SUSITNA HYDROELECTRIC PROJECT

FERC LICENSE APPLICATION

EXHIBIT E

CHAPTER 10

DRAFT

NOVEMBER 15, 1982

Prepared by:

ACRES

ALASKA POWER AUTHORITY

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VOLUME 5 CHAPTER 10

ALTERNATIVE LOCATIONS, DESIGNS, AND ENERGY SOURCES

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10 - ALTERNATIVE LOCATIONS, DESIGNS, AND ENERGY SOURCES

This chapter presents the results of assessments of the environmental impacts of alternatives to the proposed Susitna Hydroelectric Project. Included in this assessment is a consideration of alternative hydroelectric generating sites outside the upper Susitna basin and alternative sites within the basin. The alternatives considered in formulating the proposed project are discussed. Finally, an environmental assessment of alternative methods of generation, coal-fired hydroelectric, gas oil and tidal and other alternatives, is presented in terms of differential environmental impact.

10.1 - Alternative Hydroelectric Sites

(a) Non-Susitna Hydroelectric Alternatives

The analysis of alternative sites for non-Susitna hydropower development followed the plan formulation and selection methodology discussed in Exhibit B.

Step 1 in the plan formulation and selection process was to define the overall objective of the exercise. For Step 2 of the process, all feasible sites were identified for inclusion in the subsequent screening process. The screening process (Step 3) eliminated those sites that did not meet the screening criteria and yielded candidates which could be refined to include in the formulation of Railbelt generation plans (Step 4).

Details of each of the above planning steps are given below and presented in Figure E.10.1. The objective of the process was to determine the optimum Railbelt generation plan which incorporates the proposed non-Susitna hydroelectric alternatives.

(i) Screening of Candidate Sites

As discussed in Exhibit B, numerous studies of hydroelectric potential in Alaska have been undertaken. A significant amount of the identified potential is located in the Railbelt region. Review of the above studies and in particular the various published inventories of potential sites identified a total of 91 potential sites (Table E.10.1). All of these sites are technically feasible and, under Step 2 of the planning process, were identified for inclusion in the subsequent screening exercise.

The screening process applied to these sites for this analysis required the application of four iterations with progressively more stringent criteria.

- First Iteration

The first screen or iteration determined which sites were not economically viable and rejected these sites. The standard for economic viability in this iteration was defined as energy production cost less than 50 mills per kWh, based on economic parameters. This value for energy production cost was considered to be a reasonable upper limit consistent with Susitna Basin alternatives for this phase of the selection process.

As a result of this screen, 26 sites were eliminated from the planning process (Table E.10.1). The remaining 65 sites were subjected to a second iteration of screening which included additional criteria on environmental acceptability.

- Second Iteration

The inclusion of environmental criteria into the planning process required a significant data survey to obtain information on the location of existing and published sources of environmental data. A detailed review of this data and the sources used are presented in Reference 1.

The basic data collected identified two levels of detail of environmental screening. The purpose of the first level of screening was to eliminate those sites which were least acceptable from an environmental standpoint. Rejection of sites occurred if:

o They would cause significant impacts within the boundaries of an existing National Park, Wild and Scenic River, National Wilderness Area, or a proclaimed National Monument area;

o Or they were located on a river in which:

  . Anadromous fish are known to exist;

  . The annual passage of fish at the site exceeds 50,000; and

  . Upstream from the site, a confluence with a tributary occurs in which a major spawning or fishing area is located.

The definition of the above exclusion criteria was made only after a review of the possible impacts of hydropower development on the natural environment and the effects of land issues on particular site development.

Of the 65 sites remaining after the preliminary economic screening, 19 sites were eliminated on the basis of the requirements set for the second screen. These sites appear in Table E.10.1, and the reason for their rejection in Table E.10.2. The location of the remaining 46 sites appears in Figure E.10.2.

- <u>Third Iteration</u>

The reduction in the number of sites to 46 allowed a reasonable reassessment of the capital and energy production costs for each of the remaining sites to be made. Adjustments were made to take into account transmission line costs necessary to link each site to the proposed Anchorage-Fairbanks intertie. This iteration resulted in the rejection of 18 sites based on judgmental elimination of the more obvious uneconomic or less environmentally acceptable sites (Table E.10.1). The remaining 28 sites were subjected to a fourth iteration which entailed a more detailed numerical environmental assessment.

- <u>Fourth Iteration</u>

To facilitate analysis, the remaining 28 sites were categorized into sizes as follows:

o Less than 25 MW: 5 sites;
o 25 MW to 100 MW: 15 sites; and
o Greater than 100 MW: 8 sites.

The fourth and final screen was performed using a detailed numerical environmental assessment which considered eight criteria chosen to represent the sensitivity of the natural and human environments at each of the sites.

The eight evaluation criteria are listed in Table E.10.3. For each of the evaluation criteria, a system of sensitivity scaling was used to rate the relative sensitivity of each site. A letter (A, B, C or D) was assigned to each site for each of the eight criteria to represent this sensitivity. The scale rating system is defined in Table E.10.4.

Each evaluation criterion has a definitive significance to the Alaskan environment and degree of sensitivity to impact (Reference 1, Appendix C2). A summary of the evaluation and comparison of each site on the basis of these criteria is presented in the following paragraphs.

(ii) Basis of Evaluation

The criteria were initially weighted in accordance with their relative significance in comparisons. The first four criteria--big game, agricultural potential, birds, and anadromous fisheries were chosen to represent the most significant features of the natural environment. These resources require protection and careful management because of their position in the Alaskan environment, their roles in the existing patterns of life of the state residents, and their importance in the future growth and economic independence of the state. They were viewed as more important than the following four criteria because of their quantifiable and significant position in the lives of the Alaskan people.

The remaining four criteria--wilderness; cultural, recreation and scientific features; restricted land use; and access--were chosen to represent the institutional factors to be considered in determining any future land use. These are special features which have been identified or protected by governmental laws or programs and may have varying degrees of protected status; or the criteria represent existing land status which may be subject to change by the potential developments.

Data relating to each of these criteria were compiled separately and recorded for each site, forming a data-base matrix. Then, based on these data, a system of sensitivity scaling was developed to represent the relative sensitivity of each environmental resource (by criterion) at each site. A detailed explanation of the scale rating may be found in Table E.10.5.

The scale ratings for the criteria at each site were recorded in the evaluation matrix. Site evaluations of the 28 sites under consideration are given in Table E.10.6. Preliminary data regarding technical factors were also recorded for each potential development. Parameters included installed capacity, development type (dam or diversion), dam height, and new land flooded by impoundment. The complete evaluation matrix may be found in Table E.10.7.

In this manner, the environmental data were reduced to a form from which a relative comparison of sites could be made. The comparison was carried out by means of a ranking process.

(iii) Rank Weighting and Scoring

For the purpose of evaluating the environmental criteria, the following relative weights were assigned to the criteria. A higher value indicates greater importance or sensitivity than a lower value.

Big Game	8
Agricultural Potential	7
Birds	8
Anadromous Fisheries	10
Wilderness Values	4
Cultural Values	4
Land Use	5
Access	4

The criteria weights for the first four criteria were then adjusted down, depending on related technical factors of the development scheme.

All the sites were ranked in terms of their dam heights which were assumed to be the factor having the greatest impact on anadromous fisheries.

Sites were also ranked in terms of their new reservoir area, or the amount of new land flooded, which was considered to be the one factor with greatest impact on agriculture, bird habitat, and big game habitat. The same adjustments were made for the big game, agricultural potentials, and bird habitat weights based on this flooded area impact (see Table E.10.8).

The scale indicators were also given a weighted value as follows:

- o B = 5
- o C = 3
- o D = 1

To compute the ranking score, the scale weights were multiplied by the adjusted criteria weights for each criteria and the resulting products were added.

Two scores were then computed. The total score is the sum of all eight criteria. The partial score is the sum of the first four criteria only, which gives an indication of the relative importance of the existing natural resources in comparison to the total score.

(iv) Evaluation Results

The evaluation of sites took place in the following manner: sites were first divided into three groups in terms of their capacity.

Based on the economics, the best sites were chosen and environmentally evaluated as described above. Table E.10.9 lists the number of sites evaluated in each of the capacity groups in ascending order according to their total scores for each of the groups. The partial score was also compared. The sites were then grouped as better, acceptable, questionable, or unacceptable, based on the scores.

The partial and total scores for each of the sites, grouped according to capacity, appear in Table E.10.10.

Sixteen sites were chosen for further consideration. Three constraints were used to identify these 16 sites. First, the most economical sites which had passed the environmental screening were chosen. Second, sites with a very good environmental impact rating which had passed the economic screening were chosen. And finally, a representative number of sites in each capacity group were to be chosen (Table E.10.11).

From the list of 16 sites, 10 were selected for detailed development and cost estimates required as input to the generation planning. The ten sites chosen are underlined in Table E.10.1.

Further discussion of the basis of selection of these 10 sites is presented in Reference 1, Appendix C2.

(v) Plan Formulation and Evaluation

Steps 4 and 5 in the planning process was the formulation of the preferred sites identified in Step 3 into Railbelt generation scenarios. To adequately formulate these scenarios, the engineering, energy, and environmental aspects of the ten short-listed sites were further refined (Step 4).

This resulted in formulation of the ten sites into five development plans incorporating various combinations of these sites as input to the Step 5 evaluations. The five development plans are given in Table E.10.12.

The essential objective of Step 5 was established as the derivation of the optimum plan for the future Railbelt generation, incorporating non-Susitna hydro generation as well as required thermal generation. The methodology used in the evaluation of alternative generation scenarios for the Railbelt is discussed in detail in Reference 2, Section 8. The criterion on which the preferred plan was finally selected in these activities was least present-worth cost based on economic parameters established in Reference 2, Section 8.

The selected potential non-Susitna hydro developments (Table E.10.13) were ranked in terms of their economic cost of energy. These developments were then introduced into the all-thermal generating scenario in groups of two or three. The most economic schemes were introduced first followed by the less economic schemes.

On the basis of these evaluations, the most viable alternative to the Susitna project was found to be the development of the Chakachamna, Keetna, and Snow sites for hydroelectric power, supplemented with a thermal generating facility. The potential environmental impacts of hydroelectric development at these sites are discussed below; discussion of the environmental effects of thermal development is in Section 10.3(a).

(b) Environmental Assessment of Selected Alternative Sites

The analysis of alternative development scenarios outside the upper Susitna Basin showed Chakachamna, Snow and Keetna hydroelectric sites offer the most suitable schemes for development. Because maximum total power production from these three sites would be only 650 MW, additional thermal and tidal development would also be required. The potential environmental impacts of hydroelectric development at these three sites are discussed below; coal-fired thermal and tidal power are discussed in Sections 10.3(a) and 10.3(b).

The Chakachanmna area has been studied previously for hydroelectric development and is currently under study by the Power Authority (3). As such, fairly detailed information is available. Keetna and Snow, however, have not been intensively studied and information is limited primarily to non-specific inventory data and resource maps.

(i) Description of Chakachamna Site

Chakachamna Lake is located in the Alaska range approximately 80 miles west of Anchorage. The lake is drained by the Chakachatna River which runs southeasterly out of the lake and eventually into Cook Inlet. The most likely development of Chakachamna Lake would be with a lake tap of Chakachamna Lake with a diversion tunnel (approximately 23 feet in diameter) to the MacArthur River Basin. This development would provide some allocation of water for fish purposes. The power plant would have an installed capacity of 330 MW and could provide approximately 1,446 GWH of firm energy. Transmission lines would run from the site to a location near the Chugach Electric Association (CEA) Beluga power plant and would then parallel existing lines to a submarine crossing of Knik Arm and then to a terminal on the eastern shore (3).

- Topography and Geology

Chakachamna Lake is located in a deep valley of the Alaska range surrounded by glaciers and high mountains. From an elevation of approximately 1200, land elevation drops fairly rapidly to sea level within 40 miles. In lower elevations, drainage is poor with numerous wetlands present.

Lake Chakachamna was formed by the Barrier Glacier and associated morainal deposits descending from the south side of Mount Spurr. The area is underlain by semi-consolidated volcanic debris of late Tertiary or Quaternary age and, closer to Cook Inlet, by alluvial and tidal sand, silt, and gravel of Holocene age (4). Past movement by glaciers has resulted in scattered boulders and glacially scattered till. Chakachamna Lake, the south side of the Chakachatna River Valley, and the MacArthur River Canyon are bordered by granitic bedrock. The north side of the Chakachatna River Valley is bordered by volcanic bedrock.

- Surface Hydrology

Chakachamna Lake is approximately 13 miles in length and is 1.5 to 3.0 miles wide. Inflow to the lake is primarily glacial in origin and consists of the Nagishlamina and Chilligan Rivers entering from the north (6).

The Chakachatna River originates at the outlet of Chakachamna Lake and flows easterly approximately 15 miles through a canyon and then through lowland areas to Cook Inlet. Mean annual discharge at its origin is 3645 cfs with a range from 441 cfs in April to 12,000 cfs in July; average annual stream flow at the reservoir site is estimated at 2.5 million acre feet (3). The total length is 36 miles and the total drainage area is 1,620 square miles.

The MacArthur River originates from the MacArthur glacier and is also fed by the Blockade glacier. The river is later joined by waters from Noaukta Slough, which carry water from the Chakachatna River. The MacArthur River continues to the confluence with the Chakachatna and then empties into Trading Bay.

- Terrestrial Ecology

Vegetation in the project area varies with elevation and moisture conditions. The major community types present include spruce forest, bogs, and willow thickets. Dominant species present include paper birch, black cottonwood, alder, bog blueberry, and willow (3).

Big game species utilizing the area include moose, caribou, black bear, and grizzly bear. Other species present include wolverine, mink, and various small mammals (3).

Birds present in the area are typical for the area of Alaska, with peak numbers and species occurring during the spring and fall migration periods. Goldeneyes were observed nesting in the area in 1960 with other waterfowl species present during migration, including redheads, greenwinged teal and mallards; bald eagles and trumpeter swans are known to nest in the area primarily near Cook Inlet (3).

- Aquatic Ecology

The water of the tributaries to Chakachamna Lake, the lake itself and the Chakachatna and MacArthur Rivers provide a variety of water temperatures, water quality and substrate, resulting in various types of aquatic habitats.

Chakachamna Lake contains populations of lake trout, Dolly Varden, whitefish and sculpins (6). More importantly, sockeye salmon migrate up the Chakachatna River and spawn within Chakachamna Lake. Although the lake is not heavily utilized by sport fishermen, these spawning salmon contribute to the commercial fisheries of Cook Inlet.

The Chakachatna River is utilized by a wider variety of fish species. The upper reaches are characterized by boulders and swift currents and do not appear to be a spawning area. The main stem of the Chakachatna River is utilized primarily as an avenue for fish to travel to Chakachamna Lake and its tributories. Spawning of anadromous fish has primarily taken place in the tributaries to the Chakachatna River and Chakachamna Lake along with some clear water sloughs adjacent to the Chakachatna River.

The MacArthur River supports a fishery similar to that of the Chakachatna (7). Dolly Varden are present with chinook, coho, pink, sockeye, and chum salmon present as spawners in the side channels. Pygmy whitefish occur further downstream (3).

- Cultural Resources

The Alaska Heritage Resource Survey File maintained by the State Historic Preservation Office lists no sites present in the Chakachamna project area. The area has not been thorougly studied and further investigations would be necessary should the project proceed.

- Socioeconomics

The Chakachamna project is located in a sparsely populated area of the Kenai Peninsula Borough. The only community in the vicinity of the project area is the native village of Tyonek, population 239. Commercial fishing and subsistence activities are the major sources of income with some employment provided by timber harvesting, gas and oil exploration activities and government employment.

Housing consists primarily of prefabricated structures. One school serves grades K through 12, with a current enrollment of 146. Police protection is provided by the

Alaskan State Troopers, headed by a resident constable. Fire protection is provided by the U.S. Bureau of Land Management. Medical services are available in a medical center located in the village. Water is supplied from a nearby lake and wastewater disposed via septic systems.

Transportation is limited to gravel surface roads and small airstrips.

The Kenai Borough and City of Anchorage would likely contribute to the work force for the project. The work force in the Borough is 12,300, with 9.8 percent unemployed; Anchorage has a work force of 91,671, with 6.9 percent unemployment (3).

(ii) Description of Snow Site

The Snow site is located on the Snow River in the Kenai Peninsula (Figure E.10.2). Power development would include a dam with diversion through a tunnel approximately 7,500 to 10,000 feet in length. A transmission line would extend from the site northward for nine miles to Kenai Lake and then northwesterly for 16 miles to tie in with existing lines.

The Snow River at the proposed damsite flows in a deep narrow gorge cut into bedrock on the floor of a glacial valley. Graywacke and slate are exposed and this overburden is evident (8). The river flows west and north into the south end of the Kenai Lake. The average annual streamflow at the damsite is estimated at 510,000 to 535,000 cfs. The damsite would be fed by 105 square miles of the river's 166 square mile drainage area (8).

Vegetation in the area is primarily a hemlock-spruce forest. Black bear, wolf and dall sheep are known to occur in the area, and a moose concentration area is present. Waterfowl utilize the area both for nesting and molting.

No anadromous fish are known to occur in the Snow River, but sockeye and coho salmon are present in the drainage. Rainbow trout and whitefish also occur in Kenai Lake.

Reports consulted listed no known cultural resource sites in the Snow area.

(iii) Description of Keetna Site

The Keetna site is located on the Talkeetna River, approximately 70 miles north of Anchorage (Figure E.10.2). Power development would include a dam with a diversion tunnel.

The Talkeetna River, with headwaters in the Talkeetna mountains, flows southwesterly to its confluence with the Susitna River. The damsite has a drainage area of 1,260 square miles; stream flow records indicate discharge at the site to be 1,690,000 acre feet (8).

Vegetation on the lower elevations of the valley are primarily upland spruce-hardwood forest. The upper elevations have little vegetation. Black bear and brown bear are present and the area is a known moose concentration area. A caribou winter range is nearby.

Four species of anadramous fish are present in the area (chinook, sockeye, coho, and chum salmon). The chinook salmon is known to spawn in tributaries upstream of the proposed site.

Reports consulted listed no known cultural resources at the site.

(iv) Environmental Impacts of Selected Alternatives

Most environmental impacts at the Chakachamna, Snow and Keetna sites would be those that typically occur with hydroelectric development. Vegetation and wildlife habitat would be lost, resulting in a reduction in carrying capacity and wildlife populations at the site. Based on the availability of habitat in surrounding areas, this would likely not be a major impact. Reductions in fish populations would reduce the food source for bears, eagles, and other fish-eating wildlife; this could affect local populations. Creation of a reservoir at the Snow and Keetna sites would provide a different habitat type and benefit such species groups as waterfowl and furbearers.

Any archaeological or historic sites in the reservoir areas would be flooded. On-ground surveys, salvage operations and protection of areas outside the reservoir but within the construction area, would mitigate most of these potential impacts.

The Keetna reservoir would inundate two scenic areas; Sentinel Rock and Granite Gorge.

Socioeconomic impacts would be similar at each site. It is expected there would be an increase in population in the towns near the site and associated increase in demand for housing, schools and other services. Because all three sites are located within 100 miles of Anchorage, it is expected much of the labor force would be drawn from this area where an adequate work force is present. Construction camps would likely be erected to house workers, thereby reducing demand on surrounding towns. Socioeconomic impacts for the Chakachamna site would be similar to those described for thermal development but of lesser magnitude.

The greatest potential impact of these developments is to the fisheries resources, particularly at the Chakachamna site. Creation of the reservoir at the Keetna and Snow sites would flood river areas, thereby reducing this type of habitat. At the Keetna site, spawning areas may be affected and upstream migration of the anadromous salmon also curtailed, unless fish ladders are constructed and adequate downstream flows maintained. At this time, the detailed studies necessary to determine adequate flows for power generation and fishery maintenance have not been conducted.

Dam and power development at the Chakachamna site has the potential to negatively impact anadromous fish. This impact would result from decreased flowing or dewatering from the upper portions of the Chakachatna River, alterations in water quality, loss of spawning habitat, or decrease in the food base. All of these impacts, if large enough, could impact the commercial fisheries of Cook Inlet; the magnitude of these impacts would depend upon the design and operating scheme to produce power.

The diversion into the MacArthur River via tunnels would increased flows and could result in changes in water quality and temperature, perhaps affecting the ability of anadromous fish to migrate upstream to the spawning areas.

(c) Upper Susitna Basin Hydroelectric Alternatives

A second feature of the alternatives analysis involved the consideration of alternative sites within the Upper Susitna Basin. This process involved consideration of technical, economical, environmental, and social aspects.

This section describes the environmental consideration involved in the selection of Devil Canyon/Watana sites as the preferred sites within the Upper Susitna Basin and also presents a brief comparison of the environmental impacts associated with alternatives that proved economically feasible. This section concentrates on the environmental aspects of the selection process. Details of the technical and economic aspects of this evaluation are discussed in Reference 2, Section 8, and also in Reference 1, Section 8.

The objectives of the selection process were to determine the optimum Susitna Basin Development Plan and to conduct a preliminary environmental assessment of the alternatives in order to compare those judged economically feasible. The selection process followed the Generic Plan Formulation and Selection Methodology described in Exhibit B. Damsites were identified following the objectives described above. These sites were then screened and assessed through a sequential "narrowing down" process to arrive at a recommended plan (Figure E.10.4).

(i) Damsite Selection

In the previous Susitna Basin studies discussed in Reference 2, Section 4, 12 damsites were identified in the upper portion of the basin, i.e., upstream from Gold Creek (see Figure E.10.5). These sites are listed below:

- Gold Creek
- Olson (alternative name: Susitna II)
- Devil Canyon
- High Devil Canyon (alternative name: Susitna I)
- Devil Creek
- Watana
- Susitna III
- Vee
- Maclaren
- Denali
- Butte Creek
- Tyone

Longitudinal profiles of the Susitna River and probable typical reservoir levels associated with the selected sites were prepared to depict which sites were mutually exclusive, i.e., those which cannot be developed jointly since the downstream site would inundate the upstream site. All relevant data concerning dam type, capital cost, power, and energy output were assembled (Reference 2, Section 8). Results appear in Table E.10.14.

(ii) Site Screening

The objective of this screening exercise was to eliminate sites which would obviously not feature in the initial stages of a Susitna Basin development plan and which, therefore, do not require any further study at this stage. Three basic screening criteria are used; these include environmental, alternative sites, and energy contribution.

- Environmental Screening Criteria

The potential impact on the environment of a reservoir located at each of the sites was assessed and catagorized as being relatively unacceptable, significant, or moderate.

o Unacceptable Sites

Sites in this category are classified as unacceptable because either their impact on the environment would be extremely severe or there are obviously better alternatives available. Under the current circumstances, it is expected that it would be difficult to obtain the necessary agency approval, permits, and licenses to develop these sites.

The Gold Creek and Olson sites both fall into this category. As salmon are known to migrate up Portage Creek, a development at either of these sites would obstruct this migration and inundate spawning grounds. Available information indicates that salmon do not migrate through Devil Canyon to the river reaches beyond because of the steep fall and high flow velocities.

Development of the mid-reaches of the Tyone River would result in the inundation of sensitive big game and waterfowl areas, provide access to a large expanse of wilderness area, and contribute only a small amount of storage and energy to any Susitna development. Since more acceptable alternatives are obviously available, the Tyone site is also considered unacceptable.

o Sites With Significant Impact

Between Devil Canyon and the Oshetna River, the Susitna River is confined to a relatively steep river valley. Upstream from the Oshetna River the surrounding topography flattens, and any development in this area has the potential of flooding large areas even for relatively low dams. Since the Denali Highway is relatively close by, this area is not as isolated as the Upper Tyone River Basin. It is still very sensitive in terms of potential impact on big game and waterfowl. The sites at Butte Creek, Denali, Maclaren, and, to a lesser extent, Vee fit into this category.

o Sites With Moderate Impact

Sites between Devil Canyon and the Oshetna River have a lower potential environmental impact. These sites include the Devil Canyon, High Devil Canyon, Devil Creek, Watana and Susitna sites, and, to a lesser extent, the Vee site.

- Alternative Sites

Sites which are close to each other and can be regarded as alternative dam locations can be treated as one site for project definition study purposes. The two sites which fall into this category are Devil Creek, which can be regarded as an alternative to the High Devil Canyon site, and Butte Creek, which is an alternative to the Denali site.

- Energy Contribution

The total Susitna Basin potential has been assessed at 6,700 GWh. As discussed in the load forecasts in Exhibit B, additional future energy requirements for the period 1982 to 2010 are forecast to range from 2,400 to 13,500 GWh. It was therefore decided to limit the minimum size of any power development in the Susitna Basin to an average annual energy production in the range of 500 to 1,000 GWh. The upstream sites such as Maclaren, Denali, Butte Creek, and Tyone do not meet this minimum energy generation criterion.

- Screening Process

The screening process involved eliminating all sites falling in the unacceptable environmental impact and alternative site categories. Those failing to meet the energy contribution criteria were also eliminated unless they had some potential for upstream regulation. The results of this process are as follows:

- o The unacceptable site environmental category eliminated the Gold Creek, Olson, and Tyone sites.
- o The alternative sites category eliminated the Devil Creek and Butte Creek sites.
- o No additional sites were eliminated for failing to meet the energy contribution criteria. The remaining sites upstream from Vee, i.e., Maclaren and Denali, were retained to insure that further study be directed toward determining the need and viability of providing flow regulation in the headwaters of the Susitna.

(iii) Formulation of Susitna Basin Development Plans

In order to obtain a more uniform and reliable data base for studying the seven sites remaining, it was necessary to develop engineering layouts for these sites and re-evaluate the costs. In addition, it was also necessary to study staged developments at several of the larger dams. These layouts were then used to assess the sites and plans from an environmental perspective.

The results of the site-screening exercise described above indicate that the Susitna Basin Development Plan should incorporate a combination of several major dams and powerhouses located at one or more of the following sites:

- Devil Canyon,
- High Devil Canyon,
- Watana,
- Susitna III,
- Vee.

In addition, the following two sites should be considered as candidates for supplementary upstream flow regulation:

- MacLaren,
- Denali.

To establish very quickly the likely optimum combination of dams, a computer screening model was used to directly identify the types of plans that are most economic. Results of these runs indicate that the Devil Canyon/Watana or the High Devil Canyon/Vee combinations are the most economic. In addition to these two basic development plans, a tunnel scheme, which provides potential environmental advantages by replacing the Devil Canyon dam with a long power tunnel, and a development plan involving the two most economic damsites, High Devil Canyon and Watana, were also introduced. These studies are described in more detail in Table E.10.15.

These studies resulted in three basic plans involving dam combinations and one dam/tunnel combination. There were Plan 1 which involved the Watana-Devil Canyon sites; Plan 2, the High Devil Canyon-Vee sites; Plan 3, the Watana-tunnel concept; and Plan 4, Watana-High Devil Canyon sites.

- Plan 1

  Three subplans were developed:

  o Subplan 1.1: Stage 1 involves constructing Watana Dam to its full height and installing 800 MW. Stage 2 involves constructing Devil Canyon Dam and installing 600 MW.

  o Subplan 1.2: For this subplan, construction of the Watana dam is staged from a crest elevation of 2,060 feet to 2,225 feet. The powerhouse is also staged from 400 MW to 800 MW. As for Subplan 1.1, the final stage involves Devil Canyon with an installed capacity of 600 MW.

  o Subplan 1.3: This subplan is similar to Subplan 1.2 except that only the powerhouse and not the dam at Watana is staged.

- Plan 2

  Three subplans were also developed under Plan 2:

  o Subplan 2.1: This subplan involves constructing the High Devil Canyon Dam first with an installed capacity of 800 MW. The second stage involves constructing the Vee Dam with an installed capacity of 400 MW.

  o Subplan 2.2: For this subplan, the construction of High Devil Canyon Dam is staged from a crest elevation of 1,630 to 1,775 feet. The installed capacity is also staged from 400 to 800 MW. As for Subplan 2.1, Vee follows with 400 MW of installed capacity.

  o Subplan 2.3: This subplan is similar to Subplan 2.2 except that only the powerhouse and not the dam at High Devil Canyon is staged.

- Plan 3

This plan involves a long power tunnel to replace the Devil Canyon dam in the Watana/Devil Canyon development plan. The tunnel alternative could develop similar head as the Devil Canyon dam development and would avoid some environmental impacts by avoiding inundating Devil Canyon. Because of low winter flows in the river, a tunnel alternative was considered only as a second stage to the Watana development.

A plan involving a tunnel to develop the Devil Canyon dam head and a 245-foot-high re-regulation dam and reservoir was selected with the capacity to regulate diurnal fluctuations caused by the peaking operation at Watana. The plan involves two subplans.

o Subplan 3.1: This subplan involves initial construction of Watana and installation of 800 MW of capacity. The next stage involves the construction of the downstream re-regulation dam to a crest elevation of 1,500 feet and a 15-mile-long tunnel. A total of 300 MW would be installed at the end of the tunnel and a further 30 MW at the re-regulation dam. An additional 50 MW of capacity would be installed at the Watana powerhouse to facilitate peaking operations.

o Subplan 3.2: This subplan is essentially the same as Subplan 3.1 except that construction of the initial 800 MW powerhouse at Watana is staged.

- Plan 4

This single plan was developed to evaluate the development of the two most economic damsites, Watana and High Devil Canyon, jointly. Stage 1 involves constructing Watana to its full height with an installed capacity of 400 MW. Stage 2 involves increasing the capacity at Watana to 800 MW. Stage 3 involves constructing High Devil Canyon to a crest elevation of 1470 so that the reservoir extends to just downstream from Watana. In order to develop the full head between Watana and Portage Creek, an additional smaller dam would be added downstream from High Devil Canyon. This dam would be located just upstream from Portage Creek so as not to interfere with the anadromous fisheries. It would have a crest elevation of 1030 and an installed capacity of 150 MW. For purposes of these studies, this site is referred to as the Portage Creek site.

(iv) Plan Evaluation Process

The overall objective of this step in the evaluation process was to select the preferred basin development plan. A preliminary evaluation of plans was initially undertaken to determine broad comparisons of the available alternatives. This was followed by appropriate adjustments to the plans and a more detailed evaluation and comparison.

Table E.10.14 lists pertinent details such as capital costs and energy yields associated with the selected plans. The cost information was obtained from the engineering layout studies. The energy yield information was developed using a multi-reservoir computer model.

A more detailed description of the model appears in Reference 2, Section 8.

In the process of evaluating the schemes, it became apparent that there would be environmental problems associated with allowing daily peaking operations from the most downstream reservoir in each of the plans described above. In order to avoid these potential problems while still maintaining operational flexibility to peak on a daily basis, re-regulation facilities were incorporated in the four basic plans. These facilities incorporate both structural measures, such as re-regulation dams, and modified operational procedures under a series of form modified plans, E1 through E4.

- E1 Plans

  For Subplans 1.1 to 1.3, a low, temporary re-regulation dam is constructed downstream from Watana during the stage in which the generating capacity is increased to 800 MW. This dam would re-regulate the outflows from Watana and allow daily peaking operations. It has been assumed that it would be possible to incorporate this dam with the diversion works at the Devil Canyon site, and an allowance of $100 million has been made to cover any additional costs associated with this approach.

  In the final stage, only 400 MW of capacity is added to the dam at Devil Canyon instead of the original 600 MW. Reservoir operating rules are changed so that Devil Canyon dam acts as the re-regulation dam for Watana.

- E2 Plans

For Subplans 2.1 to 2.3, a permanent re-regulation dam is located downstream from the High Devil Canyon site, while at the same time, the generating capacity is increased to 800 MW. An allowance of $140 million has been made to cover the costs of such a dam.

An additional Subplan E2.4 was established. This plan is similar to E2.3 except that the re-regulation dam is utilized for power production. The damsite is located at the Portage Creek site with a crest level set to utilize the full head. A 150 MW powerhouse is installed. As this dam is to serve as a re-regulating facility, it is constructed at the same time as the capacity of High Devil Canyon is increased to 800 MW, i.e., during Stage 2.

- E3 Plan

The Watana tunnel development plan already incorporates an adequate degree of re-regulation, and the E3.1 Plan is, therefore, identical to the 3.1 Plan.

- E4 Plans

The E4.1 Plan incorporates a re-regulation dam downstream from Watana during Stage 2. As for the E1 Plans, it has been assumed that it would be possible to incorporate this dam as part of the diversion arrangements at the High Devil Canyon site, and an allowance of $100 million has been made to cover the costs. The energy and cost information for these plans is presented in Exhibit B.

These evaluations basically reinforce the results of the screening model; for a total energy production capability of up to approximately 4,000 GWh, Plan E2 (High Devil Canyon) provides the most economic energy while for capabilities in the range of 6,000 GWh, Plan E1 (Watana-Devil Canyon) is the most economic.

(v) Comparison of Plans

The evaluation and comparison of the various basin development plans described above, was undertaken in a series of steps.

In the first step, for determining the optimum staging concept associated with each basic plan (i.e., the optimum subplan) economic criteria only are used and the least-cost staging concept is adopted. For assessing which plan is the most appropriate, a more detailed evaluation process incorporating economic, environmental, social, and energy contribution aspects is taken into account.

Economic evaluation of the Susitna Basin development plans was conducted via a computer simulation planning model (OGP5) of the entire generating system. This model and the results are described in Reference 2, Section 8.

As outlined in the generic methodology (Exhibit B), the final evaluation of the development plans is to be undertaken by a perceived comparison process on the basis of appropriate criteria. The following criteria are used to evaluate the shortlisted basin development plans. They generally contain the requirements of the generic process with the exception that an additional criterion, energy contribution, is added. The objective of including this criterion is to insure that full consideration is given to the total basin energy potential that is developed by the various plans.

- Economic Criteria

  The parameter used is the total present-worth cost of the total Railbelt generating system for the period 1980 to 2040 listed and discussed in Exhibit B.

- Environmental Criteria

  A qualitative assessment of the environmental impact on the ecological, cultural, and aesthetic resources is undertaken for each plan. Emphasis is placed on identifying major concerns so that these could be combined with the other evaluation attributes in an overall assessment of the plan.

- Social Criteria

  This attribute includes determination of the potential non- renewable resource displacement, the impact on the state and local economy, and the risks and consequences of major structural failures caused by seismic events. Impacts on the economy refer to the effects of an investment plan on economic variables.

- Energy Contribution

The parameter used is the total amount of energy produced from the specific development plan. An assessment of the energy development foregone is also undertaken. This energy loss is inherent to the plan and cannot easily be recovered by subsequent staged developments.

Economic and technical comparisons are discussed in Exhibit B; environmental, social, and summary comparisons appear in Tables E.10.16 through E.10.18.

(vi) Results of Evaluation Process

The various attributes outlined above have been determined for each plan. Some of the attributes are quantitative while others are qualitative. Overall evaluation is based on a comparison of similar types of attributes for each plan. In cases where the attributes associated with one plan all indicate equality or superiority with respect to another plan, the decision as to the best plan is clear cut. In other cases where some attributes indicate superiority and others inferiority, these differences are highlighted and trade-off decisions are made to determine the preferred development plan. In cases where these trade-offs have had to be made, they are relatively convincing and the decision-making process can, therefore, be regarded as fairly robust. In addition, these trade-offs are clearly identified so the reader can independently address the judgment decisions made.

The overall evaluation process is conducted in a series of steps. At each step, only a pair of plans is evaluated. The superior plan is then passed on to the next step for evaluation against an alternative plan.

(vii) Devil Canyon Dam Versus Tunnel

The first step in the process involves the evaluation of the Watana-Devil Canyon dam plan (E1.3) and the Watana tunnel plan (E3.1). As Watana is common to both plans, the evaluation is based on a comparison of the Devil Canyon dam and tunnel schemes.

In order to assist in the evaluation in terms of economic criteria, additional information was obtained by analyzing the results of the OGP5 computer runs. This information, presented in Exhibit B, illustrates the breakdown of the total system present-worth cost in terms of capital investment, fuel, and operation and maintenance costs.

- Economic Comparison

From an economic point of view, the Devil Canyon dam scheme is superior. On a present worth basis, the tunnel scheme is $680 million or about 12 percent more expensive than the dam scheme. For a low-demand growth rate, this cost difference would be reduced slightly to $610 million. Even if the tunnel scheme costs are halved, the total cost difference would still amount to $380 million. Consideration of the sensitivity of the basic economic evaluation to potential changes in capital cost estimate, the period of economic analysis, the discount rate, fuel costs, fuel cost escalation, and economic plant lives do not change the basic economic superiority of the dam scheme over the tunnel scheme.

- Environmental Comparison

The environmental comparison of the two schemes is summarized in Table E.10.16. Overall, the tunnel scheme is judged to be superior because:

o It offers the potential for enhancing anadromous fish populations downstream from the re-regulation dam because of the more uniform flow distribution that will be achieved in this reach;

o It inundates 13 miles less of resident fisheries habitat in river and major tributaries;

o It has a lower impact on wildlife habitat because of the smaller inundation of habitat by the re-regulation dam;

o It has a lower potential for inundating archaeological sites because of the smaller reservoir involved;

o It would preserve much of the characteristics of the Devil Canyon gorge, which is considered to be an aesthetic and recreational resource.

- Social Comparison

Table E.10.17 summarizes the evaluation in terms of the social criteria of the two schemes. In terms of impact on state and local economics and risks resulting from seismic exposure, the two schemes are rated equally. However, the dam scheme has, because of its higher energy yield, more potential for displacing nonrenewable energy resources, and, therefore, scores a slight overall plus in terms of the social evaluation criteria.

- Energy Comparison

The results show that the dam scheme has a greater potential for energy production and develops a larger portion of the basin's potential. The dam scheme is, therefore, judged to be superior from the energy contribution standpoint.

- Overall Comparison

The overall evaluation of the two schemes is summarized in Table E.10.18. The estimated cost saving of $680 million in favor of the dam scheme is considered to outweigh the reduction in the overall environmental impact of the tunnel scheme. The dam scheme is, therefore, judged to be superior overall.

(viii) Watana-Devil Canyon Versus High Devil Canyon-Vee

The second step in the development selection process involves an evaluation of the Watana-Devil Canyon (E1.3) and the High Devil Canyon-Vee (E2.3) development plans.

- Economic Comparison

In terms of the economic criteria, the Watana-Devil Canyon plan is less costly by $520 million. As for the dam-tunnel evaluation discussed above, the sensitivity of this decision to potential changes in the various parameters considered (i.e., load forecast, discount rates, etc.) does not change the basic superiority of the Watana-Devil Canyon Plan.

- Environmental Comparison

The evaluation in terms of the environmental criteria is summarized in Table E.10.19. In assessing these plans, a reach-by-reach comparison is made for the section of the Susitna River between Portage Creek and the Tyone River. The Watana-Devil Canyon scheme would create more potential environmental impacts in the Watana Creek area. However, it is judged that the potential environmental impacts which would occur in the upper reaches of the river with a High Devil Canyon-Vee development are more severe in comparison overall.

From a fisheries perspective, both schemes would have a similar effect on the downstream anadromous fisheries, although the High Devil Canyon-Vee scheme would produce a slightly greater impact on the resident fisheries in the Upper Susitna Basin.

The High Devil Canyon-Vee scheme would inundate approximately 14 percent (15 miles) more critical, winter, riverbottom moose habitat than the Watana-Devil Canyon scheme. The High Devil Canyon-Vee scheme would inundate a large area upstream from the Vee site utilized by three subpopulation of moose that range in the northeast section of the basin. The Watana-Devil Canyon scheme would avoid the potential impacts on moose in the upper section of the river; however, a larger percentage of the Watana Creek basin would inundated.

The condition of the subpopulation of moose utilizing this Watana Creek Basin and the quality of the habitat appears to be decreasing. Habitat manipulation measures could be implemented in this area to improve the moose habitat.

Nevertheless, it is considered that the upstream moose habitat losses associated with the High Devil Canyon-Vee scheme would probably be greater than the Watana Creek losses associated with the Watana-Devil Canyon scheme.

A major factor to be considered in comparing the two development plans is the potential effects on caribou in the region. It is judged that the increased length of river flooded, especially upstream from the Vee damsite, would result in the High Devil Canyon-Vee plan creating a greater potential diversion of the Nelchina herd's range. In addition, a larger area of caribou range would be directly inundated by the Vee reservoir.

The area flooded by the Vee reservoir is also considered important to some key furbearers, particularly red fox. In a comparison of this area with the Watana Creek area that would be inundated with the Watana-Devil Canyon scheme, the area upstream from Vee is judged to be more important for furbearers.

As previously mentioned, the area between Devil Canyon and the Oshetna River on the Susitna River is confined to a relatively steep river valley. Along these valley slopes are habitats important to birds and black bears.

Since the Watana reservoir would flood the river section between the Watana damsite and the Oshetna River to a higher elevation than would the High Devil Canyon reservoir (2200 as compared to 1750), the High Devil Canyon-Vee plan would retain the integrity of more of this river valley slope habitat.

From the archaeological studies done to date, there tends to be an increase in site intensity as one progresses towards the northeast section of the Upper Susitna Basin. The High Devil Canyon-Vee plan would result in more extensive inundation and increased access to the northeasterly section of the basin. This plan is judged to have a greater potential for directly or indirectly affecting archaeological sites.

Because of the wilderness nature of the Upper Susitna Basin, the creation of increased access associated with project development could have a significant influence on future uses and management of the area. The High Devil Canyon-Vee plan would involve the construction of a dam at the Vee site and the creation of a reservoir in the more northeasterly section of the basin. This plan would thus create inherent access to more wilderness than would the Watana-Devil Canyon scheme. As it is easier to extend access than to limit it, inherent access requirements are detrimental, and the Watana-Devil Canyon scheme is judged to be more acceptable in this regard.

Except for the increased loss of river valley, bird, and black bear habitat, the Watana-Devil Canyon development plan is judged to be more environmentally acceptable than the High Devil Canyon-Vee plan.

- Energy Comparison

The evaluation of the two plans in terms of energy contribution criteria shows the Watana-Devil Canyon scheme to be superior because of its higher energy potential and the fact that it develops a higher proportion of the basin's potential.

Table E.10.17 summarizes the evaluation in terms of the social criteria. As in the case of the dam versus tunnel comparison, the Watana-Devil Canyon plan is judged to have a slight advantage over the High Devil Canyon-Vee plan because of its greater potential for displacing nonrenewable resources.

- Overall Comparison

The overall evaluation is summarized in Table E.10.20 and indicates that the Watana-Devil Canyon plans are generally superior to all the other evaluation criteria.

(ix) Preferred Susitna Basin Development Plan

Comparisons of the Watana-Devil Canyon plan with the Watana tunnel plan and the High Devil Canyon-Vee plans are judged to favor the Watana-Devil Canyon plan in each case.

The Watana-Devil Canyon plan is therefore selected as the preferred Susitna Basin development plan, as a basis for continuation of more detailed design optimization and environmental studies.

10.2 - Alternative Facilty Designs

(a) Watana Facility Design Alternatives

Environmental factors considered in Watana facility design are summarized below.

(i) Diversion/Emergency Release Facilities

Tables B.61 and B.62 of Exhibit B show the minimum flow releases from the Watana and Devil Canyon dams required to maintain an adequate flow at Gold Creek. These release levels have been established to avoid adverse affects on the Salmon fishery downstream.

At an early stage of the study, it was established that some form of low level release facility was required to permit lowering of the reservoir in the event of an extreme emergency, and to meet instream flow requirements during filling of the reservoir. The most economical alternative available would involve converting one of the diversion tunnels to permanent use as a low level outlet facility. Since it would be necessary to maintain the diversion scheme in service during construction of th elow level outlet works, two or more diversion tunnels would be required. The use of two diversion tunnels also provides an additional measure of security to the diversion scheme in case of the loss of service of one tunnel.

(ii) Main Spillway

During development of the general arrangements for both the Watana and Devil Canyon dams, a restriction was imposed on the amount of excess dissolved nitrogen permitted in the spillway discharges. Supersaturation occurs when aerated flows are subjected to pressures greater than 30 to 40 feet of head which forces excess nitrogen into solution. This occurs when water is subjected to the high pressures that occur in deep plunge pools or at large hydraulic jumps. The excess nitrogen would not be dissipated within the downstream Devil Canyon reservoir and a buildup of nitrogen concentration could occur throughout the body of water. It would eventually be dishcarged downstream from Devil Canyon with harmful effects on the fish population. On the basis of an evaluation of the related impacts, and discussions with interested federal and state agencies, spillway facilities will be designed to limit discharges of water from either Watana or Devil Canyon that may become supersaturated with nitrogen to a recurrence period of not less than 1:50 years.

Three basic alternative spillway types were examined:

- Chute spillway with flip bucket;
- Chute spillway with stilling basin; and
- Cascade spillway

Consideration was also given to combinations of these alternatives with or without supplemental facilities such as valved tunnels and an emergency spillway fuse plug for handling the PMF discharge.

The stilling basin spillway is very costly and the operating head of 800 feet is beyond precedent experience. Erosion downstream should not be a problem but cavitation of the chute could occur. This scheme was therefore eliminated from further consideration.

The cascade spillway was also not favored for technical and economic reasons. However, this arrangement does have an advantage in that it provides a means of preventing nitrogen supersaturation in the downstream discharges from the project which could be harmful to the fish population. A cascade configuration would reduce the dissolved nitrogen content, and hence, this alternative was retained for further evaluation. The capacity of the cascade was reduced and an emergency rock channel spillway was included to take the extreme floods.

(iii) Power Intake and Water Passages

Apart from the potential nitrogen supersaturation problem discussed above, the major environmental constraints on the design of the power facilities are:

- Control of downstream river temperatures; and
- Control of downstream flows.

The intake design has been modified to enable power plant flows to be drawn from the reservoir at four different levels throughout the anticipated range of reservoir drawdown for energy production in order to control the downstream river temperatures within acceptable limits.

Minimum flows at Gold Creek during the critical summer months have been studied to mitigate the project impacts on salmon spawning downstream of Devil Canyon. These minimum flows represent a constraint on the reservoir operation, and influence the computation of average and firm energy produced by the Susitna development.

(iv) Outlet Facilities

As a provision for drawing down the reservoir in case of emergency, a mid-level release will be provided. The intake to these facilities will be located at depth adjacent to the power facilities intake structures. Flows will then be passed downstream through a concrete-lined tunnel, discharging beneath the downstream end of the main spillway flip bucket. In order to overcome potential nitrogen supersaturation problems, a system of fixed cone valves will be installed at the downstream end of the outlet facilities. The valves will be sized to discharge in conjunction with the powerhouse operating at 7000 cfs capacity, flows up to the equivalent routed 50-year flood.

(b) Devil Canyon Facility Design Alternatives

(i) Installed Capacity

The decision to operate Devil Canyon primarily as a based loaded plant was governed by the following main considerations:

- Daily peaking is more effectively performed at Watana than at Devil Canyon; and

- Excessive fluctuations in discharge from the Devil Canyon dam may have an undesirable impact on mitigation measures incorporated in the final design to protect the downstream fisheries.

Given this mode of operation, the required installed capacity at Devil Canyon has been determined as the maximum capacity needed to utilize the available energy from the hydrological flows of record, as modified by the reservoir operation rule curves.

(ii) Spillway Capacity

The avoidance of nitrogen supersaturation in the downstream flow also will apply to Devil Canyon. Thus, the discharge of water possibly supersaturated with nitrogen from Devil Canyon will be limited to a recurrence period of not less than 1:50 years by the use of solid cone valves similar to Watana.

(iii) Power Intake and Water Passages

In addition to potential nitrogen-saturation problems caused by spillway operation, the major impacts of the Devil Canyon power intake facilities development will be:

- Changes in the temperature regime of the river; and
- Fluctuations in downstream river flows and levels.

Temperature modeling has indicated that a multiple level intake design at Devil Canyon would assist downstream water temperature control. Consequently, the intake design at Devil Canyon will incorporte a multi-level draw-off about 80 feet below maximum reservoir operating level (El 1455).

The Devil Canyon station will normally be operated as a baseloaded plant throughout the year, to satisfy the requirement of no significant daily variation in power flow.

(c) Access Alternatives

(i) Plan Selection

Detailed access studies resulted in the development of eighteen possible access plans within three corridors.

An initial evaluation was made to determine the plan in each corridor that was most responsive to project objectives as well as inputs from the community and agencies. The project objectives of cost and schedule control along with the need to have maximum flexibilty of access were given prime consideration. A flexible support system utilizing both road and rail was considered a necessity to reduce risks and control costs. Access plans that could not provide access within one year of receipt of the FERC license or imposed a restraint on construction activities were therefore eliminated. Plans that did not provide access between sites for the operation and maintenance phase of the project were also eliminated. In addition, a number of plans were eliminated because more recently developed plans were superior to similar plans within the same corridor by virtue of the fact that they reduced community and agency concerns. The initial evaluation reduced the acceptable options to the following three alternative access corridors:

Corridor 1 - Parks Highway to Watana via north side of Susitna River

Corridor 2 - Parks Highway to Watana via south side of Susitna River

Corridor 3 - Denali Highway to Watana

The eighteen alternatives were developed by laying out routes on topographical maps in accordance with accepted road and rail design criteria. Subsequent field investigations resulted in minor modifications to reduce environmental impacts and improve alignment.

(ii) Plan Evaluation

Plan evaluation and screening are discussed in detail in Exhibit B, Section 2.6 (e). As the result of the evaluation process, three plans were chosen as best representing the three corridors: Plan 13 "North", Plan 16 "South", and Plan 18 "Denali - North".

The potential environmental impacts of the three plans are presented below.

- Wildlife and Habitat

  The three selected alternative access routes are made up of five distinct wildlife and habitat segments:

  1. Hurricane to Devil Canyon: This segment is composed almost entirely of productive mixed forest, riparian, and wetlands habitats important to moose, furbearers, and birds. It includes three areas where slopes of over 30 percent will require side-hill cuts, all above wetland zones vulnerable to erosion related impacts.

2. Gold Creek to Devil Canyon: This segment is composed of mixed forest and wetland habitats, but includes less wetland habitat and fewer wetland habitat types than the Hurricane to Devil Canyon segment. Although this segment contains habitat suitable for moose, black bears, furbearers and birds it has the least potential for adverse impacts to wildlife of the five segments considered.

3. Devil Canyon to Watana (North Side): The following comments apply to both the Denali-North and North routes. This segment traverses a varied mixture of forest, shrub, and tundra habitat types, generally of medium to low productivity as wildlife habitat. It crosses the Devils and Tsusena Creek drainages and passes by Swimming Bear Lake which contains habitat suitable for furbearers.

4. Devil Canyon to Watana (South Side): This segment is highly varied with respect to habitat types, containing complex mixtures of forest, shrub, tundra, wetlands, and riparian vegetation. The western portion is mostly tundra and shrub, with forest and wetlands occurring along the eastern portion in the vicinity of Prairie Creek, Stephan Lake, and Tsusena and Deadman Creeks. Prairie Creek Lake, and Tsusena and Deadman Creeks. Prairie Creek supports a high concentration of brown bears and the lower Tsusena and Deadman Creek areas support lightly hunted concentrations of moose and black bears. The Stephan Lake area supports high densities of moose and bears. Access development in this segment would probably result in habitat loss or alteration, increased hunting and human-bear conflicts.

5. Denali Highway to Watana: This segment is primarily composed of shrub and tundra vegetation types, with little productive forest habitat present. Although habitat diversity is relatively low along this segment, the southern portion along Deadman Creek contains an important brown bear concentration and browse for moose. This segment crosses a peripheral portion of the range of the Nelchina caribou herd and there is evidence that as herd size increases, caribou are likely to migrate across the route and calve in the vicinity. Although it is not possible to predict with any certainty how the physical presence of the road itself or traffic will affect caribou movements, population size or productivity it is likely that a variety of site-specific mitigation measures will be necessary to protect the herd.

The three access plans are made up of the following combinations of route segments:

North	Segments 1 and 3
South	Segments 1, 2, and 4
Denali-North	Segments 2, 3, and 5

The North route has the least potential for creating adverse impacts to wildlife and habitat for it traverses or approaches the fewest areas of productive habitat and zones of species concentration or movement. The wildlife impacts of the South Plan can be expected to be greater than those of the North Plan due to the proximity of the route to Prairie Creek, Stephan Lake and the Fog Lakes, which currently support high densities of moose and black and brown bears. In particular Prairie Creek supports what may be the highest concentration of brown bears in the Susitna Basin. Although the Denali-North Plan has the potential for disturbances of caribou, brown bear and black bear concentrations and movement zones, it is considered that the potential for adverse impacts with the South Plan is greater.

- Fisheries

All three alternative routes would have direct and indirect impacts on the fisheries. Direct impacts include the affects on water quality and aquatic habitat whereas increased angling pressure is an indirect impact. A qualitative comparison of the fishery impacts related to the alternative plans was undertaken. The parameters used to assess impacts along each route included: the number of streams crossed, the number and length of lateral transits (i.e., where the roadway parallels the streams and runoff from the roadway can run directly into the stream), the number of watersheds affected, and the presence of resident and anadromous fish.

The three access plan alternatives incorporate combinations of seven distinct fishery segments.

1. Hurricane to Devil Canyon: Seven stream crossings will be required along this route, including Indian River which is an important salmon spawning river. Both the Chulitna River watershed and the Susitna River watershed are affected by this route. The increased access to Indian River will be an important indirect impact to the segment.

Approximately 1.8 miles of cuts into banks greater than 30 degrees occur along this route requiring erosion control measures to preserve the water quality and aquatic habitat.

2. Gold Creek to Devil Canyon: This segment crosses six streams and is expected to have minimal direct and indirect impacts. Anadromous fish spawning is likely in some streams but impacts are expected to be minimal. Approximately 2.5 miles of cuts into banks greater than 30 degrees occur in this section. In the Denali-North Plan, this segment would be railroad whereas in the South Plan it would be road.

3. Devil Canyon to Watana (North Side, North Plan): This segment crosses twenty streams and laterally transits four rivers for a total distance of approximately twelve miles. Seven miles of this lateral transit parallels Portage Creek which is an important salmon spawning area.

4. Devil Canyon to Watana (North Side, Denali-North Plan): The difference between this segment and segment 3 described above is that it avoids Portage Creek by traversing through a pass four miles to the east. The number of streams crossed is consequently reduced to twelve, and the number of lateral transits is reduced to two with a total distance of four miles.

5. Devil Canyon to Watana (South Side): The portion between the Susitna River crossing and Devil Canyon requires nine steam crossings, but it is unlikely that these contain significant fish populations. The portion of this segment from Watana to the Susitna River is not expected to have any major direct impacts, however, increased angling pressure in the vicinity of Stephan Lake may result due to the proximity of the access road. The segment crosses both the Susitna and the Talkeetna watershed. Seven miles of cut into banks of greater than 30 degrees occur in this segment.

6. Denali Highway to Watana: The segment from the Denali Highway to the Watana damsite has twenty-two stream crossings and passes from the Nenana into the Susitna watershed. Much of the route crosses or is in proximity to seasonal grayling habitat and runs parallel to Deadman Creek for nearly ten miles. If

recruitment and growth rates are low along this segment it is unlikely that resident populations could sustain heavy fishing pressure. Hence, this segment has a high potential for impacting the local grayling population.

7. Denali Highway: The Denali Highway from Cantwell to the Watana access turnoff will require upgrading. The upgrading will involve only minor realignment and negligible alteration to present stream crossings. The segment crosses eleven streams and laterally transits two rivers for a total distance of five miles. There is no anadromous fish spawning in this segment and little direct or indirect impact is expected.

   The three alternative access routes are comprised of the following segments:

North	Segments 1 and 3
South	Segments 1, 2, and 5
Denali-North	Segments 2, 4, 6 and 7

   The Denali-North Plan is likely to have a significant direct and indirect impact on grayling fisheries given the number of stream crossings, lateral transits, and watershed affected. Anadromous fisheries impact will be minimal and will only be significant along the railroad spur between Gold Creek and Devil Canyon.

   The South Plan is likely to create significant direct and indirect impacts at Indian River, which is an important salmon spawning river. Anadromous fisheries impacts will also occur in the Gold Creek to Devil Canyon segment as for the Denali-North Plan. In addition indirect impacts may occur in the Stephan Lake area.

   The North Plan, like the South Plan may impact salmon spawning activity in Indian River. Significant impacts are likely along Portage Creek due to water quality impacts through increased erosion and due to indirect impacts such as increased angling pressure.

   With any of the selected plans, direct and indirect effects can be minimized through proper engineering design and prudent management. Criteria for the development of borrow areas and the design of bridges and culverts for the proposed access plan together with mitigation recommendations are discussed in Exhibit E.

(d) Transmission Alternatives

(i) Corridor Selection Methodology

Development of the proposed Susitna project will require a transmission system to deliver electric power to the Railbelt area. The building of the Anchorage-Fairbanks Intertie System will result in a corridor and route for the Susitna transmission lines between Willow and Healy. Three areas have been studied for corridor selection: the northern area connecting Healy with Fairbanks; the central area connecting the Watana and Devil Canyon damsites with the Intertie; and the southern area connecting Willow with Anchorage.

Using the selection criteria discussed in Exhibit B, Section 2.7 (b), corridors 3 to 5 miles wide were selected in each of the three study areas. These corridors were then evaluated to determine which ones met the more specific screening criteria (Exhibit B, Section 2.7 (c)). This screening process resulted in one corridor in each area being designated as the recommended corridor for the transmission line.

(ii) Environmental Selection Criteria

The environmental criteria used in selection of the candidate corridors are listed below.

	Criteria	Selection
Primary	Development	Avoid existing or proposed developed areas.
	Existing Transmission Right-of-Way	Parallel where possible.
	Land Status	Avoid private lands, wildlife refuges, parks.
	Topography	Select gentle relief where possible.
Secondary	Vegetation	Avoid heavily timbered areas.

Since the corridors that were studied range in width from three to five miles, the base criteria had to be applied to broad areas. Some of the criteria used in the environmental selection process were also pertinent to the technical and economical analysis. For example, it is economically advantageous to avoid high right-of-way costs in developed areas; and gentle topography enhances technical reliability through ease of access.

(iii) Identification of Corridors

The Susitna transmission line corridors that were selected for further screening are located in three geographical areas:

- The southern Study area between Willow and Anchorage;
- The central study area between Watana, Devil Canyon, and the Intertie; and
- The northern study area between Healy and Fairbanks.

Twenty-two corridors were selected and are described in Exhibit B, Section 2.7 (b) and shown in Exhibit B figures B.47, B.48, and B.49.

(iv) Environmental Screening Criteria

Because of the potential, adverse environmental impacts from transmission line construction and operation, environmental criteria were carefully scrutinized in the screening process. Past experience has shown the primary environmental considerations to be:

- Aesthetic and Visual (including impacts to recreation)
- Land Use (including ownership and presence of existing rights-of-way)

Also of significance in the evaluation process are:

- Length
- Topography
- Soils
- Cultural Resources
- Vegetation
- Fishery Resources
- Wildlife Resources

- Primary Aspects:

  o Aesthetic and Visual

  The presence of large transmission line structures in undeveloped areas has the potential for adverse aesthetic impacts. Furthermore, the presence of these lines can conflict with recreational use, particularly those nonconsumptive recreational activities such as hiking and bird watching where great emphasis is placed on scenic values. The number of road crossings encountered by transmission line corridors is also a factor that needs to be inventoried because of the potential for visual impacts. The number of roads crossed, the manner in which they are crossed, the nature of existing vegetation at the crossing site (i.e., potential visual screening), and the number and type of motorists using the highway all influence the desirability of one corridor versus another. Therefore, when screening the previously selected corridors, consideration was focused on the presence of recreational areas, hiking trails, heavily utilized lakes, vistas, and highways where views of transmission line facilities would be undesirable.

  o Land Use

  The three primary components of land use considerations are: 1) land status/ownership, 2) existing rights-of-way, and 3) existing and proposed development.

  . Land/Status/Ownership

  The ownership of land to be crossed by a transmission line is important because certain types of ownership present more restrictions than others. For example, some recreation areas such as state and federal parks, game refuges and military lands, among others, present possible constraints to corridor routing. Private landowners generally do not want transmission lines on their lands. This information, when known in advance, permits corridor routing to avoid such restrictive areas and to occur in areas where land use conflicts can be minimized.

  . Existing Rights-of-Way

  Paralleling existing rights-of-way tends to result in less environmental impact than that which is associated with a new right-of-way because the creation of a new right-of-way may provide a means of access to areas normally accessible only on foot. This can be a critical factor if it opens sensitive, ecological areas to all terrain vehicles.

Impact on soils, vegetation, stream crossings, and others of the inventory categories can also be lessened through the paralleling of existing access roads and cleared rights-of-way. Some impact is still felt, however, even though a right-of-way may exist in the area. For example, cultural resources may not have been identified in the original routing effort. Wetlands present under existing transmission lines may likewise be negatively influenced if ground access to the vicinity of the tower locations is required.

There are common occasions where paralleling an existing facility is not desirable. This is particularly true in the case of highways that offer the potential for visual impacts and in situations where paralleling a poorly sited transmission facility would only compound an existing problem.

. Existing and Proposed Developments

This inventory identifies such things as agricultural use; planned urban developments, such as the proposed capital site; existing residential and cabin developments; the location of airports and of lakes used for float planes; and similar types of information. Such information is essential for locating transmission line corridors appropriately, as it presents conflicts with these land use activities.

- Secondary Aspects:

o Length

The length of a transmission line is an environmental factor and, as such, was considered in the screening process. A longer line will require more construction activity than a shorter line, will disturb more land area, and will have a greater inherent probability of encountering environmental constraints.

- Topography

  The natural features of the terrain are significant from the standpoint that they offer both positive and negative aspects to transmission line routing. Steep slopes, for example, present both difficult construction and soil stabilization problems with potentially long-term, negative environmental consequences. Also, ridge crossings have the potential for visual impacts. At the same time, slopes and elevation changes present opportunities for routing transmission lines so as to screen them from both travel routes and existing communities. When planning corridors then, the identification of changes in relief is an important factor.

- Soils

  Soils are important from several standpoints. First of all, scarification of the land often occurs during the construction of transmission lines. As a result, vegetation regeneration is affected, as are the related features of soil stability and erosion potential. In addition, the development and installation of access roads, where necessary, are very dependent upon soil types. Tower designs and locations are dictated by the types of soils encountered in any particular corridor segment. Consequently, the review of existing soils information is very significant.

- Cultural Resources

  The avoidance of known or potential sites of cultural resources is an important component of the routing of transmission lines. In planning for Susitna Project transmission lines, however, information on the presence of cultural resources is, for the most part, unavailable. An appropriate program for identifying and mitigating impacts of the finally selected route is necessary.

- Vegetation

  The consideration of the presence and location of various plant communities is essential in transmission line siting. The inventory of plant communities, such as those of a tall-growing nature or wetlands, is significant from the standpoint of construction, clearing, and access road development requirements.

In addition, identification of locations of endangered and threatened plant species is also critical. While several Alaskan plant species are currently under review by the U.S. Fish and Wildlife Service, none are presently listed under the Endangered Species Act of 1973. No corridor traverses any location known to support these identified plant species.

- Fishery Resources

The presence or absence of resident or anadromous fish in a stream is a significant factor in evaluating suitable transmission line corridors. The corridor's effects on a stream's resources must be viewed from the standpoint of possible disturbance to fish species, potential loss of habitat, and possible destruction of spawning beds. In addition, certain species of fish are more sensitive than others to disturbance.

Closely related to this consideration is the number of stream crossings. The nature of the soils and vegetation in the vicinity of the streams and the manner in which the streams are to be crossed are also important environmental considerations when routing transmission lines. Potential stream degradation, impact on fish habitat through disturbance, and long-term negative consequences resulting from siltation of spawning beds are all concerns that need evaluation in corridor routing. Therefore, the number of stream crossings and the presence of fish species and habitat value were considered when data were available.

- Wildlife Resources

The three major groups of wildlife which must be considered in transmission corridor screening are big game, birds, and furbearers. Of all the wildlife species to be considered in the course of routing studies for transmission lines, big game species (together with endangered species) are most significant. Many of the big game species, including grizzly bear, caribou, and sheep, are particularly sensitive to human intrusion into relatively undisturbed areas. Calving grounds, denning areas, and other important or unique habitat areas as identified by the Alaska Department of Fish and Game were incorporated into the screening process.

Many species of birds such as raptors and swans are sensitive to human disturbance. Identifying the presence and location of nesting raptors and swans permits avoidance of traditional nesting areas. Moreover, if this category is investigated, the presence of endangered species (viz, peregrine falcons) can be determined.

Important habitat for furbearers exists along many potential transmission line corridors in the railbelt area, and its loss or disruption would have a direct effect on these animal populations. Investigating habitat preferences, noting existing habitat, and identifying populations through available information are important steps in addressing the selection of environmentally acceptable alternatives.

(v) Environmental Screening Methodology

In order to compare the alternative corridors from an environmental standpoint, the environmental criteria discussed above were combined into environmental constraint tables (Tables E10.21, E10.22, and E10.23). These tables combine information for each corridor segment under study. This permitted the assignment of an environmental rating, which identifies the relative rating of each corridor within each of the three study areas. The assignment of environmental ratings is a subjective technique intended as an aid to corridor screening. Those corridors that are recommended are identified with an "A," while those corridors that are acceptable but not preferred are identified with a "C." Finally, those corridors that are considered unacceptable are identified with an "F."

(vi) Screening Results

Table E.10.24 summarizes the comparisons of the 22 corridors studied in the southern, central, and northern study areas. Environmental, economical, and technical ratings are presented as well as a summary rating for each corridor. Because of the critical importance of enviromental considerations, any corridor which received an F rating for environmental impacts was assigned a summary rating of F. Thus, a corridor which may be excellent from a technical and economic viewpoint was considered not acceptable if the environmental rating was unacceptable.

Descriptions of the rationale for each corridor's rating are presented below.

- Southern Study Area

  Three alternative corridors were evaluated in the southern study area. As previously identified, two corridors connect Willow with Point MacKenzie. The third corridor connects Willow with Anchorage.

  o Corridor One (ABC') - Willow to Anchorage vai Palmer

    . Technical and Economical

      This 73-mile corridor is the longest of the three being considered for the southern area. As a consequence, there will be more clearing of right-of-way required, more miles of line, and more towers. Several highway and railway crossings will also be encountered, including crossing of the Glenn Highway. The corridor is located in a well-developed, inhabited area which will require easements on private properties. There also could be a problem of radio and television interference.

    . Environmental

      Several constraints were identified in evaluating this corridor, chief among which were constraints under the land use category.

      A new right-of-way would be required from Willow to a point in the vicinity of Palmer. This would necessitate the development of a pioneer access road and, since this area is wooded, attendant vegetation clearing and opening of a previously inaccessible area. The corridor also bisects lands in the vicinity of Willow that have been proposed for use as the new capital site.

      Between Eklutna and Anchorage, this route parallels an existing transmission line that now crosses extensively developed areas. Paralleling existing corridors usually is the most appropriate means of traversing developed areas. Because homes and associated buildings abut the right-of-way, however, additional routes through this developed area present problems, among which aesthetics is most important. In addition, this corridor alternative crosses 5 rivers and 28 creeks potentially affecting not only the rivers and streams but also fish species inhabiting these water courses. From the standpoint of aesthetics, a transmission line in the vicinity of Gooding Lake would negatively affect an existing bird-watching area. However, because this area is not heavily utilized and routing variations are available within the corridor, it is considered environmentally acceptable.

Ratings:

Technical	Economical	Environmental	Summary
C	C	C	C

- Corridor Two (ADFC) - Willow to Point MacKenzie via Red Shirt Lake

  - Technical and Economical

    Corridor ADFC crosses the fewest number of rivers and roads in the southern study area. It has the advantage of paralleling an existing tractor trail for a good portion of its length, thereby reducing the need for new access roads. Easy access will allow maintenance and repairs to be carried out in minimal time. This corridor also occurs at low elevations and is approximately one-half the length of Corridor One.

  - Environmental

    This corridor crosses extensive wetlands from Willow to Point MacKenzie. At higher elevations or in the better drained sites, extensive forest cover is encountered. Good agricultural soils have been identified in the vicinity of this corridor; the state plans an agricultural lands sale for areas to be traversed by this corridor. The corridor also crosses the Susitna Flats Game Refuge. The presence of an existing tractor trail near considerable portions of this corridor diminishes the significance of some of these constraints. Furthermore, its short length and the fact that it has only one river and eight creek crossings increases its environmental acceptability.

Ratings:

Technical	Economical	Environmental	Summary
A	A	A	A

o Corridor Three (AEFC) - Willow to Point MacKenzie via Lynx Lake

. Technical and Economical

This corridor has the same physical features as Corridor Two. Both corridors have extensive wetlands. AEFC cuts across a developed recreational area and hence will require special routing procedures to circumvent some of the private property it will traverse. This corridor is very accessible. Technically, because of its short length and low elevation, it is a desirable corridor, but economically it would be costly to obtain easements and to route the line through the several privately owned properties.

. Environmental

As with the previous corridor, this route crosses extensive wetlands requiring, in the better drained areas, extensive clearing of associated forest. Just south of Willow, this route passes through the Nancy Lakes recreation area. Substantial development of both residential and recreational facilities has occurred in the past and is continuing. These facilities would be affected by the presence of the transmission line, not only from a land use standpoint, but also from an aestnetics standpoint. Because of this unavoidable land use conflict associated with this corridor, particularly in the Nancy Lake area, it is not considered to be environmentally acceptable.

Ratings:

Technical	Economical	Environmental	Summary
A	C	F	F

- Central Study Area

Fifteen corridors utilizing different combinations of corridor segments were identified in the central study area. These corridors connect the damsites with the Intertie at four separate locations. These locations are in the vicinity of Indian River near its confluence with the Susitna River and near the communities of Chulitna, Summit, and Cantwell.

Because of the range in length of the corridors, those with long lengths were assigned low economic ratings. These corridors, numbers Four (ABCJHI), Five (ABECJHI), Seven (CEBAHI), Eight (CBAG), Nine (CEBAG), Ten (CJAG), and Twelve (JACJHI), have lengths of 76 to 97 miles. In addition to these, Corridors Four and Six (CBAHI) were assigned an F technical rating because they cross mountainous areas over 4,000 feet in elevation.

Corridors Four and Six were rated unacceptable technically and therefore were eliminated because reliability cannot be compromised. The remaining six corridors, although unacceptable economically (F rating), were evaluated on an environmental basis. This was done to determine whether one of these long corridors was much more acceptable environmentally than a shorter one.

Therefore, environmental information is presented for the eight abovementioned corridors. This is followed by a discussion of the economic, technical, and environmental features of the remaining seven corridors in the central study area.

Corridors Technically and/or Economically Unacceptable

o Corridor Four (ABCJHI) - Watana to Intertie via Devil Creek Pass/East Fork Chulitna River

  This corridor connects Devil Canyon with Watana and exits the Devil Canyon project to the north following the drainages of Devil, Portage, and Tsusena Creeks. To route this corridor to the Intertie as required, the line crosses some mountain passes over 4,000 feet in elevation with steep slopes and shallow bedrock areas (Corridor Segment CJHI).

  The transmission line would interrupt the existing viewshed of the recreation facility at High Lake. Existing patterns of land use in the vicinity of High Lake may also be significantly disrupted by the transmission line. Once on the north side of the river, this corridor crosses 42 creeks between Devil Canyon and the connection with the Intertie. Potential for stream degradation exists because of the lack of existing access. Sensitive wildlife species, such as caribou, wolves, and brown bear, as well as a golden eagle nest site, could be potentially harmed by this corridor.

Ratings:

Technical	Economical	Environmental	Summary
F	F	F	F

- Corridor Five (ABECJHI) - Watana to Intertie via Stephan Lake and the East Fork Chulitna River

  This corridor crosses areas of high elevations and shallow soils underlain by bedrock. Land use constraints are encountered in the vicinity of both High Lake and Stephan Lake, two significant recreation and lodge areas. Relatively important waterfowl and migrating swan habitat would be affected, as would habitat for some of the major big game species. In addition, this corridor makes 42 creek crossings. Extensive vegetation clearing would be required, opening areas to access. Because of the visual impacts and increased access, this corridor received an F rating.

  Ratings:

Technical	Economical	Environmental	Summary
F	F	F	F

- Corridor Six (CBAHI) - Devil Canyon to the Intertie via Tsusena Creek/Chulitna River

  Reversing the sequence by which the damsites are connected, Corridor Six extends from Devil Canyon to Watana (Corridor Segment CBA) and from Watana north along Tsusena Creek to the point of connection with the Intertie near Summit Lake (Corridor Segment AHI). Access roads are presently absent along most of this corridor, and a pioneer route would need to be established. This corridor also traverses elevations above 4,000 feet and encounters shallow soils underlain by bedrock. Wetlands, extensive forest cover, and 32 creek crossings also constrain the development of this corridor. A bald eagle nest in the vicinity of Tsusena Butte, as well as the presence of sensitive big game species such as caribou and sheep, present additional constraints to the routing of the corridor. This corridor was rated F, primarily because of increased access and potential negative impact on sensitive wildlife species.

Ratings:

Technical	Economical	Environmental	Summary
F	C	F	F

o <u>Corridor Seven (CEBAHI) - Devil Canyon to Intertie via Stephan Lake and Chulitna River</u>

The primary environmental constraints associated with this corridor are the result of visual and increased are the result of visual and increased access impacts. The corridor crosses near residential and recreational facilities at Stephan Lake and is in the viewshed of the Alaska range. Access road construction would be necessary through wetlands and areas of heavy timber.

In addition, the corridor crosses 45 creeks, including some with valuable spawning areas. It also crosses habitat for wolves and bears, including Prairie Creek which is heavily used by brown bears during salmon runs. This offers the potential for increased bear-human contacts.

Again, because of potential for visual impacts and increased access, this corridor received an F rating.

Ratings:

Technical	Economical	Environmental	Summary
C	F	F	F

o <u>Corridor Eight (CBAG) - Devil Canyon to Intertie via Deadman/ Brushkana Creeks and Denali Highway</u>

Constraints in the categories of land use, aesthetics, and fish and wildlife resources are present in this corridor. Among the longest of corridors under consideration, this route passes near recreation areas, isolated cabins, lakes used by float planes, and land-based airstrips. In traversing lands from the Watana Damsite to the point of connection with the Intertie, the route also intrudes upon some scenic areas. Along much of its length, the corridor crosses woodlands and, since a pioneer access road probably would be required, vegetation clearing would likely be extensive. Once north of the Watana Damsite, the transmission line corridor makes 35 creek crossings and traverses the habitat not only for a variety of sensitive big game species but also for waterfowl and raptors. In addition, the line passes near the location of an active bald eagle nest on Deadman Creek.

For these reasons, a rating of F was assigned.

Ratings:

Technical	Economical	Environmental	Summary
C	F	F	F

- <u>Corridor Nine (CEBAG) - Devil Canyon to Intertie via Stephan Lake and Denali Highway</u>

  Corridor Nine is the longest under construction in the central study area and, hence, would require disturbance of the largest land areas. It also crosses areas of shallow bedrock, important waterfowl migratory habitat at Stephan Lake, and 48 creeks, including valuable spawning areas.

  The corridor passes near Stephan Lake, utilized heavily for recreation, and any line constructed in this area would be visible when looking towards the looking towards the Alaska range. Although one of the proposed access roads to the damsites does occur in this area offering the potential for parallel rights-of-way, the extreme length of this corridor and the potential for unavoidable adverse land use and aesthetic impacts result in its being judged unacceptable. Thus, an F rating was assigned.

  Ratings:

Technical	Economical	Environmental	Summary
C	F	F	F

- <u>Corridor Ten (CJAG) - Devil Canyon to Intertie via North Shore, Susitna River, and Denali Highway</u>

  This is the second longest of the corridors under investigation by this study. Routing above 3,000 feet and its concomitant bedrock and steep slopes are important restrictions of this corridor. It would also encounter the land use constraints identified in Corridor Nine, as well as several other drawbacks, most notable of which are in the areas of aesthetics and fish and wildlife resources. Forty-seven creek crossings would be required by this corridor.

  This corridor could also parallel one of the proposed access roads. However, as with Corridor Nine, its long length, land use, and visual impacts do not make it an acceptable corridor.

All of the above and particularly the aesthetic constraints result in an F rating.

Ratings:

Technical	Economical	Environmental	Summary
C	F	F	F

o Corridor Twelve (JA-CJHI) - Devil Canyon - Watana to Intertie via Devil/Chulitna River

This corridor has a number of environmental constraints which together make it environmentally unacceptable. Land use conflicts would likely occur, since much of the land crossed is privately owned. In addition, aesthetic impacts would occur in the High Lakes area, because the corridor is in the viewshed of the Alaska Range. Finally, the corridor crosses 40 creeks, including valuable salmon-spawning grounds, and crosses near a golden eagle nest.

This corridor, primarily because of impacts to access, private lands, and aesthetics, received an F rating.

Ratings:

Technical	Economical	Environmental	Summary
C	F	F	F

Corridors Technically and Economically Acceptable

o Corridor One (ABCD) - Watana to the Intertie via South Shore of the Susitna River

. Technical and Economical

Corridor One is one of the shortest corridors considered, approximately 40 miles long, making it economically favorable. No technical restrictions were observed along the entire length of this corridor.

. Environmental

Because of its short length, environmental disturbance caused by transmission line construction would be reduced. The more noteworthy constraints are those identified under the categories of land use and vegetation. Corridor One would require the development of a new right-of-way between Watana and Devil Canyon with some opportunity existing to utilize the COE-developed road for access between the Intertie and Devil Canyon. The potential does exist in this corridor to use one of the proposed access roads currently under consideration. Wetlands and discontinuous forest cover occur in the corridor, especially in the eastern third of the route. Access road development, if required in this area, and the associated vegetation clearing present additional constraints to this corridor.

Ratings:

Technical	Economical	Environmental	Summary
A	A	A	A

o Corridor Two (ABECD) - Watana to Intertie via Stephen Lake

. Technical and Economical

This corridor is approximately five miles longer than Corridor One and would require an additional five miles of access road for construction purposes. The corridor will rise to a maximum elevation of 3,600 feet, and also crosses wetlands and extensive forest cover. This higher elevation, increased clearing, and longer length result in a lower technical and economic rating than Corridor One.

. Environmental

This corridor is identical to Corridor One with the exception of Corridor Segment BEC. Because of this deviation, several additional problems arise in this corridor as compared with Corridor One. First, an access road about nine miles longer than that required for the construction of Corridor One would be needed. A new road may also have to be developed along most of this route, which would also cross wetland and forested areas. Residential and recreational facilities at Stephan Lake and the much higher visibility of the transmission facilities to the users of this recreation area would be a major constraint posed by this corridor.

The corridor would also intrude upon habitat for wolves, bear, and caribou, as well as for raptors and waterfowl. Of note, brown bears utilizing the fish resources of Prairie Creek would likely encounter this alternative corridor more frequently than they would Corridor One, thus potentially bringing bears and people into close contact.

These potential impacts to aesthetics and creation of new access road result in this corridor being environmentally unacceptable.

Ratings:

Technical	Economical	Environmental	Summary
C	C	F	F

- Corridor Three (AJCF) - Watana to Intertie via North Shore of the Susitna River

  . Technical and Economical

  This corridor is similar in length to Corridor Two and shares the same technical and economical considerations. There are no existing roads for nearly the entire length, and it does encounter some steep slopes. These will reduce the reliability of the line and add to the cost of construction.

  . Environmental

  The corridor in this area would likely require a pioneer access road. This route would also be impeded by the existence of recreation facilities in the vicinity of High Lake and, more significantly, Otter Lake. The corridor is within sight of recreation facilities at these lakes and may also interfere with the use of High Lake by planes during certain weather conditions. The route also crosses Indian River and Portage Creek; both streams support significant salmon resources. Potential damage to spawning areas could occur as a result of construction along this corridor. An active golden eagle nest exists in the Devil Creek vicinity. This species is sensitive to development activities and could be adversely affected by Corridor Three.

Ratings:

Technical	Economical	Environmental	Summary
C	C	C	C

o Corridor Eleven (CJAHI) - Devil Canyon to the Intertie via Tsusena Creek/Chulitna River

. Technical and Economical

This corridor has a disadvantage over the others discussed because of its 70-mile length. New access roads and vegetative clearing would be required for a considerable portion of the corridor, thereby increasing costs of construction.

. Environmental

Corridor Segments CJA (part of Corridor Three) and AHI (part of Corridor Six) comprise this alternative and, as such, have been previously discussed. The long length of this corridor, its crossing of 36 creeks, and development of a new right-of-way and land use conflicts contribute to an unacceptable environmental rating.

Ratings:

Technical	Economical	Environmental	Summary
C	C	F	F

o Corridor Thirteen (ABCF)- Watana to Devil Canyon via South Shore, Devil Canyon to Intertie via North Shore, Susitna River

. Technical and Economical

This corridor, 41 miles in length, is one of the shorter ones being considered. Although it crosses deep ravines, and forest clearing will be required over a considerable portion of its length, it is rated high technically because of its short length and low elevation.

. Environmental

Since this corridor combines segments from Corridor One (ABC) and Corridor Three (CF), the same constraints for those two routes apply which have been previously described. This corridor presents a few environmental problems. Conflicts with recreation near Otter Lake can be resolved through careful selection of one final right- of-way.

Ratings:

Technical	Economical	Environmental	Summary
A	C	A	A

o <u>Corridor Fourteen (AJCD) - Watana to Devil Canyon via North Shore, Devil Canyon to Intertie via South Shore, Susitna River</u>

. <u>Technical and Economical</u>

This corridor is also one of the shortest among the fifteen studied in the central area. Some access roads will be required for this corridor and some clearing necessary. Advantage will be taken of the proposed project access road where possible to locate the transmission line close by.

Corridor Fourteen is rated as recommended both economically and technically, because of gentle relief, short length, and small amounts of clearing.

. <u>Environmental</u>

This corridor reverses the routing between damsites and the Intertie proposed by Corridor Thirteen. Constraints are, therefore, the same as those presented for Corridors Three and One, and are not great. However, the unavoidable conflict with land use at High Lake results in a C rating.

Ratings:

Technical	Economical	Environmental	Summary
A	A	C	A

o <u>Corridor Fifteen (ABECF)- Watana to Devil Canyon via Stephan Lake, Devil Canyon to Intertie via North Shore, Susitna River</u>

. <u>Technical and Economical</u>

This corridor is approximately 45 miles long and would require construction of new access roads and forest clearing for almost its entire length. These negative economical points contribute to the low rating of this corridor.

. <u>Environmental</u>

This corridor combines segments from Corridor Two (ABEC) and Corridor Three (CF). The constraints for these corridors have been presented under their respective discussions. Extensive new access and detrimental visual impacts near Stephan Lake were the primary constraints along the corridor segment from Corridor Two which resulted in an unacceptable environmental rating.

Ratings:

Technical	Economical	Environmental	Summary
C	C	F	F

- Northern Study Area

Constraints appeared in the routing of all four corridors evaluated in the northern study area. The shortest route was 85 miles and the longest was 115 miles. Topography and soils restrictions are constraints to each of the corridors evaluated. In addition, the two eastern corridors of the study area cross mountain slopes. Each of the corridors would be highly visible in the floodplain of the Tanana River. Major highways skirt these floodplains at some distance to the north, however; and only scattered, isolated residential areas would be encountered by the corridors. Little information has been collected concerning the cultural resources in the vicinity of any of the four corridors of this study area. The Dry Creek archaeologic site near Healy has been identified; however, the presence of numerous sites in the foothills of the Alaska Range and in the vicinity of the Tanana River are suspected. Additional constraints peculiar to the four separate corridors are presented below.

o Corridor One (ABC) - Healy to Fairbanks via Parks Highway

. Technical and Economical

This corridor crosses the fewest water courses in the northern study area. Although it is approximately four miles longer than Corridor Two, it is technically favored because of the existence of potential access roads for almost the entire length.

. Environmental

Because it parallels an existing transportation corridor for much of its length, this corridor would permit line routing that would avoid most visually sensitive areas. The three proposed road crossings for this corridor (as opposed to the 19 road crossings of the Healy-Fairbanks transmission line) could occur at points where roadside development exists, in areas of visual absorbtion capability or in areas recommended to be opened to long-distance views (D.N.R. 1981).

Four rivers and 40 creeks are crossed by this corridor, with potential for impacts. It crosses the fewest number of water courses of any route under consideration in the northern study area. In addition, the inactive nest site of a pair of peregrine falcons occurs within this proposed corridor.

As with visual impacts, land use, wildlife, and fishery resource impacts can be lessened through careful route location and utilization of existing access. Impacts on forest clearing can also be lessened through the sharing of existing transmission line corridors.

Ratings:

Technical	Economical	Environmental	Summary
A	A	A	A

o Corridor Two (ABDC) - Healy to Fairbanks via Wood River Crossing

. Technical and Economical

This is the shortest corridor (86 miles) studied in this area. Although comparable to Corridor One, it crosses additional wetlands, increasing the technical difficulty of transmission line construction. Development of roads will also pose a major constraint.

. Environmental

Corridor Two is the shortest under consideration in the northern study area. As it is a variation of Corridor One, many of the same constraints apply here. The lack of existing rights-of-way is a constraint throughout much of this route. Prior to crossing the Tanana River, this corridor deviates farther to the northeast than does Corridor One, thereby crossing additional wet soils; thus, access-road development poses a major constraint. Forest clearing would be necessary in the broad floodplain of the Tanana River. While it is the shortest route, this corridor still crosses 5 rivers and 44 creeks as well as prime habitat and important habitat for peregrines and golden eagles. These constraints, and visual and public land conflicts, result in a C rating.

Ratings:

Technical	Economical	Environmental	Summary
C	A	C	C

- o <u>Corridor Three (AEDC) - Healy to Fairbanks via Healy Creek and Japan Hills</u>

. <u>Technical and Economical</u>

This 115-mile corridor is the longest in the northern study area. Its considerable length would contribute substantially to increased costs of construction. The crossing of areas over 4,500 feet in elevation results in the corridor's being technically unacceptable for reasons discussed above.

. <u>Environmental</u>

This corridor crosses a high mountain pass and, in some locations, encounters bedrock overlaid with shallow, wet soils. Access is a problem because, except for the road into the Usibelli coal fields, no rights-of-way exist along the route. Crossing the broad floodplain of the Tanana and Wood Rivers would require extensive forest clearing and result in aesthetic impacts. In addition, this corridor involves 3 river and 72 creek crossings. Prime habitat for caribou, peregrine falcons, sheep, and waterfowl as well as important habitat for golden eagles and brown bear would be affected.

The increased length and increased visual impacts result in this corridor's being environmentally unacceptable.

Ratings:

Technical	Economical	Environmental	Summary
F	C	F	F

o Corridor Four (AEF) - Healy to Fairbanks via Wood River and Fort Wainwright

. Technical and Economical

The technical and economical constraints associated with this corridor are the same as those in Corridor Three. The long distance of this corridor (105 miles) and the crossing of areas over 4,500 feet in elevation reduce its attractiveness from a technical and economical viewpoint.

. Environmental

Corridor Four is very similar to Corridor Three in that it parallels Healy Creek drainage north. Therefore, impacts to this mountainous region would be identical to those described for this corridor segment in Corridor Three. In the vicinity of Japan Hills, however, the corridor parallels an existing sled road for part of its length as it traverses the wet, heavily forested floodplain of the Tanana and Wood Rivers. Clearing requirements might, therefore, be reduced, as would be the need for access roads in this area. Important habitat or prime habitat for peregrine falcons, bald eagles, sheep, caribou, and brown bear exists within this corridor. This corridor is unacceptable from a land use standpoint because it is within the Blair Lake Air Force active bombing range, precluding further consideration of this corridor.

Ratings:

Technical	Economical	Environmental	Summary
F	C	F	F

(vii) Proposed Corridor

The Recommended corridor for the Susitna Project consists of the following segments:

- Southern study area, Corridor ADFC;
- Central study area, Corridor ABCD; and
- Northern study area, Corridor ABC.

This corridor is shown in Exhibit B, Figures B.51 through B.57.

(viii) Route Selection Methodology

After identifying the preferred transmission line corridors, the next step in the route selection process involved the analysis of the data as gathered and presented on the base maps. The map is used to select possible routes within each of the three selected corridors. By placing all major constraints (e.g., area of high visual exposure, private lands, endangered species, etc.) on one map, a route of least impact was selected. Existing facilities, such as transmission lines and tractor trails within the study area, were also considered during the selection of a minimum impact route. Whenever possible, the routes were selected near existing or proposed access roads, sharing whenever possible existing rights-of-way.

The data base used in this analysis was obtained from the following sources:

- An up-to-date land status study;
- Existing aerial photos;
- New aerial photos conducted for selected sections of the previously recommended transmission line corridors;
- Environmental studies including aesthetic considerations;
- Climatological studies;
- Geotechnical exploration;
- Additional field studies; and
- Public opinions.

(ix) Environmental Route Selection Criteria

The purpose of this section is to identify three selected routes: one from Healy to Fairbanks, the second from the Watana and Devil Canyon damsites to the Intertie, and the third from Willow to Anchorage. Route location objectives were to obtain an optimum combination of reliability and cost with the fewest environmental problems.

The previously chosen corridors were subject to a process of refining and evaluation based on the same technical, economic, and environmental criteria used in corridor selection. In addition, special emphasis was concentrated on the following points:

- Satisfy the regulatory and permit requirements;
- Selection of routing that provides for minimum visibility from highways and homes; and
- Avoidance of developed agricultural lands and dwellings.

The corridors selected were analyzed to arrive at the route width which is the most compatible with the environment and also meet the engineering and economic objectives. The environmental analysis was conducted by the process described below:

- <u>Literature Review</u>

  Data from various literature sources, agency communications, and site visits were reviewed to inventory existing environmental variables. From such an inventory, it was possible to identify environmental constraints in the recommended corridor locations. Data sources were cataloged and filed for later retrieval.

- <u>Avoidance Routing by Constraint Analysis</u>

  To establish the most appropriate location for a transmission line route, it was necessary to identify those environmental constraints that could be impediments to the development of such a route. Many specific constraints were identified during the preliminary screening; others were determined during the 1981 field investigations.

  By utilizing information on topography, existing and purposed land use, aesthetics, ecological features, and cultural resources as they exist within the corridors, and by careful placement of the route with these considerations in mind, impact on these various constraints was minimized.

- <u>Base Maps and Overlays</u>

  Constraint analysis information was placed on base maps. Constraints were identified and presented on overlays to the base maps. This mapping process involved using both existing information and that acquired through Susitna Project studies. This information was first categorized as to its potential for constraining the development of a transmission line route within the preferred corridor and then placed on maps of the corridors. Environmental constraints were identified and recorded directly onto the base maps. Overlays to the base maps were prepared indicating the type and extent of the encountered constraints.

Three overlays were prepared for each map: one for visual constraints, one for man-made, and one for biological constraints. These maps are presented in Reference 22.

(ix) Results and Conclusions

A study of existing information along with data from aerial overflights was used to locate the recommended route in each of the southern, central, and northern study areas.

Additional environmental information and land status studies made it possible to align the routes to avoid any restraints.

The proposed transmission line route is presented in Exhibit G. The marked route represents the centerline of a 400-foot right-of-way which is sufficient for three single-circuit, parallel lines. Between Devil Canyon and the Intertie, the right-of-way is 700 feet to accommodate five single-circuit lines.

(e) Borrow Site Alternatives

(i) Watana Borrow Sites

A total of seven borrow sites and three quarry sites have been identified for dam construction material (A, B, C, D, E, F, H, I, J, and L) (Figure E10.6). Of these, Borrow Sites D and H are considered as potential sources for semipervious to pervious material; Sites C, E, and F for granular material; Sites I and J for pervious gravel; and Quarry Sites A, B, and L for rock fill.

Several of these sites (B, C, and F), previously identified by the Corp of Engineers, were not considered as primary sites for this study because: 1) a source of suitable material exists closer to the damsite; 2) of adverse environmental impacts; 3) of insufficient quantity; or 4) poor quality of the material. Therefore, no work was performed in these areas during 1980-81. These sites, however, have not been totally eliminated from consideration as alternative sources and are therefore included in this discussion.

Since adequate quality and quantity of quarry rock are readily available adjacent to the damsites, the quarry investigation was principally limited to general field reconnaissance to delineate boundaries of the quarry sites and to determine approximate reserve capacity. This allowed for a more detailed investigation in the borrow sites.

The borrow investigations consisted of seismic refraction surveys, test pits, auger holes, instrumentation, and laboratory testing. The results of this study are discussed below.

Each site is presented in the following sequence:

(1) Proposed use of the material and why the site was selected;

(2) Location and geology, including topography, geomorphology, vegetation, climatic data, groundwater, permafrost, and stratigraphy;

(3) Reserves, lithology, and zonation; and

(4) Engineering properties which include index properties and laboratory test results.

Laboratory test results on samples from the borrow areas are shown in Reference 21.

- Quarry Site A

  o Proposed Use

  Quarry Site A is a large exposed diorite and andesite porphyry rock knob at the south abutment of the Watana damsite. The predominant rock type is diorite. The proposed use for the quarry is for blasted rockfill and riprap.

  Quarry Site A was selected based on its apparent good rock quality and close proximity to the damsite.

  o Location and Geology

  The boundaries of Quarry Site A include the bedrock "knob" from approximate Elevation 2300 to about 2600. The knob covers an area approximately one square mile. Glacial scouring has gouged out east-west swales in the rock. These swales likely corresponded with fractured, sheared, and altered zones within the rock body. Overburden ranges from 0 to several feet over the site. Vegetation is limited to scrubby spruce, vines, and tundra, with limited alder growth in the lower areas. Surface water is evident only in isolated deeper swales. The groundwater table is expected to be deep in this area with an estimated average depth to the water table from 50 to 100 feet. It is likely that the groundwater level will be near the quarry floor during operation, but inflows are expected to be small, diminishing with time.

Although no borings have been drilled in this site, it is likely that permafrost will be encountered as shallow as 5 feet in depth. The permafrost, however, is near the thaw point and, because of the high exposure to sunlight in this area, is expected to dissipate rapidly. The permafrost zones are expected to be more common in the more fractured and sheared zones.

The western portion of the site has been mapped as sheared andesite porphyry with the remainder of the site being gray diorite. Mapping on the northern half of the site showed the rock to grade between black andesite porphyry and a coarse-grained gray andesite with sections grading into diorite. Despite these lithologic variations, the rock body is relatively homogeneous. Based on airphoto interpretation, severe shearing and alteration appear to be present on the northeast corner of the delineated site area.

- Reserves

The rock exposure in Quarry Site A provided adequate confidence in assessing the quality and quantity of available rockfill necessary for feasibility. Allowing for spoilage of poor quality rock caused by alteration and fracturing, and assuming a minimum bottom elevation of 2300, the estimated volume of sheared or weathered rock is 23 million cubic yards (mcy) and 71 mcy of good quality rock.

Additional rock fill, if required, can be obtained by deepening the quarry to near the proposed dam crest elevation of 2210 without adversely affecting the dam foundation or integrity of the reservoir.

- Engineering Properties

Weathering and freeze-thaw tests were conducted to determine the rock's resistance to severe environmental conditions. Results indicate that the rock is very resistant to abrasion and mechanical breakdown, seldom losing strength or durability in presence of water and demonstrating high resistance to breakdown by freeze-thaw.

The rock is expected to make excellent riprap, rock shell, or road foundation material.

- Quarry Site B

  o Proposed Use

  Quarry Site B was identified in previous investigations as a potential rock quarry for dam construction. The area was identified based on outcrops exposed between Elevations 1700 and 2000 along the Susitna River and Deadman Creek. During the 1980-81 field reconnaissance, mapping and additional seismic refraction surveys were performed in this area.

  o Location and Geology

  Quarry Site B is located about two miles upstream from the damsite between Elevations 1700 and 2000. This area initially appeared economically attractive because of the short-haul distance and low-haul gradient to the damsite. However, geologic mapping and seismic refraction surveys performed in this area indicate that the rock is interfingered with poor quality sedimentary volcanic and metamorphic rocks with thick overburden in several areas.

  Vegetation cover is heavy, consisting of dense alder marshes and alder with aspen and black spruce in the higher, drier areas. The entire south-facing side of the site is wet and marshy with numerous permafrost features. The quarry side facing Deadman Creek is dry, with thick till overburden, which appears frozen. Permafrost in the area is expected to be continuous and deep. Surface runoff from Borrow Site D flows southward passing through Quarry Site B.

  o Reserves

  Because of 1) the deep overburden; 2) generally poor rock quality; and 3) the extreme vegetation and topographic relief, Quarry Site B was not considered as a primary quarry site. Therefore, no reserve quantities were determined for feasibility.

- **Engineering Properties**

  No material property testing was performed for this area.

- **Borrow Site C**

- **Proposed Use**

  Borrow Site C was identified in previous studies as a possible source of gravels and sands for filter material. The 1980-81 investigation identified adequate volumes of granular material much closer to the damsite in Borrow Site E. Therefore, no additional work was performed in this area during this study.

- **Location and Geology**

  Borrow Site C, as delineated by the COE, extends from a point approximately 4-1/2 miles upstream from Tsusena Butte to the northwest toe of the butte. The site is a broad glacial valley filled with till and alluvium. Vegetation ranges from alpine tundra on the valley walls to heavy brush and mixed trees at the lower elevations, thinning to mixed grass and tundra near the river and on terraces. The groundwater table is assumed to be a subdued replica of the topography, being shallow on the valley walls with gradients towards the valley floor. Groundwater migration is expected to be rapid through the highly permeable alluvial material. Permafrost may be intermittent.

  The stratigraphy appears to consist of over 200 feet of basal till overlain by outwash, and reworked outwash alluvium. The upper 100 to 200 feet of material is believed to be saturated gravels and sands.

- **Reserves**

  Because the site is not currently being considered as a borrow source, no detailed quantity estimate has been made. However, assuming an approximate area of 1,500 acres and an excavation depth of 15 feet above water table, a gravel quantity on the order of 25 mcy can be approximated. Additional quantities may be obtained at depth; however, further studies will be required to determine the volumes.

o Engineering Properties

The test pit and reconnaissance mapping show the material in the floodplain and terraces to be a 4-inch minus, well- washed gravel with approximately 60 percent gravel, 40 percent sand, and negligible fines. The gradations are representative of a clean, well-washed material with a percentage of cobbles and fines at depth.

- Borrow Site D

o Proposed Use

Borrow Site D was identified in 1975 as a potential primary source for impervious and semipervious material by the COE.

Based on the field studies performed by the COE in 1978, it was tentatively concluded that:

- Borrow Site D had potentially large quantities of clay and silt;
- The deposit was of adequate volume to provide the estimated quantity of material needed for construction; and
- The site had favorable topography and hydrology for borrow development.

As a result of these previous studies, Borrow Site D became a primary site for detailed investigation during the 198081 study.

o Location and Geology

Borrow Site D lies on a broad plateau immediately northwest of the Watana damsite. The southern edge of the site lies approximately 1/2 mile northeast of the dam limits and extends eastward towards Deadman Creek for a distance of approximately 3 miles. The topography slopes upward from the damsite elevation of 2150 northward to approximate Elevation 2450.

The ground surface has localized benches and swales up to 50 feet in height. The ground surface drops off steeply at the slopes of Deadman Creek and the Susitna River.

Vegetation is predominantly tundra and sedge grass averaging about one foot thick with isolated strands of spruce trees on the higher and dryer portions of the site.

Climatic conditions are similar to those at the damsite with the exception that the borrow site is more exposed to winds and sunlight. The relatively open rolling topography is conductive to drifting and blowing snow, frequently resulting in drifts up to six feet deep.

The northwest portion of the site has numerous lakes and shallow ponds with the remaining portions of the site having localized standing water perched on either permafrost or impervious soils. Surface runoff is towards Deadman Creek to the northeast and Tsusena Creek to the west. Generally, much of the area is poorly drained, with many of the low-lying areas wet and boggy.

Instrumentation installed throughout the borrow site shows intermittent "warm" permafrost. Temperatures in the permafrost zones are all within the -1°C range. Thermistor plots show annual frost penetration of approximately 15 to 20 feet. Annual amplitude (fluctuation) in ground temperature reaches depths of 20 to 40 feet. The greatest depth of temperature amplitude is in the unfrozen holes, while the permafrost holes reach 20 to 25 feet. This may be caused by either the effect of greater water content at the freezing interface lessening the seasonal energy variations, or the thicker vegetation cover in the permafrost area causing better insulation.

o <u>Reserves</u>

The boundaries of the borrow site are somewhat arbitrary, being limited on the south side by the apparent limit of undisturbed material; to the east by Deadman Creek; to the northwest by low topography; and to the north by shallowing bedrock. If further studies indicate the need for additional materials, it may be feasible to extend the borrow site to the northwest and west. Factors to be considered in borrow site expansion are:

- Siting of other facilities in this area;
- Impacts on the relict channel;
- Haul distance; and
- Environmental impacts.

The reserve estimates for Borrow Site D have assumed an average material thickness throughout the site limits. Based on the currently established boundaries (encompassing about 1,075 acres) and an excavation depth of 120 feet, a total of 200 mcy of material is available.

o Engineering Properties

Grain size distribution within the borrow site ranges from coarse gravels to clay. Almost all samples were well graded, ranging from gravel to fine silt and/or clay. Moisture contents range from a low of 6 percent to a high of 42.5 percent with an average of approximately 14 percent.

- Borrow Site E

o Proposed Use

Borrow Site E was identified by the COE as a principal source of concrete aggregate and filter material for the Watana dam. The apparent volume of material and its close proximity to the site made it the primary site for detailed investigations during the 1980-81 program.

- Location and Geology

Borrow Site E is located three miles downstream from the damsite on the north bank at the confluence of Tsusena Creek and the Susitna River. The site is a large flat alluvial fan deposit which extends for 12,000 feet east-west and approximately 2,000 feet northward from the Susitna River up Tsusena Creek. Elevation across the site varies from a low of 1410 near river level to 1700 where the alluvial and terrace materials lap against the valley walls to the north.

The area is vegetated by dense spruce and some alders, tundra, and isolated brush. Vegetation cover averages about one foot thick underlain by up to four feet of fine silts and volcanic ash.

Groundwater was found to be generally greater than 10 feet deep. Groundwater levels fluctuate up to five feet from winter to summer, indicating a free draining material.

The hydrologic regime shows summer peak flows in the area reaching approximate Elevation 1435-1440 at the north of Tsusena Creek. This elevation corresponds with the limit of scoured and unvegetated river bank. The estimated 50year flood level is approximately 1,473 feet.

The underlying bedrock overlain by a sequence of bouldery till, river and floodplain gravels and sands. As in the case of Borrow Site D, the grain size distribution in Site E varies from boulders to fine silt and clay. Within this wide range of soil types, five distinct soil gradations (A through E) can be delineated. However, the complex depositional history and the limited exploration performed in this area does not allow for ready correlation of these soil types over the site. Generally, however, the finer silts and sands are found in the upper five feet of the deposit. Several abandoned river channels of either the Tsusena Creek or the Susitna River cross cut the site. The infilling and cross cutting of these streams and rivers through the site has resulted in a complex heterogeneous mixing of the materials. Exploration indicates that, although the five principal soil types are persistent within the site, they vary in depth from near surface to approximately 40 to 70 feet.

No permafrost has been encountered in the borrow site, probably because the site has a south-facing exposure and has a continuous thawing effect caused by the flowing river. Seasonal frost, up to 3 to 6 feet deep, was observed in test pits that encountered groundwater (mid-March 1981) and up to at least 13 feet in pits on the northwest side of the site that did not intercept the groundwater table. In areas of shallow groundwater, the frost was almost exclusively confined to the upper shallow sand and silt layers, while dry gravels showed deeper frost penetration. Annual frost penetration may be assumed to be about 3 to 6 feet in silty or clayey soils and at least 11 feet in loose dry gravels.

o Reserves

Quantities were calculated on the basis of known and inferred deposits above and below the current river regime. Assuming an overall surface area of approximately 750 to 800 acres, the estimated quantity of material above river elevation is 34 mcy. An additional volume of 52 mcy is available below river elevation assuming a total maximum depth of excavation of 125 feet in the southwest corner of the borrow site, decreasing to a minimum of 20 feet in the northeast corner.

Approximately 80 percent of the identified material in the borrow site is within the floodplain area, 10 percent in the hillside terraces, and 10 percent in the Tsusena Creek segment.

Average stripping is estimated at one foot of vegetation and three to four feet of fine grained material.

o Engineering Properties

The soil units A through E range from coarse sandy gravel through gravelly sand, silty sand, cobbles and boulders, silty sand and silt. Several of these material units correlate well with the material in Sites I and J. Moisture contents for the silts range from 25 to 30 percent; sand from 4 to 15 percent; and gravels from 1 to 5 percent. The percentage of material over 6 inches is roughly estimated at 10 percent with the over-12-inch estimated at 5 percent.

Selective mining may be possible to extract particular types of material. Further detailed investigations in this area will be required to accurately define the location and continuity of stratigraphic units.

- Borrow Site F

o Proposed Use

Borrow Site F was identified by the COE as a potential source of filter material for the main dam. Preliminary work performed by the COE showed the site to have limited quantities of material spread over a large area. For this reason, Borrow Site E became the preferred site, with Borrow Site F being considered as an alternative source for construction material for access roads, runways, and camp construction.

o Location and Geology

Borrow Site F occupies the middle stretch of Tsusena Creek from just above the high waterfall to north of Clark Creek where it abuts Borrow Site C. The northeast portion of the valley is confined by the flank of Tsusena Butte and its talus slopes. The vegetation in the area is mixed spruce and tundra, with isolated areas of undergrowth and alders. Groundwater is expected to be near surface. Limited permafrost is likely to be encountered in north- and west-facing exposures but is expected to thaw readily when exposed during summer months. Deposits above stream level are expected to be fairly well drained with lower areas saturated.

Limited test pits indicate the material in Borrow Site F is the same as that in Borrow Site C. The depth of clean sands and gravels is estimated to be approximately 20 to 30 feet, ranging from a shallow 5 feet to a maximum of 40 feet. The area consists of a series of gravel bars and terraces extending up to 1,500 feet away from the stream.

o Reserves

No detailed topography was obtained for the site; however, assuming a conservative depth of 20 feet of material, a total volume of approximately 15 to 25 mcy is likely available.

Additional investigation in this area will be required to confirm these volumes.

o Engineering Properties

Test pits excavated by the COE show gravelly sand overlain by a very thin silt and sandy silt cover. No detailed testing was performed on this material.

- Borrow Site H

o Proposed Use

Borrow Site H has been defined as an alternative site to Borrow Site D for impervious and semipervious material.

o Location and Geology

The topography of Borrow Site H is generally rolling, sloping towards the Susitna River. Elevations range from 1400 to 2400 across the site and average about 2100. Most of the site is covered by swamps and marshes, indicating poor drainage. The vegetation consists of thick tundra, muskeg, alder, and underbrush growth.

Groundwater and surface water are perched on top of impervious material with numerous seeps and ponded surface water. The extensive coverage of spruce trees may be indicative of a degrading permafrost area. A large ice deposit exists in a slump exposure on the west end of the site. The deposit and associated solifluction flow with a multiple regressive headwall are approximately 100 to 150 feet across.

Of the eight auger holes drilled in the site, six encountered permafrost at depths ranging from 0 to 14 feet in depth. All the holes but one showed the water table at or near the surface.

The site stratigraphy consists of an average of 1.5 feet of organics, underlain by 1.5 to 4.5 feet of brown sand or silt material with traces of organics. Below this upper material, most of the holes show mixed silt, sandy silt, and sandy clay to depths of 6 to 13 feet, which in turn is underlain by zones of gravels, gravelly sand, and mixed silts with sand and gravel. A color change from brown to gray occurs at depths of 6 to 28 feet. Insufficient data exist to allow for detailed stratigraphic correlation across the site.

o <u>Reserves</u>

The quantity estimate has assumed a relatively homogeneous mix of material over a surface area of 800 acres, with 5.5 feet of stripping required to remove organics and clean silts and sands. Assuming an estimated usable thickness of 32 feet (based on drilling data) approximately 35 mcy of material is available from this site.

o <u>Engineering Properties</u>

A detailed assessment of the grain size distribution shows three distinct gradation groupings (A through C). Gradation A denotes a gravelly sand, characterized by less than 40 percent fines and a significant fraction exceeding 3/4 inch; B is a silty sand without the generally coarser fraction; and C is a silt unit which is generally less than 1 inch in maximum particle size and contains in excess of 40 percent fines.

In conclusion, Borrow Site H material is considered suitable for use as impervious and semipervious fill. However, problems such as wet swampy conditions, permafrost, and the lengthy haul distance to the site may affect the potential use of this site as a borrow source.

- Borrow Sites I and J

  o Proposed Use

  Reconnaissance mapping was performed within a 10-mile radius of the damsite to locate potential sources of freedraining gravels for use in the dam shell. The large volume needs of this material requires that the source be relatively close to the damsite and in an area that would minimize environmental impacts during borrowing operations. As a result, the Susitna River valley alluvium was delineated as a potential borrow source.

  o Location and Geology

  A seismic refraction survey performed across the river channel indicated large quantities of sands and gravel within the river and floodplain deposits both upstream and downstream from the damsite.

  Borrow Site I extends from the western limits of Borrow Site E downstream for a distance of approximately 9 miles, encompassing a wide zone of terrace and floodplain deposits.

  Borrow Site J extends upstream from the damsite for a distance of approximately 7.6 miles. The site area extends from river bank to river bank and includes several terraces and stream deltas.

  Borrow Sites I and J are fully within the confines of the Devil Canyon and Watana reservoirs, respectively.

  Both sites are in an active fluvial environment. Borrow Site J is flanked by bedrock, talus and till-covered valley walls; while Borrow Site I includes extensive terraces extending several hundred feet up the valley walls above river level.

o Reserves

For purposes of volume calculation, it was assumed that all materials with seismic velocity of 6,500 feet per second represented suitable gravel deposits. Materials with velocities higher than 6,500 were assumed to be either too bouldery or dense. Not included in the estimate were:

- The river material between the two sites;
- Material between the west boundary of Site J and the downstream area of the damsite; and
- The section from the damsite to Borrow Site E.

This last area was considered to require excessive dredging and could likely affect the hydraulics of the tailwater.

An active slope failure was identified near Borrow Site H. If further studies show that the excavation of river material beneath this slide may result in slope failure, than this section of alluvium will be left in place. In summary, a total of 125 mcy of material were estimated in Borrow Site I extending a distance of 8.5 miles downstream and 75 mcy in Borrow Site J over a distance of 7 miles upstream.

o Engineering Properties

Three basic gradations are present within the two sites. These are fine grained silty sand, sand and gravel. The fine silty sand fraction was encountered in 25 percent of the test pits and ranged in thickness from 6 inches to 6 feet. The second gradation is a sand which varies from a well-sorted clean sand to a gravelly poorly sorted sand. This type of material was encountered in only 15 percent of the 22 pits, and where present, underlies the silt layer with an average thickness of about 4 feet. The bulk of the samples are of a moderately sorted gravel mixed with from 20 to 40 percent of sand and silt with less than 5 percent silt and clay size fraction.

- Quarry Site L

o Proposed Use

Quarry Site L has been identified as a source for cofferdam shell material.

o Location and Geology

Quarry Site L is located 400 feet upstream from the proposed upstream cofferdam on the south bank. The site is a rock knob immediately adjacent to the river which is separated from the main valley walls by a topographically low swale that has been mapped as a relict channel.

The rock in the quarry area is diorite along the western portion of the knob with andesitic sills or dikes found farther upstream. The rock exposure facing the river is sound with very few shears or fractures. The vegetation is heavy brush with tall deciduous trees on the knob and alders with brush in the swale to the south. Little surface water is present on the knob; however, the low lying swale is marshy. Permafrost may be expected to be present throughout the rock mass.

Quarry Site L lies opposite "The Fins" feature which is exposed on the north abutment; however, extensive mapping in this area shows no apparent shearing or fracture that could be correlative with the extension of this feature.

o Reserves

Because of limited bedrock control, the site has been delineated into two zones for estimating reserves. Zone I delimits the total potential reserves based on assumed overburden and rock volumes, while Zone II identifies that volume of rock that, with a high degree of confidence, is known to be present. Based on field mapping and airphoto interpretation, the total useable volume of material has been estimated to be 1.3 mcy for Zone I and 1.2 mcy for Zone II, over an area of 20 acres.

o Engineering Properties

No testing was performed on rock samples for Quarry Site L. However, based on field mapping, it appears that the rock properties and quantities will be similar to those at the damsite.

(ii) Devil Canyon Borrow Sites

One borrow site and one quarry site were identified for the Devil Canyon study (Figure E.10.7). Borrow Site G was investigated as a source for concrete aggregate and Quarry Site K for rockfill. Despite detailed reconnaissance mapping around the site, no local source for impervious or semipervious material could be found. As a result, Borrow Site D from the Watana inventory has been delineated as the principal source for this material. Further investigations may identify a more locally available source. The following sections provide a detailed discussion of the borrow and quarry sites for the Devil Canyon development.

- Borrow Site G

  o Proposed Use

  Borrow Site G was previously identified by the USBR and investigated to a limited extent by the COE as a primary source for concrete aggregate. Because of its close proximity to the damsite and apparent large volume of material, it became a principal area for investigation.

  o Location and Geology

  Borrow Site G is located approximately 1,000 feet upstream from the proposed damsite. The area delineated as Borrow Site G is a large flat fan or terrace that extends outward from the south bank of the river for a distance of approximately 2,000 feet. The site extends for a distance of approximately 1,200 feet east-west. Cheechako Creek exits from a gorge and discharges into the Susitna River at the eastern edge of the borrow site. The fan is generally flat-lying at Elevation 1000, approximately 80 feet above river level. Higher terrace levels that form part of the borrow site are found along the southern edge of the site above Elevation 1100.

  Vegetation is scattered brush with mixed deciduous trees found on the floodplain and fan portions. On the southern hillside portion of the borrow site, heavy vegetation is evident with dense trees and underbrush. The ground cover averages up to 0.5 foot in thickness and is generally underlain by 1 to a maximum of 6.5 feet of silts and silty sands. This silt layer averages 1.5 feet thick on the flat-lying deposits, and up to 2 feet thick on the hillsides above Elevation 950.

No groundwater was encountered in any of the explorations. The high permeability of the material provides for rapid drainage of the water to the river. Annual frost penetration can be expected to be from 6 to 15 feet. No permafrost has been encountered in the area.

The borrow material has been classified into four basic types, based on the interpretation of field mapping and explorations. The four types of material are: Susitna River alluvial gravels and sand, ancient terraces, Cheechako Creek alluvium, and talus.

The large fan deposits are a combination of rounded alluvial fan and river terrace gravels composed of various volcanic and metamorphic rocks and some sedimentary rock pebbles. This material is well-washed alluvial material.

o <u>Reserves</u>

The quantities of fine sands and gravels above river level have been estimated to be approximately 1.1 and 1.9 mcy, respectively. Additional quantities could be obtained by excavating below river level. The quantity of material from the ancient terrain is tentatively estimated to be approximately 2 mcy. This, however, has been based on an inferred depth to bedrock. If bedrock is shallower than estimated, this quantity would be less.

Cheechako Creek alluviaum is estimated at 1.1 mcy, while the quantity of talus is 55,000 mcy. Talus quantities are too small to warrant consideration as a borrow material.

An estimate of the total quantity of borrow material is about 3 mcy with an additional 3 mcy potentially available from inferred resources. The increase in river level caused by diversion during construction may affect the quantity of available material from this site. Therefore, further work will be required in subsequent studies to accurately determine available quantities and methods and schedules for excavation.

o Engineering Properties

The deposit is a gravel and sand source composed of rounded granitic and volcanic gravels, with a few boulders up to 3 feet in diameter. Deteriorated materials comprise about 8 to 10 percent of the samples.

Testing performed by the USBR indicates that about 2 to 4 percent of the material was considered adverse material for concrete aggregate.

Two distinct grain sizes are found in the site: 1) from the auger holes, a fairly uniform, well sorted coarse sand with low fine content and 2) from the test trenches, a fairly well-graded gravelly sand averaging 10 percent passing No. 22 sieve. The principal reason that the auger drilling did not encounter the coarser material is likely reflective of the sampling technique where the auger sampling could not recover the coarser fractions.

A finer silty layer overlies much of the borrow site. Samples from the higher elevations are more sandy than those from the fan area.

Based on observed conditions, the grain sizes from the trenches are considered more representative of the material in Borrow Site G at depth, while the finer fraction represents the near surface material.

- Quarry Site K

o Proposed Use

Quarry Site K was identified during this study as a source for rockfill for the construction of the proposed saddle dam on the south abutment.

o Location and Geology

The proposed quarry site is approximately 5,300 feet south of the saddle damsite, at approximate Elevation 1900. The site consists of an east-west face of exposed rock cliffs extending to 200 feet in height. Vegetation is limited to tundra and scattered scrub trees.

Drainage in the area is excellent with runoff around the proposed quarry site being diverted to the north and east toward Cheechako Creek. The groundwater table is expected to be low and confined to open fractures and shears.

The bedrock is a white-gray to pink-gray, medium grained, biotite granodiorite similar to that at the Watana damsite. The rock has undergone slight metamorphism and contains inclusions of the argillite country rock with local gneissic texture. The rock is generally massive and blocky, as evidenced by large, blocky, talus slopes at the base of the cliffs.

The rock is probably part of a larger batholith of probable Tertiary age which has intruded the sedimentary rocks at the damsite.

- Reserves

The limits that have been defined for the quarry site have been based on rock exposure. Additional material covered by shallow overburden is likely to be available, if required. However, since the need for rock fill is expected to be small, no attempt was made to extend the quarry site to its maximum limits. The primary quarry site is east of Cheechako Creek. This area was selected primarily because of its close proximity to the damsite and high cliff faces which is conducive to rapid quarrying. The low area west of the site was not included because of possible poor quality sheared rock. A secondary (backup) quarry source was delineated west of the primary site. Because of the extensive exposure of excellent quality rock in this area, additional exploration was not considered necessary for this study.

The approximate volume of rock determined to be available in the primary site is about 2.5 mcy per 50 feet of excavated depth, or approximately 7.5 mcy within about a 30- acre area. The alternative backup site to the west of Quarry K has been estimated to contain an additional 35 mcy for 150 feet of depth, covering some 145 acres.

- Engineering Properties

The granodiorite was selected over the more locally available argillite and graywacke because of the uncertainty about the durability of the argillite and graywacke under severe climatic conditions.

The properties of the granodiorite are expected to be similar to those found at the Watana damsite.

Freeze-thaw and wet-drying (absorption) tests performed on rock types similar to those found on Quarry K by the COE exhibited freeze-thaw losses of <1 percent at 200 cycles and absorption losses of 0.3 percent. Both tests showed the rock to be extremely sound and competent.

10.3 - Alternative Electrical Energy Sources

A detailed study of the Alaska Railbelt Generating Alternatives was undertaken by Battelle Pacific Northwest Lab. Most of the information in this section is taken from reports documenting that study (20).

(a) Coal-Fired Generation Alternative

Previous studies have indicated that alternative generating resources available to supply power to the Railbelt region include use of the Beluga coal fields. The economic and technical feasibility of developing this resource and of the selection process utilized to conclude the economic feasibility of Beluga coal, is discussed in Exhibit B.

Information presented in this section was extracted from previous reports prepared in conjunction with studies of developing the Beluga coal fields (4, 5, 9, 19). Because specifics of plant design and location are not available, the existing environment is described for the general area and impacts are discussed in generic terms only.

For purposes of this evaluation, an electrical generating plant with total capacity of 400 MW was assumed. Coal would be strip-mined from the Beluga fields, transported to the plants, and burned to produce electricity. Treatment of waste streams, including air, water, and solid waste, would occur at the site. Approximately 1.5 million tons of coal per year would be burned. A construction camp would be built near the site, and a permanent village maintained for mining personnel and plant operators.

(i) Existing Environmental Condition

The Beluga coal fields are located approximately 50 to 60 miles southwest of Anchorage on the western side of Cook Inlet. The coal fields are bordered by Cook Inlet on the east and south, the Chakachatna River on the west, and the Beluga River, Beluga Lake, and Capps Glacier on the north (13).

- Air Quality

Air quality in the Cook Inlet and Beluga coal field area can be described as good. The Cook Inlet Air Quality Control Region is designated as a Class II Attainment area for all criteria pollutants. The Tuxedni National Wildlife Refuge approximately 80 miles southwest of the project area is Class I Attainment area for all criteria pollutants.

- Topography, Geology, and Soils

The topography of the western shore of Cook Inlet is dominated by high glaciated mountains dropping rapidly to a glacial moraine/outwash plateau which slopes gently to the sea. The outwash/moraine deposits begin at an elevation of approximately 2500 and drop to tidewater in 30 to 50 miles (4).

The major geologic feature of the area is the Nikolai moraine which lies in contact with sedimentary Tertiary rocks (9). Most coals occur in the Tyonek Formation of the Tertiary Kenai Group (10). The area is geologically young with higher upland elevations consisting of slightly to moderately modified glacial moraines and associated drifts.

The lowland areas are mantled with glacial deposits and overlaid by silt loam.

Soils are variable in the area. Generally, soils in the southern portion of the area are sandy but poorly drained, and soils in the west are well drained and dark, formed in fine volcanic ash and loam. Soils in the east and northern areas range from poorly drained fibrous peat to well-drained loamy soils of acidic nature.

- Surface Hydrology

The three major river systems in the Beluga coal field area are the Chakachatna, Beluga, and Chuitna. The Chakachatna is the largest, with headwaters in Chakachamna Lake and a 1,620-square-mile drainage area, and a length of 36 miles. The Chuitna River begins near Capps Glacier, flows 27 miles, and drains approximately 150 square miles. The Beluga River is 35 miles in length and drains 930 square miles (9).

- Terrestrial Ecosystem

o Flora

Four major vegetative communities in the region are the upland spruce-hardwood forest, high brush, wet tundra, and alpine tundra.

The upland spruce-hardwood forest is centered in the southern and central portions of the Beluga area and covers 40 percent of the area (9). This forest is composed of paper birch, quaking aspen, black cottonwood, and balsam poplar (4).

The high brush community in the west central portion of the Beluga district covers 15 percent of the land area. This type occupies a wide variety of soil types and may occur as pure thickets in low-lying areas. Principal species include sitka sider, raspberry dogwood, and spirea (4, 9).

The wet tundra plant community occupies 7 percent of the area in the extreme southwest portion and along the eastern boundary. The vegetative mat is dominated by sedges and cottongrass, with scattered woody and herbaceous plants. Principal species include willow, birch, labrador tea, grasses, and lichens.

The alpine tundra area occupies less than 3 percent of the land area and occurs only at the higher elevations. This community comprises primarily low mat plants, both woody and herbaceous. Principal species include birches, willows, blueberry, rhododendron, and sedges.

o Fauna

The area of the Beluga coal fields supports wildlife population typical for this area of Alaska. Big game in the areas include moose, black bear, and brown bear. Both species of bear den in the area and utilize the Selvon fishery as a food source (4). A major fall and winter concentration of moose occurs in the high brush community in the west central portion of the coal fields near the Chuitna River. They are also found throughout the area during other times of the year (9).

A high diversity of bird life is present in the area, particularly during the fall and spring migration periods. Active nesting sites of bald eagles and trumpeter swans occur on the Chuitna River and peregrine falcons occur in the area (4). The coastal areas are heavily utilized by waterfowl (9). Harbor seals, Beluga whales, and other species of marine mamals occupy Cook Inlet near the study area.

- Aquatic Ecosystem

The cold, running waters of river and streams in the area support both resident and anadramous fisheries. The Chuitna River supports five species of salmon (pink, king, chum, coho, and sockeye) plus rainbow trout, Dolly Varden and round white fish (9). Nikolai Creek, Jo's Creek, Pitt Creek, and Stedatana Creek are also known to support anadramous fish populations.

- Marine Ecosystem

The Cook Inlet region just south of the Beluga coal fields is a diverse area, with both aquatic and terrestrial habitats. Intertidal and shallow subtidal habitats contain broad expanses of gravel and sand and extensive areas of mud flats. These areas show varying levels of productivity, with the mud flat areas generally at low levels (4). Dominant fauna present include pelecypods and polychaete worms. The area of gravel and sand support moderate densities of amphipods and isopods.

The Cook Inlet area is also important to commercial and sport fisheries. Four species of salmon and halibut utilize this area and are harvested on a commercial basis, as are herring, shrimp, and crabs. Commercial salmon harvested in 1980 was estimated at 20.4 million pounds with a value of $18 million. The average annual herring catch is 6.4 million pounds, worth approximately $1.3 million. The smaller halibut fisheries yield approximately 0.6 million pounds, worth $400,000, while the shellfish harvest of crab and shrimp yields 16 million pounds annually, worth $8.5 million (4).

Subsistence fishing is also conducted by local natives, particularly by those from the Tyonek area. Species harvested include clams, bottomfish, salmon, and smelt.

The diverse wetland and aquatic habitats support large numbers of birds, particularly during the migration periods. The coastal wetlands and mud flats are heavily utilized by waterfowl, cranes, and shorebirds, while the offshore waters and sea cliffs are inhabited by sea birds such as gulls, puffins, and murres.

Marine mammals present in the Cook Inlet area include seals, whales, and dolphins. Only the harbor seal and Beluga whale are known to occur in the upper Cook Inlet.

- Cultural Resources

Historic sites occur within the modern town of Tyonek. Other sites nearby include Californsky's fish camp, old village sites, and cemeteries. Few archaeological sites are believed to be in the area, primarily because the violent actions of the tide would have destroyed most of the sites left by coastal-dwelling natives.

- Socioeconomic Conditions

The only substantial settlement on the west coast of Cook Inlet is Tyonek, inhabited by approximately 270 Tanaina Indians. The village is typical of many small villages in Alaska, with high unemployment. Recently, government programs have somewhat alleviated this problem.

Employment on the west side of Cook Inlet is supplied by three commercial developments: the Chugach generating station, Kodiak lumber mill, and crude oil processing and transportation facilities. Commercial fishing and subsistence activities are the major sources of income.

Housing consists primarily of prefabricated structures. One school, with total enrollment of 140, serves kindergarten through the 12th grade. Police protection is provided by the Alaska State Troopers utilizing a resident constable. Fire protection is provided by the U.S. Bureau of Land Management. Medical services are available in a medical center located in the village. Water is supplied from a nearby lake and wastewater disposed of via septic systems (4, 9).

Transportation facilities in the areas are limited to gravel logging roads and small airstrips.

(ii) Environmental Impacts

- Air Quality

Coal mining and power generation will result in emissions to the atmosphere of particulate matter, nitrogen oxide, sulfur oxide, carbon monoxide, and hydrocarbons, as well as lesser amounts of other pollutants. Their impacts cannot be quantified without detailed air monitoring and modeling; however, some generalizations can be made.

Mining emissions would comprise primarily particulate matter from vehicular traffic, surface disturbance, and wind across coal piles and disturbed areas. Heavy equipment operations would also result in nitrogen oxide, carbon monoxide, hydrocarbon, and sulfur oxide emissions.

Beluga coal is characterized as sub-bituminous (6,500 - 7,500 Btu/lb) with low sulfer (0.2 percent), high moisture (25 to 28 percent) and high ash content (14 to 25 percent) (4). This sulfur and heat content is comparable to that of Powder River Basin coal in Wyoming, but the moisture content is approximately twice the Powder River value. Utilizing these figures and calculations from previous reports yields approximate daily emission rates for a 700 MW facility (11).

SO_2	40 to 60 tons per day (no scrubber)
Fly ash	3 to 5 tons per day (with precipitators)

Exact amounts of these pollutants and of nitrogen oxides cannot be calculated without specific design criteria and details on pollution-control devices.

A Prevention of Significant Deterioration (PSD) review would be necessary prior to construction. This process would require that any emissions be within the allowable increments established in the Clear Air Act regulations. However, because the area is currently relatively free of air pollution, the emissions from coal mining and generating station operation would likely result in a noticeable degradation of existing air quality. In addition, short term maximum concentrations could, under certain meteorological conditions, exceed the National Ambient Air Quality standards near the power plant (10). This would would be particularly true during periods of inversion.

- <u>Topography, Geology, and Soils</u>

Coal mining and construction of the generating facilities have the potential to impact topography and soils in the area. Mining operations would unavoidably change the topography of the area, although reclamation and compliance with regulations of the Surface Mining Control and Reclamation Act would minimize these impacts. Soil erosion from mining and plant construction activities could also occur if proper precautions are not implemented.

- <u>Hydrology</u>

Little is known about ground water resources in the area (4). Strip mining has the potential to degrade the water quality and interferes with ground water flows. Regulations of the Surface Mining Control and Reclamation Act and the state of Alaska would require these impacts be minimized.

Surface water could be affected from runoff from the mined area, coal storage piles, site grading, road building, and other construction activities. Plant operation would also result in polluted and heated water from electrical generation. Potential sources of contamination are acid mine drainage, treatment chemicals, dust, spoil-pile runoff, fuel spillage, ash, and industrial waste. This could impact surface water quality through changes in

turbidity, rates of photosynthesis, dissolved oxygen, temperature, pH, and heavy metals.
It can be expected all point sources of discharge will meet Federal New Source Performance standards and other regulations of the Federal Water Pollution Control Act. However, because of the high water quality of the river and streams in the area, any impacts will be noticeable. In addition, because of the seasonal fluctuation of flows in the area, the impacts of sedimentation and other water quality effects may be increased (10).

- Terrestrial Ecosystems

Surface mining will unavoidably result in the removal of vegetation and wildlife habitat. If not properly restored and revegetated, erosion would result and the habitat permanently reduced in value. The areas of the generating facility, roads, and ancillary facilities would be permanently removed as wildlife habitat.

In addition to the direct impacts to wildlife, secondary effects would also occur. These include increased hunting pressure on moose and bear because of a larger human population and greater activity. New roads will add access to the area, resulting in habitat disruption and disturbance to the animals. This reduction in habitat and other secondary effects will result in a substantial loss in carrying capacity for most wildlife species and a subsequent decline in their population levels.

- Aquatic and Marine Ecosystems

The impacts to aquatic and marine ecosystems would depend primarily upon the effectiveness of siltation control devices and degree of water treatment. Some aquatic habitat would be lost because of mining activities. In addition, increase sedimentation, interuption or reduction in flows, and degradation of water quality could all result in negative impacts to aquatic habitats, thereby reducing fish population in the area. The potential also exists for changes in water quality to interfere with anadromous fish runs and reproduction, thereby affecting marine resources in Cook Inlet. Impacts to other marine resources, unless water quality is severely impaired, are not expected to occur.

- Cultural Resources

Potential impacts to cultural resources include disturbance of sites, destruction of artifacts, and increased access to the areas resulting in disturbances to sites previously inaccessible. A cultural resource survey would be required on all areas to be mined or built upon. If significant sites are discovered, mitigation will likely occur, utilizing either avoidance or salvage operations.

Thus, with the exception of the disturbance of areas outside the project site but not currently accessible, impacts to cultural resources should be mitigatable.

- Socioeconomic Conditions

There are many impacts which affect socioeconomic factors in an area. These include construction camp location (if any), commuter modes, family relocation, worker need for services, amount of local labor available, and construction schedules. Thus, only generalized impacts can be predicted.

Depending upon the size of the generation facility, direct and indirect jobs will range from 400 to 1,300 (4, 9). Most of these workers would likely come from the available work force in Anchorage, with some from the Kenai Peninsula and the local village of Tyonek.

If a construction camp or new village were created near the plant site, local population would increase by several thousand. This would require construction of new roads, sewage and water systems, and other infrastructures necessary to support these workers and their families. Some of these services would be supplied by the Kenai Peninsula Borough, but most would likely be supplied either by the state of Alaska or the company building and operating the generating facility. Thus, financial impacts to the borough should be small (4). However, because the Beluga coal fields are only 75 miles from Anchorage, it is not likely a large, permanent village would be required, since most workers would prefer to live in the construction camp and leave their families in the Anchorage area.

The generating facility could add substantially to tax revenues in the Kenai-Soldotna area. This revenue would likely expand government services in the area and thereby create additional employment opportunities.

Finally, there would likely be impacts to the village of Tyonek. The large generation facility would result in increased contact with non-native people and their way of life. There could also be conflicts with subsistence hunting and fishing activities and a potential, through sport hunting, to reduce the resource bases utilized by the natives. These increased contacts with non-natives could result in the continued erosion of native customs and cultural values.

Employment opportunities would be available for Tyonek village residents. In addition, native business could likely increase to supply goods or services to the construction workers and construction site. Thus, the project would result in positive economic benefits to the village.

In summary, socioeconomic impacts to the area of plant development would not be great, primarily because of the proximity of the site to the greater Anchorage area. This area would supply most of the labor force and absorb most of the impacts from development of goods and services to supply the site. Population levels at the site would increase, with the magnitude dependent on the nature of the construction camp; however, it is likely there would not be more relocation of families to the site. Positive economic benefits would occur to the native village of Tyonek, but potential negative impacts to the cultural values also exist.

(b) Tidal Power Alternatives

The Cook Inlet area has long been recognized as having some of the highest tidal ranges in the world, with mean tide ranges of more than 30 feet at Sunrise on Turnagain Arm, 26 feet at Anchorage, and decreasing towards the lower reaches of Cook Inlet to 15 feet or so near Seldovia. Information concerning feasibility of tidal power generation and environmental impacts were gathered mainly from current studies being conducted for the Office of the Governor, State of Alaska. Initial studies of Cook Inlet tidal power development (12) have concluded that generation from tide fluctuation is technically feasible, and numerous conceptual schemes ranging in estimated capacity of 50 MW to 25,900 MW have been developed.

(i) Preferred Tidal Schemes

Studies conducted for the Governor's office (16) have indicated three sites are best suited for tidal power development. This analysis, based on capacity, energy generation and costs, considered sixteen sites and chose the following (Figure E.10.6):

- Rainbow - This site crossed Turnagain Arm from a point near the mouth of Rainbow Creek to a point approximately two miles east of Resurrection Creek.
- Point MacKenzie/Point Woronzof - This site crosses Knik Arm near Anchorage.
- Eagle Bay/Goose Bay - This site crosses Knik Arm at the narrowing of the channel along Eagle and Goose bays.

Tidal power generation basically involves impounding water at high tide level and converting the head difference between the corresponding basin and the ebbing tide. Present technology allows for extraction of this energy by low-head hydraulic turbines to generate electricity. A tidal power generation project, therefore, would involve construction of dams, sluice ways, powerhouses, and transmission lines (12).

(ii) Environmental Considerations

Environmental assessments of the preferred Cook Inlet tidal development involve consideration of physical and biological characteristics anticipated impacts, and short- and long-term effects.

- Physical Characteristics

Several major characteristics of Cook Inlet are relevant to an understanding of the processes and the potential for change in the estuarine environment. These are the tidal regime, hydrology, sediment load, and climate.

The mean tide range in Knik and Turnagain Arms is 25 to 30 feet. This extreme tidal variation, combined with shallow water depths, results in a high velocity current, turbulence, and high levels of suspended sediments. Thus, suspended sediment load is also affected by the high concentration of silts and sediments present in glacial runoff that enters Cook Inlet.

Runoff from glaciers also affects the salinity concentration in Cook Inlet. In the summer months, when freshwater flows are high, salt concentrations drop and suspended load increases. In the winter, as streamflows diminish, salinity concentration increases.

- Biological Characteristics

Cook Inlet is an estuary where freshwater and saltwater environments meet. These areas are usually highly productive partly because of high nutrient levels.

In Knik and Turnagain Arms, high turbidity and limited light penetration result in low biological productivity. Resident and shell-fishery populations are present only in low numbers; however, anadromous fish do use the turbid water for passage between the lower inlet and the natural streams. Five species of salmon are found in the tributaries to the Knik and Turnagain Arms. Comparatively, the Knik Arm tributaries appear to sustain a more significant anadromous fishery than Turnagain Arm. The important salmon rivers in Turnagain Arm are Chickaloon River, Bird Creek, Indian Creek, Portage Creek, Resurrection Creek, and Six Mile Creek. Of these, the largest salmon runs have been identified in the Chickaloon River. In Knik Arm, the most important salmon tributary is the Little Susitna River. Other important streams are Fish Creek, Wasilla Creek, Cottonwood Creek, Knik River and Matanuska River.

Intertidal areas, mud flats, and lowlands are extensive in the Cook Inlet area partially because of the wide tidal fluctuations. Mud flats are broad expanses with little vegetation. Above these areas are marshland habitats, supporting grasses, emergents, submergents, and shrub vegetation. In terms of biological productivity, these coastal marshes are the most important areas within Cook Inlet. They provide important nesting and staging habitat for hundreds of thousands of shorebirds and waterfowl during the spring and fall migrations. This results in extensive recreational hunting opportunities for Alaska's most heavily populated area. During the years from 1971 to 1976, approximately 30 percent of the state duck harvest occurred in Cook Inlet.

Five coastal marshes in Cook Inlet are protected as state game refuges; four of these are in proximity to proposed tidal power development sites. They are Potter Point, located just south of Anchorage at the mouth of Turnagain Arm; Palmer Hayflats, in the upper reaches of Knik Arm; Goose Bay, on Knik Arm ten miles north of Anchorage; and Susitna Flats, to the west of Point MacKenzie at the mouth of the Susitna and Little Susitna rivers. Other important marshlands not protected as refuges are Eagle River Flats, across Knik Arm from Goose Bay, and Chickaloon Flats, across Turnagain Arm from Potter Point.

Although Cook Inlet is not an important habitat area for marine mammals, a few species do occasionally migrate to the area. Beluga whales are known to occur in the water offshore from Anchorage.

The endangered Arctic peregrine falcon is known to nest in the upper Cook Inlet region and to utilize coastal areas during the migration periods. Bald eagles, not classified as endangered in Alaska, also are present in the region. No endangered waterfowl species have been verified in Cook Inlet, although habitat for the Aleutian Canadian goose may occur in the southern reaches of the Inlet.

- Anticipated Impacts

The construction and operation of a tidal power plant in either Knik or Turnagain Arm will affect the physical processes of Cook Inlet and cause changes that may directly or indirectly influence the natural environment. These impacts can be divided into short-term and long-term effects.

- Short-Term Effects

Short-term effects are those associated with construction activities and include:

o Site development and construction;
o Site access and traffic;
o Operation of equipment;
o Dredging and dredged material disposal; and
o Development of construction material sources.

These short-term activities will affect, for the most part, only the environment in the vicinity of the site and will extend for the construction period. Some permanent changes will occur in the environment, such as placement of permanent facilities, but the effects will be site-specific. It should be noted that many of the negative impacts normally associated with construction can be eliminated by proper wastewater facilities, erosion control methods, and other mitigating measures.

o Dredge and Fill

The activities associated with dredging and filling may cause the most significant construction effect, because of the quantities of materials being moved and the necessary use of remote sites for dredged material disposal and acquisition of construction materials.

The Eagle Bay and Rainbow sites will both require dredging of 30 million cubic yards of sediments from the inlet bottom. Most of this will not be suitable as construction material and will need to be transported from the site for disposal. Acceptable sites for marine dumping can be found downstream where the Inlet broadens, but care must be taken to avoid commercial fisheries located in the Fire Island vicinity. The dredged material itself is not polluted or chemically contaminated. The physical constituents of the dredged material are likely to be similar to the bottom sediments found further downstream. Disposal of dredged material may temporarily disturb bottom organisms, but habitats would soon be re-established. Careful planning in the timing and choice of disposal sites can insure minimal impacts.

Because little of the dredged material at either the Eagle Bay or Rainbow sites would be suitable as construction material, upwards of seven million cubic yards of fill material must be procured from offsite sources. This would cause disturbance of upland habitats resulting from the activities of excavation and transport. Unavoidable impact of these activities may be reduced by avoiding development in sensitive environments.

The Point MacKenzie site is most attractive from the standpoint of dredge/fill operations. Less than one quarter of the dredging required for either Rainbow or Eagle Bay will be necessary for Point MacKenzie. Additionally, a substantial portion of the material removed will be rock, gravel, and sand that may be appropriate for dam construction. This further diminishes the volumes required for acquisition and disposal.

- Site Access and Traffic

Establishing access to the site by land and by sea and providing for the high volume of traffic that will occur during the construction period will affect the environment. Roads and marine docking facilities will be constructed. Marine traffic for construction purposes, delivery of equipment, and dredging operations will occur in areas where little or no shipping or boating of any type has occurred. Access roads will be established in previously undeveloped areas.

To minimize these impacts, land routes can be chosen to avoid sensitive areas such as waterfowl habitat, and the high volumes of traffic can be limited to construction periods. Marine traffic is not likely to affect the few resident species nor block the mobile anadromous species as they migrate up and downstream. The marshlands, waterfowl habitats, and upland game reserves would be most affected by development, noise, and traffic activities.

- Site Development and Construction

The preparation of the site for construction, as well as the activities associated with construction, will have its greatest impacts on the site itself. Alterations of topography and existing habitats will occur. The presence of large, noise-producing equipment and human activity will be disruptive to habitats.

Site development can be conducted in a manner that will minimize impacts. Minimization of land use, implementation of plans for erosion control and landscaping, and development of permanently useful facilities such as dry docks will aid in reducing impacts.

Noise factors are potentially most significant at the Eagle Bay site, which is located only a few miles upstream from Goose Bay State Game Refuge. The noise levels have the potential to disrupt waterfowl, but habituation can be expected.

The marine construction activities will affect the aquatic environment. Dredging, fill placement, dry dock construction, caisson construction, and installation will occur in the water. There are few resident species to be disturbed, but migration of anadromous fish may be affected. It is likely that measures to insure fish passage will be required during all stages of construction, reducing these impacts.

- Long-Term Effects

Certain aspects of plant operation may alter the physical regime of the estuary. These will be discussed in terms of their environmental implications:

. the altered tidal regime and estuarine hydrology; and
. the alteration of hydraulic characteristics: currents/ velocities, erosion/sedimentation.

Additionally, the following long-term impacts will be considered:

. impacts added by the causeway alternative.

o Effects of an Altered Tidal Regime

The process of capturing the tide in a basin behind the barrier and regulating the flows through it has two important consequences. First, the mean tide level in the newly formed basin will be raised by several feet. Second, the mean tide range will be substantially decreased. Mean high tide levels will probably be slightly lower and mean low tide levels will be higher than what presently exist.

The result of these changes can be conceptualized as follows. The extent of the mud flats will likely be somewhat diminished. The lowest reaches of the mud flats will remain totally submerged, since the tide will never reach its previous low levels. At the upper limits of the mud flats, marshland vegetation may encroach seaward. As the frequency of inundations decreases at the edges of the marshland, marsh grasses will grow on the former edges of the mud flats. This will result in shifts in locating mud flats and possible changes in acreages.

Other changes may alter the distribution of plant types on the lands affected by the tides. A net increase in the mean water level may alter the water table and hence runoff and other hydrologic characteristics of adjacent marshlands. Also significant is the effect of altered salinities that may occur as tidal waters are stored in the basin. There is some potential that intrusion of saltwater may have harmful effects on the ground water table. It should be noted that the Cook Inlet marshlands are high stress environments, characterized by large seasonal variation of salines. Therefore, changes in seasonal variation of salinities will probably not be detrimental to marshland vegetation.

Other hydrologic characteristics could be affected, such as backwater and flooding. The raised water table could affect lowland drainage and vegetation. It appears that, although the potential for alteration is great, it is also possible that only slight changes in populations will occur that will not greatly alter the nature of the environment as a habitat for waterfowl, shorebirds, and furbearing species.

The tidal regime may also be altered downstream from the barrier. However, the impoundment of a portion of high tide water behind the barrier will not greatly alter existing water levels or tidal fluctuation downstream. Possible effects caused by resonance of tidal waves will have to be studied in detail, but it appears likely that the effects of the barrier will have much greater potential for impact upstream from the dam.

o <u>Hydraulic Characteristics of the Basin</u>

Regulation of flow in the basin will affect hydraulics local to the dam itself, as well as having more widespread impacts. Existing current patterns and velocities throughout the basin would be altered. The most noticeable change will occur near the dam where the concentration of flow velocities through turbines and sluiceways would alter local flow patterns. These local high velocities will be dissipated with increasing distance from the dam. The decreased tidal range may result in an overall decrease in turbulence and mixing, although the tide range will still be substantial in relation to the depth of water so that the regime of total mixing may not be altered.

The effect of siltation on the environment and on the operation of the tidal power plant has not been fully assessed. Investigations of sedimentation in the Bay of Fundy, La Rance and other construction reported that siltation caused by construction within the tidal flow is a function of: the degree of flow reduction caused by construction; the availability of appropriate sized sediment in the water; and the combined supply of material to the site.

Knowledge of the origin of sediments and the existing transport mechanism is necessary to analysis of the latter.

Sedimentation and erosion processes may be affected in the silt-laden estuary. The mud flats and bottom conditions of the Arms are highly mobile. Changes can result from a net increase or a net decrease in velocities and from redistribution of wave energy on the shoreline. These will have the greatest potential for harmful impacts to the natural environment on the shorelines of marshlands, where erosion of the outlying mud flats could result in eventual erosion of the marshland and loss of habitat. It is possible, however, that a net decrease in energy in the basin (lower tide range, decreased mixing, decreased tide range) will result in higher sedimentation rates. If this is the case, it may cause decreased storage in the basin, and correspondingly, a buildup of mud flats and an extension of marshlands.

The effects of sedimentation may also be significant downstream from a barrier in Cook Inlet. Observation of recently constructed causeways at Windsor, Nova Scotia, and on the Petitcodiac estuary in New Brunswick reveals the development of large, mid-channel mud flats seawards of the barrier caused by local flow reductions. This could result in a reduction of sediments which are normally deposited further downstream in the estuary. Effects on navigation may be significant in the Knik Arm where shoaling is already a problem in the approaches to Anchorage harbor.

Another factor related to sediment load in the Inlet waters is that of penetration of light as required for biological productivity. At present, high turbidities limit light penetration. This may be the limiting factor for growth of the aquatic food chains. It is possible that along with a decrease in sediment load, an increase in food production could result in a habitat more amenable to aquatic species.

o Causeway Development

The addition of a causeway to the tidal power project would not create any additional impacts to the upstream and shoreline environment. The most significant impacts would result from development of a permanent road through previously undeveloped areas and from the residential and commercial growth that would occur because of the new access. Other impacts to the Inlet include increased traffic noise across the causeway and increased human access to the wetlands for recreational purposes.

(iii) Effects on Biological Resources

Construction and operation of a tidal power facility has the potential to affect anadromous fish in Cook Inlet. Because of the commercial and recreational importance of this resource, specific mitigation techniques would have to be developed to minimize these impacts.

Anadromous fish return to their natural streams to spawn. The mechanism by which they locate these streams is not fully understood, but it is believed the fish respond to changes in water chemistry. Thus, although it is unlikely retiming of tides will affect the hydrology and physical or chemical composition of water upstream from the reach of tidal fluctuations, the changes in sediment load and salinity of water below the power facilities could potentially affect the migration.

The largest salmon runs in Turnagain Arm occur in the Chickaloon River. Since the river is located approximately 10 miles downstream from the Rainbow site, migration should not be directly affected. In the Knik Arm area, the most important salmon tributary is the Little Susitna River, which is 10 miles downstream from the Point MacKenzie site; impacts there also should not be great. However, in both cases, it should be noted that as fish appproach their natal streams, they may wander as far as 10 miles past the mouth before turning back to the ultimate goal. In this manner, the Point MacKenzie and Rainbow sites could conceivably affect migration to the Little Susitna and Chickaloon River, respectively, although the damsites appear to be the limits of the interaction zone.

- Wetlands and Waterfowl Habitat

There are three primary mechanisms by which the tidal plant would directly cause impacts to marshlands:

- Distrubance along the shores of the impounded basin;
- Interaction with the construction site, noise, activity, and equipment; and
- Imposition of an altered flow regime downstream from the dam.

Of these three primary impacts, the potentially most significant would be the effects of the altered tidal regime on the stability and productivity of the marshland ecosystems within the impoundment basin. Altered sedimentation patterns could result in eroded shorelines. A raised water table could result in a more saline ground water table. Altered surface hydrology may affect filtering and transport of nutrients and organics within the marsh. A loss of marsh area and a loss of vegetation types required for support of bird populations can be envisioned, thus diminishing productivity and resulting in degradation of the waterfowl habitat.

Alternatively, sedimentation may result in an enlargement of marshlands. Effects of changes in hydrology, inundations, and nutrient supplies could produce an environment more attractive to waterfowl and other species. Somewhere between the best case and the worst case lie any number of variations where, for example, vegetation or land areas may be altered but have little impact on bird populations. The conclusion, at this point, is that the interactions between hydrology, hydraulics, and the wetland ecosystem must be better understood in order to predict effects with more reliability. This should be the main focus of future environmental studies.

Operation of the tidal project may affect the hydraulics of the inlet downstream from the dam. These effects should be studied in greater detail for their impacts on coastal marshlands. Later phases of engineering studies should include modeling the effects of the dam on downstream hydraulics and water levels to determine ecological impacts.

- <u>Marine Mammals</u>

Construction of tidal-generating facilities could affect the movement of marine mammals in the area. Care must be taken in design of intake structures and dam approaches to prevent harm to these animals in the event of their interaction with the structure. Other mammals may also be involved, and their movements may extend to the other damsites. This question should be more thoroughly investigated in later studies, including potential effects on marine mammal food sources.

(iv) Other Effects

- Water Quality

Present water quality is characterized by extremely high turbidity, relatively high dissolved oxygen content, variable salinity and nutrient concentrations, and low levels of primary biological productivity. Several activities associated with the tidal project may affect water quality. These include the excavation and construction of the dam, increased ship traffic, and operation of marine equipment, as well as the regulation of flows to and from the basin.

Dredging, excavation, and placement of materials for dam construction in the submarine and intertidal environments may temporarily increase suspended sediment concentrations near the dam. Given the existing turbulence and turbidity of the water, this should not be a problem. Additionally, the introduction of new materials (sand, rock, gravel) from other sources may result in leaching of some chemical constituents not normally found in the waters. The possibility of serious chemical problems is very small.

The presence of construction equipment, tugs, barges and human activity indicates an increased possibility for such accidents as oil spills, fires, dumping of debris, and disposal of untreated sewage into the water. Adherence to health and safety plans and control of construction areas can minimize most undesirable effects.

The presence of the dam and the resultant flow patterns may act as a physical barrier which limits exchange of salt, nutrients, sediments, etc., between the freshwater inflows and the saltwater influence from the ocean. Although the total flow of water may be reduced by the dam, large volumes of water will still be exchanged. A well-mixed basin would result, although local flow patterns and water quality may be affected.

It appears that, though there are many potentials for impact to water quality, the associated risks are low.

- Climatology

Short-term and long-term changes in the climate of the region may occur as a result of tidal power development. Changes in ice formation, for example, could alter air temperatures in the basin vicinity.

- Rare and Endangered Species

  It is not anticipated that tidal power development would affect the endangered peregrine falcon.

(v) Socioeconomic Assessment

The socioeconomic issues of a tidal development would be similar to those of other capital intensive developments, particularly to those of a large hydropower project. The construction period, characterized by very high levels of activity and expenditure, would be followed by a long operational period during which these levels would become quite low. Annual costs of operation consist mainly of capital charges. The costs of maintenance and replacement would be quite small compared to these capital charges, and the other costs of operating the facility would be negligible.

A tidal project presents, however, certain aspects and options that are very different from more conventional power modes and which may yield distinctly different social and economic results. The following examples will illustrate the characteristics in the tidal power development that may make it unique from the socioeconomic viewpoint:

- Storage and generation will take place in the sea. Consequently, very few, if any, relocations of people and very little reallocation of land and water resources will be required.

- One of the more likely construction options will be the floating in of hugh prefabricated caissons and sinking them on location as components of the structure. If this method is adopted, a significant amount of the work may be done off the site.

- Depending upon final design and the site selected for development, a tidal project in the Cook Inlet will require from 30 to 60 turbine-generating units. Such a large number may be sufficient to justify establishment of a local industry for their manufacture and overhaul.

- Tidal power will be generated in surges lasting from 4 to 6 hours followed by interruptions of approximately 8-1/2 to 6-1/2 hours duration (adding up to lunar cycle of 12 hours and 25 minutes). Energy-intensive industries that could work on the rhythm of power availability might find the general region of tidal power plants to be an attractive location.

(vi) Impact on Adjacent Land Uses

The major impacts from tidal development in the Cook Inlet would occur in the Greater Anchorage Area Borough located in the south- central portion of Alaska at the head of Cook Inlet on a roughly triangular area of land between the two estuarine drainages, Knik and Turnagain Arms.

The areas within the boundaries of the municipality of Anchorage suitable for urban development are to the west of Chugach State Park, south and east including Alyeska-Girdwood, and north and east to Eagle River-Birchwood. Potential changes in land use would be to convert these areas into industrial use as businesses are attracted by availability of power.

(vii) Materials Origin Supply Study

The raw materials, intermediate goods, and equipment required for a tidal project can be grouped into three main categories:

- Raw Materials

These materials include aggregate, rock, cement, and lumber. It is expected that aggregate and rock can be supplied locally. The final aggregate (sand) will be transported from the Palmer area. The coarse aggregate for concrete will be crushed in the rock quarry areas near the selected sites as follows:

o Rainbow:	North and south side of Turnagain Arm--5-mile haul
o Point MacKenzie:	North side of Turnagain area near Rainbow site--30-mile haul
o Eagle Bay:	Mount Magnificant--15-mile haul

An estimate of direct labor required for the production of these items indicates that about 300 to 400 jobs may be involved during the construction period.

- Steel Products

These include reinforcement and fabricated gates. It is likely that these supplies would be from sources outside Alaska.

- Generating Equipment

This includes hydroelectric and electrical equipment, such as the turbines, generators, transformers, and switchgear. This equipment would be supplied from North America or Europe depending on market conditions.

(viii) Labor Supply and Limitations

A preliminary estimate indicates that the direct, onsite, labor requirements for the three sites considered would be approximately as follows:

Site	Rainbow	Eagle Bay	Point MacKenzie
Average man-years per year:			
Over 7.5 years	1,875		
10.5 years		2,000	
11.5 years			2,500
Peak demand man-years per year:	2,000	2,200	2,750

The peak labor requirements for any site development are not much higher than the average requirement, and it is likely that careful scheduling of the work will make it possible to arrange for a relatively steady level of employment throughout the construction period.

For each of the sites, the total demand amounts to less than 3 percent of the total labor force and about 50 percent of the construction labor force in the impact region (Anchorage-Mat-Su Borough) as of March 1981. It likely, therefore, that a large part of the labor that would be required during the 1990s could be recruited in the surrounding region.

In 1980, the unemployment rate was about 8 percent in Anchorage-Mat-Su region immediately around and north of the project sites, 12 percent in the Gulf Coast region and 10 percent in the state of Alaska. It is possible the rate of employment would be lower during the 1990s than at present, but it seems unlikely it will have become very low. Most probably, sufficient labor will be available in the region around the project sites and construction of one of the projects would likely offer a welcome contribution to reduction of unemployment in the area during the years of construction.

Supplementary labor requirements, in addition to the direct onsite requirements, are of two types. The first consists of labor employed in the production of supplies, such as cement, concrete, lumber, aggregate, steel products, turbines, generators, and other electrical products. Parts of these activities will not be located in the impact region, or even in the state of Alaska. A preliminary estimate indicated that possibly up to 300 or 400 additional jobs in the production of raw materials could be created in the Anchorage region during the construction period if in-state manufacturing facilities are developed.

Another type of supplementary labor requirement consists of additional jobs to supply the demand for services by the labor employed onsite and in supply activities.

(ix) Community Impact

Direct, onsite employment would reach, in the peak years, about 2,000 to 2,750. The impact region would be the municipality of Anchorage. A socioeconomic study by the Bureau of Land Management indicates that population growth in Anchorage was responsive to the growth in economic activities: Kenai oil, Prudhoe Lease, and Trans-Alaska pipeline construction. The population of the municipality of Anchorage was estimated in that study at 195,654 as of July 1, 1979. It is likely that Anchorage could supply labor and services of sufficient variety to accommodate a project of this size.

The temporary construction activities may provide opportunities to strengthen the local infrastructure and provide lasting benefits. Transport facilities, for example, would have to be improved to facilitate construction. For site access, new roads or upgrading of existing roads would have to be done except at Eagle Point. Adjustments near the military airport would be necessary at Point MacKenzie. A viaduct off the highway over existing railroad tracks (north side) would be built at Rainbow as well as a road to the storage and work area along the shore (north side). Whenever possible, expansion of the transport facilities as required for construction should take into account opportunities to create lasting beneficial effects, but at the same time should not necessarily interfere with existing communities. It will be desirable, if and when a decision is made to build one of the projects, to initiate joint planning with municipal authorities early as possible to minimize the unavoidable strains on the communities and to maximize the benefits that can be obtained from the temporary increase in activity in the area.

(x) Impacts of a Causeway

Construction of a tidal power project at any site considered in this study could be planned to provide a causeway. At Rainbow, a crossing of Turnagain Arm could be built as an integrated part of the tidal power project, and, therefore, its costs would be reduced. Turnagain Arm Crossing between the Anchorage area and the Kenai Peninsula has been considered in various studies over the past 30 years. It has been recognized that a major improvement such as a crossing of Turnagain Arm would have a great impact on the area which it serves or through which it passes.

Tourism plays a major role in the regional economics of the Anchorage-Kenai area. The opening up of territory heretofore unserved by a highway becomes of major importance.

Alaska with its scenary has likewise unlimited potential for recreation. Good transportation makes realization of these potentials possible as well as being one of the basic ingredients of commerce and industry. The improvement of the basic network of transportation within the Anchorage-Kenai area will produce favorable results with all of these activities.

A crossing of Turnagain Arm would bring the city of Kenai, the center of a rapidly growing petroleum industry, to the existing highway system. The 1968 study by the Alaska Department of Highways indicated that the distance between the city of Kenai and Anchorage through the crossing would be 94 miles by way of a lowlevel highway, whereas the distance over existing roads is 154 miles over mountain roads with long grades and passes subject to heavy snowfall.

The construction of a tidal power project at either site, Point MacKenzie or Eagle Bay, could also be planned jointly with a Knik Arm crossing. A causeway crossing joining the two sides of Knik Arm near Anchorage would provide civil benefits as well as defense benefits. The 1972 study by the state of Alaska Department of Highways indicated that the crossing will allow future economic development of the west side of Knik Arm, which would certainly add to the potential of the metropolitan area of Anchorage (13). It would shorten the Anchorage-Fairbanks highway and also would provide the necessary access for a new international airport on the west side of the arm. Such a facility presents an interesting stimulus for the future economic development of the west side of Knik Arm. In addition, the causeway crossing would provide means for development access of lands north of Knik Arm. The geographic position of Anchorage, being presently surrounded by water, mountains, and military facilities, makes the development of the lands north and west of Knik Arm very desirable. A crossing of Knik Arm would give access to the Beluga area and the Alaska Peninsula with its mineral and recreation potentials.

(c) Thermal Alternatives Other than Coal

(i) Natural Gas

Natural gas resources available or potentially available to the Railbelt region include the North Slope (Prudhoe Bay) reserves and the Cook Inlet reserves. Information on these reserves is summarized in Table E.10.21.

The Prudhoe Bay Field contains the largest accumulation of oil and gas ever discovered on the North American continent. The in-place gas volumes in the field are estimated to be in excess of 40 trillion cubic feet (Tcf). With losses considered, recoverable gas reserves are estimated at 29 Tcf. Gas can be made available for sale from the Prudhoe Bay Field at a rate of at least 2.0 billion cubic feet per day (Bcfd) and possibly slightly more than 2.5 Bcfd. At this rate, gas deliveries can be sustained for 25 to 35 years, depending on the sales rate and ultimate gas recovery efficiency.

During the mid-seventies, three natural gas transport systems were proposed to market natural gas from the North Slope Fields to the Lower 48. Two overland pipeline routes (Alcan and Arctic) and a pipeline/LNG tanker (El Paso) route were considered. The Alcan and Arctic pipeline routes traversed Alaska and Canada for some 4000 to 5000 miles, terminating in the central U.S. for distribution to points east and/or west. The El Paso proposal involved an overland pipeline route that would generally follow the Alyeska oil pipeline utility corridor for approximately 800 miles. A liquefaction plant would process approximately 37 million cubic meters of gas per day. The transfer station was proposed at Point Gravinia south of the Valdez termination point. Eleven 165,000 cubic meter cryogenic tankers would transport the LNG to Point Conception in California for regasification.

The studies noted above concluded with the decision to construct a 4800 mile, 2.4 Bcfd, Alaska-Canada Natural Gas pipeline project, costing between $22 and $40 billion. The pipeline project would pass approximately 60 miles northeast of Fairbanks. Although the project was in the active planning and design phase for several years, it is now inactive due to financial difficulty.

The Cook Inlet reserves (Table E.10.25) are relatively small in comparison to the North Slope reserves. Gas reserves are estimated at 4.2 Tcf as compared to 29 Tcf in Prudhoe Bay. Of the 4.2 Tcf, approximately 3.5 Tcf is available for use, the remaining reserves are considered shut-in at this time. The gas production capability in the Kenai Peninsula and Cook Inlet region far exceeds demand, as no major transportation system exists to export markets. As a result of this situation, the two Anchorage electric utilities have a supply of natural gas at a very economic price. Export facilities for Cook Inlet natural gas include one operating and one proposed LNG scheme. The facility in operation, the Nikiski terminal, owned and operated by Phillips-Marathon is located on the eastern shore of Cook Inlet. Two Liberian cryogenic tankers transport LNG some 4000 miles to Japan. Volume produced is 185 MMCFD with raw natural gas requirements of 70 percent from a platform in Cook Inlet and 30 percent from existing on-shore fields.

There is also some potential for a gasline spur to be constructed from the Cook Inlet region some 310 miles north to intersect with the proposed Alaska-Canada Natural Gas pipeline project in order to market the Cook Inlet gas. This concept has not been extensively studied but could prove to be a viable alternative.

(ii) Oil

Both the North Slope and the Cook Inlet Fields have significant quantities of oil resources as seen in Table E.10.26. North Slope reserves are estimated at 8375 million barrels. Oil reserves in the Cook Inlet region are estimated at 198 million barrels. As of 1979, the bulk of

Alaska crude oil production (92.1 percent) came from Prudhoe Bay, with the remainder from Cook Inlet. Net production in 1979 was 1.4 million barrels per day.

Oil resources from the Prudhoe Bay field are transported via the 800 mile trans-Alaska pipeline at a rate of 1.2 million barrels per day. In excess of 600 ships per year deliver oil from the port of Valdez to the west, Gulf and east coasts of the U.S. Approximately 2 percent (or 10 million barrels) of the Prudhoe Bay crude oil was used in Alaska refineries and along the pipeline route to power pump stations. The North Pole Refinery, located 14 miles southeast of Fairbanks, is supplied from the trans-Alaska pipeline via a spur. Refining capacity is around 25,000 barrels per day with home heating oils, diesel and jet fuels the primary products.

Much of the installed generating capacity owned by Fairbanks utilities is fueld by oil. FMUS has 38.2 MW and GVEA has 186 MW of oil-fired capacity. Due to the high cost of oil, these utilities use available coal-fired capacity as much as possible with oil used as standby and for peaking purposes.

Crude oil from offshore and onshore Kenai oil fields is refined at Kenai primarily for use in-state. Thermal generating stations in Anchorage rely on oil as standby fuel only.

(iii) Diesel

Most diesel plants in operation today are standby units or peaking generation equipment. Nearly all the continuous duty units have been placed on standby service for several years due to the high oil prices and the consequent high cost of operation. The lack of system interconnection and the remote nature of localized village load centers has required the installation of many small diesel units. The installed capacity of these diesel units is 64.9 MW and these units are solely used for load following. The high cost of diesel fuel makes new diesel plants expensive investments for all but emergency use.

(iv) Environmental Considerations

- Air Pollution

Several kinds of air pollutants are normally emitted by fuel-burning power plants. These include particulate matter, sulfur dioxide, nitrogen oxides, carbon monoxide, unburned hydrocarbons, water vapor, noise and odors.

- Particulate Matter

  Particulate matter consists of finely divided solid material in the air. Natural types of particulate matter are abundant and include wind-borne soil, sea salt particles, volcanic ash, pollen, and forest fire ash. Man-made particulate matter includes smoke, metal fumes, soil-generated dust, cement dust, and grain dust. On the basis of data collected by the U.S. Environmental Protection Agency (EPA), total suspended particulate matter (TSP) has been determined to cause adverse human health effects and property damage.

  Fuel combustion power plants produce particulate matter in the form of unburned carbon and non-combustible minerals. Particulates are removed from flue gas by use of electrostatic precipitators or fabric filters (baghouses). They are routinely required, however, and collection efficiencies can be very high (in excess of 99 percent).

- Sulfur Dioxide

  Sulfur dioxide (SO_2) is a gaseous air pollutant which is emitted during combustion of fuels that contain sulfur. Residual oil contains sulfur in amounts of a few tenths of a percent to a few percent, while pipeline natural gas contains relatively little sulfur. Sulfur dioxide, like particulate matter, has been identified as being harmful to human health, and it appears to be particularly serious when combined with high concentrations of particulate matter. It is damaging to many plant species, including several food crops such as beans.

- Nitrogen Oxides

  Nitrogen oxides (NO_2 and NO, primarily) are gaseous air pollutants which form as a result of high-temperature combustion or oxidation of fuel-bound nitrogen. Nitrogen oxides damage plants and play an important role in photochemical smog.

  Pollution control technology for nitrogen oxides has developed more slowly than for most other air pollutants. Lack of chemical reactivity with conventional scrubbing compounds is the main difficulty. Thus current control strategies focus on control of NO_x production. Principal strategies include control of combustion temperatures (lower combustion temperatures retard formation of NO_x) and control of combustion air supplies to minimize introduction of excess air (containing 78 percent nitrogen).

- Carbon Monoxide

  Carbon monoxide (CO) emissions result from incomplete combustion of carbon-containing compounds. Generally, high CO emissions result from suboptimal combustion conditions and can be reduced by using appropriate firing techniques. However, CO emissions can never be eliminated completely, using even the most modern combustion techniques and clean fuels. CO emissions

  are regulated under the Clean Air Act because of their toxic effect on humans and animals.

- Water Vapor

  Plumes of condensed water vapor will emanate from a wet cooling tower as its exhaust is cooled below its saturation point. The plume will persist downwind of the tower until the water vapor is diluted to a level below saturation. In cold or cool, moist climates the plumes are particularly long because the ambient air can hold little added moisture. Formation of these plumes is particularly hazardous during "fogging" conditions when a high wind speed causes the plume to travel along the ground. During freezing conditions, such plumes may lead to ice formation on nearby roads and structures. Plume generation, fogging, and icing can be controlled or virtually eliminated through the use of wet/dry or dry cooling towers.

- Noise and Odor

  Noise levels beyond the plant property line can be controlled by equipment design or installation of barriers. Generally noise and odors are not as great a concern as the air pollutants contained in exhaust gasses.

- Comparison of Projected Emissions

The critical comparison of fuel combustion technologies for their imapcts on air quality is determined by the anticipated rate of emissions of each of the pollutants. Emission levels for the various technologies are presented for sulfur dioxide in Table E.10.27, for particulates in Table E.10.28, and for nitrogen oxides in Table E.10.29. Data are taken from EPA publications or the enforced New Source Performance Standards.

The development of these tables are based on various assumptions. A 33 percent efficiency of conversion is assumed for steam electric plants, and a 25 percent efficiency for combustion turbines. For the power plant sizes provided in the tables, emissions are directly proportional to the heat rate input for a given technology. The following heat input factors were assumed: for oil 20,000 Btu/lb; and for natural gas 1,000 Btu/standard cubic foot.

- Regulatory Framework

In 1970, the federal Clean Air Act established the national strategy in air pollution control. The Act established New Source Performance Standards (NSPS) for new stationary sources, including fuel combustion facilities. Levels of acceptable ambient air quality (National Ambient Air Quality Standards) were also established, and the regulations were promulgated to maintain these standards or reduce pollution levels where the standards were exceeded.

New source performance standards (NSPS) have been promulgated for coal-fired steam electric power plants, and for combustion turbines. In addition, any combustion facility designed to burn coal or coal mixtures, or is capable of burning any amount of coal, or if such use is planned, is subject to the coal-fired power plant standards. Standards of allowable emissions for each fuel combustion technology for each major pollutant for a range of sizes for power plants are presented in Tables E.10.27 through E.10.29. The standards are being enforced for both newly constructed and significantly retrofitted facilities and represent the expected level of controlled emissions from these power plants.

In Alaska, the Department of Environmental Conservation enforces regulations regarding ambient air quality standards and source performance standards. A permit to operate will be required for all fuel-burning electric generating equipment greater than 250 kW generating capacity.

Major changes were made to the Clean Air Act in 1977 when the Prevention of Significant Deterioration (PSD) program was added by Congress. The PSD program has established limits of acceptable deterioration in existing ambient air quality (SO_3 and TSP) throughout the United States. Pristine areas of national significance (Class I areas), were set aside with very small increments in allowable deterioration. The remainder of the country was allowed a greater level of deterioration. Other regulatory factors apply to areas where the pollution levels are above the national standards. State and local agencies may take over the administration of these programs through the development of a state implementation plan acceptable to the EPA. See Table E.10.30 for National Ambient Air Quality Standards and allowable PSD increments.

The PSD program is currently administered by the U.S. EPA. A PSD review will be triggered if emissions of any pollutant are above 100 tons per year for coal-fired power plants or above 250 tons per year for the other power plants. The review entails a demonstration of compliance with ambient air quality standards, the employment of best available control technology, a demonstration that allowable PSD increments of pollutant concentrations (currently promulgated for sulfur dioxide and suspended particulates) will not be violated, and a discussion of the impact of pollutant emissions on soils, vegetation, and visibility. It also generally includes a full year's on-site monitoring of air quality and meteorological conditions prior to the issuance of a permit to construct. In the near future, PSD control over other major pollutants, including NO_x, CO, oxidants, and hydrocarbons will be promulgated. Obtaining a PSD permit represents one of the largest single obstacles to the construction of a major fuel-burning facility.

Alaska has two permanent Class I areas in or near the Railbelt region, Denali National Park and the pre-1980 areas of the Tuxedni Wildlife Refuge. The new National Parks and Wildlife Preserves have not been incuded in the original designation, but the state may designate additional Class I areas in the future. New major facilities located near Class I areas cannot cause a violation of the PSD increment near a Class I area; this requirement presents a significant constraint to the development of nearby facilities.

A potentially important aspect of the PSD program to development of electric power generation in the Railbelt region is that Denali National Park (Mt. McKinley National Park prior to passage of the 1980 Alaska Lands Act) is Class I, and it lies close to Alaska's only operating coal mine and the existing coal-fired electric generating unit (25 MWe) at Healy. Although the PSD program does not affect existing units, an expanded coal-burning facility at Healy would have to comply with Class I PSD increments for SO_2 and TSP. Decisions to permit increased air pollution near Class I areas can only be made after careful evaluation of all the consequences of such a decision. Furthermore, Congress required that Class I areas must be protected from impariment of visibility resulting from man-made air pollution. The impact of visibility requirements on Class I areas are not yet fully known.

- Water Pollution

Potential sources of water pollution include cooling system blowdown, demineralizer regeneration wastewater, fuel oil releases, and miscellaneous cleaning wastes.

o Cooling Water Blowdown

In general, the operation of all steam cycles require substantial amounts of cooling water and therefore produce cooling water blowdown. The quantity and quality of this wastewater depend upon the type of cooling system used and the specific characteristics of the source. In general, total dissolved solids (TDS), chlorine, and waste heat are the primary pollutants of concern.

o Demineralizer Regeneration Wastewaters

All steam cycle facilities produce demineralizer regeneration wastewaters which have high TDS levels and generally low pH values.

o Fuel Oil Releases

Potential oil pollution impacts are associated with oil-fired power plants and other facilities which may use oil as an auxiliary fuel. These include fuel storage areas and the accidental release of oil through spillage or tank rupture. Potentially significant impacts which may result from oil releases are generally mitigated through the mandatory implementation of a Spill Prevention Control and Countermeasures (SPCC) Plan, as required under 40 CFR 110 and 40 CFR 112. This plan is intended to ensure the complete containment of all releases and the proper recovery or disposal of any waste oil. The plan must also be formulated in light of the Alaska Oil and Hazardous Substances Pollution Regulations.

- Miscellaneous Wastewaters

All steam cycle plants have many other miscellaneous wastewaters that are derived from floor drainage, system component cleaning, and domestic water use. The quantity and quality of these wastewaters will vary considerably, but oil and grease, suspended solids, and metals are the effluents of most concern.

All of these enumerated wastewaters are strictly managed within a specific steam cycle facility. The management vehicle is generally termed a "water and wastewater management plan" and in some technologies is developed in conjunction with a "solid waste management plan". The purpose of these studies is to balance environmental, engineering, and cost considerations, and develop a plant design and operational procedures operation that ensures plant reliability and environmental compatibility, and minimizes costs.

For plants developed in the Railbelt region, relevant regulations would include the Clean Water Act and its associated National Pollutant Discharge Elimination System (NPDES) permit requirements and federal effluent limitation guidelines; Alaska State water quality standards, which regulate all parameters of concern in all Alaska waters depending upon the specific water resource's designated use; the Resource Conservation and Recovery Act and Alaska solid waste disposal requirements; and the Toxic Substances Control Act.

Compliance with all regulations does not eliminate water resource impacts. Alaska water quality standards permit a wastewater discharge mixing zone; water quality concentrations will therefore be altered in this area. Downstream water quality will also be altered, as receiving stream standards are rarely identical to the existing site-specific water quality regime of the receiving water body. If secondary impacts associated with wastewater discharges such as those to aquatic ecosystems are deemed significant, further waste management and treatment technologies may be employed. Water quality impacts can only be avoided if the plant is designed to operate in a "zero discharge" mode. This is technically possible for all steam cycle facilities, but can be extremely costly.

Values for selected rivers in the Railbelt region are given in Table E.10.31. Based on these values, there does not appear to be any extraordinary or unusual water quality characteristic which would preclude construction or operation of a properly designed steam cycle facility. Most of the river systems can be considered moderately mineralized based upon the total dissolved solids values and the concentrations of the major ionic components. Values for calcium, magnesium, and silica are not low and will limit the natural reuse (without treatment) of a number of wastewater streams, most significantly cooling tower blowdown. "Standardized" power plant water management technologies will be required to mitigate any adverse water quality impacts. Also, based on the sufficiently high bicarbonate levels and alkaline pH values, appears these natural waters to have sufficient assimilative capacity to mitigate effects from potential acid rain events.

- Hydrologic Impacts

Impacts to the hydrological regime of ground and surface water resources can result from the physical placement of the power plant and its associated facilities, and from the specific location and operation of a generating plant's intake and discharge structures. The siting of the power plant may necessitate the elimination or diversion of surface water bodies and will modify the area's runoff pattern. Stream diversion and flow concentration may result in increased stream channel erosion and downstream flooding. Proper site selection and design can minimize these impacts. If, after siting, localized impacts remain a concern, various mitigative techniques, such as runoff flow equalization, runoff energy dissipation, and stream slope stabilization may be employed.

Other hydrological impacts can result from the siting and operation of the power plant's makeup water system and wastewater discharge system. The physical placement of these structures can change the local flow regime and possibly obstruct navigation in a surface water body. Potential impacts associated with these structures are generally mitigated, however, through facility siting and structure orientation. Discharge of power plant wastewaters may create localized disturbances in the flow regime and velocity characteristics of the receiving water body. This potential problem is minimized through proper diffuser design, location, and orientation. Consumptive water losses associated with the power plant may also affect hydrological regimes by reducing the downstream flow of the water resource. However, as discussed previously, surface water supplies in the Railbelt region are plentiful. Hydrologic impacts due to reduced streamflow should therefore not be significant.

(d) Nuclear Steam Electric

Nuclear steam electric generation is a mature, commercially available technology. At present, some 73 units with a total installed capacity of 54,000 MWe are operable in the United States. An additional 104 units representing approximately 116,000 MWe of capacity have either been ordered or are in some phase of the licensing or construction process. Canada, France, Germany, Japan, Sweden, and the United Kingdom also have a large nuclear steam electric capacity based either on U.S. developed technology or on technologies developed within those respective countries.

In spite of this impressive backlog of experience, nuclear power is experiencing social and political problems that might seriously affect its viability. These problems manifest themselves in licensing and permit delays, and are thus of significance to the Alaskan electrical supply situation given their cost and schedule impacts.

Diminished load growth rates, concerns over nuclear weapons proliferation, adverse public opinion fueled by the Three-Mile Island accident, expanding regulatory activity, and lack of overt support at the highest political levels have all resulted in no new domestic orders for nuclear units since 1977. The industry is currently maintaining its viability through completion of backlog work on domestic units and by pursuing new foreign orders.

The State of Alaska's policy on nuclear power is expressed in the legislation establishing the Alaska Power Authority. The Power Authority may not develop nuclear power plants.

(i) Siting and Fuel Requirements

Nuclear plant siting has more constraints than other technologies because of stringent regulatory requirements resulting from the potential consequences of accidents involving the release of radioactive materials. These requirements alone, however, would not be expected to bar the development of nuclear power in Alaska.

Under the siting criteria of the Nuclear Regulatory Commission (10 CFR 100), nuclear facilities must be isolated to the degree that proper exclusion areas and low population zones may be maintained around the facility. Nominal distances ranging from 2,000 to 5,000 feet to the nearest boundary (encompassing areas of 250 to 2,000 acres) are typically sufficient to meet the first criterion for almost any sized nuclear facility. Additionally, a physical separation of 3 to 5 miles from areas of moderate population density allows compliance with the second criterion. These requirements are of little real consequence in the present case considering the low population densities existing in the Railbelt region.

Seismic characteristics of a potential site are a major factor in plant siting since the nuclear plant must be designed to accommodate forces that result from earthquake activity. Total exclusion of nuclear plants on this basis is not indicated since nuclear plants have been designed and constructed on a worldwide basis in each of the seismic zones found in the Railbelt region.

In addition to meeting the specific nuclear safety requirements of the U.S. Nuclear Regulatory Commission, a nuclear plant site must meet the more typical criteria required of any large steam-electric generation technology. A 1,000-MW nuclear project represents a major long-term construction effort, involving the transportation of bulky and heavy equipment and large quantities of construction materials. Means of transportation capable of handling these items limit the potential Railbelt sites to the corridor along the Alaska Railroad and port areas of Cook Inlet and Prince William Sound. As noted previously, it is necessary to site a nuclear plant in an area of low population density. This requirement for remote siting must be balanced against the cost of transmission facilities required to deliver power to high-density population areas and load centers.

The heat rejected by a 1,000-MW plant is substantial; a potential site must thus have a sufficient supply of cooling water to remove the heat in a manner complying with environmental criteria for thermal discharges. Once-through cooling of a 1000-MWe facility requires a water flow of approximately 3,000 cfs and would almost certainly require coastal siting. Closed cycle systems require less water than once-through systems (probably less than 100 cfs), thus expanding the range of siting options to some of the rivers of the region.

Reactor fuel, a highly refined form of enriched uranium fabricated into complex fuel elements, is not produced in Alaska and would have to be obtained from fuel fabrication facilities located in the western portion of the United States. The proximity of the nuclear plant to the fuel source is relatively unimportant compared to fossil-fired and geothermal plants. Uranium is a high-energy density fuel, and refueling is accomplished on a batch rather than a continual basis. Refueling is required about once a year and is usually scheduled during summer months in cold climates to prevent weather induced delays and to occur during periods of low electrical demand.

Current estimates indicate known uranium supplies are sufficient to fuel only those reactors now in service or under construction for their estimated lifetime. However, the latest nuclear designs are capable of being fueled by plutonium as well as uranium, and assuming that breeder reactors, producing surplus fuel-grade plutonium, become commercial, then long-term fuel supply should not be a limiting factor. Although Alaska has identified uranium deposits, the economic forces for developing the resource are tied to the world market conditions rather than to the use of uranium as fuel for nuclear plants located in Alaska.

(ii) Environmental Considerations

Water resource impacts associated with the construction and operation of a nuclear power plant are generally mitigated through appropriate plant siting and a water and wastewater management program. It should be noted, however, that due to the large capacities required for nuclear power stations (1000 MW), the magnitude of water withdrawal impacts associated with a given site may be greater than for other baseload technologies. Magnitude, however, does not necessarily imply significance. A favorable attribute of nuclear pwoer is the lack of wastewater and solid waste associated with fuel handling, combustion, and flue gas treatment experienced in other combustion steam cycle technologies.

Nuclear power plants cause no deterioration in the air quality of the locale, other than the routine or accidental release of radionuclides. To assess the potential dosages of these radioactive materials, a complex meteorological monitoring program is required. The wind speeds and dispersive power of the atmosphere play a crucial role in diluting the effluent. Generally, sites in sheltered valleys and near population or agricultural centers are not optimal from a meteorological point of view. Large amounts

of heat are also emitted by nuclear power plants. Some modification of microclimatic conditions onsite will be noted, but these modifications will be imperceptible offsite. The U.S. Nuclear Regulatory Commission will ensure that the ambient meteorological conditions are properly measured and considered in the siting of a nuclear power plant. These constraints will not preclude the construction of such a facility at many locations in the Railbelt region.

In addition to the effects on aquatic and marine ecosystems resulting from cooling water withdrawal and thermal discharges common to other steam cycle plants, nuclear facilities have the potential for routine low level and possibly accidental higher level discharge of radionuclides into the aquatic environment. The minimum size for a nuclear facility (1,000 MW) indicates that these plants would be the largest water users of any steam cycle plants, using approximately 310,000 gpm for once-through cooling systems and 6,200 gpm for recirculating cooling water systems. Their rate of use (gpm/MW) is also higher than many other technologies because of somewhat lower plant efficiencies. Potential impingement and entrainment impacts would therefore be somewhat higher than for other baseload technologies of comparable size. Detrimental effects of discharge may also be high because of the large quantity of water used. But the discharge water may have fewer hazardous compounds than may be found in other steam cycle wastewaters.

The predominant biotic impact on terrestrial biota is habitat loss. Nuclear power plants require land areas (100-150 acres) second in size to those of coal- and biomass-fired plants. Furthermore, lands surrounding the plant island are at least temporarily modified by ancillary construction activities (i.e., laydown areas, roads, etc.). Partial recovery of these lands could possibly be accomplished through revegetation. Other imapcts difficult to mitigate could be accidental releases of radionuclides. The effects of such accidents on soils, vegetation, and animals could be substantial. However, proper plant design and construction should prevent these emissions. One positive feature of nuclear power is the absence of air pollution emissions and resulting effects on biota.

(iii) Potential Application in the Railbelt Region

Fuel availability and siting constraints would probably not significantly impair construction of commercial nuclear power plants in Alaska. Potential sites, however, would have to be near existing or potential port facilities or along the Alaska Railroad because of the need to deliver large amounts of construction material and very large and heavy components to the site. Interior siting would have more favorable seismic conditions.

More constraining than site availability is the rated capacity of available nuclear units in comparison with forecasted electrical demand in the Railbelt region. The Railbelt System, with a forecasted interconnected load of 1,550 MW in 2010, will probably be too small to accommodate even the smaller nuclear power units, primarily from the point of view of system reliability. If nuclear power were available to the Railbelt System, significant reserve capacity would still have to be available to provide generating capacity during scheduled and unscheduled outages.

In addition, the large capacity of most current nuclear units limits the adaptability to growth to very large increments, which are not characteristic of projected Railbelt demands. Nuclear capacity is not added easily, as a strict licensing, construction, and operation process must be followed.

(e) Biomass

Biomass fuels potentially available in the Railbelt region for power generation include sawmill residue and municipal waste. Biomass fuels have been used in industrial power plants for many years. Biomass plants are distinct from fossil-fired units in that maximum plant capacities are relatively small; in addition, they have specialized fuel handling requirements. The generally accepted capacity range for biomass-fired power plants are approximately 5 to 60 MW (14). The moisture content of the fuel, as well as the scale of operation, introduces thermal inefficiencies into the power plant system.

(i) Siting and Fuel Requirements

Biomass fuels are generally inexpensive but are characterized by high moisture content, low bulk densities, and modest heating values. Typical net heating values of biomass fuels are compared to coal below:

Fuel	Btu/lb
Municipal Waste	4,000
Peat	5,000
Wood	4,500
Coal	9,000

Since the supply of any one biomass fuel may be insufficient to support a power plant, provisions may have to be made for dual fuel firing (e.g., wood and municipal waste). For example, the estimated supply of both wood and municipal waste biomass fuel in Greater Anchorage will support a 19-MW power plant operating 24 hr/day at a heat rate of 15,000 Btu/kWh.

The rate of fuel consumption is a function of efficiency and plant scale. Fuel consumption as a function of plant capacity is presented below.

Plant Size (Megawatts)	Hourly Fuel Requirements (Tons)	Truck Loads Per Hour
5	11	--
15	25	1
25	40	2
35	55	3
50	80	4

Siting requirements for biomass-fired power plants are dictated by the condition of the fuel, location of the fuel source, and cooling water requirements. Because biomass fuels are high in moisture content and low in bulk density, economical transport distances do not exceed 50 miles (15). Biomass power plants are thus typically sited at, or close to, the fuel source and may function as part of a cogeneration system. Sites must be accessible to all-weather highways since biomass fuels are usually transported by truck. (Approximately four trucks per hour would be required, for example, for a 50-MW plant.)

While proximity to the fuel source may be the most limiting factor, sites also must be accessible to water for process and cooling purposes. Land area requirements are a function of scale, extent of fuel storage, and other design parameters. Typically, a 5-MW stand-alone power plant will require 10 acres; a 50-MW stand-alone plant will require 50 acres.

Plants that use peat will require additional land for air drying the fuel. A 1 to 3-month fuel supply should be provided to assure fuel availability during prolonged periods of inclement weather.

(ii) Environmental Considerations

Water resource impacts associated with the construction and operation of a biomass-fired power plant are not expected to be significant or difficult to mitigate in light of the small plant capacities that are considered likely.

The burning of biomass could lead to significant impacts on ambient air quality. Impacts arise largely from particulate matter and nitrogen oxides emitted by the system. The emissions of particulates can be well-controlled by using techniques such as electrostatic precipitators or baghouses. The tradeoff between emission controls and project costs must be assessed at each facility, but wood burning facilities larger than about 5 MWe will require the application of these air pollution control systems.

Potentially significant impacts to aquatic systems from biomass plants are similar to other steam cycle plants and result from the water withdrawal and effluent discharge. Although these plants are second only to geothermal facilities in rate of water use (730 gpm/MW), their total use for a typical plant would only exceed that of oil and natural gas-fired plants because of the small size of prospective plants. Approximately 18,250 gpm and 362 gpm would be required for once-through and recirculating cooling water systems, respectively. Proper siting and design of intake and discharge structures could reduce these impacts.

The major impact on the terrestrial biota is the loss or modification of habitat. Land requirements for biomass-fired plants, approximately 50 acres for a 50-MW plant, are similar to coal-fired plants, and are generally intermediate between those for nuclear and the other steam cycle power plants.

Potential primary locations of biomass-fired power plants in the Railbelt region are near Fairbanks, Soldatna, Anchorage, and Nenana. Lands surrounding these five areas contain seasonal ranges of moose. Waterfowl also inhabit these areas with high use occurring along the Matunuska and Susitna River deltas near Anchorage, and areas around Nenana. The Soldatna region also contains populations of black bear and calving, migration corridors, and seasonal ranges of caribou. Populations of mountain goats, caribou, and Dall sheep occupy habitats in the Susitna and Matunuska River drainages near Anchorage. Impacts on these animal populations will depend on the characteristics of the specific site and the densities of the wildlife populations in the site area. Due to the relatively small plant capacities involved, however, impacts should be minimized through the plant siting process.

(iii) Potential Applications in the Railbelt Region

Potential sources of biomass fuels in the Railbelt region include peat, mill residue from small sawmills, and municipal waste from the cities of Fairbanks and Anchorage.

Fuel availability for wood residue and municipal waste in the Railbelt region is shown in Table E.10.32.

Only broad ranges of wood residue availability have been developed since little information is available on lumber production as a function of markets, lumber recovery, and internal fuel markets. Volumes of municipal waste have been identified from studies of refuse recycling in the Anchorage area (16). Fuel supplies for a wood or municipal waste-fired biomass plant may be sufficient in greater Anchorage, but marginal in Fairbanks or the Kenai Peninsula. Peat deposits are substantial but many other fuels are available which compete economically with peat.

Biomass power plants in the Railbelt region may potentially contribute 0.5 percent to 5 percent of future power needs. As such, the biomass-fired units would be central station installations capable of serving individual community load centers or interconnection to a Railbelt power grid.

Since the biomass-fired systems are relatively small, they are particularly adaptable to the modest incremental capacity needs forecast for the Railbelt region.

(f) Geothermal

Geothermal energy is defined as the heat generated within the earth's interior. If this heat is close to the surface, it may be tapped as an energy source. Geothermal energy may be utilized for electricity generation, which usually requires temperatures of at least 280°F, or for direct applications at temperatures less than 280°F. Direct heating applicatiuons include space heating for homes and businesses, applications in agriculture and aquaculture, industrial process heating, and recreational or therapeutic use in pools. Approximate required temperatures of geothermal fluids for various applications is presented in Table E.10.33.

Three types of geothermal resources hold potential for development: hydrothermal, geopressured brine, and hot dry rock. Only hydrothermal systems are in commercial operation today. Although hot dry rock resources represent over half the U.S. geothermal potential, satisfactory technologies have not yet been developed for extracting heat from this resource. Hydrothermal geothermal resources are classified as vapor-dominated or liquid-dominated systems. A typical vapor dominated system produces saturated to slightly superheated steam at pressures of 435 to 500 psi and temperatures of approximately 450°F.

Liquid-dominated systems may be subdivided into two types, those producing high enthalpy fluids greater than 200 calories/gram (360 Btu/lb), and those producing low enthalpy fluids less than 200 calories/gram. The high enthalpy fluids may be used to generate electrical power; the lower enthalpy fluids may be useful for direct heating applications.

Wells drilled into high enthalpy, liquid-dominated systems produce a mixture of steam and water. The steam may be separated for turbine operation to produce electricity.

(i) Siting Requirements

Geothermal plants are always located at the site of the geothermal resource. The four most important siting criteria used to evaluate geothermal resources for application to electric power production are:

- o Fluid temperatures in excess of approximately 140°C (280°F);
- o Heat sources at depths less than 10,000 ft with a temperature gradient at 25°F per 1,000 ft;
- o Good rock permeability to allow heat exchange fluid to flow readily; and

o Water recharge capability to maintain production.

Individual geothermal wells should have a capacity to supply 2 MW of electricity. The power station's long-term viability is dependent on the prediction of reservoir energy capacity and management of reservoir development.

The site must have access available for construction, operation, and maintenance personnel, and a source of water available for condenser cooling (and injection in the hot rock technology).

The land area required for the electrical generating and auxiliary equipment portion of a geothermal plant will be similar to that required for an oil-fired unit; however, the total land area will be vastly larger because of the diffuse location of the wells. A 10 MW plant, excluding wells, can be situated on approximately 5 acres of land. After exploratory wells are sunk to determine the most productive locations (both for production and injection wells), the plant would be located based on minimum cost of pipelines and other siting factors. A network of piping would then be established to complete the installation.

(ii) Environmental Impacts

A problem unique to geothermal steam cycles involves the water quality characteristics of the geothermal fluid and the subsequent disposal method. This fluid is generally saline and, because of this characteristic, most geothermal plants in the United States mitigate this potential problem through reinjection into the geothermal zone. If the geothermal zone is highly pressurized, however, not all of the brine may be reinjected, and alternative treatment and disposal methods must be considered. For geothermal fields located in the Chigmit Mountains, brine disposal in Cook Inlet should not prove to be too difficult. The interior fields, however, could reuqire extensive wastewater treatment facilities to properly mitigate water quality impacts to freshwater resources and comply with all relevant Alaska regulations. Depending upon a specific field's water quality characteristics, the costs associated with these treatment facilities could also preclude development.

Geothermal plants have the highest per megawatt water use of any steam cycle plant (845 gpm/MW). A maximum size plant for the Railbelt region (50 MW) would use less water than only nuclear-fired or coal-fired plants, with a total water use rate of 42,200 gpm or 750 gpm for once-through and recirculating cooling water systems, respectively.

Emissions of gases and particulates into the atmosphere from the development of geothermal resources will consist primarily of carbon dioxide and hydrogen sulfide (H_2S). Other emissions may consist of ammonia, methane, boron, mercury, arsenic compounds, fine rock particles, and radioactive elements. There is considerable variability in the nature and amount of these emissions, and this uncertainty can be removed only by testing wells in the proposed project area. Emissions are also a function of operational techniques. If the reinjection of geothermal fluids is used, emissions into the atmosphere may be reduced to nearly zero. Even when reinjection is not used, H_2S emissions can be controlled by oxidizing this compound to sulfur dioxide (SO_2) and subsequently using conventional scrubber technology on the product gases. Emissions may also be controlled in the water stream by an "iron catalyst" system or a Stretford sulfur recovery unit. Efficiencies of these systems have ranged as high as 90 percent H_2S removal. At the Geysers generating area in California, H_2S concentrations average 220 ppm by weight. The power plants emit about 3 lb/hr of H_2S per megawatt of generating capacity. Regulation of emissions of other toxic compounds can be controlled by various techniques as stipulated by the regulations governing the specific hazardous air pollutants. Control of hazardous pollutants will probably not preclude the development of geothermal resources in the Railbelt region.

In addition to major potential impacts associated with water withdrawal and effluent discharge that are similar for all steam cycle plants, geothermal plants have some unique problems that may have hazardous effects on the aquatic environment. Geothermal water is often high in slats and trace metal concentrations, and is often caustic. The caustic nature of the solution often corrodes pipes, which can add to the toxic nature of the brine. Current regulations require reinjection of spent geothermal fluid; however, entry of these brine solutions into the aquatic environment either by discharge, accidental spills, or groundwater seepage, could cause acute and chronic water quality effects.

One of the major geothermal potential areas in the Railbelt is located in the Wrangell Mountains near Glennallen. This area drains into the Copper River, which is a major salmonid stream. The result of accidental discharge of geothermal fluids into this system may have significant impacts on these fish, and other aquatic organisms, depending on the size and location of the release.

Other large geothermal areas are in the Chigmit Mountains on the west side of Cook Inlet. Much of this area is close to the marine environment. In general, geothermal waters would have less detrimental effects on marine organisms (because of their natural tolerance to high salt concentrations) than on fresh water organisms.

The primary impact resulting from geothermal plants on the terrestrial biota is habitat loss. Land requirements for geothermal plant facilities, on a per-kilowatt basis, are comparable to those for oil and natural gas plants. Biomass, coal, and nuclear plants require larger tracts of land than geothermal, either from the standpoint of capacity or kilowatt production. However, geothermal lands are more likely to be located in remote areas than other steam cycle power plants. Disturbances to these areas could be extensive depending on the land requirements of the geothermal well field.

Primary geothermal development locations are within the Wrangell and Chigmit Mountains. The latter area is remote and is inhabited by populations of moose and black bear. The Wrangell Mountain area is generally more accessible and includes populations of moose, Dall sheep, caribou, and possibly mountain goats. Impacts could be greatest in remote areas since an extensive road network would have to be built to service the well field. Roads would cause the direct destruction of habitat and also impose additional disturbances to wildlife and vegetation from increased accessibility to people.

(iii) Potential Application in the Railbelt Region

Only hot dry rock (hot igneous) and low-temperature, liquid-dominated hydrothermal convection systems have been identified in or near the Railbelt region. Some low-temperature geothermal resources in the Fairbanks area are used for heating swimming pools and for space heating. In southwest Alaska some use is made of geothermal resources for heating greenhouses as well as space heating. Hot dry rock geothermal resources with temperatures that may be high enough to generate electricity have been discovered in the Wrangell and Chigmit Mountains. The Wrangell system, located approximately 200 miles from Anchorage, has subsurface temperatures exceeding 1200°F. The Chigmit System, to the west of Cook Inlet, is isolated from the load centers by 200 miles of rugged terrain.

Little is known about the geothermal properties of either system.

A geothermal resource in granite rock has been identified in the Willow area. A deep exploration well was discovered to have a bottom hole temperature of 170°F. Exploration data to date indicate that while this resource may prove useful for low temperature applications, its relatively low temperature makes it an unlikely source for electric generation.

The geothermal areas (with the exception of Mt. Spurn) of both Wrangell and Chigmit Mountains are located in lands designated as National Parks. The federal Geothermal Steam Act prohibits leasing and developing National Park lands. If, however, townships within these areas are selected by a Native corporation under the Alaskan Native Claims Settlement Act, and if the surface and subsurface estates are conveyed to private ownership, then the federal government jurisdiction would not apply, and development could be possible. The Alaska National Interest Lands Conservation Act of 1980 allows the granting of rights-of-way for pipelines, transmission lines and other facilities across National Interest Lands for access to resources surrounded by National Interest Lands.

(g) Wind

Until the mid 1930s, wind energy supplied a significant amount of energy to rural areas of the United States. With the advent of rural electrification, wind energy ceased to be competitive with other power alternatives. However, rising fuel costs and the increased cost of power from competing technologies has renewed interest in the development of wind resources. This energy source may come to play a significant role in electric power generation in rural areas, small communities, and possibly for large interconnected energy systems.

(i) Large Wind Systems

Large wind turbines are being developed in response to this renewed interest and are in a demonstration phase. In 1979, a MOD-1, 2-MW, 200 ft diameter turbine was completed at Boone, North Carolina. Three MOD-2 wind turbines, rated at 2.5-MW capacity, are under construction near Goldendale, Washington by the Bonneville Power Administration, U.S. Department of Energy, and NASA. These and other wind turbines in the 1-MW range of rated output are available for production, but benefits of assembly line production have not been realized. Commercially available, mass produced wind machines are at present quite small and only available in unit sizes of about 5 kW, with the maximum at 45 kW. This section will focus on large wind turbines of 0.1 MW rated capacity or more such as might by employed as centralized power generating facilities by a utility.

- Siting Requirements

The siting of the wind turbines is crucial in wind energy conversion systems. The most significant siting consideration is average wind speed and variability. These depend on large-scale weather patterns but are also affected by local topography, which can enhance or reduce the average wind speeds. Since wind energy potential is directly proportional to the cube of the wind speed, siting wind machines to take advantage of even small incremental increases in wind speed is important (17). Extremely high winds and turbulence may damage the wind turbines, and any sites exhibiting these characteristics must be avoided.

Other important siting considerations include the proximity of the site to load centers, site access, founding conditions, and meteorological conditions. Undesirable meteorological conditions in addition to turbulence include glazing conditions, blowing sand or dust, heavy accumulations of snow, and extreme cold.

- Environmental Considerations

Wind turbines extract energy from the atmosphere and therefore have the potential of causing slight modifications to the surrounding climate. Wind speeds will be slightly reduced at surface levels and to a distance equivalent to five rotor diameters, which for a single 2.5-MW facility would be approximately 1500 ft. Small modifications in precipitation patterns may be expected, but total rainfall over a wide area will not be affected. Nearby temperatures, evaporation, snowfall, and snow drift patterns will be affected only slightly. The microclimatic impacts will be qualitatively similar to those noted around large isolated trees or tall structures.

The rotation of the turbine blades may interfere with television, radio, and microwave transmission. Interference has been noted within 0.6 miles (1 km) of relatively small wind turbines. The nature of the interference depends on signal frequencies, blade rotation rate, number of blades, and wind turbine design. A judicious siting strategy could help to avoid these impacts.

Stream siltation effects from site and road construction are the only potential aquatic and marine impacts associated with this technology. Silt in streams may adversely affect feeding and spawning of fish, particularly salmonids which are common in the Railbelt region. These potential problems can be avoided by proper construction techniques and should not be significant unless extremely large wind farms are developed. Wind-powered energy requires varying amounts of land area for development. The amounts of area required depend on number, spacing, and types of wind-powered units used. This can range from approximately 2 acres for one 2.5-MW generating unit to over 100 square miles for a 1000 MW wind farm. These developments, due to requirements for persistent high-velocity winds, would probably be established in remote areas.

Because of the land requirements involved, the potentially remote siting locations and the possible need for clearing of vegetation, the greatest impact resulting from wind energy projects on terrestrial biota would be loss or disturbance of habitat. Wind generating structures could also affect migratory birds by causing collisions. Other potential impacts include low frequency noise emanating from the generators and modification of local atmospheric conditions from air turbulence created by the rotating blades. The impacts of these latter disturbances on wildlife, however, are presently unclear.

Environmentally sensitive areas in the Railbelt region presently proposed for wind energy development are exposed coastal areas along the Gulf of Alaska, and possibly hilltops and ridgelines in the interior. Alteration of coastal bluffs could negatively affect seasonal ranges of mountain goats of the Kenai Mountain Range, and nesting colonies of sea birds in the Chugach Islands, Resurrection Bay, Harris Bay, Nuka Pass, and other areas along the Gulf Coast. Shoreline development could affect harbor seals and migratory birds. Harbor seals utilize much of the coastline for hauling-out. The Copper River Delta is a key waterfowl area. Scattered use of shoreline habitat by black bear, brown bear, and Sitka blacktailed deer occurs in Prince William Sound. The presence of wind energy structures in any of these areas could potentially cause collisions with migrating waterfowl, bald eagles, peregrine falcons (endangered species), and other birds, if situated in migratory corridors. Inland development of wind energy could negatively affect Dall sheep, mountain goat, moose, and caribou if situated on critical range lands.

These terrestrial imapcts can generally be mitigated by siting plants in areas of low wildlife use. This would include avoiding critical ranges of big game, traditional haul-out areas of seals and nesting colonies of birds, and known migratory bird corridors or key feeding areas. The feasibility of mitigation will, of course, depend on the size of the wind energy development.

- Potential Application to Railbelt Energy Demand

A wind-turbine system consisting of five machines has been installed at Gambell on St. Lawrence Island in Alaska to provide wind electric power for community facilities. Another wind turbine has been installed at Nelson Lagoon on the Alaskan Peninsula.

Studies to identify wind energy resources in the Railbelt would require a significant data base. Such a data base is currently lacking. Currently available literature is not adequate to comprehensively identify potential wind energy conversion system sites in the Railbelt region. Studies necessary to assess wind energy potential include: preparing and examining detailed contour patterns of the terrain, modeling selected sites, monitoring meteorological conditions at prime sites for at least one year (preferably three years), analyses using modeled and measured data, developing site-specific wind duration curves, and selecting final sites.

The University of Alaska has conducted a preliminary assessment of wind power potential in Alaska. The results of these studies indicated a potential for favorable sites for wind energy development at exposed coastal locations and possibly along ridgelines or hills in the interior (19).

(ii) Small Wind Systems

Small wind energy conversion systems (SWECS) are wind machines with rated output of 100 kW or less. Typically these machines would be sited in a dispersed manner, at individual residences or in small communities, as compared to the large wind energy conversion systems which would be sited, generally in clusters, as centralized power production facilities.

Small wind energy conversion systems are available in horizontal and in vertical axis configuration. The horizontal areas machines exhibit superior efficiency but require a substantial tower to support the generating equipment as well as the blades. In addition, the blade/generator assembly must revolve in conformance with changing wind direction, requiring provision of head bearings and slip rings and machine orientation devices.

Although of lower efficiency than horizontal axis machines, the vertical axis generator is located in a fixed position near the ground, minimizing tower structure and eliminating the need for head bearings or slip rings. Because of these advantages, vertical axis machines may exhibit superior cost characteristics in the small wind machine sizes.

A number of small wind machines are now in commercial production in sizes ranging from 0.1 to 37 kW.

Historically, battery-charging systems have been the primary application for Small Wind Energy Conversion Systems in Alaska; however, this is beginning to change.

The subject of this study has been concerned with SWECS which interface directly with the utility grid. Off-grid installations were not considered.

- Siting Requirements

  A wind speed of 7 to 10 mph is required to start most SWECS producing power. An annual average of 10 mph is usually considered a lower economic cut-off for most applications; however, this is very dependent on the site, energy costs, and particular wind generator design.

  Turbulent energy is the worst for SWECS. It can be caused by trees, buildings, and topography. Because wind acts like a fluid in that it slows down when it encounters an object or rough terrain, the higher up from the ground, the stronger the wind. Thus each site must be evaluated for terrain and what affect that may have on winds speeds at different heights.

A small wind machine which is to be intertied to the utility grid must be reasonably close to existing or planned power lines. This requirement may eliminate many ridge tops because of the high transmission line losses.

- Environmental Impacts

Studies have shown some enhancement of local wildlife due to downwind shelters, as well as a possible adverse impact on low flying night migratory birds in bad weather. However, the kill rate is not significant.

Aesthetic intrusiveness is difficult to assess and highly subjective. Many people surveyed have found small wind machines to be visually pleasing. Small generators noise is not significant with proper blade design.

Small wind machines mounted on towers required no more than 100 sq ft at the base plus any exclusion area which the owner wishes to fence off for safety reasons (usually no more than about five blade diameters).

Radio frequency interference can be mitigated with proper blade design (nonmetallic) and siting.

Potential safety risks involve the possibility of tower or blade failure aircraft collision. Actions taken to decrease those risks include:

o maintenance of an exclusion area around the turbine;

o automatic monitoring of turbine operation;

o regular preventative maintenance;

o visitor control measures; and

o adherence to FAA requirements for tall structures.

- Potential Application to the Railbelt Region

Until recently there were only a handful of SWECS manufacturers. Today there are over 50 with a half dozen mass producing generators at a respectable rate (20-200/ month).

A dealership and repair network is already in existence in the Railbelt region and would grow as the number of installed WECS increases. Engineering and design expertise is also present in the region. Five system design organizations, four suppliers and one installer were operating in the Railbelt in 1981.

The major obstacle to the availability of wind generators seems to be the lack of venture capital in an unstable economic climate, which makes needed plant expansion difficult for manufacturers. Once the market penetration and mass production has brought the unit cost down and manufacturers have internalized major R&D efforts, then widespread use of SWECS may become a reality.

Wind data have historically been collected from airports at a height usually no greater than 30 ft. Wind generators are typically not located near airports (which are usually sited in locations protected from winds) and are placed at least twice as high as conventional meteorological stations. A few examples will illustrate the problem:

- The annual average recorded for Anchorage is 5 mph taken at the international airport. Closer to the mountains at the site of an installed wind generator the average is 6 mph. At Flat Top Mountain, a homeowner who plans to install a SWECS has recorded months of 15 mph averages.

- In Homer the recorded annual average is 9 mph at the airport, while on the "spit" the average is reported to be closer to 13 mph. Further up the hill at the site for an 18 kW SWECS, the winds have not been measured but are expected to be better than at the airport.

- In Fairbanks the average is recorded as 4 mph, yet as one climibs out of the valley the average wind speed almost triples near Murphy Dome.

This suggests that existing data are not very helpful in determining the potential of SWECS in the Railbelt. The number of mountain passes with channeling effects, glaciers with their constant source of winds, and coastal regions with the windy maritime influences yield thousands of potential SWECS sites in the Railbelt.

Because of the lack of data taken for siting small wind machines, there is no quantitative means for assessing the possible contribution SWECS would have in the Railbelt region. However, since most of the population lives in two known areas of low winds (Anchorage and

Fairbanks), it is reasonable to assume that without large-scale utilization of "wind farms," only a small percentage of the total Railbelt load could be met by wind power (less than 10 percent) in the next five years. If a decision were made to develop clusters of SWECS, then this contribution could become significant in the midterm (five to ten years).

(h) Solar

Two basic methods for generating electric power from solar radiation are under development, solar thermal conversion and photovoltaic systems. Solar thermal systems convert solar radiation to heat in a working fluid. This working fluid can include water, steam, air, various solutions, and molten metals. Energy is realized as work when the fluid is used to drive a turbine. Photovoltaic systems is a more direct approach. Solar energy is converted to electric energy by the activation of electrons in photosensitive substances.

At present, commercially available photovoltaic cells are made of silicon wafers and assembled largely by hand. Nearly two dozen technologies and automatic assembly techniques are under development. Photovoltaic technology is undergoing a burst of innovation comparable to the integrated circuit-semiconductor technology. New and more efficient cell designs have been proposed capable of converting 30 to 40 percent of the sunlight falling on them to electricity.

Both solar technologies suffer from the same constraints. Available solar energy is diurnally and seasonally variable and is subject to uncertainties of cloud cover and precipitation. Solar energy resources must be employed as a "fuel saving" option or they must be installed with adequate storage capacity. In addition, if the diurnal and annual cycles are out of phase with solar energy potential cycles, the inducements for development of this resource are further reduced. The energy demand and solar availability cycles are out of phase in the Railbelt region, where demand generally peaks in winter and at night.

(i) Siting Requirements

Solar electric generating systems are optimally located in areas with clear skies. The geographic latitude of the proposed site also plays an important role in determining the intensity of solar insolation. Low sun angles, characteristic of high latitudes, provide less solar radiation per unit area of the earth's surface, requiring greater collector area to achieve a given rated capacity.

Increasing the "tilt" of collectors relative to the surface of the earth increases the solar power density per unit area of collector but results in shading of adjacent collection devices at low sun angles. These factors place severe constraints on the development of solar energy in the Railbelt region.

In addition to the latitudinal and cloudiness constraints, potential sites must not be shaded by topographic or vegetative features. This type of shading does not present a severe restriction for development in the Railbelt region. The potential for snow and ice accumulation also inhibits development of solar energy resources.

(ii) Environmental Considerations

Photovoltaic systems do not require cooling water or other continuous process feedwater for their efficient operation. Small quantities of water are required for domestic uses, equipment cleaning, and other miscellaneous uses, but if standard engineering practice is followed, water resource effects should be insignificant. If hot water cogeneration systems are employed in conjunction with photovoltaic systems, continuous feedwater will be required to offset system losses. In light of the small plant capacities that would be considered for the Railbelt and the absence of cooling water requirements, water resource effects should be minimal.

The development of solar thermal conversion systems would produce water resource effects similar to other of steam cycle facilities. Boiler feedwater and condenser cooling water will be required and will necessitate proper management techniques. Water requirements are extremely site-specific as efficiencies ranging from 10 to 70 percent are possible depending upon climatic factors. However, in light of the small capacities considered, impacts should not be significant.

Solar thermal conversion systems may also be operated utilizing a working fluid other than water. Fluids such as liquid sodium, sodium hydroxide, hydrocarbon oils, and sodium and potassium nitrates and nitrites have the potential to adversely affect water quality through accidental spills and normal system flushing. Specialized transportation and handling techniques will be required to minimize spill risk and properly mitigate potential impacts.

Water resource impacts would also occur if pumped storage facilities were utilized as the energy storage technology for either photovoltaic or solar thermal conversion systems.

Solar thermal and photovoltaic electric power conversion systems have no impact on ambient air quality because they do not emit gaseous pollutants. Water vapor plumes may emanate from cooling systems associated with solar thermal processes, however. These plumes will be substantially reduced because solar thermal systems operate best in full sunlight when the air tends to be well below saturation. The water droplets are quickly evaporated into a dry atmosphere. The plumes can also be mitigated by using dry or wet/dry cooling tower systems.

Some modification of the microclimate will occur near a solar energy facility. The heat is merely redistributed within the facility and will not affect climatic conditions offsite. The climatic response of these facilities will be similar to that of any comparably large construction project.

Due to minimal water requirements, the operation of photovoltaic systems will have insignificant impacts on fresh or marine aquatic biota but solar thermal conversion plants may have impacts similar to those of other steam cycle plants. These impacts, however, should be small and easy to mitigate in light of the small plant capacities considered.

The major terrestrial impact associated with photovoltaic or solar thermal conversion systems is habitat loss. If these systems are located in remote areas, the potential for wildlife disturbance through increased human access may also be significant. Spills of non-water working fluids if used, could adversely affect local ecosystems. In general, however, impacts to the terrestrial biota of the Railbelt region should be minimal, since power plant capacities for both photovoltaic and thermal conversion systems will be small.

(iii) Potential Application to the Railbelt Region

Data collected at Fairbanks and at Matanuska, near Anchorage, reflect the influence of both cloudiness and the annual cycle in sun angle at these locations. At Fairbanks the total daily solar radiation on a horizontal surface is

13 Btu/ft^2 in December and 1969 Btu/ft^2 in June. At Matanuska these values range from 48 Btu/ft^2 in December to 1730 Btu/ft^2 in June. In comparison, in the arid southwestern United States, January values of 1200 Btu/ft^2 are common with many areas having July values over 2500 Btu/ft^2. Even in less favored areas such as Minnesota, these same values vary from 550 Btu/ft^2 to 2000 Btu/ft^2 during the year. These data indicate that while there is an abundant supply of solar energy on a horizontal surface in midsummer in Alaska, the mid-winter values are an order of magnitude less than those of even poor sites in the remainder of the country. The obvious lack of sunshine in the winter restrains the development of solar energy in the Railbelt region. Even on south-facing vertical walls, the daily total solar radiation in Matanuska is only 300 Btu/ft^2 in December, which indicates that the mere reorientation of collecting surfaces will not alleviate the siting constraint.

None of the existing or developing solar photovoltaic technologies represents an economically viable form of large-scale electric power generation in the Railbelt. Current systems provide only a few watts of output and are not currently planned for large-scale application.

10.4 - Environmental Consequences of License Denial

Should the FERC license for the Susitna Hydroelectric project be denied, the State of Alaska would have to pursue other electrical power generating schemes. These other schemes would necessarily include heavy reliance on thermal sources if the projected energy demand is to be met.

As discussed previously, thermal generation is associated with increased air pollution problems, increased fuel storage problems, increased surface and groundwater contamination problems, increased waste disposal problems, and increased fuel transportation problems. The Alaskan environment would be exposed to these risks.

The majority of Alaska's population would be denied a source of power generation that offers long term stability in power costs with relative insulation from the influence of inflation and fossil fuel prices dictated largely by internation political economic events. Further, the non-renewable fossil fuel resources used would be lost for future use or for use in locations where hydroelectric potential is unavailable.

Potential benefits would be centered in the upper Susitna basin where access road and transmission line corridors would remain in their natural state. Public access would remain limited and established wildlife patterns would remain undisturbed. In addition, the flow modification and thermal problem that might result from the dams would not affect anadromous fish.

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TABLE E.10.1: SUMMARY OF RESULTS OF SCREENING PROCESS

Site [1]	Elimination Iteration 1	2	3	4	Site [1]	Elimination Iteration 1	2	3	4	Site [1]	Elimination Iteration 1	2	3	4	Site [1]	Elimination Iteration 1	2	3	4
Allison Creek					Fox	*				Lowe				*	Talachulitna River	*			
Beluga Lower			*		Gakona		*			Lower Chulitna				*	Talkeetna R. -Sheep	*			
Beluga Upper				*	Gerstle			*		Lucy	*				Talkeetna - 2				
Big Delta	*				Granite Gorge			*		McClure Bay			*		Tanana River			*	
Bradley Lake				*	Grant Lake			*		McKinley River		*			Tazlina				*
Bremmer R. -Salmon	*				Greenstone			*		McLaren River	*				Tebay Lake		*		
Bremmer R. -S.F.	*				Gulkana River			*		Million Dollar		*			Teklanika		*		
Browne					Hanagita		*			Moose Horn	*				Tiekel River	*			
Bruskasna					Healy		*			Nellie Juan River	*				Tokichitna				*
Cache					Hicks					Nellie Juan R. -Upper				*	Totatlanika	*			
Canyon Creek	*				Jack River	*				Ohio			*		Tustumena				*
Caribou Creek	*				Johnson				*	Power Creek		*			Vachon Island		*		
Carlo		*			Junction Island		*			Power Creek - 1	*				Whiskers				*
Cathedral Bluffs				*	Kanhshna River			*		Ramport		*			Wood Canyon		*		
Chakachamna					Kasilof River		*			Sanford		*			Yanert - 2		*		
Chulitna E.F.	*				Keetna					Sheep Creek			*		Yentna			*	
Chulitna Hurrican			*		Kenai Lake				*	Sheep Creek - 1	*								
Chulitna W.F.	*				Kenai Lower			*		Silver Lake				*					
Cleave		*			Killey River	*				Skwentna				*					
Coal			*		King Mtn	*				Snow									
Coffee				*	Klutina				*	Solomon Gulch			*						
Crescent Lake			*		Kotsina	*				Stelters Ranch	*								
Crescent Lake - 2		*			Lake Creek Lower		*			Strandline Lake									
Deadman Creek	*				Lake Creek Upper				*	Summit Lake	*								
Eagle River	*				Lane				*	Talachulitna			*						

Notes:

(1) Final site selection underlined.

* Site eliminated from further consideration.

TABLE E.10.2: SITES ELIMINATED IN SECOND ITERATION

Site	Criterion
Carlo Yanert - 2	Denali National Park, National Park Wilderness
Healy Lake Creek Upper McKinley River Teklanika	Denali National Park
Cleave Wood Canyon	Wrangell-St. Elias National Park & Preserve, National Park Wilderness, Major Fishery
Tebay Lake Hanagita	Wrangell-St. Elias National Park & Preserve, National Park Wilderness
Gakona Sanford	Wrangell-St. Elias National Park & Preserve
Cresent Lake	Lake Clark National Park
Kasilof River Million Dollar Rampart Vachon Island Junction Island Power Creek	Major Fishery
Gulkana	Wild & Scenic River

TABLE E.10.3: EVALUATION CRITERIA

Evaluation Criteria	General Concerns
(1) Big Game	- Protection of wildlife resources
(2) Agricultural Potential	- Protection of existing and potential agricultural resources
(3) Waterfowl, Raptors & Endangered Species	- Protection of wildlife resources
(4) Anadromous Fisheries	- Protection of fisheries
(5) Wilderness Consideration	- Protection of wilderness and unique features
(6) Cultural, Recreation & Scientific Features	- Protection of existing and identified potential features
(7) Restricted Land Use	- Consideration of legal restriction to land use
(8) Access	- Identification of areas where the greatest change would occur

TABLE E.10.4: SENSITIVITY SCALING

Scale Rating	Definition
A. EXCLUSION	The significance of one factor is great enough to exclude a site from further consideration. There is little or no possibility for mitigation of extreme adverse impacts, or development of the site is legally prohibited.
B. HIGH SENSITIVITY	1) The most sensitive components of the environmental criteria would be disturbed by development, or 2) There exists a high potential for future conflict which should be investigated in a more detailed assessment.
C. MODERATE SENSITIVITY	Areas of concern were less important than those in "B" above.
D. LOW SENSITIVITY	1) Areas of concerns are common for most or many of the sites. 2) Concerns are less important than those of "C" above. 3) The available information alone is not enough to indicate a greater significance.

TABLE E.10.5: SENSITIVITY SCALING OF EVALUATION CRITERIA

Evaluation Criteria	SCALE			
	A Exclusion	B High	C Moderate	D Low
Big Game:	--	- seasonal concentration - are key range areas - calving areas	- big game present - bear denning area	- habitat or distribution area for bear
Agricultural Potential	--	- upland or lowland soils suitable for farming	- marginal farming soils	- no identified agricultural potential
Waterfowl, Raptors and Endangered Species	--	- nesting areas for: • Peregrine Falcon • Canada Goose • Trumputee Swan - year-round habitat for neritic seabirds and raptors - key migration area	- high-density waterfowl area - waterfowl migration and hunting area - waterfowl migration route - waterfowl nesting or molt area	- medium or low density waterfowl areas - waterfowl present
Anadromous Fisheries	- major anadromous fish corridor for three or more species - more than 50,000 salmon passing site	- three or more species present or spawning - identified as a major anadromous fish area	- less than three species present or spawning - identified as an important fish area	- not identified as a spawning or rearing area.
Wilderness Consideration	--	All of the following - good-to-high quality: • scenic area • natural features • primitive values - selected for wilderness consideration	Two of the following - good-to-high quality: • scenic area • natural features • primitive value - site in or close to an area selected for wilderness consideration	One or less of the following - good-to-high quality: • scenic area • natural features • primitive value
Cultural, Recreational and Scientific Features	--	- existing or proposed historic landmark - reserve proposed for the Ecological Reserve System	- Site affects one or more of the following: • boating potential • recreational potential • historic feature • historic trail • archaeological site • ecological reserve nomination • cultural feature	- site near one of the factors in B or C

TABLE E.10.5 (Continued)

Evaluation Criteria	SCALE			
	A Exclusion	B High	C Moderate	D Low
Restricted Land Use	- Significant impact to: . Existing national park . Federal lands withdrawn by National Monument Proclamations	- Impact to: . National wildlife range . State park . State game refuge, range, or wilderness preservation area	- Increase: . National forest . Proposed wild and scenic river . National resource area . Forest land withdrawn for mineral entry	- In one of the following: . State land . Native land . None of A, B, C
Access	--	- no existing roads, railroads or airports - terrain rough and access difficult - increase access to wilderness area	- existing trails - proposed roads or - existing airports - close to existing roads	- existing roads or railroads - existing power lines

TABLE E.10.6: SITE EVALUATIONS

Site	Evaluation Criteria: Big Game	Agricultural Potential	Waterfowl, Raptors, Endangered Species	Anadromous Fisheries	Wilderness Consideration	Cultural, Recreational, and Scientific Features	Restricted Land Use
Allison Creek	- Black and Grizzly bear present	- None identified	- Year-round habitat for neritic seabirds and raptors - Peregrine falcon nesting area - Waterfowl present	- Spawning area for two salmon species	- High-to-good-quality scenic area	- None identified	- Near Chugach National Forest
Bradley Lake	- Black and Grizzly bear present - Moose present	- 25 to 30 percent of soil marginally suitable for farming - high quality forests	- Peregrine Falcon nesting areas	- None identified	- Good-to-high-quality scenery	- Boating area	- None identified
Browne	- Black and Grizzly bear present - Moose present - Caribou winter range	- More than 50 percent marginally suitable for farming	- Low density of waterfowl	- None	- None	- Boating potential	- None identified
Bruskasna	- Black and Grizzly bear present - Moose present - Caribou winter range	- None identified	- Low density of waterfowl - Nesting and molting area	- None	- Good-to-high-quality scenery	- Boating potential - Proposed ecological reserve site	- None identified
Chakachamna	- Black bear habitat - Moose present	- Upland spruce, hardwood forest	- Waterfowl nesting and molting area	- Two species present	- Area under wilderness consideration - Good-to-high-quality scenery - Primitive and natural features	- Boating areas	- None identified
Coffee	- Black and Grizzly bear present - Moose present	- More than 50 percent of upperland suitable for agriculture - Good forests	- Key waterfowl habitat	- Four species present, two spawning in area	- None identified	- Boating area	- None identified
Cathedral Bluffs	- Black and Grizzly bear present - Moose present - Dall sheep present - Moose concentration area	- More than 50 percent of land marginal for farming - Upland spruce-hardwood forest	- Low density of waterfowl - Nesting and molting area	- One species present	- Good scenery	- None identified	- None identified
Hicks	- Black and Grizzly bear present - Caribou present - Moose wintering area	- None identified	- Waterfowl nesting and molting area	- Far downstream from site only	- None identified	- None identified	- No present restrictions
Johnson	- Black and Grizzly bear present - Moose, caribou and bison present	- 25 to 50 percent of upland soil suitable for farming - Upland spruce-hardwood forest	- Low density of waterfowl - Nesting and molting area	- Salmon spawning area, one species present	- None identified	- Boating potential	- None identified
Keetna	- Black and Grizzly bear present - Caribou winter area - Moose fall/winter concentration area	- None identified	- None identified	- Four species present, one species spawning near site	- Good-to-high-quality primitive lands	- High boating potential	- None identified
Kenai Lake	- Black and Grizzly bear present - Dall sheep habitat - Moose fall/winter concentration area	- None identified - Coastal hemlock-sitka spruce forest	- Waterfowl nesting and molting area	- Four species present, two spawning	- High-quality scenery - Natural features	- Boating potential	- Chugach National Forest

TABLE E.10.6 (Continued)

Site	Big Game	Agricultural Potential	Waterfowl, Rapters, Endangered Species	Anadromous Fisheries	Wilderness Consideration	Cultural, Recreational, and Scientific Features	Restricted Land Use
	Evaluation Criteria						
Klutina	- Black and Grizzly bear present - Caribou present - Moose fall concentration area	- 25 to 50 percent of soils marginal for farming - Climate marginal for farming upland spruce-hardwood forest	- Low-density waterfowl area - Nesting and molting area	- Two species present, one species spawn in vicinity of site	- High-quality scenery - Natural formations - Primitive lands - Selected for wilderness consideration	- Boating potential	- None identifed
Lane	- Black bear present - Moose present - Caribou present	- More than 50 percent of the soils in upperlands suitable for farming - Bottomland spruce-poplar forest	- Low-density waterfowl area - Nesting and molting area	- Five species present and spawn in site vicinity	- None identified	- Boating opportunities identified	- None identified
Lowe	- Black and Grizzly bear present - Moose present	- None identified - Coastal western hemlock-sitka spruce forest	- Peregrine Falcon nesting area	- One species present, others downstream of site	- Good-to-high-quality scenery - Area selected for wilderness consideration	- Historical feature - Proposed ecological reserve site	- Located near the border of Chugach National Forest
Lower Chulitna	- Black and Grizzly bear present - Caribou present	- More than 50 percent of the upland soils suitable for farming	- Medium-density waterfowl area - Nesting and molting area	- Four species present, three spawning in vicinity	- Area selected for wilderness consideration	- Boating potential	- None identified
Silver Lake	- Black and Grizzly bear present - High density of seals	- None identified - Coastal western hemlock-sitka spruce forest	- Year-round habitat for neritic seabirds and raptors	- One species present, more downstream	- Good-to-high-quality scenery - Primitive value	- Boating area potential	- Chugach National Fores
Skwentna	- Black and Grizzly bear present - Moose winter concentration area	- 50 percent of upperlands suitable for farming - Lowland spruce-hardwood forest	- Low-density waterfowl area - Nesting and molting area	- Three species present, spawning in area	- None identified	- Boating area - Historical trails	- None identified
Snow	- Black bear present - Dall sheep habitats - Moose winter concentration area	- None identified	- Nesting and molting area	- None	- None identified	- Proposed ecological reserve site	- Located in Chugach National Forest
Strandline Lake	- Moose, black bear habitat - Grizzly bear present	- 25 to 50 percent marginal farming soils - Alpine tundra	- Nesting and molting area	- None present	- Good-to-high-quality scenery - Primitive lands	- None identified	- None identified
Talkeetna 2	- Black and Grizzly bear presnt - Moose fall/winter concentration area - Caribou winter range	- None identified	- None identified	- Four species present, one species spawns at site	- Good-to-high-quality scenery - Primitive lands	- Boating potential	- None identified
Cache	- Black and Grizzly bear present - Moose winter concentration area - Caribou winter range	- None identified	- None identified	- Four species of salmon present, spawning areas identified	- Good-to-high-quality scenery - Primitive lands	- Boating potential	- None identified
Tazlina	- Black and Grizzly bear present - Moose winter range - Caribou winter range	- None identified - Lowland spruce-hardwood forest	- Medium-density waterfowl area - Nesting and molting area	- Two species present at site and upstream	- None identified	- Boating potential	- None identified
Tokichitna	- Black bear present - Moose present - Caribou present	- More than 50 percent of soils are usable for farming (in upper lands)	- Medium-density waterfowl area - Nesting and molting area	- Four species present, three species spawn in site vicinity	- Border primitive area	- Boating potential	- None identified

TABLE E.10.6 (Continued)

Site	Evaluation Criteria					
	Big Game	Agricultural Potential	Waterfowl, Raptors, Endangered Species	Anadromous Fisheries	Wilderness Consideration	Cultural, Recreational, and Scientific Features	Restricted Land Use
Tustumena	- Black bear habitat - Dall sheep habitat	- None identified	- None identified	- None identified	- Selected for wilderness consideration - Good-to-high-quality scenery - Natural features - Primitive lands	- None identified	- Located in Kenai National Moose Range - Site within a designated National Wilderness area
Upper Beluga	- Moose present	- More than 50 percent of upperlands are suitable for farming - Lowland spruce-hardwood forest	- Medium density waterfowl area - Nesting and molting area	- Four species present, two species spawn in area	- None identified	- Boating area	- None identified
Upper Nellie Juan	- Grizzly bear present - Moose present - Black bear habitat	- None identified - Coastal western hemlock-sitka spurce forest	- None identified	- None identified	- Selected for wilderness consideration - High primitive, scenic, and natural features	- Boating potential	- Chugach National Forest
Whiskers	- Black and Grizzly bear present - Moose present - Caribou present	- 50 percent of upperlands suitable for farming - Bottomland spruce-poplar forest	- Low-density waterfowl area - Nesting and molting area	- Five species present, two spawn in area	- None identified	- Boating potential	- None identified
Yentna	- Black and Grizzly bear present - Moose, spring/summer/winter concentration	- 25 to 50 percent of soils in lowlands are suitable for farming - Bottomland spruce-poplar forest	- Medium-density waterfowl area - Nesting and molting area	- Five species spawn in area	- None identified	- Boating potential	- None identified

TABLE E.10.7: SITE EVALUATION MATRIX

	Big Game	Agricultural Potential	Waterfowl, Raptors, Endg. Species	Anadromous Fisheries	Wilderness Consideration	Cult, Recrea, & Scientific	Restricted Land Use	Access	Installed Capacity (MW)	Scheme	Dam Height (ft)	Land Flooded (Acres)
Crescent Lake	C	D	D	B	C	C	A	B	--	Reservoir w/Diversion	<150	<5000
Chakachamna	C	D	C	C	B	C	B	C	>100	Reservoir w/Diversion	<150	<5000
Lower Beluga	C	D	C	B	D	C	D	D	<25	Reservoir and Dam	<150	<5000
Coffee	C	B	C	B	D	C	D	D	25-100	Dam and Reservoir	<150	<5000
Upper Beluga	C	B	C	B	D	C	D	D	25-100	Dam and Reservoir	150-350	5000 to 100,000
Strandline Lake	C	C	C	D	C	D	D	D	<25	Reservoir w/Diversion	<150	<5000
Bradley Lake	C	C	B	D	C	C	D	D	25-100	Reservoir w/Diversion	<150	<5000
Kasilof River	C	B	C	A	D	C	B	D	---	Reservoir w/Diversion	150-350	>100,000
Tustumena	C	D	D	D	B	D	B	B	<25	Reservoir w/Diversion	<150	<5000
Kenai Lower	C	B	C	B	C	C	B	D	25-100 M	Dam and Reservoir	<150	<5000
Kenai Lake	B	D	C	B	C	D	C	D	>100	Dam and Reservoir	>350	5000 to 100,000
Crescent Lake-2	C	D	C	C	C	C	C	D	<25	Reservoir w/Diversion	<150	<5000
Grant Lake	B	D	C	B	C	C	C	D	<25	Reservoir w/Diversion	<150	<5000
Snow	B	D	C	D	D	C	C	D	25-100	Reservoir w/Diversion	150-350	5000 to 100,000
McClure Bay	D	D	B	C	B	D	C	C	<25	Reservoir w/Diversion	<150	<5000
Upper Nellie Juan R	C	D	D	D	B	C	C		<25	Reservoir w/Diversion	<150	<5000
Allison Creek	D	D	B	C	D	D	D	D	<25	Reservoir w/Diversion	<150	<5000
Solomon Gulch	D	D	B	C	D	D	D	D	<25	Reservoir w/Diversion	<150	<5000
Lowe	C	D	B	C	C	C	D	D	25-100	Dam and Reservoir	150-350	5000 to 100,000
Silver Lake	D	D	B	C	C	C	C	C	<25	Reservoir w/Diversion	<150	<5000
Power Creek	D	D	B	A	C	C	C	C	<25	Reservoir w/Diversion	<150	<5000
Million Dollar	D	D	B	A	B	C	C	C	--	Dam and Reservoir	<150	5000 to 100,000

TABLE E.10.7 (Continued)

	Big Game	Agricultural Potential	Waterfowl, Raptors, Endg. Species	Anadromous Fisheries	Wilderness Consideration	Cult, Recrea, & Scientific	Restricted Land Use	Access	Installed Capacity (MW)	Scheme	Dam Height (ft)	Land Flooded (Acres)
Keetna	B	D	D	B	D	C	D	C	25-100	Dam and Reservoir	>350	5000 to 100,000
Granite Gorge	B	D	D	B	C	C	D	C	25-100	Reservoir w/Diversion	150-350	<5000
Talkeetna-2	B	D	D	B	C	C	D	C	25-100	Dam and Reservoir	>350	5000 to 100,000
Greenstone	B	D	D	B	C	C	D	C	25-100	Reservoir w/Diversion	150-350	<5000
Cache	B	D	D	B	C	C	D	C	25-100	Dam and Reservoir	150-350	<5000
Hicks	B	D	C	D	D	D	D	D	25-100	Dam and Reservoir	150-350	<5000
Rampart	C	B	B	A	D	C	C	--	>100	Dam and Reservoir	>350	>100,000
Vachon Island	B	B	C	A	D	C	D	C	>100	Dam and Reservoir	<150	>100,000
Junction Island	B	B	C	A	D	C	D	C	>100	Dam and Reservoir	150-350	>100,000
Kantishna River	C	B	C	B	D	C	D	C	25-100	Dam and Reservoir	<150	>100,000
McKinley River	B	D	C	D	B	C	A	--	--	Dam and Reservoir	150-350	<5000
Teklanika River	B	D	D	D	B	D	A	B		Dam and Reservoir	>350	5000 to 100,000
Browne	B	C	D	D	D	C	D	D	>100	Dam and Reservoir	150-350	5000 to 100,000
Healy	B	C	D	D	B	B	A	D	--	Dam and Reservoir	150-350	5000 to 100,000
Carlo	B	D	D	D	B	C	A	D	--	Dam and Reservoir	150-350	<5000
Yanert-2	B	D	D	D	B	C	A	D	--	Dam and Reservoir	150-350	5000 to 100,000
Bruskasna	B	D	C	D	D	B	D	D	25-100	Dam and Reservoir	150-350	5000 to 100,000
Tanana	B	B	C	B	D	C	D	D	25-100	Dam and Reservoir	<150	5000 to 100,000
Gerstle	B	B	C	C	D	C	D	C	25-100	Dam and Reservoir	<150	<5000
Johnson	C	B	C	C	D	C	D	D	>100	Dam and Reservoir	<150	5000 to 100,000
Cathedral Bluffs	B	C	C	C	D	D	D	D	>100	Dam and Reservoir	150-350	5000 to 100,000

TABLE E.10.7 (Continued)

	Big Game	Agricultural Potential	Waterfowl, Raptors, Endg. Species	Anadromous Fisheries	Wilderness Consideration	Cult, Recrea, & Scientific	Restricted Land Use	Access	Installed Capacity (MW)	Scheme	Dam Height (ft)	Land Flooded (Acres)
Cleave	C	D	B	B	B	C	A	D	--	Dam and Reservoir	150-350	5000 to 100,000
Wood Canyon	C	D	C	B	B	B	A	D	--	Dam and Reservoir	>350	>100,000
Tebay Lake	C	D	D	C	B	D	A	B	--	Reservoir w/Diversion	<150	<5000
Hanagita	C	D	D	D	B	D	A	B	--	Reservoir w/Diversion	<150	<5000
Klutina	B	C	C	C	B	C	D	--	25-100	--	--	--
Tazlina	B	D	C	C	D	C	C	--	>100	Dam and Reservoir	150-350	5000 to 100,000
Gakona	B	C	C	C	D	C	A	D	--	Dam and Reservoir	150-350	5000 to 100,000
Sanford	B	C	C	C	D	C	A	D	--	Dam and Reservoir	--	--
Gulkana	B	D	C	C	D	B	B	D	25-100	Reservoir w/Diversion	150-350	5000 to 100,000
Yentna	B	B	C	B	D	C	D	C	>100	Dam and Reservoir	<150	>100,000
Talachulitna	B	B	C	B	D	C	D	C	25-100	Dam and Reservoir	<150	5000 to 100,000
Skwentna	B	B	C	B	D	C	D	C	25-100	Dam and Reservoir	>350	5000 to 100,000
Lake Creek Upper	C	D	C	C	C	D	A	C	--	Reservoir w/Diversion	<150	<5000
Lake Creek Lower	C	B	C	B	D	C	D	C	--	Dam and Reservoir	150-350	<5000
Lower Chulitna	C	B	C	B	C	C	D	D	25-100	Dam and Reservoir	150-350	<5000
Tokichitna	C	B	C	B	C	C	D	D	>100	Dam and Reservoir	150-350	5000 to 100,000
Coal	B	D	C	C	C	C	D	D	25-100	Dam and Reservoir	150-350	<5000
Ohio	B	D	C	C	C	C	D	D	25-100	Dam and Reservoir	150-350	<5000
Chulitna	B	D	C	C	C	C	D	D	25-100	Dam and Reservoir	150-350	<5000
Whiskers	C	B	C	B	D	C	D	C	25-100	Dam and Reservoir	<150	<5000
Lane	C	B	C	B	D	C	D	C	>100	Dam and Reservoir	150-350	<5000
Sheep Creek	B	D	D	D	C	C	D	C	25-100	Dam and Reservoir	>350	<5000

TABLE E.10.8: CRITERIA WEIGHT ADJUSTMENTS

	Initial Weight	Adjusted Weights: Dam Height +	Dam Height ++	Dam Height +++	Reserv. Area +	Reserv. Area ++	Reserv. Area +++
Big Game	8				6	7	8
Agricultural Potential	7				5	6	7
Birds	8				6	7	8
Fisheries	10	8	9	10			

TABLE E.10.9: SITE CAPACITY GROUPS

Site Group	No. of Sites Evaluated	No. of Sites Accepted
≤ 25 MW	5	3
25- 100 MW	15	4 - 6
≥100 MW	8	4

TABLE E.10.10: RANKING RESULTS

Site Group	Partial Score	Total Score
Sites: < 25 MW		
Strandline Lake	59	85
Nellie Juan Upper	37	96
Tustumena	37	106
Allison Creek	65	82
Silver Lake	65	111
Sites: 25 - 100 MW		
Hicks	62	79
Bruskasna	71	104
Bradley Lake	71	104
Snow	71	106
Cache	86	127
Lowe	89	122
Keetna	89	131
Talkeetna - 2	98	134
Coffee	101	126
Whiskers	101	134
Klutina	101	142
Lower Chulitiua	106	139
Beluga Upper	117	142
Talachultna River	126	159
Skwentna	136	169
Sites > 100 MW		
Chakachamna	65	134
Browne	69	94
Tazlina	89	124
Johnson	96	121
Cathedral Bluffs	101	126
Lane	106	139
Kenai Lake	112	147
Tokichitna	117	150

TABLE E.10.11: SHORTLISTED SITES

Environmental Rating	Capacity 0 - 25 MW	25 - 100 MW	100 MW
Good	Strandline Lake* Allison Creek* Tustumena Silver Lake	Hicks* Snow* Cache* Bruskasna*	Browne* Johnson
Acceptable		Keetna*	Chakachamna*
Poor		Talkeetna-2* Lower Chulitna	Lane Tokichitna

* 10 selected sites

TABLE E.10.12: ALTERNATIVE HYDRO DEVELOPMENT PLANS

Plan	Description	Installed Capacity	On-Line Date
A.1	Chakachamna	500	1993
	Keetna	100	1997
A.2	Chakachamna	500	1993
	Keetna	100	1997
	Snow	50	2002
A.3	Chakachamna	500	1993
	Keetna	100	1996
	Snow	50	1998
	Strandline	20	1998
	Allison Creek	8	1998
A.4	Chakachamna	500	1993
	Keetna	100	1996
	Snow	50	2002
	Strandline	20	2002
	Allison Creek	8	2002
A.5	Chakachamna	500	1993
	Keetna	100	1996
	Snow	50	2002
	Talkeetna - 2	50	2002
	Cache	50	2002
	Strandline	20	2002
	Allison Creek	8	2002

TABLE E.10.13: OPERATING AND ECONOMIC PARAMETERS FOR SELECTED HYDROELECTRIC PLANTS

No.	Site	River	Max. Gross Head Ft.	Installed Capacity (MW)	Average Annual Energy (Gwh)	Plant Factor (%)	Capital Cost[1] ($$10^6$)	Economic Cost of Energy ($/1000 Kwh)
1	Snow	Snow	690	50	220	50	255	45
2	Bruskasna	Nenana	235	30	140	53	238	113
3	Keetna	Talkeetna	330	100	395	45	477	47
4	Cache	Talkeetna	310	50	220	51	564	100
5	Browne	Nenana	195	100	410	47	625	59
6	Talkeetna-2	Talkeetna	350	50	215	50	500	90
7	Hicks	Matanuska	275	60	245	46	529	84
8	Chakachamna	Chakachatna	945	500	1925	44	1480	30
9	Allison	Allison Creek	1270	8	33	47	54	125
10	Strandline Lake	Beluga	810	20	85	49	126	115

NOTES:
(1) Including engineering and owner's administrative costs but excluding AFDC.

TABLE E.10.14: SUSITNA DEVELOPMENT PLANS

			Stage/Incremental Data				Cumulative System Data		
Plan	Stage	Construction	Capital Cost $ Millions (1980 values)	Earliest On-line Date[1]	Reservoir Full Supply Level - ft.	Maximum Seasonal Draw-down-ft	Annual Energy Production Firm GWH	Avg. GWH.	Plant Factor %
1.1	1	Watana 2225 ft 800MW	1860	1993	2200	150	2670	3250	46
	2	Devil Canyon 1470 ft 600 MW	1000	1996	1450	100	5500	6230	51
		TOTAL SYSTEM 1400 MW	2860						
1.2	1	Watana 2060 ft 400 MW	1570	1992	2000	100	1710	2110	60
	2	Watana raise to 2225 ft	360	1995	2200	150	2670	2990	85
	3	Watana add 400 MW capacity	130[2]	1995	2200	150	2670	3250	46
	4	Devil Canyon 1470 ft 600 MW	1000	1996	1450	100	5500	6230	51
		TOTAL SYSTEM 1400 MW	3060						
1.3	1	Watana 2225 ft 400 MW	1740	1993	2200	150	2670	2990	85
	2	Watana add 400 MW capacity	150	1993	2200	150	2670	3250	46
	3	Devil Canyon 1470 ft 600 MW	1000	1996	1450	100	5500	6230	51
		TOTAL SYSTEM 1400 MW	2890						

TABLE E.10.14 (Continued)

			Stage/Incremental Data				Cumulative System Data		
Plan	Stage	Construction	Capital Cost $ Millions (1980 values)	Earliest On-line Date[1]	Reservoir Full Supply Level - ft.	Maximum Seasonal Draw-down-ft.	Annual Energy Production Firm GWH	Annual Energy Production Avg. GWH	Plant Factor %
2.1	1	High Devil Canyon							
		1775 ft 800 MW	1500	1994[3]	1750	150	2460	3400	49
	2	Vee 2350 ft 400 MW	1060	1997	2330	150	3870	4910	47
		TOTAL SYSTEM 1200 MW	2560						
2.2	1	High Devil Canyon							
		1630 ft 400 MW	1140	1993[3]	1610	100	1770	2020	58
	2	High Devil Canyon add 400 MW Capacity raise dam to 1775 ft	500	1996	1750	150	2460	3400	49
	3	Vee 2350 ft 400 MW	1060	1997	2330	150	3870	4910	47
		TOTAL SYSTEM 1200 MW	2700						
2.3	1	High Devil Canyon							
		1775 ft 400 MW	1390	1994[3]	1750	150	2400	2760	79
	2	High Devil Canyon add 400 MW capacity	140	1994	1750	150	2460	3400	49
	3	Vee 2350 ft 400 MW	1060	1997	2330	150	3870	4910	47
		TOTAL SYSTEM 1200 MW	2590						
3.1	1	Watana 2225 ft 800 MW	1860	1993	2200	150	2670	3250	46
	2	Watana add 50 MW tunnel 330 MW	1500	1995	1475	4	4890	5430	53
		TOTAL SYSTEM 1180 MW	3360						

TABLE E.10.14 Continued)

			Stage/Incremental Data				Cumulative System Data		
Plan	Stage	Construction	Capital Cost $ Millions (1980 values)	Earliest On-line Date[1]	Reservoir Full Supply Level - ft.	Maximum Seasonal Draw-down-ft.	Annual Energy Production Firm GWH	Avg. GWH	Plant Factor %
3.2	1	Watana 2225 ft 400 MW	1740	1993	2200	150	2670	2990	85
	2	Watana add 400 MW capacity	150	1994	2200	150	2670	3250	46
	3	Tunnel 330 MW add 50 MW to Watana	1500	1995	1475	4	4890	5430	53
			3390						
4.1	1	Watana 2225 ft 400 MW	1740	1995[3]	2200	150	2670	2990	85
	2	Watana add 400 MW capacity	150	1996	2200	150	2670	3250	46
	3	High Devil Canyon 1470 ft 400 MW	860	1998	1450	100	4520	5280	50
	4	Portage Creek 1030 ft 150 MW	650	2000	1020	50	5110	6000	51
		TOTAL SYSTEM 1350 MW	3400						

NOTES:

(1) Allowing for a 3 year overlap construction period between major dams.
(2) Plan 1.2 Stage 3 is less expensive than Plan 1.3 Stage 2 due to lower mobilization costs.
(3) Assumes FERC license can be filed by June 1984, ie. 2 years later than for the Watana/Devil Canyon Plan 1.

TABLE E.10.15: RESULTS OF SCREENING MODEL

	Total Demand		Optimal Solution				First Suboptimal Solution				Second Suboptimal Solution			
Run	Cap. MW	Energy GWh	Site Names	Max. Water Level	Inst. Cap. MW	Total Cost $ million	Site Names	Max. Water Level	Inst. Cap. MW	Total Cost $ million	Site Names	Max. Water Level	Inst. Cap. MW	Total Cost $ million
1	400	1750	High Devil Canyon	1580	400	885	Devil Canyon	1450	400	970	Watana	1950	400	980
2	800	3500	High Devil Canyon	1750	800	1500	Watana	1900	450	1130	Watana	2200	800	1860
							Devil Canyon	1250	350	710				
							TOTAL		800	1840				
3	1200	5250	Watana	2110	700	1690	High Devil Canyon	1750	800	1500	High Devil Canyon	1750	820	1500
			Devil Canyon	1350	500	800	Vee	2350	400	1060	Susitna III	2300	380	1260
			TOTAL		1200	2490	TOTAL		1200	2560	TOTAL		1200	2760
4	1400	6150	Watana	2150	740	1770	NO SOLUTION				NO SOLUTION			
			Devil Canyon	1450	660	1000								

TABLE E.10.16: ENVIRONMENTAL EVALUATION OF DEVIL CANYON DAM AND TUNNEL SCHEME

Environmental Attribute	Concerns	Appraisal (Differences in impact of two schemes)	Identification of difference	Appraisal Judgment	Scheme judged to have the least potential impact: Tunnel	DC
Ecological:						
- Downstream Fisheries and Wildlife	Effects resulting from changes in water quantity and quality.	No significant difference between schemes regarding effects downstream from Devil Canyon.	---	Not a factor in evaluation of scheme.		
		Difference in reach between Devil Canyon dam and tunnel re-regulation dam.	With the tunnel scheme controlled flows between regulation dam and downstream powerhouse offers potential for anadromous fisheries enhancement in this 11 mile reach of the river.	If fisheries enhancement opportunity can be realized the tunnel scheme offers a positive mitigation measure not available with the Devil Canyon dam scheme. This opportunity is considered moderate and favors the tunnel scheme. However, there are no current plans for such enhancement and feasibility is uncertain. Potential value is therefore not significant relative to additional cost of tunnel.	X	
Resident Fisheries:	Loss of resident fisheries habitat.	Minimal differences between schemes.	Devil Canyon dam would inundate 27 miles of the Susitna River and approximately 2 miles of Devil Creek. The tunnel scheme would inundate 16 miles of the Susitna River.	Loss of habitat with dam scheme is less than 5% of total for Susitna main stem. This reach of river is therefore not considered to be highly significant for resident fisheries and thus the difference between the schemes is minor and favors the tunnel scheme.	X	
Wildlife:	Loss of wildlife habitat.	Minimal differences between schemes.	The most sensitive wildlife habitat in this reach is upstream from the tunnel re-regulation dam where there is no significant difference between the schemes. The Devil Canyon dam scheme in addition inundates the river valley between the two damsites resulting in a moderate increase in impacts to wildlife.	Moderate wildlife populations of moose, black bear, weasel, fox, wolverine, other small mammals and songbirds and some riparian cliff habitat for ravens and raptors, in 11 miles of river, would be lost with the dam scheme. Thus, the difference in loss of wildlife habitat is considered moderate and favors the tunnel scheme.	X	
Cultural:	Inundation of archaeological sites.	Potential differences between schemes.	Due to the larger area inundated, the probability of inundating archaeological sites is increased.	Significant archeological sites, if identified, can probably be excavated. Additional costs could range from several hundreds to hundreds of thousands of dollars, but are still considerably less than the additional cost of the tunnel scheme. This concern is not considered a factor in scheme evaluation.	-	-
Land Use:	Inundation of Devil Canyon.	Significant difference between schemes.	The Devil Canyon is considered a unique resource, 80 percent of which would be inundated by the Devil Canyon dam scheme. This would result in a loss of both an aesthetic value plus the potential for white water recreation.	The aesthetic and to some extent the recreational losses associated with the development of the Devil Canyon dam is the main aspect favoring the tunnel scheme. However, current recreational uses of Devil Canyon are low due to limited access. Recreation development of the area is similar for both schemes.	X	

OVERALL EVALUATION: The tunnel scheme has overall a lower impact on the environment.

TABLE E.10.17: SOCIAL EVALUATION OF SUSITNA BASIN DEVELOPMENT SCHEMES/PLANS

Social Aspect	Parameter	Tunnel Scheme	Devil Canyon Dam Scheme	High Devil Canyon/ Vee Plan	Watana/Devil Canyon Plan	Remarks
Potential non-renewable resource displacement	Million tons Beluga coal over 50 years	80	110	170	210	Devil Canyon dam scheme potential higher than tunnel scheme. Watana/ Devil Canyon plan higher than High Devil Canyon/ Vee plan.
Impact on state economy	--	All projects would have similar impacts on the state and local economy.				
Impact on local economy	--					
Seismic exposure	Risk of major structural failure	All projects designed to similar levels of safety.				Essentially no difference between plans/schemes.
	Potential impact of failure on human life.	Any dam failures would affect the same downstream population.				
Overall Evaluation	1. Devil Canyon dam superior to tunnel. 2. Watana/Devil Canyon superior to High Devil Canyon/Vee plan.					

TABLE E.10.18: OVERALL EVALUATION OF TUNNEL SCHEME AND DEVIL CANYON DAM SCHEME

ATTRIBUTE	SUPERIOR PLAN
Economic	Devil Canyon Dam
Energy Contribution	Devil Canyon Dam
Environmental	Tunnel
Social	Devil Canyon Dam (Marginal)
Overall Evaluation	Devil Canyon dam scheme is superior Tradeoffs made: Economic advantage of dam scheme is judged to outweigh the reduced environmental impact associated with the tunnel scheme.

TABLE E.10.19: ENVIRONMENTAL EVALUATION OF WATANA/DEVIL CANYON AND HIGH DEVIL CANYON/VEE DEVELOPMENT PLANS

Environmental Attribute	Plan Comparison	Appraisal Judgment	Plan judged to have the least potential impact HDC/V	W/DC
Ecological: 1) Fisheries	No significant difference in effects on downstream anadromous fisheries. HDC/V would inundate approximately 95 miles of the Susitna River and 28 miles of tributary streams, including the Tyone River. W/DC would inundate approximately 84 miles of the Susitna River and 24 miles of tributary streams, including Watana Creek.	Because of the avoidance of the Tyone River, lesser inundation of resident fisheries habitat, and no significant difference in the effects on anadromous fisheries, the W/DC plan is judged to have less impact.		X
2) Wildlife a) Moose	HDC/V would inundate 123 miles of critical winter river-bottom habitat. W/DC would inundate 108 miles of this river-bottom habitat. HDC/V would inundate a large area upstream from Vee utilized by three sub-populations of moose that range in the northeast section of the basin. W/DC would inundate the Watana Creek area utilized by moose. The condition of this sub-population of moose and the quality of the habitat they are using appears to be decreasing.	Because of the lower potential for direct impact on moose populations within the Susitna, the W/DC plan is judged superior.		X
b) Caribou	The increased length of river flooded, especially upstream from the Vee damsite, would result in the HDC/V plan creating a greater potential division of the Nelchina herd's range. In addition, an increase in range would be directly inundated by the Vee reservoir.	Because of the potential for a greater impact on the Nelchina caribou herd, the HDC/V scheme is considered inferior.		X
c) Furbearers	The area flooded by the Vee reservoir is considered important to some key furbearers, particularly red fox. This area is judged to be more important than the Watana Creek area that would be inundated by the W/DC plan.	Because of the lesster potential for impact on furbearers the W/DC is judged to be superior.		X
d) Birds and Bears	Forest habitat, important for birds and black bears, exists along the valley slopes. The loss of this habitat would be greater with the W/DC plan.	The HDC/V plan is judged superior.	X	
Cultural:	There is a high potential for discovery of archaeological sites in the eaterly region of the Upper Susitna Basin. The HDC/V plan has a greater potential of affecting these sites. For other reaches of the river the difference between plans is considered minimal.	The W/DC plan is judged to have a lower potential effect on archaeological sites.		X

TABLE E.10.19 (Continued)

Environmental Attribute	Plan Comparison	Appraisal Judgment	Plan judged to have the least potential impact: HDC/V	W/DC
Aesthetic/ Land Use				
	With either scheme, the aesthetic quality of both Devil Canyon and Vee Canyon would be impaired. The HDC/V plan would also inundate Tsusena Falls.	Both plans impact the valley aesthetics. The difference is considered minimal.	-	-
	Because of construction at Vee Dam site and the size of the Vee Reservoir, the HDC/V plan would inherently create access to more wilderness area than would the W/DC plan.	As it is easier to extend access than to limit it, inherent access requirements were considered detrimental and the W/DC plan is judged superior. The ecological sensitivity of the area opened by the HDC/V plan reinforces this judgment.		X

OVERALL EVALUATION: The W/DC plan is judged to be superior to the HDC/V plan. (The lower impact on birds and bears associated with HDC/V plan is considered to be outweighed by all the other impacts which favour the W/DC plan.)

Notes:

W = Watana Dam
DC = Devil Canyon Dam
HDC = High Devil Canyon Dam
V = Vee Dam

TABLE E.10.20: OVERALL EVALUATION OF THE HIGH DEVIL CANYON/VEE AND WATANA/DEVIL CANYON DAM PLANS

ATTRIBUTE	SUPERIOR PLAN
Economic	Watana/Devil Canyon
Energy Contribution	Watana/Devil Canyon
Environmental	Watana/Devil Canyon
Social	Watana/Devil Canyon (Marginal)
Overall - Evaluation	Plan with Watana/Devil Canyon is superior Tradeoffs made: None

Table E.10.21

Environmental Constraints - Southern Study Area (Willow to Anchorage/Point MacKenzie)

Corridor	Length	Topography/Soils	Land Use	Aesthetics	Cultural Resources [a]	Vegetation	Fish Resources	Wildlife Resources	Environmental Rating [b]
1 (ABC')	73	Some soils with severe limitations to off road travel; some good agricultural soils	No existing ROW in AB; residential uses near Palmer; proposed capital site; much U.S. Military Wdl., Private, and Village Selection Land	Iditarod Trail; trail paralleling Deception Ck.; Gooding L. bird-watching area; 5 crossings of Glenn Hwy, 1 crossing of Parks Hwy	Archeologic sites-data void	Wetlands along Deception Ck. and at Matanuska River crossing; extensive clearing in upland, forested areas needed	5 river and 28 creek crossings; valuable spawning sites, especially salmon: Knik area Matanuska area data void	Passes through or near waterfowl and shorebird nesting and feeding areas, and areas used by brown bear	C
2 (ADFC)	38	Most of route potentially wet, with severe limitations to off road travel; some good agricultural soils	Trail is only existing ROW; residential and recreational areas; Susitna Flats Game Refuge; agricultural land sale	Susitna Flats Game Refuge; Iditarod Trail; 1 crossing of Parks Hwy	Archeologic sites-data void	Extensive wetlands; clearing needed in forested areas	1 river and 8 creek crossings; valuable spawning sites, especially salmon: L. Susitna R. data void	Passes through or near waterfowl and shorebird nesting, feeding, and migration areas, and areas used by furbearers and brown bear	A
3 (AEFC)	39	Same as Corridor 2	No known existing ROW; residential and recreational use areas, including Nancy Lakes; lakes used by float planes; agricultural land sale	Lake area south of Willow; Iditarod Trail; 1 crossing of Parks Hwy	Archeologic sites-data void	Extensive wetlands; clearing needed in forested areas	1 river and 8 creek crossings; valuable spawning sites, especially salmon: L. Susitna R. data void	Same as Corridor 2	F

a. Coastal area probably has many sites; available literature not yet reviewed.

b. A = recommended
C = acceptable but not recommended
F = unacceptable

Table E.10.22

Environmental Constraints - Central Study Area (Dam Sites to Intertie)

Corridor	Length (Miles)	Topography/Soils	Land Use	Aesthetics	Cultural Resources	Vegetation	Fish Resources	Wildlife Resources	Environmental Rating[a]
1 (ABCD)	40	Crosses several deep ravines; about 1000' change in elevation; some wet soils	Little existing ROW except Corps rd.; mostly Village Selection and Private Lands	Fog Lakes; Stephan Lake; proposed access road	Archeologic sites near Watana dam site, Stephan Lake and Fog Lakes; data void from Gold Creek to Devil Canyon; historic sites near the communities of Gold Creek and Canyon	Wetlands in eastern third of corridor; extensive forest-clearing needed	1 river and 17 creek crossings; valuable spawning areas, especially grayling: data void	Unidentified raptor nest located on trib. to Susitna; passes through, habitat for: raptors, furbearers, wolves, wolverine, brown bear, caribou	A
2 (ABECD)	45	Crosses several deep ravines; about 2000' change in elev.; some steep slopes; some wet soils	Little existing ROW except Crops rd. and at D; rec. and resid. areas; float plane areas; mostly Village Selection and Private Lands	Fog Lakes; Stephan Lake; proposed access road; high country (Prairie & Chulitna Ck. drainages) and viewshed of Alaska Range	Same as Corridor 1	Wetlands in eastern half of corridor; extensive forest-clearing needed	1 river and 17 creek crossings; valuable spawning areas, especially grayling: data void	Passes through habitat for: raptors, waterfowl, migrating swans, furbearers, caribou, wolves, wolverine, brown bear	F
3 (AJCF)	41	Crosses several deep ravines; about 2000' change in elevation; some steep slopes; some wet soils	No existing ROW except at F; rec. areas; float plane areas; mostly Village Selection and Private Land; resid. & rec. development in area of Otter L. and old sled rd.	Viewshed of Alaska Range & High Lake; proposed access rd.	Archeologic sites by Watana dam site, & near Portage Ck./Susitna R. confluence; possible sites along Susitna R.; Historic sites near communities of Gold Ck. and Canyon	Forest-clearing needed in western half	14 creek crossing; valuable spawning areas, especially grayling and salmon: Indian River Portage Creek data void	Golden eagle nest along Devil Ck. near High L.; active raven nest on Devil Ck.; passes through habitat for: raptors, furbearers, wolves, brown bear	C
4 (ABCJHI)	77	Crosses several deep ravines; >2000' change in elevation; routing above 4000'; steep slopes; some wet soils; shallow bedrock in mts.	No existing ROW; rec. areas and isolated cabins; lakes used by float planes; much Village Selection Land	Fog Lakes; Stephan Lake; proposed access rd; viewshed of Alaska Range	Archeologic sites near Watana dam site, Stephan L. and Fog Lakes; possible sites along pass between drainages; data void between H and I	Small wetland areas in JA area; extensive forest-clearing needed; data void	1 river and 42 creek crossings; valuable spawning areas, especially grayling	Golden eagle nest along Devil Ck. near High L.; caribou movement area; passes through habitat for: raptors, waterfowl, furbearers, wolves, wolverine, brown bear	C

a. A = recommended
C = acceptable but not recommended
F = unacceptable

Table E.10.22 (Cont'd)

Environmental Constraints - Central Study Area (Dam Sites to Intertie)

Corridor	Length (Miles)	Topography/Soils	Land Use	Aesthetics	Cultural Resources	Vegetation	Fish Resources	Wildlife Resources	Environmental Rating
5 (ABFCJHI)	82	Crosses several deep ravines; changes in elevation >2000'; routing above 4000'; steep slopes; some wet soils; shallow bedrock in mts	Same as Corridor 4	Fog Lakes; Stephan Lake; High Lake; proposed access rd; viewshed at Alaska Range	Same as Corridor 4	Wetlands in JA and Stephan Lake areas; extensive forest-clearing needed	42 creek crossings; valuable spawning areas, especially grayling and salmon: data void	Same as Corridor 4 with important waterfowl and migrating swan habitat at Stephan Lake	F
6 (CBAHI)	68	Crosses several deep ravines; changes in elevation of about 1600'; routing above 4000'; steep slopes; some wet soils; shallow bedrock in mts.	No known existing ROW; rec. areas and isolated cabins; float plane area; Susitna area and near I are Village Selection Land	Fog Lakes and Stephan Lake; proposed access rd.; Tsusena Butte; viewshed of Alaska Range	Archeologic sites near Watana dam site, Fog Lakes and Stephan L.; data void between H and I	Extensive wetlands from B to near Tsusena Butte; extensive forest-clearing needed	32 creek crossings; valuable spawning areas, especially grayling: data void	Bald eagle nest s.e. of Tsusena Butte; area of caribou movement; passes through habitat for: raptors, waterfowl, furbearers, wolves, wolverine, brown bear	C
7 (CEBAHI)	73	Crosses several deep ravines; change in elevation of about 1600'; routing above 3000'; steep slopes; some wet soils; shallow bedrock in mts.	Same as Corridor 6	Fog Lakes and Stephan Lake; proposed acess rd.; high country (Prairie-Chunilna Cks); Tsusena Butte; viewshed of Alaska Range.	Same as Corridor 6	Extensive wetlands in Stephan L., Fog Lakes, Tsusena Butte areas; extensive forest-clearing needed	45 creek crossing; valuable spawning areas, especially grayling: data void	Same as Corridor 6, with important waterfowl and migrating swan habitat at Stephan Lake	F
8 (CBAG)	90	Crosses several deep ravines; change in elevation of about 1600'; routing above 3000'; steep slopes; some wet soils; shallow bedrock in mts.	No existing ROW; rec. areas and isolated cabins; float plane areas; air strip and airport; much Village Selection and Federal Land	Fog Lakes; Stephan Lake; access rd; scenic area of Deadman Ck.; viewshed of Alaska Range	Archeologic sites near Watana dam site, Fog Lakes, Stephan Lake and along Deadman Ck.	Wetlands between B and mountains; extensive forest-clearing needed	1 river and 43 creek crossings; valuable spawning areas, expecially grayling: data void	Important bald eagle habitat by Denali Hwy. and Deadman L.; unchecked bald eagle nest near Tsusena Butte; passes through habitat for: raptors, furbearers, wolves, wolverine, brown bear	C

Table E.10.22 (Cont'd)

Environmental Constraints - Central Study Area (Dam Sites to Intertie)

orridor	Length (Miles)	Topography/Soils	Land Use	Aesthetics	Cultural Resources	Vegetation	Fish Resources	Wildlife Resources	Environmental Rating
9 (EBAG)	95	Crosses several deep ravines; changes in elevation of about 1600'; routing above 3000'; steep slopes; some wet soils; shallow bedrock in mts.	Same as Corridor 8	Fog Lakes; Stephan Lake; proposed access rd; high country (Prairie and Chunilna Cks.); Deadman Ck.; viewshed of Alaska Range	Same as Corridor 8	Wetlands in Stephan L./Fog Lakes areas; extensive forest-clearing needed	1 river and 48 creek crossings; valuable spawning areas, expecially grayling: data void	Same as Corridor 8, with important waterfowl and migrating swan habitat at Stephan Lake	F
10 (JAG)	91	Same as Corridor 8	No existing ROW; rec. areas and isolated cabins; float plane areas; air strip and airport; mostly Village Selection and Federal Land	High Lakes area; proposed access rd.; Deadman Ck. drainage; viewshed at Alaska Range	Archeologic sites near Watana dam site and along Deadman Ck.	Small wetlands in JA area; extensive forest-clearing needed	1 river and 47 creek crossings; valuable spawning areas, expecially grayling: data void	Golden eagle nest along Devil Ck. near High Lake; unchecked bald eagle nest near Tsusena Butte; area of caribou movement; passes through habitat for: raptors, waterfowl, furbearers, brown bear	C
11 (JAHI)	69	Crosses several deep ravines; changes in elevation of 1000'; routing above 3000'; steep slopes; some wet soils; shallow bedrock in mts.	No existing ROW; rec. areas and isolated cabins; float plane areas; mostly Village Selection and Private Land	High Lakes area; proposed access rd,; viewshed of Alaska Range	Archeologic sites near Watana dam site	Small wetland areas in JA area; some forest-clearing needed	36 creek crossings; valuable spawning areas, especially grayling and salmon: data void	Golden eagle nest along Devil Ck. near High Lake; bald eagle nest s.e. of Tsusena Butte; passes through habitat for: raptors, furbearers, brown bear	C
12 (JA-CJHI)	70	Same as Corridor 11	No existing ROW; rec. areas and isolated cabins; float plane area; mostly Village Selection and Private Land	High Lakes area; proposed access rd.; Tsusena Butte; viewshed of Alaska Range	Archeologic site near Watana dam site; possible sites along pass between drainages	Small wetland areas in JA area; fairly extensive forest clearing needed	40 creek crossings; valuable spawning areas, especially grayling and salmon: data void	Golden eagle nest along Devil Ck. near High Lake; passes through habitat for: raptors, furbearers, wolves, brown bear	F

Table E.10.22 (Cont'd)

Environmental Constraints - Central Study Area (Dam Sites to Intertie)

Corridor	Length (Miles)	Topography/Soils	Land Use	Aesthetics	Cultural Resources	Vegetation	Fish Resources	Wildlife Resources	Environmental Rating
13 (ABCF)	41	Crosses several deep ravines; about 1000' change in elevation; some wet soils	No known existing ROW except at F; rec. areas; float plane areas; resid. and rec. use near Otter L. and old sled rd.; isolated cabins; mostly Village Selection Land; some Private Land	Fog Lakes, Stephan L.; proposed access rd.	Archeologic sites near Watana dam site, Portage Ck./Susitna R. confluence, Stephan L., and Fog Lakes; historic sites; near communities of Canyon and Gold Ck.	Wetlands in eastern third of corridor; extensive forest-clearing needed	15 creek crossings; valuable spawning areas, especially grayling and salmon: Indian River Portage Creek data void	Unidentified raptor nest on tributary to Susitna; passes through habitat for: raptors, furbearers, wolves, wolverine, brown bear, caribou	A
14 (AJCD)	41	Crosses deep ravine at Devil Ck.; about 2000' change in elevation; routing above 3000'; some steep slopes; some wet soils	Little existing ROW except old Corps rd. and at D; rec. areas; isolated cabins; much Village Selection land; some Private Land	Viewshed of Alaska Range and High Lake; proposed access road	Archeologic sites by Watana dam site, possible sites along Susitna R.; historic sites near communities of Canyon and Gold Ck.	Forest-clearing needed in western half	1 river and 16 creek crossings; valuable spawning areas, especially grayling: data void	Golden eagle nest in Devil Ck./High Lake area; active raven nest on Devil Ck.; passes through habitat for: raptors, furbearers, wolves, brown bear, caribou	A
15 (ABECF)	45	Crosses several deep ravines; about 2000' change in elevation; some wet soils	No known existing ROW except at F; rec. areas; float plane areas; resid. and rec. use near Otter L. and old sled rd.; isolated cabins; mostly Village Selection land with some Private Land	Fog Lakes; Stephan Lake; proposed access road; high country (Prairie and Chunilna Cks. drainages); viewshed of Alaska Range	Same as Corridor 13	Wetlands in eastern half of corridor; extensive forest-clearing needed	15 creek crossings; valuable spawning areas, especially grayling and salmon: Indian River Portage Creek data void	Important waterfowl and migrating swan habitat at Stephan L.; passes through habitat for: raptors, waterfowl, furbearers, wolves, wolverine, brown bear, caribou	F

Table E.10.23

Environmental Constraints - Northern Study Area (Healy to Fairbanks)

Corridor	Length (Miles)	Topography/Soils	Land Use	Aesthetics	Cultural Resources	Vegetation	Fish Resources	Wildlife Resources[a]	Environme Ratin
1 (ABC)	90	Some wet soils with severe limitations to off-road traffic	Air strip; residential areas and isolated cabins; some U.S. Military Withdrawl and Native land	3 crossings of Parks Hwy; Nenana R.- scenic area	Archeologic sites probable since there is a known site nearby; data void	Extensive wetlands; forest clearing needed mainly north of the Tanana River	4 river and 40 creek crossings; valuable spawning sites: Tanana River data void	Passes through or near prime habitat for: peregrines, waterfowl, furbearers, moose; passes through or near important habitat for: peregrines, golden eagles	A
2 (ABDC)	86	Severe limitations to off-road traffic in wet soils of the flats	No existing ROW n. of Browne; scattered residential and isolated cabins; airstrip; Fort Wainwright Military Reservation	3 crossings of Parks Hwy; high visibility in open flats	Dry Creek archeologic site near Healy; possible sites along river crossings; data void	Probably extensive wetlands between Wood and Tanana Rivers; extensive forest clearing needed n. of Tanana River	5 river and 44 creek crossings; valuable spawning sites: Wood River data void	Passes through or near prime habitat for: peregrines, waterfowl, furbearers; passes through or near important habitat for: golden eagles, other raptors	C
3 (AEDC)	115	Change in elevation of about 2500'; steep slopes; shallow bedrock in mts.; severe limitations to off-road traffic in the flats	No existing ROW beyond Healy/Cody Ck. confluence; isolated cabins; airstrips; Fort Wainwright Military Reservation	1 crossing of Parks Hwy; high visibility in open flats	Dry Creek archeologic site near Healy; possible sites near Japan Hills and in the mts.; data void	Probably extensive wetlands between Wood and Tanana Rivers; extensive forest clearing needed n. of Tanana River; data lacking for southern part	3 river and 72 creek crossings; valuable spawning sites: Wood River data void	Passes through or near prime habitat for: peregrines, waterfowl, furbearers, caribou, sheep; passes through or near important habitat for: golden eagles, brown bear	F
4 (AEF)	105	Same as Corridor 3	Airstrips; isolated cabins; Fort Wainwright Military Reservation	High visibility in open flats	Archeologic sites near Dry Creek and Fort Wainwright; possible sites near Tanana River; data void	Probably extensive wetlands between Wood and Tanana Rivers	3 river and 60 creek crossings; valuable spawning sites: Wood River data void	Passes through or near prime habitat for:peregrines, bald eagles, waterfowl, furbearers, caribou, sheep; passes through or near important habitat for: golden eagles, brown bear	C

a. Source: VanBallenberghe personal communication. Prime habitat = minimum amount of land necessary to provide a sustained yield for a species; based upon knowledge of that species' needs from experience of ADF&G personnel. Important habitat = land which ADF&G considers not as critical to a species as is Prime habitat, but is valuable.

b. A = recommended
C = acceptable but not preferred
F = unacceptable

TABLE E.10.24: SUMMARY OF SCREENING RESULTS

Corridor	RATINGS Env.	Econ.	Tech.	Summary
- Southern Study Area				
(1) ABC'	C	C	C	C
(2) ADFC	A	A	A	A
(3) AEFC	F	C	A	F
- Cental Study Area				
(1) ABCD	A	A	A	A
(2) ABECD	F	C	C	F
(3) AJCF	C	C	C	C
(4) ABCJHI	F	F	F	F
(5) ABECJHI	F	F	F	F
(6) CBAHI	F	C	F	F
(7) CEBAHI	F	F	C	F
(8) CBAG	F	F	C	F
(9) CEBAG	F	F	C	F
(10) CJAG	F	F	C	F
(11) CJAHI	F	C	C	F
(12) JACJHI	F	F	C	F
(13) ABCF	A	C	A	C
(14) AJCD	C	A	A	C
(15) ABECF	F	C	C	F
- Northern Study Area				
(1) ABC	A	A	A	A
(2) ABDC	C	A	C	C
(3) AEDC	F	C	F	F
(4) AEF	F	C	F	F

A = recommended
C = acceptable but not preferred
F = unacceptable

TABLE E.10.25: ALASKAN GAS FIELDS

Location/Field	Remaining Reserves[1] Gas (billion cubic feet)	Product Destination or Field Status
North Slope:		
Prudhoe Bay	29,000	Pipeline construction to Lower 48 underway
East Umiat	Unknown	Shut-in
Kavik	Unknown	Shut-in
Kamik	Unknown	Shut-in
South Barrow[2]	25	Barrow residential and commercial users
Total:	29,025+	
Cook Inlet:		
Albert Kaloa	Unknown	Shut-in
Beaver Creek	250	Local
Beluga	767	Beluga River Power Plant (CEA)
Birch Hill	20	Shut-in
Falls Creek	80	Shut-in
Ivan River	5	Shut-in
Kenai	1313	LNG Plant, Anchorage and Kenai users
Lewis River	Unknown	Shut-in
McArthur River	78	Local
Moquawkie	None	Field Abandoned
Nicolai Creek	17	Granite Pt. Field
North Cook Inlet	1074	LNG Plant
North Fork	20	Shut-in
North Middle Ground Shoal	125	Shut-in
Sterling	23	Kenai users
Swanson River	300	Shut-in
West Foreland	120	Shut-in
West Fork	7	Shut-in
Total:	4189+	

Notes:

Source: Reference ( )

(1) Recoverable reserves estimated to show magnitude of field only.
(2) Producing.

TABLE E.10.26: ALASKAN OIL FIELDS

Location/Field	Remaining Reserves[1] Gas (million barrels)	Product Destination or Field Status
North Slope:		
Prudhoe Bay[2]	8,375	Pipeline to Valdez
Simpson	Unknown	Shut-in
Ugnu	Unknown	Shut-in
Umiat	Unknown	Shut-in
Total:	8,375+	
Cook Inlet:		
Beaver Creek	0	Refinery
Granite Point	21	Drift River Terminal
McArthur River	118	Drift River Terminal
Middle Ground Shoal	36	Nikiski Terminal
Redoubt Shoal	None	Field Abandoned
Swanson River	22	Nikiski Terminal
Trading Bay	4	Nikiski Terminal
Total:	198+	

Notes:

Source: Reference ( )

(1) Recoverable reserves estimated to show magnitude of field only.
(2) Producing.

TABLE E.10.27: SULFUR DIOXIDE EMISSIONS FOR VARIOUS TECHNOLOGIES

Technology	Emission Rate ($lb/10^6$ Btu)	Annual Emissions at 75% Load Factor (Tons/Yr) Facility Size (MWe) 20	50	200	400	600
Steam Electric						
Oil[(a)]	0.20	131	329	1314	2628	3942
Gas	0.0006	0	1	4	8	12
Combustion Turbine						
Oil	0.30	269	673	--	--	--
Gas[(b)]	--	--	--	--	--	--

(a) New Source Performance Standard.

(b) Negligible.

TABLE E.10.28: PARTICULATE MATTER EMISSIONS FOR VARIOUS TECHNOLOGIES

Technology	Emission Rate ($lb/10^6$ Btu)	Annual Emissions at 75% Load Factor (Tons/Yr) Facility Size (MWe) 20	50	200	400	600
Steam Electric						
Oil[(a)]	0.03	20	49	197	394	591
Gas[(b)]	0.01	7	16	66	131	197
Combustion Turbine						
Oil	0.05	46	125	--	--	--
Gas[(c)]	--	--	--	--	--	--

(a) New Source Performance Standard.

(b) Typical.

(c) Negligible.

TABLE E.10.29: NITROGEN OXIDES EMISSIONS FOR VARIOUS TECHNOLOGIES

Technology	Emission Rate ($lb/10^6$ Btu)	Annual Emissions at 75% Load Factor (Tons/Yr) Facility Size (MWe) 20	50	200	400	600
Steam Electric						
Oil[a]	0.3	197	493	1971	3942	5913
Gas[a]	0.2	131	329	1314	2628	3942
Combustion Turbine						
Oil	0.59	530	1272	--	--	--
Gas[b]	--	--	--	--	--	--

(a) New Source Performance Standard.

(b) Comparable to oil.

TABLE E.10.30 NATIONAL AMBIENT AIR QUALITY STANDARDS AND PREVENTION OF SIGNIFICANT DETERIORATION INCREMENTS FOR SELECTED AIR POLLUTANTS

	National Ambient Air Quality Standard			Prevention of Significant Deterioration Increments					
				Class I			Class II		
Pollutant	3-h[a]	24-h[a]	Annual	3-h	24-h	Annual	30-h	24-h	Annual
Total Suspended Particulate Matter (g/m^3)	None 260	150[b] 75	60[b] 3[c]	None	37	19	None	10	5
Sulfur Dioxide (g/m^3)	1300[b]	365[d]	80[d]	512	91	20	25	5	2
Nitrogen Dioxide (g/m^3)	None	None	100[d]	N/A	N/A	N/A	N/A	N/A	N/A
Carbon Monoxide[e] (mg/m^3)			None	N/A	N/A	N/A	N/A	N/A	N/A

N/A - Not applicable (no standards have been issued).

(a) Not to be exceeded more than once per year.

(b) Secondary or welfare-protecting standard.

(c) Annual geometric mean, advisory indicator of compliance.

(d) Primary or health-protecting standard.

(e) Carbon monoxide primary ambient air quality standards are as follows. The value not to be exceeded more than 1 hr/yr is 40 mg/m^3 (may be changed to 29 mg/m^3; the value not to be exceeded more than one 8-h period per year is 10 mg/m^3.

TABLE E.10.31 WATER QUALITY DATA FOR SELECTED ALASKAN RIVERS[(a)]

River/Location	Station No.	Flow (cfs)	Silica (mg/l)	Iron (mg/l)	Manganese (mg/l)	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Potassium (mg/l)
Copper River near Chitina	15212000	6,100	14	--	--	36	9.3	12	1.6
		159,000	8.5	--	0.02	23	3.5	4.3	2.0
Matanuska River at Palmer	15284000	11,600	4.5	0.02	--	28	1.8	3.8	0.9
		566	6.3	0.07	--	44	4.8	8.9	0.9
Susitna River at Gold Creek	15292000	34,000	5.7	--	--	12	1.4	3.1	1.3
		1,960	11	0.19	--	34	4.5	11	2.4
Susitna River at Susitna Station	15294350	6,790	10	0.09	0.13	26	4.2	7.1	1.5
		148,000	3.6	0.07	0.85	17	2.3	1.8	1.5
Chena River at Fairbanks	15514000	10,200	6.4	2.7	0.75	12	2.3	1.1	2.1
		182	23	3.2	0.82	36	7.6	4.9	2.8
Tanana River at Nenana	15515000	4,740	19	--	--	54	10	4.8	2.9
		34,300	7.4	--	--	24	5.0	2.7	1.9
Nenana River near Healy	15518000	497	8.2	--	--	36	10	5.6	2.6
		8,750	4.0	0.55	--	18	3.6	2.7	1.4
Gulkana River at Sourdough	15200280	286	--	--	--	--	--	--	--
		6,130	--	--	--	--	--	--	--
Talkeetna River near Talkeetna	15292700	1,930	7.3	--	--	19	2.2	8.3	1.0
		19,800	5.1	--	--	8.1	1.0	2.6	0.5
Yukon River at Ruby	15564800	345,000	6.2	0.19	0.02	27	6.1	2.2	1.9
		26,900	12	0.39	0.02	46	10	3.9	2.0
Chakachutna River near Tyonek	15294500	6,640	5.3	0.03	0.01	9.1	2.1	1.4	1.5
		15,100	5.3	0.94	0.05	14	1.8	1.5	1.7
Skwentna River near Skwentna	15294300	6,760	11	--	--	17	5.0	4.4	0.9
		1,330	13	--	--	28	4.3	7.7	1.7
Lowe River near Valdez	15226500	--	5.0	--	--	28	0.8	1.2	2.7
		390	2.0	0.04	0.02	22	1.0	1.4	2.5
Fortymile River near Steel Creek	--	1,100	11	0.08	--	20	7.5	4.6	1.2

(a) Adapted from U.S.G.S. Water Data Report AK-77-1 and U.S.G.S. Open File Report 76-513.

TABLE E.10.31 WATER QUALITY DATA FOR SELECTED ALASKAN RIVERS[a] (Contd)

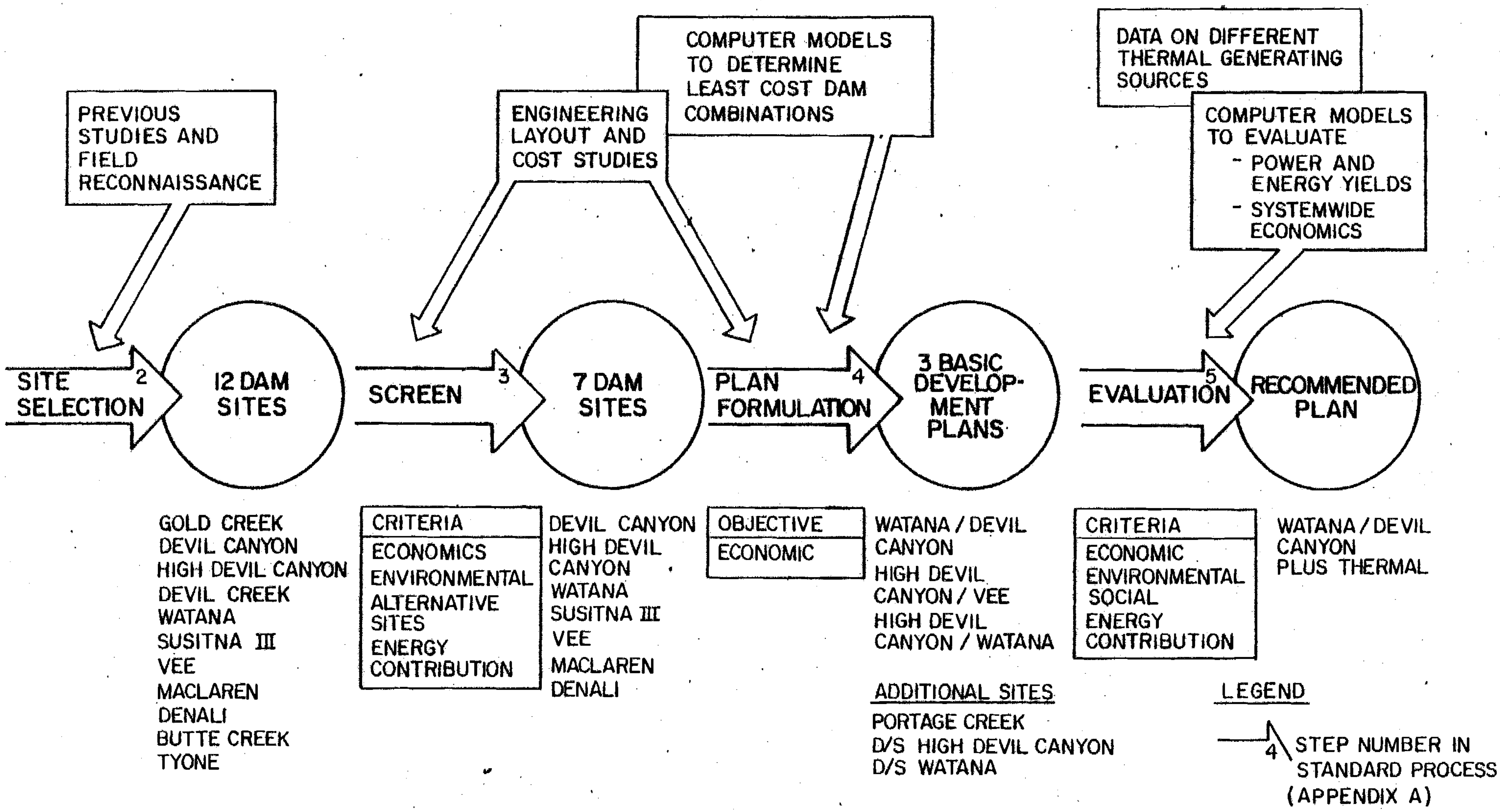
River/Location	Station No.	Flow (cfs)	Silica (mg/l)	Iron (mg/l)	Manganese (mg/l)	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Potassium (mg/l)
Copper River near Chitina	15212000	116	26	18	0.9	--	--	174	7.2
		78	15	3.2	0	--	--	98	7.6
Matanuska River at Palmer	15284000	61	29	2.5	0.2	--	--	94	7.0
		100	41	13	0.25	--	--	169	8.1
Susitna River at Gold Creek	15292000	36	6.0	4.0	0.14	--	--	52	6.8
		98	12	29	0.11	--	--	152	8.0
Susitna River at Susitna Station	15294350	82	15	13	0.24	0.0	--	116	6.9
		59	13	2.2	0.05	1.1	11.3	64	8.1
Chena River at Fairbanks	15514000	30	10	0.7	0.27	--	--	54	7.0
		140	13	2.1	0.52	--	--	165	6.6
Tanana River at Nenana	15515000	173	33	2.4	0.30	--	--	212	7.5
		72	34	2.5	0.10	--	--	113	7.2
Nenana River near Healy	15518000	102	51	5.0	0.11	--	--	169	7.0
		57	14	1.1	0.09	--	--	74	7.0
Gulkana River at Sourdough	15200280	110	--	--	0.15	0.03	10.1	--	7.5
		40	--	--	0.04	0.15	11.0	--	7.1
Talkeetna River near Talkeetna	15292700	52	10	12	--	0.00	14.1	91	7.7
		28	2.8	2.6	0.20	0.08	11.7	37	6.8
Yukon River at Ruby	15564800	94	1.4	0.2	0.04	--	--	113	7.6
		165	25	1.3	0.23	--	--	183	--
Chakachutna River near Tyonek	15294500	26	12	2.0	0.00	--	--	46	7.1
		26	11	1.4	0.03	--	--	51	7.5
Skwentna River near Skwentna	15294300	52	20	6.0	0.05	--	--	91	7.4
		77	24	12	0.18	--	--	130	7.1
Lowe River near Valdez	15226500	57	3.2	0.8	0.32	--	--	100	7.6
		46	22	1.2	0.34	--	--	77	7.3
Fortymile River near Steel Creek	--	65	37	0.5	0.47	--	--	116	7.4

TABLE E.10.32: FUEL AVAILABILITY FOR WOOD AND MUNICIPAL WASTES

Railbelt Region	Daily Tons Wood Fuel (Tons/Day)	Municipal Refuse (Tons/Day)
Greater Anchorage	200 - 600	400
Kenai Peninsula	60 - 180	--
Fairbanks	10 - 30	150
Nenana	40 - 140	--

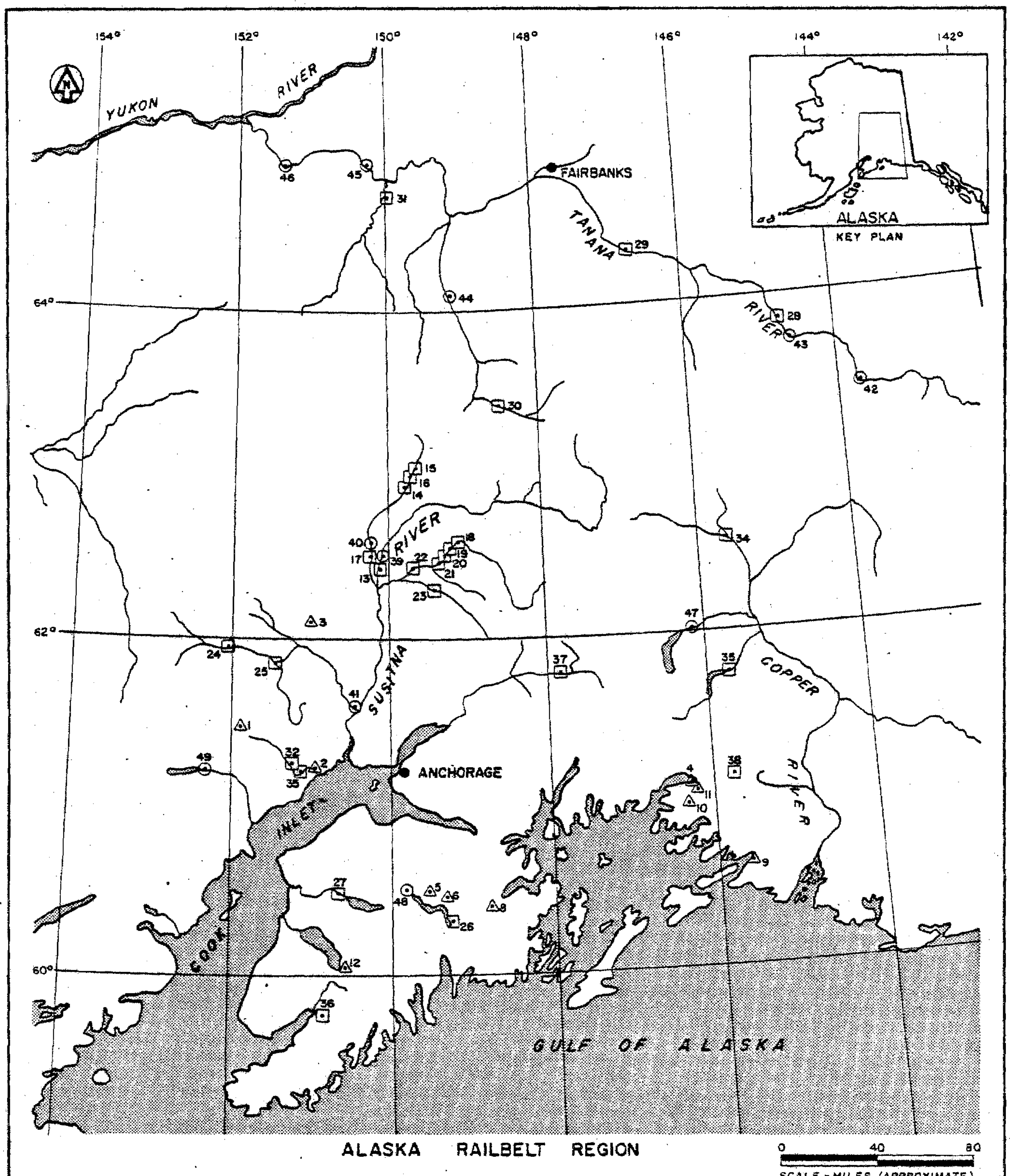
TABLE E.10.33: APPROXIMATE REQUIRED TEMPERATURE OF GEOTHERMAL FLUIDS FOR VARIOUS APPLICATIONS

	°C		
	200		
	190		
	180	Evaporation of highly concentrated solutions Refrigeration by ammonia absorption Digestion in paper pulp (Kraft)	
Saturated Steam	170	Heavy water via hydrogen sulfide process Drying of diatomacious earth	
	160	Drying of fish meal Drying of timber	Conventional power production
	150	Alumina via Bayer's process	
	140	Drying farm products at high rates Canning of food	
	130	Evaporaton in sugar refining Extraction of salts by evaporation and crystallization Fresh water by distillation	
	120	Most multi-effect evaporation; concentration of saline solution	
	110	Drying and curing of aggregate slabs	
	100	Drying of organic materials, seaweeds, grass, vegetables, etc. Washing and drying of wool	
	90	Drying of stock fish Intense de-icing operations	
	80	Space-heating (buildings and greenhouse)	
Hot Water	70	Refrigeration (lower temperature limit)	
	60	Animal husbandry Greenhouses by combined space and hotbed heating	
	50	Mushroom growing Balneology	
	40	Soil warming	
	30	Swimming pools, biodegradation, fermentations Warm water for year-round mining in cold climates De-icing	
	20	Hatching of fish; fish farming	



SUSITNA BASIN PLAN FORMULATION AND SELECTION PROCESS

FIGURE E.10.1



△ 0 - 25 MW

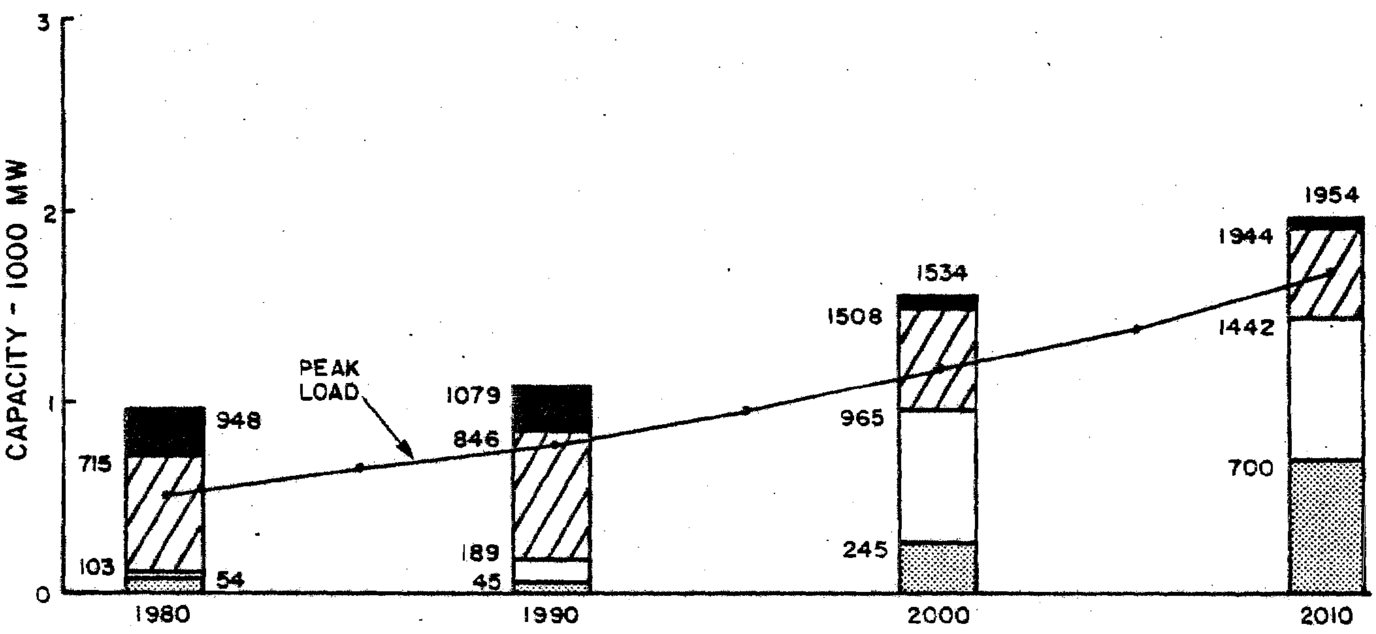
⊡ 25 - 100 MW

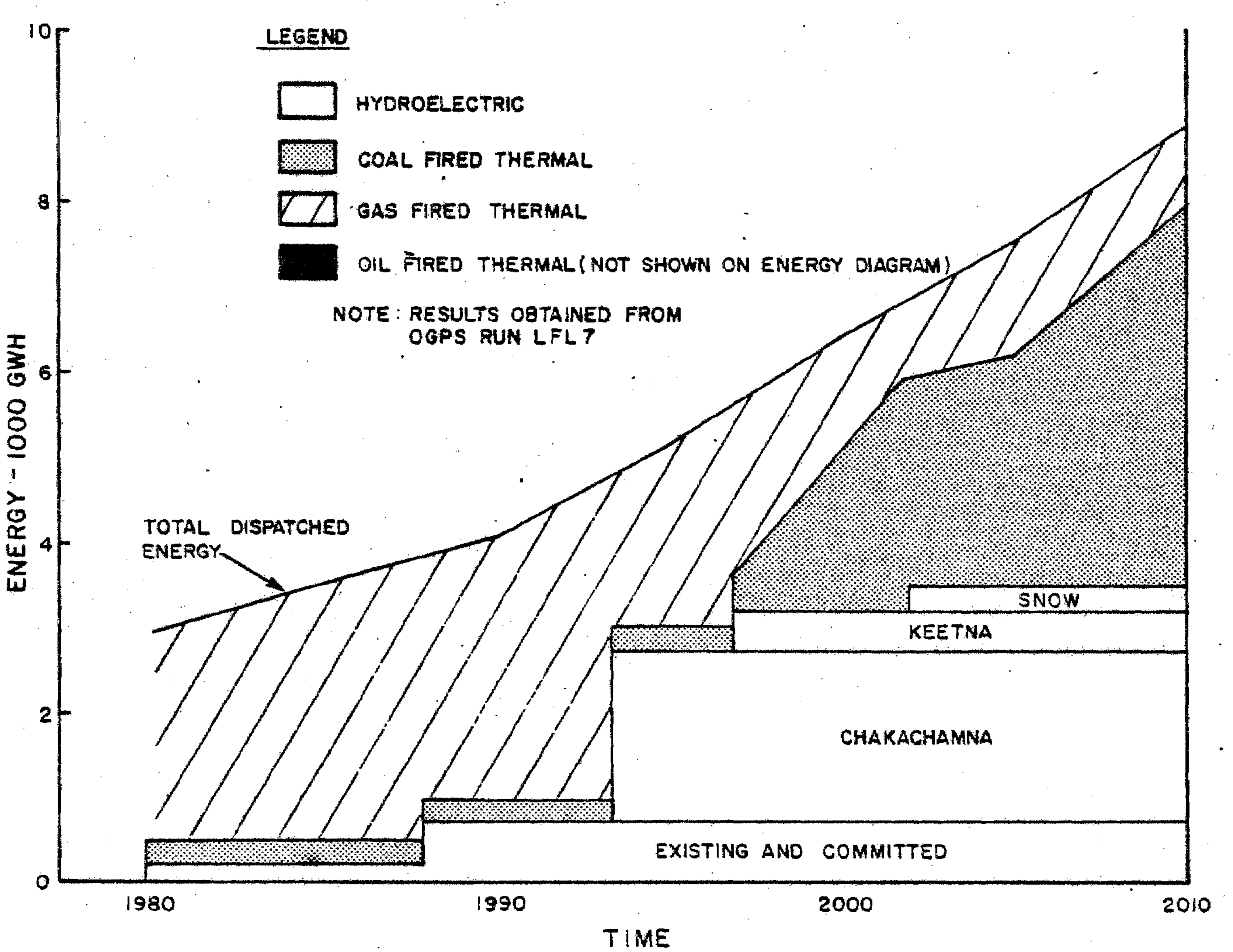
⊙ > 100 MW

1. STRANDLINE L.
2. LOWER BELUGA
3. LOWER LAKE CR.
4. ALLISON CR.
5. CRESCENT LAKE 2
6. GRANT LAKE
7. McCLURE BAY
8. UPPER NELLIE JUAN
9. POWER CREEK
10. SILVER LAKE
11. SOLOMON GULCH
12. TUSTUMENA
13. WHISKERS
14. COAL
15. CHULITNA
16. OHIO
17. LOWER CHULITNA
18. CACHE
19. GREENSTONE
20. TALKEETNA 2
21. GRANITE GORGE
22. KEETNA
23. SHEEP CREEK
24. SKWENTNA
25. TALACHULITNA
26. SNOW
27. KENAI LOWER
28. GERSTLE
29. TANANA R.
30. BRUSKASNA
31. KANTISHNA R.
32. UPPER BELUGA
33. COFFEE
34. GULKANA R.
35. KLUTINA
36. BRADLEY LAKE
37. HICK'S SITE
38. LOWE
39. LANE
40. TOKICHITNA
41. YENTNA
42. CATHEDRAL BLUFFS
43. JOHNSON
44. BROWNE
45. JUNCTION IS.
46. VACHON IS.
47. TAZILNA
48. KENAI LAKE
49. CHAKACHAMNA

SELECTED ALTERNATIVE HYDROELECTRIC SITES

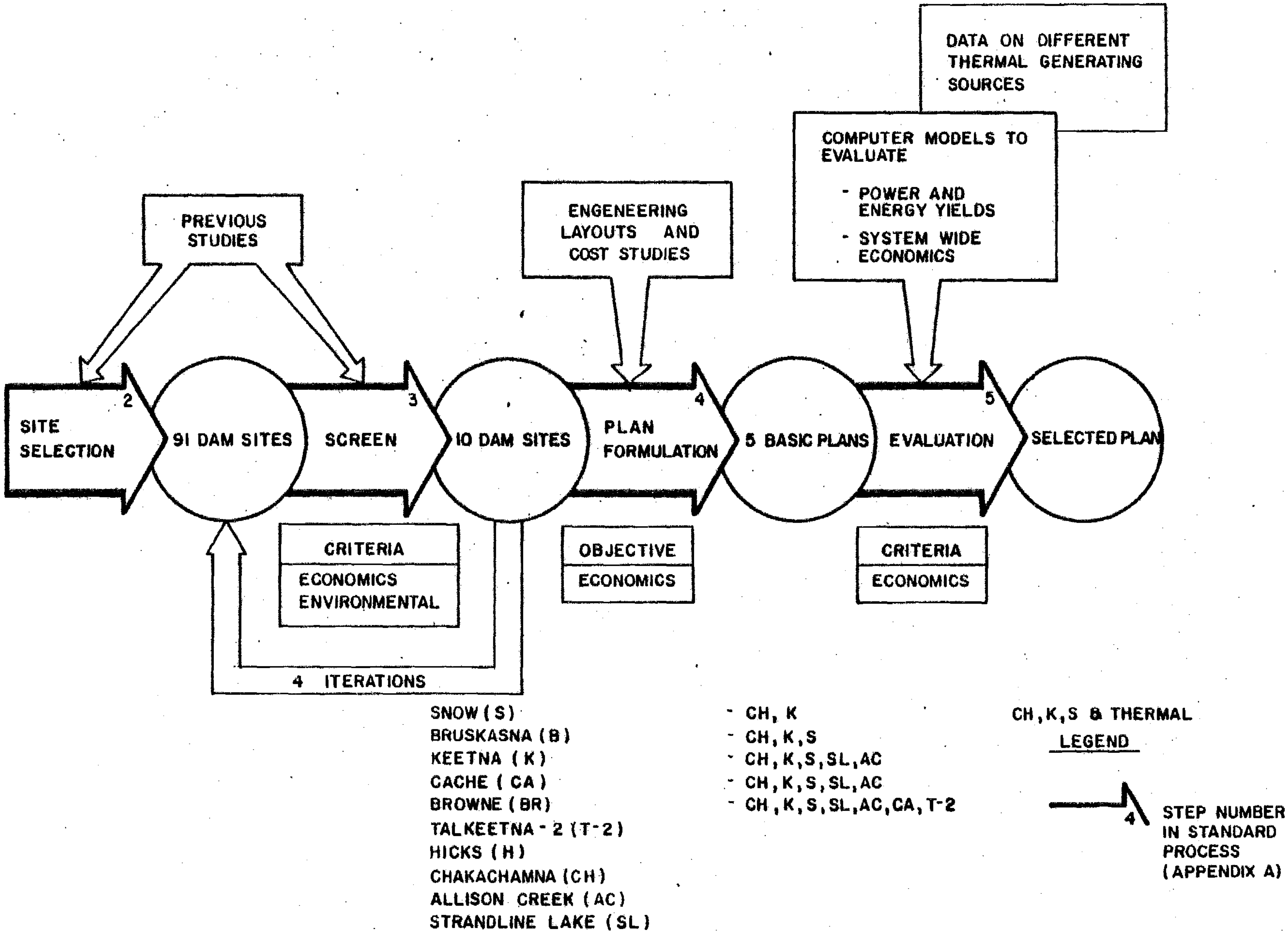
FIGURE E.10.2





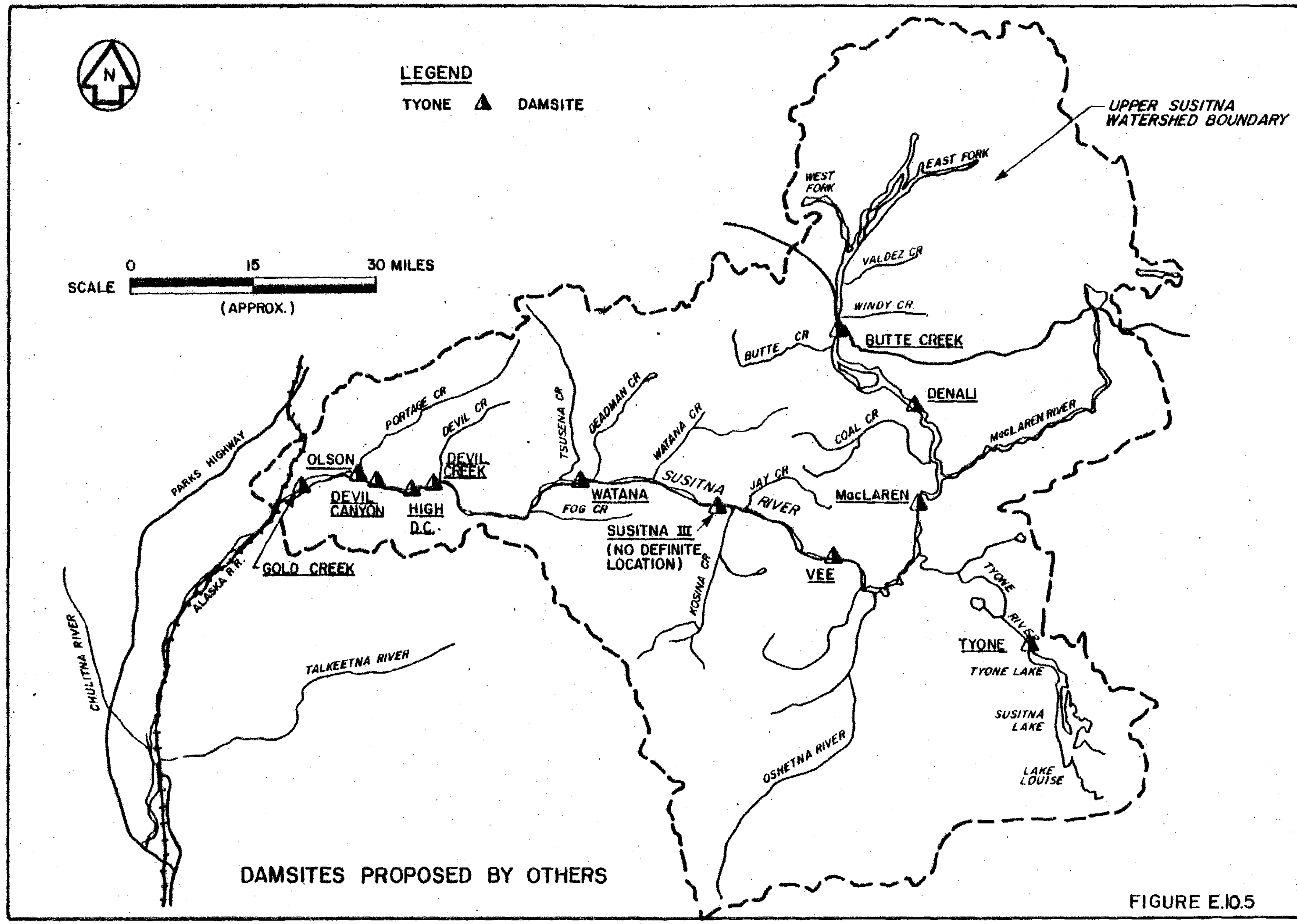
GENERATION SCENARIO INCORPORATING THERMAL AND ALTERNATIVE HYDROPOWER DEVELOPMENTS - MEDIUM LOAD FORECAST -

FIGURE E.10.3



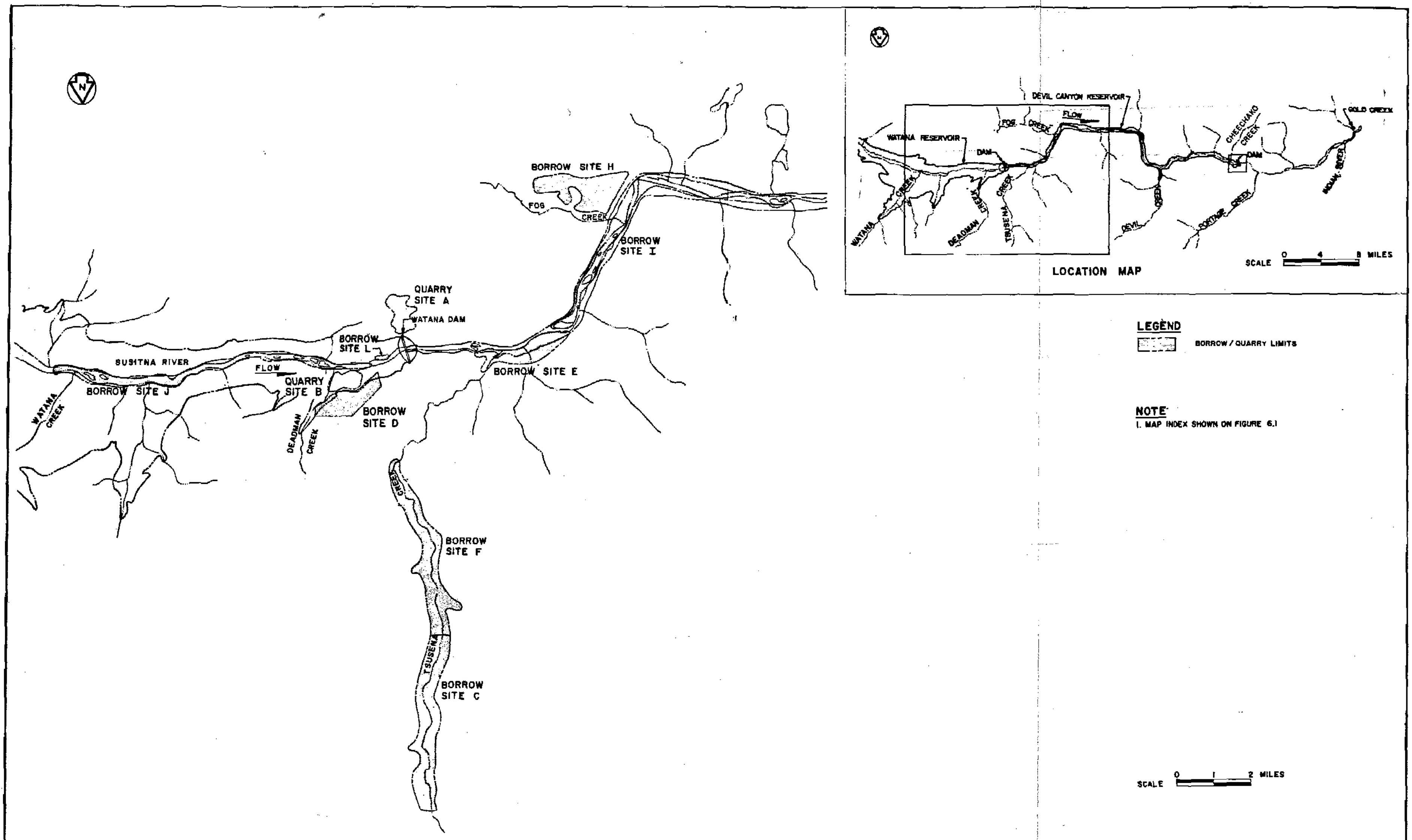
FORMULATION OF PLANS INCORPORATING NON-SUSITNA HYDRO GENERATION

FIGURE E.10.4



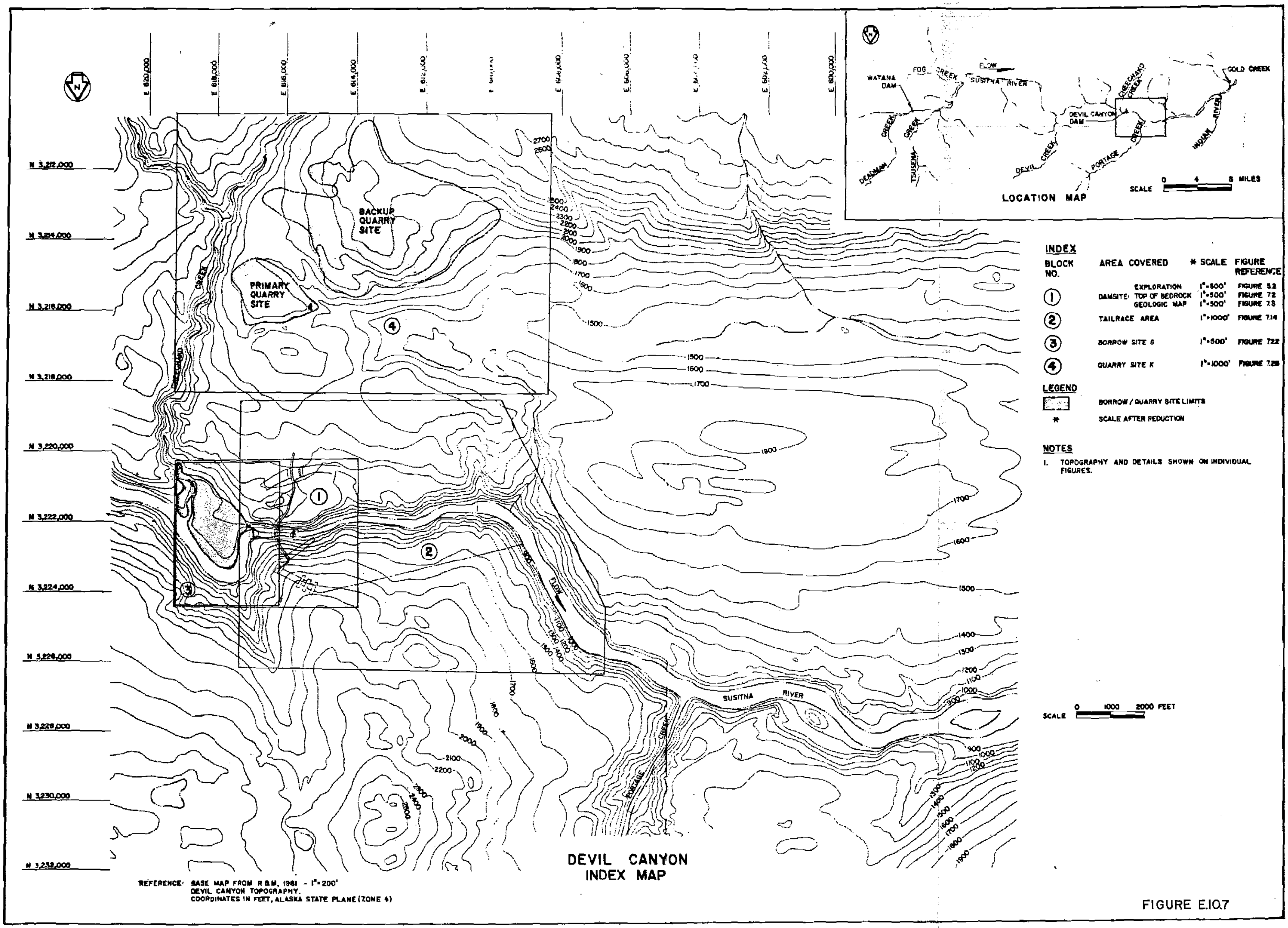
DAMSITES PROPOSED BY OTHERS

FIGURE E.10.5



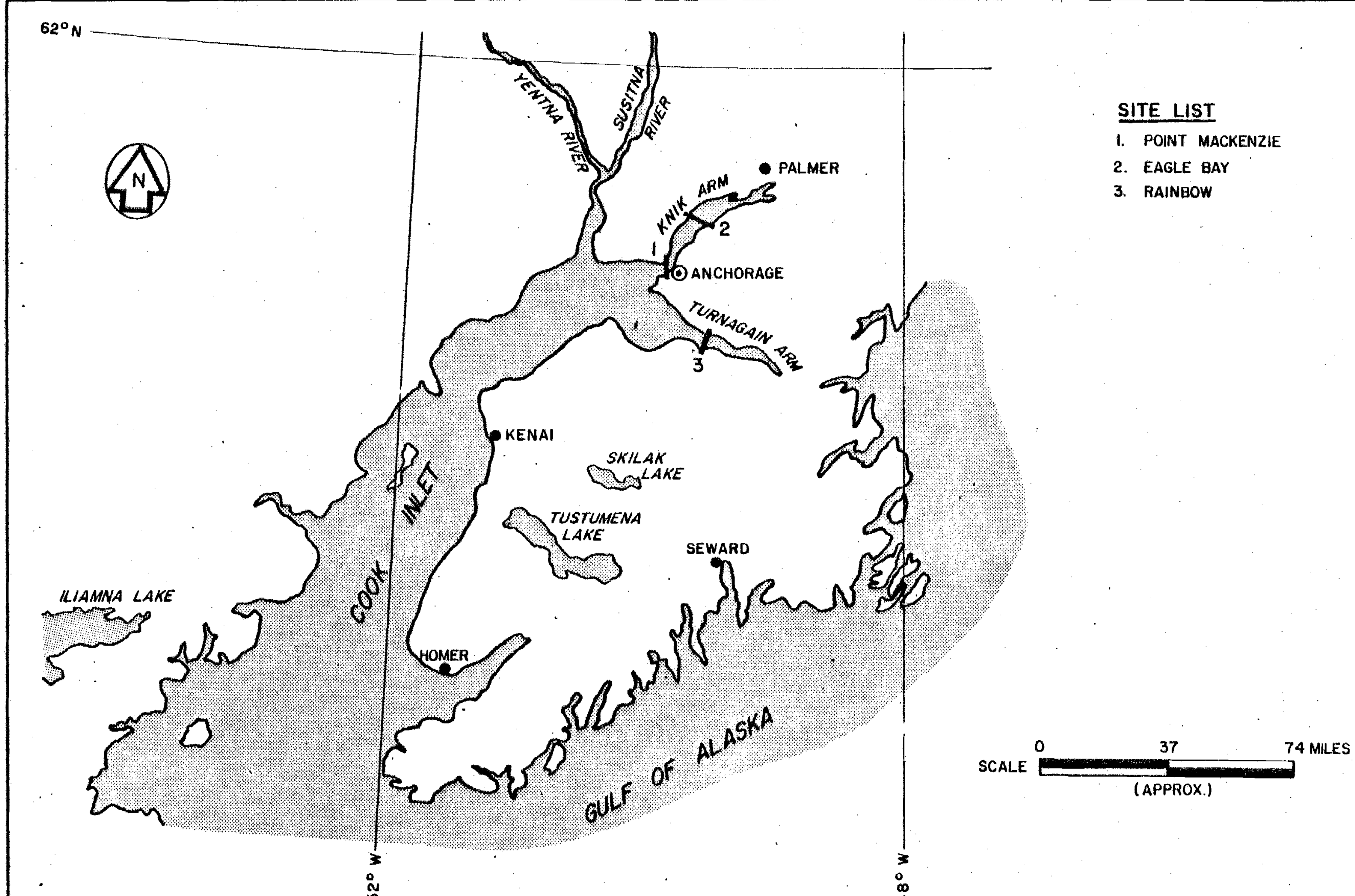
WATANA
BORROW SITE MAP

FIGURE E.10.6



DEVIL CANYON
INDEX MAP

FIGURE E.10.7



POTENTIAL TIDAL POWER SITES

FIGURE E.10.8