSIS

Construction cost estimates for the Grant Lake hydropower alternatives are given in Chapter 5. These costs form the basis for the analysis performed in this chapter to determine the economic feasibility of the project. Only alternative 1 is evaluated here; alternatives 2, 3, and 4 are not analyzed because of their high cost and their low energy output compared to alternative 1 (see Table 5-1).

Analyses are given below for investment cost estimates (i.e., bond issue requirements), annual costs, and power costs for alternative 1. In addition, comparative assessments of the economic merits of this alternative are given relative to other sources of electric power.

FINANCIAL COSTS

The investment costs for the Grant Lake project will consist of design and construction expenses, interest during construction, a deposit to the reserve account in the bond fund, bond discount and financing expenses, working capital, and an allowance for escalation both before and during construction. Investment cost estimates are given in Table 7-1 for alternative 1 both with and without the Falls Creek diversion. The actual financing requirements will be established on the basis of the financing method and advice by Seward's financial consultant and bond counsel. The following assumptions were made in developing the investment cost estimates.

- Revenue bonds repayable over a 30-year period would provide funds to recover the capital investment cost of the project. The debt service would be paid from guaranteed annual revenues.
- Tax-exempt bonds would bear an annual 8-1/2-percent interest rate
- Payment of interest on bond issue borrowing during construction would be at the annual 8-1/2-percent rate
- Bond issue funds not immediately required for construction expenditures would be reinvested in Treasury certificates and would earn interest at an annual 12-percent rate.
- A period of 24 months would elapse between bond sale and final payment of construction expenditures.

Table 7-1
ESTIMATED INVESTMENT COSTS
FOR ALTERNATIVE 1

	Without Diversion	With Diversion
Total Construction Cost (January 1980 price levels)	$15,187,000	$18,637,000
Price Escalation Prior to Construction	3,190,000	3,913,000
Price Escalation During Construction	1,781,000	2,185,000
Net Interest Expense During Construction	1,026,000	1,260,000
Reserve Account in Bond Fund (1 year bond interest)	2,028,000	2,490,000
Bond Discount and Finance Expense (2% of bond issue)	476,000	586,000
Working Capital Expense (1-month debt service)	185,000	227,000
Total Investment Cost (equal to bond issue)	$23,870,000	$29,295,000

Assumptions: First year of construction is 1982.
Length of construction is 2 years.
First year of project operation is 1984.

- Inflation (or price level escalation) would average 10 percent annually from 1980 through 1982, 8 percent annually for years 1983 and 1984, and 7 percent annually thereafter.
- The required reserve account in the bond issue fund is equivalent to one year's interest expense on the bond issue.

- The bond discount and finance expense is equivalent to 2 percent of the bond issue.

- The required working capital is equivalent to one month of debt service on the bond issue.

ANNUAL COSTS

The estimated annual costs include the fixed charges for capital recovery or debt service on the bond issue and the annual operating expenditures covering administration, insurance, operation and maintenance, allowance for equipment replacement, license costs, fees and other miscellaneous expenses. The estimated annual costs in the first year of project operation of alternative 1 are shown in Table 7-2. The following basis was used to determine the estimated annual expenditures.

- Capital Recovery. Revenue bonds repayable over a 30-year period would provide funds to recover the project's capital investment cost. The debt service would be paid from guaranteed annual revenues resulting from project operation. Tax-exempt bonds would bear an annual 8-1/2-percent interest rate.

- Insurance. Insurance coverage would be required for fire and storm damage, vandalism, property damage, and public liability. An average rate of 0.1 percent of the total investment cost was used to determine first-operating-year insurance costs.

- Operation and Maintenance. Operation and maintenance expenses cover the costs for manpower, services, offices, repair shops, equipment, and parts. Operation and maintenance costs were estimated to be 0.8 percent of the total investment cost the first year of project operation.

- Interim Capital Replacements. The interim capital replacement expense provides an allowance for the replacement of components and facilities that have an estimated useful life significantly shorter than the 30-year amortization period for project capital investment costs. These facilities include hydraulic turbines, generators, governors and valves, switching facilities, transformers, substations and other auxiliary mechanical and electrical equipment. The interim capital replacement expense for the first year of operation was assumed to be 0.25 percent of the total investment cost.

Table 7-2
ESTIMATED ANNUAL COST AND POWER COST IN FIRST YEAR OF OPERATION FOR ALTERNATIVE 1

	Without Diversion	With Diversion
Debt Service (30 years at 8-1/2% interest)	$2,221,000	$2,726,000
Interim Capital Replacements (0.25% of total investment cost)	66,000	73,000
Insurance (0.1% of investment cost)	24,000	29,000
Operation and Maintenance (0.8% of investment cost)	190,000	234,000
Administrative and General (0.3% of investment cost)	71,000	88,000
Credit for Interest Earned on Reserve Account Funds (earnings computed at 10% interest rate)	(203,000)	(249,000)
Total Annual Cost in First Year of Operation	$2,363,000	$2,901,000
Annual Energy Production (kWh/yr)	27,300,000	32,800,000
Power Cost in Mills/kWh in First Year of Operation	87	88

Note: Costs are for 1984 prices and assume first year of operation is 1984.

- Administrative. Administrative and other miscellaneous general costs required during hydropower project operation for supervision and administration activities were estimated at 0.3 percent of the total investment cost for the first year of project operation.

- Credit for Interest Earned on Reserve Account Holdings. Interest revenues would be earned on the funds held in the bond issue reserve account. The interest earned would be based on an annual 10-percent interest rate.

Inflation, or price-level escalation, was assumed to average 10 percent annually from 1980 through 1982, 8 percent annually for 1983 and 1984, and 7 percent annually thereafter.

POWER COSTS

The estimated power cost for alternative 1 with and without the Falls Creek diversion is shown in Table 7-2. These estimates are for the first year of project operation (1984) and are expressed in 1984 price levels. The least cost alternative is alternative 1 without the Falls Creek diversion. This alternative has an estimated power cost of 87 mills/kWh in 1984 (1984 prices).

The cost estimates are for the first year of project operation. Power costs would increase over time in response to inflation. The variable expenses (insurance, operation and maintenance, interim capital replacement, and administrative costs) would increase, roughly at the rate of general inflation, while debt service expenses would remain fixed regardless of inflation levels. The net aggregate effect over time would be to increase project power costs at a rate much less than the general inflation rate. For an inflation rate after 1985 of 7 percent annually, the estimated power costs for alternative 1 without the Falls Creek diversion would increase to 94 mills per kWh in 1990 (1990 prices) and then to 113 mills per kWh in the year 2000 (year-2000 prices).

PROJECT FINANCING

A City of Seward bond issue would be required to procure funds to construct a Grant Lake hydropower project. In the current bond market, the city could issue a revenue bond at an 8-1/2-percent interest rate repayable over 30 years. Debt service on the bond would be repayable from guaranteed annual revenues generated from sales of Grant Lake-generated electric power.

Alternative sources of construction funds offering lower interest rates might be available to the city for financing construction of the project. One such source of funding could be the Alaska Power Authority. Using an alternative source of construction funds that offers an interest rate lower than the 8-1/2-percent annual rate would result in Grant Lake alternative 1 becoming more economically attractive.

COSTS OF ALTERNATIVE POWER SOURCES

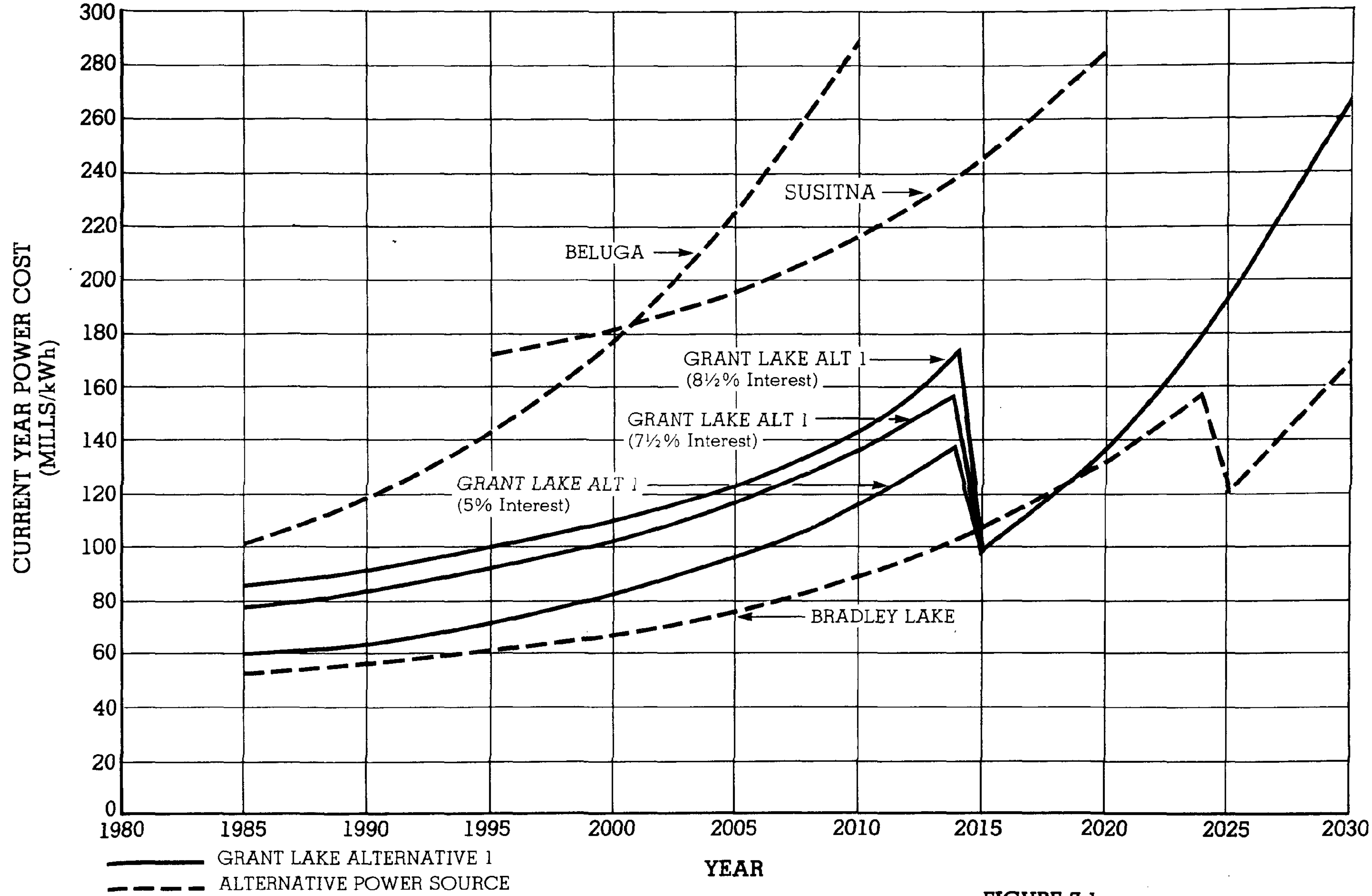
Estimates of the cost of power from alternative electric power sources expected to be available to Seward were given in Chapter 2. Purchasing electric power from the CEA is one low-cost alternative source of electric power available to Seward. The cost to Seward would be based on a one-component rate of 22 to 28 mills per kWh in 1985 (1980 prices). It is expected that after 1985 this electric power cost would increase at an average rate of 0 to 5 percent annually in real terms (i.e., 0 to 5 percent per year above general inflation).

A second low-cost electric power source is the Bradley Lake hydropower project. Seward could participate in the construction and operation of the project with others, such as Anchorage Municipal Light and Power Company or the Alaska Power Administration. The cost of power to Seward (including transmission costs) from Bradley Lake is expected to be 40 to 60 mills per kWh in 1985 (1985 prices). It is expected that after 1985 the power cost from Bradley Lake will increase slightly over time.

The cost of the least cost source of alternative power represents the value of the power produced from the Grant Lake projects. The alternative source power values multiplied by the electric power production from Grant Lake are used in the next section to establish the expected benefits (electric power sales revenues) achievable from a Grant Lake project.

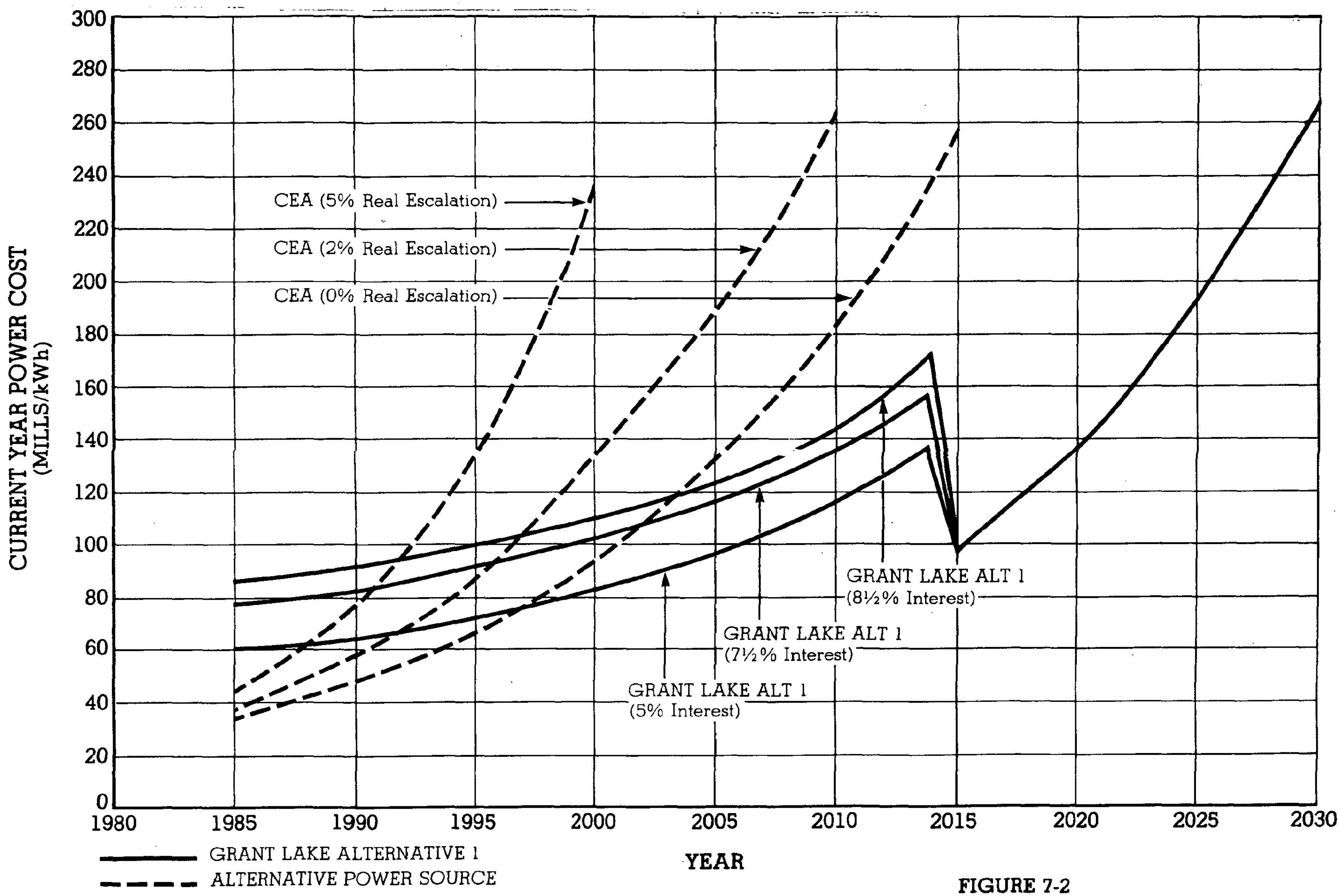
COMPARATIVE BENEFIT-COST ANALYSIS

The estimates developed for the cost of power from alternative 1 and the other alternative power sources are shown in Figures 7-1 and 7-2. The alternative 1 estimates are for 30-year financing and for annual interest rates of 8-1/2 percent, 7-1/2 percent, and 5 percent. Because of the uncertainty in future price escalation rates, CEA purchased power prices are shown for real purchase price escalation rates of 0, 2, and 5 percent annually (nominal price escalation rates of 7, 9, and 12 percent, respectively). The power costs are shown in current year price levels. Transmission expenses from Anchorage to Seward were assumed to be 4 mills/kWh.



NOTE: Initial investment amortization period is 30 years (Grant Lake Alternative) and 40 years (Bradley Lake Alternative).

FIGURE 7-1
ESTIMATED POWER COSTS FOR GRANT LAKE ALTERNATIVE 1, AND ALTERNATIVE POWER SOURCES



NOTE: Initial investment amortization period is 30 years.

FIGURE 7-2
ESTIMATED POWER COSTS FOR GRANT LAKE ALTERNATIVE 1, AND ALTERNATIVE POWER SOURCES

The comparative analysis began with a benefit-cost analysis to determine the economic advantage or disadvantage of using a Falls Creek diversion. Alternative 1 with and without the Falls Creek diversion was used in this analysis for the comparison with the low-cost alternative power sources. Because the energy output with the Falls Creek diversion differs from the output without diversion, the benefit-cost analysis was based on the assumption that both configurations must provide an annual power output equal to the output with diversion (32,800,000 kWh). The without-diversion configuration must purchase makeup power to meet this energy requirement. This put the two configurations on an equivalent basis for comparison. The analysis was based on an initial generation of power in the year 1984 and assumes average water conditions. The alternative with the highest benefit-cost ratio greater than 1 is economically most feasible, as determined by a comparison of benefits to costs over a 30-year planning period on a present worth basis. The benefit-cost analysis results are shown in Table 7-3.

Table 7-3
BENEFIT-COST COMPARISON OF ALTERNATIVE 1
WITH AND WITHOUT FALLS CREEK DIVERSION

Alternative Power Source	Present Value Benefit-Cost Ratio of Grant Lake Hydropower Alternative 1* Without Diversion	With Diversion
CEA (assuming 0% real price escalation per year)	.71	.65
CEA (assuming 2% real price escalation per year)	.95	.91
CEA (assuming 5% real price escalation per year)	1.46	1.58
Bradley Lake Hydroelectric Project	.65	.59

Assumptions: 32,800,000 kWh/yr supply to Seward
8-1/2-percent discount rate
30-year planning period

* At beginning of plant operation.

Table 7-3 indicates that for most of the alternative electric power sources considered, the benefit/cost ratios for alternative 1 with and without the Falls Creek diversion are similar. For this reason, it cannot be clearly established that use of a Falls Creek diversion is economically advantageous.

This result differs from the preliminary evaluation of the Falls Creek diversion in Chapter 2, which seemed to indicate that Falls Creek was economically beneficial. Further and more comprehensive study beyond the scope of this feasibility study will be required to determine the specific economic merit of a Falls Creek diversion. The remaining analyses performed as part of this feasibility study assumed the Grant Lake project to be without a Falls Creek diversion.

A second benefit-cost analysis was performed, and the results are given in Table 7-4. The analysis compared Grant Lake alternative 1 without the Falls Creek diversion to the two low-cost alternative electric power sources. Table 7-4 includes benefit-cost values calculated for 30-year project financing at 8-1/2, 7-1/2, 5, and 3 percent annual interest rates.

The benefit-cost ratios presented in Table 7-4 show that the economic feasibility of the Grant Lake hydropower project is sensitive to the cost of alternative source energy.

Table 7-4
BENEFIT-COST COMPARISON OF
ALTERNATIVE 1
WITHOUT FALLS CREEK DIVERSION

	Present Value Benefit-Cost Ratio For Alternative 1 at Beginning of Plant Operation			
30-year Project Financing Interest Rate (%)	Bradley Lake Hydroelectric Project	CEA (assuming 0% real price escalation per year)	CEA (assuming 2% real price escalation per year)	CEA (assuming 5% real price escalation per year)
8-1/2	.61	.67	.93	1.61
7-1/2	.67	.76	1.07	1.90
5	.85	1.05	1.53	2.83
3	1.01	1.36	2.01	3.87

At the 8-1/2 percent interest rate expected to be available to the city, Grant Lake hydropower alternative 1 has a favorable benefit-cost ratio (i.e., greater than 1.0) when compared to CEA purchased power at 5-percent real price escalation. It is expected that power purchased from CEA will escalate at least at the 2-percent real level and probably higher. Therefore, Grant Lake hydropower alternative 1 is expected to be economically feasible compared to CEA purchased power.

When compared to the Bradley Lake hydropower project, Grant Lake suffers from economies of scale and difficult site conditions. Grant Lake alternative 1 does not compare favorably with the Bradley Lake project.

However, the analysis performed was based on Bradley Lake cost projections derived from previous reports alone. No attempt was made to update or critique these costs estimates by using studies currently being performed by the Alaska District Corps of Engineers.

If the City of Seward can obtain all of its power needs over the next 30 years by participation in or purchase from the Bradley Lake project as proposed, they should do so. However, if the city cannot meet all of its energy needs with Bradley Lake power, if Bradley Lake is delayed, or if the Bradley Lake cost escalates, Grant Lake should be considered an economically viable alternative.

Chapter 8
PROJECT IMPLEMENTATION

The findings in Chapters 5, 6, and 7 indicate that the Grant Lake hydropower project appears technically, environmentally, and economically feasible. The feasibility will be further assessed during preparation of the FERC license application for the project. This chapter discusses the permits and licenses required for project implementation and gives the project schedule.

PERMITS, LICENSES, AND APPROVALS

A number of Federal, State, and local agencies were contacted during this study to discuss in general terms any concerns they might have about the Grant Lake project. Table 8-1 shows all licenses, permits, and approvals currently known to be required.

The Federal Energy Regulatory Commission (FERC) hydroelectric license application will require the major cost and effort during the permit/license application phase. Preparation of the FERC license is expected to take approximately 8 months. Granting of the license could require 12 to 18 months. The maximum processing time for any other permit or license is estimated at 6 months.

As discussed in the section titled Land Status, Chapter 6, the land ownership of part of the site is expected to change within 5 years. The transfers of State-selected lands from Federal, to State, then to Borough ownership will affect the timing and applicability of certain permit and license requirements. All Federal permits except the U.S. Forest Service Special Use Permit are required regardless of which jurisdiction owns the land. The U.S. Forest Service Special Use Permit is only applicable to development on Forest Service lands.

Most State permit requirements are applicable regardless of land ownership. However, several apply only to lands in State ownership, such as the rightof-way or easement permit, special land use permit, and leases administered by the Alaska Department of Natural Resources.

When land is transferred between governmental jurisdictions during development or operation of a project, some permits are appurtenant to the land. The permittee is often given perference in negotiating permits or leases required by the new jurisdiction. For example, according to the State's lease requirements, "...if an existing federal lease or an existing U.S. Forest Service permit is in effect in a State selected area at the time the area is patented by the State, the lessee or permittee has preference rights to lease the land from the State (before, and if, it is offered to the general public). When a Federal lease exists, the terms in the State lease will be equal to those granted in the original lease, and the State lease may not be less than its appraised market value." (Ref. 1).

The Kenai Peninsula Borough is currently developing a plan for Borough-owned lands. This plan might be applicable to the project, depending on land ownership and status of the Borough plan during the preconstruction and operation phases.

PROJECT SCHEDULE

The schedule developed for the Grant Lake hydropower project is shown in Figure 8-1. This is the most optimistic possible schedule and will bring the project on line by late 1983. The major area of potential delay lies in the license and permit approvals. If, for example, the FERC license takes 20 months instead of 12 as shown, the project will probably be delayed one full year. It is assumed that with the recent streamlining of FERC license procedures and with favorable local support, the license will be granted at the end of 1981.

As shown on the schedule, final design must be started in advance of receipt of the FERC license. This is a normal occurrence when an accelerated schedule is desired. This will require the commitment of further funds prior to a firm approval from FERC. Award of the turbine/generator contracts prior to FERC approval will also entail some risk but will greatly accelerate the project. Preliminary indications from FERC on the outcome of the application can help to guide the decisions as to how much effort should be committed prior to FERC license receipt.

Table 8-1
REQUIRED PERMITS, LICENSES, AND APPROVALS

Jurisdiction	Agency	Permit, License, or Approval	Remarks
Local	Kenai Peninsula Borough	Approval--conformance with Borough land use plans	Borough currently developing plan for Borough-owned lands that could include project site
State	Department of Fish & Game Habitat Protection	Anadromous Fish Protection Permit	Requires protection of fish spawning routes and grounds
	Department of Natural Resources	Preconstruction Cultural Resources Survey	Recommended; the sites have not previously been surveyed for historic and prehistoric resources (Alaska Statute 41.35.070)
		Upland Lease Permit	Required for use of State lands Maximum term 55 years
	Division of Land and Water Resources	Water Use Permit	Required for an appropriation of State waters
		Right-of-way or Easement Permit	Required for construction of a road, trail, etc., on State lands
		Special Land Use Permit	Required for placing of temporary improvements or equipment on State land
	Department of Environmental Conservation	Water Quality Certification	Applies to navigable water courses.
		Solid Wate Disposal Permit	Permit required if solid waste generated during construction is to be disposed of on site.

Source: Alaska Department of Commerce and Economic Development, Department of Environmental Conservation. Directory of Permits. June 1979.

Table 8-1 (Cont.)

Jurisdiction	Agency	Permit, License, or Approval	Remarks
State	Department of Commerce and Economic Development Public Utilities Commission	Certificate of Public Convenience and Necessity	Required for the ownership and operation of a public utility
	Department of Transportation and Public Facilities	Utility Permit and Highway Right-of-way	Required for new construction, improvements, or changes in existing facilities such as transmission lines
Federal	Federal Energy Regulatory Commission (FERC)	Hydroelectric License	Preliminary permit may be applied for to secure priority of license application. License application is sent to variety of State and Federal agencies for review.
	Council on Environmental Quality	Environmental Impact Statement	Appropriate agency (e.g., FERC) prepares environmental assessment and then determines need for full EIS. EIS is circulated to State and Federal agencies for review; public hearings are also held.
	Environmental Protection Agency	NPDES Permit	Applies to discharge from project. Requires "401" certification by ADEC
	Corps of Engineers	Section 404 Permit	Required for discharge of dredged or fill material into United States waters
	Forest Service	Special Use Permit	May not be required, depends on whether structures or activities will occur on Forest Service lands (e.g., Falls Creek)

Source: Alaska Department of Commerce and Economic Development, Department of Environmental Conservation. Directory of Permits. June 1979.

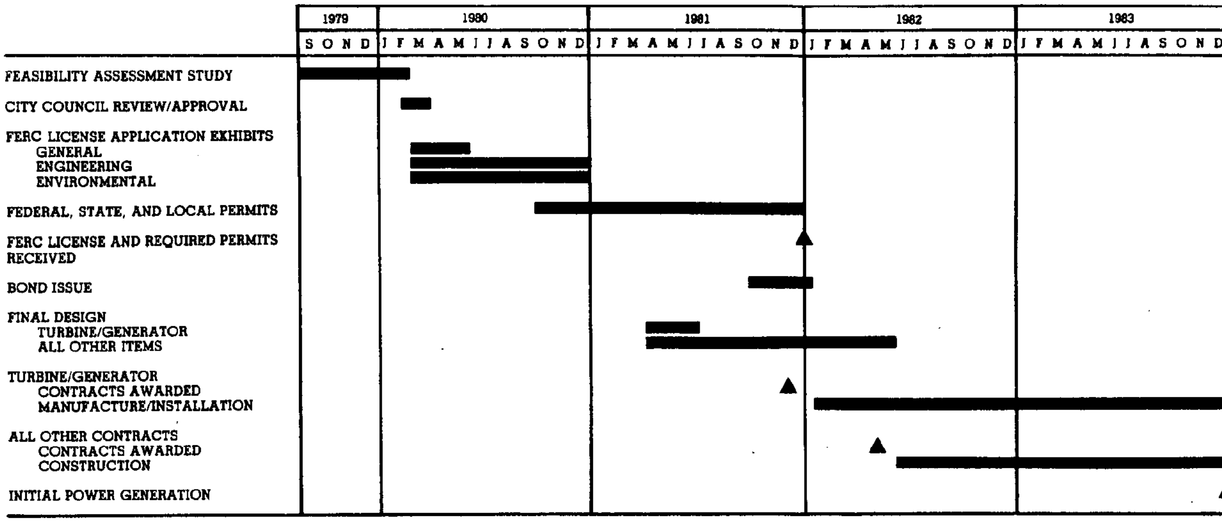


FIGURE 8-1
PROJECT SCHEDULE

Chapter 9
REFERENCES

1. Alaska Department of Commerce and Economic Development, Department of Environmental Conservation. Directory of Permits 1979.

2. Alaska Housing Authority. Kenai Peninsula Borough Comprehensive Planning Program. 1970.

3. Application for License for Crescent Lake Hydroelectric Project. Project No. 2171. City of Seward application before Federal Power Commission. Prepared by Howard T. Harstad & Associates, Seattle, Washington.

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25. ———————. Plan and Profile, Grant Creek and Grant Lake, Alaska, Dam Site. Topography by Gordon C. Giles, surveyed in 1950. Printed in 1951.

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Appendix A
Environmental and Institutional Constraints

CH2M HILL

TASK MEMORANDUM

Task 4. Environmental and Institutional Constraints

DATE: 8 October 1979

PROJECT: Seward Hydro, K12404.CO

PREPARED BY: S. Brody, C. Howell

The City of Seward is exploring the possibility of developing its own source of electric energy. Toward this endeavor, CH2M HILL has initiated a feasibility assessment of hydroelectric generation at three sites--Crescent, Grant and Ptarmigan Lakes. An important element in the assessment process is the early identification of all environmental and institutional issues related to development at the sites.

A meeting was held on Wednesday, October 3, 1979, in which concerned agencies helped initiate the identification of issues which need to be addressed in the feasibility study. The following is a review of the concerns expressed in this meeting and by others not able to attend, plus a brief description of the projects.

PROJECT DESCRIPTIONS

Crescent Lake

Many schemes have been suggested for this site; the most likely plan is to raise the level of the lake enough to reverse the flow into Carter Lake and out Carter Creek. The dam crest would be approximately 1,000 feet long and a 5- to 10-foot cut would be made between Crescent and Carter Lakes. A 15-foot dam would be built on the outlet of Carter, as well as a 50-foot dam on Crescent Lake. The average head would be about 1,000 feet, with an average regulated flow of 40 cfs, an average power output of 2,770 kW, and an installed capacity of 5,500-6,000 kW. Reservoir capacity would be 50,000 acre-feet. The lake surface elevation is expected to fluctuate 50 feet in a yearly cycle. The minimum elevation will be the present water surface elevation, occurring when the snow melt runoff begins. The maximum elevation would probably occur in September, 50 feet above the present elevation. No new access corridor for transmission lines would be required, as the power house will be located close to the existing highway and transmission lines. Access roads to the dams would be required for construction and maintenance.

Grant Lake

The dam site is approximately one mile from the Seward Highway and the Alaska Railroad. The dam would be built at the outlet of the lake, with a crest length of about 550 feet, and a height of 50 feet. A small saddle dam would be needed. Approximately 75,000 acre-feet would be required for complete regulation of the 170 cfs flow. One mile of pipeline with about 800 feet of penstock would achieve an approximate mean head of 250 feet. The lake surface elevation is expected to fluctuate 50 feet in a yearly cycle. The minimum elevation will be the present water surface elevation, occurring when the snow melt runoff begins. The maximum elevation would probably occur in September, 50 feet above the present elevation. The power house would be close to the highway and existing transmission lines. Average power output would be 3,000 kW, with an installed capacity of 6,000 kW. No new access corridor would be needed for transmission lines. An access road to the dam would be required for construction and maintenance.

Ptarmigan Lake

The development of Ptarmigan Lake would be similar to Grant Lake, with a dam height of approximately 50 feet and an average power output of 3,000 kW (6,000 kW installed capacity). The dam would be at the outlet of Ptarmigan Lake, with the power house close to the highway. This site is also close to existing transmission lines and no new corridor would be required. Road access would be required to the dam for construction and maintenance.

SITE SPECIFIC ISSUES

Site specific environmental and institutional are described below under seven categories: fish, wildlife, land status, recreation and scenic values, archaeology and history, water quality, and public safety. These issues are addressed for each project site.

Crescent Lake

Fish: Grayling is a resident fish in Crescent Lake and spawns at the lake's outlet and about one-half mile downstream along Crescent Creek. The proposed project would severely impact the popular sport fish. In addition, salmon (including king, coho and sockeye) use Crescent Creek for spawning. The salmon spawning problem might be mitigated by maintaining a minimum flow in Crescent Creek. However, since the grayling still would be sorely affected, the Department of Fish and Game would strongly oppose the proposed development

(1)*. The alteration of the direction of streamflow may cause confusion to those salmon returning upstream to spawn (6,7).

Wildlife: Some big game inhabit this area, primarily moose. Waterfowl use the area for nesting and molting. The proposed development will probably have little effect on these animals (1)(6,7). The U.S. Fish and Wildlife Service recommends the wildlife survey be updated in this area. Also, possible wetlands inpacts should be investigated (6,7).

Land Status: Crescent Lake and the area involved in this project are on Federal land administered by the U.S. Forest Service. This is presently designated as a "Further Planning" area and has been considered for Wilderness designation. The Forest Service is developing a plan for this entire area, including all three proposed sites. The draft of this plan is to be released in January 1980, and the final is to be completed in July 1980 (4)(10).

Recreation and Scenic Value: Crescent Lake and Creek are presently the most popular of the three sitesfor recreation. Sport fishing, day hiking, and camping are the primary activities, with Forest Service cabins available (1) (4)(10).

Archaeology and History: The investigation by the Office of History and Archaeology, Alaska Division of Parks, is not completed at this time, but will be forthcoming (14).

Water Quality: During construction, turbidity and sediment need to be minimized (6,7). Discharge temperatures during operation should be controlled so that they do not significantly vary from the original natural temperatures of the creek (1)(6,7).

Public Safety: This concern was not raised at the meeting. No development is present at this time downstream from the proposed dams. Development should be restricted if the project is constructed.

Grant Lake

Fish: No sport fish reside in Grant Lake. King and sockeye salmon spawn downstream of the existing falls. Hence, minimum maintenance flows may be a mitigation measure to maintain this salmon run. No fish passage occurs into the lake. This appears to be the least sensitive project regarding fisheries impacts (1)(6,7).

* Numerals in parenthesis refer to the numbers assigned to the meeting participants listed in the references

Wildlife: The area surrounding Grant Lake is a fall and winter concentration area for moose. Mountain goats have often been seen in the surrounding hills. Waterfowl use the lake for nesting and molting. The proposed development will probably have little effect on these animals (1). The U.S. Fish and Wildlife Service recommends the wildlife survey be updated in this area. Also, possible wetlands impacts should be investigated (6,7).

Land Status: Grant Lake is under U.S. Forest Service administration. Its status is the same as Crescent Lake (described previously). The planned location of the dams, the intake structure, penstock, and powerhouse are on State selected lands. These have been nominated by the Kenai Peninsula Borough, as well. The lands may be conveyed to the state in six months to two years. In one to two more years the land is likely to be conveyed to the Kenai Peninsula Borough from the state (12). The Kenai Peninsula Borough is currently establishing planning goals for these areas (3).

There is a mine on Grant Lake, and this may be patented. Also, five acres of land along Trail Lake and Grant Creek are owned privately by Mr. Jack Warner of Seward. His land includes a substantial house at the inlet of Grant Creek into Trail Lake. Mr. Warner favors the building of a dam and power plant at Grant Lake.

Recreation and Scenic Environment: Grant Lake currently supports very little recreational activities. No access exists across the creek between Upper and Lower Trail Lakes. An old Forest Service trail from Moose Pass into Grant Lake is shown on maps, but this has not been maintained (10).

State Parks is concerned about the aesthetics of the site and maintenance of a scenic corridor. Access to the dam site for construction could be utilized later for recreational access. A wayside for picnicking is also possible (13).

Archaeology and History: The investigation by the Office of History and Archaeology, Alaska Division of Parks, is not completed at this time, but is forthcoming (14).

Water Quality. During construction, turbidity and sediment need to be minimized (6,7). Discharge temperatures during operation should be controlled so that they do not significantly vary from the original, natural temperatures (1)(6,7).

Public Safety: This concern was not raised at the meeting. At this time no development, except one home, is present downstream from the proposed dam. Development should be restricted if the project is constructed.

Ptarmigan Lake

Fish: Ptarmigan Creek supports king, sockeye, and coho salmon spawning. No fish passage occurs from the creek to the lake (1). Ptarmigan Lake supports dolly varden and trout. Many dolly varden spawn on the gravel on the beach. Hence, these fish could be severely impacted with changes in elevation of the lake surface. Minimum maintenance flow would be a possible mitigation measure for the salmon spawning (6,7). The Forest Service has recently worked on the channel of Ptarmigan Creek to enhance spawning (4).

Wildlife: Ptarmigan Lake is a fall and winter concentration area for moose. Mountain goats are common to the surrounding hills. Waterfowl use the lake for nesting and molting. These should not be significantly impacted by the proposed project. The U.S. Fish and Wildlife Service recommends the wildlife survey be updated in this area. Also, possible wetlands impacts should be investigated (6,7).

Land Status: Ptarmigan Lake has been designated a "Further Planning" area by the U.S. Forest Service and is being considered for possible Wilderness designation. The proposed power house would be located on state selected land, which are borough nominated as well.

Recreation and Scenic Values: Ptarmigan Lake is often used by sport fishermen and day hikers (10). A Forest Service trail provides access to the lake. State Parks is concerned about the effect of development on the scenic qualities of the site.

Archaeology and History: The investigation by the Office of History and Archaeology, Alaska Division of Parks, is not completed at this time, but is forthcoming.

Water Quality: During construction, turbidity and sediment need to be minimized (6,7). Discharge temperatures during operation should be controlled so that they do not vary significantly from the original, natural temperatures (1)(6,7).

Public Safety: This concern was not raised at the meeting. At this time no development is downstream from the proposed dam. Development should be restricted if the project is constructed.

PERMITS AND AUTHORIZATIONS

The following list outlines some of the permits, authorizations, and legislation which will apply to the proposed projects.

- Federal Energy Regulatory Commission (FERC) license.
- National Environmental Policy Act procedures--CEQ.
- Anadramous Fish Act--authorization required from Alaska Fish and Game and U.S. Fish and Wildlife Service.
- Fish and Wildlife Coordination Act.
- RARE II--compliance and approval, U.S. Forest Service.
- Antiquities Act--Department of Interior.
- Kenai Peninsula Borough land use study for borough nominated lands.
- Sec. 404, Clean Water Act--EPA, DEC.
- Endangered Species Act--Dept. of Interior.
- Federal Land Policy and Management Act of 1976--Dept. of Interior.
- NPDES--EPA, DEC (this may not apply).

PROJECT ALTERNATIVES

Consideration must be given in this study to alternatives to the proposed projects (2). The following are points which should be addressed.

- If no action is taken, the City of Seward will definitely be affected (5). The City will be totally dependent on fossil fuel sources, regional gas-turbine power and diesel-fired generators, used in peak periods as well as for emergency power.
- Regional power will be available in the future from the Bradley Lake and Susitna River projects, as well as the existing Beluga plant.
- Renewable energy resources such as solar, wind, and water, are preferable to non-renewable resources for power (e.g. fossil fuels)(11).

- Any new source of power must be a compatible addition to the existing system (e.g. phasing)(2).

REFERENCES

Participants in 3 October Meeting

1. Bruce Barrett, Alaska Fish & Game Department
2. Dale Rusnell, Alaska Division of Energy & Power Development
3. Phil Waring, Kenai Peninsula Borough
4. Chuck Harnish, U.S. Forest Service
5. Robert Mohn, Alaska Power Authority
6. David McGillivary, U.S. Fish & Wildlife Service
7. Paul Hanna, U.S. Fish & Wildlife Service
8. Rikki Fowler, Alaska Department of Environmental Conservation
9. Marie Odorizzi, Sierra Club
10. David Finkelstein, Sierra Club
11. Nancy Lee, Alaska Center for the Environment

Other Participants

12. John Skelton, Alaska Division of Land & Resource Planning, DNR
13. Al Meiners, Alaska Division of Parks, Park Planning
14. Ty Dilliplane, Alaska Division of Parks, Office of History & Archaeology

Data and Reports

Alaska Department of Fish and Game, Data on fish use of Crescent, Grant, Ptarmigan Lakes and Creeks.

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Kenai Peninsula Borough, Land Use Plan for Borough Selected Land (forthcoming, 1980).

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U.S. Forest Service, RARE II land use plan and public comments on proposed designations (draft in January, 1980, final in July 1980).

Appendix B
Peakload and Energy Forecast

LOAD FORECAST
CITY OF SEWARD

October 1979

CONTENTS

TABLES

APPENDIX TABLES

FIGURES

INTRODUCTION

This peak load and energy forecast was prepared for the City of Seward for use as a planning tool in evaluating future energy source alternatives. To allow decision makers to see the outcome of several possible economic scenarios, high and low projections were calculated with an average of the two serving as the most probable medium projection. Energy requirement projections were based on an evaluation of Seward's economy, population trends, and energy use trends. Much of the general information in the historical development section is from the land use plan of the city of Seward, done by CH2M HILL in August of 1979.

The peak load projections in this report were calculated assuming an average load factor. To facilitate calculations rate schedule classifications have been reduced to 5 customer classes: residential, commercial, power and government, Seward water system, city and street lighting (GSCS). Historical data in disaggregated form as well as backup worksheets to the report tables are presented in the Appendix tables.

ECONOMIC DEVELOPMENT OF SEWARD

HISTORICAL DEVELOPMENT

Population Growth

Population trends in the City of Seward are shown below for the period 1950 to 1978.

Table 1. POPULATION GROWTH, CITY OF SEWARD

Year	Population	Average Annual Increase/Decrease
1950	2,114	
1960	1,891	-1.1
1970	1,587	-1.7
1978	2,130[a]	3.8

Source: U.S. Census

[a] Department of Community and Regional Affairs (DCRA) estimate for revenue sharing

A U.S. Special Census was conducted for Seward in September 1978. However, the official census count of 1,756 has been officially protested by the city and has not been certified by the Borough Assembly. The City of Seward's estimate for state revenue sharing purposes of 2,130 will be used in this study. The population of Seward decreased from 1950 to 1970, but has increased by over 500 since 1970, a 34 percent increase. On an annual basis the population has been increasing at the average rate of 3.8 percent over the last 8 years.

Economic Base

Major contributors to Seward's economy include fishing and fish processing, port and transportation services, wood processing, and educational and health care institutions. Other sources of basic economic activity have been tourist-related retail services, port activity related to construction of the Alaska pipeline, and services to offshore oil and gas development. Both pipeline and outer continental shelf (OCS) activity have declined since 1977 and are not currently significant sources of employment in Seward.

Major industries and employers are briefly described below.

Fish Processing

The major fish processing business in the city is Seward Fisheries, which is located near the railroad dock. The Seward Fisheries processing plant currently processes halibut, crab, shrimp, scallops, salmon, and herring. It employs from 190 to 280 people. The plant has also been expanded in the last few years to produce fish meal from fish wastes.

Timber Harvesting and Processing

Louisiana-Pacific's Kenai Lumber Company operates a saw and chip mill in Seward. It employs about 40 people on a full- and part-time basis. The mill is currently purchasing timber from outside the area and processing it for the Japanese as well as the domestic market.

Tourism

Major tourist activities in Seward include camping, sport fishing, boating, and sightseeing. The August Silver Salmon Derby and the 4th of July and Labor Day weekends draw peak numbers of summer visitors to the city. Tourist facilities in Seward include the small boat harbor which has 594 slips and a waiting list of over 300 and the Seventh Avenue greenbelt area, an undeveloped camping area which draws a large number of summer campers. The Alaska State Ferry, which is home-ported in Seward, provides service to Valdez, Cordova, and Homer.

Education and Health Services

The elementary and secondary schools, Skill Center, University of Alaska marine science institute, Wesleyan Nursing Home, and hospital all make an important contribution to local employment opportunities. The hospital and nursing home together employ about 70 people and the Skill Center has about 50 on its payroll.

PROJECTED ECONOMIC DEVELOPMENT

Seward's economic growth potential depends on a number of factors. The city's assets include available land for industrial and residential growth, an ice-free harbor, good deep-water port facilities, and transportation links to Anchorage by air, rail, and highway.

The city's economy is expected to continue its relatively rapid growth of recent years. A proposed shipbuilding repair facility is expected to have a major impact on the local economy. Other potential resource development activities include bottomfish processing, construction of the Alcan pipeline, outer continental shelf development, and wood processing. The economy will continue to grow, to some extent, in response to increasing tourism and government employment.

Seward is expected to play a role in future Alaska bottomfish development. Seward, along with the City of Homer, is located within a 300-mile radius where over 200,000 metric tons of bottomfish have been harvested annually by foreign fleets in the past. In addition, a Danish consulting group selected Seward as one of five sites (out of 19 considered) with the best potential for bottomfish development along Alaska's coast. Other sites identified were Unalaska, Kodiak, Yakutat, and Sitka.

Seward is expected to play only a secondary role in support of future OCS lease sales in the lower Cook Inlet, Kodiak, and Kodiak-Aleutian areas due to its distance from the lease areas. Its role in the Gulf of Alaska has decreased for the time being. However, with the development of a shipbuilding and repair facility, Seward's role in OCS development could greatly increase.

The future of tourism depends largely on the economy of Anchorage since a majority of Seward's tourism comes from the Anchorage area. Most of the demand for pleasure boat slips in the small boat harbor, for example, is generated by Anchorage residents. Tourist activity is expected to increase as Anchorage population increases and as existing facilities are expanded or new ones developed.

Continuation or expansion of wood processing operations will depend on the potential for maintaining or increasing timber harvest. The demand for timber in Japan and the United States will also influence the development of the local wood processing industry.

There are some specific developments in local industrial activity that are likely to have a significant impact on employment and population in Seward. Major plans by existing industries are discussed below as well as plans for new industrial development.

Development Plans - Existing Industry

As mentioned above, Seward Fisheries is planning to construct a major bottomfish processing plant in Seward, although the schedule is indefinite. Originally the plant was scheduled for construction in the near future. However, the domestic and international market for bottomfish has not been favorable and the plans have been delayed indefinitely. A spokesman for the Seward Fisheries indicated that the plant would eventually be built in the next 15 years. Their existing fish processing operations are expected to continue at present levels.

The other major industrial employer in Seward, Kenai Lumber Company, is facing an uncertain future due to unavailability of timber supply. The company's current contracts will keep them supplied to the end of 1979. The State of Alaska is committed to a land sale in 1980 which will ensure a 3-year supply, but the date of the sale is not yet known. If the company does not obtain enough timber to supply the mill in the interim, it may shut down permanently, resulting in the loss of 40 jobs. Given enough timber to maintain operations until the land sale, the company will likely expand its current operations in the future to include a planing mill and dry kilns, requiring an additional 15 employees in 1981-82.

Development Plans - New Industry

In addition to developments in existing industries, a major shipbuilding and repair facility has been proposed for the Fourth of July Creek area in Seward. The facility is expected to be a joint venture between a Danish firm, Burmeister Wain, and an American firm, Northern Offshore, Inc. The proposed facility would be capable of initially producing 10 to 12 boats per year, with possible expansion in the future. Boat production would include OCS rig tenders and bottomfishing boats. The facility could also provide fabrication and repair services to offshore oil rigs. The new development would employ about 200 people and special training programs through the Seward Skill Center are anticipated. The interested firms hope to begin construction in 1980 and begin operations in 1981.

The development of a successful shipbuilding and repair center could also lead to development of a marine industrial park including related industries such as cold storage plants, fish processing, and various marine support services.

Population Forecast

High and low population projects were developed for the Seward electric system service area as shown in table 2. The average of the two constitutes a medium projection which is considered most probable. The service area encompasses all of Seward and an estimated 734[1] residents outside the city.

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[1] Number of residents outside the city estimated by multiplying number of residential meters outside the city by 2.8 persons per household.

Table 2. HIGH AND LOW POPULATION PROJECTIONS
SEWARD ELECTRIC SYSTEM SERVICE AREA

	1	2	3	4	5	6	
		Adjustments to Base Population Forecast					
	Base Population	Changes in Employment			Adjusted Changes in	Annual Population	Percent
High Projection	Projection	Direct	Indirect	Total	Population	Projection	Change
1978	2,864*	--	--	--	--	2,864	--
1979	3,007	--	--	--	--	3,007	5.0
1980	3,158	37	19	56	112	3,270	8.7
1981	3,315	115	58	173	346	3,661	12.0
1982	3,481	215	108	323	646	4,127	12.7
1983	3,655	215	108	323	646	4,301	4.3
1984	3,838	215	108	323	646	4,484	4.3
1985	4,030	215	108	323	646	4,676	4.3
1986	4,231	215	108	323	646	4,877	4.3
1987	4,443	215	108	323	646	5,089	4.3
1988	4,665	215	108	323	646	5,311	4.4
1989	4,898	215	108	323	646	5,544	4.4
1990	5,143	215	108	323	646	5,789	4.4
Low Projection							
1978	2,864*	--	--	--	--	2,864	--
1979	2,950	--	--	--	--	2,950	3.0
1980	3,038	30	15	45	90	3,128	6.0
1981	3,130	60	30	90	180	3,310	5.8
1982	3,223	160	80	240	480	3,703	11.9
1983	3,320	160	80	240	480	3,800	2.6
1984	3,420	160	80	240	480	3,900	2.6
1985	3,522	160	80	240	480	4,002	2.6
1986	3,628	160	80	240	480	4,108	2.6
1987	3,737	160	80	240	480	4,217	2.7
1988	3,849	160	80	240	480	4,329	2.7
1989	3,964	160	80	240	480	4,444	2.7
1990	4,083	160	80	240	480	4,563	2.7

* Seward population 2,130 plus estimated population outside service area 734.

Column 1 - Low projected at 3 percent annually.
- High projected at 5 percent annually.

Column 2 - Low projection, Kenai Lumber shutdown in 1981, decrease employment by 40.
- High projection, Kenai Lumber expands, increase employment by 7 in 1980, 8 in 1981.
- Both, shipyard construction crew of 30 in 1980, employment of 100 in 1981, 200 in 1982.

Column 3 - Column 2 multiplied by 0.5.
Column 4 - Column 2 plus Column 3.
Column 5 - Column 4 multiplied by 2.0.
Column 6 - Column 1 plus Column 5.

A study done by CH2M HILL in August 1979 provided low and high baseline population projections for the city of Seward.[2] The projected growth rates of 3 percent and 5 percent from the land use plan were used to project low and high "base" populations. These base populations were then adjusted for major industrial developments that would significantly impact population growth.

The low population growth rate assumes that the economy will grow at historical levels and produce approximately the same rate of population growth in the future as it has in the past. From 1960 to 1978 the economy produced an annual population growth rate of 3.8 percent, slightly higher than the low population growth rate of 3 percent.

The high population growth rate of 5 percent assumes that Seward will participate more actively in development of local and regional resources and represents an "upper limit" on population growth. The population projections which resulted from the 3-percent and 5-percent growth rates are base population projections that do not include any specific, major industrial developments. The base populations were then adjusted for anticipated changes in industrial employment.

Both the low and high projections were adjusted to include the 200 employees expected to be employed by the shipbuilding repair facility. In addition, the low projection assumed the Kenai Lumber would be unable to obtain timber and would cease operations in 1981. The high projection assumed that Kenai Lumber will expand its operations, hiring 15 new employees in the period 1980 to 1982.

In addition to direct employment changes, there are indirect employment changes that result from the direct change. An analysis of employment in 1970 and 1975 showed that for every two employees in a major industry in Seward there is one local, service-oriented employee, resulting in an employment multiplier of 1.5. Analysis of employment to population in 1970 and 1975 showed there were two residents for every employee in the Seward region, yielding a population multiplier of 2.0.

Both high and low population projections show larger percent increases in the period 1980 to 1982, reflecting increased industrial employment and then level off to annual increases of approximately 4 percent and 3 percent from 1982 to 1990.

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[2] CH2M HILL, Land Use Plan, City of Seward, August 1979.

ELECTRIC LOAD GROWTH AND FORECAST

HISTORICAL PEAK LOAD AND ENERGY CHARACTERISTICS

Seward's peakload requirement has grown from 1.7 MW to 6.7 MW over the 12-year period since 1967 for an average annual growth rate of 9.2 percent. As shown in table 3, the growth has been extremely volatile, varying as much as 81 percent in one year (1970-1971). Total energy requirements have grown at a more uniform rate, tripling since 1967.

The residential load has decreased as a percent of the total system load from 41 percent to 31 percent since 1967[1]. During the same period, however, average residential use has increased 1.7 MW hours, a 33 percent increase, and the number of residential customers has grown by 73 percent. The combination of increases in number of customers and average use per customer has resulted in a 140 percent increase in the residential load from 2,987 MWh in 1967 to 7,176 MWh in 1979.

The 1979 commercial class contribution to system load of 19 percent is the same as the 1967 commercial class contribution. An increase of 43 percent in the number of commercial customers and 124 percent in average use per customer has produced an increase of 22 percent in the commercial load since 1967.

Large power loads have experienced the greatest historical increase, jumping from 4 percent of the system load in 1967 to 19 percent in 1979. In 1979 the large power load was almost 17 times its 1967 level even though the number of large power customers had remained at the 1968 level. The average use of the two current large power customers is approximately 2,200 MWh per year. The combined government Seward water system, city, and street lighting (GSCS) loads have dropped from 36 to 30 of total system loads since 1967. The GSCS loads have increased to almost 3 times their 1967 levels, the result of almost doubling the number of meters and a 44 percent increase in average use per meter.

System losses vary from a low of 12.8 percent to a high of 26.7. System load factors, reflecting the combination of volatile peak demands and fairly stable growth in energy requirements vary from 31.6 percent to 61.6 percent.

The ratio of residential customers to commercial customers ranges from 4.8 to 6.2. The ratio of residential customers to GSCS customers ranges from 11.0 to 13.9.

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[1] All percentages of total system load exclude losses.

Table 3. SEWARD ELECTRIC SYSTEM
ENERGY USE DATA
1967-1979

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979*	Change from 1967-79 Total	Change from 1967-79 %	Annual Rate of Change 1965-79	Annual Rate of Change 1975-79
Average Number of Customers																	
Residential	583	628	659	717	782	738	765	791	840	891	944	1,006	1,049	466	79.9	4.6	5.7
Commercial	122	128	124	121	127	127	124	128	136	151	157	170	174	52	42.6	2.8	0.4
Power	2	2	7	9	9	3	2	2	2	2	2	2	0	0	0	0	0
Gov't SWS, City, Street Lighting	50	66	60	60	59	58	69	67	65	64	72	79	93	43	86.0	4.9	9.4
TOTAL	757	824	850	907	977	960	960	988	1,043	1,108	1,175	1,257	1,318	561	74.1	4.4	6.0
Residential Customers/ Commercial Customers	4.8	4.9	5.3	5.9	6.2	5.8	6.2	6.2	6.2	5.9	6.0	5.9	6.0				
Residential Customers/ Gov't, SWS, City, Street Lighting	11.7	9.5	11.0	12.0	13.3	12.7	11.1	11.8	12.9	13.9	13.1	12.7	11.3				
Average Use Per Customer (MWh)																	
Residential	5.1	5.1	5.3	5.0	5.2	5.7	6.1	5.9	6.1	6.3	6.4	6.8	6.8	1.7	33.3	2.2	2.8
Commercial	11.5	10.9	11.9	12.2	12.6	14.4	16.1	17.6	20.4	21.7	24.1	23.8	25.8	14.3	124.3	6.4	6.0
Power	133.0	268.0	96.0	74.3	128.6	537.3	971.5	1051.0	2056.5	2186.5	1724.0	1653.5	2214.0	2081.0	1564.7	24.2	1.9
Gov't, SWS, City, Street Lighting	52.1	42.2	50.2	52.4	63.7	72.8	65.5	61.3	68.6	73.5	55.8	67.3	75.2	23.1	44.3	2.9	2.3
Energy Sales and Requirements (MWh)																	
Residential	2,987	3,179	3,481	3,559	4,101	4,215	4,696	4,664	5,120	5,632	6,020	6,807	7,176	4,189	140.2	7.0	8.8
Commercial	1,398	1,395	1,480	1,472	1,595	1,834	1,997	2,251	2,777	3,275	3,791	4,041	4,494	3,096	221.5	9.4	12.8
Power	266	536	672	669	1,157	1,612	1,943	2,102	4,113	4,373	3,448	3,307	4,428	4,162	1564.7	24.2	1.9
Gov't., SWS, City Street Lighting**	2,603	2,786	3,011	3,142	3,760	4,223	4,521	4,110	4,462	4,704	4,015	5,317	6,989	4,386	168.5	7.9	11.9
TOTAL	7,255	7,895	8,644	8,842	10,613	11,883	13,158	13,128	16,472	17,982	17,274	19,473	23,086	15,831	218.2	9.3	8.8
System Losses (MWh)	1,266	1,076	1,252	2,271	2,361	2,899	2,056	2,806	NA	2,651	4,866	4,333	3,797			8.8	NA
Total Requirements (MWh)	8,521	8,971	9,896	11,113	12,974	14,782	15,214	15,934	NA	20,633	22,140	23,806	26,883			9.2	NA
Percent System Losses (%)	14.9	12.0	12.7	20.4	18.2	19.6	13.5	17.6	NA	12.8	22.0	18.2	14.1				
Annual Peak Demand (kW)	1,764	1,944	3,384	2,268	4,104	2,664	4,752	5,760	6,084	4,032	4,104	5,040	6,696			10.8	2.4
System Load Factor	55.1	52.7	33.4	55.9	36.1	63.3	36.5	31.6	NA	58.4	61.6	53.9	45.8				

* 8 months data annualized.
** May not add due to rounding.

Currently there is a very small residential electric heating load in Seward. It is estimated that less than 2.5 percent of the residential customers have electric heating systems.

Appendix tables 1 and 5 present historical data on number of customers and energy use by rate schedule. Appendix table 2 shows the monthly peak and energy consumption for 1978.

FORECAST METHODOLOGY AND ASSUMPTIONS

The energy and peakload forecast are based on the foregoing population forecast and economic projections; major forecast assumptions are presented in table 5. Table 4 shows the projected number of residential, commercial, and combined GSCS customers. Residential customers are calculated by dividing the population by the estimated persons per household. Commercial customers and GSCS customers are calculated based on their historical ratios to the number of residential customers. The ratios of 6.0 residential customers per commercial customer and 12.0 residentials per GSCS customer were derived from analysis of historical ratios on table 3.

It is expected that a certain number of new residential customers will install electric heating systems. As discussed above it is estimated that less than 2.5 percent of all current residential customers have electric heat; however, at present rates it is less expensive to heat with electricity than with oil. On a BTU basis, Seward consumers pay $8.79 per MBTU for electric heating assuming 100-percent efficiency and a rate of 34¢ per kWh. Oil heating costs about $9.85 per MBTU assuming 60 percent efficiency and an average of oil price of 82¢ per gallon. Chugach Electric Company, the current supplier of electricity to the City of Seward, generates primarily with natural gas which is presently underpriced and likely to escalate in the future. Our forecast assumes that electric heat will remain comparable to the cost of oil heat, and as a result about 25 percent of new residential customers will heat with electricity.

Average consumption for residential electric heat was estimated at 32.2 MWH annually per customer based on a sample of customer bills from Homer Electric Company in Homer, Alaska. Weather data for Seward and Homer show that although Seward experiences slightly more extreme temperatures, average annual heating degree days are about the same.

The average use per customer for residential nonheating loads and all other class loads was projected at slightly below the average annual growth rates over the last 4 years. The reason for selecting a lower-than-historical rate is the anticipated increase in conservation.

Table 4. NUMBER OF CUSTOMERS (BY CLASS)
HIGH AND LOW PROJECTIONS
SEWARD ELECTRIC SYSTEM

	Adjusted Population[1]	Persons per Household[2]	Number of Households/ Residential Customers[3]	Number of Commercial Customers[4]	Number of Gov't, City, SWS Street Lighting Customers[5]
High Projection					
1978	2,864*	2.8	1,004*	170*	79*
1979	3,007	2.8	1,049*	174*	93*
1980	3,270	2.8	1,168	195	97
1981	3,661	2.8	1,308	218	109
1982	4,127	2.8	1,474	246	123
1983	4,301	2.8	1,536	256	128
1984	4,484	2.8	1,601	267	133
1985	4,676	2.8	1,670	278	139
1986	4,877	2.8	1,742	290	145
1987	5,089	2.8	1,818	303	152
1988	5,311	2.8	1,897	316	158
1989	5,544	2.8	1,980	330	165
1990	5,789	2.8	2,068	345	172
Low Projection					
1978	2,864	2.8	1,004*	170*	79*
1979	2,950	2.8	1,049*	174*	93*
1980	3,128	2.8	1,117	186	93
1981	3,310	2.8	1,182	197	99
1982	3,703	2.8	1,323	221	110
1983	3,800	2.8	1,357	226	113
1984	3,900	2.8	1,393	232	116
1985	4,002	2.8	1,429	238	119
1986	4,108	2.8	1,467	245	122
1987	4,217	2.8	1,506	251	126
1988	4,329	2.8	1,546	258	129
1989	4,444	2.8	1,587	265	132
1990	4,563	2.8	1,630	272	136

* Actual.

1 Table 2, column 6.
2 Kenai Peninsula Borough, Profile of Five Kenai Peninsula Towns, 1977, page 57.
3 Column 1 divided by column 2.
4 Column 3 divided by 6.0, see table 3.
5 Column 3 divided by 12.0, see table 3.

Table 5. LOAD FORECAST ASSUMPTIONS

Forecast Parameters	Low	High
Annual Population Increase	3.0%	5.0%
Persons per Household - New Residential Customers	2.8	2.8
Residential Customers per Commercial Meter	6.0	6.0
Residential Customers per Government, City, Seward Water System, Street Lighting Meter	12.0	12.0
Annual Increase in Average Use per Customer (Meter)		
Residential	2.0%	2.0%
Commercial	5.0%	5.0%
Gov't, SWS, City, St. Lighting	2.0%	2.0%
Power	1.0%	1.0%
Percentage New Customers with Electric Heat	25.0%	25.0%
Annual Consumption for Residential Heat per Customer	32.2 MWh	32.2 MWh
Industrial Loads		
Kenai Lumber Company	-2,409 MWh in 1980	+2,409 MWh in 1981
Shipbuilding, repair facility	+4,308 MWh in 1981	+4,308 MWh in 1981

Industrial loads were also adjusted to reflect the range of economic scenarios described above. Both high and low projections include a 1-MW increase in load due to the shipbuilding repair facility in 1981. The low projection assumed a decrease in load in 1980 due to Kenai Lumber Company going off the system. The high projection also included an increase in load due to addition of a dry kiln and planing mill at Kenai Lumber Company.

PEAK AND ENERGY FORECAST

High and low peak and energy projections were calculated to reflect high and low economic and population forecasts discussed above. A composite projection which averages the high and low projections was also calculated and is considered to most representative of what will occur in the future.

As shown in table 4, total system energy requirements increase from 23,806 MWh to 58,274 MWh in the low projection and to 78,762 MWh in the high projection during the forecast period 1978 to 1990. Energy requirements increase more rapidly in the first four years due to large increases in industrial loads and the beginning of a higher incidence of residential home heating. The average annual rates of change range from 13.4 to 17.0 for the first four years and 4.8 and 5.4 for the last eight years. The contribution of each class to total system energy requirements remains roughly the same; the low projection forecast residential and commercial contributions slightly above 1978 levels and large power and GSCS contributions slightly below. One high projection forecast residential and power contributions slightly above 1978 levels and commercial and GSCS contributions slightly below.

The increase in peakload ranges from 6,864 MW to 9,086 MW from 1978 to 1990. Since the peakload was derived from the energy requirement projections using a constant load factor, the largest increases also occur from 1978 to 1982. Of the 6,864 MW increase in the low projection, 3,126 MW occurs in the first four years and 2,738 in the remaining eight years. In the high projection, an increase of 5,302 occurs by 1982 and 3,784 from 1982-1990.

Appendix tables 3 and 4 present more detailed calculations for the high and low projections.

Table 6. HIGH, MEDIUM, AND LOW PROJECTIONS 1978-1990
ENERGY BY CUSTOMER CLASS, PEAK KW

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Low Projection													
Customer Class													
Residential (MWh)	6,807	7,176	8,676	9,740	11,935	12,622	13,345	14,064	14,853	15,660	16,485	17,345	18,264
Commercial (MWh)	4,041	4,494	4,985	5,496	6,409	6,825	7,285	7,759	8,330	8,860	9,469	10,123	10,998
Power (MWh)	3,307	4,428	2,039	6,440	6,504	6,569	6,635	6,701	6,767	6,835	6,904	6,973	7,042
Gov't, SWS, City, Street Lighting	5,317	6,989	7,133	7,742	8,778	9,198	9,628	10,079	10,541	11,101	11,597	12,104	12,716
TOTAL (MWh)	19,473	23,087	22,833	29,418	33,626	35,214	36,893	38,603	40,491	42,456	44,455	46,546	49,020
System Losses (MWh)[1]	4,333	3,797	3,882	5,001	5,716	5,986	6,272	6,563	6,883	7,218	7,557	7,913	8,333
Total System Requirements (MWh)	23,806	26,883	26,715	34,419	39,342	41,200	43,165	45,166	47,374	49,674	52,012	54,459	57,353
Peak KW[2]	5,040	6,696	6,900	7,144	8,166	8,552	8,959	9,375	9,833	10,310	10,796	11,303	11,904
High Projection													
Customer Class													
Residential (MWh)	6,807	7,176	9,413	11,571	14,171	15,288	16,458	17,688	19,008	20,409	21,885	23,465	25,139
Commercial (MWh)	4,041	4,494	5,226	6,082	7,134	7,731	8,384	9,063	9,860	10,696	11,597	12,606	13,697
Power (MWh)	3,307	4,428	4,472	11,354	11,468	11,582	11,698	11,815	11,932	12,052	12,173	12,295	12,417
Gov't, SWS, City, Street Lighting	5,317	6,989	7,440	8,524	9,815	10,419	11,039	11,773	12,528	13,391	14,204	15,131	16,065
TOTAL (MWh)	19,473	23,087	26,551	37,531	42,588	45,020	47,579	50,339	53,328	56,548	59,859	63,497	67,318
System Losses (MWh)[1]	4,333	3,797	4,514	6,380	7,240	7,653	8,088	8,558	9,066	9,613	10,176	10,794	11,444
Total System Requirements (MWh)	23,806	26,883	31,065	43,911	49,828	52,673	55,667	58,897	62,394	66,161	70,035	74,291	78,762
Peak KW[2]	5,040	6,696	7,900	9,114	10,342	10,933	11,554	12,225	12,950	13,732	14,536	15,420	16,348

Table 6. (cont.)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Medium Projection*													
Customer Class													
Residential	6,807	7,176	9,045	10,656	13,053	13,955	14,902	15,876	16,931	18,035	19,185	20,405	21,702
Commercial	4,041	4,494	5,106	5,789	6,772	7,278	7,835	8,411	9,095	9,778	10,533	11,365	12,348
Power	3,307	4,428	3,256	8,897	8,986	9,076	9,167	9,258	9,350	9,444	9,539	9,634	9,730
Gov't, SWS, City, Street Lighting	5,317	6,989	7,287	8,133	9,297	9,809	10,334	10,926	11,535	12,246	12,901	13,618	14,391
TOTAL	19,473	23,087	24,692	33,475	38,107	40,118	42,236	44,471	46,910	49,502	52,157	55,022	58,169
System Losses (MWh)[1]	4,333	3,797	4,198	5,691	6,478	6,820	7,180	7,561	7,975	8,416	8,867	9,354	9,889
Total System Requirements (MWh)	23,806	26,883	28,890	39,165	44,585	46,937	49,416	52,032	54,884	57,918	61,024	64,375	68,058
Peak KW[2]	5,040	6,696	7,400	8,129	9,254	9,743	10,257	10,800	11,392	12,021	12,666	13,362	14,126

* Totals may not add due to rounding.

1 Average of percentage losses over last 4 years, 17 percent.
2 Average of system load factor over last 4 years, 55 percent.

NOTE: 1978 data actual, 1979 data estimated based on 8 months data.

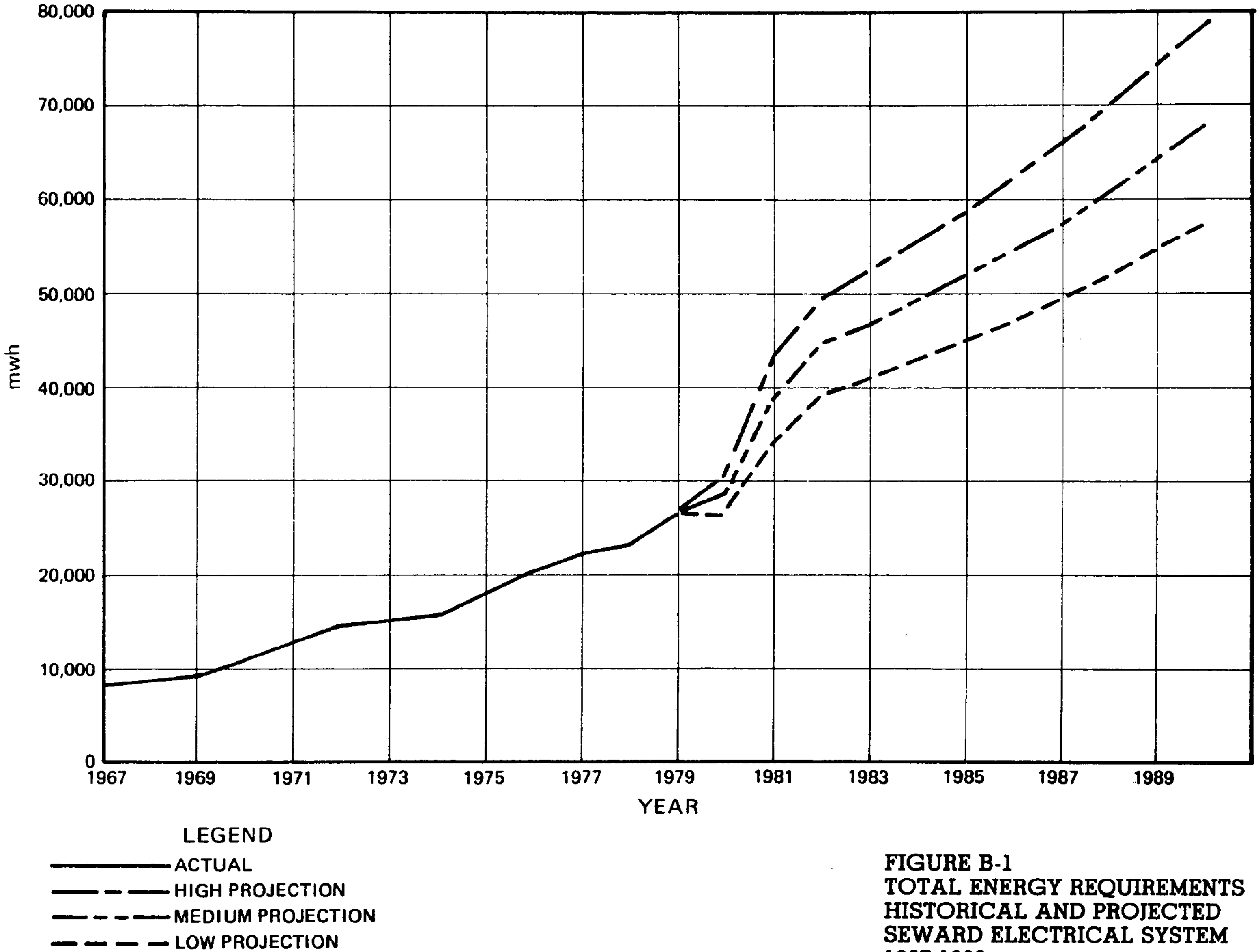

FIGURE B-1
TOTAL ENERGY REQUIREMENTS
HISTORICAL AND PROJECTED
SEWARD ELECTRICAL SYSTEM
1967-1990

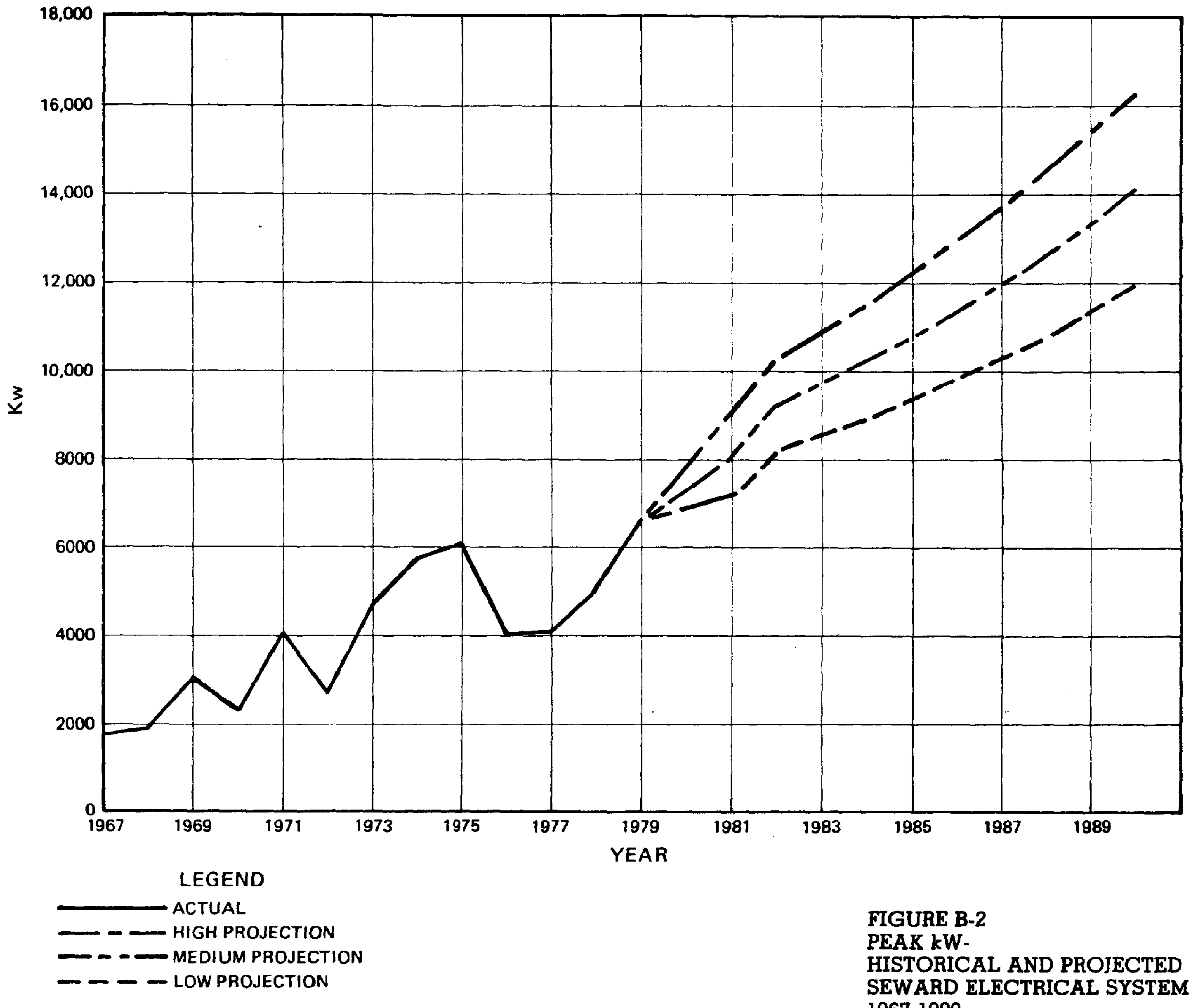

FIGURE B-2
PEAK kW-
HISTORICAL AND PROJECTED
SEWARD ELECTRICAL SYSTEM
1967-1990

Appendix Tables

APPENDIX TABLE 1
SEWARD ELECTRIC SYSTEM
ENERGY USE DATA
1965-1979

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Average Annual Percent 1965-1970	1970-1975	1975-1979
Average Number of Customers																
Residential																
Domestic	386	418	432	484	514	495	519	534	582	635	677	721	756	.7	1.8	6.8
All Electric	197	210	227	233	268	243	246	257	258	256	267	283	293	2.8	2.1	3.2
Commercial	122	128	124	121	127	127	124	128	136	151	157	170	174	(1.7)	2.4	6.4
Power	2	2	7	9	9	3	2	2	2	2	2	2	2	17.6	2.4	0.0
Government	29	41	36	39	40	36	42	43	43	43	50	52	56	6.1	2.0	6.8
SWS	3	3	3	3	3	3	3	3	2	2	2	4	6	8.4	(7.8)	31.6
City, St. Lighting, Thawing	18	22	21	18	16	19	24	21	20	19	20	23	31	12.5	2.1	11.6
Total	757	824	850	907	977	926	961	988	1,044	1,109	1,176	1,256	1,319	1.4	2.9	6.0
Residential Customers/Commercial																
Average Use Per Customer (MWH)																
Residential																
Domestic	3.4	3.2	3.4	3.2	3.6	4.1	4.8	4.1	4.4	4.7	4.8	4.9	4.8	3.5	6.6	2.2
All Electric	8.6	8.7	8.8	8.7	8.4	9.0	9.0	95.8	9.9	10.4	10.5	11.6	12.0	1.0	2.6	4.9
Commercial	11.5	10.9	11.9	12.2	12.6	14.4	16.1	17.6	20.4	21.7	24.1	23.8	25.8	0.0	10.8	6.0
Power	133.1	267.9	95.9	74.4	128.6	537.3	971.7	1051.2	2056.7	2186.4	1724.0	1653.3	2213.9	6.7	94.2	1.9
Government	62.5	46.2	56.9	58.6	64.8	77.8	68.5	61.8	71.3	76.5	50.9	79.7	88.1	32.4	4.0	5.4
SWS																
City, St. Lighting, Thawing																
Energy Sales and Requirements																
Residential																
Domestic	1,295	1,352	1,481	1,526	1,837	2,030	2,484	2,201	2,566	2,979	3,216	3,519	3,672	3.6	11.0	9.4
All Electric	1,692	1,827	2,000	2,033	2,263	2,185	2,212	2,463	2,554	2,652	2,805	3,288	3,504	3.9	4.7	8.2
Commercial	1,398	1,395	1,480	1,472	1,595	1,834	1,997	2,251	2,777	3,275	3,791	4,041	4,494	(1.7)	13.5	12.8
Power	266	536	672	669	1,157	1,612	1,943	2,102	4,113	4,373	3,448	3,307	4,428	25.5	32.9	1.9
Government	1,812	1,895	2,049	2,285	2,251	2,801	2,875	2,658	3,065	3,288	2,893	4,145	4,934	34.0	6.0	12.6
SWS	86	92	149	65	416	441	606	436	371	430	133	144	930	9.1	41.7	25.8
City, St. Lighting, Thawing	705	799	813	792	793	981	1,040	1,015	1,026	986	989	1,028	1,125	33.1	5.3	2.3
Total	7,255	7,895	8,644	8,842	10,312	11,883	13,158	13,128	16,472	17,982	17,274	19,473	23,086	9.5	13.3	8.8
System Losses																
Total Requirements	8,521	8,971	9,896	11,113	12,974	14,782	15,214	15,934	13,133	20,633	22,140	23,806	26,883			
Percent System losses	-	-	-	-	-	-	-	-	-	12.8	22.0	18.2	14.1			
Annual Peak Demand	1,764	1,944	3,384	2,268	4,104	2,664	4,752	5,760	6,084	4,032	4,104	5,040	6,696			
Month of Peak Demand	Dec.	June	July	Dec.	March	May/ June	Aug/ Sept.	Aug/ Nov.	May	Aug/ Nov.	Feb.	Aug	Jan.			

APPENDIX TABLE 2
MONTHLY PEAKS, ENERGY 1978
SEWARD ELECTRIC SYSTEM

	Peak KW	Energy-MWh	Load Factor
January	3,600	2,192	83.4
February	4,248	1,947	62.8
March	3,420	1,624	65.0
April	3,600	1,684	64.1
May	3,960	1,678	58.0
June	4,248	2,032	65.5
July	4,320	2,548	80.8
August	5,040	1,990	54.1
September	3,960	1,757	60.8
October	3,672	1,579	58.9
November	4,140	2,308	76.4
December	4,320	2,465	78.2
Total	5,040	23,806	53.9

Source: Chugach Electric Company bills to City of Seward.
City monthly generation data.

APPENDIX TABLE 3
LOW ENERGY USE PROJECTION WORKSHEET

		1978*	1979**	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	Residential													
1	Residential Customers	1,004	1,049	1,117	1,182	1,323	1,357	1,393	1,429	1,467	1,506	1,546	1,587	1,630
2	New Residential Customers	-	45	68	65	141	34	36	36	38	39	40	41	43
3	With Electric Heat (line 2x2.5)	-	11	17	16	35	9	9	9	10	10	10	10	11
4	Total Electric Heat Customers	25	36	53	69	104	113	122	131	141	151	161	171	182
5	Residential Heating Use (line 4 x 32.2 month)[1]	805	1,159	1,707	2,222	3,349	3,639	3,928	4,218	4,540	4,862	5,184	5,506	5,860
6	Average nonheating use/customer[2]	6.0	6.12	6.24	6.36	6.49	6.62	6.76	6.89	7.03	7.17	7.31	7.46	7.61
7	Total Residential Non Heating Use (line 1 x line 6)	6,002	6,017	6,970	7,518	8,586	8,983	9,417	9,846	10,313	10,798	11,301	11,839	12,404
8	Total Residential Use (line 5 x line 7)	6,807	7,176	8,677	9,740	11,935	12,622	13,345	14,064	14,853	15,660	16,485	17,345	18,264
	Commercial													
9	Commercial Customers	170	174	186	197	221	226	232	238	245	251	258	265	272
10	Avg. Use/Commercial Customer	23.8	25.8	26.8	27.9	29.0	30.2	31.4	32.6	34.0	35.3	36.7	38.2	39.7
11	Total Commercial kWh Use (MWH)[3] (line 9 x line 10)	4,046	4,489	4,985	5,496	6,409	6,825	7,285	7,759	8,330	8,860	9,469	10,123	10,798
	Govt. SWS, City, St. Lighting													
12	GSCS Customers	79	93	93	99	110	113	116	119	122	126	129	132	136
13	Ave Use/GSCS Customer[4] (MWH)	67.3	75.2	76.7	78.2	79.8	81.4	83.0	84.7	86.4	88.1	89.9	91.7	93.5
14	Total GSCS Use (MWH) (line 12 x line 13)	5,317	6,994	7,133	7,742	8,778	9,198	9,628	10,079	10,541	11,101	11,597	12,104	12,716
15	Powers													
16	Seward Fisheries	1,508	2,019	2,039	2,060	2,080	2,101	2,122	2,143	2,164	2,187	2,208	2,230	2,253
17	Kenai Lumber Co	1,799	2,409	-	-	-	-	-	-	-	-	-	-	-
18	Shipbuilding/repair	-	-	-	4,380	4,424	4,468	4,513	4,558	4,603	4,649	4,696	4,743	4,790
19	Total Power Use	3,307	4,428	2,039	6,440	6,504	6,569	6,635	6,701	6,767	6,835	6,904	6,973	7,042
20	Total	19,473	23,087	22,833	29,418	33,626	35,214	36,893	38,603	40,491	42,456	44,455	46,546	49,020

* 1978 data actual.

** 1979 data 8 months annualized.

1 Average use for residential home heating estimated to be 32.2 mwh/customer.

2 Escalated at 2 percent annualy.

3 Escalated at 3 percent annually.

4 Escalated at 2 percent annually.

4 Escalated at 1.0 percent annually.

APPENDIX TABLE 4
HIGH ENERGY USE PROJECTION WORKSHEET

		1978*	1979**	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	Residential													
1	Residential Customers	1,004	1,049	1,168	1,308	1,474	1,536	1,601	1,670	1,742	1,818	1,897	1,980	2,068
2	New Residential Customers	-	45	119	140	166	62	65	69	72	76	79	83	88
3	With Electric Heat (line 23 x .25)	-	11	30	35	42	16	16	17	18	19	20	21	22
4	Total Electric Heat Customers	25	36	66	101	143	159	175	192	210	229	249	270	292
5	Residential Heating Use[1] (line 4 x 32.2 month)	805	1,159	2,125	3,252	4,605	5,120	5,635	6,182	6,762	7,374	8,018	8,694	9,402
6	Average Nonheating Use/customer[2]	6.0	6.12	6.24	6.36	6.49	6.62	6.76	6.89	7.03	7.17	7.31	7.46	7.61
7	Total Electric Nonheating Use (line 1 x line 6)	6,024	6,017	7,288	8,319	9,566	10,168	10,823	11,506	12,246	13,035	13,867	14,771	15,737
8	Total Residential Use (line 5 x line 7)	6,829	7,176	9,413	11,571	14,171	15,288	16,458	17,688	19,008	20,409	21,885	23,465	25,139
	Commercial													
9	Commercial Customers	170	174	195	218	246	256	267	278	290	303	316	330	345
10	Avg. Use/Commercial Customer[3]	23.8	25.8	26.8	27.9	29.0	30.2	31.4	32.6	34.0	35.3	36.7	38.2	39.7
11	Commercial kWh Use (MWH)	4,046	4,428	5,226	6,082	7,134	7,731	8,384	9,063	9,860	10,696	11,597	12,606	13,697
12	GSCS Customers	79	93	97	109	123	128	133	139	145	152	158	165	172
13	Ave Use/GSCS Customer[4]	67.3	75.2	76.7	78.2	79.8	81.4	83.0	84.7	86.4	88.1	89.9	91.7	93.5
14	Total GSCS Use (MWH) (line 12 x line 13)	5,317	6,989	7,440	8,524	9,815	10,419	11,039	11,773	12,528	13,391	14,204	15,131	16,065
15	Powers													
16	Seward Fisheries	1,508	2,019	2,039	2,060	2,080	2,101	2,122	2,143	2,164	2,187	2,208	2,230	2,253
17	Kenai Lumber	-	-	2,433	4,914	4,964	5,013	5,063	5,114	5,165	5,216	5,267	5,322	5,374
18	Shipbuilding/repair	-	-	-	4,380	4,424	4,468	4,513	4,558	4,603	4,649	4,696	4,743	4,790
19	Total Power Use	3,307	4,428	4,472	11,354	11,468	11,582	11,698	11,815	11,932	12,052	12,173	12,295	12,417
20	Total	19,473	23,087	26,551	37,531	42,488	45,020	47,579	50,339	53,328	56,548	59,859	63,497	67,318

* 1978 data actual.

** 1979 data 8 months annualized.

1 Average use for residential home heating estimated to be 32.2 mwh/customer.

2 Escalated at 2 percent annualy.

3 Escalated at 3 percent annually.

4 Escalated at 2 percent annually.

5 Excalated at 5 percent annually.

APPENDIX TABLE 5
SEWARD ELECTRIC SYSTEM
AVERAGE NUMBER OF CUSTOMERS BY CLASS
1965-1979

	Domestic			Commercial			All Electric			Power			Government					
	In City	Out City	Total	In City	Out City	Total	In City	Out City	Total	In City	Out City	Total	In City	Out City	Total	City	SWS	Total
1965	416	51	467	128	4	132	191	12	203	3	1	4	23	6	29	10	2	847
1966	329	81	410	115	8	123	187	19	206	2	1	3	21	6	27	14	1	784
1967	299	87	386	111	11	122	178	19	197	1	1	2	23	6	29	18	3	757
1968	326	92	418	113	15	128	190	20	210	1	1	2	34	7	41	22	3	824
1969	330	102	432	111	13	124	205	22	227	6	1	7	28	8	36	21	3	850
1970	367	117	484	110	11	121	210	23	233	8	1	9	31	8	39	18	3	907
1971	372	142	514	115	12	127	240	28	268	8	1	9	34	6	40	16	3	977
1972	353	142	495	116	11	127	211	32	243	3	0	3	28	8	36	19	3	926
1973	371	148	419	115	9	124	215	31	246	2	0	2	32	10	42	24	3	961
1974	376	158	534	117	11	128	221	36	257	2	0	2	34	9	43	21	3	992
1975	414	168	582	125	11	136	221	37	258	2	0	2	32	11	43	20	2	1,044
1976	451	184	635	141	10	151	218	38	256	2	0	2	28	15	43	19	2	1,109
1977	474	203	677	146	11	157	224	43	267	2	0	2	31	19	50	20	2	1,176
1978	506	215	721	158	12	170	236	47	283	2	0	2	31	21	52	23	4	1,256
1979	520	236	756	162	12	174	242	51	293	2	0	2	33	23	56	31	6	1,319

SOURCE: City records.

Appendix C
Geological Investigation

Appendix C
GEOLOGICAL INVESTIGATION

INTRODUCTION

This summarizes the results of our investigation of the geology of the Grant Lake hydroelectric development for the City of Seward. The purpose of this work has been to define the geology of the project area and identify those aspects pertinent to the proposed development. Our investigation was limited to a 1-day site visit, review of available geologic literature, study of NASA high altitude photographs, and discussions with personnel of the U.S. Geological Survey, Corps of Engineers, and other agencies. This report should be considered preliminary, and the actual conditions may be found to vary from those described here. Additional geologic exploration is required before detailed designs and cost estimates can be prepared.

Location and Access

Grant Lake is located about 23 miles (37 kilometers) north of Seward, Alaska, on the Kenai Peninsula. Although the proposed damsite is located less than 1 mile (1.6 kilometer) east of the Seward-Anchorage Highway, site access is quite difficult except by air. As shown on the attached geologic map, Grant Lake is separated from the highway by a low ridge and by Upper Trail Lake. Upper Trail Lake can be crossed on foot using the railroad bridge near Moose Pass. Not apparent from the topographic map is that the low ridge terminates in an abrupt cliff just east of Upper Trail Lake. The ridge itself has a gently rolling surface, with the low spots being very soft and marshy, even in late summer.

Previous Studies

The earliest published investigation covering the project area was by Martin, et al. (1915). This included a highly generalized geologic map of the Kenai Peninsula at a scale of 1:250,000. Subsequent work by Plafker (1955) was directed at the geology of specific potential hydroelectric sites on the Kenai Peninsula, including Grant Lake. Plafker's report included geologic maps of the damsite area at a scale of 1:3000, and of the area between Grant Lake and Upper Trail Lake at a scale of 1:30000. These are reproduced in this appendix. Four pages of descriptive text on the Grant Lake area geology were included in Plafker's report. Plafker's work seems to be very reliable, and most of our conclusions about the dam, powerhouse, and penstock sites are based on that work. This is supplemented by a more recent regional geologic map of the Seward and Blying Sound Quadrangles (Tysdale and Case, 1979) at a scale of 1:250,000.

REGIONAL SETTING

The project is located in the Border Ranges geologic province of Alaska. This province occupies of an arcuate belt up to 80-km wide extending from Kodiak Island, along the eastern half of Kenai Peninsula, through the Chugach and Saint Elias Mountains, and gradually narrowing until it terminates in the vicinity of Skagway. This is a strike length of about 375 miles (600 km). The rocks of this province consist primarily of shale and graywacke sandstone, with lesser amounts of basaltic volcanic rocks. These rocks are typical of deep oceanic trench deposits, sometimes called eugeosynclinal deposits. All the rocks have been strongly deformed and generally dip steeply. Isoclinal folds and bedding plane faults are common. Faults and axial planes of the folds are commonly parallel to the strike of the strata, and this in turn tends to parallel to the boundaries of the geologic province. Most of the rocks have been metamorphosed to the lower greenschist facies.

The rocks of the Border Ranges province range in age from late Jurassic (150 million years old) to Paleocene (60 million years old), with the younger rocks occurring on the oceanward side of the province.

To the north and northeast, the rocks of the Border Ranges province are juxtaposed along the Border Range Fault with rocks of similar age but much different geologic character. These include siltstone, sandstone, and conglomerate which are locally fossilliferous. They represent shallow marine shelf-type deposits, and have been only slightly deformed and not metamorphosed. The Border Ranges Fault is a northwesterly dipping thrust fault which extends from Kodiak Island to the Matanuska Valley.

PROJECT GEOLOGY

Lithology

Valdez Group

All project facilities are underlain by rocks of the Valdez Group of late Cretaceous age (about 150 million years old). The Valdez Group consists mainly of a thick sequence of interbedded graywacke sandstone and shale which have been metamorphosed to the greenschist facies. The metamorphism has converted the shale to slate and created a faint foliation in the sandstone parallel to the bedding planes. Units shown on the geologic map are described below.

Sandstone. Sandstone is gray, fine- to medium-grained, graywacke. The rock has low porosity, and is hard, fresh, and moderately jointed. Bedding is medium to thick. Rock Quality Designation (RQD) will probably be good or excellent (greater than 75 percent). Permeability will probably be around 10^{-4} cm/sec, plus or minus one order of magnitude. Areas mapped as sandstone typically contain minor amounts of interbedded slate.

Slate. The slate is hard, thin bedded, fine grained, and gray to black. The slate breaks readily along cleavage planes parallel to bedding.

Sandy Slate. Plafker's (1955) map shows sand-slate mixtures as "sandy slate." These rocks contain variable amounts of sand and rock fragments and tend to break into irregular slabs.

Structure

Rocks within the project area have a rather consistent geologic structure, generally striking to the north (plus or minus 5 degrees) and dipping 40 to 50 degrees east. Plafker (1955) maps one small tight anticlinal fold west of the damsite. Many tightly isoclinal folds are present in the region and are probably also present in the project area, but have not been mapped due to the homogeneity of the rocks. Plafker also maps one small northerly trending fault about 200 feet (60 m) downstream of the dam, and a northeasterly trending fault which intersects Grant Creek about 1,000 feet (300 m) downstream of the dam. Study of NASA high altitude (1:63000) color-infrared photographs taken in 1978 suggests that the latter fault extends northeast through the damsite, crossing the dam axis on the left abutment near the 710-foot contour. This appears to parallel a number of linear structures which are clearly visible on the NASA photographs. These lineaments trend northeast and are spaced at 1,000-foot (300 m) or so intervals along the ridge between Grant Lake and Upper Trail Lake.

TECTONICS

The geology of the Border Ranges province is the product of the collision of two semi-rigid plates of the earth's crust. Today, the East Pacific Plate is moving northwards relative to the Alaskan portion of the North American Plate at a rate of about 2 inches per year (5 cm/yr). Since the rocks of the North American Plate are lighter than those of the East Pacific Plate, the North American Plate is overriding the latter in a thrust-fault type relation called a subduction zone. Where the oceanic rocks are bent downwards into the subduction zone a deep oceanic trench forms. This process is active today and has been active since at least Mesozoic times. The rocks which now underlie the Border Ranges province were deposited as sediments in an oceanic trench as described above. These sediments were subsequently consolidated, metamorphosed, folded, and accreted to the North American continent along the Border Range Fault. The oceanic trench and subduction zone has since shifted farther south to its present position off the Aleutian Islands. The present subduction zone dips at a very low angle beneath the Kenai Peninsula.

GEOLOGIC HISTORY

The sediments of the Valdez Formation were deposited in a deep oceanic trench during the late Cretaceous period (about 150 million years ago). During early Tertiary time compressive forces from the south folded and faulted the rocks. Regional metamorphism to the greenschist facies accompanied the deformation and converted shale to slate, and produced a faint foliation in the sandstone. The rocks were then uplifted and eroded. The area has been extensively glaciated, beginning in the Pliocene (about 2 million years ago) and continuing to the present day in some areas. This created the conspicuous, steep-walled, U-shaped valleys that dominate the topography. At their maximum extent, the glaciers filled the valleys to about elevation 4,000 feet (1,200 m), leaving the higher peaks protruding above the ice. In recent times the glaciers have retreated from the lower elevations, leaving morainal and till deposits in some localities. Glaciers still present at higher elevations contribute sediment to the present day streams, accounting for the turbidity of many of the streams.

ENGINEERING CONSIDERATIONS

Dam Foundation

The proposed alignment places the dam almost totally on graywacke sandstone which should provide a suitable foundation for the dam. Stripping and cutoff trench requirements are minimal. A fault crosses the dam axis on the left abutment near elevation 710 feet (210 m). No active faults have been reported in this area and this fault is therefore probably inactive. Should subsequent investigations show the fault to be active or indeterminant, then the dam will need to be designed to withstand the possibility of fault rupture. Geologic evidence suggests that this is a minor fault and potential offsets will probably not be large. Bedding strikes approximately parallel to the dam axis and dips upstream, a favorable orientation. Especially weak or compressible seams are probably not present in the foundation. Seepage through the foundation rock will probably not be excessive. Foundation conditions need to be verified during subsequent phases.

Borrow Material

Material from structural excavations will probably be suitable for rockfill. Rockfill material could be quarried from any of the areas shown on the geologic map as graywacke. The graywacke sandstone can probably be processed to obtain aggregate and drain material. No fine-grained materials appear to be available on the project site. Some alluvial deposits are present upstream of the left abutment of the dam; these deposits probably contain mainly sand and gravel.

Intake Structure

The foundation for the intake structure will probably also be hard sandstone. Excavations will probably require blasting. The intake structure is located on a clearly identified photo lineament, which may be a fault.

Penstock Route

The penstock route crosses uneven ground of variable nature. The higher portions are underlain by hard graywacke sandstone and slate, while lower areas have marsh-type deposits at the surface. The thickness of these marsh deposits is not known; they may be underlain at shallow depth by glacial till or bedrock, or they may be tens of feet thick. The penstock route runs along a clearly identified photo lineament, which may be a fault.

Powerhouse

The presently planned powerhouse location appears to be founded on hard rock. However, alluvial deposits which are not shown on the geologic map may be locally present.

Surge Tower

The presently planned location for the surge tower is probably underlain by hard slate and sandstone at shallow depth. This should provide adequate foundation bearing and good bolt anchorage for the proposed structure.

SEISMICITY

Seismotectonics

Earthquakes in south-central Alaska are the result of the present tectonic environment already described. The East Pacific Plate is moving northwards and is being forced under the Alaskan portion of the North American Continent. The thrust fault or subduction zone along which this is occurring passes under the Kenai Peninsula at a depth of about 19 miles (30 km). Since the majority of slip is occurring along this fault plane, the largest earthquakes will also occur along it. However, the buildup of stresses in the upper plate rocks can cause fault ruptures and earthquakes at shallower depth. These earthquakes would presumably be of smaller magnitude.

Historic Earthquakes

South-central Alaska has been an area of extremely high seismic activity in historic times. A search of the Earthquake Data File of the National Oceanic and Atmospheric Administration showed that nine instrumentally recorded earthquakes with Richter magnitudes larger than 6.0 have occurred within 94 miles (150 km) of the site since 1933. Information on smaller earthquakes is less reliable since seismograph coverage of Alaska was not very complete until after 1964. Since 1964, 271 instrumentally recorded epicenters with Richter magnitude greater than 4.0 have occurred within 94 miles (150 km) of the site.

Included in the above total is the great 1964 Prince William Sound earthquake. The epicenter of that earthquake was located about 63 miles (100 km) northeast of the project site, with a focal depth of around 21 miles (33 km). The 1964 earthquake had a Richter magnitude of 8.4 and was one of the largest earthquakes ever to have struck the North American continent in historic times. Although damage was severe in Anchorage and in other areas with alluvial foundations, damage due to shaking was only slight to structures founded on rock on the Kenai Peninsula.

Active Faults

In addition to the subduction zone thrust fault which occurs beneath the site, several faults within 93 miles (150 km) of the project are known to be active (Brogan, et al., 1975). These are shown in Table 1, together with an estimate of the maximum credible earthquake (Slemmons, 1977).

Table 1
KNOWN ACTIVE FAULTS
WITHIN 150 KM OF GRANT LAKE

Fault	Mapped Length (km)	Maximum Credible Earthquake	Distance From Site (km)
Castle Mountain	150+	7.5	130 NW
Hanning Bay	6	6.0	105 SE
Johnstone Bay	70	7.0	60 SE
Patton Bay	62	7.0	116 SE

The Placer River Fault is a major northerly trending fault that passes about 6 miles (10 km) east of the damsite. Tysdale and Case (1979) report that no evidence of recent movement was found where the fault crosses Quaternary sediments east of Turnagain Arm. Several other major faults occur 25 miles (40 km) or more east of the site. These include the Eagle River and Border Ranges faults. None of these faults are thought to be active (Tysdale and Case, 1979, Brogan et al., 1975). The fault which crosses the dam axis, and other parallel faults in the vicinity of the site, have not been studied to assess their activity.

Preliminary Design Earthquake

The faults listed in Table 1 are all at such great distance from the site that earthquakes associated with them do not pose a significant hazard to the site. The design earthquake ground motions will therefore be the result of movements associated with the subduction zone which passes about 19 miles (30 km) beneath the site. Very large earthquakes (greater than about Richter magnitude 7.5) will probably be restricted to depths of 19 miles (30 km) or so. Review of the instrumental records shows that many moderate earthquakes up to Richter magnitude 6.0 have occurred at depths as shallow as 6 miles (10 km). To account for this, three different combinations of magnitude and depth were considered:

- Magnitude 6.0 at 6 miles (10 km)
- Magnitude 7.0 at 12 miles (20 km)
- Magnitude 8.5 at 19 miles (30 km)

The latter event is considered to be the maximum credible earthquake for this area.

To determine ground surface responses to these earthquakes, it is necessary to know the rate at which seismic energy is attenuated as it moves away from the rupture area. Several empirical relationships have been developed to account for this (Schnabel and Seed, 1973, Donovan and Bornstein, 1978, and others). Most of the data on which these are based, however, are from shallow focus earthquakes (usually less than 5 km deep), and mostly in California, where the tectonics are predominantly strike-slip. Whether these relationships can be applied to moderately deep focus earthquakes in an area of compressive reverse-slip tectonics is not known. Based on observed damage from the 1964 Prince William Sound earthquake (Plafker, et al., 1969), it appears that bedrock accelerations 12 to 18 miles (20 to 30 km) from the epicenter (40 to 45 km from the hypocenter) did not exceed about 0.20 g (Trifunac and Brady, 1975). This is somewhat lower than what would have been anticipated using the hypocentral distance in the attenuation relationships of Schnabel and Seed (1973). It therefore appears that substantial attenuation does occur due to the depth of focus and that available empirical relationships may provide a reasonable estimate of probable ground response. Applying the relationships of Schnabel and Seed (1973) to the earthquakes listed above, it appears that the controlling event will be the magnitude 8.5 occurring at 30 km beneath the site. This would result in a peak, free-field, bedrock acceleration of about 0.40 g with a predominant period of about 0.4 to 0.5 second and a duration of ground motion greater than 0.05 g of about 30 seconds.

GEOLOGIC HAZARDS

Fault Rupture

A fault rupture hazard to the dam may exist from the fault that crosses the left abutment. This fault is probably not active, but this needs to be verified. If critical structures are to be located astride or adjacent to these faults, then their exact location and activity should be evaluated. Proper design can minimize the potential for damage to these facilities if the faults are found to be potentially active.

Liquefaction

A liquefaction hazard may be present if the powerhouse is situated on alluvial deposits. Proper foundation design or structure siting can minimize or eliminate this hazard.

Seiches

Because of the short lake fetch perpendicular to the dam axis, seiches are probably not a significant hazard.

Earthquake Induced Landslides

The potential for earthquake induced landslides exists wherever steep slopes can be subjected to strong ground shaking. The hazard is most prominent where unconsolidated, saturated deposits are present high on hillsides. This condition may exist in the steep canyon approximately 1-1/4 miles (2 km) east of the damsite at about elevation 3000 feet (900 m). At this location, a study of high altitude photos suggests that a glacier has retreated up the canyon leaving exposed what may be glacial moraine or alluvial deposits. The potential hazard and probability for earthquake induced landslides at the project area needs to be more fully studied.

ADDITIONAL EXPLORATIONS

The following are areas that require additional exploration and evaluation during subsequent phases of the work:

- o Test drilling of the dam, outlet works, powerhouse, and surge tower sites
- o Exploration of excavation and foundation conditions along the outlet channel and penstock route
- o Investigation of the fault on the left abutment, possibly including trenching, mapping, and seismic refraction
- o Evaluation of the earthquake-induced landslide hazard described in the text
- o Evaluation of the effect of depth of focus on earthquake attenuation relationships

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