Revision pages

SOUTHCENTRAL RAILBELT AREA ALASKA
UPPER SUSITNA RIVER BASIN

INTERIM FEASIBILITY REPORT

HYDROELECTRIC POWER

AND RELATED PURPOSES

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SYLLABUS

The present electrical power system of the Railbelt area of Southcentral Alaska consists primarily of natural gas thermal and turbine plants in the Anchorage area and coal-fired thermal plants in the Fairbanks area. Power demand, presently 2 billion kilowatt-hours annually, is projected to reach 5.5 billion kilowatt-hours by 1980 and 15 billion by the year 2000. This demand could be met through expanded use of natural gas, coal, and petroleum; however, recognition of the limited supply and rapid rate of depletion of these vital nonrenewable resources demands their conservation and most beneficial use.

This interim study is to determine the feasibility of providing electrical energy to the Railbelt area through the development of the renewable hydroelectric resource potential of the Upper Susitna River Basin. The study finds such development technically, economically, and environmentally feasible and justified.

The study finds that the plan best serving the public interest consists of a two-dam system utilizing the Watana and Devil Canyon damsites near miles 165 and 134, respectively, on the Susitna River. The Watana Dam, to be constructed first, would be an 810-foot-high earthfill structure with a powerplant and appurtenant access, transmission, and other facilities. The Devil Canyon Dam would be a 635-foot-high concrete thin-arch structure with a powerplant and appurtenant facilities.

The system, including limited visitor and recreation facilities, would have a project cost of $1,520,000,000, and provide 6.91 billion kilowatt-hours of energy annually. Annual costs of $104,020,000 would be exceeded by annual benefits of $137,876,000, and would give a benefit-to-cost ratio of 1.3 as compared to a conventional coal-fired generation alternative.

SOUTHCENTRAL RAILBELT AREA, ALASKA
INTERIM FEASIBILITY REPORT FOR HYDROELECTRIC POWER AND RELATED WATER RESOURCES DEVELOPMENT FOR UPPER SUSITNA RIVER BASIN

TABLE OF CONTENTS

Revised 1 Jun 1976

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

Revised 1 Jun 1976

TABLE OF CONTENTS (Cont'd)

RESOURCES OF THE STUDY AREA

THE STUDY AREA

In keeping with the directive of Congress, the study area for this report encompasses the Southcentral Railbelt area of Alaska. This area contains Alaska's largest concentration of population and economic activity. Because of its great size and diversity, the study area is divided into three subregions for purposes of description. These are denoted as the Cook Inlet, Gulf of Alaska, and Tanana subregions. The following discussion of the study area and its economy is designed to provide information on which to base judgments as to water resource development needs and impacts of any proposed solutions. (Most of the information in this section of the report has been taken from Resources of Alaska, compiled in July 1974 by the Resource Planning Team of the Joint Federal-State Land Use Planning Commission for Alaska. It is the most comprehensive and up-to-date compendium of resource information for the study area.)

CLIMATE

Cook Inlet Subregion: At Anchorage, average annual precipitation is 14.7 inches, with half to two-thirds falling during the period July through November. The mean daily January temperature is +12.1°F and the mean July temperature is +58.2°F. Record low and high temperatures at Anchorage are -38°F and +86°F. There are about 125 frost-free days per year with the last freeze in the spring occurring about 11 May, and the first fall freeze occurring about 18 September.

Gulf of Alaska Subregion: Inland of the Chugach Mountains is an area characterized by a semi-arid climate with relatively clear skies and extreme temperatures. The mean annual temperature is generally about 29°F. The southern flank of these mountains is somewhat warmer. The first freeze in the fall occurs about 14 September, and the last freeze in the spring usually occurs about 24 May, giving an annual average of about 110 frost-free days. Precipitation varies widely, as demonstrated by annual averages of 60 inches at Valdez, and 80 inches at Cordova, with 100-300 percent more precipitation in the mountains than in the lowlands. Earth tremors are common, especially along the southern portion of this subregion.

Tanana Subregion: The average annual precipitation is 11.3 inches at Fairbanks, and over one-half of the annual precipitation falls in the spring and summer months. At Fairbanks, record high and low temperatures are about 99°F and -65°F. The mean daily January temperature is about -16°F and the mean daily July temperature is about 60°F. Fairbanks averages 89 frost-free days per year.

TOPOGRAPHY AND HYDROLOGY

Cook Inlet Subregion: The subregion is characterized by rugged mountain ranges surrounding a central lowland and the ocean arm of Cook Inlet. Moderate precipitation, including the annual snowpack combined with glacial melt, generally provides a plentiful water supply. On the west side of Cook Inlet, the largest rivers are the Chakachatna and Beluga. To the north of Cook Inlet is the Susitna River, sixth largest river system in Alaska, with a total drainage area of 19,400 square miles. This system includes the major tributaries: Yentna, Chulitna, Talkeetna, and Tyonek Rivers.

To the east of the Susitna are the drainages of the Matanuska (2,170 square miles), Knik and Eagle Rivers. The rivers of the Kenai Peninsula are relatively small, the largest being the Kenai River with a 2,000-square-mile drainage area.

The low ground area within the subregion is generally free of permafrost, while permanently frozen ground may exist in the higher elevations. The Kenai Mountains and the Aleutian and Alaska Ranges contain glaciers.

The Cook Inlet subregion contains Anchorage, Alaska's largest city, as well as the communities of Kenai, Soldotna, and Homer. It also contains one of Alaska's important farming areas in the Matanuska-Susitna valleys, with Palmer being the hub city. The subregion contains the "Railbelt," extending from the deep water ports of Seward and Whittier through Anchorage to Fairbanks. A major share of the State's highway system is also here; however, large areas remain without road access.

Gulf of Alaska Subregion: This subregion includes parts of the Alaska Range, the Wrangell and Chugach-Kenai Mountains, and the Copper River Lowland. Massive mountains, rising in altitude to more than 16,000 feet in the Wrangells support the largest ice fields and glaciers in North America.

Principal watershed of the subregion is the Copper River system with a 24,400-square-mile drainage area. It drains the south slopes of the Alaska Range, south and west slopes of the Wrangell Mountains, most of the Chugach Mountains, the Copper River Basin, and a small section of the Talkeetna Mountains. The land surface is largely rough and mountainous, with a narrow coastal plain along the Gulf and broad lake basin in the Gulkana area between the mountain systems.

The coastal portion of the subregion is generally free of permafrost, while the interior portion is underlain by discontinuous permafrost. Glaciers cover most of the higher peaks in the Wrangell Mountains and nearly all of the crest of the Kenai-Chugach Mountains, which separate the coastal area from the interior.

Gold and copper lodes are in the Seward district and eastern part of the Kenai Peninsula. Copper, gold, silver, and molybdenum lodes are between the Chitina River and the crest of the Wrangell Mountains. Other mineralized sites occur throughout the subregion.

Tanana Subregion: Low potential for oil and gas exist in the basins within the subregion. There may be potential for gas in connection with coal beds in the Tanana Basin. The remainder of the subregion is underlain by rocks that are nonporous or too structurally complex for petroleum accumulation.

Large coal deposits exist in the young basins which flank the northern front of the Alaska Range. The coal deposits in the Nenana coal field have been mined since about 1918 and are presently producing about 700,000 tons per year. The coal is lignite to subbituminous, occurs in beds 2-1/2 feet to over 50 feet in thickness, has low sulfur content, and is used for power generation and domestic use in Fairbanks. Coal resources for all fields in this belt are estimated at nearly 7 billion tons located less than 3,000 feet deep.

Geothermal potential is present in the subregion.

Sand and gravel potential is high. Outwash deposits fronting the Alaska Range are economically significant. The Nenana gravel near Healy could be utilized. Other localities with potential for sand and gravel occur in the flood plains of the Tanana River and its major tributaries.

Limestone containing a high content of calcium suitable for cement occurs in outcrops at Windy Creek and Foggy Pass near Cantwell and the railroad. Other deposits of limestone are in the Minto Flats-Dugan Hills area west of Fairbanks.

Metallic minerals are present in a number of districts. The mineral potential of the Hot Springs district is moderate and contains silver, lead, minor amounts of gold, iron, copper, and other copper associated minerals. Chromite is found south of Boulder Creek. Nickel minerals are found in the vicinity of Hot Springs Dome.

Tolovana district lodes contain gold, silver, antimony, mercury, chromium, nickel, and iron.

Fairbanks district lodes have produced important amounts of gold and small quantities of silver, lead, tungsten, and antimony ore.

Delta River district lodes contain gold and silver, molybdenum, antimony, copper, lead, zinc, nickel, and chromium minerals.

The Chisana district is well known for its lode deposits of gold, copper, silver, lead, zinc, molybdenum, iron, and antimony. Lode production from the Nabesna mine was substantial and consisted of gold and subordinate copper and silver.

HUMAN RESOURCES

Population: Since 1930, Alaska's rate of population growth has exceeded that of the contiguous United States, and even that of the western states. This population growth has been characterized by a relatively high rate of natural increase which accounted for 60 percent of the 1950 to 1960 growth, and 81 percent of the growth between 1960 and 1970. Increases in military population were significant in Alaska's growth up to 1960, after which it has remained fairly stable at about 33,000 persons, accounting for about 9 percent of total population.

Earliest records indicate that Alaska's population, around 1740 to 1780, consisted of an estimated 74,500 native people. Of this total, 40,000 were Eskimos, 16,000 were Aleuts, 6,900 were Athabascan Indians, and 11,800 were Tlingit, Haida and Tsimpshean Indians. The native population declined from that time to the early 20th century, apparently because of social disruption and disease. About 1920, improved economic and health conditions reversed the decline in the native population which is now growing rapidly but has yet to reach the level of the late 1700's.

The following table shows the proportion of native residents in the various census divisions of the study area.

Percent of Native Population in the Study Area
By Census Division, 1970

Census Division	Population	% Native
Anchorage	124,542	3
Cordova-McCarthy	1,857	15
Fairbanks	45,864	4
Kenai-Cook Inlet	14,250	7
Matanuska-Susitna	6,509	4
Seward	2,336	11
Southeast Fairbanks	4,179	12
Valdez-Chitina-Whittier	3,098	23
Yukon-Koyukuk	4,752	46

Source: Adapted from information in the 1970 Census and from the University of Alaska, Institute of Social, Economic and Governmental Research, March 1972, Vol. IX, No. 1.

Published in: Alaska Statistical Review, Department of Economic Development, Dec. 1972.

A high rate of natural increase plus migration boosted the population from 128,000 in 1950 to 227,000 in 1960. By 1970, the population had advanced to 302,000 and it is now estimated to be 386,000. The following table shows Railbelt area population in relation to State totals:

Study Area Population As Percent of Total 1/

Year	Total Alaska	Study Area	Percent of Total
1880	33,426	6,920	21
1890	32,052	8,445	26
1900	63,592	15,600	25
1910	64,356	25,964	40
1920	55,036	19,137	35
1940	72,524	25,226	35
1950	128,643	73,101	57
1960	226,167	157,979	70
1970	302,173	220,271	73
1973	330,365	245,291	74

Source Note: Population statistics for 1960 and prior years are from G.W. Rogers and R.A. Cooley, Alaska's Population and Economy, all population statistics for 1970 are from the U.S. Census, and population estimates for 1973 are from the Alaska Department of Labor.

Published in: Alaska Statistical Review, Department of Economic Development, Dec. 1972.

1/ The boundaries of the study area do not coincide with census districts and, therefore, population figures for the study area are approximate.

The Southcentral Railbelt area of Alaska contains the State's two largest population centers, Anchorage and Fairbanks, and almost three-fourths of the State's population. The Anchorage area alone has over half the residents in the State.

Employment: Alaska's civilian workforce amounted to 148,900 persons in 1974. The largest sector was government with 30 percent of the number employed. The next most important sector was trade followed by the service sector. The following table provides a tabulation of Alaskan employment.

LABOR FORCE SUMMARY - 1974

	Annual Average
TOTAL	148,900
Total Unemployment	14,900
Percent of Labor Force	10.0
Total Employment	134,000
TOTAL Non-Agricultural	128,200
Mining	3,000
Metal Mining	200
Oil and Gas	2,600
Other Mining	200
Contract Construction	14,100
Manufacturing	9,600
Food Processing	4,300
Logging-Lumber and Pulp	3,600
Other Manufacturing	1,700
Transp.-Comm. & Pub. Utilities	12,400
Trucking & Warehousing	2,200
Water Transportation	1,000
Air Transportation	4,000
Other Transportation	1,300
Comm. and Public Utilities	3,900
Trade	21,100
Wholesale	4,000
Retail	17,100
Gen. Mdse. and Apparel	4,100
Food Stores	2,000
Eating and Drinking Places	5,000
Other Retail	6,000

LABOR FORCE SUMMARY - 1974 (continued)

Finance-Ins. and Real Estate	4,900
Services	18,300
Hotel, Motels, and Lodges	2,500
Personal Services	800
Business Services	3,000
Medical Services	3,800
Other Services	8,200
Government	43,800
Federal	18,000
State	14,200
Local	11,600
Misc. and Unclassified	1,000

Source: Alaska Department of Labor

Location quotients compare the share of total personal income from an industry in Alaska to the share of total personal income arising from the same industry for the United States. A quotient greater than one indicates that Alaska is more dependent on that industry than the U. S. as a whole. The following table provides location quotients for the various employment sectors.

Location Quotients For Alaska
Vis-A-Vis United States (1960, 1971)

	1960	1971
Mining	1.6	3.7
Contract Construction	2.2	1.8
Manufacturing	.2	.2
Transportation, Communications, and Public Utilities	1.3	1.5
Trade	.7	.8
Finance, Insurance, and Real Estate	.5	.6
Service	.7	.8
Government (Excludes Military)	2.8	2.3

Source: Derived from data in Survey of Current Business and Statistical Abstract of United States, both compiled by the U.S. Department of Commerce.

Published in: Alaska Statistical Review, Department of Economic Development, 1972 Edition.

Alaska has experienced unemployment rates consistently higher than the national average. In 1974, Anchorage and Fairbanks experienced an average unemployment rate of 8.6 percent, somewhat lower than the statewide 10 percent rate of unemployment.

Income: The following table shows the per capita personal income for Alaska, far west region, and U.S. average for 1970 through 1973. This table reduces Alaskan income by a 25-percent cost of living adjustment to show an estimated real per capita income relative to other parts of the United States.

Per Capita Personal Income for Alaska, Far West Regions, and U.S. Average

Year	Alaska	Alaska -25% COL	Percent of U.S. Average	Far West Region	U.S. Average
1970	$4,603	$3,452	87.6	$4,346	$3,943
1971	4,907	3,680	88.4	4,535	4,164
1972	5,141	3,856	85.8	4,866	4,492
1973	5,613	4,210	85.6	5,322	4,918

Source: Survey of Current Business

Published in: Alaska Statistical Review, Department of Economic Development, Supplement to December 1972 Edition.

Education: Enrollment in primary and secondary schools grew at a slightly faster rate than Alaska's total population over the period since statehood. As of 1970, a significantly higher share of personal income in Alaska went to education than for the nation, and Alaska's pupil-teacher ratio was slightly more favorable than the U.S. average.

ECONOMY OF THE STUDY AREA

GENERAL

The Southcentral Railbelt area of Alaska is the focus of continuing substantial growth in economic activity. Construction of the trans-Alaska oil pipeline is providing the primary impetus, with impacts being felt in virtually all sectors of the economy. A continued high level of Federal Government spending coupled with substantial State spending is supporting the growth. This expansion is expected to continue for at least five to seven years, supported largely by activities of, or relating to, the petroleum industry. The following provides an indication of these recent trends for the Alaskan economy. (Unless otherwise noted, all tables and graphs in this section of the report are taken from The Alaskan Economy, Department of Commerce and Economic Development, Mid-Year Review, 1975.)

ALASKAN ECONOMIC INDICATORS

		1970	1971	1972	1973	1974	1975*
	Total Resident Population	302.4	311.0	322.1	330.4	351.2	386.3
Thousands	Labor Force	108.2	115.9	122.9	129.6	148.9	176.5
	Total Employment	98.5	103.8	110.0	115.6	134.0	160.5
	Wage & Salary Employment	93.1	98.3	104.2	109.9	128.2	154.5
	Number Unemployed	9.7	12.1	12.9	13.9	14.9	16.0
	Percent Unemployed	9.0%	10.4%	10.5%	10.7%	10.0%	9.1%
Millions of $	Wage & Salary Payments	$1,116.2	$1,283.7	$1,422.7	$1,546.8	$2,078.0	$3,100.0
	Total Personal Income	1,412.8	1,548.3	1,697.1	1,957.8	2,398.0	3,500.0
	Alaska Gross Product	2,196.4	2,354.7	2,508.3	2,756.3	3,790.0	5,800.0

*Estimates

Source: 1970-74 Personal Income from U.S. Department of Commerce; 1970-73 Gross Product from Man in the Arctic Program, ISEGR, University of Alaska; 1974 Gross Product by Division of Economic Enterprise; 1975 Projections by Division of Economic Enterprise.

Industrial Requirements: Industrial use (as defined by APA for purposes of this analysis) accounts for about 2 percent of the Railbelt area's 1974 total power requirement and is expected to grow to 19 percent in 2000, according to the mid-range projection. This remains well below the industrial share nationwide. The industrial requirement is the most speculative aspect of the projection because it is very difficult to foresee the timing of new facilities.

The analysis assumes a high probability of major new mineral production and processing. Also expected are significant further developments in timber processing, and it is assumed that Alaska energy and the availability of other resources such as water, industrial sites, and port sites will attract energy-intensive industries. The primary data source for the industrial sector projections was a 1973 study by the Alaska Department of Economic Development. That study included review and estimates of power requirements for Alaska's fishery, forest products, petroleum, natural gas, coal, and other mineral industries, all premised on significant identified resource potentials and on power needs for similar developments elsewhere. Several qualifying assumptions were made by APA to adapt this study for use in the marketability analysis.

1. Power requirements for fish processing industries and support services for industrial development are not included, having already been addressed in the "utility requirement" portion of the analysis.

2. Estimated mineral industry loads (except for petroleum and related industry) for the year 2000 were adopted as APA's "higher range" estimate, with estimates for 1980 and 1990, reflecting anticipated minimum lead times for developing the resources involved. The mid-range estimate assumes a 10-year deferral of the Department of Economic Development's projected growth scenario, and the lower range estimate a 20-year deferral.

3. Power requirements assumed for Alaska petroleum and petrochemical industries are smaller than estimates in the reference study, based on expectations that most Alaska oil and gas production would be exported during the period of the survey. For example, the mid-range estimate assumes 7 percent of petroleum industry loads estimated in the reference study.

4. A somewhat slower pace of development was assumed for forest products industries.

All of the above qualifying assumptions, with the exception of No. 1 which had a neutral effect, were downward adjustments, decreasing the estimates of the basic study. Specific industrial development assumed for the study is presented in Section G, Appendix 1. Only planned expansions to existing facilities and realistically identifiable new industry closely tied to proven resource capabilities were assumed.

SUMMARY

When combined, the composite annual growth rates for the projected power requirements are as indicated in the following table.

COMPOSITE ANNUAL GROWTH RATES FOR ELECTRIC POWER
(Percent)

ESTIMATE:	1974-1980	1980-1990	1990-2000
Higher Range	12.4	20.2 1/	3.0
Likely Mid-range	9.6	6.7	7.0
Lower Range	7.5	5.8	4.0

1/ This high rate is caused by the assumed introduction of a 2500 MW nuclear fuel enrichment plant as an example of a possible large industrial load. Without this load, the 1980-1990 growth rate would be 9.3 percent and the following decade's would be 6.6 percent. No such load is assumed for the mid and lower range projections.

The three growth projections are displayed in the following graph and compared to the last decade's historical growth rate of 14 percent projected to the year 2000.

Watana: The proposed single dam development of the upper Susitna basin located at the Watana site would be an earthfill dam with structural height of about 810 feet. The reservoir would have a normal maximum pool elevation of 2,200 feet, would have a surface area of approximately 43,000 acres, and would extend about 54 river miles upstream to a point between the Oshetna and Tyone Rivers. The annual firm electrical production of Watana would be 3.1 billion kilowatt-hours from a dependable capacity of 706 megawatts. Such a project would be economically feasible; however, it would develop only about one-half of the basin potential while having adverse environmental effects of nearly the same magnitude as plans having both economic feasibility and twice as much power output. Further study of this alternative is not deemed justified for this report.

Two-Dam Systems:

Devil Canyon-Denali: This alternative system would include the thin-arch concrete dam at Devil Canyon and a 260-foot-high earthfill dam in the vicinity of Denali. The Denali Dam would provide storage only and would have no powerhouse. This system would generate 2.5 billion kilowatt-hours of firm annual energy from a dependable capacity of 571 megawatts at Devil Canyon Dam. The surface acres flooded would total about 62,000 acres (Devil Canyon, 7,550; Denali, 54,000). Project energy output is less than half of the basin potential and economic feasibility is lacking. Further study of this alternative is not deemed justified for this report.

Devil Canyon-Watana: This alternative two-dam system would include the concrete dam at Devil Canyon plus the earthfill dam at Watana. The firm annual production of electrical power with these two dams would be 6.1 billion kilowatt-hours from a dependable capacity of 1,568 megawatts. The reservoirs would flood approximately 51,000 acres (Devil Canyon, 7,550; Watana, 43,000), and extend to a point between the Oshetna and Tyone Rivers. This project is economically feasible and develops nearly 96 percent of the basin potential. Further study and evaluation of this alternative is justified.

Three-Dam System:

Devil Canyon-Watana-Denali: This system would add the 54,000-acre Denali storage reservoir to the previous plan. The combined electrical production of the three dams would provide 6.8 billion kilowatt-hours of firm energy annually from a dependable capacity of 1,578 megawatts. The surface area flooded would be approximately 105,000 acres (Devil Canyon, 7,550; Watana, 43,000; Denali, 54,000). This alternative would develop nearly the full basin potential. Even though probable environmental effects would be considerably greater than the preceding two-dam system, further study and evaluation of this alternative is justified.

Four-Dam Systems:

Devil Canyon-Watana-Vee-Denali: This is the system proposed by the Bureau of Reclamation in its 1952 report on hydropower resources of the Upper Susitna River Basin. USBR recommended initial development of Devil Canyon Dam plus the upstream storage reservoir at Denali; further development would include earthfill dams at the Watana and Vee Canyon sites between the two initial dams. In this system, the height of the Watana Dam would drop from 810 feet to 515 feet. The height of the Vee Dam would be 455 feet. This system would generate 6.1 billion kilowatt-hours of firm annual electrical energy from a dependable capacity of 1,570 megawatts. The surface area flooded by these four dams would total approximately 85,000 acres (Devil Canyon, 7,550; Watana, 14,000; Vee, 9,400; Denali, 54,000). This alternative would also develop about 95 percent of the full basin potential. Even though probable environmental effects would be as great or greater than the preceding three-dam system, further study and evaluation of this alternative is justified.

High Devil Canyon (Susitna I)-Olson (Susitna II)-Vee (Susitna III)-Denali: The September 1974, Henry J. Kaiser Company's report also proposed a four-dam ultimate development plan for the Upper Susitna River Basin. The Kaiser plan was not detailed except as to the Devil Canyon High Dam (Susitna I), but in effect proposed a low dam (Susitna II) at a site which is equivalent to the Olson damsite of USBR, a higher dam (Susitna III) at the upstream limit of the Susitna I reservoir, and a storage dam at Denali. For comparison purposes, the Susitna II and Susitna III dam concepts have been equated to USBR's Olson Dam and Vee Dam. On this basis, the firm annual energy would be 5.9 billion kilowatt-hours and the surface acres flooded would total about 88,000 acres (High Devil Canyon, 24,000; Olson, 850; Vee, 9,400; and Denali, 54,000). The system not only develops less of the basin potential than several other alternatives but is not economically justified. Further study of this alternative is not deemed justified for this report.

ALTERNATIVES SELECTED FOR FURTHER STUDY

The preliminary screening disclosed four alternatives with economic justification, adequate scale, technical feasibility, and no adverse environmental effects of such obvious magnitude as to preclude plan implementation. These include one plan which depicts the most probable future if no Federal action is taken to meet the projected power needs of the Railbelt and three diverse hydroelectric plans for utilization of the power potential of the upper Susitna River. The four selected alternatives are:

Coal
Devil Canyon-Watana Dams
Devil Canyon-Watana-Denali Dams
Devil Canyon-Watana-Vee-Denali Dams.

EVALUATION OF ALTERNATIVES

Selection of the best plan from among the alternatives involves evaluation of their comparative performance in meeting the study objectives as measured against a set of evaluation criteria.

These criteria derive from law, regulations, and policies governing water resource planning and development. The following criteria were adopted for evaluating the alternatives.

Technical Criteria:

The growth in electrical power demand will be as projected by the Alaska Power Administration.

That power generation development, from any source or sources, will proceed to satisfy the projected needs.

A plan to be considered for initial development must be technically feasible.

National Economic Development Criteria:

Tangible benefits must exceed project economic costs.

Each separable unit of work or purpose must provide benefits at least equal to its cost.

The scope of the work is such as to provide the maximum net benefits.

The benefits and costs are expressed in comparable quantitative economic terms to the fullest extent possible. Annual costs are based on a 100-year amortization period, an interest rate of 6-1/8 percent, and January 1975 price levels. The annual charges include interest; amortization; and operation, maintenance, and replacement costs.

Power benefits are based on the costs of providing the energy output of any plan by conventional coal-fired thermal generation.

Environmental Quality Criteria:

Conservation of esthetics, natural values, and other desirable environmental effects or features.

The use of a systematic approach to insure integration of the natural and social sciences and environmental design arts in planning and utilization.

The application of overall system assessment of operational effects as well as consideration of the local project area.

The study and development of recommended alternative courses of action to any proposal which involved conflicts concerning uses of available resources.

Evaluation of the environmental impacts of any proposed action, including effects which cannot be avoided, alternatives to proposed actions, the relationship of local short-term uses and of long-term productivity, and a determination of any irreversible and irretrievable resource commitment.

Avoidance of detrimental environmental effects, but where these are unavoidable, the inclusion of practicable mitigating features.

Social Well-Being and Regional Development Considerations:

In addition to the basic planning criteria, consideration was given to:

The possibility of enhancing or creating recreational values for the public;

The effects, both locally and regionally, on such items as income, employment, population, and business;

The effects on educational and cultural opportunities;

The conservation of nonrenewable resources.

Coal: This alternative is, effectively, the "without" condition, the probable future that would develop if no Federal action were taken to provide electrical power through a hydroelectric generation development. It is the economic standard against which each of the hydropower plans is tested. That is, the power benefits of a given hydro system represent the cost of producing the same amount of power by constructing and operating a conventional, state-of-the-art, generation system using coal as fuel. Included in all cases are the costs of the necessary transmission systems to bring the power to the same load distribution centers in the Anchorage and Fairbanks areas. Thus, a benefit-to-cost ratio of greater than one (1.0) indicates that a hydro system is more economical than its coal competitor, while a ratio of less than unity indicates that it is economically inferior. For any given alternative coal system, the sum of the energy and capacity benefits is identical to the costs giving a benefit-to-cost (B/C) ratio of 1.0 and no net benefits.

The coal-fired development most directly comparable to the hydropower alternatives would be a single large complex located near Healy, with a transmission system essentially identical to the Anchorage-Fairbanks intertie provided by the hydro plants. However, such a massive capital investment by private interests is less likely than continued separate expansion of the existing local generation-distribution systems. For this reason, the coal alternative considered hereafter will consist of two mine-mouth plants, one at Beluga serving the Anchorage-Kenai Peninsula load center, and one at Healy serving the Fairbanks load center. No transmission intertie would be provided.

The two powerplants would have the following projected characteristics:

Load Center	Fairbanks	Anchorage-Kenai	Total
Plant Location	Healy vicinity	Beluga vicinity	
Size and No. of Units			
Initial (c. 1980)	2-75 mw	3-150 mw	
Final (c. 1995)	4-75 mw	8-150 mw	
Total Capacity-Final	300 mw	1,200 mw	1,500 mw
Land Required (Acres)			
Buildings and Grounds	10	30	40
30-day Stockpile	20	70	90
Stripmining (Acres)			
Per Year	44	140	184
100-year Total	4,400	14,000	18,400
Coal Consumption (million T)			
Per Year	1.44	4.41	5.85
100-year Total	155	441	585
Waste Disposal (Acres)			
Per Year	4.4	14	18.4
100-year Total	440	1,400	1,840
Mill Rate to Distributor	31.4	26.4	

The Healy Creek district has estimated reserves of 537.5 million tons of coal in seams over five feet thick and under less than 1,000 feet of overburden. The Beluga River and adjacent Capps Glacier districts have estimated reserves of 242.7 million tons and 405.8 million tons, respectively, of coal in similar formations.1/ Thus, among the three districts, there appears to be sufficient stripable coal to sustain both plants for required century.

To estimate the probable impacts from strip mining, an idealized mining operation was projected, which resulted in each acre of mine producing 209,733 cubic yards of material composed of 29,040 cubic yards of recovered coal and 180,693 cubic yards of mine wastes. The annual coal requirement would mean that a total of 183 to 184 acres of land annually would have to be mined, or 18,300 to 18,400 acres in 100 years. It should be emphasized that the disturbed acreage is based on a relatively favorable formation of coal seams and on a 90-percent rate of recovery which both tend to minimize the land requirements.

The Healy Creek Valley is covered by upland spruce-hardwood forest below 2,500 feet, m.s.l. The higher lands are generally alpine tundra. As a result, the majority of the area is classified as fall and winter moose concentration area. Dall sheep range extends on both sides of the valley and along the southern rim of the westward area. The valley upstream of the 2,500-foot elevation is winter range for caribou. The valley of the Nenana River running north-south at the western end of Healy Creek is listed as a nesting-moulting area for waterfowl and a major migration route (flyway). The Nenana River supports both resident and anadromous fish.

Vegetation at the Beluga River-Capps Glacier area occurs as three bands parallel to Cook Inlet. Adjacent to the water is a 3-5-mile-wide band of wet tundra. Next, there is a 10-12-mile-wide band of upland spruce-hardwood forest. Finally, there is a wide area of lowland spruce-hardwood with spots of muskeg, bog, and high brush. Waterfowl, especially during spring and fall migrations, make heavy use of the area, with the result that it is classified as extremely important for resting. Ducks predominate although small numbers of geese and swans also pass through. Moose occur throughout the entire region with significant fall concentrations to the north of Beluga River and spring and winter concentrations in the tundra band astride the mouth of the river. Black and brown-grizzly bear range the entire region with suspected brown bear denning areas between Capps Glacier and Beluga Lake. Beluga River and other streams are salmon spawning areas, while Beluga Lake supports resident populations of several species.2/

1/ Coal Resources of Alaska, Geological Survey Bulletin 1242-B, 1967.
2/ Alaska's Wildlife and Habitat, Alaska Department of Fish and Game, 1973.

Thus, at either locale, the destruction of the vegetative cover and land disturbance would be, acre for acre, destruction of important wildlife habitat. Natural revegetation would be possible, but very slow. Artificial revegetation could restore habitat much more quickly, but at an increased price of power. In addition to the effects on wildlife habitat, the coal alternative would have a range of other environmental impacts. The mining and hauling of the coal could be expected to put considerable amounts of dust into the air around the projects. Since the operations would, in general, be following natural water courses, there is a strong probability that sediments could not be prevented from reaching the streams and being carried into the major rivers where the increases in turbidity could be expected to have adverse effects on fish populations. Further, although the coal is low in sulfur content, ground water and runoff waters in contact with the beds and the uncovered coal residues could well experience chemical changes which in turn could have adverse effects on the rivers, their fish, and other aquatic biota.

The operation of the generating plants would have environmental impacts also. Even with pollution control devices to restrict and/or remove harmful substances, there would be some degradation of air quality from water vapor, carbon particles, sulfur compounds, and unburned gases to the limits permitted by air quality regulations. The characteristic odor of burning coal would be pervasive over wide areas, including Tyonek and perhaps Anchorage. Water, either from groundwater sources, or more likely, from the major rivers would be required to provide cooling for the steam condensers of the plants. This water would need to be returned to the rivers in exchange for cold waters to continue the function of system. This could effect a sharp change in the thermal regime of the rivers with possible adverse effects on their ecosystems. Alternatively, cooling towers or other artificial means could be installed to avoid thermal pollution, but at a substantial increase in the costs of the project. Other possible environmental impacts from the plant lie in the need for disposal of the solid combustion wastes. These could be added to the mine wastes, thus increasing the bulk of these spoil ridges or could be disposed on other lands. Either method would involve probable adverse effects in that the ash-cinders would tend to hinder efforts at revegetation of the mine wastes while dumping elsewhere would remove additional acreage from wildlife habitat or other beneficial use. Again, leaching of chemicals by surface waters could well cause water quality problems in the streams of the disposal area.

The Healy Creek vicinity has a long history of mining and mineral exploration which increases the probability that historic sites would be of above average occurrence within the area of project effects. The State Division of Parks considers the area to be extremely rich in archaeological potential. The west shore of Cook Inlet and the Beluga Lake area also have a long history of habitation or use by indigenous peoples of the region. As such, it also should be rich in potential for the discovery of historic and/or prehistoric sites. Strip mining would tend to have adverse effects on preservation of historic sites while it could both encourage discovery and recovery of prehistoric artifacts and destroy sites for continued archaeological study.

The coal alternative would make no contribution to either flood control or recreation in the Railbelt area. In fact, the destruction of habitat and the widespread presence of human activities could be expected to reduce the recreational potential for hunting and fishing.

It is estimated that construction of the coal facilities would impact on the regional economy in much the same way and magnitude as the alternative hydropower plans. The year-by-year effects would be more evenly spread over a longer total period since construction would be in several stages as the power demand grew and would not be completed (to the output level of the hydropower alternatives) until about 1995. Permanent jobs arising from operation of the facilities are estimated to be 67 in the mining-hauling of the coal, and 35 in actual powerplant operation and maintenance.

Response to Study Objectives: The response of the coal alternative to the study objectives is summarized as follows:

Power: Provides power equivalent to any other alternative (6.88 to 6.91 billion kilowatt-hours annually). Meets the projected demand until the mid-1990's.

Flood Control: Nonresponsive.

Air Pollution: Adverse response.

Fish and Wildlife: Direct loss of 18,000-20,000 acres of important moose, caribou habitat, bear, and waterfowl. Probable adverse effects on anadromous fish. No positive contributions.

Recreation: Nonresponsive.

Conservation of Nonrenewable Resources: Adverse response--expend 5.83-5.85 million tons of coal annually.

Energy Independence: Conserves equivalent of 112.5-112.9 billion cubic feet of natural gas annually, or 15.1-15.2 million barrels of oil.

Devil Canyon-Watana: This alternative would consist of a concrete thin-arch dam 635 feet high with a four-unit powerhouse and a switchyard at river mile 134 of the Susitna River, an earthfill dam 810 feet high with a three-unit powerhouse and a switchyard at river mile 165, an access road 64 miles long from the vicinity of Chulitna Station on the Alaska

Railroad and the Parks Highway, and 364 miles of transmission lines. Included in the permanent facilities would be living quarters for operating personnel, visitor centers at each dam, boat launching ramps, and a limited system of recreational facilities including camping spots and hiking trails. The first cost of the project is estimated as $1.52 billion. Annual costs are estimated as $104,020,000, including $2,500,000 for operation, maintenance, and replacements. Average annual project benefits accrue as follows:

Power	$128,153,000
Recreation	300,000
Flood Control	50,000
Area Redevelopment	9,373,000
Total	$137,876,000

The benefit-to-cost (B/C) ratio is 1.3 to 1.
Net annual benefits are $33,856,000.

The system would have an average annual energy output of 6.91 billion kilowatt-hours and a firm energy output of 6.10 billion kilowatt-hours from an installed capacity of 1,394 MW. The projected energy cost to the distributors would be 21.1 mills per kilowatt-hour.

Known and suspected project impacts for the proposed Devil Canyon-Watana hydroelectric project are discussed below.

River Flows: The natural average daily flows at Devil Canyon from the latter part of May through the latter part of August fluctuate in the range of 13,000 to 27,000 cubic feet per second (cfs). For November through April, the average daily flows range between 1,000 and 2,300 cfs. The river also carries a heavier load of glacial sediment during high runoff periods. During winter when low temperatures reduce water flows, the streams run practically silt free.

With a project, significant reductions of the late spring and early summer flows would occur and substantial increases of the winter flows. The average regulated downstream flows for this plan computed on a monthly basis are estimated between about 7,600 cfs in October to about 15,000 cfs in August. In extreme years, the monthly averages would range from about 6,500 cfs to over 28,000 cfs. The following table compares natural and regulated flows.

Month	Regulated cfs	Unregulated cfs
January	9,896	1,354
February	9,424	1,137
March	9,020	1,031
April	8,261	1,254
May	8,192	12,627
June	8,324	26,763
July	9,618	23,047
August	15,066	21,189
September	10,802	13,015
October	7,556	5,347
November	8,367	2,331
December	8,964	1,656

The high flows of the summer and fall plus unregulated flood flows of much higher magnitude presently require an average annual expenditure of $50,000 by the Alaska Railroad to prevent erosion of the roadbed. The regulated flows would make such protection unnecessary. The resulting savings is the source of the flood control benefit.

Water Quality: The heavier sediment material now carried by the river between Devil Canyon and the junction of the Chulitna and Talkeetna Rivers with the Susitna River during high runoff periods would be substantially reduced, and a year-round, somewhat milky-textured "glacial flour" (suspended glacial sediment) would be introduced into the controlled water releases below the dams. Preliminary studies indicate that the suspended materials in the releases below the dams would be in the range of 15 to 35 parts per million.

On occasions after the development of upstream storage, when spilling over Devil Canyon Dam would be necessary during periods of high flows, nitrogen supersaturation could be introduced into the river below the dam and would cause an adverse impact on fish for some distance downstream from the dam depending on the level and duration of the supersaturated condition. Fish exposed to this environment suffer gas bubble disease (like bends to a deep-sea diver) which is often fatal, particularly to juvenile salmon.

With the use of appropriate operational procedures, spilling would occur about every second year with an average annual duration of 14 days. Nitrogen supersaturation introduced by the spilling should be substantially reduced in the turbulent river section just downstream of the dam. The proposed spillway at the Watana Dam is not conducive to nitrogen supersaturation. Because of the flood storage capacity of this fluctuating impoundment and the large release capabilities of the outlet works and powerhouse, use of the spillway should be required only about once in 50 years.

Compared to natural conditions, temperature of the controlled releases of water from Devil Canyon Dam would tend to be cooler in the summer and warmer in the winter. Cooler summer water temperatures and warmer winter water temperatures could have both beneficial and adverse effects on migrating salmon, juvenile salmon, and resident fish populations, and will be investigated further in post-authorization studies.

Variations in water releases at Devil Canyon Dam would cause less than a one-foot daily fluctuation of downstream water levels in the river during the May through October period unless the reservoir were to be used for peaking purposes. The regulated daily fluctuations during the winter months could range up to two feet under normal peaking conditions. According to U.S. Geological Survey studies, the natural normal daily fluctuations in the Susitna River below Devil Canyon range up to about one foot.

Stratification conditions within the reservoirs could cause some temperature and dissolved oxygen problems in the river for some distance downstream from the Devil Canyon Dam and within the reservoirs themselves. This could have an adverse impact on the downstream fishery and to fish within the reservoirs.

The multilevel intake structures at both dams provide for selective withdrawal of waters from varying depths within the reservoirs. This feature allows for considerable control of both downstream water temperature and dissolved oxygen content of the release waters. Because the lowest intake levels are well above the dead storage areas of the reservoirs, there should be no increase in passage of sediments even when the deepest intake levels are used.

General channel degradation caused by a river's attempt to replace the missing sediment load with material picked up from the riverbed is not expected to be a significant concern along the gravel bed reaches of the Susitna River between Talkeetna and Devil Canyon. There will undoubtedly be some degradation where bed conditions are favorable. It is expected that the river will channelize into a single deep watercourse during the winter months. However, because of the generally coarse nature of the surface materials of the riverbanks, no significant bank erosion is predicted.

Upstream from the dams the major environmental impacts would be caused by the reservoir impoundments. The reservoir behind the Devil Canyon Dam would remain essentially full throughout the year, while Watana reservoir would fluctuate between 95 and 120 feet below full pool during the average year.

Devil Canyon reservoir would cover about 7,550 acres in a steep-walled canyon with few known areas of big-game habitat and a minimal amount of resident fish habitat at the mouths of some of the tributaries that enter the Susitna River in the 28-mile section above the proposed damsite. The reservoir would, however, flood 9 of the 11 miles of the whitewater section known as Devil Canyon. These rapids are highly regarded by whitewater enthusiasts for their extreme violence and for their rarity, being rated as Class VI--cannot be attempted without risk of life to the most expert boatman. This very violence has, to date, limited recreational boating use of this section of the river to only a few highly expert individuals and/or parties. No significant future use by the general public, either for active boating or esthetic appreciation, seems likely considering the difficulty of access and the extreme danger of the waters. Construction of this alternative project would provide access to the canyon area and the remaining two miles of rapids below Devil Canyon Dam.

Watana reservoir would flood about 43,000 acres in a 54-mile section of the Susitna River that would reach upstream to the Oshetna River. Except in a few areas near the mouths of tributary creeks and most of the Watana Creek valley, the Watana reservoir would be contained within a fairly narrow canyon for much of its length.

Watana reservoir would flood areas used by migrating caribou in crossing the Susitna River and would also flood moose winter range in the river bottom. The reservoir would cover existing resident fish habitat at the mouths of some of the tributaries and possibly would create other fish habitat at higher elevations on these tributaries.

Fish: How some of the downstream river conditions caused by the proposed hydropower project would affect the anadromous and resident fish populations below the dams has not yet been fully determined, but past, ongoing, and future studies by State and Federal agencies coordinated by the U.S. Fish and Wildlife Service should provide the answers needed to further define adverse and beneficial impacts of the proposed project on fish and wildlife.

In a 1974 study by the Alaska Department of Fish and Game on surveys conducted to locate potential salmon rearing and spawning sloughs on the 50-mile section of the Susitna River between Portage Creek and the Chulitna River, 21 sloughs were found during the 23 July through 11 September study period. Salmon fry were observed in at least 15 of these 21 backwater areas. Adult salmon were present in 9 of the 21 sloughs. In 5 of the sloughs, the adult salmon were found in low numbers (6 to 7 average). In 4 other sloughs, large numbers were present (350 average).

During December 1974 and January and February 1975, the Alaska Department of Fish and Game investigated 16 of the 21 sloughs previously surveyed during the summer of 1974. Of the 16 sloughs, 5 indicated presence of coho salmon fry. Many of the 16 sloughs surveyed were appreciably dewatered from the summer/fall state. Also, a number of coho fry were captured in the Susitna River near Gold Creek, indicating that some coho salmon fry do overwinter in the main river.

It is reasonable to assume on the basis of existing data that there will be some changes in the relationship between the regulated river and access to existing salmon rearing and spawning sloughs and tributaries downstream from Devil Canyon Dam. It appears feasible to develop a program to improve fish access to and from some of the sloughs and tributaries in the Susitna River, if such is determined to be needed as a consequence of the project's stabilizing effect on summer flows. Such a program would be a project consideration.

Periodic flood conditions that presently destroy salmon eggs in this stretch of the river would be almost completely eliminated by regulation of the upper Susitna River flows.

Reduction in flows, turbidity, and water temperatures below Devil Canyon Dam might cause some disorientation of salmon migrating into the section of the Susitna River between Portage Creek and the Chulitna River during an initial period after construction of the dams.

According to a study discussed in the Journal of Fisheries Research Board of Canada--Volume 32, No. 1, January 1975, Ecological Consequences of the Proposed Moran Dam on the Fraser River, some of the beneficial downstream impacts of the dam could include the following:

The higher regulated winter flows might enhance the survival of salmon eggs in the river downstream from the dam. The increased flows could insure better coverage and better percolation through the gravel and presumably enhance egg and alevin survival.

An additional consequence of reduced turbidity below the dam might be a gradual reduction in the percentage of fine materials in the salmon spawning areas. This could also lead to improved percolation through the gravel in the streambed and possibly improve survival of eggs.

Reduced siltation during the summer months could prove beneficial for both anadromous and resident fish species in the 50-mile section of the Susitna River between the proposed Devil Canyon Dam and Talkeetna. With the almost total elimination of the heavier glacial sediment loads of the river, it is likely that the potential for recreational sport fishing would be improved in this section of the Susitna.

Upstream from the dams, the major impact on the resident fish populations would be caused by the reservoir impoundments. Devil Canyon reservoir would fluctuate very little. The steep-walled canyon of this reservoir might prove less than desirable to develop a resident fish population; however, some species of fish might adapt to this reservoir and provide sport fishing benefits.

Watana Dam would have a widely fluctuating reservoir and thus be generally detrimental to the development of resident fish populations. Suspended glacial sediment could be a factor in both of the reservoirs after the heavier glacial sediments have settled out; however, many natural lakes in Alaska such as Tustumena and Tazlina, with silt-laden inflows sustain fish populations under similar conditions.

Most resident fish populations, especially grayling, utilize the clearwater tributaries of the Susitna River or areas near the mouths of these streams as they enter the glacially turbid main river during periods of high runoff. All of these tributaries, approximately 10 in number, would be flooded in their lower reaches by the proposed reservoir impoundments. Resident fish populations would be affected by the increased water levels in the proposed reservoirs. In about half of the areas, access to the less precipitous slopes of the upper tributaries would be improved by increased water elevations and could benefit resident fish populations.

Fish would experience extremely high mortality rates if they attempted to migrate downstream through turbines or outlet works at the proposed dams.

It appears highly unlikely that anadromous fish such as salmon could be introduced into the Upper Susitna River Basin. The related problems and costs of passing migrating fish over and through high dams appear infeasible. However, the introduction of a resident land-locked salmon species, such as sockeye (kokanee), to some waters of the upper Susitna basin might prove feasible.

Wildlife: Reservoir impoundments behind the proposed dams would have varying degrees of environmental impact on wildlife.

The Devil Canyon reservoir would be located within the confines of a narrow, steep-walled canyon with few areas of big-game habitat and no major migration routes for big-game animals. Based on observations of terrain slopes, and vegetation, it is estimated that about 100 acres of this reservoir might be favorable moose habitat. The reservoir would create about 65 miles of lake shoreline. Because the pool level would vary little, it is assumed that a fringe of water-oriented vegetation such as willow or alder would develop along the shore. Such a fringe zone could provide favorable habitat for a variety of small mammals and birds, and might provide replacement habitat for moose. A continuous fringing zone only 50 feet in width around the lake would represent 300-400 acres.

The proposed Watana Dam would be generally contained within a fairly deep and narrow river canyon. Watana reservoir would lie across one of the intermittent caribou migration routes between the north side of the Susitna River and the main calving area of the Nelchina caribou herd, located south of the river in the northeast foothills of the Talkeetna Mountains. Calving generally takes place during a month-long period starting in the middle of May. Ice-shelving conditions along the shoreline caused by winter drawdown on Watana reservoir or ice breakup conditions on the reservoir could cause problems for caribou migrating to the calving grounds. This reservoir would have a high water shoreline about 145 miles long. Development of a fringe habitat would be considerably less likely than for Devil Canyon because of the highly variable water level of the lake. Creation of beneficial habitat is doubtful.

As caribou are strong swimmers, they should have fewer problems crossing the narrow reservoir during July after calving than they would crossing the swollen glacial river during natural periods of high runoff. Caribou could migrate around the reservoir. Caribou migration patterns for the Nelchina herd are continually changing, as stated in Alaska Department of Fish and Game study reports. Under adverse ice conditions, the reservoirs could cause increased mortality in some segments of the herd, and some permanent changes in traditional herd movements.

A moose survey conducted in early June 1974 by the Alaska Department of Fish and Game indicated that, although spring counting conditions were less than ideal, a total of 356 moose were seen along the upper Susitna River and in the lower drainage areas of the major tributaries. A 1973 fall count in the same general area sighted a total of 1,796 moose. Of the 356 moose counted in the June 1974 survey, 13 were seen in the area of the proposed Watana reservoir. None were sighted within the proposed Devil Canyon reservoir impoundment. Based on visual observations and map studies of vegetation and terrain slopes, it is estimated that 2,000 to 3,000 acres, mostly in the lower reaches of Watana Creek, could be favorable moose habitat. Wildlife management agencies state that such habitat for moose should be considered as critical, especially as winter habitat. Further studies to delineate both the extent and value of the habitat would be required to determine the need and/or extent of mitigation.

The loss of habitat for bears, wolves, wolverines, Dall sheep, and other animals appears to be minimal. Other birds, including raptors, songbirds, shorebirds, and game birds, do not appear to be significantly affected by the reduction of habitat in the area of the proposed dams and reservoirs, although some habitat will be lost for all species of wildlife.

Road access to the two damsites could have a significant impact on fish and wildlife resources in areas opened to vehicle encroachment. Specific areas such as Stephan Lake, Fog Lakes, lower Deadman Creek, and the northern slopes of the Talkeetna Mountains could be greatly impacted by hunters, fishermen, and other recreationists as a result of the access road to Watana Dam. However, such an impact is properly a function of the establishment and enforcement of proper regulations by management authorities, not of the project.

The proposed reservoirs at Devil Canyon and Watana are located along a major flyway for waterfowl. Very few waterfowl appear to nest on the sections of the river that would be flooded by these reservoir proposals. On the other hand, the reservoirs would provide suitable resting areas for waterfowl migrating through the basin.

Migrating birds would possibly suffer some mortality from collisions with towers or lines, but such losses should be negligible. The line would generally parallel normal north-south migration routes. The cables would be large enough to have a high degree of visibility and would be widely enough spaced to be ineffective snares. Electrocution of birds is also unlikely since the distance between lines and between lines and ground would be great enough to make shorting out by birds almost impossible.

A transmission line per se will not have many impacts upon wildlife; most of the impacts will be as a result of construction and maintenance. Direct destruction will affect the less mobile animals such as the small mammals, whose territories may be small enough to be encompassed by the construction area. The significance of this impact to these animals is small in relation to their population in surrounding areas.

<u>Recreation</u>: Much of the Upper Susitna River Basin, except near the Denali Highway and Lake Louise vicinity, has little recreational activity at the present time. A combination of poor road access, rough terrain, and great distances limits the use of the 5,800-square-mile basin, especially the lands directly impacted by this alternative, to a few hunters, fishermen, and campers who utilize these lands for recreational purposes.

The construction of the proposed hydroelectric project would have an impact on a number of present and projected recreational activities both in the immediate dam and reservoir areas and downstream from the dams.

Construction Activities: Project related construction activities would include the building of the dams and related facilities; the clearing of reservoir areas; the construction of roads, electrical distribution systems, and recreational facilities; and the building of facilities for workers. The construction of the Devil Canyon and Watana project is estimated to take 10 years to complete, with an estimated 5 to 6 years required for construction at each of the two sites. The activities will overlap as simultaneous construction will occur in the final 1-2 years of the Watana project.

The activities themselves would cause varying degrees of physical pollution to the air, land, and water within the project area and to some areas outside the development area. Fish, wildlife, vegetation, visual resources, soils, and other resource values could be severely impacted by construction activities.

Roads and other facilities would be needed in order to obtain materials from borrow sources and quarry sites for the construction of the dams. Areas would also be needed to dispose of some materials and debris. All construction activities could be controlled to minimize or to eliminate adverse environmental impacts; environmental enhancement could be considered where feasible.

Workers' Facilities: No communities within commuting distance of the proposed project area could absorb the number of workers required for the construction of the dams and related facilities. Temporary construction camps with the necessary facilities would need to be provided during the construction periods. Permanent facilities would have be built for maintenance and operational personnel after completion of the construction phase.

The construction and operations of the workers' camps would have to meet State and Federal pollution control laws and standards, and all activities could be controlled to minimize the adverse environmental impacts presented by the camps.

Esthetics: The project would be located in areas that have practically no permanent signs of man's presence. The land between Portage Creek and the Denali Highway is an undisturbed scenic area.

The construction of a hydroelectric project would have a substantial impact on the existing natural scenic resource values within the project area. Any dam construction on the upper Susitna would change a free-flowing river into a series of manmade lakes. Devil Canyon reservoir would fluctuate up to 5 feet, while Watana reservoir could fluctuate up to 120 feet below full pool under normal operating conditions. The seasonal fluctuation of the Watana impoundment would not have a substantial scenic impact, inasmuch as the major drawdown would occur in the winter when public access was not possible, and the pool would be essentially refilled by the time access was restored. The whitewater section of the Susitna River through Devil Canyon would be substantially inundated by a dam at Devil Canyon. Roads and transmission lines would also impact the natural scenic resource values of the area.

After dam construction, many visitors could view the manmade structures and their reservoirs. It can be expected that a considerable number of tourists and State residents would visit the dams.

If consideration were given to minimizing the adverse impacts of construction activities, a great deal could be accomplished to maximize scenic resource values within the project area. Good landscape management practices would add substantially to the recreational experience of the project visitor.

Air Pollution: Most of the existing electrical power in the Southcentral Railbelt area is produced by gas, coal, and oil-fired generating units which cause varying degrees of air pollution.

Cook Inlet gas is a clean fuel that causes few serious air pollution problems at the present time. The existing gas turbines have very low efficiencies and give off visible water vapor emissions during the colder winter months. Also, nitrogen emissions could be of significant concern for any proposed larger gas-fired plants.

Hydroelectric energy could replace the burning of fossil fuels for electric power generation in much of the Fairbanks area and could help to alleviate winter ice fog and smoke problems, which are caused in part by coal-fired electrical plants in that area.

Hydroelectric projects provide a very clean source of power with practically no direct air pollution-related problems. This type of electrical power generation could reduce a substantial amount of future air pollution problems associated with the burning of gas, oil, and coal.

An ice-free stretch of warmer, open water below Devil Canyon Dam could cause ice-fog conditions in that area during periods of extreme cold weather.

Social:

Population: Substantial increases in population are expected within the Southcentral Railbelt area through the year 2000, and with the possible relocation of Alaska's State capital from Juneau to the Railbelt, an additional population impact can be expected in this area.

The population of the area will increase with or without the development of hydroelectric projects proposed for the Susitna River;

construction of the project is not expected to have any significant effect on overall population growth.

Economics: The proposed two-dam Devil Canyon-Watana hydroelectric development would have a minimal to moderate overall effect depending on various factors involved in the construction program itself. If the construction unit is brought in from outside Alaska to develop the project, the social and economic impact on the local system would be minimized, but if the project were constructed using substantial labor and material from the Anchorage-Fairbanks area, it would have a more moderate effect on local conditions during construction of the project and would help to stabilize economic conditions during that development period. It is projected that about 80 percent (878 out of 1,097 workers) of the labor force would be local and that half (439 workers) of that is labor that would otherwise be un- or underemployed. The resulting benefit to such labor is the source of Area Redevelopment benefit.

Various community, borough, State, and private facilities and agencies would be impacted to varying degrees by the workers involved in the construction of the proposed project. Workers' camps would be built in the vicinity of some of the various construction activities, but additional impacts would be created by the families of the construction workers living in various nearby communities, who would require additional facilities and services.

After the construction of the project, an estimated 45 permanent personnel would be required to operate and maintain the project and project-related facilities--these people would not create a significant overall socioeconomic impact on the Railbelt area.

Other Effects: The lands within the reservoir areas have sporadic occurrences of permafrost. The lakes would thaw such material to a considerable depth and increase the probability of earthslides and erosion of the material. However, the overburden depth to rock is quite shallow throughout most of the sharply incized canyon terrain of the two reservoirs and the quantities of materials which would be involved in such slides and/or erosion are thus not considered significant either in terms of reservoir sedimentation or in the creation of large waves of danger to the dams. It is estimated that of the 210 miles of combined shoreline, 40 miles could experience significant erosion, while the remaining 170 miles would be subject to only minor effects. The effects of even the severe erosion would be expected to last only a few years until the thawed and saturated slopes had attained equilibrium.

Response to Study Objectives: The response of the Devil Canyon-Watana hydropower alternative to the study objectives is summarized as follows:

Power: Provides 6.91 billion kilowatt-hours average annual energy. Meets the projected demand until the mid-1990's.

Flood Control: Provides minor flood control benefits.

Air Pollution: Provides partial air pollution abatement by displacing and or delaying increased use of coal in Railbelt area.

Fish and Wildlife: Direct loss of 50,550 acres of land including 2,100-3,100 acres of critical winter moose habitat. Possible adverse effect on caribou migration and anadronous fish. Probable creation of 300-400 acres of replacement moose habitat. Possible contribution to establishment of non-migration fish population. Provides 50,550 acres of possible waterfowl resting area.

Recreation: Provides light use recreational facilities equivalent to 77,000 visitor days. Adverse effect on 9 miles of whitewater boating potential.

Conservation of Nonrenewable Resources: Conserves equivalent of 5.85 million tons of coal annually.

Energy Independence: Conserves equivalent of 112.9 billion cubic feet of natural gas, or 15.2 million barrels of oil annually.

Devil Canyon-Watana-Denali: This alternative would be identical to the previous two-dam system except for the addition of a 260-foot-high earthfill dam at river mile 248 near Denali. This dam would provide an additional storage area of 54,000 acres, and would have no powerhouse. The first cost of the three-dam system is estimated as $1.89 billion. Annual costs are estimated as $115,566,000, including $2,600,000 for operation, maintenance, and replacements. Average annual project benefits accrue as follows:

Power	$133,922,000
Recreation	300,000
Flood Control	50,000
Area Redevelopment	10,905,000
Total	$145,177,000

The B/C ratio is 1.3 to 1.
Net annual benefits are $29,611,000.

The system would have an average annual energy output of 6.91 billion kilowatt-hours and a firm energy output of 6.80 billion kilowatt-hours from an installed capacity of 1,552 MW. The project cost of energy to the distributors would be 21.0 mills per kilowatt-hour.

Project effects would be essentially identical to the two-dam project, except as follows:

River Flows: Average regulated downstream flows at Devil Canyon would range from about 8,900 cfs in October to 11,000 cfs in February. In extreme years, the flows would range from 7,800 cfs to 16,000 cfs. Overall, the effect would be to provide better river regulation. Flood control would remain essentially unchanged with flood control benefits identical.

Water Quality: Devil Canyon reservoir would remain unchanged. Watana reservoir would receive less heavy sediment, approximately 3.5 million tons per year rather than 7.1 million tons per year. Denali reservoir would have a high pool surface area of 54,000 acres and would fluctuate an average of 30 to 40 feet annually to a low surface area of 35,000 acres. The reservoir would be 34 miles long and 6 miles wide at high pool. The pool would force relocation of 19 miles of the Denali Highway.

Fish: Resident fish would be severely impacted by the fluctuating pool. Some might survive in the tributary streams at low pool, but many would be trapped in temporary pools and die during drawdown. Downstream effects on anadromous fish would be identical to the preceding plan. Adverse effects to resident fish in Watana reservoir could be increased marginally since the fluctuation of that reservoir would be increased from 95-120 feet annually to 110-140 feet, providing a less favorable environment. Stocking of Denali reservoir would probably be nonbeneficial in that the pool fluctuations would have the same adverse effects on these fish as on fish now resident to the tributary streams.

Wildlife: The impacts on wildlife would be increased greatly. Of the 54,000 acres inundated by Denali reservoir, an estimated 52,000 acres are moist tundra and pothole lakes which provide moderate habitat to moose and are highly significant as caribou habitat. In addition, the lakes, estimated to number about 400, provide significant resting and nesting for waterfowl. Effects at the two downstream dams would not be significantly changed. Human access, via the reservoir at full pool, would be improved to the headwater areas of the Susitna River. The major ecosystem in these areas, alpine tundra, is quite fragile and could be adversely impacted if access were not carefully regulated. The Denali reservoir would have a high water shoreline about 100 miles long. However, because of the frequent and rapid pool fluctuations, little beneficial habitat could be expected to develop.

Recreation: The Denali reservoir could have significant adverse impacts on present recreational uses made of the area. Moose and caribou hunting in this area now accessible by the Denali Highway provides a large part of the present recreational activity in the Upper Susitna River Basin. Establishment of the reservoir, by removing much of the suitable habitat of the game animals, would greatly reduce the hunting opportunities. Because of the fluctuations in the reservoir level and the resulting unfavorable conditions for fish, little if any replacement recreational opportunity would be provided to offset this loss. No recreational facilities would be provided at the reservoir in view of the unfavorable conditions.

Historic and Archaeological Sites: In addition to the single site of historic interest and 40 zones of archaeological interest contained in the two-dam system, the Denali reservoir would emcompass 20 archaeological zones of interest and 3 potential historical sites.

Mining: The area adjacent to the Denali reservoir has a long and continuing history of gold mining. Although no active mines would be inundated by the reservoir, further exploration and/or development within the confines of the impoundment would be hampered or precluded.

Transmission System: Because Denali Dam would have no generation capacity, no additional transmission lines or effects would result.

Roads: In addition to the effects of the two-dam system, there would be a required relocation of about 19 miles of the Denali Highway. The temporary construction access roads would, for the most part, be merged into the permanent road. The most significant effects of the relocation would be loss of about 200 additional acres of wildlife habitat and better access to the damsite vicinity, which could impose added pressures on wildlife.

Construction Activities: The general effects would be those listed for the two-dam system with the addition of an estimated three to four years of such activity at the Denali site.

Workers' Facilities: Construction of a Denali Dam would require a temporary camp for about 600 workers since the only nearby settlements, Denali and Paxson, do not have facilities which could absorb the workforce. The impacts and controls required would be the same as listed for the two-dam system.

Esthetics: The Denali Dam and reservoir, with the Denali Highway crossing the dam structure itself, would be highly visible to all motor traffic. The reservoir at less than full pool would have a definite adverse impact on the scenic values of the area. Because of the generally flat terrain within the reservoir, even a few feet of fluctuation in the pool level would create a wide "bathtub ring" of defoliated shore. At large drawdowns, the ring could be a mile or more in width.

No means of preventing or significantly lessening the impact of this feature is compatible with the power production objective which requires the drawdown.

Air Pollution: Except for the short-term effects of construction activities at Denali Dam, the effects of the three-dam system would be identical to the two-dam system.

Social: The effects would be the same as for the two-dam system except that additional employment would be provided. The increased Area Redevelopment benefits reflect the additional use of un- or under-employed labor in the construction of the additional dam and facilities. As previously stated, the addition of the Denali Dam would result in an increase of 4, from 45 to 49, in permanent jobs created in operation and maintenance of the dam system. The construction of permanent living quarters at the damsite might be foregone in favor of locating the personnel at Paxson.

Other Effects: The Denali reservoir area is underlain by permafrost. Inundation would cause a significant thawing of this material. Because of the very flat terrain, earthslides should not be of consequences. However, the materials are generally very fine-grained and when thawed and saturated could have poor structural integrity when subjected to earthquakes. As such, the materials pose a difficult technical problem in the design of a Denali Dam. The cost of adequate remedial foundation treatment for the structure is a significant factor in the overall cost of what would otherwise be a relatively small dam. Erosion of the thawed shoreline would not contribute significantly to sedimentation of the reservoir. It is estimated that all of the 100-mile shoreline could be subject to severe erosion until equilibrium was restored and vegetation reestablished.

Response to Study Objectives: The response of the Devil Canyon-Watana-Denali hydropower alternative to the study objectives is summarized as follows:

Power: Provides 6.91 billion kilowatt-hours average annual energy. Meets the projected demand until the mid-1990's.

Flood Control: Provides minor flood control benefit.

Air Pollution: Provides partial air pollution abatement by displacing and/or delaying increased use of coal in Railbelt area.

Fish and Wildlife: Direct loss of 104,550 acres of land, including 2,100-3,100 acres of critical winter moose habitat, and 52,000 acres of important caribou habitat and waterfowl nesting area. Possible adverse effects on caribou migration and anadromous fish. Probable creation of 300-400 acres of replacement moose habitat. Possible contribution to establishment of nonmigratory fish population. Provides 104,550 acres of possible waterfowl resting area.

Recreation: Provides light use recreational facilities equivalent to 77,000 visitor days. Adverse effect on 9 miles of whitewater boating potential. Probable adverse effect on recreational hunting and fishing in 54,000-acre Denali reservoir.

Conservation of Nonrenewable Resources: Conserves equivalent of 5.85 million tons of coal annually.

Energy Independence: Conserves equivalent of 112.9 billion cubic feet of natural gas, or 15.2 million barrels of oil annually.

Devil Canyon-Watana-Vee-Denali: This alternative would consist of the previously described dams at Devil Canyon and Denali with a lower (515 feet vs 810 feet) earthfill Watana Dam and a 455-foot-high earthfill dam in Vee Canyon at the extreme head of Watana reservoir at river mile 208. The three downstream dams would have powerhouses and switchyards. An additional 40 miles of access road would connect Vee Dam to Watana Dam. An additional 40 miles of transmission line would also be required to connect Vee Dam to the downstream system. The dam would have a visitor center, a boat ramp, and limited recreational facilities. The project first cost is estimated as $1.95 billion. Annual costs are estimated as $102,491,000, including $3,200,000 for operation, maintenance, and replacements. Average annual project benefits accrue as follows:

Power	$107,865,000
Recreation	400,000
Flood Control	50,000
Area Redevelopment	10,971,000
Total	$119,286,000

The B/C ratio is 1.2 to 1.
Net annual benefits are $16,795,000.

The system would have an average annual energy output of 6.88 billion kilowatt-hours and a firm energy output of 6.15 billion kilowatt-hours from an installed capacity of 1,404 MW. The projected energy cost to the distributors would be 24.3 mills per kilowatt-hour.

Workers' Facilities: As with the preceding systems, no existing communities could absorb the project workforce. Commuting distance from the nearest established camp facility, Watana Dam, would be too great for economical use of these facilities. Thus, a temporary camp would be required in the vicinity of the damsite. The effects would be identical and additive to those previously described for the two-and three-dam systems.

Esthetics: The previously discussed adverse visual impacts would be increased. The "bathtub ring" at Denali reservoir would be increased by the added drawdown. The Vee reservoir area, not so much the steep canyon sections downstream of Oshetna River, but the more gently sloped, rolling terrain in the Tyone River and upstream area, would acquire a similar ring of defoliated barren land which would decrease the scenic value drastically. These would be additions to the downstream effects described for the other systems.

Air Pollution: Except for the short-term effects during construction of Vee Dam, the effects of the four-dam system would be identical to the three-dam system.

Social: The effects would be the same as for the two- and three-dam systems except that additional employment would be provided. The Area Redevelopment benefits from this plan reflect the increase in use of un- or underemployed labor over the other plans. Facilities would have to be provided at the dam for permanent operating personnel. It is estimated that 10 additional permanent jobs would be created by construction of Vee Dam, raising the system total to 59.

Other Effects: The effects of the reservoir on underlying permafrost would be a combination of the effects at the downstream reservoirs and the Denali impoundment since the Vee reservoir would lie in part in steep canyons with shallow frozen overburden and in part in flatter terrain similar to the Denali area. No significant reservoir sedimentation or slide-caused waves would be expected. Significant shoreline erosion would be expected to affect about 35 miles of the shoreline for a few years until an equilibrium condition was reached.

Response to Study Objectives: The response of the Devil Canyon-Watana-Vee-Denali hydropower alternative to the study objectives is summarized as follows:

Power: Provides 6.88 billion kilowatt-hours average annual energy. Meets the projected demand until the mid-1990's.

Flood Control: Provides minor flood control benefits.

Air Pollution: Provides partial air pollution abatement by displacing and/or delaying increased use of coal in Railbelt area.

Fish and Wildlife: Direct loss of 84,950 acres of land including 9,100-10,100 acres of critical winter moose habitat, and 52,000 acres of important caribou habitat and waterfowl nesting area. Possible adverse effects on caribou migration and anadromous fish. Probable creation of 300-400 acres of replacement moose habitat. Possible contribution to establishment of non-migratory fish population. Provides 84,950 acres of possible waterfowl resting area.

Recreation: Provides light use recreational facilities equivalent to 100,000 visitor days. Adverse effect on 9 miles of whitewater boating potential. Probable adverse effect on present hunting-fishing use of Tyone River confluence.

Conservation of Nonrenewable Resources: Conserves equivalent of 5.83 million tons of coal annually.

Energy Independence: Conserves equivalent of 112.2 billion cubic feet of natural gas, or 15.1 million barrels of oil annually.

NED PLAN

From the preceding evaluations, it is concluded that the system comprised of dams at the Devil Canyon and Watana sites best accomplishes the objective of maximizing National Economic Development. The two-dam system has the highest B/C ratio at 1.3 and the maximum net benefits at $33,856,000 annually while producing electrical energy equal to any of the other plans.

EQ PLAN

From the preceding evaluations, it is evident that no means of producing a meaningful output of electrical energy was found to be free of significant adverse environmental effects. The plan which minimizes the unavoidable adverse impacts on fish and wildlife values while providing beneficial contributions to air and water quality and social well-being is considered to contribute most to the Environmental Quality objectives. On this basis, the system of two dams at Devil Canyon and Watana is also the EQ plan.

THE SELECTED PLAN

The two-dam Devil Canyon-Watana system is selected as the plan providing the best overall response to the study objectives. The following table displays a summary comparison of the significant facts and factors which guided formulation of the selected plan.

THE SELECTED PLAN

The selected plan, shown on Plate 1, consists of a two-dam development on the upper Susitna River. The Devil Canyon damsite is located at river mile 134, about 14.5 miles upstream from Gold Creek, the closest point on the Alaska Railroad. The Watana damsite is located at river mile 165, approximately 2 river miles upstream from the upper limit of the Devil Canyon reservoir. Watana Dam will be constructed first.

WATANA DAM FEATURES

The main dam, shown on Plate 2, consists of an earthfill structure 810 feet high with a crest length of 3,200 feet. The upstream side slope is 1 on 2.5 and a downstream side slope of 1 on 2, and the crest elevation is 2,210 feet, msl. The dam was designed for earthquakes using a Maximum Credible Earthquake (MCE) of magnitude 8.5 on the Richter Scale, originating at the Denali Fault 40 miles to the north. Consideration was given to the effects of a lesser magnitude (6.0) earthquake originating at the short Susitna Fault 2-1/2 miles east of the damsite.

The saddle spillway is 210 feet wide with a low ogee crest at elevation 2162 feet, msl. The spillway is controlled with three 59-foot x 42-foot tainter gates. Routing of the design flood through the spillway resulted in a maximum discharge of 193,000 cfs at a reservoir pool elevation of 2205 feet, msl.

The intake structure is approximately 370 feet high and is located on the left bank about 700 feet upstream from the dam. It has multi-level intake portals sized to pass a discharge of 24,500 cfs.

The diversion plan at the damsite consists of two intake structures in the right abutment, one at elevation 1925 and the other at elevation 1725, which join the two 30-foot horseshoe diversion tunnels near the dam axis. Each of the tunnels is about 4,000 feet long. The facilities will provide protection of the construction site for a 20-year frequency flood estimated to be 72,000 cfs and allow reservoir drawdown under emergency conditions.

The Watana powerplant is located in an underground chamber in the left abutment and will house three 236-MW generating units and three 324,000-horsepower Francis turbines. The powerhouse chamber will also contain transformers, two 600-ton cranes, machine shop, and other necessary equipment. Vehicle access to the powerplant is provided by a service road 1.9 miles long, including a 2,100-foot tunnel.

SUMMARY COMPARISON OF ALTERNATIVE PLANS

	PLAN A	PLAN B	PLAN C	PLAN D
	WITHOUT CONDITION	NATIONAL ECONOMIC DEVELOPMENT (NED) ENVIRONMENTAL QUALITY (EQ) PLANS	MAXIMUM POWER DEVELOPMENT PLAN	PREVIOUSLY RECOMMENDED PLAN
	Conventional Coal Thermal Plant	Devil Canyon-Watana Dams	Devil Canyon-Watana-Denali Dams	USBR Four-Dam System
A. PLAN DESCRIPTION	Non-Federal financing of a 300-mw coal-fired generating plant at Healy and a 1,200-mw coal-fired plant at Beluga. The plants would have 35-year service lives. Project would include costs for coal mining and separate Healy-to-Fairbanks and Beluga-to-Anchorage transmission systems.	Federal financing of the total system to include a thin-arch dam and underground powerplant at the Devil Canyon site, and an earthfill dam and underground powerplant at the Watana site. Both projects would provide at-site power generation. Watana would provide the seasonal storage for the system. Plan would also include transmission system between projects and to the Anchorage and Fairbanks load centers.	This plan is basically the same as the Plan B, but with the addition of the Denali Project would have no at-site power generation and would be used only for low flow augmentation of the two downstream projects.	This is the system proposed by the Bureau of Reclamation in its 1952 report on hydropower resources of the Upper Susitna River Basin. Federal financing of the total system to include a thin-arch dam and powerplant at the Devil Canyon site, a low head earthfill dam and powerplant at the Watana site, an earthfill dam and powerplant at the Vee site, and a flow augmentation reservoir at the Denali site. Plan would also include transmission system between projects and to the two load centers.
1. Dam Heights	No Dams	1. Devil Canyon - 635 feet 2. Watana - 810 feet	1. Devil Canyon - 635 feet 2. Watana - 810 feet 3. Denali - 260 feet	1. Devil Canyon - 635 feet 2. Watana - 515 feet 3. Vee - 455 feet 4. Denali - 260 feet
2. Dependable Capacity	1,500,000 kilowatts	1,394,000 kilowatts	1,552,000 kilowatts	1,404,000 kilowatts
B. SIGNIFICANT IMPACTS	(Included in Relationship to Four Accounts)	(Included in Relationship to Four Accounts)	(Included in Relationship to Four Accounts)	(Included in Relationship to Four Accounts)
C. PLAN EVALUATION				
1. Contribution to Planning Objective				
a. Firm Annual Energy	6,800,000,000 kilowatt-hours	6,100,000,000 kilowatt-hours	6,800,000,000 kilowatt-hours	6,150,000,000 kilowatt-hours
b. Average Annual Energy	6,910,000,000 kilowatt-hours	6,910,000,000 kilowatt-hours	6,910,000,000 kilowatt-hours	6,880,000,000 kilowatt-hours
c. Percent of Basin Potential	Not Applicable	96%	96%	95%
d. System Dependability	No grid intertie of major load centers. Reduced dependability.	Provides grid intertie of major load centers.	Provides grid intertie of major load centers.	Provides grid intertie of major load centers.
2. Relationship to Four Accounts				
a. National Economic Development (NED)				
NET NED BENEFITS	0	$33,856,000	$29,611,000	$16,795,000
BENEFIT-TO-COST RATIO	1.0	1.3	1.3	1.2
b. Environmental Quality (EQ)				
Acreage Inundated or Destroyed	20,000	50,550	104,550	84,950
Drawdown Zone Acreage	0	13,000	45,000	45,000
Stream Mileage Inundated or Degraded	110-120	82	116	138
Whitewater Mileage Inundated	0	9	9	9
Major Ecosystems, Acreage Inundated or Destroyed				
Important Moose Habitat	18,000	4,000	4,000	10,000
Important Caribou Habitat	2,000	0	52,000	52,000
Important Waterfowl Habitat (number of pothole lakes)	2,000 acres	0	400	400
Archaeological Zones Precluded from Post-Construction Studies	Unquantified area has very high potential	40	60	85
Prehistoric Sites Inundated or Destroyed	0	0	0	1
Historic Sites Inundated or Destroyed	0	1	4	4
c. Social Well-Being (SWB)				
Energy Resources Conserved in Tons per Year		5,850,000	5,850,000	5,830,000
d. Regional Development (RD)				
Cost of Power in Mills/Kwhr	26.4 - 31.4	21.1	21.0	24.3
3. Plan Response to Associated Evaluation Criteria				
a. Acceptability	This plan is the worst from the standpoint of conservation of nonrenewable resources. It has large adverse EQ effects in that it requires strip-mining of 20,000 acres of important wildlife habitat, it degrades water quality by chemical inputs and suspended sediments, and it degrades air quality by inputs of particulates and chemical pollutants. Its NED performance is acceptable. It provides no flood control or recreational opportunity.	Maximum beneficial impacts of options studied in NED and EQ accounts. Supported by consensus of most publics. Plan has drawn some concern because of possibility for induced population growth associated with initial power on line, as well as the adverse impact on fish and wildlife values. Would provide flood control and recreation potential.	Greater adverse EQ effects than in recommended plan. Ranks second to the recommended plan in the NED account. Would provide maximum firm power of hydro development plans. Would provide flood control and recreation potential.	Beneficial impacts in NED, SWB, and RD accounts. Has good potential for stage development of hydro projects and is plan favored by Alaska Power Administration. Ranks low in the EQ account in comparison to other alternatives. Would provide flood control and recreation potential.

	PLAN A WITHOUT CONDITION Conventional Coal Thermal Plant	PLAN B NATIONAL ECONOMIC DEVELOPMENT (NED) ENVIRONMENTAL QUALITY (EQ) PLANS Devil Canyon-Watana Dams	PLAN C MAXIMUM POWER DEVELOPMENT PLAN Devil Canyon-Watana-Denali Dams	PLAN D PREVIOUSLY RECOMMENDED PLAN USBR Four-Dam System
C. PLAN EVALUATION (Cont.)				
3. Plan Response to Associated Evaluation Criteria (Cont.)				
b. Certainty	This appears to be an implementable plan which could be pursued to meet energy needs for the near and long range future. It is the most flexible plan in terms of incremental development and operation potentials.	Foundation conditions appear adequate for construction of both projects. Transmission system is within the means of present technology. Least flexible of alternatives to changes in projected power demand.	Same evaluation as for Plan B except for storage control project at Denali site. Additional explorational required before this structure could be recommended. More flexible than Plan B.	Same evaluation as for Plan C except for the power project at the Vee site. Additional exploration of abutment material required before this dam could be recommended for the structural height stated above. Most flexible of hydro alternatives.
c. Completeness	Could match the energy output of any plans evaluated herein as long as fuel source is available.	Provides adequate power to satisfy projected demand growth until mid-1990's Little potential for expansion. Demand beyond the project capability will have to be met by other development.	Provides adequate power to satisfy projected demand growth until mid-1990's Little potential for expansion. Demand beyond the project capability will have to be met by other development.	Provides adequate power to satisfy projected demand growth until mid-1990's. Little potential for expansion. Demand beyond the project capability will have to be met by other development.
d. Effectivenss	Could be expanded indefinitely to limits of fuel.	Would develop 96 percent of basin development potential.	Develops greatest firm power - equal to Plan B in average annual power.	Would develop 95 percent of basin development potential.
D. IMPLEMENTATION RESPONSIBILITY				
1. Financial Responsibility	Private and/or semi-public entities coordinated with Federal and State regulatory agencies.	Federal Government with power marketed through the Alaska Power Administration.	Federal Government with power marketed through the Alaska Power Administration.	Federal Government with power marketed through the Alaska Power Administration.
2. Recreation Sponsorship	None	State of Alaska	State of Alaska	State of Alaska

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A cost comparison between an above ground versus an underground powerplant at the Watana damsite showed that the underground plant was less expensive. This and other factors, such as severe winter weather conditions, short construction season, higher maintenance costs, and scarcity of a good above ground powerplant site location, led to the selection of the underground powerhouse.

The Watana switchyard is placed on the left bank of the Susitna River just downstream of the dam. The switchyard is approximately 700 feet by 500 feet, and at elevation 2100 feet, msl.

A large portion of the lands within the Watana reservoir area was withdrawn for power purposes in February 1958 by Powersite Classification No. 443. The powersite withdrawal for Watana includes all lands below the 1910-foot contour. However, access roads, transmission corridors, and some other project features, as well as additional lands required for the larger reservoir, were not included in the withdrawal. There are no existing roads, railroads, or other improvements affected by the reservoir impoundment. The additional lands required are estimated at 35,000 acres.

Watana reservoir would have a surface area of 43,000 acres at normal full pool elevation of 2,200 feet. The normal minimum power pool level would be at elevation 1950, while the maximum elevation produced by the design flood would be 2,205 feet. The reservoir will extend about 54 miles upstream to above the confluence of the Oshetna River.

A 24-foot-wide access road, designed to AASHO standards, will connect the damsites to the Parks Highway near Chulitna. A 650-foot-long bridge will be required to cross the Susitna River downstream of Devil Canyon. Devil Canyon damsite will be near mile 27 of the 64-mile road to Watana.

A subsidiary purpose in the construction of the electric transmission line will be the interconnection of the two largest electrical power distribution grids in the State of Alaska, which will result in increased reliability of service and lower cost of power generation.

Most of the power generated would be used in the Fairbanks-Tanana Valley and the Anchorage-Kenai Peninsula areas. The transmission system proposed would consist of two 198-mile, 230 kv single circuit lines from Devil Canyon switchyard to Fairbanks (called the Nenana corridor), and two 136-mile, 345 kv single circuit lines from the switchyard to the Anchorage area (called the Susitna corridor). Power would be carried from Watana to Devil Canyon by two 30-mile, 230 kv transmission lines. Total length of the lines would be 364 miles. Transmission line corridors would require a right-of-way totaling about 8,200 acres. The cleared portion would be 186-210 feet wide and total about 6,100 acres.

Towers would be either steel or aluminum, and of free-standing or guyed type, depending upon final design and local conditions.

Tentative sites have been selected for the temporary trailer-modular dormitory construction camp as well as for permanent facilities. Operation and maintenance facilities at the damsite include a 50-foot by 100-foot warehouse, a vehicle storage building, and permanent living quarters.

DEVIL CANYON DAM FEATURES

The main dam, shown on Plate 3, consists of three integral sections: (1) a 635-foot-high concrete, double curvature, thin-arch section with crest length of 1,370 feet; (2) a 110-foot-high concrete thrust block section with crest length of 155 feet; and (3) a 200-foot-high fill section in the left abutment with a 950-foot crest length. An earthquake stability analysis was made based on the same 8.5 MCE as for Watana.

The intake structures will be integral with the arch dam. They will be gated to provide selective withdrawal at intervals between elevations 1,100 and 1,400. The chute spillway is placed in the left abutment between the thrust block and fill sections of the dam. The spillway design flood is 222,000 cfs. The spillway will have an ogee crest at elevation 1395 with two 64-foot by 60-foot gates. The chute will terminate in a superelevated flip bucket at elevation 1110, which will discharge parallel to the river. This spillway design should minimize nitrogen supersaturation as well as riverbed erosion.

The outlet works consist of four 11-foot by 7-1/2-foot gated sluiceways at elevation 1075, which will have a minimum discharge capacity of 21,000 cubic feet per second at a 75-foot head. Each sluiceway ends in a flip lip to project water away from the dam toe. The outlet works are adequate to meet emergency drawdown requirements.

The Susitna River will be diverted through a 1,150-foot-long, 26-foot concrete-lined horseshoe tunnel located in the left abutment. Cellular cofferdams will be constructed upstream and downstream of the dam to provide protection of the construction site against the Watana Dam power flows of 20,000 cubic feet per second.

The Devil Canyon powerhouse is located in an underground chamber in the right abutment. Initially, four 171-MW generating units are to be installed with four 234,000-horsepower Francis turbines. The powerhouse will also contain two 425-ton cranes, service areas, and a machine shop for equipment maintenance and repair. A separate upstream underground chamber will house transformers and circuit breakers.

ECONOMICS OF THE SELECTED PLAN

PROJECT COSTS

The estimated construction cost of the selected plan is $1,520,000,000, which includes $572,000 in non-Federal recreational costs. Adding the $11,800,000 value of public domain transferred without cost gives a total project cost of $1,531,800,000.

Interest during construction is computed as simple interest on project costs from the estimated date of expenditure to the appropriate power-on-line date. The project costs and interest during construction for the Devil Canyon Dam are discounted to the Watana power-on-line date of October 1986.

The investment cost, $1,653,136,000, is the project cost plus interest during construction, both discounted to the 1986 power-on-line date.

Project Cost (Present Worth)	$1,401,295,000
Interest During Construction (PW)	251,841,000
Investment Cost	$1,653,136,000

Amortization of this amount with interest at a rate of 6-1/8 percent and a project economic life of 100 years results in an annual cost of $101,520,000.

The estimated average annual operation and maintenance cost over the 100-year project life of the selected plan is $1,928,000. Annual costs for replacement of mechanical equipment and other items which normally have a useful life less than the 100-year project life are estimated at $572,000. 1/

The following table summarizes the average annual cost for the selected plan:

Interest and Amortization	$101,520,000
Operation and Maintenance	1,928,000
Replacement	572,000
Average Annual Cost	$104,020,000

A detailed cost estimate for the selected plan is contained in Section B, Appendix I.

1/ The O,M&R costs other than those for recreation were provided by Alaska Power Administration.

COST ALLOCATION

Allocation of estimated costs according to the Alternative Justifiable Expenditure method resulted in the following apportionment of joint-use costs:

PURPOSE	PERCENT OF JOINT-USE COSTS
Power	99.69%
Recreation	0.22%
Flood Control	0.09%

The cost allocation results are tabulated below:

COST ALLOCATION ($1,000)

	Power	Recreation	Flood Control	Total
Construction Cost	$1,516,326	$2,912	$762	$1,520,000
Public Domain Cost	11,768	23	9	11,800
Interest During Construction	280,839	587	164	281,590
Operation, Maintenance, and Replacement (Annual Cost)	2,397	102	1	2,500

PROJECT BENEFITS

Benefits accrue to the selected plan from the sale and improved reliability of electric power provided by the project, flood damages prevented, recreational opportunity provided, and Area Redevelopment from the utilization of unemployed labor.

Power: Power benefits are calculated by applying the project capacity and energy to power values derived by the Federal Power Commission and from increased reliability provided by the intertie of the Anchorage-Fairbanks power grids.

Summary of Power Benefits ($1,000)

Capacity	Prime Energy	Secondary Energy	Intertie	Total
93,807	30,883	2,516	947	128,153

Recreation: Recreational benefits are calculated as the use-day value of recreational opportunity provided by the project.

Summary of Recreational Benefits ($1,000) 1/

General	Specialized	Total
110	190	300

1/ Rounded

Flood Control: Flood control benefits are calculated as the value of decreased maintenance of erosion protection to the Alaska Railroad. The benefit totals $50,000 annually.

Area Redevelopment: The Area Redevelopment benefit is calculated as the value of employment provided to un- or underemployed Alaskan labor by project construction. Such employment is estimated as 4,390 man-years giving an average annual benefit of $9,373,000.

Summary of Benefits: Estimated annual benefits are summarized as follows:

Category	Value ($1,000)
Power	128,153
Recreation	300
Flood Control	50
Area Redevelopment	9,373
Total	137,876

PROJECT JUSTIFICATION

The following table summarizes the project economic factors.

Summary of Economic Factors

Item	Recreation	Non-Recreation	Total
Average Annual Benefits	$300,000	$137,576,000	$137,876,000
Annual Costs	165,000	103,855,000	104,020,000
B/C Ratio	1.8	1.3	1.3
Net Annual Benefits	$135,000	$ 33,721,000	$ 33,856,000

The analyses show the project and the incremental recreational development to be justified.

DIVISION OF PLAN RESPONSIBILITIES

The project benefits accrue 93.4 percent to power, 6.3 percent to Area Redevelopment, 0.2 percent to recreation, and 0.1 percent to flood control. All purposes except recreation are solely the responsibility of the Federal Government, while recreation requires participation by a sponsor. In the case of the selected plan, although title to most of the project lands presently rests with the Bureau of Land Management, there is every indication that title will, in the near future, pass to the State of Alaska. Thus, project sponsorship for recreation will also rest with the State.

FEDERAL RESPONSIBILITIES

The United States will design, construct, maintain, and operate the dams, powerplants, roads, and transmission facilities, and will share in the planning, design, and construction of the recreational facilities following Congressional authorization and funding, and after receipt of all required non-Federal contributions and assurances.

The presently estimated Federal share of the total first cost of the project is $1,520,000,000, including an estimated cost of $572,300 for recreation. Annual operation, maintenance, and replacement costs, exclusive of recreation, are $2,400,000.

NON-FEDERAL RESPONSIBILITIES

Non-Federal interests must, prior to the start of construction of recreational facilities, provide to the Secretary of the Army acceptable assurances that they will, in accordance with the Federal Water Project Recreation Act, Public Law 89-72:

a. Administer land and water areas for recreation.

b. Pay, contribute in kind, or repay (which may be through water-use fees) with interest, one-half of the separable costs of the project allocated to recreation.

c. Bear all costs of operation, maintenance, and replacements of lands and facilities for recreation.

Late stage public meetings were held at Anchorage on 7 October 1975 and at Fairbanks on 8 October 1975 to present the study findings and the District Engineer's tentative conclusions and recommendations. A number of environmental groups were represented at one or both of these meetings. They included: the Isaac Walton League, the Mountaineering Club of Alaska, the Alaska Conservation Society, Knik Kanoers and Kayakers, and Fairbanks Environmental Center. Comments included the need for Corps funding for fish and wildlife studies and data processing of environmental information. Expressed concerns included the inundation of a scenic, whitewater river, location of the project area too close to a proposed Talkeetna State Park, too much human use in the area, impacts on moose habitat and downstream salmon runs, differences reflected in the 1960 and 1975 cost estimates, the low interest rate used in computing project benefits, who would operate the dams and sell the power, reservoir siltation, turbidity, fluctuations in streamflows, impacts on permafrost, the possibility of earthquakes, the formation of frazil ice, the geology of the area, benefits claimed for flood control, the location of transmission corridors and construction of transmission lines, land status, impacts upon population growth, recreational development, the production of secondary energy, and others. Most of these groups voiced either strong opposition to the project or reserved judgment pending further studies and specific project recommendations.

Many organizations, groups, and individuals expressed support of the selected plan. An informal poll of people attending the late stage public meetings indicated about five persons favoring to each person opposing the project.

WORKSHOPS

Workshop meetings were arranged and held with the following interested groups:

30 April 1974 with environmental organizations

29 October 1974 with Federal and State agencies

13 March 1975 with the Cook Inlet and AHTNA regional native corporations.

INFORMAL MEETINGS

Informal meetings at the field level were held throughout the study with participating and interested Federal and State agencies on topics including but not limited to technical, environmental, archaeological and historical, economic, and recreational aspects of the study.

CORRESPONDENCE

Appendix 2 contains a representative display of correspondence from non-Federal agencies, groups, and individuals. Included specifically is a letter from the State of Alaska, Division of Parks, expressing willingness to participate in the cooperative planning and development of recreation for the project.

The concurring comments of the State of Alaska, Department of Fish and Game, are included in report of the United States, Fish and Wildlife Service project report which is reproduced in Appendix 2.

DISCUSSION

LOAD GROWTH PROJECTIONS

Load growth projections as provided by Alaska Power Administration for the period 1974 through the year 2000 covered a range of power requirements, high, mid-range and low. Feasibility report utilized the mid-range projection which has been endorsed by both Alaska Power Administration and Federal Power Commission. Substantial amounts of new generating capacity will be needed to meet future power requirements of the Southcentral Railbelt area. Recent studies of the Southcentral and Yukon region (which includes the Southcentral Railbelt as its main component), as defined in the 1974 Alaska Power Survey Report of the Executive Advisory Committee, indicate that rapid rates of increase in power requirements will continue at least for the balance of the 1970's, reflecting economic activity associated with North Slope oil development and expansion of commercial and public services. Estimates beyond 1980 reflect a range of assumptions as to the extent of future resources use and industrial and population growth. All indications are that accelerated growth will continue through the year 2000, with economic activity generated by North Slope oil and natural gas development being a major factor - but only one of several important factors. It is generally considered that the Southcentral-Yukon regional population will continue to grow at a faster rate than the national and State averages, that future additional energy systems and other potential mineral developments will have a major effect, and that there will be notable expansion in transportation systems. Significant economic advances for all of Alaska and especially for the Alaska native people should be anticipated as a result of the Alaska Native Claims Settlement Act. Other influencing factors could be cited, but the general outlook is for further rapid expansion of energy and power requirements in the Southcentral-Yukon area. A range of estimates for future power requirements of the Southcentral and Yukon regions is presented in the 1974 Report of the Alaska Power Survey Technical Advisory Committee on Economic Analysis and Load Projections. The range of estimates attempts to balance a myriad of controlling factors including costs, conservation technologies, available energy sources and types of Alaskan development. The higher growth range anticipates significant new energy and mineral developments from among those that appear more promising. The lower growth range generally assumes an unqualified slackening of the pace of development following completion of the Alyeska pipeline and is not considered realistic. The mid-range growth rate appears to be a reasonable estimate which we adopt as most representative based on recent manifestations and assessment of future conditions. It should be noted that there are several responsible advisory committee members who feel that recent acceleration of mineral raw material shortages of all kinds indicates a possibility that even the high range estimates could be exceeded.

ALTERNATIVE ENERGY SOURCES

Alternative energy sources for electric power generation include fossil fuels, oil, natural gas and coal and nuclear power. Alaska has large known and potential reserves of fossil fuels. Alaska power systems now depend on oil and gas for about 60 percent of total energy production. The predominant energy source for Anchorage is presently natural gas and for Fairbanks service area, coal and oil.

The Federal Power Commission has provided at-market power values for the Anchorage and Fairbanks market areas at 1975 price levels. The at-market power values for the Fairbanks area are based on estimated costs of power from an alternative coal-fired generating plant with 150 MW total capacity consisting of two 75 MW units; heat rate, 12,000 btu/kwh; capital cost, $640 per kilowatt; service life, 35 years; and coal cost of 60¢ per million btu. For the Anchorage area, the at-market power values are based on estimated costs of power from two alternative sources, coal fired and combined cycle. The combined cycle power values are based on a plant with 450 MW total capacity and natural gas operating cost of 70¢ per million btu. The coal fired power values are based on a plant with 450 MW total capacity and coal cost of 50¢ per million btu.

Due to the uncertainty of the future availability of natural gas after 1985 for new generating capacity, the unforeseen possibility of its restrictive use if available, and its sensitivity to worldwide economic pressures, coal is considered to be the most likely alternative fuel for thermal-electric plants to be constructed in the Anchorage service area after 1985.

The present day price of 70¢ per million btu paid for natural gas used by the Anchorage utilities is not a realistic basis for selecting the most likely source of fuel for future thermal electrical generation after 1985. The current price does not reflect true economic value because of the existence of regulated markets. Also, the source of gas presently supplying Anchorage needs will, because of limited reserves, increasing local needs, and national and international competition for supplies, not be available in the post 1986 time frame. If gas is to continue to be utilized for power generation in the Anchorage area, Prudhoe Bay or equally costly sources will have to be tapped. The value of North Slope gas in Anchorage under reasonable assumptions regarding transportation systems is approximately $1.46 per million btu. This value of gas would result in a comparable cost for the combined cycle and coal-fired alternatives.

The extensive coal deposits near Cook Inlet are attractive future alternative sources of energy for this region and could lead to options to convert from oil and natural gas to coal as the major power source during the 1980's. Coal reserves in the Beluga River area north and west of Anchorage contain an estimated 2.3 billion tons, or the equivalent of almost 6 billion barrels of oil. Coal resources in the Nenana field south of Fairbanks near Healy contain an estimated 7 billion tons.

In summary, coal is the least costly alternative to hydroelectric power in the Fairbanks area and in the mid-1980 time frame, natural gas and coal in the Anchorage area are comparable as the most economical alternative. Recognizing the uncertainty of the future availability of natural gas and oil after 1985 for new generating capacity, the possibility of its restrictive use if available and its sensitivity to worldwide demand and economic pressures, coal is considered the most likely alternative fuel for thermal-electric plants to be constructed in the mid-1980's and beyond for the Anchorage area.

FORMULATION

A number of alternative plans were studied in the process of developing the most feasible project for developing the hydroelectric potential of the upper Susitna River Basin. The most favorable of all the plans investigated is a combination of two dams, Devil Canyon, located at river mile 134 with normal pool elevation of 1450, and Watana, located at river mile 165, 31 miles upstream of the Devil Canyon site, with a normal pool elevation of 2200. The selected two-dam system would provide 6.1 billion kilowatt-hours of firm electrical power annually from a dependable capacity of 1394 megawatts, or nearly 96 percent of the basin potential.

The two dams were analyzed separately and together as a coordinated system for maximum development of the hydroelectric potential of the basin. As a single unit, Watana could develop 3.1 billion kilowatt-hours of firm power annually and Devil Canyon, as an independent unit, 0.9 billion kilowatt-hours of firm annual energy. As a system, the two dams would provide 6.1 billion kilowatt-hours of firm power annually because of the value of Watana storage in providing flow releases to increase Devil Canyon power production. An analysis was also made to identify the best sequence of construction. It was found that Watana, first added, that is Watana constructed first with power on line date of 1986 and Devil Canyon last added with power on line date of 1990, was the best sequence. Benefit-to-cost ratio for Watana, first added, is 1.28 while Devil Canyon, first added, results in a benefit-to-cost ratio of 0.80. The combination of the two dams, with either Watana or Devil Canyon constructed first, would not materially change the benefit-to-cost ratio of 1.3 for the total project.

The multiple-purpose projects, while providing for the projected power needs for the Railbelt Area, would also provide flood damage reduction downstream of Devil Canyon and for recreational opportunities associated with the two reservoirs. Construction of the project would also provide employment opportunities for better utilization of under-utilized and unemployed labor.

The selected combination of Watana-Devil Canyon provides the most efficient national economic development (NED) plan with a maximum of net benefits exceeding $33.8 million annually. The selected plan also makes a positive contribution toward the environmental quality (EQ) of the study area. Development of the hydroelectric potential of the Susitna River Basin would conserve over 5.8 million tons of coal annually or 15 million barrels of oil annually. Positive contributions to improvements in air and water quality would result from reduction in coal-fired plants and reduction in the mining of coal.

A transmission intertie between the major load centers of Anchorage and Fairbanks would provide an increased reliability and would allow transfer of energy between the load centers with greater flexibility of operation. The transmission system would consist of two single circuit 345 KV lines a distance of 136 miles to Anchorage and two single circuit 230 KV lines a distance of 198 miles to Fairbanks. Value of the transmission intertie has been estimated and included in the economic feasibility analysis for the project.

The Watana and Devil Canyon dam sites are located some 50 miles from existing roads and the only access presently is by helicopter. Early construction of an access road would facilitate preconstruction planning activities for mapping and foundation explorations, with a reduction in total project costs as compared to access by helicopter. In scheduling the construction activities to meet the expedited power-on-line date of 1986, it was also found that early construction of the access road was essential to mobilize the men, equipment and supplies necessary for construction of a project of this magnitude. For these reasons, the access road should be constructed during the initial phase of preconstruction planning rather than incur a delay of at least one year in meeting initial power-on-line date of 1986. In addition to the savings that would be incurred in mobilizing men and equipment during the early phases of the operation, early construction of the access road would provide an additional year of power revenue estimated at approximately $115 million. Construction of the access road at an estimated cost of $22.3 million is well justified.

FEASIBILITY OF ADDITIONAL UNITS

Studies have indicated the need and feasibility of providing hydropower from the Susitna River projects to meet the railbelt area's future load growth from a projected power-on-line date of 1986 through 1996 when the projects full power capability would be utilized. After 1996, the system would require additional generating capacity; hydropower, fossil fuel, or nuclear thermal generation.

Past studies by a number of agencies have indicated substantial hydropower potential available for development to meet load requirements well beyond the year 2000. The State of Alaska has a hydropower potential of over 27 million kilowatts. Generally, as the availability of fossil fuels becomes increasingly scarce and more valuable over time, the alternative renewable hydropower resource will continue to provide the most economical means for meeting the railbelt area's power needs beyond the year 2000. The feasibility of adding units at Watana and Devil Canyon for system peaking requirements in conjunction with thermal base energy was analyzed, in the event more expensive thermal base energy was added to the system in the post 2000 period. For this analysis it was assumed that the baseload thermal plants would operate at 50 percent plant factor the first year and 65 percent thereafter; also, the pre-Susitna thermal generation facilities would be retired after their 30 year economic life, with the last units retiring in year 2015. A load resource analysis determined that the additional units would be needed as follows:

Watana #4	2003
Watana #5	2005
Devil Canyon #5	2008
Devil Canyon #6	2010

Costs were estimated for construction of skeleton bays during initial powerhouse construction, including penstocks and tailrace excavation. Incremental costs at Watana for two skeleton bays are estimated at $67,560,000 (1984-85) and $45 million per unit in years 2002 and 2004, for a total of $157,560,000. Incremental costs at Devil Canyon for two skeleton bays are estimated at $32,240,000 (1990-91) and $40 million per unit in years 2007 and 2009, for a total of $112,240,000. Total costs for the four added units are estimated at $270 million. These costs do not include a reregulating dam downstream of Devil Canyon with an estimated cost in excess of $100 million. The reregulating dam would probably be required if additional units were added at Devil Canyon.

Estimated average annual costs and benefits are as follows:

($1000)	Watana	Devil Canyon
Annual costs	6950	3750
Annual benefits	7470	4110
BCR	1.07	1.10
Comparability ratio	0.98	1.0

As can be seen, even under the most optimistic of assumptions, added units at Watana cannot pass the comparability test; units at Devil Canyon are marginal; however, with the added costs of a reregulating dam, added units at Devil Canyon would also not be justified.

ENVIRONMENTAL CONSIDERATIONS

The Susitna River, with an overall drainage area of about 19,400 square miles, is the largest stream discharging into Cook Inlet and is an important access route to upper river and tributary spawning and rearing areas for the five species of Pacific Salmon found as adults in the inlet. Portage Creek, three miles below the Devil Canyon damsite, is the uppermost tributary on the Susitna River where significant numbers of spawning salmon have been noted. Investigations conducted by the Fish and Wildlife Service intermittently from 1952 to 1975 failed to reveal the presence of adult or juvenile salmon in the Susitna River above the proposed Devil Canyon damsite. No actual waterfalls or physical barriers have been observed in or above the Devil Canyon area which would preclude salmon from utilizing the Susitna River drainage area above the damsite. The most logical reason for the absence of salmon is the presence of a hydraulic block resulting from high water velocities for several river miles within Devil Canyon.

Twenty-seven spring fed slough areas adjacent to the main stream Susitna River between the Devil Canyon damsite and downstream to the confluence with the Chulitna and Talkeetna Rivers, a distance of approximately 60 miles, have recently been identified as being important for fish rearing. Adult spawning salmon have been recorded in 9 of the 27 sloughs. Rearing salmon fry have been observed in 17 of the sloughs. Additional slough areas are probably present in the same reach or further downstream. However, those slough areas downstream of Devil Canyon would not be appreciably influenced by flow releases with normal daily fluctuation of less than one foot or under rare, extreme conditions of up to three feet at Gold Creek, 15 miles below Devil Canyon. In addition, any change in turbidity as a result of the project would not be evident below the confluence of the Chulitna and Talkeetna Rivers.

Regulated flow vs. natural flow data should be obtained in the important slough areas to determine whether remedial measures would be necessary to prevent dewatering of the sloughs during spawning and incubation times. Reduction in flows and turbidity in the summer months may have a minor impact on adult fish orientation. However, these impacts should be negligible after the first five years after construction as juveniles that have been exposed to the changed flow and turbidity regimen would be returning as adults. Reduced turbidities in the summer months could be beneficial for fish production and for sport fishery. Increased turbidities are forecasted to occur during the winter months; however, the amount expected to occur would be below a level that would adversely impact fish. Selective withdrawal structures will be incorporated in the proposed project to permit the release of water that has been mixed to approach natural temperature conditions. Dissolved gas supersaturation that might occur when spilling would be substantially reduced in the turbulent river section that would be present just downstream of the Devil Canyon Dam. Upstream from the dams, the major impact on the resident fish populations would be caused by the reservoir impoundments. Under the proposed plan, Devil Canyon Reservoir would fluctuate very little. Even though the steep-walled canyon of this reservoir might prove less than desirable for a program to develop a resident fish population, some species of fish might be able to adapt to this reservoir and provide some future sport fishing benefits.

Watana Dam would have a wide range of drawdown in the reservoir which although not impacting the fishery resource would make access more difficult, resulting in lower fishing pressure. Suspended glacial sediment could be a factor in both of the reservoirs after the heavier glacial sediments have settled out; however, many natural lakes in Alaska such as Tustumena and Tazlina, with heavy inflows of glacial debris sustain fish populations under similar conditions, so to develop populations of fish under related conditions should prove feasible. Most resident fish populations, especially grayling, utilize some of the clearwater tributaries of the Susitna River or areas near the mouths of these streams as they enter the glacially turbid main river channel during periods of high runoff. Many of these tributaries would be flooded in their lower reaches by the proposed reservoir impoundments. The resident fish populations would be affected by the increased water levels in the proposed reservoirs; but in some areas, access to tributaries for resident fish may be improved by increased water elevations.

Impacts on wildlife would occur primarily in the Watana Reservoir portion of the Susitna River. The area downstream of the Watana Dam is a narrow steep-walled canyon with few areas of big game habitat and is not crossed by any major migration route for big game. The upper section of the Watana Reservoir would lie across one the Netchina caribou use as an intermittent seasonal migration route between their main calving area and their summer range. The reservoir could conceivably alter historical herd movement and distribution and prior to ice break-up mortalities could occur because of ice-shelving. Moose habitat would be lost upstream of Watana Dam. Data on the number of acres of good habitat impacted and the number of animals using the areas are preliminary. Additional data are needed on both the moose and caribou herds before a determination can be made for the need for compensation measures.

Transmission corridors required to distribute the electric power that would be generated by the proposed project would total about 364 miles. The corridor to Fairbanks is identified as the Nenana Corridor and the one to Anchorage the Susitna Corridor. These corridors would require approximately 8,200 acres, of which 6,100 acres would have to be cleared. Aquatic impacts would occur primarily during the clearing for and the construction of the actual transmission facilities and would be of a temporary nature. Some erosion, causing turbid condition in streams crossed by the corridors, could occur on cleared land after construction, but is expected to be minor. Impacts on caribou would be limited to the 136 mile segment of the Nenana Corridor north of Cantwell since there is no significant caribou use of areas to the south. Although physical destruction of caribou habitat will not be a significant impact, indirect consequences such as man-caused fires, noise generated by transmission lines and increased human access could be significant. Moose are found throughout the length of the transmission line corridor. The greatest impact to these animals would be the increased hunting access provided by roads and the openness of the corridor itself. Habitat would overall be improved. Subclimax growth within the transmission line corridor would increase moose browse. A transmission line, per se, will not have many lasting impacts upon wildlife; most of the impacts will be a result of construction and maintenance.

CONCLUSIONS

On the basis of data and studies presented in this report, it is concluded that:

a. Power needs in the Railbelt Area of Alaska are estimated to more than double by 1985 from the present 2 billion kilowatt-hours to 5.5 billion kilowatt-hours and 15 billion kilowatt-hours by the year 2000. These values represent the mid-range growth projections of the three ranges of projections prepared by Alaska Power Administration, the Federal marketing agent for electrical energy in Alaska.

b. The formulated plan would meet the need for increased supplies of electrical energy while conserving non-renewable fossil fuels, oil, natural gas and coal. Coal is the least costly alternative to hydroelectric power in the Fairbanks area and in the mid-1980 time frame, natural gas and coal are comparable as the most economical alternative in the Anchorage area. Recognizing the uncertainty of the future availability of natural gas and oil after 1985 for new generating capacity, the possibility of its restrictive use if available and its sensitivity to world-wide demand and economic pressures, coal is the most likely alternative fuel for thermal-electric plants to be constructed during the project life for the Anchorage area.

c. Of the alternative plans analyzed, the best plan is a combination of two dams, Devil Canyon, located at river mile 134 with normal pool elevation of 1450, and Watana, located at river mile 165 with a normal pool elevation of 2200.

d. The best sequence of construction would be Watana first added with Devil Canyon second. The two dams acting together would provide 6.1 billion kilowatt-hours of firm power annually. Watana reservoir's 6.5 million acre-feet of usable storage provides the required flow releases for dependable power production at Watana and Devil Canyon.

e. Under normal load requirements, the Watana project would be operated to meet peaking requirements with Devil Canyon operating at a more uniform rate in the base load. Watana and Devil Canyon reservoirs would fluctuate only slightly in response to daily load requirements and daily fluctuations in river stage downstream of Devil Canyon would be less than one foot. Under extremely rare adverse load conditions, downstream river fluctuations could be as much as three feet at Gold Creek, 15 miles below Devil Canyon. Because Devil Canyon would be operating essentially as a reregulating dam to control the rate of downstream flow releases, a reregulating structure downstream of Devil Canyon is not required.

f. The future addition of units at Watana and Devil Canyon, based on 1975 price levels and projected power demand beyond the year 2000, is not economically feasible at this time. However, during preconstruction planning for the project, the feasibility of adding units would be reanalyzed.

g. Reservoir storage on the Susitna River will permit multiple use of the water resource through hydropower generation, flood control and recreation. Total annual benefits exceed total annual costs by $33.8 million. The benefit-to-cost ratio is 1.3 and the comparability ratio for power is 1.2. Costs allocated to power would be repaid over a 50-year period from power revenues at an average cost of 21 mills per kilowatt-hour.

h. Positive contributions toward the environmental quality of the study area would result from development of the Upper Susitna River Basin. Hydroelectric generation would conserve over 5.8 million tons of coal annually or 15 million barrels of oil annually. Improvements in air and water quality would result from reduction in coal-fired plants and reduction in the mining of coal.

i. We have not been able to identify any need for mitigation measures at this time. However, more detailed studies, including pre-impoundment studies of the reservoir areas and studies of fishery habitat below Devil Canyon, are planned during pre- and post-construction periods. Any mitigation measure found necessary and economically justified will be provided for at that time.

j. Early construction of access road to the projects would facilitate preconstruction planning activities and expedite construction and initial power on line.

k. Construction of the two dams and transmission system would be the responsibility of the Corps of Engineers and the operation and maintenance of the projects and transmission system would be the responsibility of the marketing agency. One-half of the separable investment cost allocated to reservoir recreation would be reimbursable and all costs of operation, maintenance and replacement of lands and facilities for recreation would be paid by non-Federal interests, all in accordance with the Federal Water Project Recreation Act, Public Law 89-72. All costs to power would be repaid to the Federal Treasury from power revenues.

RECOMMENDATIONS

The District Engineer recommends:

a. Construction by the Corps of Engineers of the Susitna River Project consisting of a combination of two dams and reservoirs designated as the Watana and Devil Canyon on the upper Susitna River, Alaska, and of transmission facilities and grid system for southcentral and interior Alaska, for hydroelectric power, flood control, and recreation in accordance with the selected plan described in this report, and with such modifications as in the discretion of the Chief of Engineers may be advisable, all at a Federal cost presently estimated at $1,520,000,000, exclusive of the cost of preauthorization studies.

b. That operation and maintenance of the projects and appurtenant transmission facilities be the responsibility of the marketing agency, such costs presently estimated at $2,400,000 annually, including the cost associated with major replacements.

Provided that, prior to start of construction of recreational facilities, responsible non-Federal entities provide assurances acceptable to the Secretary of the Army, they will, in accordance with the Federal Water Project Recreation Act, Public Law 89-72:

a. Administer land and water areas for recreation.

b. Pay, contribute in kind, or repay (which may be through water user fees) with interest, one-half of the separable cost of the project allocated to recreation, presently estimated to be $572,300.

c. Bear all costs of operation, maintenance, and replacement of lands and facilities for recreation, presently estimated to be $100,000 annually.

It is further recommended that authority for construction of necessary access roads to the projects be provided for in the authorization for advanced engineering and design. Such roads, estimated to cost $22,300,000, will provide necessary access for detailed preconstruction site investigations and facilitate timely construction of the projects.

All costs to power, presently estimated at $1,516,000,000 for construction, and $2,397,000 annually for operation, maintenance, and major replacements, are to be repaid to the Federal Treasury from power revenues.

CHARLES A. DEBELIUS
Colonel, Corps of Engineers
District Engineer

NPDPL-PF (12 Dec 75) 1st Ind
SUBJECT: Interim Feasibility Report, Upper Susitna River Basin, Alaska

DA, North Pacific Division, Corps of Engineers, 210 Custom House, Portland, Oregon 97209 31 December 1975

TO: Chief of Engineers

I concur in the conclusions and recommendations of the District Engineer.

WESLEY E. PEEL
Major General, USA
Division Engineer