3438

BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

APPLICATION FOR LICENSE FOR MAJOR PROJECT

SUSITNA HYDROELECTRIC PROJECT

VOLUME 14

D R A F T

EXHIBIT E

CHAPTER 10

CHAPTER 11

HARZA-EBASCO
SUSITNA JOINT VENTURE

Alaska Power Authority

BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

APPLICATION FOR LICENSE FOR MAJOR PROJECT

SUSITNA HYDROELECTRIC PROJECT
DRAFT LICENSE APPLICATION

VOLUME 14

EXHIBIT E
CHAPTER 10 - ALTERNATIVE LOCATIONS, DESIGNS AND ENERGY SOURCES
CHAPTER 11 - AGENCY CONSULTATION

November 1985

NOTICE

A NOTATIONAL SYSTEM HAS BEEN USED
TO DENOTE DIFFERENCES BETWEEN THIS AMENDED LICENSE APPLICATION
AND
THE LICENSE APPLICATION AS ACCEPTED FOR FILING BY FERC
ON JULY 29, 1983

This system consists of placing one of the following notations beside each text heading:

(o) No change was made in this section, it remains the same as was presented in the July 29, 1983 License Application

(*) Only minor changes, largely of an editorial nature, have been made

(**) Major changes have been made in this section

(***) This is an entirely new section which did not appear in the July 29, 1983 License Application

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VOLUME NUMBER COMPARISON

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ALTERNATIVE LOCATIONS, DESIGNS, AND ENERGY SOURCES

This chapter presents the results of assessments of alternatives to the proposed Susitna Hydroelectric Project. It also compares the environmental impacts of these alternatives with the proposed project wherever practical.

Included in these assessments are FERC selected alternative hydroelectric generating sites outside the middle Susitna Basin, and alternative hydro sites within the basin. In addition, alternative methods of generation (coal-fired, gas, oil, hydroelectric, tidal and other alternatives) are assessed and compared with the proposed project. All appurtenances applicable to each energy generating scenario have been considered, including transmission lines and access routes. Alternative operating scenarios are discussed below and in Sections 2 and 3.

The following sections of this document summarize the studies carried out while formulating and selecting the preferred alternative scenarios. These studies were conducted over the period 1979 through 1982 and are based on cost data and load forecasts from that period of study. Ultimately, the environmental, engineering, and economic impacts are discussed and compared, and it is shown that the proposed Susitna Hydroelectric Project is the most attractive from an environmental perspective.

1 - ALTERNATIVE HYDROELECTRIC SITES (*)

1.1 - Non-Susitna Hydroelectric Alternatives (*)

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 studies, and, in particular, the various published inventories of sites, identified a total of 91 potential sites (Table E.10.1.1). All of these sites are technically feasible and were included as alternative candidate sites for power development. To identify the best sites amongst the 91 potential sites a screening process was used.

The screening process involved the step-wise application of progressively more stringent criteria that eliminated candidate sites based on unfavorable economic and environmental characteristics. The details of this process are presented in the Susitna Development Selection Report (Acres 1981a). Through this process, 10 of the original 91 sites were selected for detailed development and cost estimates. Of these, three sites -Chakachamna, Snow and Keetna- were proposed by the Applicant as the primary sites to be examined in alternative scenarios, and compared to the optimum development on the Susitna River.

In the Draft Environmental Impact Statement (FERC 1984), it was concluded that a combination of five specific hydroelectric sites - Johnson site (210 MW) on the Tanana River, Browne site (100 MW) on the Nenana River, Keetna site (100 MW) on the Talkeetna River, Snow Site (100 MW) near Kenai Lake and the Chakachamna site (300 MW) on Chakachamna Lake - should be used to partially fulfill the energy needs of the Railbelt (FERC 1984). Furthermore, it was concluded that "based on considerations of engineering feasibility, economic characteristics and environmental impacts...a mixed thermal-based generation scenario, with selected non-Susitna hydropower projects added as needed, appears to be the most effective approach to meeting the projected generation requirements of the Railbelt area" (FERC 1984).

As a result of these conclusions the Applicant re-examined the five recommended sites in greater detail from engineering, economic, and environmental perspectives. Results of the evaluation are summarized in Section 1.2. Detailed results of the evaluation are contained in "Alaska Power Authority Comments on the Federal Energy Regulatory Commission Draft Environmental Impact Statement of May 1984", Volume 4, Appendix II - Evaluation of Non-Susitna Hydroelectric Alternatives (APA 1984). The overall conclusion of the reexamination was that the economic and environmental characteristics of the non-Susitna hydro alternatives were unfavorable compared to the proposed project.

A summary comparison of the non-Susitna hydro alternatives and the proposed project is presented in Section 1.4. Because the maximum total power production from these non-Susitna alternative hydro sites would not meet future energy needs as well as the proposed project, additional thermal development would also be required (APA 1984). Environmental impacts of thermal development are discussed in Section 4.0.

1.2 - Assessment of Selected Alternative Hydroelectric Sites (***)

The alternative hydro sites outside the middle Susitna Basin that were analyzed by the Applicant (APA 1984) in response to the DEIS (FERC 1984) included the Johnson, Browne, Keetna, Snow, and Chakachamna sites. The Chakachamna area has been studied previously for hydroelectric development and a recent feasibility level study has been completed by the Applicant (Bechtel 1983a). As such, fairly detailed information is available for this site. The four other alternative sites have not been as intensively studied. However, sufficient information is available to compare these project sites with the Watana/Devil Canyon sites.

The following sections describe the site and project characteristics and the significant environmental and engineering impacts from development for each alternative.

1.2.1 - Johnson Dam and Reservoir (***)

(a) Description (***)

The Johnson site is located on the Tanana River, 120 miles southeast of Fairbanks. The damsite is just downstream from the confluence of the Johnson and Tanana Rivers at latitude 63°45'N, longitude 144°38'W (APA 1984). The climate of the project area is described as continental. Mean annual air temperature is 23°F. Temperatures range from a mean minimum of -12°F in January to a mean maximum of 68°F in July. Precipitation averages 20 inches annually. Permafrost conditions exist at the damsite and in the drainage basin.

The project is located in Probability Zone 2, according to seismic risk maps of the Uniform Building Code (International Conference of Building Officials 1980). This places it in the moderate damage category (corresponds to intensity VII on the Modified Mercalli Intensity Scale).

The drainage area above the damsite is 10,500 square miles. The Tanana River streamflow has been recorded near Tanacross (USGS Gage No. 15476000) and at Big Delta. Big Delta records are available from 1948 to 1952 and from 1953 to 1957 and have since been discontinued. Tanacross records are continuous from 1953 to the present. Since the record at Tanacross is longer and continuous, the flows at the damsite were estimated from Tanacross flows by linear proportion to the catchment area. The average annual streamflow at the damsite is estimated at 9,800 cubic feet per second (cfs) or about 7,100,000 acre-feet per year.

The Johnson Reservoir would be formed by the construction of an earth dam across the Tanana River. The dam would have a maximum height of 210 feet from the base at elevation 1,280 to the crest at elevation 1,490. The crest length would be about 6,400 feet. A 2,000 foot long saddle dam of undetermined height would be required about 3.5 miles northeast of the main dam.

The Tanana River Valley is known to contain deep, permeable unconsolidated sediments, and such deposits would most likely be present at the site. The unconsolidated deposits could contain permafrost except for a shallow surface zone that thaws in summer. For seismic stability reasons, these materials would probably have to be excavated so the dam embankment could rest on bedrock. The powerplant would have an installed capacity of 210 megawatts (MW) with a 50 percent plant factor if the powerplant is not limited by system energy requirements. The generators would be driven by four Francis turbines.

The normal maximum operating level of Johnson Reservoir would be at elevation 1,470 feet. The corresponding reservoir surface area and storage volume are 94,500 acres and 7,000,000 acre-feet respectively. Active storage would be 5,300,000 acre-feet after the 50-year sediment allocation is made. Estimated reservoir drawdown capability would be 80 feet. This drawdown could expose some 48,000 acres of unsightly mud flats and/or eroded slopes devoid of any vegetation. The maximum depth of the reservoir would be 190 feet and retention time would be 11 months. Reservoir length would be 36 miles.

The drawdown of the reservoir would start with the recession of flow in the fall. The reservoir would be gradually drawn down through the winter, reaching the minimum reservoir level in May of each year. Annual filling would commence in May and continue for the remainder of the summer.

The minimum flows for the project are based on those presented in Table 2-7 of the DEIS (FERC 1984). Minimum flows would be 24,000 cfs during the months of June, July and August and 3,200 cfs during the other months. The June, July, and August flow of 24,000 cfs represents the maximum of the historical Q^{90} value and is similar to the average flow occurring in the summer. Consequently, during dry hydrological years, it may not be possible to maintain this minimum flow. Maximum gross head would be 180 feet and average gross head would be approximately 149 feet. Tailwater elevation would be at approximately elevation 1,290 feet. Mean annual energy could reach approximately 950 Gigawatt hours (GWh) if energy production is not limited by the system requirement.

(b) Environmental Assessment (***)

Two communities, Dot Lake (a native village) and The Living Word, a religious community, with populations of approximately 70 and 200 persons respectively, would need to be relocated because they are within the impoundment zone and would be indundated by the reservoir. Worldwide, forced relocation of small rural, cultural and/or racial minority populations has been found to result in noticeable increases in both morbidity and mortality rates, particularly among the older members of the affected community. For this reason, in particular, this alternative is judged to be of highly doubtful environmental feasibility. Construction and operation also would affect the infrastructure of Delta

Junction and Tok. Other significant environmental problems associated with this site are described below.

An above-ground petroleum pipeline that transects the inundation zone would have to be relocated. This would entail moving the pipeline from a fairly direct route and level gradient to one that traverses steep terrain. The new route would be less direct.

Approximately 23 miles of the Alaska Highway, the major overland route between Alaska and the lower 48, would need to be relocated. The relocated section would be considerably longer (approximately 33 miles) and thus would require more travel time.

The surface area of this impoundment (94,500 acres) would be almost double the Susitna Project impoundment area (45,800 acres) and thus would inundate greater existing habitat. Approximately 30,000 acres of palustrine wetlands (eg. marshes, bogs, wet meadows, and ponds) would be inundated. Also hunting and fishing sites in an extensive wilderness area would be inundated.

Four peregrine falcon nest locations occur along the shoreline of the proposed impoundment zone. Three of these were active in 1983. This would make licensing of the project very difficult, if not impossible, because this species is classified by the Department of the Interior, U.S. Fish and Wildlife Service as "endangered".

The floodplain in this area is an important wintering and calving area for moose and contains important black bear and furbearer habitat. Loss of this habitat would significantly decrease the carrying capacity of the area for moose and other wildlife and result in lower populations.

Anadromous salmon are known to exist upstream of the site. These fish are predominantly chum salmon, a species that would not successfully utilize passage facilities and therefore would probably be eliminated from upstream areas.

Flow reductions in the summer could severely disrupt commercial navigation on the river, particularly in the lower Tanana. If both the Browne and Johnson sites were developed, the cumulative impact of both projects on navigation downstream from the town of Nenana could be significant.

(c) Engineering Assessment (***)

This site is remotely located with respect to the Anchorage-Fairbanks Transmission Intertie. To connect the site with Fairbanks would require approximately 135 miles of transmission line at a cost of approximately $62,000,000. Approximately 1,640 acres of land would be affected by the installation of the transmission line.

Extensive relocations of existing communities, the Alaska Highway, and a currently inactive petroleum pipeline would require from 24 to 36 months of the construction schedule.

This site would be susceptible to sedimentation and the development of extensive mud flats that would result in lost storage capacity and therefore winter energy generation.

There would be difficulties in obtaining sufficient impervious borrow materials, and extensive foundation excavations may be required.

The site would probably require incorporation of fish passage facilities which are not always effective (Bell 1984). These facilities would materially add to the cost of the site development.

1.2.2 - Browne Dam and Reservoir (***)

(a) Description (***)

The Browne site is located on the Nenana River, approximately 65 air miles southwest of Fairbanks. The climate of the project area is described as continental. Mean annual air temperature is 23°F. Temperatures range from a mean minimum of -12°F in January to a mean maximum of 69°F in July. Precipitation averages 20 inches annually. The damsite has a tributary drainage area of 2,450 square miles. The basin drains the foothills on the north side of the Alaska Range. Terrain throughout much of the basin is relatively flat.

Nenana River streamflow records exist for three locations: Nenana River near Windy, Nenana River near Healy, and Nenana River near Rex. The Nenana River near Windy (USGS Gage No. 15516000) has a drainage area of 710 square miles and 22 years of record (1951-1973). The Nenana River near Healy (USGS Gage No. 15518000) has a drainage area of 1,910 square miles and 29 years of record. The Nenana River near Rex (USGS Gage No. 15518300) is in close proximity to the Browne damsite. This gaging station has a drainage area of

2,450 square miles but only 4 years of flow data. Based on the Nenana River near Healy record, the average annual flow at the damsite is estimated to be 4,500 cfs (3,250,000 acre-feet). Mean monthly flows range from an average of about 500 cfs in late winter to 14,000 cfs in June.

The project is located in Probability Zone 3, per seismic risk maps of the Uniform Building Code (ICBO 1980). This places it in the major damage category (corresponds to intensity VIII and higher on the Modified Mercalli Intensity Scale).

The estimated sediment load is 1.2 acre-feet/square mile/year. This equates to a 50-year deposition of 150,000 acre-feet in the active portion of the reservoir.

The Nenana River flows in a gently sloping U-shaped valley. The steep abutments existing at the damsite indicate bedrock is nearly exposed on either side of the river. Foundation conditions are commensurate with construction of an earth and rockfill dam at this site.

The dam would be built with the crest at elevation 995± feet and the base at elevation 730± feet. The crest length would be about 6,300 feet. An ogee type gated spillway would be located on the right abutment. A power tunnel would be connected through the left abutment to a surface powerhouse. Four Francis turbines, each rated at 34,600 horsepower (hp) at a net design head of 170 feet, would be installed. The total capacity would be 100 MW at a plant factor of 50 percent. Construction materials might be obtained from the adjacent rock outcrops along with alluvial deposits in the river valley.

The Browne Reservoir would be operated at a normal maximum reservoir elevation of 975 feet. At this elevation, the reservoir would have a surface area of 12,500 acres and a total storage of 1,100,000 acre feet. Maximum drawdown capability of the reservoir is 85 feet, corresponding to a minimum reservoir elevation of 890 feet. This drawdown could expose 7,000± acres of unsightly mud flats and/or eroded slopes devoid of any vegetation. The active reservoir storage would be 760,000 acre-feet. Maximum depth of the reservoir would be about 205 feet. Retention time would be 4 months. The reservoir length would be 11 miles.

The reservoir would be gradually filled each year during the high flow summer period of May through September. During the winter low flow period, the reservoir would be gradually drawn down, reaching the minimum reservoir elevation about

May. Minimum flow releases from the project would be 9,300 cfs during June, July and August and 1,400 cfs during the other months. These discharges are based on releases presented in Table 2-7 of the DEIS (FERC 1984).

With the maximum reservoir elevation of 975 and a tailwater elevation of 780 feet, the resulting maximum head would be 195 feet. Average gross head would be approximately 180 feet. Mean annual energy is approximately 440 GWh if energy production is not limited by the system requirement.

(b) Environmental Assessment (***)

Impacts associated with development of this site would include relocating 8.5 miles of the George Parks Highway, 16 miles of the Alaska Railroad, and 16 miles of existing Golden Valley Electric Association transmission line. Communities that would be significantly impacted by construction include Healy and Nenana.

Anadromous salmon are known to exist upstream of this site. As with the Johnson site, one of the species is chum salmon which would be expected to be eliminated from upstream areas. Fish passage facilities for other species would be needed for this site. Changes in flow regimes downstream of the project could also impact salmon spawning and rearing habitat.

The Nenana River is used for recreational rafting. This would be eliminated from this reach of river. Downstream navigation, particularly in the lower Tanana, could be significantly disrupted by flow regulation from this site (and the Johnson site).

As indicated in the DEIS, approximately 50 cultural resources sites are known to exist at this site.

The river floodplain in the impoundment zone is an important overwintering area for moose. Loss of this habitat would significantly decrease the carrying capacity of the area for moose and result in lower moose populations.

(c) Engineering Assessment (***)

Extensive relocations of the existing major highway route between Fairbanks and Anchorage, the Alaska Railroad, a Golden Valley Electric Association (GVEA) transmission line, and several homes would be required. This could require up to 48 months.

The site could require substantial foundation excavations in excess of 100 feet in depth. The site would also require incorporation of fish passage facilities, which are costly and oftentimes not effective.

1.2.3 - Keetna Dam and Reservoir (***)

(a) Description (***)

The Keetna site is located on the Talkeetna River, approximately 85 miles north of Anchorage and 14 miles northeast of Talkeetna, approximately 1.5 miles downstream from Disappointment Creek. The climate of the project area is described as continental. The mean annual air temperature is 30°F. Temperatures range from a mean minimum of -2°F in January to a mean maximum of 68°F in July. Precipitation averages 30 inches annually. Permafrost conditions exist at the site and in the drainage basin.

The project is located in Probability Zone 3, per seismic risk maps of the Uniform Building Code (ICBO 1980). This places it in the major damage category (corresponds to intensity VIII and higher on the Modified Mercalli Intensity Scale).

The damsite has a tributary drainage area of 1,260 square miles. The basin lies east of the Susitna River and drains the western slopes of the Talkeetna Mountains. The lower elevations support growth of timber and other vegetation, while the upper elevations have little or no vegetal cover.

Streamflow records of the Talkeetna River are available from June 1964 to the present time for a gage 5-miles upstream from the river mouth (USGS Gage No. 15292700). For the energy simulation studies conducted for this document, 14 years of streamflow data were used (1964-1978). Mean annual discharge at the Keetna damsite for this period was estimated to be 2,500 cfs (1,800,000 acre-feet), based on a proportioning of flow by drainage area.

Approximately six percent of the drainage area is glaciated. USGS sediment discharge measurements from 1981 through 1983 at the Talkeetna River gaging station indicate that the sediment load is approximately half of the sediment load of the Susitna River above the Chulitna River. Based on a proportioning of the sediment load by drainage area and trap efficiencies adapted from Brune (U.S. Bureau of Reclamation 1977), it was determined that 65,000 acre-feet of sediment would accumulate in the reservoir in a 50 year period.

At the project site, the Talkeetna River flows in a steep-walled, U-shaped valley. The near vertical abutments indicate bedrock is nearly exposed on either side of the river. Insofar as could be determined from the aerial reconnaissance, foundation conditions would allow construction of either an earth and rockfill dam or a concrete arch dam at this site.

The dam would be built with the crest at approximately elevation 965 and the base at elevation 550± feet. The crest length would be about 1,200 feet. The diversion and power tunnels would be located on the left abutment along with an ogee type gated spillway. The surface powerhouse would be conected to the reservoir by a 1,300± feet long tunnel. The powerplant would have an installed capacity of 100 MW and a plant factor of 49 percent.

Twenty-five miles of access road would be required from Talkeetna to the project. Construction of this access road would involve approximately 300 acres of right-of-way.

Construction materials might be obtained from the adjacent rock outcrops and the alluvial deposits in the river valley.

The Keetna Reservoir would have a normal maximum water surface at elevation 945 feet. At this elevation, the reservoir area would be 5,500 acres. Total reservoir capacity would be 850,000 acre-feet, including 350,000 acre-feet of dead storage and 500,000 acre-feet of live storage. Drawdown capability would be 125 feet. This drawdown could expose about 2,000± acres of unsightly mud flats and/or eroded slopes devoid of any vegetation. Maximum reservoir depth would be about 240 feet. Retention time would be 5.5 months. The reservoir length would be 10 miles.

The Keetna Reservoir would be drawn down to its minimum level in May of each year. During the high flow summer period (May through September) the reservoir would be gradually filled. During the fall and winter, the stored water would be gradually released until the minimum reservoir elevation is reached in May.

Minimum flow would be 5,000 cfs during the summer months of June, July and August and 720 cfs during the winter months. These flows are based on those presented in the DEIS (FERC 1984, Table 2-7). Maximum gross head would be 330 feet and the average net operating head about 286 feet. Tailwater elevation would be at approximately 430 GWh if energy production is not limited by the system requirement.

(b) <u>Environmental Assessment</u> (***)

Highly significant runs of anadromous salmon exist upstream of the project. Salmon are known to spawn in areas within and upstream of the impoundment zone. Important spawning areas within the impoundment zone would be eliminated. In addition, there is a high risk that the chum salmon runs upstream of the project would be eliminated as well, primarily because they do not adapt well to using fish passage facilities. Changes in flow regimes downstream of the project could also impact salmon spawning and rearing habitat.

The high concentrations of salmon (particularly chinook salmon) in Prairie Creek (upstream of the site) attract large numbers of brown bears (up to 100) that feed on the salmon. This resource is considered a seasonally important critical habitat and may be important for maintaining the current levels of brown bear numbers in the area.

This section of the Talkeetna River (including Disappointment Creek) has been recommended by the Alaska Department of Natural Resources as a state recreation river (Alaska Department of Natural Resources 1985). White-water kayaking in the impoundment reach and upstream passage of river boats from Talkeetna (which currently access upstream areas as far as approximately 2 miles above Iron Creek) would be eliminated.

Moose utilize the proposed impoundment zone year-round and concentrate in the floodplain during the fall and winter. Loss of this habitat would decrease the carrying capacity of the area for moose and result in lower moose populations.

The project could significantly impact bald eagles and other nesting raptors either through loss of nesting sites or a reduction in prey base.

(c) <u>Engineering Assessment</u> (***)

There may be difficulty in obtaining sufficient impervious borrow materials at this site. This would require development of additional on-site roads along steep slopes to gain access to higher elevation where materials may be available. Inherent stability problems are associated with excavations on steep slopes. The only suitable location of the construction camp site may be subject to flooding. The site would require incorporation of fish passage facilities which are costly and lack proven effectiveness for certain species.

1.2.4 - Snow Dam and Reservoir (***)

(a) Description (***)

The damsite is on the Snow River in the Kenai Peninsula at river mile 8 (latitude 60°18'N, longitude 149°16'W). The climate of the project area is described as continental. The mean annual air temperature is about 36°F with temperatures ranging from a mean January minimum 12°F to a mean July maximum of 63°F. Precipitation averages approximately 100 inches annually.

The damsite has a tributary drainage area of 105 square miles. The mountainous basin lies approximately 12 miles north of Seward in the Kenai Mountains. The lower elevations support the growth of timber and other vegetation while the upper elevations contain numerous glaciers with little or no vegetation.

Snow River streamflow has been measured at a point approximately 1.5 miles upstream from the proposed damsite. The records from this gage ("Snow River near Divide") are available from December 1960 to July 1965. These records were extended by correlating with the records from the "Trail River" gage near Lawing which are available from May 1947. However, the floods caused by glacial outbursts, as they were considered in the flow data in the responses to Exhibits B and D of the License Application submitted to FERC on August 18, 1983, were not considered in this stream flow analysis. Based on this correlation, the average annual streamflow at the damsite is estimated at 660 cfs (478,000 acre-feet). Mean monthly flows vary from as little as 10 cfs in March to approximately 2,000 cfs in the July through September period.

Release of water from an ice dammed lake high above the Snow River Valley has produced flood flows of about the same magnitude as storms (Post and Mayo 1971). The outburst flood of 1967 was estimated at 20,000 cfs. Historical records indicate that the glacial outburst floods in the Snow River Valley from the glacier-filled lake have occurred every 2 to 3 years. Should "outburst" flows occur simultaneously with a non-outburst flood, the combined flow could exceed 40,000 cfs.

The project is located in Probability Zone 4, according to seismic risk maps of the Uniform Building Code (ICBO 1980). This is noted as the highest risk category.

At the damsite, the Snow River flows in a deep, narrow gorge incised in bedrock on the floor of a steep-walled, U-shaped, glacial valley. Bedrock is well exposed in the near-vertical abutments although thin overburden mantles portions of the upper left abutment. The beds strike nearly due north, normal to the canyon, and dip steeply upstream. Insofar as could be determined from aerial reconnaissance, geologic conditions are favorable for construction of either a rockfill or a concrete arch dam at this site. A power tunnel along the right valley wall would penetrate rock similar to that exposed at the damsite. Construction materials might be obtained from the adjacent rock outcrops along with alluvial and glacial deposits from the lower reaches of the river near its confluence with the South Fork Snow River, approximately 4 miles downstream from the site.

For estimating purposes it is assumed that a dam would be built with the crest at approximately elevation 1,210 feet and the base at elevation 900 feet for a maximum structural height of 310± feet. The crest length would be about 820 feet. The diversion and power tunnels would be located on the right abutment and a spillway would be constructed at the southern end of the reservoir, approximately 1 mile from the dam. The powerplant would be connected to the reservoir by 10,000 feet of ± 11-foot-diameter tunnel and 2,000 feet of ± 8-foot-diameter surface penstock. The powerplant would have an installed capacity of 63 MW with a 50 percent plant factor.

The Snow Reservoir would have a normal maximum operating level of 1,200 feet above sea level. At this elevation, the reservoir surface area would be 3,200 acres and the total storage would be 179,000 acre-feet. With a total drawdown capability of 150 feet, the active reservoir storage would be 173,000 acre-feet. This drawdown could expose 2,200± acres of unsightly mud flats and/or eroded slopes devoid of vegetation. Maximum depth of the reservoir would be about 300 feet. Retention time would be 4 months. Reservoir length would be 7 miles. Lower Paradise Lake would be inundated at full pool elevation.

During the high runoff period of June, July, August and September the reservoir would be gradually filled from its minimum elevation of 1,050 feet. During the period October through May, the reservoir would be drawn down to its minimum level. Minimum flow for the project would be 740 cfs during June, July and August and 210 cfs at other times. These flows are based on those described in Table 2-7 of the DEIS (FERC 1984).

Tailwater level would be at elevation 500 feet, resulting in the maximum gross head of 700 feet at full pool elevation. The average head would be 620 feet, allowing for 30 feet of head loss in the penstock. The energy output capabilities of the Snow Project were reevaluated using revised streamflow data. The 100 MW installed capacity, presented in both the License Application and the DEIS, was previously based on combined normal streamflow and flow resulting from glacial outburst flooding. This high flow gave the false impression that the Snow River could produce a more continuous energy than it realistically could. Hence, a 100-MW powerplant is not appropriate for this project. Subsequent study considering only actual steamflow data (excluding flow from glacier outbursts) indicates that a 63-MW powerplant is more realistic, based on a plant factor of about 50 percent. This reduced capacity is used in this analysis as part of a more realistic preliminary design. Mean annual energy is approximately 270 GWh if the energy production is not limited by the system energy demand.

(b) Environmental Assessment (***)

The project would inundate hunting and fishing areas in a wilderness valley, and an existing recreational fishery in Lower Paradise Lake would be eliminated. Changes in flow regimes downstream of the project could impact salmon spawning and rearing habitat in the Kenai River, a prime sport fishing river in the state of Alaska.

Riparian areas within the impoundment zone would be eliminated. This is important habitat to moose and other wildlife. Loss of this habitat would decrease the carrying capacity of the area for moose and result in lower moose populations.

Views of the dam, transmission lines and other facilities would be highly visible to recreationists in the South Fork valley and to sightseers on the Seward Highway and the Alaska Railroad.

(c) Engineering Assessment (***)

This site would require upgrading approximately 83 miles of existing transmission line between the project area and Anchorage at a cost of approximately $1,476,000. A 4-mile long transmission line stub would be required from the powerhouse substation to this existing transmission facility.

The site is subjected to glacial outburst flooding every two to three years. This would entail very high costs for special design treatment in the way of increased project freeboard, increased spillway capacity or emergency spillways, or a reduced operating pool level.

1.2.5 - Chakachamna Dam and Reservoir (***)

(a) Description (***)

The Chakachamna site would be located on the Chakachatna River, approximately 80 miles west of Anchorage. The economic and environmental feasibility of this site for power generation was extensively studied by the Power Authority (Bechtel 1983a), and the following information is derived from that study.

The climate of the project area is described as transitional. Mean annual air temperature is 28°F. Temperatures range from a mean minimum of 8°F in January to a mean maximum of 69°F in July. Precipitation averages 80 inches per year. The damsite has a tributary drainage area of 1,120 square miles. Continuous streamflow records for the Chakachatna River near Tyonek (USGS Gage No. 15294500) are available for the period June 1959 to August 1971. This station is located at the outlet to Chakachamna Lake. Mean annual flow is 3,750 cfs (2.7 million acre-feet).

The project would be located in Probability Zone 3, according to seismic risk maps of the Uniform Building Code (ICBO 1980). Proximity to a volcano plus the seismic potential put Chakachamna in the major damage category (corresponds to intensity VIII and higher on the Modified Mercalli Intensity Scale).

The project would consist of a rockfill dike constructed at the outlet of Lake Chakachamna (Alternative E, Bechtel 1983a). The dike would have a crest length of 600 feet and a crest elevation of 1,177 feet. Water would be diverted to a powerhouse located near the McArthur River via a tunnel 10 miles long. The diameter of this power tunnel would be 24 feet. Four vertical Francis turbines would be installed with a total installed capacity of 330 MW. The plant factor would be 45 percent. Fish passage facilities would be incorporated into the design.

Chakachamna Lake would have a normal maximum water level of 1,155 feet. Reservoir area at this elevation would be 17,500 acres while the total volume would be 4,483,000 acre-feet. Active storage would be 1,105,000 acre-feet, corresponding to a drawdown capability of 72 feet. This drawdown could expose 2,200± acres of unsightly mud flats and/or eroded slopes devoid of vegetation. Retention time would be 1.65 years.

The project would be operated to provide for fishery releases. From May through September the instream flow release would be 1,094 cfs. During the remainder of the year the instream flow release would be about 365 cfs. (These are the flows recommended in Alternative E, Bechtel 1983b). The minimum flows recommended in Table 2-7 of the DEIS could not be satisfied for Chakachamna Alternative E. Since the requirements could be satisfied for Alternative D, this Alternative was used in the power and energy analysis presented by APA in the response to DEIS comments (APA 1984). Maximum gross head would be 945 feet and the average net operating head about 905 feet. Tailwater elevation would be at 210 feet. Mean annual energy production is estimated to be 1,301 GWh.

(b) <u>Environmental Assessment</u> (***)

There is a potential loss of a significant sockeye salmon run (up to 40,000 fish) upstream of the site, and impacts to approximately 64,000 additional adults either downstream of the dam site on the Chakachatna River or in the McArthur River. In total, the number of adult salmon that could be significantly affected is over 100,000. These impacts may be due to either fish passage difficulties or diversion of flow from the Chakachatna River to the McArthur River which could result in miscueing for migration, changes in spawning habitat resulting from flow change, or delays in migration.

Changes in flow by diversion could also significantly affect fish rearing habitat downstream, particularly in areas such as Noaukta Slough on the Chakachatna River, that are known rearing areas. The decrease in river flow would also result in dewatering of areas used as nesting habitat by waterfowl.

The project would adversely affect brown bear use of salmon spawning areas on the Chilligan and Chakachatna Rivers. Stabilization of river and slough banks due to reduced flow of water down the Chakachatna River would have eventual, long-term impacts on moose and furbearers.

(c) Engineering Assessment (***)

The power tunnel, which is approximately 10 miles long, would require very detailed geologic investigation and study because of its greater susceptibility to problems created by changes in geological structures along its length. High in-situ rock stresses may occur near the underground powerhouse due to the nearby presence of the Lake Clark-Castle Mountain fault. These stresses will cause significant design and construction problems which will be costly and time consuming. The nearby presence of Barrier, Blockade, and McArthur Glaciers could make lake level prediction, and the resulting regulation of storage for power production difficult. This could also cause outburst flooding, which would endanger the tailrace channel and portals of the tailrace tunnel and access tunnel to the underground powerhouse.

A large eruption of Mt. Spurr Volcano located about 7 miles from the outlet of Chakachamna Lake could inundate the proposed power intake site with volcanic ash, or trigger a large landslide or mudflow which would bury both the upstream and downstream ends of the fish passage facilities, dam, spillway, and power intake structure.

The site lies within a zone of high seismic risk.

This site is remotely located with respect to the Anchorage-Fairbanks Intertie and would require an extensive transmission line (approximately 130 miles in length and 1,200 acres of corridor at an estimated project cost of $60,000,000).

In addition to new access requirements, extensive improvement to existing roads and transportation facilities (e.g., Tyonek dock facilities) would be necessary. Improvements to existing access facilities could take up to 48 months.

The site would require incorporation of potentially ineffective fish passage facilities for both upstream and downstream migrating fish involving a 930 foot long approach channel, and a 300 foot long tunnel connecting the downstream discharge facilities.

1.3 - Middle Susitna Basin Hydroelectric Alternatives (o)

A second feature of the alternatives' analysis involved the consideration of alternative sites within the middle 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 middle 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 a development selection report (Acres 1981a) and also in the Susitna Hydroelectric Project Feasibility Report (Acres 1982c).

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.10.1.1).

1.3.1 - Damsite Selection (o)

In the Susitna Basin studies discussed previously (Acres 1982c), 12 damsites were identified in the upper portion of the basin, i.e., upstream from Gold Creek (see Figure E.10.1.2). 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; and
- 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 (Acres 1982c). Results appear in Table E.10.1.2.

1.3.2 - Site Screening (o)

The objective of this screening exercise was to eliminate sites which obviously should not be included 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 were used; these include environmental, alternative sites, and energy contribution.

(a) Environmental Screening Criteria (o)

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

(i) Unacceptable Sites (o)

Sites in this category were 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. Since 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 practically no salmon 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.

(ii) Sites With Significant Impact (o)

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, 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.

(iii) <u>Sites With Moderate Impact</u> (o)

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.

(b) <u>Alternative Sites</u> (o)

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.

(c) <u>Energy Contribution</u> (o)

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.

(d) <u>Screening Process</u> (o)

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; and
- 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.

1.3.3 - 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; or
- Vee.

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

- MacLaren; and
- Denali.

To establish the likely optimum combination of dams, a computer screening model was used to directly identify the types of plans that are most cost effective. Results of these runs indicate that the Devil Canyon/Watana or the High Devil Canyon/ Vee combinations are the most favorable . 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.10.1.3.

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

(a) Plan 1 (*)

Three subplans were developed:

(i) 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.

(ii) 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.

(iii) Subplan 1.3 (*)

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

(b) Plan 2 (*)

Three subplans were also developed under Plan 2:

(i) 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.

(ii) 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.

(iii) 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.

(c) 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 the inundation of 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.

(i) 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.

(ii) 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.

(d) 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 1,470 feet 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 1,030 feet and an installed capacity of 150 MW. For purposes of these studies, this site is referred to as the Portage Creek site.

1.3.4 - Plan Evaluation Process (o)

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.10.1.2 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 detailed description of the model appears in the Susitna Hydroelectric Project Feasibility Report (Acres 1982c).

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 four modified plans, E1 through E4.

(a) E1 Plans (o)

For Subplans 1.1 to 1.3, a low, temporary re-regulation dam would be 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 would be 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.

(b) E2 Plans (o)

For Subplans 2.1 to 2.3, a permanent re-regulation dam would be located downstream from the High Devil Canyon site, while at the same time, the generating capacity would be 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 would be utilized for power production. The damsite would be located at the Portage Creek site with a crest level set to utilize the full head. A 150-MW powerhouse would be installed. Since this dam is to serve as a re-regulating facility, it would be constructed at the same time as the capacity of High Devil Canyon is increased to 800 MW, i.e., during Stage II.

(c) E3 Plan (o)

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.

(d) E4 Plans (o)

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.

1.3.5 - Comparison of Plans (o)

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 were used and the least-cost staging concept was adopted. For assessing which plan is the most appropriate, a more detailed evaluation process incorporating economic, environmental, social, and energy contribution aspects was 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 the Susitna Hydroelectric Project Feasibility Report (Acres 1982c).

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 were 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, was added. The objective of including this criterion was to insure that full consideration is given to the total basin energy potential that is developed by the various plans.

(a) Economic Criteria (o)

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

(b) Environmental Criteria (o)

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

(c) Social Criteria (o)

This attribute includes determination of the potential nonrenewable 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.

(d) Energy Contribution (o)

The parameter used was the total amount of energy produced from the specific development plan. An assessment of the energy development foregone was 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.10.1.4 through E.10.1.6.

1.3.6 - Results of Evaluation Process (o)

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

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

1.3.7 - Devil Canyon Dam Versus Tunnel (o)

The first step in the process involved the evaluation of the Watana-Devil Canyon dam plan (E1.3) and the Watana tunnel plan (E3.1). Since Watana is common to both plans, the evaluation was 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.

(a) Economic Comparison (o)

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 does not change the basic economic superiority of the dam scheme over the tunnel scheme.

(b) Environmental Comparison (o)

The environmental comparison of the two schemes is summarized in Table E.10.1.4. 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; and
- o It would preserve much of the characteristics of the Devil Canyon gorge, which is considered to be an aesthetic and recreational resource.

(c) Social Comparison (o)

Table E.10.1.5 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.

(d) Energy Comparison (o)

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.

(e) Overall Comparison (o)

The overall evaluation of the two schemes is summarized in Table E.10.1.6. 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.

1.3.8 - Watana-Devil Canyon Versus High Devil Canyon-Vee (o)

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

(a) Economic Comparison (o)

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.

(b) Environmental Comparison (o)

The evaluation in terms of the environmental criteria is summarized in Table E.10.1.7. In assessing these plans, a reach-by-reach comparison was 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 was 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 middle Susitna Basin.

The High Devil Canyon-Vee scheme would inundate approximately 14 percent (15 miles, or 24 km) more winter habitat utilized by moose 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 subpopulations 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. Nevertheless, the upstream moose habitat losses associated with the High Devil Canyon-Vee scheme would probably be more significant 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 was 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 was 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, the High Devil Canyon-Vee plan would retain the integrity of more of this river valley slope habitat.

From the archeological studies done to date, there tends to be an increase in site intensity as one progresses towards the northeast section of the middle 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 was judged to have a greater potential for directly or indirectly affecting archeological 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. Since it is easier to extend access than to limit it, inherent access requirements are detrimental, and the Watana-Devil Canyon scheme was 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 was judged to be more environmentally acceptable than the High Devil Canyon-Vee plan.

Table E.10.1.5 summarizes the evaluation in terms of the social criteria. As in the case of the dam versus tunnel comparison, the Watana-Devil Canyon plan was judged to have a slight advantage over the High Devil Canyon-Vee plan because of its greater potential for displacing nonrenewable resources.

(c) Energy Comparison (o)

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.

(d) Overall Comparison (o)

The overall evaluation is summarized in Table E.10.1.8 and indicates that the Watana-Devil Canyon plans are generally superior to all the other evaluation criteria.

1.3.9 - Preferred Susitna Basin Development Plan (***)

One-on-one comparisons of the Watana/Devil Canyon plan with the Watana tunnel plan and the High Devil Canyon/Vee plan are judged to favor the Watana/Devil Canyon plan in each case. The Watana/Devil Canyon plan was therefore selected as the preferred Susitna basin development plan.

In May 1985, the Applicant concluded that a number of benefits would be derived from a modification of the Watana/Devil Canyon two-dam plan providing for completion of construction in three stages (APA 1985).

Accordingly, the Applicant has prepared alternative facility designs and operation studies of a construction plan that permits construction in three stages: first, construction and operation of a facility at the Watana site with a dam elevation of 2,025 feet (Stage I); second, completion and operation of the Devil Canyon facility at the originally proposed dam elevation of 1,463 feet (Stage II); and third, further elevation of the dam at the Watana facility to the 2,205 foot level proposed in the July 1983 License Application (Stage III) (APA 1983b). Although the three-stage construction plan will not alter the character of the fully completed project, staging construction in three steps will accomplish certain desirable changes over the course of project development.

The development of Watana to its full height results in concentration of expenditures in the early years of the Susitna project. Completion of Watana Stage I at a 2,025 foot crest elevation would reduce the initial materials requirement and construction time. The result would be both a reduction in initial state financial commitments and improved opportunity for private financing. Moreover, stretching out the pace of development of project energy and capacity would permit a better matching of load growth and capacity available, thereby ensuring greater flexibility in responding to future rates of system growth. Therefore, the three staged plan is the basis for continuation of more detailed design optimization and environmental studies.

1.4 - Overall Comparison of Non-Susitna Hydroelectric Alternatives to the Proposed Susitna Project (***)

Based on the environmental, engineering, and economic analyses described in Sections 1.1 through 1.3 (and the details provided in the report submitted by the Applicant (APA 1984) in response to the DEIS, the proposed project is the most favorable for development. The FERC five-site non-Susitna hydroelectric alternatives are compared with this preferred Susitna Hydroelectric Project (Watana - Stages I and III, Devil Canyon Stage II) in the following Section 1.4, where it is conclusively demonstrated that Susitna is the more attractive and beneficial project.

Key environmental considerations which strongly favor development of the proposed project include the following:

- The non-Susitna alternative sites would place a significant number of anadromous salmon that migrate upstream of the dam sites at high risk. Salmon are known to migrate upstream of all alternative sites except perhaps the Snow site. Although little is known about numbers of fish passing the Johnson and Browne sites, it is known that chum and coho salmon pass upstream of either or both sites. At least 40,000 adult sockeye utilize areas upstream of the Chakachamna site (Bechtel 1983a) and 9,000 chinook were observed in 1984 in Prairie Creek, a tributary upstream of the Keetna site (Alaska Department of Fish and Game 1985). Chum, coho, and sockeye salmon also are known to utilize areas upstream of the Keetna site. In comparison to the alternative sites, no salmon migrate upstream of the Watana site and only a few (estimated at less than 100) are able to pass through Devil Canyon. Thus, the cumulative impact of the alternative sites would affect far greater resources than the proposed project.

- The alternative sites would impact many more communities during construction and operation and would require the relocation of two communities, one a native village and one a religious community. It is expected that this would seriously disrupt the infrastructure of these communities. In contrast, the proposed project would impact few communities during construction and operation and would not require any relocations.

- The total acreage inundated plus areas disturbed (e.g., transmission lines, camps, etc.) by the alternatives would be 124,770 acres compared to 60,860 acres for the proposed project. This would result in more extensive wildlife and botanical impacts for the alternatives. The Johnson site, alone, would impact 98,160 acres which is about 1.5 times more acreage than the Watana and Devil Canyon sites combined.

- The alternative sites would require the relocation of major highways, railroads, and transmission lines. Highways include the main route between Anchorage and Fairbanks (Browne site) and the main route between Alaska and the lower 48 (Johnson site). The railroad relocation would be on the only route between Anchorage and Fairbanks and the transmission line would be the Anchorage-Fairbanks Intertie. In comparison, the proposed project would require virtually no such relocations.

- The alternatives would eliminate existing free-flowing rivers that are now extensively used for boating and recreational rafting. One of these, the Talkeetna River (Keetna site), has been recommended as a state recreation river. In comparison, few people utilize the river section that will be inundated by the proposed project.

- Alteration of flows of the Johnson and Browne sites could severely disrupt important navigation and commerce, particularly on the lower Tanana River and perhaps on the Yukon River. No significant impacts to navigation are expected on the Susitna downstream of the project.

A comparative summary of the most promising non-Susitna hydroelectric alternatives, and the proposed Susitna Project is presented in Table E.10.1.9. It is readily apparent from this comparison that the proposed Susitna Project offers definite economic and environmental advantages over the non-Susitna scenario. The costs presented in the table are estimated construction costs, and do not include any costs for operation and maintenance, mitigation, financing, etc.

Susitna will cost $2 billion less than the non-Susitna alternatives to build. The aforementioned costs not included in this construction cost may be expected to widen the difference in cost. For this additional $2 billion cost, the non-Susitna scenario would have less than half the capacity of the proposed project. It would also inundate almost four times as much land as Susitna, much of which could affect the socioeconomic growth of the area and greatly disrupt existing transportation arteries and existing transmission facilities.

The alternatives would cost approximately three times as much per installed megawatt of available capacity as the the proposed Susitna project. They would also inundate nearly 6 times as much land for each megawatt of capacity than the Susitna project would.

Results from the study in response to the DEIS (APA 1984) show that each site would have potential environmental impacts, engineering problems, or unfavorable project costs that often exceed those of the Susitna Project.

When the sum total of impacts is considered, it is clear that the cumulative impacts of the non-Susitna hydro alternatives result in a scenario that is not viable compared to the proposed project, particularly when it is noted that the power produced will only partially fulfill the Railbelt's total energy needs. Adding thermal units to meet those needs would only compound the environmental impacts. The feasibility of a combined hydro-thermal scenario, as suggested by FERC in the DEIS (FERC 1984), becomes even more tenuous with the difficulties, both technical and sociopolitical, of siting coal-fired thermal units near the visually sensitive, Class I air quality area of Denali National Park and Preserve. The Susitna Project would meet more of the energy needs of the Railbelt with far fewer adverse impacts. Also, when costs are based on consistent analysis, the Susitna Project's cost per unit of installed capacity is significantly lower than for the hydro alternatives.

2 - ALTERNATIVE FACILITY DESIGNS (*)

2.1 - Watana Facility Design Alternatives (*)

Environmental factors considered in Watana facility design are summarized below.

2.1.1 - Diversion/Emergency Release Facilities (*)

Table E.10.2.1 shows the Case E-VI environmental flow requirements. These are flows measured at Gold Creek and have been established to avoid adverse affects on the fisheries resources downstream. These flow requirements would be met during filling and operation of the project.

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 the low-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.

2.1.2 - Main Spillway (**)

As a result of discussions with interested state and federal agencies and on the basis of an evaluation of impacts of nitrogen supersaturation, provisions for releasing reservoir waters while minimizing nitrogen supersaturation for floods with return periods of 50-years or less have been incorporated in the general arrangements of both Watana and Devil Canyon Dams.

Nitrogen supersaturation occurs when aerated flows are subjected to pressures greater than one atmosphere forcing excess gas into solution. This can occur in plunge pools and stilling basins downstream of spillways. Nitrogen comes out of solution as the supersaturated water is exposed to atmospheric pressure. If supersaturation were to occur at Watana with Watana operating alone, the level of supersaturation would be reduced with distance downstream of Watana. When Devil Canyon is operating and supersaturation occurs at Watana, it may not be reduced within the Devil Canyon Reservoir and discharges from Devil Canyon would contain approximately the same concentration of gas as in the outflow from Watana.

In order to minimize potentially harmful concentrations of nitrogen, consideration was given to designing the spillways in such a manner that flows released through the spillways would not cause excess nitrogen concentrations.

Three basic alternative spillway types were examined:

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

Consideration was also given to combinations of these alternatives with or without supplemental facilities such as valved tunnels (see Section 2.1.4) and an emergency spillway fuse plug for handling the PMF discharge.

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

Two spillway and outlet works arrangements were considered further:

- o The cascade spillway was not favored for technical and economic reasons. However, this arrangement does have an advantage in that it may provide a means of preventing nitrogen supersaturation in the downstream discharges from the project. However, there is no conclusive evidence that the cascade spillway would not produce excessive nitrogen concentrations. This alternative was retained for further evaluation. The cascade spillway was designed for the 10,000 year flood and an emergency rock channel spillway utilizing a fuse plug was included to take the PMF.

- o The second alternative that was considered further was a combination of a flip bucket spillway and an outlet works with fixed cone valves. The fixed cone valve outlet works in combination with a flood storage pool between El. 2,185 and 2,193 would be capable of storing and releasing all floods up to the 50-year event while minimizing gas concentrations downstream. (See Section 2.1.4 and Exhibit E, Chapter 2, Section 6.) Floods in excess of the 50 year event might require operation of the flip bucket spillway. The flip bucket is not designed to disperse flows as much as fixed cone valves and may result in greater gas concentrations downstream than cone valve operation. The original layout included a fuse plug spillway to handle flood flows in excess of the 10,000 year event up to the

PMF. This was later eliminated in favor of increasing the flip bucket spillway capacity to handle the PMF, while retaining the cone valve outlet works for floods less than 50-year recurrence intervals.

2.1.3 - Power Intake and Water Passages (o)

In addition to the nitrogen supersaturation considerations discussed above, other environmental considerations in the design of the power facilities are:

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

The Watana intake designs have been modified to enable power plant flows to be drawn from the reservoir at several different levels throughout the anticipated range of reservoir drawdowns for energy production in order to provide acceptable downstream river temperatures during all stages of operation.

The policy for operating the multi-level intakes and the effects on temperature are discussed in Exhibit E, Chapter 2, Sections 4.1.3(c), 4.2.3(c) and 4.3.3(c) for Stages I, II, and III, respectively. A description of the intakes are given in Exhibit A.

2.1.4 - 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 minimize potential nitrogen supersaturation downstream, 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, the equivalent of the routed 50-year flood.

2.2 - Devil Canyon Facility Design Alternatives (o)

2.2.1 - Installed Capacity (o)

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

- o 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.

2.2.2 - Spillway Capacity (**)

The minimization of nitrogen supersaturation in the downstream flow also will apply to Devil Canyon. Thus, fixed cone valves similar to Watana have been incorporated into the Devil Canyon layout and a provision for surcharging Devil Canyon Reservoir has been made in order to prevent spillway flip bucket usage for floods with return periods of 50-years or less.

2.2.3 - Power Intake and Water Passages (*)

In addition to nitrogen-saturation, other considerations in the design of the Devil Canyon power intake facilities are:

- 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 structure at Devil Canyon would assist downstream water temperature control. Consequently, the intake design at Devil Canyon will incorporate a two level intake without located between 30 and 80 feet below maximum reservoir operating level of 1,455 feet.

Devil Canyon will be operated as a baseloaded plant. However, daily discharge may vary by up to 10% (+) of the average weekly discharge. Refer to Chapter 2 of Exhibit E for further discussion of this issue.

2.3 - Access Alternatives (o)

2.3.1 - Objectives (o)

Throughout the development, evaluation, and selection of the access plans, the foremost objective was to provide a transportation system that would support construction activities and allow for the orderly development and maintenance of site facilities.

Meeting this fundamental objective involved the consideration not only of economics and technical ease of development but also many other diverse factors. Of prime importance was the potential for impacts to the environment, namely impacts to the local fish and wildlife populations. In addition, since the Native villages and the Cook Inlet Region will acquire surface and subsurface rights adjacent to the project, their interests were recognized and taken into account as were those of the local communities and general public.

With so many different factors influencing the choice of an access plan, it was evident that no one plan would satisfy all interests. The aim during the selection process was to consider all factors in their proper perspective and produce a plan that represented the most favorable solution to both meeting project-related goals and minimizing impacts to the environment and surrounding communities.

2.3.2 - Corridor Identification and Selection (o)

The Acres Plan of Study, February 1980, identified three general corridors leading from the existing transportation network to the damsites. This network consists of the George Parks Highway and the Alaska Railroad to the west of the damsites and the Denali Highway to the north. The three corridors appear in Figure E.10.2.1.

Corridor 1 - From the Parks Highway to the Watana damsite via the north side of the Susitna River.

Corridor 2 - From the Parks Highway to the Watana damsite via the south side of the Susitna River.

Corridor 3 - From the Denali Highway to the Watana damsite.

The access road studies identified a total of eighteen alternative plans within the three corridors. The 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.

The preliminary design criteria adopted for access road and rail alternatives were selected on the basis of similar facilities provided for other remote projects of this nature. Basic roadway parameters were as follows:

- Maximum grade of 6 percent;
- Maximum curvature of 5 degrees;

- o Design loading of 80^k axle and 200^k total during construction; and
- o Design loading of HS-20 after construction.

Railroad design parameters utilized were as follows:

- o Maximum grade of 2.5 percent;
- o Maximum curvature of 10 degrees; and
- o Loading of E-72.

Once the basic corridors were defined, alternative routes which met these design parameters were established and evaluated against technical, economic, and environmental criteria. Next, within each corridor, the most favorable alternative route in terms of length, alignment, and grade was identified. These routes were then combined together and/or with existing roads or railroads to form the various access plans. The development of alternative routes is discussed in more detail in the R & M Access Planning Study (R&M Consultants 1982a) and the R&M Access Planning Study Supplement, (R&M Consultants 1982b). These documents contain maps of all the routes.

2.3.3 - Development of Plans (*)

At the beginning of the study, a plan formulation and initial selection process was developed. The criteria that most significantly affected the initial selection process were identified as:

- o Minimizing impacts to the environment;
- o Minimizing total project costs;
- o Providing transportation flexibility to minimize construction risks; and
- o Providing ease of operation and maintenance.

This led to the development of eight alternative access plans.

During evaluation of these access plans, input from the public, resource agencies, and Native organizations was sought and their response resulted in an expansion of the original list of eight alternative plans to eleven. Plans 9 and 10 were added as a suggestion by an earlier constituted Susitna Hydroelectric Steering Committee as a means of limiting access by having rail only access as far as the Devil Canyon damsite to reduce adverse environmental impacts in and around the project area. Plan 11 was added as a way of providing access from only one main terminus, Cantwell, and thus alleviate socioeconomic impacts to the other communities in the Railbelt (principally Gold Creek, Trapper Creek, Talkeetna and Hurricane).

Studies of these eleven access plans culminated in the production of the Acres Access Route Selection Report of March 1982 which recommended Plan 5 as the route which most closely satisfied the selection criteria. Plan 5 starts from the George Parks Highway near Hurricane and traverses along the Indian River to Gold Creek. From Gold Creek the road continues east on the south side of the Susitna River to the Devil Canyon damsite, crosses a low level bridge and continues east on the north side of the Susitna River to the Watana damsite. For the project to remain on schedule, it would have been necessary to construct a pioneeer road along this route prior to the FERC license being issued to assure completion of the two major bridges over the Susitna River that would be required.

In March of 1982, the Alaska Power Authority presented the results of the Susitna Hydroelectric Feasibility Report, of which Access Plan 5 was a part, to the public, agencies, and organizations. During April, comment was obtained relative to the feasibility study from these groups. As a result of these comments, the pioneer road concept was eliminated, the evaluation criteria were refined, and seven additional access alternatives were developed.

Maps and detailed descriptions of the 18 alternatives considered are contained in R&M (1982a, 1982b) and Acres (1982b). The evaluation process is described below.

2.3.4 - Evaluation of Plans (*)

The refined criteria used to evaluate the eighteen alternative access plans were:

- No pre-license construction;
- Provide initial access within one construction season;
- Provide access between sites during project operation phase;
- Provide access flexibility to ensure project is brought on-line within budget and schedule;
- Minimize total cost of access;
- Minimize initial investment required to provide access to the Watana damsite;
- Minimize risks to project schedule;
- Minimize environmental impacts;

- o Accommodate current land uses and plans;
- o Accommodate Agency preferences;
- o Accommodate preferences of Native organizations;
- o Accommodate preferences of local communities; and
- o Accommodate public concerns.

All eighteen plans were evaluated using these refined criteria to determine the most responsive access plan in each of the three basic corridors. An explanation of the criteria and the plans which were subsequently eliminated is given below.

To meet the overall project schedule requirements for the Watana development, it is necessary to secure initial access to the Watana damsite within one construction season of the FERC license being issued. The constraint of no pre-license construction resulted in the elimination of any plan in which initial access could not be completed within one construction season. This constraint led to the elimination of the access plan submitted in the Susitna Hydroelectric Project Feasibility Report (Plan 5) and five other plans (2, 8, 9, 10, and 12).

Upon completion of both the Watana and Devil Canyon dams, it is planned to operate and maintain both sites from one central location (Watana). To facilitate these operation and maintenance activities, access plans with a road connection between the sites were considered superior to those plans without a road connection. Plans 3 and 4 do not have access between the sites and were discarded.

The ability to make full use of both rail and road systems from southcentral ports of entry to the railhead facility provides the project management with far greater flexibility to meet contingencies, and control costs and schedule. Limited access plans utilizing an all rail or rail link system with no road connection to an existing highway have less fleixibility and would impose a restraint on project operation that could result in delays and significant increases in cost. Four plans with limited access (Plans 8, 9, 10 and 15) were eliminated because of this constraint.

Residents of the Indian River and Gold Creek communities are generally not in favor of a road access near their communities. Plan 1 was discarded because Plans 13 and 14 achieve the same objectives without affecting the Indian River and Gold Creek areas.

Plan 7 was eliminated because it includes a circuit route connecting to both the George Parks and Denali Highways. This circuit route was considered unacceptable by the resource agencies since it aggravated the control of public access.

The seven remaining plans found to meet the selection criterion were Plans 6, 11, 13, 14, 16, 17 and 18. Of these, Plans 13, 16, and 18 in the North, South, and Denali corridors, respectively, were selected as being the most responsive plan in each corridor. The three plans are described below.

2.3.5 - Description of Most Responsive Access Plans (**)

(a) Plan 13 "North" (see Figure E.10.2.2) (o)

This plan utilizes a roadway from a railhead facility adjacent to the George Parks Highway at Hurricane to the Watana damsite following the north side of the Susitna River. A spur road seven miles in length would be constructed at a later date to service the Devil Canyon development. Travelling southeast from Hurricane, the route passes through Chulitna Pass, avoids the Indian River and Gold Creek areas, then parallels Portage Creek at a high elevation on the north side. After crossing Portage Creek the road continues at a high elevation to the Watana damsite. Access to the south side of the Susitna River at the Devil Canyon damsite would be attained via a high level suspension bridge approximately one mile downstream from the Devil Canyon dam. This route crosses mountainous terrain at high elevations and includes extensive sidehill cutting in the region of Portage Creek. Construction of the road, however, would not be as difficult as Plan 16, the South route.

(b) Plan 16 "South" (see Figure E.10.2.3) (o)

This route generally parallels the Susitna River, traversing west to east from a railhead at Gold Creek to the Devil Canyon damsite, and continues following a southerly loop to the Watana damsite. To achieve initial access within one year, a temporary low level crossing to the north side of the Susitna River is required approximately twelve miles downstream from the Watana damsite. This would be used until completion of a permanent high level bridge. In addition, a connecting road from the George Parks Highway to Devil Canyon, with a major high level bridge across the Susitna River, is necessary to provide full road access to either site. The topography from Devil Canyon to Watana is mountainous and the route involves the most difficult construction of the three plans, requiring a number of sidehill cuts and the construction of two major bridges. To provide initial access to the Watana damsite, this route presents the most difficult construction problems of the three routes, and has the highest potential for schedule delays and related cost increases.

(c) Plan 18 "Denali-North" (see Figure E.10.2.4) (o)

This route originates at a railhead in Cantwell, and then follows the existing Denali Highway to a point 21 miles east of the junction of the George Parks and Denali highways. A new road would be constructed from this point due south to the Watana damsite. The majority of the new road would traverse relatively flat terrain which would allow construction using side borrow techniques, resulting in a minimum of disturbance to areas away from the alignment. This is the most easily constructed route for initial access to the Watana site. Access to the Devil Canyon development would consist primarily of a railroad extension from the existing Alaska Railroad at Gold Creek to a railhead facility adjacent to the Devil Canyon camp area. To provide access to the Watana damsite and the existing highway system, a connecting road would be constructed from the Devil Canyon railhead following a northerly loop to the Watana damsite. Access to the north side of the Susitna River would be attained via a high level suspension bridge constructed approximately one mile downstream from the Devil Canyon dam. In general, the alignment crosses terrain with gentle to moderate slopes which would allow roadbed construction without deep cuts.

2.3.6 - Comparison of the Selected Alternative Plans (*)

To determine which of the three access plans best accommodated both project related goals and the concerns of the resource agencies, Native organizations, and affected communities, the plans were subjected to a multi-disciplinary evaluation and comparison. Among the issues addressed in this evaluation and comparison were:

- Costs;
- Schedule;
- Environmental issues;
- Cultural resources;
- Socioeconomics/Community preferences;
- Preferences of Native organizations;
- Relationship to current land stewardships, uses and plans; and
- Recreation.

(a) Costs (**)

The relative cost of the three access alternatives is presented below. This outlines the total costs of the three plans with the schedule constraint that initial access must be completed within one construction season of receipt of the FERC license. Costs to complete the access requirement for the Watana development only are also shown. The costs of the three alternative plans can be summarized as follows:

Estimated Total Cost ($ x 10^6)

Plan	Watana	Devil Canyon	Total	Discounted Total
North (13)	241	127	368	287
South (16)	312	104	416	335
Denali-North (18)	224	213	437	326

The costs are in terms of 1982 dollars and include all costs associated with design, construction, maintenance, and logistics. Discounted total costs (present worth as of 1982) have been shown here for comparison purposes to delineate the differences in timing of expenditure.

For the initial development of access to the Watana site, the Denali-North Plan has the least cost and the lowest probability of increased costs resulting from unforeseen conditions. The North Plan is ranked second. The North Plan has the lowest overall cost while the Denali-North has the highest. However, a large portion of the cost of the Denali- North Plan would be incurred more than a decade in the future. When converting costs to equivalent present value, the overall costs of the Denali-North and the South plans are similar.

(b) Schedule (*)

The schedule for providing initial access to the Watana site was given prime consideration since the cost ramifications of a schedule delay are highly significant. The elimination of pre- license construction of a pioneer access road has resulted in the severe compression of on-site construction activities during the initial construction seasons. With the present overall project scheduling, should diversion not be completed prior to spring runoff in the fourth year of construction, dam foundation preparation work would be delayed one year, and hence cause a delay to the overall project of one year. It has been estimated that the resultant increase in cost would likely be in the range of 100-200 million dollars. The access route that assures the quickest completion and hence the earliest delivery of equipment and materials to the site has a distinct advantage. The forecasted construction period for initial access, including mobilization, for the three plans are:

Denali-North	6 months
North	9 months
South	12 months

It is evident that with the Denali-North Plan, site activities can be supported at an earlier date than by either of the other routes. Consequently, the Denali-North Plan offers the highest probability of meeting schedules and hence the least risk of project delay and increase in cost.

(c) Environmental Issues (o)

Environmental issues have played a major role in access planning to date. The main issue is that a road will permit human entry into an area which is relatively inaccessible at present, causing both direct and indirect impacts. A summary of these key impacts with regard to wildlife, wildlife habitat, and fisheries for each of the three alternative access plans is outlined below.

(d) Wildlife and Habitat (o)

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

(i) Hurricane to Devil Canyon (o)

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.

(ii) Gold Creek to Devil Canyon (o)

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.

(iii) 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. However, it crosses the Devil and Tsusena Creek drainages which are important moose and brown bear habitat.

(iv) 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 Creek. Prairie Creek supports a very high seasonal concentration of brown bears and the lower Tsusena Creek area supports concentrations of moose and black bears. The Stephan Lake area also supports relatively high densities of moose and bears. In addition to habitat loss or alteration and increased hunting, significant human-bear conflicts would probably result from access development in this segment.

(v) Denali Highway to Watana (o)

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 important brown bear habitat and browse for moose. This segment crosses a peripheral portion of the range of the Nelchina caribou herd which is occupied by a subherd that uses the area year-round including during calving. 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 wildlife habitat segments:

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

The North plan has the least potential for creating adverse impacts to wildlife and habitat, since 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 seasonally 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.

(e) Fisheries (o)

All three alternative routes would have direct and indirect impacts on the fisheries. Direct impacts include the effects 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.

(i) Hurricane to Devil Canyon (o)

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.

(ii) Gold Creek to Devil Canyon (*)

This segment would cross six streams and is expected to have minimal direct and indirect impacts. Anadromous fish spawning is limited to the lower reaches of Jack Long Creek, the tributary to Slough 21 at road corridor mile 43.3, Waterfall Creek, and Gold Creek (ADF&G 1984c). 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.

(iii) Devil Canyon to Watana (North Side, North Plan) (o)

This segment crosses 20 streams and laterally transits four rivers for a total distance of approximately 12 miles. Seven miles of this lateral transit parallels Portage Creek, which is an important salmon spawning area.

(iv) Devil Canyon to Watana (North Side, Denali-North Plan) (o)

The difference between this segment and Segment iii described above is that it avoids Portage Creek by traversing through a pass 4 miles to the east. The number of streams crossed is consequently reduced to 12, and the number of lateral transits is reduced to two, with a total distance of 4 miles.

(v) Devil Canyon to Watana (South Side) (o)

The portion between the Susitna River crossing and Devil Canyon requires nine stream 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 cuts into banks of greater than 30 degrees occur in this segment.

(vi) Denali Highway to Watana (o)

The segment from the Denali Highway to the Watana damsite has 22 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 10 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.

(vii) Denali Highway (o)

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 11 streams and laterally transits two rivers for a total distance of 5 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 fisheries 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 both direct and indirect impacts on grayling fisheries given the number of stream crossings, lateral transits, and watersheds 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 may 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. Direct impacts may occur along Portage Creek due to temporary water quality impacts through increased erosion; temporary indirect impacts, such as increased angling pressure, could also occur.

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 sites and the design of bridges and culverts for the proposed access plan together with mitigation recommendations are discussed in Chapter 3 of Exhibit E.

(f) Cultural Resources (**)

A preliminary evaluation of the relative cultural resources sensitivity of the three access plans was made. This consisted of a review of relevant literature and information on previously recorded sites in the general area, and a flyover of the three routes by archeologists. Random ground checks were made during the course of the latter. The Denali-North plan, because of its greater overall length and its location parallel to Deadman Creek is believed to have the greatest potential for impacting archeological sites. The South Plan, although it traverses less archeologically sensitive terrain than the North Plan, by virtue of its greater length is believed to have a greater potential for impacting acheological resources than the latter plan. The ranking from the least to the highest with regard to cultural resources impacts is therefore South, North, and Denali-North.

Impacts to archeological sites can to be adequately mitigated by avoidance or data recovery, consequently, this issue is not critical to the selection process. It should be noted, however, the less forested nature of the terrain along the Denali-North, and portions of the North Plan would allow for more efficient identification of cultural resources in these areas than along the more forested South Route during pre-construction surveys.

(g) Socioeconomics (*)

Socioeconomic impacts on the Mat-Su Borough as a whole would be similar in magnitude for all three plans. However, each of the three plans affects future socioeconomic conditions in differing degrees in certain areas and communities. The important differences affecting specific communities are outlined below.

(i) Cantwell (o)

The Denali-North Plan would create substantial increases in population, local employment, business activity, housing and traffic. These impacts result because a railhead facility would be located at Cantwell and because Cantwell would be the nearest community to the Watana damsite. Both the North and South Plans would impact Cantwell to a far lesser extent.

(ii) Hurricane (*)

The North Plan would substantially affect the Hurricane area, since currently there is little population, employment, business activity or housing. Socioeconomic impacts for Hurricane would be less under the South Plan and considerably less under the Denali-North Plan because they avoid the area.

(iii) Trapper Creek and Talkeetna(o)

Trapper Creek would experience slightly larger changes in economic indicators with the North Plan than under the South or Denali-North Plans. The South Plan would impact the Talkeetna area slightly more than the other two plans.

(iv) Gold Creek (*)

With the South Plan, a railhead facility would be developed at Gold Creek creating significant socioeconomic impacts in this area. The Denali-North Plan includes construction of a railhead facility at the Devil Canyon site which would create impacts at Gold Creek, but not to the same extent as the South Plan. Minimal impacts would result in Gold Creek under the North Plan.

(h) Preferences of Native Organizations (o)

Cook Inlet Region Inc. (CIRI) has selected lands surrounding the impoundment areas and south of the Susitna River between the damsites. CIRI has officially expressed a preference for a plan providing road access from the George Parks Highway to both damsites along the south side of the Susitna River. The Tyonek Native Corporation and the CIRI village residents have indicated a similar preference. The South Plan provides full road access to their lands south of the

Sutina River and thus comes closest to meeting these desires. The Ahtna Native Region Corporation presently owns land bordering the Denali Highway and they, together with the Cantwell Village Corporation, have expressed a preference for the Denali-North Plan. None of the Native organizations support the North Plan.

(i) Relationship to Current Land Stewardships, Uses and Plans(*)

Much of land required for project development has been or may be conveyed to Native organizations pursuant to the terms of the Alaska Statehood Act and/or the Alaska Native Claims Settlement Act. The remaining lands are generally under state and federal control. The South Plan traverses more Native-selected lands than either of the other two routes, and the Native organizations have expressed an interest in potentially developing their lands for mining, recreation, forestry, or residential use.

The other land management plans that have a bearing on access development are the Bureau of Land Management's (BLM) decision to open the Denali Planning Block to mineral exploration, and the Susitna Area Plan. In general, none of the plans would be in major conflict with any present federal, borough, or Native management plans.

(j) Recreation (o)

Following meetings, discussions, and evaluation of various access plans, it became evident that recreation plans are flexible enough to adapt to any of the three selected access routes. No one route was identified which had superior recreational potential associated with it. Therefore, compatibility with recreational aspects was essentially eliminated as an evaluation criterion.

2.3.7 - Summary of Final Selection of Plans (o)

In reaching the decision as to which of the three alternative access plans was to be recommended, it was necessary to evaluate the highly complex interplay that exists between the many issues involved. Analysis of the key issues described in the preceeding pages indicates that no one plan satisfied all the selection criteria nor accommodated all the concerns of the resource agencies, Native organizations and public. Therefore, it was necessary to make a rational assessment of tradeoffs between the sometimes conflicting environmental concerns of impacts on fisheries, wildlife, socioeconomics, land use, and recreational opportunities on the one hand, with project cost, schedule, construction risk and management needs on the other.

With all these factors in mind, it should be emphasized that the primary purpose of access is to provide and maintain an uninterrupted flow of materials and personnel to the damsite throughout the life of the project. Should this fundamental objective not be achieved, significant schedule and budget overruns will occur.

(a) Elimination of "South Plan" (o)

The South route, Plan 16, was eliminated primarily because of the construction difficulties associated with building a major low level crossing 12 miles downstream from the Watana damsite. This crossing would consist of a floating or fixed temporary bridge which would need to be removed prior to spring breakup during the first three years of the project (the time estimated for completion of the permanent bridge). This would result in a serious interruption in the flow of materials to the site. Another drawback is that floating bridges require continual maintenance and are generally subject to more weight and dimensional limitations than permanent structures.

A further limitation of this route is that, for the first three years of the project, all construction work must be supported solely from the railhead facility at Gold Creek.

This problem arises because it will take an estimated three years to complete construction of the connecting road across the Susitna River at Devil Canyon to Hurricane on the George Parks Highway. Limited access such as this does not provide the flexibility needed by the project management to meet contingencies and control costs and schedule.

Delays in the supply of materials to the damsite, caused by either an interruption of service of the railway system or the Susitna River not being passable during spring breakup, could result in significant cost impacts. These factors, together with the realization that the South Plan offers no specific advantages over the other two plans in any of the areas of environmental concern, led to the South Plan being eliminated from further consideration.

(b) Schedule Constraints (o)

The choice of an access plan thus narrowed down to the North and Denali-North Plans. Of the many issues addressed during the evaluation process, the issue of "schedule" and "schedule risk" was determined as being the most important in the final selection of the recommended plan.

Schedule plays such an important role in the evaluation process because of the special set of conditions that exist in a subarctic environment. Building roads in these regions involves the consideration of many factors not found elsewhere in other environments. Specifically, the chief concern is one of weather and the consequent short duration of the construction season. The roads for both the North and Denali-North plans will, for the most part, be constructed at elevations in excess of 3,000 feet. At these elevations, the likely time available for uninterrupted construction in a typical year is 5 months, and at most 6 months.

The forecasted construction period, for initial access including mobilization, is 6 months for the Denali-North and 9 months for the North. At first glance, a difference in schedule of 3 months does not seem great; however, when considering that only 6 months of the year are available for construction, the additional 3 months become highly significant, especially when read in the context of the uncertainty regarding the schedule for issuance of the FERC license.

The risk of delays in the project increase:

- The later in the year the FERC license is issued; and
- The longer the schedule required for construction of initial access.

If diversion is not achieved prior to spring runoff in 1991, dam foundation preparation work will be delayed one year, and hence, cause a delay to the overall project of one year.

(c) Cost Impacts (o)

The increase in costs resulting from a one year delay have been estimated to be in the range of 100-200 million dollars. This increase includes the financial cost of investment by spring of 1991, the financial costs of rescheduling work for a one year delay, and replacement power costs.

(d) Conclusion (o)

The Denali-North Plan has the highest probability of meeting schedule and least risk of increase in project cost for two reasons. First, it has the shortest construction schedule (six months). Second, a possible route could be constructed even under winter condition, owing to the relative flat terrain along its length. In contrast, the North route is mountainous and involves extensive sidehill cutting, especially in the Portage Creek area. Winter construction along sections such as this would present major problems and increase the probability of schedule delay.

2.3.8 - Modifications to Recommended Access Plan (*)

Following approval of the recommended plan by the Alaska Power Authority Board of Directors in September 1982, further studies were conducted to optimize the route location, both in terms of cost and minimizing impacts to the environment. Each of the specialist subconsultants was asked to review the proposed plan to identify specific problem areas, develop modifications and improvements, and contribute to drawing up a set of general guidelines for access development. The results of this review are capsulized below:

- An important red fox denning area and a bald eagle nest were identified close to the proposed road alignment. Consequently the road was realigned to create a buffer zone of at least one half mile between the road and the sites.

- Portions of the access road between the Denali Highway and the Watana damsite will traverse flat terrain. In these areas, a berm type cross section will be formed with the crown of the road being 2 to 3 feet above the elevation of adjacent ground. Steep side slopes would present an unnatural barrier to migrating caribou, exaggerate the visual impact of the road itself, and aggravate the problem of snow removal. To reduce these problems, the side slopes will be flattened using excavated peat material and rehabilitated through scarification and fertilization.

- The chief fisheries concern was the proximity of the proposed route to Deadman Creek, Deadman Lake, and Big Lake. For a distance of approximately 16 miles the road parallels Deadman Creek, which contains good to excellent grayling populations. To alleviate the problem of potential increased angling pressure, the road was moved one half to one mile west of Deadman Creek. The road was moved even further to the west of Deadman and Big Lakes, which contain both grayling and lake trout, for the same reason.

- The preliminary, reconniassance level cultural resource survey conducted on the proposed access route located and documented 24 sites on or in close proximity to the right-of-way and/or potential borrow sites. The number of these sites that will be directly or indirectly affected will not be known until a more detailed investigation is completed. However, indications are that all sites can be mitigated by avoidance, protection, or salvage.

- The community that will undergo the most growth and socio economic change with the proposed access plan is Cantwell. Subsequent to the selection of this access plan, the residents of Cantwell were solicited for their comments and suggestions. Their responses resulted in the following modifications and recommendations:

- The plan was modified to include paving the road from the railhead facility to four miles east of the junction of the George Parks and Denali Highways. This will eliminate any problem with dust and flying stones in the residential district.

  For safety reasons, it is recommended that:

  Speed restrictions be imposed along the above segment;

  A bike path be provided along the same segment because of the proximity of the local school; and

  Improvements be made to the intersection of the George Parks and Denali Highways including pavement markings and traffic signals.

- The main concern of the Native organizations represented by CIRI is to ensure that access route development for the project will also provide the natives a new opportunity to gain access to their land south of the Susitna River which is presently inaccessible. Under the proposed access plan, these lands will be accessible by both road and rail, the railroad being from Gold Creek to the Devil Canyon damsite on the south side of the Susitna River. After completion of the Watana dam, road access will be provided across the top of the dam to Native lands. Similarly, a road across the top of the Devil Canyon dam will be constructed once the main works at Devil Canyon are completed. In addition, alternative road access will be available via the high level suspension bridge one mile downstream from the Devil Canyon dam.

- From an environmental standpoint, it is desirable to limit the number of people in the project area in order to minimize impacts to wildlife habitat and fisheries. An unpaved road with limited access would reduce these impacts and serve to maintain as much as possible the undeveloped character of the area. An evaluation of projected traffic volumes and loadings confirmed that an unpaved gravel road with a 24 ft running surface and 5 ft wide shoulder would be adequate.

- For the efficient, economical, and safe movement of supplies, the following design parameters were chosen:

Maximum grade	6 percent
Maximum curvature	5 degrees
Design loading:	
during construction	80^k axle, 200^k total
after construction	HS-20

2.4 - Transmission Alternatives (o)

2.4.1 - Corridor Selection Methodology (o)

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 has resulted in a corridor and route for the Susitna transmission lines between Willow and Healy. Three areas have been studied for additional Susitna 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 for economic, technical, and environmental considerations discussed in Exhibit B, Section 2.7.2, 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 2.7.3 and below). This screening process resulted in one corridor in each area being designated as the recommended corridor for the transmission line. The environmental selection and screening processes are described below.

2.4.2 - Environmental Selection Criteria (o)

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	Parallel where

	Right-of-Way	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.

2.4.3 - Identification of Corridors (o)

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

- o The southern Study area between Willow and Anchorage (to carry Susitna power into Anchorage);
- o The central study area between Watana, Devil Canyon, and the Intertie (to carry Susitna power to the Intertie right-of-way); and
- o The northern study area between Healy and Fairbanks (to carry Susitna power into Fairbanks).

Twenty-two corridors were selected and are shown in Figures E.10.2.5, E.10.2.6, and E.10.2.7.

2.4.4 - Environmental Screening Criteria (o)

Because of the potential 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:

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

Also of significance in the evaluation process are:

- o Length;
- o Topography;
- o Soils;
- o Cultural Resources;
- o Vegetation;
- o Fishery Resources; and
- o Wildlife Resources.

(a) Primary Aspects (o)

(i) Aesthetic and Visual (o)

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.

(ii) Land Use (o)

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 (o)

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 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 (o)

  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 since 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 (o)

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

(b) Secondary Aspects (o)

(i) Length (o)

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.

(ii) Topography (o)

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. Therefore, when planning corridors the identification of changes in relief is an important factor.

(iii) Soils (o)

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.

(iv) Cultural Resources (o)

The avoidance of known or potential sites of cultural resources is an important component of the routing of transmission lines. A cultural resources reconnaissance survey has been conducted along a large portion of the transmission corridors. In those areas where no information has been collected to date, an appropriate program for identifying and mitigating impacts will be conducted. This program is discussed in more detail in Chapter 4 of Exhibit E.

(v) Vegetation (o)

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.

(vi) 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.

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.

(vii) Wildlife Resources (*)

The three major groups of wildlife which must be considered in transmission corridor selection 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.

2.4.5 - Environmental Screening Methodology (o)

In order to compare the alternative corridors from an environmental standpoint, the environmental criteria discussed above were combined into environmental constraint tables (Tables E.10.2.2, E.10.2.3, and E.10.2.4). 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."

The data base used for this analysis was obtained from:

- Existing aerial photos;
- U. S. geological survey maps;
- Land status maps;
- The report entitled, "Hydroelectric Power and Related Purposes: Southcentral Railbelt Area, Alaska, Upper Susitna River Basin, Interim Feasibility Report," prepared in 1975 by the U. S. Army Corps of Engineers;
- The report entitled, "Anchorage-Fairbanks Transmission Intertie, Economic Feasibility Report," prepared in 1979 by

International Engineering Company and Robert W. Retherford Associates; and

- o Aerial and ground reconnaissance of the potential corridor.

These constraint tables were prepared in 1981-82, at which time the routing of the proposed access road was undecided. Thus, numerous corridors refer to being near a proposed access road. Once the access road decision was reached in August 1982, these corridors in the Central Study area were re-evaluated in light of the common corridor concept for both access and transmission. This re-evaluation is discussed in Section 2.4.10 below.

2.4.6 - Screening Results (o)

Table E.10.2.5 summarizes the comparisons of the 22 corridors studied in the southern, central, and northern study areas, prior to the selection of the access road. 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 might 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.

(a) Southern Study Area (o)

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.

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

- Technical and Economical (o)

This 73-mile corridor is the longest of the three being considered for the southern area, and provides an alternative to the submarine cable crossings of Knik Arm that are inherent in the other two southern corridors. 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.

- Environmental (*)

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

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.

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 five 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

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

- Technical and Economical (o)

Corridor ADFC crosses the smallest number of rivers and roads in the southern study area, but would require a submarine cable crossing of Knik Arm. 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 (o)

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

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

- Technical and Economical (o)

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 (o)

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 aesthetics 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

(b) Central Study Area (o)

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 economic ratings of F. These corridors, numbers Four (ABCJHI), Five (ABEGJHI), 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 4000 feet in elevation.

The eight 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.

(i) Corridors Technically and/or Economically Unacceptable (o)

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

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 4000 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, sheep, 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 (o)

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 swan migration 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 (o)

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, sheep, and brown bear, 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	F	F	F

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

The primary environmental constraints associated with this corridor 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

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

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 floatplanes, 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

- Corridor Nine (CEBAG) - Devil Canyon to Intertie via Stephan Lake and Denali Highway (o)

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, which is utilized for recreational purposes, and any line constructed in this area would be visible when looking towards the Alaska range. Although one of the proposed access roads to the damsites is located 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

- Corridor Ten (CJAG) - Devil Canyon to Intertie via North Shore, Susitna River, and Denali Highway (o)

  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

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

  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

(ii) Corridors Technically and Economically Acceptable (o)

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

  - Technical and Economical (o)

    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 (o)

    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. 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

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

  . Technical and Economical (o)

  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 would rise to a maximum ele vation of 3,600 feet, and cross 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 (o)

  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 9 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 a 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 (o)

  . Technical and Economical (o)

  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 (o)

  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. However, conflicts with recreation near Otter Lake cana be resolved through careful selection of the final right-of-way. 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

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

  . Technical and Economical (o)

  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 (o)

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

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

. Technical and Economical (o)

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 (o)

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 the final right-of-way.

Ratings:

Technical	Economical	Environmental	Summary
A	C	A	A

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

. Technical and Economical (o)

This corridor is also one of the shortest among the 15 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.

. Environmental (o)

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

- Corridor Fifteen (AFECF) - Watana to Devil Canyon via Stephan Lake, Devil Canyon to Intertie via North Shore, Susitna River (o)

. Technical and Economical (o)

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.

. Environmental (o)

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

(c) Northern Study Area (o)

Constraints appeared in the routing of all 4 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 is suspected. Additional constraints specific to the four separate corridors are presented below.

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

- Technical and Economical (o)

This corridor crosses the fewest water courses in the northern study area. Although it is approximately 4 miles longer than Corridor Two, it is technically favored because of the existence of potential access roads for almost the entire length.

- Environmental (o)

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 absorption capability, or in areas recommended to be opened to long-distance views.

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

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

- Technical and Economical (o)

This 86-mile corridor is the shortest 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 (o)

Corridor Two is the shortest under consideration in the northern study area. Since 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 five 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

(iii) Corridor Three (AEDC) - Healy to Fairbanks via Healy Creek and Japan Hills (o)

- Technical and Economical (o)

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 being technically unacceptable for reasons discussed above.

- Environmental (o)

This corridor crosses a high mountain pass and, in some locations, encounters bedrock overlain 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 three 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 being environmentally unacceptable.

Ratings:

Technical	Economical	Environmental	Summary
F	C	F	F

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

- Technical and Economical (o)

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 (o)

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.

Ratings:

Technical	Economical	Environmental	Summary
F	C	F	F

2.4.7 - Proposed Corridor (o)

Therefore, the recommended corridor for the Susitna project at this point in the analyses consisted of the following segments:

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

These appear in Figures E.10.2.5, E.10.2.6, and E.10.2.7.

2.4.8 - Route Selection Methodology (o)

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:

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

2.4.9 - Environmental Route Selection Criteria (o)

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:

- o Satisfaction of the regulatory and permit requirements;
- o Selection of routing that provides for minimum visibility from highways and homes; and
- o 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 meets the engineering and economic objectives. The environmental analysis was conducted by the process described below:

(a) Literature Review (o)

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.

(b) Avoidance Routing by Constraint Analysis (o)

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 proposed 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.

(c) Base Maps and Overlays (o)

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 Acres/TES 1982.

2.4.10 - Re-Evaluation Following Access Road Decision (o)

In September 1982, the Alaska Power Authority Board of Directors selected the Denali-North Plan as the proposed access route for the Susitna development. The location of existing and proposed access is of prime importance both from an economic and environmental standpoint. Therefore, subsequent to the access decision, each of the four corridors within the Central Study Area was subjected to a more detailed evaluation and comparison.

Within these corridors, a number of alternative routings were developed and the route in each corridor which was found to best meet the selection criteria was retained for further analysis. The four corridors are comprised of the following route segments:

- o Corridor One ABCD
- o Corridor Three AJCF
- o Corridor Thirteen ABCF
- o Corridor Fourteen AJCD

It is evident that there are two acceptable segments (segments ABC and AJC), to link Watana and Devil Canyon; and similarly, two segments (segments CD and CF) to link Devil Canyon with the Intertie. On closer examination of the possible routes between Devil Canyon and the Intertie, the route in segment CD was found to be superior to the route in segment CF for the following reasons.

(a) Economic (o)

A four-wheel drive trail is already in existence on the south side of the Susitna River between Gold Creek and the proposed location of the railhead facility at Devil Canyon. Therefore, the need for new roads along segment CD, both for construction and operation and maintenance, is significantly less than for segment CF, which requires the construction of a pioneer road. In addition, the proposed Gold Creek to Devil Canyon railroad extension will also run parallel to segment CD.

Another primary economic aspect considered was the length of the corridors. However, since the lengths of segments CD and CF are 8.8 miles and 8.7 miles, respectively, this was not a significant factor.

One of the secondary economic considerations is that of topography. Segment CF crosses more rugged terrain at a higher elevation than segment CD and would therefore prove more difficult and costly to construct and maintain. Hence, segment CD was considered to have a higher overall economic rating.

(b) Technical (o)

Although both segments are routed below 3,000 feet in elevation, segment CF is slightly more difficult since it crosses more rugged, exposed terrain with a maximum elevation of 2,600 feet. Segment CD, on the other hand, traverses generally flatter terrain and has a maximum elevation of 1,800 feet. The disadvantages of segment CF are somewhat offset, however, by the Susitna River crossing that will be needed at river mile 150 for segment CD. Overall, the technical difficulties associated with the two segments are regarded as being similar.

(c) <u>Environmental</u> (o)

One of the main concerns of the various environmental groups and agencies is to keep any form of access away from sensitive ecological areas previously inaccessible except by foot. Creating a pioneer road to construct and maintain a transmission line along segment CF would open that area up to all-terrain vehicle and public use and thereby increase the potential for adverse impacts to the environment. The potential for environmental impacts along segment CD would be present regardless of whether or not the transmission line was built since there is an existing four-wheel drive trail, together with the proposed railroad extension in that area. It is clearly desirable to restrict environmental impacts to a single common corridor and for that reason, segment CD is preferable to segment CF from an environmental standpoint.

Largely because of the potential environmental impacts, but also because of the technical and economic ratings, segment CF was dropped in favor of segment CD. Consequently, corridors three (AJCF) and thirteen (ABCF) were eliminated from further consideration.

The two corridors remaining are, therefore, corridors one (ABCD) and fourteen (AJCD). More specifically, this reduces comparison of alternative routes to segment ABC on the south side of the Susitna River and segment AJC on the north side. These routes were then screened in accordance with the criteria set out in section (c) Corridor Screening to determine the recommended route. The economic, technical, and environmental aspects of this evaluation are outlined below.

(d) <u>Economic</u> (o)

For the Watana development, two 345-kv transmission lines need to be constructed from Watana through to the Intertie. When comparing the relative lengths of transmission line, it was found that the southern route utilizing segment ABC was 33.6 miles in total length compared to 36.4 miles for the northern route using segment AJC. Although at first glance a difference in length of 2.8 miles (equivalent to 12 towers at a spacing of 1,200 feet, seems significant, other factors have to be taken into account. Segment ABC contains mostly woodland, black spruce in segment AB. Segment BC contains open and woodland spruce forests, low shrub, and open and closed mixed forest in about equal amounts. Segment AJC, on the other hand, contains significantly less vegetation and is composed predominantly of low shrub and tundra in segment AJ and tall shrub, low shrub, and open mixed forest in segment JC. Consequently, the amount of clearing associated with segment AJC is considerably less than with segment ABC, resulting in savings not only during construction but also during periodic recutting. Also, additional costs would be incurred with segment ABC due to the increased spans needed to cross the Susitna River (at river mile 165.3) and two other major creek crossings. In summary, the cost differential between the two routes would probably be marginal.

(e) Technical (o)

Segment AJC traverses generally moderately, sloping terrain ranging in height from 2,000 feet to 3,500 feet with 9 miles of the route being at an elevation in excess of 3,000 feet. Segment ABC traverses more rugged terrain, crossing several deep ravines and ranges in height from 1,800 feet to 2,800 feet. In general, there are advantages of reliability and cost associated with transmission lines routed under 3,000 feet. The nine miles of segment AJC at elevations in excess of 3,000 feet will be subject to more severe wind and ice loadings than segment ABC and the towers will have to be strengthened accordingly. However, these additional costs will be offset by the complexity of towers needed to accommodate the more rugged topography and major river and creek crossings of segment ABC. The technical difficulties associated with the two segments are therefore considered similar.

(f) Environmental (o)

From the previous analysis, it is evident that there are no significant differences between the two routes in terms of technical difficulty and economics. The deciding factor, therefore, is the environmental impact. The access road routing between Watana and Devil Canyon was selected because it has the least potential for creating adverse impacts to wildlife, wildlife habitat, and fisheries. Similarly, segment AJC, which parallels the proposed access road, is environmentally less sensitive than segment ABC for it traverses or approaches fewer areas of productive habitat and zones of species concentration or movement. The most important consideration, however, is that, for ground access during operation and maintenance, it will be necessary to have some form of trail along the transmission line route. This trail would permit human entry into an area which is relatively inaccessible at present causing both direct and indirect impacts. By placing the transmission line and access road within the same general corridor as in segment AJC, impacts will be confined to that one corridor. If access and transmission are placed in separate corridors, as in segment ABC, environmental impacts would be far greater.

Segment AJC is thus considered superior to segment ABC. Consequently, corridor one, (ABCD) was eliminated and corridor fourteen (AJCD) selected as the proposed route.

2.4.11 - Conclusions (o)

Thus, the recommended corridors for the Susitna project consist of: Southern study area, Corridor ADFC; Central study area, Corridor AJCD, and Northern study area, Corridor ABC.

The proposed transmission line route is presented in Exhibit G. The marked route represents the centerline of a 300-foot right-of-way which is sufficient for two single-circuit, parallel lines. Between Devil Canyon and the Intertie, the right-of-way is 510 feet to accommodate four single-circuit lines.

2.5 - Borrow Site Alternatives (**)

2.5.1 - Watana Borrow Sites (**)

A total of seven potential borrow sites and three potential quarry sites have been identified for dam construction material (A, B, C, D, E, F, H, I, J, and L) (Figure E.10.2.8). Of these, Borrow Sites D and H are considered potential sources of impervious material; Sites C, E,F, I and J for granular material; and Quarry Sites A, B, and L for rockfill. Additional subsurface exploration programs would be required during the design phase of the project to verify material availability and quantity.

Several of these sites (B, C, and F) previously identified by the Corp of Engineers (USCOE) 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) of 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 considered to be 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 described according to the following characteristics:

- o Proposed use of the material and why the site was selected;
- o Location and geology, including topography, geomorphology, vegetation, climatic data, ground water, permafrost, and stratigraphy;
- o Reserves, lithology, and zonation;
- o Engineering properties which include laboratory test results; and
- o Environmental information.

Laboratory test results on samples from the borrow sites are shown in Appendix F of the Susitna Hydroelectric Project 1980-1981 Geotechnical Report (Acres 1982a).

(a) Quarry Site A (*)

(i) 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 rockfill during Stage III construction.

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

(ii) Location and Geology (*)

The boundaries of Quarry Site A include the bedrock "knob" from approximate Elevation 2,300 feet to about 2,600 feet. The knob covers an area of 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 zero to several feet over the site. Vegetation is primarily limited to spruce, dwarf birch, and ericaceous shrubs, with limited alder growth in the lower areas. Surface water is evident only in isolated deeper swales. The ground water table is expected to be deep in this area with an estimated average depth from 50 to 100 feet. It is likely that the ground water 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 rapidly thaw. 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.

(iii) 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 2,300 feet, the estimated volume of sheared or weathered rock is 23 million cubic yards (mcy). The estimated volume of good quality rock is 71 mcy. A field drilling program during the design phase of the project would be necessary to verify these estimated quantities and rock quality.

Additional rockfill, if required, can be obtained by deepening the quarry to near the proposed dam crest elevation of 2,210 feet without adversely affecting the dam foundation or integrity of the reservoir.

(iv) Engineering Properties (*)

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

The rock is expected to make excellent embankment rockfill.

(v) Environmental (*)

This area is covered primarily with black spruce and shrubland, except on the central portion, which is mat and cushion tundra. It has a low sensitivity to environmental disturbance and does not provide important habitat.

(b) Quarry Site B (*)

(i) Proposed Use (*)

Quarry Site B was identified in previous investigations as a potential source of rock materials for dam construction. The area was identified based on outcrops exposed between Elevations 1,700 and 2,000 feet along the Susitna River and Deadman Creek. During the 1980-81 field season, mapping and additional seismic refraction surveys were performed in this area.

(ii) Location and Geology (*)

Quarry Site B is located about 2 miles upstream from the damsite between elevations of 1,700 and 2,000 feet. 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. It is therefore not being considered as a primary quarry site.

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.

(iii) Reserves (o)

Because of the deep overburden, generally poor rock quality, and 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.

(iv) Engineering Properties (o)

No material property testing was performed for this area.

(v) Environmental (o)

This area is small, adjacent to other construction areas, and primarily within the proposed reservoir. As such, additional environmental disturbances will not be great.

(c) Borrow Site C (*)

(i) 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, and the site is not being considered as a primary material source.

(ii) Location and Geology (*)

Borrow Site C, as delineated by the USCOE, extends from a point approximately 4.5 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 ground water table is assumed to be a subdued replica of the topography, being shallow on the valley walls with gradients towards the valley floor. Ground water 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.

(iii) 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 and subsurface investigations will be required to determine the volumes.

(iv) Engineering Properties (o)

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.

(v) Environmental (**)

The site distance from Watana Dam would require construction of a haul road with associated impacts. The area also contains valuable riparian habitats for moose, black bear, and furbearers, and the potential exists for degradation of Tsusena Creek. The site is also partially within a fall concentration area for moose and entirely within a late spring concentration area for brown bears. There are also nine known archeological sites within the area. These reasons are partially why this area is not considered a primary site.

(d) Borrow Site D (**)

(i) Proposed Use (**)

Borrow Site D was identified in 1975 as a potential primary source for impervious material by the USCOE. It is anticipated that Borrow Site D will be used during all stages of the project.

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

- Borrow Site D had potentially large quantities of clay;
- The deposit was of adequate volume to provide the estimated quantity of impervious material needed for all three stages of 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 1980-81 study.

(ii) Location and Geology (*)

Borrow Site D lies on a broad plateau immediately northwest of the Watana dam site. The southern edge of the site lies approximately one 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 dam site elevation of 2,150 feet northward to approximate elevation of 2,450 feet.

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.

The vegetation mat is predominantly tundra and sedge grass, averaging about one foot thick with isolated stands of spruce trees on the higher and drier 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 conducive to drifting and blowing snow, frequently resulting in drifts up to 6 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 toward 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.

(iii) Reserves (*)

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. 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 may be available.

(iv) Engineering Properties (o)

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.

(v) Environmental (*)

This area is mixed forest and shrubs. No significant environmental problems are identified.

(e) Borrow Site E (**)

(i) Proposed Use (**)

Borrow Site E was identified by the USCOE as a principal source of concrete aggregate and filter material. 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. Borrow Site E is being considered for use during Stage I and Stage III (Watana) construction.

(ii) Location and Geology (*)

Borrow Site E is located 3 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 1,410 feet near river level to 1,700 feet 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. The vegetation mat averages about one foot thick underlain by up to 4 feet of fine silts and volcanic ash.

The ground water table was found to be in the range of 10 feet deep. Ground water levels fluctuate up to

5 feet from winter to summer, indicating a free draining material.

The hydrologic regime shows summer peak flows in the area reaching approximate Elevation 1,440 feet at the north of Tsusena Creek. This elevation corresponds with the limit of scoured and unvegetated river bank. The estimated 50-year flood level is approximately 1,473 feet.

The underlying bedrock is overlain by a sequence of bouldery till, river and floodplain gravels and sands. The grain size distribution in Site E varies from boulders to sands and gravels. 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 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 borrow site E, probably because the site has a south-facing exposure and because of the thermal effect of the flowing river. Seasonal frost, up to 3 to 6 feet deep, was observed in test pits that encountered ground water (mid-March 1981) and up to at least 13 feet in pits on the northwest side of the site that did not intercept the ground water table. In areas of shallow ground water, the frost was almost exclusively confined to the upper layers. Annual frost penetration may be assumed to be about 3 to 6 feet.

(iii) 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 3 to 4 feet of fine-grained material.

(iv) Engineering Properties (**)

The soils range from coarse sandy gravel through gravelly sand, silty sand, cobbles and boulders, silty sand and silt. 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.

Further detailed investigations in this area will be required to accurately define the location and continuity of stratigraphic units.

(v) Environmental (**)

This area is vegetated primarily with black and white spruce and spruce-birch forests. Except for the area near the mouth of Tsusena Creek, which contains riparian habitats valuable to moose, black bear, and furbearers, it is not an environmentally sensitive area. Chapter 3 of Exhibit E outlines mitigation techniques which will be used to reduce the impacts to the Tsusena Creek area.

(f) Borrow Site F (***)

(i) Proposed Use (**)

Borrow Site F was identified by the USCOE as a potential source of filter material for the dam. Preliminary work performed by the USCOE 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.

(ii) Location and Geology (*)

Borrow Site is located approximately five miles north of the dam in 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. Ground water 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.

(iii) Reserves (*)

Assuming a conservative depth of 20 feet of material, a total volume of approximately 15 to 25 mcy is available. Additional investigation in this area would be required to confirm these volumes.

(iv) Engineering Properties (*)

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

(v) Environmental (***)

Borrow Site F contains riparian habitats and moose winter browse. The site is also partially within a fall concentration area for moose and a late spring concentration area for brown bears. It also contains several known archeological sites. These factors are partially why this area is not considered the preferred site.

(h) Borrow Site H (**)

(i) Proposed Use (**)

Borrow Site H has been defined as an alternative site to Borrow Site D for impervious material. However, Site D has been designated the preferred source because of proximity access, and other reasons included in the following discussion.

(ii) Location and Geology (*)

Borrow site H is located on the south side of the Susitna River, approximately 9 miles downstream from the Watana Dam site. The topography of Borrow Site H is generally rolling, sloping towards the Susitna River. Elevations range from 1,400 feet to 2,400 feet across the site and average about 2,100 feet. Most of the site is covered by swamps and marshes, indicating poor drainage. The vegetation consists of thick tundra, muskeg, alder, and underbrush growth.

Ground water 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 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. Insufficient data exist to allow for detailed stratigraphic correlation across the site.

(iii) Reserves (*)

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, approximately 35 mcy of material is available from this site.

(iv) Engineering Properties (**)

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 as an alternative impervious source. However, problems such as wet swampy conditions, permafrost, the lengthy haul distance to the site, and the fact it is located on the opposite side of the river from the access road affect the potential use of this site.

(v) Environmental (*)

This area is spruce and mixed forests. Raptor nests on cliffs along Fog Creek and known archeological sites exist within the area. These reasons, along with its considerable distance from Watana Dam, contributed to its classification as a non-primary site.

(i) Borrow Sites I and J (**)

(i) Proposed Use (**)

Reconnaissance mapping was performed within a 10 mile radius of the damsite to locate potential sources of free-draining gravels. However, the long haul distances and environmental impacts of excavation has eliminated these sites from further consideration.

(ii) 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 stream 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; Borrow Site I includes extensive terraces extending several hundred feet up the valley walls above river level.

(iii) Reserves (**)

For purposes of volume calculation, it was assumed that all materials with seismic velocity of 6,500 ft/s represented suitable gravel deposits. Materials with velocities higher than 6,500 ft/s 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.

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.

(iv) 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.

(v) Environmental (**)

Borrow sites I and J are fully within the limits of the reservoir. Since these areas will be flooded, no additional impacts were identified. Exploitation of these sites, however, could contribute to increased turbidity and sedimentation in the Susitna River caused by in-stream and river bank borrow excavation operations.

(j) Quarry Site L (**)

(i) Proposed Use (**)

Quarry Site L has been identified as a source of rockfill material. However, all Stage I (Watana) rockfill needs can be satisfied by required excavations. During Stage III construction, Quarry site L will be inundated by the Stage I reservoir. This site, therefore, is not being considered for use.

(ii) 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.

(iii) Reserves (*)

Because of limited bedrock control, Quarry Site L 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 the volume of rock that, with a high degree of confidence, is known to be present. Based on field mapping and airphoto interpretation, the total usable 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.

(iv) Engineering Properties (o)

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.

(v) Environmental (**)

This area is totally within the Stage I pool of the Watana reservoir, and contributed to its consideration as an alternative site for Stage I construction.

2.5.2 - Devil Canyon Borrow Sites (*)

One borrow site and one quarry site were identified for the Devil Canyon study (Figure E.10.2.9). Borrow Site G was investigated as a source for concrete aggregate and filter material, and Quarry Site K for rockfill. Despite detailed reconnaissance mapping around the site, no local source for impervious 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.

(a) Borrow Site G (*)

(i) Proposed Use (*)

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

(ii) 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 alluvial 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 1,000 feet 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 1,100 feet.

Vegetation on the floodplain and fan portions is composed of scattered brush with mixed deciduous trees. 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 feet in thickness and is generally underlain by 1 foot 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 feet.

No ground water 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: 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.

(iii) Reserves (*)

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 alluvium 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, methods, and schedules for excavation.

(iv) 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. 200 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.

(v) Environmental (o)

Since this area is within the Devil Canyon impoundment, there will be no additional impacts.

(b) Quarry Site K (*)

(i) Proposed Use (o)

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.

(ii) Location and Geology (*)

The proposed quarry site is approximately 5,300 feet south of the saddle damsite, at approximate Elevation 1,900 feet. 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 towards Cheechako Creek. The ground water table is 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.

(iii) 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 rockfill is 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 are 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.

(iv) 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 USCOE 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.

(v) Environmental (o)

This area is primarily a cliff site. Only small amounts of material are expected to be needed so impacts should not be great.

3 - OPERATIONAL FLOW REGIME SELECTION (***)

This section describes the process that was used to arrive at an operational flow regime for the Susitna Hydroelectric Project. It includes:

- o Descriptions of the Watana and Devil Canyon reservoirs including the operations of each in meeting project objectives (Section 3.1);
- o The manner of simulating project operation to meet environmental and energy requirements (Section 3.2);
- o The development of the alternative environmental flow requirements including the objectives of each (Sections 3.3. and 3.4);
- o The selection of the Case E-VI flow requirements (Section 3.5);
- o A discussion of other project operating considerations including flow stability, dam safety and emergency situation criteria (Section 3.6); and
- o A summary of the power and energy production for Case E-VI (Sections 3.5 and 3.7).

3.1 - Project Reservoir Characteristics (***)

The Susitna development scheme is as follows:

- o Watana Stage I is the initial project. It provides 2.37 million acre-feet of active storage. This is roughly 40 percent of the mean annual flow at the damsite, and affords some seasonal regulation. All Stage I units will be operational in 1999.
- o Devil Canyon is Stage II. It will be constructed in a narrow canyon with little active storage. Hence, it mainly develops head, relying upon Watana to regulate flows for power production. All Stage II units will be operational in 2005.
- o Stage III involves raising the Watana Dam 180 feet to its ultimate height. The active storage will be 3.7 million acre-feet, about 64 percent of the mean annual flow. Commercial operation of the two additional units will be in 2012.

Storage characteristics of the Watana reservoir will differ depending on whether Stage I or Stage III is operating. Devil Canyon storage characteristics are unchanged throughout its operation period. Area and volume versus elevation curves for both Watana and Devil Canyon reservoirs are shown on Figures E.10.3.1 and E.10.3.2. The following sections briefly describe the reservoir characteristics.

3.1.1 - Watana Stage I (***)

The Watana Stage I Reservoir will have a normal operating level at el. 2,000 ft. At this level, the reservoir will be approximately 39 miles long, with a maximum width on the order of three miles. The total volume and surface area at the normal operating level will be 4.25 million acre-feet and 19,900 acres, respectively. The minimum operating level is at el. 1,850 ft, resulting in a 150-ft maximum drawdown. The active storage is 2.37 million acre-feet.

3.1.2 - Devil Canyon Stage II (***)

The Devil Canyon Reservoir will have a normal maximum operating level at el. 1,455 ft. At this level, the reservoir will be approximately 26 miles long, with a maximum width of approximately one-half mile. The total volume and surface area at the normal operating level will be 1.1 million acre-feet and 7,800 acres, respectively. The minimum operating level is at el. 1,405 ft. resulting in a 50 ft. maximum drawdown. The active storage is 350,000 acre-feet.

3.1.3 - Watana Stage III (***)

The Watana Stage III Reservoir will have a normal operating level at el. 2,185 ft. At this elevation, the reservoir will be approximately 48 miles long, with a maximum width of about five miles. The total volume and surface area at the normal operating level will be 9.5 million acre-feet and 38,000 acres, respectively. The minimum operating level is at el. 2,065 ft. resulting in a 120-ft maximum drawdown. The active storage is 3.7 million acre-feet.

3.2 - Reservoir Operation Modeling (***)

3.2.1 - Reservoir Operation Models (***)

The computer models used to simulate the operation of the reservoirs are: the monthly operation program (Monthly RESOP); and the weekly operation program (Weekly RESOP). The monthly RESOP was originally developed for the Susitna feasibility study and subsequently updated. The weekly RESOP was developed using selected subroutines from the monthly RESOP. The objectives of the reservoir operation study are to determine the operation which maximizes the Susitna Project benefits under the specified constraints and to provide estimated reservoir outflows and water levels for environmental impact analyses.

The time increment used for the simulation affects both the computational effort required and the accuracy of the results obtained. The monthly program is used to provide input to the economic analyses, while the weekly simulation is used for flow regime studies and impact analyses. A weekly time step is used for flow regime studies because the results more precisely show the fluctuation of reservoir outflows and water surface elevations and more accurately define the critical conditions. Weekly simulations also yield more gradual changes in outflow discharges from week to week than will monthly operation. This discussion addresses only the weekly simulation.

The reservoir operation analysis simulates Susitna operation over 34 years of historical streamflow records (January 1950 - December 1983). Key inputs to the model are the reservoir and powerplant characteristics, power demand distribution, and environmental constraints. The RESOP models simulate the reservoir storage, power generation, turbine discharge, outlet works release, and spill as a function of time. The resulting water levels, and releases from turbines, outlet works, and the spillway, are used for evaluation of environmental impacts of flow stability, fishery habitat, flood frequency, temperature, stage fluctuation, and ice conditions in the river downstream.

3.2.2 - Basic Concept and Algorithm of Reservoir Operation (***)

Reservoir operation simulation is basically an accounting procedure which monitors the reservoir inflow, outflow, and storage over time. The storage at the end of each week is equal to the initial storage plus inflow minus outflow within the week. Key constraints on the simulation are the operating guide and the minimum instream flow requirement at Gold Creek which must be satisifed each week. The operating guide governs the release for power, with the total powerhouse release restricted by the discharge required to meet the system power demand. Any additional flow required to meet the downstream flow requirement is released through the outlet works. Flood releases to maintain dam safety requirements are made first through the outlet works and, if the water level exceeds the 50-year flood surcharge level, through the spillway (see Section 3.6.2).

In Stages II and III the reservoir operation method attempts to keep the Devil Canyon Reservoir close to its normal maximum operating level while using Watana's storage to provide the necessary seasonal flow regulation. Therefore, the modeling effort in both the single and double reservoir operation simulation is focused on the Watana operation. The operation level constraints are summarized in Table E.10.3.1.

(a) Watana Stage I (***)

An initial iteration is done for each time step to begin the simulation. In the initial iteration, the powerhouse flow required to meet a minimum target energy for each one week time period is released. The algorithm is explained in detail in Exhibit B, Chapter 3, Section 3.2.

The energy generated by these releases is compared to the system energy demand, in each time step, and adjusted to meet the energy demand in successive iterations by increasing or decreasing the powerhouse discharge.

An operating guide is applied to make the desired Watana powerhouse release in order to optimize project energy generation. The release prescribed by the operating guide depends upon the present release rate, the time of year, and the present water level in the reservoir. The operating guide is developed through a procedure described in Exhibit B, Chapter 3, Section 3.2 and in Section 3.6.1 (a) of this chapter.

A minimum instream flow requirement is prescribed at Gold Creek to ensure that the project will release flows for environmental purposes. The historical intervening flow between Watana and Gold Creek is assumed to be available to supplement the project releases to meet the minimum flow requirement. If the flow prescribed by the operating guide does not meet the environmental requirement, the simulation will attempt to release more water through the powerhouse in order to meet the requirement. If the release required to meet environmental flow requirements exceeds the maximum powerhouse flow to meet energy demands, the difference between the required outflow and the maximum power house discharge is released through the outlet works. This outlet works release is called an environmental release since it is made only to meet the environmental flow requirement and is not used for power generation.

The outlet works capacity at Watana I is 24,000 cfs, while the powerhouse capacity is about 14,000 cfs. In the event that a flood could not be passed through the powerhouse and outlet works, because of energy demand and hydraulic capacity limitations, the reservoir is allowed to surcharge above the normal maximum water surface elevation. This surcharging is done to avoid the use of the spillway for floods less than the 50-year event. A maximum surcharge level of el. 2,014 ft. is permitted before the spillway operates. This surcharge is explained more fully in Section 3.6 of this chapter.

(b) Watana Stage I or Stage III with Devil Canyon Stage II (***)

For simulation of double reservoir operation, the initial iteration for each time step is the same as that for the single reservoir. Devil Canyon operates as run-of-river as long as the reservoir is full. The Devil Canyon Reservoir is to be refilled if the reservoir is not full, so long as the total inflow is greater than the release required to meet the environmental flow requirement. After the initial iteration, the total energy generated at Watana and Devil Canyon is compared to the system energy demand and adjusted in successive iterations by increasing or decreasing powerhouse discharges to meet system energy demands.

An operating guide is again developed and applied to optimize the Watana powerhouse releases for power generation (see Exhibit B, Chapter 3, Section 3.2). Minimum instream flow requirements and constraints on rate of change of discharge are also applied.

The intervening flow between Devil Canyon and Gold Creek is assumed to be available to supplement the project releases to meet the minimum flow requirements. If the environmental flow requirement is not met by powerhouse discharges, more water is released through the Devil Canyon powerhouse in order to meet the requirement and the Devil Canyon Reservoir will draw down. If the increased release through the Devil Canyon powerplant would cause the total energy generation to be greater than the system demand, the release from the Watana powerplant is reduced. As explained in Section 3.6 of this chapter, this is done to minimize Devil Canyon outlet works releases which may result in reduced temperatures downstream.

If the release required to meet environmental flow requirements exceeds the Devil Canyon powerhouse discharge required to meet energy demands, then the difference is released from the Devil Canyon outlet works. In the summer of dry years when the system energy demand is low and the downstream flow requirement is high, Devil Canyon may be drawn down continuously. If the water level at Devil Canyon reaches the minimum operating level of el 1,405 ft, Watana must then release water to satisfy the minimum flow requirement. If the release from Watana for the minimum flow requirement would generate more energy than the required amount, part of the release would be diverted to the Watana outlet works.

The powerhouse hydraulic capacities are about 14,000 cfs at both Watana Stage I and Devil Canyon. The capacity is about 22,000 cfs for Watana Stage III. The outlet works capacity at Devil Canyon is 42,000 cfs while the capacity at Watana is 24,000 cfs in Stage I and 30,000 cfs in Stage III. In the event that a flood could not be passed through the powerhouse and outlet works, because of energy demand and hydraulic capacity limitations, Watana is allowed to surcharge above its normal maximum level. The maximum surcharge level is el. 2,014 ft. for the Watana Stage I Dam and el. 2,193 ft, for the Stage III Dam. This allowable surcharge is more fully explained in Section 3.6 of this chapter.

3.3 - Development of Alternative Environmental Flow Cases (***)

3.3.1 - Background (***)

The February 1983 License Application (APA 1983b pp. B-2-121 through B-2-130) presented ten alternative flow regimes ranging from the regime that would maximize project power and energy benefits (Case A) to a regime that would approximate natural, average, run-of-river conditions (Case G). Seven of the cases (C, C_1, C_2, D, E, F, G) emphasized the use of flow control and planned releases to mitigate potential impacts on downstream aquatic habitats. The major difference among these environmental cases was a gradual, incremental decrease of summer minimum flows from Case G through Case A (APA 1983b Table B54). Emphasis was placed on maintaining higher flows (i.e. smaller incremental decreases) during mid-July to mid-September to mitigate impacts on access conditions into side sloughs for spawning adult salmon (APA 1983c B-2-127 and B-2-128).

Results of numerous fishery and aquatic habitat studies and analyses have become available since that time. This accumulated information has provided a more detailed and complete understanding of habitat use by the evaluation species and the importance of certain physical processes in the Susitna system as they relate to the quantity and quality of aquatic habitats. The new information is sufficient to refine the flow constraints to more adequately provide for habitat requirements of the evaluation species. As detailed below, the primary reasons to refine the flow restraints relate to (1) mainstem and side channel rearing habitats, (2) seasonal flow constraints, and (3) maximum flow constraints.

(a) Mainstem and Side Channel Rearing Habitats (***)

The use of mainstem associated habitats for rearing during the summer open water season is more common than previously perceived. Chinook salmon juveniles use side channel habitats for rearing during the summer (ADF&G 1984b). They are found in the side channels in greatest densities when flow is dominated by turbid water overflow from the mainstem. Conditions in the side channels are directly influenced by mainstem discharge at these times. Chum salmon also use turbid water, low velocity, mainstem sites for short-term rearing during their downstream migration to Cook Inlet.

(b) Seasonal Flow Constraints (***)

Environmental flow constraints for the entire year are necessary to maintain overall aquatic habitat values. Environmental considerations focused on summer flow, and winter minimum flows were based on reservoir operations for an extremely dry year (1969). There are important uses of the aquatic habitats throughout the year so there is a parallel need to establish appropriate environmental flow requirements for the entire year, rather than focusing only on the summer flow period.

(c) Maximum Flow Constraints (***)

The flow cases presented in the July, 1983 License Application did not include maximum flow constraints. Maximum constraints are not critical during summer since the project will be storing flows. Maximum flow constraints established for the summer will not be exceeded except during infrequent flood events (See Section 3.6.2 in this chapter). Winter maxima can serve to maintain a desired level of flow stability, protect peripheral habitats, and enhance the feasibility of certain mitigation alternatives, such as artificial berms and other structural modifications in side sloughs.

3.3.2 - Selection Criteria (***)

Several criteria were established for selection of alternative flow cases. These criteria were:

- The flow case had to be goal oriented. That is, the case had to be designed to achieve a specified level of habitat quantity and quality (Section 3.3.2(a)).
- The flow case had to emphasize critical or sensitive species and habitat combinations (Section 3.3.2(b)).
- The flow case had to be compatible with mitigation policy. That is, it had to focus on evaluation species, emphasize

preservation of habitats in a state of natural production, and integrate with other mitigation efforts (Section 3.3.2.c).

(a) Management Objectives (***)

The programming of flow regulation to mitigate for potential downstream project impacts requires a clear statement of objectives. A particular objective will dictate the quantity and timing of flow releases and set a standard by which the success of flow regulation can be measured.

The management objectives chosen by the Applicant emphasized chum salmon spawning in side sloughs and chinook salmon rearing in side channels (the reasons for this emphasis are detailed in Sections 3.3.2.b and 3.3.2.c below). The specific objectives for alternative flow cases were:

- To maintain quantity and quality of existing habitats (ie., no loss in habitat value);
- To maximize chinook salmon production (rearing) in existing habitats;
- To maintain 75 percent of existing side slough spawning habitat for chum salmon;
- To maintain 75 percent of existing side channel rearing habitat for chinook salmon;
- To maintain 75 percent of existing side slough and side channel habitats for chum salmon spawning and chinook salmon rearing, respectively; and
- To maintain 75 percent of existing side channel rearing habitat for chinook salmon and provide flows (spikes) for access by spawning chum salmon into side sloughs (minimum structural modification of critical reaches for access).
- To maintain 75 percent of existing side channel rearing habitat for chinook rearing and provide flows (spikes) for access by spawning chum salmon into side sloughs by spawning chum salmon (moderate structural modification of critical reaches for access).

It is important to understand that, in developing these management goals, a principle guideline for the establishment of the percentage levels is that they are designed to maintain the actual habitats utilized under natural conditions. The percentages (i.e. 75%) do not account for the possible acquisition of other habitat areas made available as a result of the altered flow regime. That is, the management goals were directed at use of water to maintain presently utilized habitat at the prescribed levels. The addition of new habitat areas to the total suitable habitat would replace the loss of existing habitat. This would, then, satisfy the overall policy of no-net-loss of habitat value.

The Applicant applied these objectives and developed eight alternative flow cases for evaluation and comparison (HE 1984). This process included an analysis of characteristics of habitat types and identification of project-sensitive habitat use by the evaluation species. These factors are detailed below.

(b) Critical Species And Habitat Combinations (***)

The primary change from natural riverine conditions due to project operations will be altered streamflows in the mainstem Susitna River. The project will change the annual sequence of streamflows by storing high summer flows for release during the normally low flow period in winter. This primary change will also alter factors associated with mainstem flow such as water temperature, turbidity and suspended sediment. These changes will not affect all habitats equally. The magnitude of effect will depend on the level of influence that mainstem conditions have on physical characteristics of the various habitat types. In addition, the habitats are not used uniformly by all species at all times. Therefore, some prioritization is necessary for effective allocation of flows. The timing and volume of flow discharge should be planned to produce the greatest possible mitigative effect for the aquatic habitats and evaluation species.

The Applicant evaluated habitat characteristics and seasonal habitat used by the evaluation species, in order to develop a rationale for establishing environmental flow requirements and to plan project operations. The general approach was to find the most important uses, based on density, frequency and duration, of the aquatic habitats that are most sensitive to mainstem flows. This process and its results were also reviewed to avoid overlooking a critical use of a less sensitive habitat that would be adversely impacted by project operation. No such circumstance was found.

(i) Habitat Sensitivity to Mainstem Conditions (***)

Changes due to project operation will be greatest in the middle river reach. The magnitude of discharge changes in the middle river will be dampened in the lower river by the dominating influence of inflow from the Chulitna, Talkeetna and Yentna Rivers, especially during spring and summer as discussed in Exhibit E, Chapter 2, Section 2.2 and Section 4. Therefore, flow regulation intended to mitigate project impacts will have limited effectiveness for lower river habitats. Other factors associated with mainstem discharge, such as temperature, turbidity, and suspended sediment, will follow the same trend. The magnitude of change will decrease with distance downstream from the project site and the effect of any design or operational measures to mitigate these changes will be "masked" by the influence of inflow from the major tributaries. This is discussed in Exhibit E, Chapter 2, Section 2.3 and Section 4. Therefore, the current analysis focuses on evaluation species and habitats found in the middle river.

Seven habitat types have been defined in the middle river basin. These are tributary, tributary mouth, lake, upland slough, side slough, side channel, and mainstem. Each was characterized and compared based on the level of influence mainstem conditions have on particular physical attributes of the habitats (Table E.10.3.2). These habitat types are defined in Exhibit E, Chapter 2, Section 2.1.

Tributary and lake habitat types are isolated from mainstem influence and their physical attributes will not be affected by project operation. Upland sloughs are usually in old overflow channels and oxbows that are presently isolated from the mainstem. They receive mainstem water only during infrequent and high flood events. Mainstem influence is limited to small backwater areas at the slough mouths so project operation will have little effect on upland slough habitats.

Side channels and side sloughs are active overflow channels that differ primarily in the frequency of receiving mainstem flow. Side sloughs are the most lateral channels and receive mainstem flow less often than side channels. Habitat characteristics of the side sloughs are controlled by local climate, runoff and groundwater upwelling during periods of relative isolation from the mainstem. Side channels are more closely associated with the mainstem and some receive mainstem flows through most of the year. Side channels may completely dewater during periods of low mainstem flow or, if groundwater or intergravel flow is sufficient, their habitat characteristics may resemble side sloughs. Both side channel and side slough habitat types are influenced by mainstem flows and several of their physical habitat components are sensitive to changes in mainstem discharge.

Tributary mouth habitat is the area bounded by the uppermost point of mainstem induced backwater effect in a tributary and the area of clearwater plume from tributary flow into the mainstem. The areal extent and physical attributes of this habitat type are controlled by both mainstem and tributary conditions.

The relative influence of mainstem flow on primary characteristics of the major habitat types is summarized in Table E.10.3.2. This summary shows that mainstem, side channel, side slough and tributary mouth habitat types are influenced by the mainstem. Several of their physical attributes are sensitive to change in mainstem discharge.

(ii) Habitat Use By The Evaluation Species (***)

The next step in the development of the refinement to Case C was to evaluate use of the habitat types by each of the evaluation species (Table E.10.3.3).

The information used for this step is contained in reports by ADF&G (1984a and 1984b). Lake habitat was not included due to its isolation from mainstem influence. Tributary habitat, although isolated from mainstem influence, was included because of its role in overall production in the middle river for most of the evaluation species.

Habitat use by each evaluation species was separated into major life history and behavioral components: migration, spawning/incubation, and rearing. Migration includes both directed movement to particular sites, such as the upstream migration of adult salmon to spawning sites, and more non-directed activity, such as movement by rearing fish from one habitat site to another. Spawning and incubation were combined because they are limited to the same habitat sites and, although their specific habitat criteria (needs) may differ, each limits the habitat flexibility of the other. Rearing is used broadly in this analysis to include the relatively active period of feeding and rapid growth during the summer and the less active overwintering period.

The habitat uses noted in Table E.10.3.3 are those judged to be the most important or predominant for each species. For example, although chinook salmon juveniles are found in upland slough and tributary mouth habitats, their use of these habitats for rearing is much less important than use of side channel, side slough and tributary sites.

- Chinook Salmon (***)

  Most of the upstream migrant adult chinook enter the middle river from mid-June to mid-July. They pass through mainstem and tributary mouth habitats to their natal tributary streams to spawn from late July to mid-August. All chinook spawning and incubation occurs in the tributaries.

  Juvenile chinook salmon (AGE 0+) begin rearing in their natal tributaries immediately after emergence. This early rearing during May and June is limited almost entirely to tributary sites. Beginning in late June, there is a gradual redistribution of large numbers of juveniles from tributary to side channel and side slough habitats. The major rearing sites during July and August are in tributaries and side channels. The juvenile chinook rearing in side channels begin moving into side sloughs in September and by November, the greatest densities are found in tributaries and side sloughs, which are the major overwintering habitats. The juvenile chinook (AGE 1+) move out of their overwintering habitats and migrate to Cook Inlet during the spring and early summer. Downstream migrant chinook are out of the middle river by mid-July.

- Coho Salmon (***)

  Adult coho salmon migrate into the middle river from early August to early September to spawn. Essentially all coho spawning occurs in tributary habitat sites from late August to early October. Coho juveniles begin rearing in natal tributary habitats immediately after emergence. Many of the juveniles leave the tributaries and redistribute into upland sloughs and side sloughs during late June and early July. The major rearing habitats during July to October are tributaries and upland sloughs. Data regarding overwintering sites suggest that upland sloughs are most important.

- Chum Salmon (***)

Adult chum salmon enter the middle river from mid-July to early September. Most spawn in either tributary or side slough habitats and a few spawn in side channels with suitable upwelling conditions. Major spawning occurs from mid-August through September. Chum salmon juveniles begin rearing in their natal habitats after emergence in the spring. They tend to remain in these sites until they begin a gradual downstream migration to Cook Inlet in June. Juvenile chum will use low velocity, backwater areas in the mainstem for holding and, perhaps, some short term rearing during downstream migration. The chum salmon juveniles move out of the middle river by mid-July.

- Sockeye Salmon (***)

Adult sockeye salmon (second run) move into the middle river from mid-July through August. They spawn almost exclusively in side sloughs, from mid-August to early October. Sockeye juveniles begin rearing in their natal side sloughs after emergence in late spring. They are most abundant in side sloughs during May and June and begin moving into upland sloughs in late June. They are most abundant in upland sloughs from July through mid-September. Their densities in the middle river decline abruptly in all habitats by mid-August. Most of the juveniles apparently move out of the middle river at this time and the few that remain overwinter in side sloughs.

- Pink Salmon (***)

Adult pink salmon migrate into the middle river from mid-July to mid-August and spawn almost exclusively in tributaries. Pink salmon juveniles begin migrating downstream immediately after emergence in the spring and are out of the middle river by late June.

- Arctic Grayling (***)

  Arctic grayling are most commonly associated with clearwater habitats. Spawning and major summer rearing occur in tributaries. They also rear in tributary mouth habitat. Some grayling move out of the tributaries into mainstem areas in late summer. Overwintering occurs in both tributary and mainstem habitats.

- Rainbow Trout (***)

  Rainbow trout are associated with clearwater habitats. Spawning and major rearing occur in tributary habitats. Some rainbow congregate at tributary mouths during late summer. This behavior appears to be in response to food supply (salmon eggs) provided by spawning salmon. Rainbow trout move out of the tributaries to tributary mouths during late summer and early fall and overwinter in the mainstem.

- Burbot (***)

  Burbot are found in the mainstem throughout the year. They occur mostly in turbid, low velocity, backwater areas directly influenced by mainstem flow. Spawning occurs during January. Although specific spawning sites in the middle river have not been found, evidence suggests they spawn at slough mouths and in deep, backwater areas influenced by groundwater.

- Dolly Varden (***)

  The majority of spawning and rearing by Dolly Varden occurs in tributary habitat. They move from the mainstem into tributaries by late June. The Dolly Varden move back out of the tributaries in late fall and overwinter in the mainstem.

- Conclusions Regarding Habitat Use (***)

  Several general observations can be drawn from the habitat uses summarized in Table E.10.3.3. First, tributary habitat is the habitat type used most commonly by the evaluation species. Sockeye salmon and burbot are the only species that do not use tributaries extensively for important life history phases. Secondly, the resident species make little use of side channel, side slough or upland slough habitats, whereas the anadromous species (salmon) frequently use these habitats. The most common use of the mainstem habitat is for migration and movement although resident species also overwinter in the mainstem.

Habitat requirements associated with migration and movement are less critical and restrictive than for the other life history categories. Only water depth and velocity have a major impact on movement of fish. Suitable depth and velocity conditions exist over a broad range of mainstem flows, and flow requirements to support migration and movement would not be restrictive to project operation. Flow requirements to satisfy the more critical needs of rearing and spawning/incubation will also satisfy the habitat needs for migration. Therefore, habitat requirements for rearing and spawning/incubation were emphasized for the remainder of the analysis.

The four sensitive habitat types from Table E.10.3.3, (Mainstem (MS), Side Channel (SC), Tributary Mouth (TM) and Side Slough (SS)) were selected for comparison based on their use for rearing and spawning/incubation (see Table E.10.3.4).

(MS) Mainstem habitat is used mostly for rearing, especially overwintering. Use of the mainstem by chum salmon is transient and short-term during their downstream movement to Cook Inlet. The major use of mainstem habitat by Arctic grayling, rainbow trout and Dolly Varden is for overwintering. The total area of mainstem habitat will be greater during the winter under the expected range of project flows than under natural flows. In addition, the populations of all the resident species in the middle river, including burbot, are characterized as low density.

(TM) Arctic grayling and rainbow trout use tributary mouth habitat for rearing during the ice-free seasons. Use by rainbow is transient, occurring mostly in the late summer and fall. The total area of this habitat will be greater and more stable under the lower and more stable mainstem flows during project operation (E.W. Trihey & Associates 1985).

(SC) Side channel habitat is used by chinook salmon for rearing and chum (and sockeye) salmon for spawning. The chum salmon spawning is limited to sites with sufficient upwelling conditions and accounts for only approximately five percent of the total chum spawning in the middle river basin.

Large numbers of chinook juveniles rear in side channels through most of the summer and early fall. The use of this habitat appears to be important to chinook production in the middle river. Therefore, chinook rearing in side channels was selected as one of the critical uses of a sensitive habitat for primary consideration in developing environmental flow requirements.

(SS) Side sloughs are used by salmon species for both rearing and spawning/incubation. Based on capture data, approximately 9 percent of chinook salmon in the middle river rear in side sloughs during the ice-free season while some 23 percent rear in side channels. The remaining two thirds of the population utilize tributary habitats. Flow requirements to maintain side channel habitat would also serve chinook rearing in side sloughs. Environmental flow cases designed to protect chinook rearing in side channels also provide for overwintering in side sloughs since, for the most part, the same fish use both habitats.

Chum and sockeye salmon use side sloughs for both spawning and rearing. Sockeye use of this habitat is so similar to chum, in time and location, that their habitat needs can be provided by concentrating on the more abundant chum salmon. Both species use side sloughs for short term, initial rearing prior to outmigration to Cook Inlet or movement to another habitat type. Chum salmon utilize side sloughs extensively for spawning. This is the most intensive use of a sensitive habitat in the middle river for spawning. Therefore, chum salmon spawning in side sloughs was selected as another critical use of a sensitive habitat for development of environmental flow cases.

3.3.3 - Compatibility with Mitigation Policy (***)

The alternative flow cases had to be compatible with the mitigation policies and procedures presented in the February 1983 License Application (APA 1983a pp. E-3-3 to E-3-6 and E-3-147 to E-3-150). The flow cases had to function well with other mitigation measures to result in no-net-loss of fish production from the Susitna system. The flow cases also had to provide for habitat of sufficient quality and quantity to maintain natural reproducing populations to the greatest extent possible, consistent with other project objectives.

The environmental flow cases designed and selected for analysis emphasized the habitat needs of the evaluation species which were considered most important and most sensitive to anticipated changes from natural conditions. The flow cases were designed to mitigate potential impacts by using flow releases to maintain natural production in existing habitats.

3.4 - Detailed Discussion of Flow Cases (***)

3.4.1 - Environmental Flow Cases (***)

Environmental flow Cases E-I through E-VI, as discussed below, are based on interpretation and analysis of all the data and information available regarding Susitna River fisheries resources and their habitats. Flow constraints contained in each case are based on the physical characteristics of particular habitats and uses of habitat by particular species and life stages under natural flow conditions. The potential for new habitat with the same characteristics but at different locations under project operation flows was not considered.

Development of the flow cases emphasized maintenance of habitats most responsive to mainstem flows. Rearing habitats in mainstem backwater areas, side channels and side sloughs were given greatest emphasis. Side sloughs are the most important spawning habitat affected by mainstem flows. Flow constraints for maintenance of summer rearing habitat included two important considerations. Minimum summer flow constraints were established to preserve the desired quantity of existing habitat and summer maximums were established to prevent extensive dislocation of rearing juveniles (i.e., provide greater flow stability). Flow constraints for juvenile over-wintering habitat were chosen to provide general flow stability and to minimize mainstem over-topping of side slough berms.

Mainstem flows affect both access to, and wetted area within, side sloughs. Minimum flow constraints were chosen to provide a specific minimum level of access and wetted area within chosen critical sloughs. These flow constraints are limited to August and September when chum and sockeye salmon enter the sloughs and spawn. Several cases include spiking flows. These short duration releases of relatively high volumes of water fulfill two purposes. Spiking flows in June provide over-topping flows into side sloughs to clear debris and sediments out of spawning areas and are not required every year. Spiking flows during August and September are to augment access conditions in side sloughs.

Minimum flow constraints are generally used to maintain a specified level of habitat quantity. Maximum flow constraints are generally used to provide flow stability (habitat quality) or minimize overtopping of mainstem water into side sloughs.

The effects of project operation on the environment discussed in Exhibit E are all based on Case E-VI, the Applicant's selected case, and so it is presented in more detail than the other cases. Environmental flow requirements are defined by water week with water week one being the period October 1 through October 7. Table E.10.3.5 shows the definition of water weeks.

(a) Case E-I (***)

(i) Management Objective (***)

Case E-I is a set of flow constraint necessary to maintain the quality and quantity of existing habitats, and represents the "no-impact" bound of the analysis. A corollary to this statement is that Case E-I achieves no net loss in productivity strictly through flow control and proper timing of flow releases. Maintenance of existing habitat and productivity does not require exact duplication of natural flow patterns and, in fact, some productivity benefits can accrue to downstream aquatic resources through increased stability by flow regulation.

(ii) Flow Constraints (***)

The E-I flow constraints are shown in Table E.10.3.6 and Figure E.10.3.3. Summer flow constraints were chosen principally to maintain existing juvenile salmon rearing habitats. These flows also provide passage conditions for upstream migration of adults. A 45,000 cfs spike is provided in June to purposely overtop sloughs and clean sediments and debris out of spawning areas. This spiking flow is not necessary in each year of operation. Flows of this magnitude may be necessary once every three to four years to achieve this purpose. Two flow spikes, 23,000 and 18,000 cfs, are provided in mid-August to allow unrestricted access by adult spawners into side sloughs. Winter minimum and maximum flows were chosen to maintain adequate over-wintering habitat and protect incubating eggs in side-slough habitats.

(iii) Project Flows (***)

Case E-I flows average 8,000 cfs at Gold Creek during the October to April period. Powerhouse discharge is increased from October to December and then decreased from December to April. December discharge can be as high as 13,000 cfs, but averages 9,800 cfs.The high minimum summer flow requirements result in low flows during the months of October, March, and April in low flow years. October flows are always greater than 4,000 cfs but 50 percent of the time, they are less than 6,000 cfs. In November, minimum flows approach 2,000 cfs. In March, minimum flows are 5,600 cfs. Lowest spring flows occur in early May and in dry years approach 4,500 cfs.

Because of the high minimum summer requirements of Case E-I, flow during May is purposely held low. Average flow during May is 7,400 cfs. During the months of June, July, August and September, project flows are the same as the minimum flow requirements 80 percent of the time. During the other 20 percent of the time, the project operation flows are usually only slightly greater than the minimum requirements. Flows would closely follow the minimum constraints during June through September, except during periods of high run off. More detailed descriptions of the flows for Case E-I are presented in Exhibit E, Chapter 2, Section 4.

(iv) Impact assessment (***)

The flow constraints in Case E-I were chosen to maintain existing spawning and rearing habitats. No loss of production is anticipated. Certain aspects of water quality will be changed by project operation. The natural temperature and turbidity regimes will be altered. Mainstem water temperatures will be generally cooler in the summer and warmer in the winter. However, these changes are well within the known tolerances of fishes utilizing mainstem habitats and no significant change of production is anticipated (APA 1984a, APA 1984c, DEIS Technical comment Nos, AQR100, AQR108, AQR119 and AQR123). Turbidity levels will be less in the summer and greater in the winter than under natural conditions. Turbidity levels in the winter will be less than natural summer levels and are within the range of tolerance for existing Susitna River stocks. The projected temperature and turbidity impacts are generally the same for all the cases and will not be repeated for each. More detailed comparison of temperatures for E-I and E-VI are described in Exhibit E, Chapter 2, Section 4.

(v) Mitigation (***)

Case E-I was designed to maintain existing habitat. Potential loss of these habitats would be minimized through timing and control of flow releases. Mitigation efforts to rectify, reduce or compensate for impacts would not be necessary. An extensive monitoring program would be conducted to measure the success of this plan in achieving the desired goal of no net loss in productivity.

(b) Case E-II (***)

(i) Management Objective (***)

Case E-II is a set of flow constraints designed to maintain 75 percent of existing chum salmon side-slough spawning habitat. Estimated numbers of chum salmon spawners in side sloughs of the middle river were less than two percent of the total escapement past Sunshine Station during the 1981-1983 seasons (ADF&G 1984f).

(ii) Flow Constraints (***)

Case E-II flow constraints are presented in Table E.10.3.7 and Figure E.10.3.4. Early summer minimum flow constraints are intended to provide for successful exit of juvenile chum from slough spawning areas and for initial downstream passage and rearing. A 35,000 cfs spike is provided in mid-June to overtop sloughs and clear spawning areas of sediments and debris. Minimum July flows of 6,000 cfs will provide for successful upstream passage of migrating adults. Maximum flow constraints are not necessary during this period to satisfy the management objective. Minimum August flows of 12,000 cfs will provide access to side sloughs by adult spawners. An 18,000 cfs spike is provided in early September to augment access to important side slough sites.

Minimum flow constraints during the winter resemble natural flow conditions and are simply to prevent unusual dewatering of spawning sites. Maximum winter flow constraints of 16,000 cfs provide a moderate level of protection to eggs incubating in side sloughs.

(iii) Project Flows (***)

Project flows for Case E-II are similar to those of Case E-V except that the October to April flows would be higher for Case E-II to reflect the fact that the July minimum flows for Case E-II are lower than for Case E-V. Flows from May to September would average 10,700 cfs and would be at the minimum flow about 55 percent of the time.

(iv) Impact assessment (***)

Several of the Case E-II flow constraints are conservative. The June spiking flow to clean side slough spawning habitat does not have to occur every year. This spike could be provided once every several years and still achieve its purpose. The summer spiking flow may be in excess of that necessary to maintain access to 75 percent of the existing side slough spawning habitat (APA 1984c comment No. AQR072). However, a 25 percent loss of chum salmon side slough spawning habitat will be assumed for this analysis.

Sockeye salmon also spawn in the side sloughs most frequently used by chum spawning. Spawning habitat loss for sockeye salmon is expected to be similar to the losses for chum. The minimum summer flows are adequate for upstream passage and tributary access to migrant adults and since coho, chinook and pink salmon spawn almost exclusively in tributaries, no loss of spawning habitat would occur for these species.

The summer minimum flow constraints established for Case E-II would not maintain 100 percent of the existing juvenile chinook rearing habitat. The 6,000 cfs minimum flows during water weeks 39 through 43 would result in the significant loss of existing chinook rearing habitat. A 75 percent loss of existing chinook rearing habitat in the middle river is thought to be a worst case estimate and will be assumed for this evaluation.

Chum salmon juveniles also utilize mainstem affected habitats for rearing. Sampling in the middle river indicates a majority (approximately 60 percent) of the chum have left this reach prior to water week 39 so the loss of rearing habitat would not be as great for chum as for chinook. A worst case estimate for loss of rearing habitat for the chum juveniles remaining in the middle river is assumed, therefore, to be 40 percent.

(v) Mitigation (***)

Case E-II minimizes some impacts through control and timing of flow releases. Potential impacts to slough spawning chum and sockeye salmon are minimized by special flow releases timed to clean spawning substrate and provide access to spawning areas. Impacts to rearing habitats are minimized through minimum summer flow constraints and increased stability through flow control.

The remaining impacts to slough spawning habitat would be rectified by structural modification of slough mouths to provide suitable access conditions at 12,000 cfs. Similar alterations would be made within the sloughs to provide passage through critical reaches. Loss of rearing habitat within the river would be rectified through replacement habitat naturally provided at other locations on the river at lower flows. The impact assessment only considered loss of habitats utilized under natural flow conditions. The channel structure of the middle Susitna River results in comparable habitat being created at different locations when discharge changes. This is supported by studies in the literature (Mosley 1982) and by preliminary results of 1984 studies of the Susitna River. However, these studies do not suggest total replacement at flows as low as 6,000 cfs. Remaining impacts to rearing habitat that could not be rectified by flow control would be compensated by construction and operation of a propagation facility.

(c) Case E-III (***)

(i) Management Objectives (***)

Case E-III flow constraints are designed to maximize chinook salmon production (rearing) in existing habitats. Chinook do not use mainstem influenced habitats for spawning so maximization in this case does not include consideration of limitations to spawning habitat.

(ii) Flow Constraints (***)

Case E-III flow constraints are presented in Table E.10.3.8 and Figure E.10.3.5. Minimum summer flow constraints of 14,000 cfs are intended to maximize the quantity of mainstem influenced rearing habitat at sites utilized under natural conditions. These flows would also provide migrant adults with upstream passage and tributary access. Maximum summer constraints are not necessary. However, it is assumed the project would store the maximum possible quantity of water during the summer resulting in greater flow stability. Winter flow constraints provide adequate rearing habitat during the ice covered season.

(iii) Project Flows (***)

Case E-III flows during the October to April period average 7,900 cfs at Gold Creek. The Case E-III winter flows are slightly less than the 8,000 cfs average for Case E-I because of the high minimum flow requirements for Case E-III during the month of May.

From May to September the average flow for Case E-III is 12,400 cfs. Project flow are at the minimum flow requirement during the period 75 percent of the time.

(iv) Impact Assessment (***)

No loss of chinook and chum rearing habitat is expected with Case E-III flows. The flow constraints and increased stability under project operation should improve rearing habitat quality and quantity compared to natural conditions.

Case E-III flows would affect access conditions into side sloughs for chum and sockeye spawning. The

14,000 cfs flows during August would provide some improvement over the 12,000 cfs flows in Case E-II. However, some additional loss is anticipated due to elimination of spiking flows. Slough 11 would be the most affected of the major side slough spawning sites. Approximately 66 percent of the slough spawning sockeye and 17 percent of the slough spawning chum utilize Slough 11 (1981-83 average). Restricted access conditions would not completely eliminate utilization of sloughs for spawning and, as noted for Case E-II, the flow criteria used in this analysis is conservative (see APA 1984 Comment No. AQR072). However, for the purpose of this evaluation, a loss of 25 percent of existing slough spawning habitat for chum and 70 percent slough spawning habitat for sockeye will be assumed.

(v) Mitigation (***)

Potential impacts to rearing habitats, tributary access and upstream passage of adults will be avoided or minimized through timing and control of flow releases. Impacts to side-slough access will be minimized by flow release.

The remaining impacts to side-slough access for spawning will be rectified by structural modification at critical access reaches to provide successful access.

(d) Case E-IV (***)

(i) Management Objectives (***)

Case E-IV flow constraints is designed to maintain 75 percent of the existing middle river side channel rearing habitat presently utilized by juvenile chinook salmon. The constraints do not account for chum salmon spawning habitat loss which are to be mitigated through structural modification of the habitat areas used for spawning.

(ii) Flow Constraints (***)

The minimum summer flow constraint of 9,000 cfs (Table E.10.3.9 and Figure E.10.3.6) is intended to maintain approximately 75 percent of the existing middle river side channel rearing habitat utilized by juvenile chinook salmon under natural flow conditions. The maximum summer flow constraint of

35,000 cfs is intended to produce moderate flow stability and prevent severe dislocation of rearing juveniles from preferred sites.

Winter constraints are designed to maintain flow stability within reasonable boundaries. The 2,000 cfs minimum is within the range of winter flows encountered under natural conditions, while the 16,000 cfs maximum would provide for flow stability and reduce the appearance and disappearance of transient rearing sites which occurs under natural conditions.

(iii) Project Flows (***)

Case E-IV minimum summer flow requirements would result in an average flow of 9,500 cfs at Gold Creek during the October to April period. This is only slightly lower than the winter average flow for Case P-1 (9,700 cfs) [Case P-1 is a set of flow constraints designed to maximize power and energy benefits of the project (HE 1984h)]. During higher flow years, when the reservoir is filled prior to October, winter flows would be the same as for Case P-1. In lower flow years, flow at Gold Creek would be about 1,000 cfs less than for Case P-1. Minimum flows in these years would be about 5,000 cfs in October, 6,000 cfs in March, 3,000 cfs in November and about 5,000 cfs in April.

May flows for Case E-IV would average 9,000 cfs. These flows are lower than for Case P-1 in order to store as much water as possible prior to the 9,000 cfs minimum requirement which takes effect in June. June, July, and August flows are at the 9,000 cfs minimum requirement more than 50 percent of the time. Average flow for these months is 10,100 cfs. In September, project flows would be the same as the minimum flow requirement 35 percent of the time.

(iv) Impact Assessment (***)

Case E-IV would reduce the availability of existing chinook salmon side channel rearing habitat by approximately 25 percent in the middle river. Rearing habitat now used by chum salmon juveniles would be reduced in side-sloughs. The major use of side slough habitat by juvenile chum salmon occurs during May and June and habitat reduction would result from loss of over-topping flows during this period. Loss of habitat could be as great as 50 percent at the sites utilized under natural flow conditions (ADF&G 1984b). No rearing habitat loss is expected in the lower river due to the dominant effects of the Chulitna and Talkeetna rivers.

Flow constraints during August and September would significantly restrict spawning access to sloughs by adult chum and sockeye salmon. Some successful access would still occur but with significant difficulty. A worst case assumption of 100 percent loss of access is assumed for this evaluation.

(v) Mitigation (***)

Impacts on chinook and chum salmon rearing habitats would be minimized through timing and control of flow releases. A minimum summer flow constraint of 9,000 cfs would maintain a majority of the rearing habitat utilized under natural flow conditions. Increased flow stability under project operation would have an augmenting effect on over-all quality of the rearing habitats, especially for side channel sites utilized by chinook juveniles. Remaining loss of existing rearing habitat would be rectified by providing replacement habitat through control of flow releases. Flow reductions during the summer would reduce the quantity of and access to individual rearing sites utilized under natural flow conditions. However, the same flow reduction would result in new sites with the appropriate physical conditions for chinook and chum salmon rearing. This result is not unusual for rivers like the Susitna with moderately complex channel configurations. The availability of rearing habitat for chum and chinook salmon is actually expected to increase over natural conditions with operation under Case E-IV (see Section 3.4.1(h) for further discussion of Case E-VI which is similar to Case E-IV).

Loss of access to side sloughs would be rectified by structural modification of critical access reaches.

(e) Case E-IVa (***)

(i) Management Objective (***)

Case E-IVa establishes flow constraints which would maintain 75 percent of the middle river side-channel rearing habitat presently utilized by chinook salmon juveniles and provide some access to the most productive side slough spawning sites for adult chum and sockeye salmon.

(ii) Flow Constraints (***)

Case E-IVa flow constraints are presented in Table E.10.3.10 and Figure E.10.3.7. These constraints are identical to those discussed for Case E-IV above (Section 3.4.1.(d)) except for the inclusion of spiking flows in water weeks 38 and 48 through 50. The purpose of the spiking flows is the same as discussed for Cases E-I and E-II (Sections 3.4.1.(a) and 3.4.1.(b)). The 30,000 cfs spike in week 38 is

to over-top slough berms to flush out accumulated sediments and debris. This flow would not be necessary each year of operation but would be provided at least once every three years. The spiking flows during weeks 48 through 50 are to provide access to the most productive side slough spawning sites.

(iii) Project Flows (***)

Case E-IVa flows would be similar to those of case E-IV except that during winter operation, flows would be reduced from Case E-IV during lower flow years to account for the reduced storage because of the required summer spiking flows.

Flow during June, July and August would be the same as the minimum requirements more than 55 percent of the time. Releases from the outlet works would be required to augment the powerhouse discharge during those periods when spiking is required.

(iv) Impact Assessment (***)

Impacts on rearing habitats would be the same as discussed for Case E-IV except for some momentary disturbance and dislocation caused by the spiking flows. The spiking flows would not cause a measurable effect since their magnitudes are well within the range of natural flood events and the rate of change in discharge would be limited.

Impacts on access to side slough spawning sites would be similar to Case E-II. Case E-IVa provides more spiking flows for access than E-II but the base flow would be 3-4,000 cfs less. Therefore, the expected net loss would be similar to Case E-II (i.e., a 25 percent loss of slough spawning habitat for chum and sockeye salmon).

(v) Mitigation (***)

Mitigation measures for loss of rearing habitat would be the same as discussed for Case E-IV.

Measures to rectify loss of access to slough spawning sites would be similar to those discussed for Case E-II (Section 3.4.1(b)) Some additional alteration would be necessary for Case E-IVa due to the lower base flows.

(f) Case E-IVb (***)

(i) Management Objective (***)

Case E-IVb flow constraints are designed to maintain 75 percent of the side channel rearing habitat utilized by chinook salmon juveniles under natural flow conditions and provide for some limited spawning access to the most productive side sloughs by chum salmon adults.

(ii) Flow Constraints (***)

Flow constraints for Case E-IVb (Table E.10.3.11 and Figure E.10.3.8) are identical to those discussed for Cases E-IV (Section 3.4.1(d)) and E-IVa (Section 3.4.1(e)) except for the magnitude of spiking flows. Spiking flows for Case E-IVb are of the same duration as those in E-IVa, but peak at lower discharges (cfs).

(iii) Project Flows (***)

Case E-IVb has flow requirements similar to Case E-IVa except that during periods when spiking flows are provided, the magnitude of the spikes are reduced for Case E-IVb. Therefore the average winter flows with Case E-IVb would be greater than for Case E-IVa and less than for Case E-IV. However, because of the similarities between Cases E-IV and E-IVa, winter flows with Case E-IVb operation would be the same as Case E-IV and E-IVa most of the time.

Summer flows would be almost the same as those of Case E-IVa most of the time and only slightly different at other times.

(iv) Impact Assessment (***)

Impacts on rearing habitats would be similar to those discussed for cases E-IV and E-IVa above.

Impacts on access to slough spawning sites would be greater with this case than with Cases E-II or E-IVa. Severe access problems would occur at sloughs IA and 11. Complete restriction at these sloughs would eliminate approximately 32 percent and 80 percent of the utilization of side sloughs for spawning by chum and sockeye salmon, respectively (ADF&G 1984a). Flows that range from the 9,000 cfs base flow to the 14,000 cfs spiking flows would result in a loss of access to aproximately 40 percent of the slough spawning areas (weighted for utilization: see APA 1984c Comment on No. AQR072). A worst case impact of a 50 percent loss of slough spawning habitat for chum and a 100 percent loss of slough spawning habitat for sockeye salmon is assumed for this evaluation.

(v) Mitigation (***)

Mitigation measures for loss of rearing habitat would be the same as discussed for Case E-IV.

Loss of access to sloughs for spawning chum and sockeye salmon would be rectified by structural modidification of the slough mouths and critical access reaches within the sloughs.

(g) Case E-V (***)

(i) Management Objective (***)

Case E-V flow constraints are designed to maintain 75 percent of the existing chum salmon slough spawning habitat and 75 percent of the existing chinook salmon side channel rearing habitat.

(ii) Flow Constraints (***)

Case E-V flow constraints were derived by combining Cases E-II and E-IV. The basic guideline used was to chose the maximum and minimum for each week from Cases E-II and E-IV that were most restrictive on project operation. Flows to maintain chinook rearing habitat were chosen for most of the year (Table E.10.3.12 and Figure E.10.3.9). Flows for chum spawning habitat were most important during weeks 36-38 and 44-49.

(iii) Project Flows (***)

Case E-V would result in an average flow of 8,600 cfs at Gold Creek during the October to April period. Power house discharge would increase from October to December and then decrease from December to April. December discharge would be as high as 12,000 cfs but would average 10,100 cfs. minimum flows would approach 5,000 cfs during October and March in low flow years. In these low flow years, April flows could be as low as 3,200 cfs.

During the May to September period, the flow at Gold Creek would be the same as the minimum flow requirements 55 percent of the time and, of course, higher, the remainder of the time. The average flow during this period would be 11,400 cfs.

(iv) Impact Assessment (***)

Loss of spawning habitat with Case E-V flow constraints would be similar to losses under Case E-II. Therefore, a 25 percent reduction of side slough spawning habitat for chum and sockeye salmon will be used for this evaluation.

The expected impacts on existing rearing habitat would be similar to those discussed for E-IV and E-IVa above. Case E-V flows would result in a 25 percent loss of existing chinook salmon side channel rearing habitat.

(v) Mitigation (***)

Mitigation measures for impacts on slough spawning habitat are discussed for Case E-II (Section 3.4.1(b)).

Mitigation measures for loss of existing rearing habitat are discussed for Case E-IV (Section 3.4.1(d)).

(h) Case E-VI (***)

Case E-VI is the Applicant's selected flow case and a more detailed description is warranted. Basically Case E-VI is a variant of E-IV with a flexible summer minimum flow constraint to achieve more economic project operation during low flow years (one in ten year low flows).

Case E-VI impact would be similar to Case E-IV and proposed mitigation measures would result in no net loss of productivity. Naturally reproducing populations would be maintained through steps to minimize and rectify project induced losses. A general improvement in the quantity and quality of rearing habitat is expected over natural conditions. The evaluation of effects of project operation on water use and quality in this Chapter and throughout Exhibit E is based on the Case E-VI flow requirements. Sensitivity analyses are provided for the Case E-I flow requirements. The effects of other flow requirements on water use and quality would be between these two bounds.

(i) Management Objective (***)

Case E-VI flow constraints are designed to maintain 75 percent of the existing chinook salmon side channel rearing habitat in all years except low flow years (defined as years with expected summer discharge less than or equal to the one in ten year low flow occurrence). Minimum summer flows are reduced to a secondary but set level during low flow years to achieve necessary but limited flexibility for project operation.

Establishment of environmental flow constraints based on the requirements of juvenile chinook salmon is a reasonable approach. Chinook salmon is one of the species of major importance to commercial and non-commercial fisheries in south-central Alaska (APA 1983a, p. E-3-1 through E-3-15). Juvenile chinook utilize habitats within or closely associated to the mainstem river for rearing during the entire year (ADF&G 1984b). The high human use value and sensitivity to potential project impacts qualifies chinook salmon as an evaluation species. Chum salmon spawning in side sloughs has been identified as the combination of species and habitat that would be most significantly affected by project operation (Woodward - Clyde 1984). However, loss of chinook mainstem rearing habitat would have to be compensated by construction and operation of artificial rearing facilities (e.g. a traditional release-return hatchery). Compensation is the least desirable option under the mitigation policies applied to the Susitna Project (APA 1983a, pp. E-3-3 through E-3-6).

(ii) Flow Constraints (***)

Case E-VI flow constraints are shown in Table E.10.3.13 and Figure E.10.3.10. The flow constraints can be separated into three major divisions; winter flows, summer flows and transitional flows.

Maximum flows are the most important winter constraints. Normal project operation would produce the greatest discharges during the winter months (November-March). The winter maximum is intended to establish a boundary near the upper range of operational flows that would result in flow stability and provide a reasonable level of protection to over-wintering habitat. Side sloughs are especially important in this context since chinook juveniles utilize this habitat for over-wintering. The 16,000 cfs maximum flow would prevent overtopping of all the major sloughs prior to freeze-up and stabilize habitat availability during ice covered periods.

The winter minimum flow is established to prevent dewatering of rearing habitats. The 2,000 cfs minimum is chosen based on natural flows and represents a high mean natural winter flow.

Flow constraints during the winter to summer transition period (May 6 to June 2) are designed to maintain rearing habitats and provide greater flow stability. Chinook juveniles are accumulating the major portion of their freshwater growth during this period and they utilize side-channel sites that are directly affected by mainstem discharge (ADF&G 1984b). A 9,000 cfs minimum flow would maintain 75 percent of the existing habitat quantity at sites presently utilized by chinook and increased flow stability would improve habitat quality over natural conditions.

(iii) Project Flows (***)

Project operation flows for Cases E-IV and E-VI would be the same for all but the lowest flow years.

Only in one year in ten would there be a significant difference. Because of this occurrence, October to April flows would average only slightly more than for Case E-IV.

May to September flows would be the same as Case E-IV, except during the one in ten year low flow when the minimum flow would be 8,000 cfs during June, July, and August. Actual flow would be the same as the minimum flow during June, July and August approximately 50 percent of the time.

(iv) Impact Assessment (***)

Case E-VI is designed to reduce impacts of project operation as compared to flow cases designed specifically for power generation However, Case E-VI does not mitigate all impacts by flow releases alone so further impact assessment and mitigation planning is necessary. This section will address significant potential impacts to each life stage of the five Pacific salmon species for habitat utilized with natural conditions. The impacts do not accout for the acquisition of other habitat areas made available as a result of the stabilized flow regime. These improvements are discussed under mitigation and show that the "no net loss" goal is achieved.

- Juvenile Rearing

Chinook salmon juveniles rear in both clear and turbid water habitats. Substantial rearing occurs in tributaries and side channels (ADF&G 1984b). Densities generally decrease in tributaries and increase in side channel habitats through the summer. Densities in side sloughs are relatively low during the summer but increase markedly during September and October. Tributary habitat would not be impacted by altered mainstem flows. Side channel habitat would be most directly affected. Case E-VI flows would reduce the quantity of available rearing habitat at side channel sites presently used by chinook by approximately 25 percent.

Chum salmon rearing is essentially limited to tributaries and side sloughs during the early summer (May-early June). Highest densities during late June and July occur in upland sloughs and side channels. Essentially all the juvenile chum have moved downstream, out of the middle river, by the end of July. Case E-VI flows would not impact rearing habitat in tributaries and upland sloughs. Chum salmon use of side channel sites is mostly for short-term holding and rearing during downstream migration. Case E-VI flows would decrease the availabilty of side channel sites presently used by chum by approximately the same magnitude estimated for chinook salmon. A 25 percent reduction will be assumed for this assessment. There would also be a loss of chum rearing habitat in side sloughs. Most of the loss would be due to a reduction or elimination of overtopped conditions in side sloughs during May and June under project operation. Loss of habitat could be as great as 50 percent at the sites utilized under natural flow conditions.

Sockeye juveniles rear predominantly in natal side sloughs during the early summer and then move mostly to upland sloughs by July. With project flows are not expected to affect upland slough habitats. The responses of weighted useable area for sockeye and chum are similar for side-slough rearing habitat. Therefore, loss of sockeye rearing habitat would be approximately 50 percent.

Coho salmon rear mostly in tributaries and upland sloughs. Impacts due to project operation are not expected in these habitats.

Pink salmon juveniles move rapidly from their natal tributaries to Cook Inlet. The mainstem and associated habitats are apparently used only for migration corridors so project flows would not impact pink salmon rearing.

- Downstream Migration

Downstream movement of salmon juveniles occurs throughout the summer (ADF&G 1984b). Chum, pink and age 1+ chinook salmon migrate toward Cook Inlet during the early summer and are out of the middle river reach by July. Sockeye, coho and age 0+ chinook move gradually downstream throughout the summer. Most of this movement is associated with rearing and gradual relocation into available rearing and overwintering habitat. Some of this downstream movement is influenced by discharge (ADF&G 1984b). Increasing discharge during flood flows can act as a stimulus to initiate seaward migration, especially during the early summer. Flood flows later in the summer, when juveniles are rearing or seeking alternative habitat sites, can cause dislocation from preferred rearing areas. Project operation will reduce the frequency, duration and amplitude of flood events in the middle river. This impact is not expected to affect seaward migration in a significant way. Factors other than flow, such as increasing day length, water temperature and physiological conditions, also trigger migration. Increased tributary flow and local run-off would also serve to stimulate migration.

- <u>Upstream migration</u>

  Adult salmon migrate up the Susitna River toward spawning areas throughout the summer. The 9,000 cfs summer minimum flows will provide sufficient conditions for upstream passage of adults.

- <u>Spawning</u>

  Salmon that spawn in the middle river basin are only a small proportion (less than 15 percent) of the total in the Susitna River System (ADF&G 1984a). Most of the salmon that spawn in the middle river basin use tributary habitats outside the influence of mainstem discharge. The spawning habitat most sensitive to changes in mainstem discharge are the side sloughs used by chum and sockeye salmon. Mainstem flows influence spawning success in side sloughs through affects on access past critical reaches, total useable areas within the slough and groundwater discharge. Access into the major spawning sloughs (8A, 9, 9A, 11 and 21) would be restricted under Case E-VI flows. An analysis using values of side sloughs weighted by observed spawning use provides an estimated loss of approximately 50 percent of side-slough spawning due to access restriction at 9,000 cfs (APA 1984, Comment

AQR072). However, considering the restricted access together with reduced area and flow within the sloughs, a worst case assumption of 100 percent loss of side-slough spawning habitat without mitigation is assumed for this evaluation.

(v) Mitigation (***)

This section will present suggested actions to mitigate potential losses due to project operation. Project operation in the absence of environmental constraints is the appropriate starting point to discuss mitigation so flow Case P-1 will be used as a standard.

Project impacts would be minimized through timing and control of flow releases by adopting the environmental flow requirements in Case E-VI. Case P-1 flows would fall below 9,000 cfs during June through August in approximately 75 percent of the years of operation. Mean monthly summer flows would be as low as 4,500 cfs in some years. This would result in the loss of most of the mainstem and side channel rearing habitat presently used by chinook and chum salmon juveniles. Case E-VI flows would minimize this impact by maintaining 75 percent of the existing side channel rearing habitat. The residual 25 percent loss of side channel habitat and the loss of chum and sockeye rearing habitat in side sloughs would be rectified by habitat replacement at the more stable, lower flows (relative to natural flows) under Case E-VI. The original rationale for design of Case E-VI and the impact assessment discussed above are based on impacts to habitat sites that are available and used under natural flow conditions. The estimates of impact relied on data and information collected at habitat sites presently utilized. The analyses and estimates did not consider the addition of new habitat sites with appropriate characteristics and qualities that would become available at lower, more stable flows. This is more fully explained in Exhibit E, Chapter 3.

Chinook salmon prefer areas of moderate depth and velocity for rearing in side channel areas. The quantity of habitat with these characteristics depends largely on channel complexity. There is relatively little of this rearing habitat available at bank full flows. The habitat quantity increases as flows drop and the flow channels become more complex. This increase will continue until a maximum is reached and habitat quantity would than decrease as discharge decreases to a level sufficiently low to restrict flow to a single thalweg channel. Comparison of channel complexity at various flows gives some indication of how habitat quantities will be impacted by project operation. Channel complexity at 9-12,000 cfs (approximate summer operational flows) is much greater than at 23,000 cfs (approximate mean summer natural flows) (see Exhibit E, Chapter 2, Section 2.2 for a discussion of natural flows). The quantity of side channel and mainstem rearing habitat for both chinook and chum salmon is expected to increase over natural conditions during project operation under Case E-VI flow requirements. Increased flow stability and decreased turbidity is expected to improve habitat quality and augment rearing potential in the middle river.

Case E-VI minimum flow constraints during late August and early September will minimize impacts of the project on chum and sockeye spawning due to operation through control of flow releases (compared to Case P-1). However, the residual impacts would be considerable and further mitigation would be necessary. Loss of side slough habitat for chum and sockeye salmon spawning would be rectified by structural modification of existing sloughs. Details of these activities are given in a report by the Applicant (Woodward-Clyde 1984) and are not repeated here.

The results of these mitigation measures are compatible with mitigation policies and objectives presented in the original License Application (APA 1983a, p. E-3-147). Habitat quantity and quality sufficient to maintain naturally reproducing populations is provided. All significant impacts would be minimized or rectified.

3.5 - Comparison of Alternative Flow Regimes (***)

The alternative flow regimes were compared, based on their performance in meeting economic and environmental objectives. The economic objective is to minimize the cost of producing energy to meet projected Railbelt system energy demands. The environmental objective (as explained in Section 3.3.2 (a) and below) is to provide sufficient habitat to maintain naturally producing populations, so called no-net-loss of habitat. The environmental objective may be achieved by providing the river flows necessary to meet the objective or by a combination of flows and other compensation such as rearing facilities. Environmental flow requirements affect Susitna energy production and may require the construction and operation of other generating facilities to meet Railbelt system energy demand. Therefore, the costs resulting from the implementation of environmental flow requirements are included in the economic evaluation of the costs to meet Railbelt energy demand. The economic and environmental objectives are combined in a single evaluation criteria which is the total cost of providing the Railbelt energy demand, including the costs of the Susitna Hydroelectric Project, other generation facilities and the costs of mitigation measures.

3.5.1 - Economic Comparison (***)

The analysis of the economic benefits of the project is based on the objective of providing the energy required to meet the projected Railbelt energy demand. This objective is achieved by the construction and operation of the Susitna Hydroelectric Project and such other generation facilities as may be required to provide energy not provided by Susitna. This analysis is explained in more detail in Exhibit B. In addition to the Susitna cost, the cost of meeting the Railbelt (system) energy demand is a function of the environmental flow requirements since these may restrict energy generation from Susitna and require additional other generation. Economic analyses of selected flow cases, ranging from P-1 to E-VI, were performed to determine the present worth of the long term (1996-2054) production costs (costs to meet Railbelt energy demand) of each alternative. The analyses were made using the OGP model (See Exhibit D, Section 2.8). The monthly average and firm energy corresponding to each flow case were obtained from the reservoir operation program. Railbelt system expansion for the period 1996 through 2025 was analyzed with Watana Stage I coming on line in 1996, Devil Canyon Stage II in 2005 and Watana Stage III in 2012. The long-term system costs for 2026 through 2054 were estimated from the 2025 annual costs, with adjustments for fuel escalation for the 29-year period. A more detailed discussion of the economic analysis method is provided in Exhibit D, Section 2.10.

The results of the analyses are illustrated in Table E.10.3.14. They indicate that as the energy benefits of the project are increased, the cost of the associated mitigation measures is also increased. When mitigation costs are incorporated as part of the system costs, Case E-VI has the lowest cumulative present worth of net system costs.

Case E-IV ranked second in lowest cost, some $7 million greater than Case E-VI. Cases P-1 and A ranked next with a total present worth of system costs about $13 million to $15 million greater than E-VI. Case C (the proposed flow requirements presented in the July 1983 License Application), E-V, and E-I had present worth of system costs increasingly greater than Case E-VI.

The total Railbelt installed generating capacity must be increased as minimum flow requirements in the months of May through September are increased. This occurs because of the resulting decrease in available Susitna winter energy during low flow years, and the consequent requirement for additional thermal capacity to meet peak demand. Increasing installed capacity results in costs for construction of the facilities and increased costs to meet Railbelt energy demands. The installed capacity of the Susitna Project is the same for all cases, but the dependable capacity is reduced when higher summer flow requirements decrease the flow available for peak winter energy demands.

The OGP program was used to evaluate system production costs and develop the relative economic raking of the flow cases. OGP is a long-term expansion planning model which uses daily load duration curves for system dispatch. A program using chronological hourly system dispatch may yield cost differences among the flow cases that are greater than shown in Table E.10.3.14.

3.5.2 - Environmental Comparison (***)

(a) Aquatic and Fisheries (***)

The environmental cases can be separated into three basic groups. Group 1 is designed to maintain rearing habitats and includes E-III, E-IV, and E-VI. Group 2 is designed to maintain chum spawning in side sloughs and includes only Case E-II. Case E-II is the most similar to Case C since protection of side slough spawning habitat was the primary environmental consideration in both. Group 3 is made up of cases designed to maintain both rearing and side slough spawning habitat. This group includes Cases E-I, E-IVa, E-IVb and E-V.

The two most important potential impacts of project operation are effects on mainstem influenced rearing habitats and spawning habitat in side sloughs. The environmental cases can be compared based on potential impacts and mitigation measures regarding these two categories.

The objective of mitigation planning for fisheries impacts of the proposed project is to provide sufficient habitat to maintain naturally producing populations wherever compatible with project objectives. Compensation through construction and operation of propagation facilities is a least desirable action. Group 2 flow cases (E-II, C) would require compensation for lost rearing habitat. Compensation within the Susitna Basin would likely require a propagation facility designed to replace lost chinook salmon production.

The major mitigation action (other than flow control) for Group 1 (E-III, E-IV, E-VI) and Group 3 (E-I, E-IVa, E-IVb, E-V) would involve rectifying for impacts on side-slough spawning habitat. The extent of necessary structural modification varies among the individual cases but the basic impacts and mitigation methods are the same. Group 3 flow cases would generally require less structural modification than for Group 1.

Mitigation actions described for all the environmental cases would result in no net loss of production due to project operation. However, Group 2 flow cases are the least desirable since they require actions at greatest variance from the mitigation objective. Group 3 cases are the most desirable based only on environmental consideration of potential impacts and the level of required mitigation actions.

Representative cases were chosen from each group for evaluation and comparisons based on power and economic objectives of the project. Cases E-IV and E-VI were chosen to represent Group 1, Case C to represent Group 2 and E-I and E-V to represent Group 3.

(b) Other Instream Flow Considerations (**)

(i) Downstream Water Rights (*)

Water rights in the Susitna basin are minimal (see Exhibit E, Chapter 2 Section 2.6.1). Therefore, since all flow scenarios provided more than enough flow to meet downsteam water rights, it was not a factor in minimum flow selection.

(ii) Navigation and Transportation (**)

Navigation and transportation use of the river was not considered a factor among the environmental flow requirements considered. Cases E-I, E-II, E-III, E-IV, E-V and E-VI all have minimum flow requirements exceeding 6,000 cfs at Gold Creek for the late May - late September period. As discussed in Exhibit E, Chapter 2, Section 2.6.3, this is considered adequate to ensure boating use of the river from the Talkeetna to Devil Canyon reach. Navigation use downstream of Talkeetna and in the Alexander Slough area are greatly influenced by flows from the Chulitna, Talkeetna and Yentna Rivers and the project flow regime would have less influence on navigation in these areas. The frequency of navigation difficulties in these areas would be similar to natural conditions with all the flow requirements cases considered.

(iii) Recreation (***)

Recreation on the Susitna River is closely associated with navigation and transportation and the fishery resource. Since the Susitna River below Devil Canyon will be navigable during the summer months at all minimum flow scenarios, this aspect of recreation was not a factor in the flow selection process. However, from a fishery perspective, if a fishery habitat is lost, this could reduce the recreational potential of the fishery. For flows equal to or greater than Case E-VI flows, the fishery impact can be mitigated. Hence, Case E-VI or greater flows should be selected as the minimum operation flow based on recreational considerations.

(iv) Riparian Vegetation and Wildlife Habitat (*)

Riparian vegetation is affected by one or more of the following: floods, freezeup and spring ice jams. Minimum flow selection for the cases considered is unrelated to any of these factors. Hence, riparian vegetation effects are not considered in minimum project flow selection.

Riparian vegetation is likely affected by the freezeup process, ice jams, and spring floods in the Devil Canyon to Talkeetna reach (Section 2.6.5 in Chapter 2 of Exhibit E). In the Talkeetna to Yentna and Yentna to Cook Inlet reaches, spring and summer flooding likely has the major impact on riparian vegetation. Hence, since spring floods in the Susitna River will be reduced from Watana to Cook Inlet (Section 4.1.3 in Chapter 2 of Exhibit E), it may be desirable to maintain riparian vegetation by simulating spring floods for a short period of time. However, the spring runoff storage is a key element of the project. Large releases for even a few days would have severe economic impact on the project. Hence, no minimum flood discharges were considered.

If summer floods occur and have an effect on riparian vegetation, there would essentially be no difference between the flow cases. This is because minimum flows would not govern if the reservoir is full, inflow will be set equal to outflow up to the capacity of the release facilities.

(v) Water Quality (*)

The natural and with-project downstream summer temperatures will be similar for all cases although the lower discharges would exhibit a faster temperature response to climatic changes.

The waste assimilative capacity for all cases will be adequate at a flow of 6,000 cfs. All other water quality parameters would be similar for all flow scenarios.

(vi) Freshwater Recruitment to Cook Inlet (*)

The change in salinity in Cook Inlet will essentially be the same for all flow scenarios although higher minimum flows would cause a salinity pattern slightly closer to natural conditions. This was not considered significant in the flow selection process.

3.5.3 - Selection of Operational Instream Flow Requirements (***)

Cases E-VI and E-IV provide benchmarks to which the economics of the various flow cases can be compared. These cases yield the lowest present worth of system costs, including mitigation costs. While Cases P-1 and A are not substantially higher, it is the Applicant's policy to avoid the use of propagation facilities if habitat for naturally reproducing populations can be maintained.

As Table E.10.3.14 shows, Cases E-I and E-V have high cost penalties. The additional fishery benefits from Case E-I and E-V flow requirements do not warrant the loss of energy benefits.

The same management objectives can be obtained through effective mitigation techniques at a much lower cost. Case C has a management objective to protect sloughs considered to be traditional salmon spawning areas. However, Case C does not adequately consider other management objectives which have been identified through ongoing studies. For example, it does not include flow constraints for juvenile rearing habitat.

Cases E-VI and E-IV are judged to be the superior flow cases considered. Case E-VI is selected as the preferred case because it meets the economic and environmental objectives and has the lowest cost.

3.6 - Other Constraints on Project Operation (***)

In addition to the constraints on minimum and maximum weekly flows, other considerations are required to assure the stability of flows within a week and from week to week; to provide for the safe operation of the project during floods; to provide for contingencies in case another part of the generating system is temporarily out of service; and to provide constraints on flows during filling of the three stages of the project.

3.6.1 - Flow Stability Criteria (***)

Flow stability criteria are designed to provide protection to the instream flow uses of the river in addition to that provided by weekly average minimum and maximum flow constraints. The flow stability constraints are indexed to flows from the downstream project (i.e. to Watana discharge when Watana is operating alone, and to Devil Canyon discharge when Devil Canyon is operating with Watana).

Indexing flow stability criteria to powerhouse flows rather than Gold Creek flows is necessary because of:

- The variability in flow from the intervening area between the powerhouses and Gold Creek, and
- The time required for changes in powerhouse discharge to be reflected in Gold Creek discharges.

As explained further below, the discharges from Watana in Stage I and Devil Canyon in Stages II and III will be allowed to fluctuate between 90 percent and 110 percent of the weekly average flow. This limitation was adopted:

- To avoid large water level fluctuations which may be detrimental to fish,

- To give the project some flexibility to provide reserve energy capacity to react to variations in system energy demand,

- To account for possible inaccuracies in the measurement of discharge which may be on the order of five to ten percent, and

- To account for variations in the flow from the intervening areas between the project sites, Gold Creek and fishery habitat located between Gold Creek and Talkeetna.

Stage fluctuations and variations in habitat surface area resulting from fluctuations in powerhouse discharge are described in Exhibit E, Chapter 2, Section 4.1.3(a).

(a) Watana Only Operation (***)

Watana operation will be guided by two sets of criteria. The first set will guide the long-term operation by providing weekly flows for power generation. The second will guide short-term project operation by providing hourly flows for power generation.

Long-term operation uses an operating guide to seasonally adjust flow for power generation. The operating guide assesses the amount of water available in the reservoir, the current energy demand, the season of the year and the previous week's energy generation to determine the release for power for the coming week. The development of the operating guides is explained in Exhibit B, Section 3.2.

The operating guides provide power releases as a function of the "expected" discharge for energy. The expected discharges for each week of the year are the discharges which would provide the required Susitna energies, while minimizing the cost of other facilities to meet Railbelt energy demand. To meet this goal Susitna energy production is scheduled in a manner to keep energy generation from thermal plants in the Railbelt constant at one value throughout the winter (October to mid-May) and constant at a different value throughout summer (mid-May through September). This minimizes the cost of building and operating other thermal generating units.

The relationship between the expected discharges and time is a smooth curve with high discharges in winter, low discharges in summer, and gradual changes at transitions. In the simulations, the weekly discharge during operation was set at 63, 80, 100, 120, or 140 percent of the "expected" discharge. The decision on which multiple of expected discharge to use is a function of reservoir storage, time of year, and previous week's discharge. The variation of discharge between two consecutive weeks is limited to 20 percent. However, the limitation can be violated if the discharge must be increased to maintain the Case E-VI minimum flow requirements. Thus, the weekly flow requirement would be met even when the intervening flow between Watana and Gold Creek is very low.

With a given weekly average flow obtained from the long-term operating guide, the short-term operation will be fit to the system load demand within a week given the following environmental constraints:

- The largest allowable discharge at Watana during any given week will be 110 percent of the weekly average discharge.

- The smallest allowable discharge will be 90 percent of the weekly average discharge.

- Watana discharge will be increased above 110 percent of the weekly Watana average in order to maintain the minimum weekly average flow requirements if intervening flows between Watana and Gold Creek decrease during the week and the discharge at Gold Creek is below the minimum weekly flow constraint.

If the average flow for a given week approximates or equals the minimum weekly flow requirements, there may be times during the week when the Gold Creek discharge is less than the minimum weekly flow requirements. This deviation will not exceed 800 cfs.

The following constraints on the hourly rate of change will also apply:

- The maximum allowable rate of change of discharge at Watana will be 10 percent per hour of the weekly average Watana discharge under increasing discharge conditions and 500 cfs per hour when discharge is being reduced.

- The same rates of change of discharge will apply and will be based on the weekly average discharge for the upcoming week when energy production and weekly average flows are being adjusted from one week to the next. The discharge change will occur during the early morning hours of a Sunday or a Monday. The change will be separate from, and in addition to, the 10 percent deviation from the average permitted during the remainder of the week.

(b) Watana and Devil Canyon Operation (***)

In discussion of Susitna Project operation, two time frames are considered. Short-term operation refers to hourly or daily flow variations. Long-term operation refers to weekly or monthly flow variations.

In long-term operation, Watana will be used for seasonal regulation of flow whereas Devil Canyon will be kept as full as possible. The Devil Canyon water level will not be reduced below el. 1,455 unless the release from Watana for power is not enough to satisfy the minimum flow requirement at Gold Creek. Once the Watana release for power is greater than needed to satisfy downstream requirements, Devil Canyon will be refilled immediately.

In short-term operation, hourly discharges from Watana can be varied without restriction because Watana will discharge directly into the Devil Canyon Reservoir. Devil Canyon will act as a re-regulating reservoir to stabilize downstream flows.

Short-term criteria at Devil Canyon in Stages II and III will be similar to those for Watana Stage I as follows:

- The largest allowable discharge at Devil Canyon during any given week will be 110 percent of the weekly average Devil Canyon discharge.

- The smallest allowable discharge will be 90 percent of the average for the week.

- The Devil Canyon discharge will be increased above the 110 percent weekly average flow fluctuation limit in order to maintain the minimum weekly average flow requirements at Gold Creek if intervening flows between Devil Canyon and Gold Creek decrease during the week and the Gold Creek discharge is below the minimum weekly flow constraint.

During a week when the Gold Creek weekly average flow is being maintained at the minimum flow requirement, there may be times when the Gold Creek discharge is less than the minimum weekly flow requirement. This deviation will not exceed 900 cfs.

The following constraint on hourly rate of change will also apply:

- o The maximum rate of change of the powerhouse discharge at Devil Canyon will be 350 cfs per hour whether discharge is being increased or decreased. At a discharge of 9,000 cfs at Gold Creek, a 350 cfs change corresponds to a 0.1 foot difference in stage at Gold Creek.

Devil Canyon powerhouse flow changes will generally be in response to changes in daily average or weekly average energy demand, not hourly demand. During the initial years of Devil Canyon operation the Railbelt system energy demand in the summer during years of high natural inflow may be met by Devil Canyon without operating Watana. It is preferable to use the Devil Canyon powerhouse during these periods to avoid outlet works discharges at Devil Canyon and resulting cooler water temperatures (See Exhibit E, Chapter 2, Section 4.2.3(c)(i)). Therefore, flow changes under these conditions may be in response to hourly demand changes.

3.6.2 - Dam Safety Criteria (***)

If the Watana Reservoir level exceeds the normal maximum operating level, dam safety criteria will supersede both weekly flow constraints and flow stability constraints. Environmental considerations are built into the dam safety criteria as discussed herein. Project operation at Watana will be similar for both Watana operating alone and Watana operating with Devil Canyon once the Watana reservoir reaches or exceeds the normal maximum operating level.

(a) Stage I - Watana Only Operation (***)

If the water level in the Watana I reservoir reaches el. 2,000.0 and continues to rise, Watana discharge will be increased by releasing water through the outlet works. Because the intake to the outlet works is approximately 80 feet below the water surface, operation of the outlet works results in reduced downstream water temperatures. In order to provide for as gradual a change in water temperature as possible, the following guidelines will apply:

- o Supply as much energy as possible from the Watana powerhouse within the constraints of the system energy demand, other generation and Watana powerhouse capacity.

- o Increase the outlet works discharge at the estimated minimum rate required to prevent the water level from exceeding el. 2,000.5. If the inflow to the reservoir is more than 24,000 cfs greater than the powerhouse can discharge, then the release from the outlet works will be 24,000 cfs when the water level reaches el. 2,000.5.

If the outlet works are not releasing water at full capacity and the water level rises above el. 2,000.5, the outlet works will be opened immediately to full capacity. If the full capacity of the outlet works and powerhouse flow are not sufficient to discharge all the inflow the water level will continue to rise.

If the water level exceeds el. 2,000.5 but does not reach el. 2,014.0 then the Watana discharge will remain relatively constant until the water level decreases to el. 2,000.5. If the water level starts to decrease below el. 2,000.5 then the outlet works will be closed in a gradual manner as they were opened. The rate of closure will be that estimated to cause the water level to reach el. 2,000.0 when the outlet works discharge reaches zero. The outlet works will be completely closed before the water level is allowed to decrease below el. 2,000.0.

The outlet works capacity and flood surcharge level have been planned to store and release the 50-year flood without operating the spillway. Thus, there is less than a 1 in 50 chance that in any one year the water level will continue to rise to el. 2,014.0. If the water level reaches el. 2,014.0 and continues to increase, the spillway will be opened. Since spillway operation may increase gas concentrations in the river downstream the spillway will also be opened up as gradually as possible, consistent with providing sufficient freeboard on the dam to meet safety requirements. The powerhouse and outlet works releases will continue as before, and the spillway will be opened at the estimated minimum rate required to prevent the water level from exceeding el. 2,014.3. If the water level reaches el. 2,014.3 and continues to rise, the spillway gates will be opened as much as needed to prevent the water level from increasing any further. As explained in Exhibit F, Appendix F3, the spillway has the capacity to pass the 10,000 year flood at a reservoir level of el. 2014.3. Thus, there is less than a one in 10,000 chance in any year that the water level would exceed el. 2,014.3.

If the reservoir water level reaches el. 2,014.3 and the fully opened spillway, outlet works and powerhouse are insufficient to pass the inflow, the water level will increase uncontrolled. The spillway is designed to pass the Probable Maximum Flood (PMF). The water level would reach approximately el. 2,017, eight feet below the dam crest during a PMF. Watana discharge would not be controlled again until the water level decreased to el. 2,014.3. When this occurs, the spillway will be closed gradually in a manner estimated for the water level to reach el. 2,014.0 when the spillway discharge is zero. The spillway gates will be completely closed before the water level is allowed to decrease below el. 2,014.0.

(b) Stage II - Watana and Devil Canyon Operation (***)

Dam safety criteria at Watana with both Watana and Devil Canyon operating will be similar to Watana only operations when the water level in Watana reservoir exceeds el. 2,000.0, especially in the early years of Devil Canyon operation. However, while Watana reservoir is filling in the spring, and before the water level reaches el. 2,000.0, the Devil Canyon powerhouse will be used to generate most of the system energy demand. Watana still must generate a portion of the energy in order to meet peak energy demands. This policy was adopted for the purpose of minimizing downstream temperature effects of using the Devil Canyon outlet works. When the Watana water level reaches el. 2,000.0, it is necessary to switch energy generation from Devil Canyon to Watana in order to pass the 50 year flood through Watana without using the spillway. The change from the Devil Canyon to the Watana powerhouse would be made in a gradual manner, but in no case would the Watana water level be allowed to rise above el. 2,000.5 without the Watana powerhouse supplying available system energy demands and the Watana outlet works releasing at 24,000 cfs. After the system load is transferred from Devil Canyon to Watana the operation at Watana would be identical to that for Watana only operation.

When the Watana water level reaches el. 2,000.0 Devil Canyon reservoir will be allowed to fill while minimum flow requirements are being met. The Watana and Devil Canyon outlet works and operating policies have been planned so that while the Devil Canyon reservoir is filling, the outlet works will be opened up in a gradual manner estimated to prevent the water level from exceeding el. 1,455.0. When the water level reaches el. 1,455.0, the outlet works will be opened as much as necessary to keep the water level stable. In this period, Devil Canyon will operate as essentially a run-of-river project, passing Watana outflows and intervening flows. The rates of change of Devil Canyon discharge will be similar to those for Watana with small modifications resulting from variations in intervening flow.

Devil Canyon can pass all of the Watana outflows and all intervening flows through its outlet works without using its spillway unless the Watana spillway is operating. As noted in Exhibit E, Chapter 2, Section 4.2.3(a)(iii), the 50-year flood inflow may exceed the capacity of the Devil Canyon outlet works. Therefore, surcharge storage is provided to store the flow in excess of the outlet works capacity. During floods, the Devil Canyon water level will be maintained at el. 1,455.0 until the outlet works is discharging at full capacity. If the inflow exceeds the capacity, the water level will be allowed to increase to el. 1,456.0. In this manner the 50-year flood can be stored and released without operating the spillway. If the water level continues to rise above el. 1456.0, the Devil Canyon spillway must be opened to maintain freeboard on the dam. The chance the spillway would be operated in any one year is less than 1 in 50. The spillway gates will be opened at whatever rate is necessary to keep the pool at this level. As explained in Exhibit F Appendix F3, the spillway has the capacity to pass the 10,000 year flood with the reservoir at el. 1456.0. Thus, there is less than a 1 in 10,000 chance that the Devil Canyon water level would exceed this level in any one year. If the spillway gates were opened completely and the reservoir level continued to rise, discharge from Devil Canyon would be uncontrolled. The Devil Canyon spillway is designed to pass the PMF. The maximum water level obtained during routing of the PMF is el. 1465.6, which is 0.4 feet below the top of the concrete parapet and 4.4 feet below the crest of the rockfill sections of the dam. Control would not be regained until the water level receded to el. 1,455.0. When the water level decreases to el. 1,455.0 the spillway and outlet works will be closed in a manner to keep the water level at el. 1,455.0.

(c) Stage III - Watana and Devil Canyon Operation (***)

Project operation at Watana with both Watana and Devil Canyon operating in Stage III will be similar to Stage II operations. However the normal maximum water level in Watana Reservoir will be el. 2,185 and the flood surcharge level will be el. 2,193. While Watana reservoir is filling in the spring, and before the water level reaches el. 2,185.0, the Devil Canyon powerhouse will be used to meet system energy demands. Watana must still generate a portion of the energy in order to meet peak system energy demands. This policy was adopted for the purpose of minimizing downstream temperature effects of using the Devil Canyon outlet works. When the Watana water level reaches el. 2,185.0, it is necessary to switch energy generation from Devil Canyon to Watana in order to pass the 50-year flood without using the spillway. The change from Devil Canyon to Watana would be made in a gradual manner, but in no case would the Watana water level be allowed to rise above el. 2,185.5 without the Watana powerhouse supplying all available system energy demands and the Watana outlet works releasing at 24,000 cfs. After the system load is transferred from Devil Canyon to Watana, the operation at Watana would be identical to that for Watana only operation.

When the Watana water level reaches el. 2,185, Devil Canyon reservoir will be allowed to fill while minimum flow requirements are being met. While the Devil Canyon Reservoir is filling, the outlet works will be opened up in a gradual manner estimated to prevent the water level from exceeding el. 1,455.0. When the water level reaches el. 1,455.0 the outlet works will be opened as much as necessary to keep the water level stable. In this period, Devil Canyon will operate as essentially a run-of-river project, passing Watana outflows and intervening flows. The rates of change of Devil Canyon discharge will be similar to those for Watana with small modifications resulting from variations in intervening flow.

Devil Canyon can pass all of the Watana outflows and all intervening flows through its outlet works without using its spillway unless the Watana spillway is operating. As noted in Exhibit E, Chapter 2, Section 4.3.3 (a)(iii), the 50-year flood inflow may exceed the capacity of the Devil Canyon outlet works. Therefore, a surcharge storage is provided to store the flow in excess of the outlet works capacity. During floods the Devil Canyon water level will be maintained at el. 1,455.0 until the outlet works are discharging at their full capacity. If the inflow exceeds the capacity, the water level will be allowed to increase to el. 1,456.0. In this manner the 50-year flood can be stored and released without operating the spillway.

If the water level continues to rise above el. 1456.0, the Devil Canyon spillway gates must be opened to maintain freeboard on the dam. The chance the spillway would be operated in any one year is less than 1 in 50. The spillway gates will be opened at whatever rate is necessary to keep the pool at this level. As explained in Exhibit F, Appendix F3, the spillway has the capacity to pass the 10,000-year flood with the reservoir water level at el. 1456.0. Thus, there is less than a 1 in 10,000 chance that the Devil Canyon water level would exceed this level in any one year. If the spillway gates were opened completely and the reservoir level continued to rise, discharge from Devil

Canyon would be uncontrolled. The Devil Canyon spillway is designed to pass the PMF. The maximum water level obtained during a routing of the PMF was el. 1,463.1 which is 2.9 feet below the crest of the concrete parapet wall and 7 feet below the top of the rockfill dam sections. Control would not be regained until the water level receded to el. 1,455.0. When the water level decreases to el. 1,455.0 the spillway and outlet works will be closed in a manner to keep the water level at el. 1,455.0.

When system energy demand increases, the operation to pass floods when the Watana reservoir reaches el. 2,185.0 would differ slightly from the early years of Devil Canyon operation. If the water level at Watana were to rise above el. 2,185.0 it would not be necessary to switch all the energy generation to Watana. Only that generation would be switched which would be necessary to keep the Watana water level from exceeding el. 2,193.0 for the 50 year flood. It is estimated that this requires a Watana powerhouse discharge of 7,000 cfs. Additionally, the increased energy demand means that Devil Canyon would have the capacity to discharge some flow from its powerhouse before it becomes necessary to open the outlet works. The additional Devil Canyon powerhouse flow would make it possible to pass the 50-year flood without surcharging the reservoir.

Overall, operation of the two dams with greater system energy demands will result in more gradual changes in discharge and less chance of outlet works or spillway operation than in the first years of Stage III operation.

3.6.3 - Emergency Situations (***)

Under normal circumstances, the minimum flow requirements at Gold Creek will be maintained at all times unless otherwise agreed to by the appropriate State and Federal agencies. In emergency situations, if powerhouse operation is not possible, outlet facilities will be operated to meet the flow requirements. Correspondingly, if another part of the energy generation system is temporarily lost, Watana and Devil Canyon may be operated to make up the deficit. The resulting discharge variation may exceed the maximum variation rate of 10 percent, and discharge may reach the maximum flow constraint. However, the discharge at Gold Creek will not be allowed to exceed the maximum weekly flow requirement and the rate of change of discharge will be constrained by the rates established in Section 3.6.1 of this chapter.

3.6.4 - Flow Requirement During Filling (***)

The Case E-VI flow requirements will be maintained at all times during filling of the three project stages. If a dry season occurs during filling of Watana Stage I, the requirements may be reduced by 1,000 cfs in order to ensure that the water level in Watana reservoir reaches a level required for testing, commissioning and operation of the units during the winter following the summer of filling. During this winter the minimum flow requirements at Gold Creek will be natural flows rather than the Case E-VI minimum requirements.

3.7 - Power and Energy Production (***)

Based on the hydrology, reservoir operation, and Case E-VI flow requirements described above, power and energy production from the Susitna project have been estimated.

3.7.1 - Watana Stage I (***)

Table E.10.3.15 provides the estimated annual power and energy production from the initial Watana development. The Stage I Project will be operated as a base-load plant because environmental flow constraints limit the project outflow fluctuation to plus or minus ten percent of the average weekly flow. This limitation on discharge fluctuation was established:

- o To avoid large water level fluctuations which may be detrimental to fish,
- o To give the project some flexibility to provide reserve energy capacity and to react to variations in system energy demand,
- o To account for possible inaccuracies in the measurement of discharge which may be on the order of five to ten percent, and
- o To account for variations in the flow from the intervening area between the project sites, Gold Creek and fishery habitat located between Gold Creek and Talkeetna.

The Stage I power output is computed as that capacity which would provide the average monthly energy generation based on a nearly constant release rate for the week (energy = capacity x time). This effectively prevents the Watana Stage I from peaking operation and, hence, avoids undesirable flow fluctuations.

3.7.2 - Watana Stage I with Devil Canyon Stage II (***)

Table E.10.3.15 also provides the estimated annual power and energy production from Watana Stage I operating with Devil Canyon Stage II. When Devil Canyon comes on-line, the Watana project can follow load with Devil Canyon regulating any flow fluctuations. Hence, the power output from Watana can equal the capability of the turbines, which is a function of Watana Reservoir elevation. Since Devil Canyon is the downstream project, it will be operated as a base-load plant, similar to Watana Stage I. The Devil Canyon power output is computed as described above (Section 3.7.1) for Watana operating as a base-load plant.

3.7.3 - Watana Stage III with Devil Canyon Stage II (***)

When Watana Stage III is operating with Devil Canyon Stage II, the additional storage available for flow regulation at Watana increases the energy production of both Watana and Devil Canyon (Table E.10.3.15). Also, two additional turbines are installed at Watana to take advantage of the added head and flow regulation. Watana can follow load, while Devil Canyon will be operated as a base-load plant as discussed above.

3.7.4 - Base-Load and Load-Following Operation (***)

The Applicant has estimated the cost of meeting the Railbelt energy demand utilizing the most downstream powerhouse as a base load plant. This section describes the analyses undertaken by the Applicant to estimate the difference in costs if the constraints on daily flow variation were removed. These costs represent a benefit which has been foregone to meet environmental objectives.

As described in this document, the Watana plant initially would operate as a base-load plant to maintain nearly uniform discharge from the power plant. The Watana powerhouse would also be utilized for spinning reserve, which would require that the discharge vary to some extent but within the constraint of 10 percent of the mean weekly flow. When Devil Canyon comes on line, Watana would change to a peaking operation, while Devil Canyon operates as a base-load plant similar to Watana Stage I.

The least economic cost method of meeting the Railbelt energy demand would be to provide the Susitna project the flexibility to follow loads, regulate frequency and voltage, provide spinning reserve, and react to system needs under all normal and emergency conditions. The project would be dispatched to minimize thermal plant operation and fuel costs. Consequently, the Susitna project output would vary as the system load fluctuates; on an hourly and seasonal basis. This would result in discharge and stage fluctuations downstream of the project which may be detrimental to fish.

To assess the economic impact of base-load versus load-following operation, the power and energy data for the load-following case were input to the OGP model and an economic evaluation was made. The with-Susitna plan, assuming base-load operation of the downstream project, has a 1985 present worth of system costs of $4,823 million. For the same plan, assuming load-following operation, the 1985 present worth of system costs are $4,694 million. The difference of $129 million can be considered as foregone power generation benefits or as mitigation costs for fishery enhancement.

4 - ALTERNATIVE ELECTRICAL ENERGY SOURCES (***)

There are a variety of alternatives to the Susitna Hydroelectric Project that can generate electricity for use in the Railbelt. These alternatives include coal-fired steam plants, simple cycle and combined cycle natural gas combustion turbines, oil or combustion diesel-fired turbines, tidal power, nuclear steam plants, biomass, geothermal, wind, and solar alternatives. In addition, conservation to reduce future energy needs may provide an opportunity to reduce the need for a limited amount of additional generating capacity. Existing electrical generating capacity in the Railbelt is supplied principally by natural gas-fired combustion turbines, with some coal-fired steam and oil-fired combustion turbine, hydroelectric, and diesel installations. More significantly, coal and natural gas are projected to be the primary alternatives to Susitna. Consequently, they are reviewed in detail below.

4.1 - Coal-Fired Generation Alternatives (***)

Based upon the OGP6 model runs, the optimum configuration for a coal-fired steam plant generation scenario consists of six 200 MW power plants. Two of these units would be located in the northern portion of the Railbelt near the existing Usibelli coal mine in the Nenana Coal fields located near the town of Healy. The remaining four units would be sited in the Beluga area to be near the source of fuel.

The following sections give a brief summary of the coal mining and power plant operations, a discussion of the existing environmental characteristics of the mine and plant sites and the potential impacts associated with the development of the power generator facilities, a summary of the environmental controls expected to be utilized for these facilities, and a description of the impacts that are likely to occur even with imposition of the appropriate control technologies.

The coal-fired power scenario discussed below would have significant impacts upon the environment surrounding the mine and power station sites. These impacts would be both short-term and long-term, and they would affect air quality, water quality, terrestrial and aquatic ecology, aesthetics, and socioeconomic conditions. Many of the negative impacts associated with coal plant development can be well controlled through appropriate use of technology, rigorous plant siting efforts, and proper planning. There is a high price associated with these controls. The air quality control system alone is expected to have a capital cost in excess of $50 million for each 200 MW power plant, and this cost amounts to nearly 10 percent of the total capital cost of the unit or over $250 per installed kilowatt. Other environmental controls (e.g., use of wet/dry cooling towers, wastewater treatment systems, landfills for solid waste disposal, mine reclamation activities, and so on) would add significant additional capital and operating costs. For example, the cost for lime for the SO_2 scrubbers at each 200 MW unit is estimated to be about $1,250,000 per year for each unit or $6,250 per installed kilowatt per year per unit. Waste disposal is estimated to cost about $1,814,000 per year for each unit or $9.070 per installed kilowatt per year per unit. These additional costs have been included in the economic analysis of this power generation alternative.

Use of the control techniques outlined above could have a major effect in reducing the negative impacts associated with the development of the coal-fired units, and all applicable regulations may be satisfied. Nevertheless, significant impacts would remain. There would be large-scale land disruptions for both the power plants and mines as well as for transmission corridors, access roads, and other associated developments. Even with employment of highly sophisticated technologies there would be air quality degradation, albeit within allowable limits. Coal mining activities would have a major impact upon the local groundwater regime, and there would be adverse aesthetic impacts associated with siting large buildings and equipment in pristine areas. There would, of course, be positive impacts. The mines and power plants would provide a stable employment base and tax base for affected areas. Electrical power would be made available to the Railbelt at reasonable rates, and natural resources would be utilized to directly benefit the citizens of Alaska.

In summary, there will be both positive and negative impacts associated with this power generation scenario. The negative impacts can be limited to a large extent, but not eliminated, through the use of costly but effective control techniques.

4.1.1 - Description of Alternatives (***)

(a) Coal Mining Operations (***)

The two major coal fields with large economic coal resources in the Railbelt area are the Nenana and Beluga fields. Both fields contain low sulfur subbituminous coal with fairly low heating value. Economically, however, the products of these two deposits differ significantly. A third coal field, the Matanuska field, is fairly small, and its resource potential for surface minable coal will be exhausted by a single 150 MW power plant proposed for that locale.

(i) Nenana Field (***)

At the Nenana coal field, it is assumed that all of the coal for the two northern Railbelt power plants would be mined from expanded operations at the existing Usibelli mine near Healy. Each of the two 200 MW power plants would require 135 tons of coal per hour. The maximum coal demand for the two plants would therefore be 6,500 tons per day. At a design capacity factor of 80 percent, a full-load annual consumption of 1,900,000 tons for the two power plants is anticipated. The coal being mined and shipped from the Nenana Field (Usibelli mine) to the Fairbanks Municipal Utility System has the following characteristics:

o Higher Heating Value	7,600 Btu/lb
o Ash	8.3 percent
o Moisture	26.5 percent
o Sulfur	0.2 percent.

The existing Usibelli coal mine at Healy has stripping ratio of about 3 to 6 tons overburden per ton of mined coal. Assuming that a stripping ratio of 3.8 would apply to expanded operations (Paul Weir Company 1984), the total daily excavation rate for the mine would be 31,200 tons per day for both power plants or 9,120,000 tons per year based upon the 80 percent capacity factor for these units. The following operations would probably take place at the mine:

- o Excavation of overburden and coal seams
- o Stockpiling of overburden
- o Transport of unwashed coal to the processing area
- o Coal washing to remove residual overburden material
- o Landfilling of coal washing wastes back into the mine area
- o Coal blending operations to provide a constant coal quality
- o Loading of coal unit trains
- o Replacement of overburden
- o Reclamation of previously mined areas.

(ii) Beluga Field (***)

The Beluga field is located in the Susitna coal field on Cook Inlet, approximately 50 miles west of Anchorage. The coal resources of the Susitna field are comprised of the Yenta area in the north and the Beluga area in the south. The Beluga area was selected as a site for the coal-fired thermal alternative to take advantage of the coal fields located there. Diamond Alaska Coal Company has taken the initial steps necessary to develop surface mining at the Beluga fields. Opening of the Beluga field is largely dependent upon the penetration of a large, long-term export market for steam coal for the Pacific Rim.

Each of the four coal-fired electric generating units to be built at Beluga will fire approximately 135 tons of coal per hour. When operating at the design capacity factor of 80 percent, a full-load annual coal consumption of 950,000 tons per unit or 3,800,000 tons for the four units is anticipated.

The quality of Beluga coal is comparable to that of Nenana coal. Paul Weir Company (1984) estimates that the average calorific value as-received of this coal is 7,500 Btu/lb. Diamond Alaska estimates the following characteristics:

- Heating Value 7,600-7,700 Btu/lb
- Ash 8 percent
- Moisture 28 percent
- Sulfur 0.2 percent.

The expected overburden stripping ratio is 6.25 tons overburden per ton of coal mined for an 8 million ton per year mine. This will result in a maximum daily excavation rate of 94,000 tons and a maximum annual rate of about 27,500,000 tons to support the four power plants at an 80 percent design capacity factor. The mine will be a surface stripping operation using two draglines with shovel-truck operations for overburden handling. Operations to be conducted at the Beluga area mine will be identical to those already described for Healy.

(b) Coal-Fired Power Plants (***)

The six coal-fired steam electric generating units (four at a Beluga area site and two at Nenana) which make up the coal portion of the thermal alternative will each be 200 MW (nominal net capacity) units. The basic components of the plants at the two sites will be similar. Site specific considerations will be made for foundations, climate, the method of coal receiving (truck at Beluga and train at Nenana), fuel analysis, and pollution control equipment. Each stand-alone plant will consist of two generating units with separate boiler buildings, turbine buildings, air quality control systems, stack, switchyard, and a shared coal system. A single transmission line right-of-way will serve each locale with a separate transmission line for each unit. Each two unit plant site will be approximately 110 acres in area not including off-site landfill for solid waste or transmission line right-of-way.

A more detailed description of the design and operation of the coal plants may be found in Exhibit D, Section 2.5(b).

Plant-specific design, construction, and operating factors which will be of environmental concern are:

During construction (short-term):

- o Clearing, grading, and excavation
- o Potential effluents of operating equipment such as fuel, oil, and engine exhaust
- o Water runoff and erosion
- o Noise
- o Socioeconomic impacts

During operation (long-term):

- o Flue gas emissions
  - Particulate
  - SO_2
  - NO_x
  - CO
  - Water vapor and ice fog (particularly at Nenana)
- o Liquid or water pollutants
  - Altered surface and subsurface drainage patterns
  - Coal pile runoff
  - Building and equipment drains
  - Water treatment effluent

- Demineralizer backwash
- Sewage
- Boiler blowdown
- Cooling tower blowdown

o Solid Waste Disposal

- Bottom ash
- Fly ash
- Demineralizer effluent
- Water treatment sludge
- Overburden spoil

o Noise

o Visual impacts

o Socioeconomic impacts

4.1.2 - Existing Environment and Potential Impacts (***)

(a) Nenana (***)

At Nenana, the proposed general site location is situated in the Nenana River lowlands southwest of the community of Nenana and near the Nenana River about 45 miles west of Fairbanks. This landscape is dominated by the braided river channels of the Nenana and Teklanika rivers that run their course over flat terrain lacking distinctive topographical features. Vegetative cover is characterized by thin to moderately dense spruce forests and muskeg and wetland bog. Views are generally open, north across the river to the forested Tanana hills and to the south, the Alaska Range. The George Parks Highway, connecting Anchorage and the state's second largest population center, Fairbanks, traverses a generally northward course to Nenana across the Nenana River lowlands and then a northeasterly direction to Fairbanks. Existing transmission lines which parallel the highway throughout this entire segment are highly visible. The Nenana River lowlands have been designated as having low aesthetic value with high absorption capability ratings due to its flat, expansive terrain and wide variety of vegetation patterns.

(i) Air Quality (***)

Meteorological conditions in Alaska present distinct problems for siting a large thermal power plant. There is little existing data for Nenana on the ambient air quality. In the absence of any major pollution contributors, it is assumed that the existing air quality is very good. The Nenana region is a Class II Attainment area, but Denali National Park, located about 50 miles southwest of Nenana, is a Class I area. Substantial amounts of data are available for Fairbanks because of the severe air quality problems that occur there during winter months.

The potential for stagnant air conditions may be a major siting constraint for the Nenana region. During the winter, winds tend to be very light or even calm for extended periods, sometimes for several days. In addition, during the winter, extremely strong temperature inversions develop and persist for days. This situation brings about stagnant conditions which greatly inhibit the atmospheric dispersion of pollutants. This concern has been analyzed in great detail for the Fairbanks area (Bowling and Benson 1978). It is likely that for coal-fired units located in this area, temperate zone notions and threshold analyses of atmosphere conditions may not apply.

Table E.10.4.1 shows the mean wind speed and percent occurrence of calm air period for stations located near the proposed sites. At Fairbanks and Nenana, the frequency of occurrence of calm air periods is extremely high during winter months when wind speeds tend to be very light.

Table E.10.4.2 gives a statistical summary of atmospheric surface-based temperature inversions at the Fairbanks airport. The frequency of occurrences of these inversions exceeds 80 percent at both observation times each day during December and January. The data also show that these inversions are quite deep, with an average depth of more than 600 m. The average inversion temperature gradient is over 2.5°C m during these months. This places the average stability classification well within the most stable category considered for diffusion modeling. Under average December/January meteorological conditions, the dispersive power of the atmosphere is extremely poor.

(ii) Terrestrial Ecology (***)

Furbearing animals utilize the riparian vegetation associated with the Nenana and Tenana River drainages (Selkregg 1974, Bechtel 1983b). There is a recorded but currently unused peregrine falcon nesting location near the Nenana coal-fired facility.

Because of the amount of land directly affected by the coal-fired facilities and the coal mines in a region of extensive undeveloped land, the impact of the sites themselves on local wildlife populations would be moderate. Coal mining activities will have impacts similar to but more significant than those of the coal plants themselves. This is due to the large areas of land involved and the major disruptions associated with surface mining.

Approximately 330 acres of spruce woodland and riparian habitat would be lost by the construction of the coal-fired plants at Nenana. In addition, losses associated with coal field activities would total about 900 acres, and additional land would be lost by construction of the transmission right-of-way, access roads, and other facilities.

(iii) Aquatic Ecology (***)

The Nenana field is located near the headwaters of streams that drain into the Kantishna and Tanana rivers. The Nenana River has runs of chinook, coho, and chum salmon (ADF&G 1983a). There is no information available on the size of these runs. Extensive commercial, sport, and subsistence fisheries exist downstream of the confluence of the Nenana and Tanana rivers, and into the lower Yukon (ADF&G 1983b). Potential impacts to regional aquatic environments are dependent on locations of mine expansion and erosion and water quality control measures; however, short-term construction-related impacts and long-term impacts associated with the mining operations and power plant discharges have the potential to create significant adverse effects to the aquatic ecosystem in this area.

(iv) Socioeconomics (***)

The largest settlements near the Nenana coal fields are Nenana, Healy, and Cantwell. Nenana, located about 40 miles north of the existing Usibelli mine, was estimated to have a 1985 population of 573, about one-half of which is Native American. The population is expected to increase to 1,093 by 2000 (Frank Orth

Associates 1985). Healy was estimated to have a 1984 population of 565, and it was expected to increase to 1,025 in 2000. Only about 3 percent of Healy's population was Native American in 1984 (Harza-Ebasco 1985). Healy is located within a few miles of the Usibelli mine. Cantwell, about 30 miles south of the mine, was estimated to have a 1984 population of 192, of which about 20 percent are Native Americans (Harza-Ebasco 1985). The projected year 2000 population for Cantwell is 265.

Employment in this area is provided chiefly by the existing coal mine and by activities related to the railroad.

Of the three communities, only Nenana has an operating local government structure. Schooling (K-12), police protection, and volunteer fire protection is provided in all three communities. Both Nenana and Healy have medical clinics staffed by physician's assistants, but many residents go to Fairbanks or Anchorage for medical care. Only Nenana has public water and sewer systems. The remaining residents of the area utilize private wells and septic systems for water supply and waste disposal.

Nenana and Cantwell have landfills for disposal of solid waste. Transportation is good for all three communities as they are located along the railroad/ highway corridor connecting Fairbanks and Anchorage. More detailed socioeconomic information for this area may be found in Chapter 5 of Exhibit E.

Construction of the power plants and the initial expansion of the mine will likely cause significant socioeconomic impacts in the small communities near the power plant and coal mine sites. The communities would be faced with the temporary need for more educational facilities, medical services, and social services due to the influx of temporary workers during construction.

Operation of the expanded coal mine and the power plants would also have an impact. Expanded medical and educational facilities and social services, as well as permanent housing, would be required. In the long term, a major impact would be a stable employment base for the area.

(b) Beluga (***)

The Beluga coal fields are located approximately 50 miles west of Anchorage on the western side of Cook Inlet. The coal fields are bordered by Cook Inlet on the east and south, the Chackachatna River on the west, and the Beluga River, Beluga Lake, and Capps Glacier on the north (State of Alaska 1972). The topography of the area is dominated by high glaciated mountains dropping rapidly to a glacial moraine/outwash plateau which slopes gently to the sea. The lowland areas are mantled with glacial deposits and overlaid by silt loam. Soils in the southern portion of the area are generally 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. Vegetative cover consists principally of upland spruce-hardwood forest, lowland spruce-hardwood forest, and high brush communities, although about 10 percent of the area is occupied by wet tundra and alpine tundra communities. There are no paved roads or other major transportation facilities in this area.

(i) Air Quality (***)

Air quality in the Cook Inlet and Beluga coal field area is good. The Cook Inlet Air Quality Control Region is designated as a Class II Attainment area for all pollutant criteria. The Tuxedni National Wildlife Refuge, approximately 80 miles southwest of the project area, is a Class I Attainment area for all pollutant criteria. As with the Nenana site, light winds and extended periods of calm would be major siting constraints for coal-fired thermal units in this area. Although very little data are available, it is expected that temperature inversions could exacerbate the stagnant conditions. Conditions are not, however, expected to be as severe as at the inland Nenana site. Wind data for Anchorage, including mean wind speed and percent frequency of calms by month, are assumed to be representative of the Beluga site. Mean wind speeds are greater and the frequency of calms is less than those of the interior stations. In the lowlands near Cook Inlet, the Anchorage data should be fairly representative for screening purposes.

(ii) Terrestrial Ecology (***)

Five major vegetative communities cover the Beluga region. The upland and lowland spruce-hardwood forests collectively account for 75 percent of the area. The high brush community covers 15 percent of the land area in the west central portion of the Beluga district. The wet tundra community occupies 7 percent of the area in the extreme southwest portion and along the eastern boundary, and alpine tundra covers about 3 percent of the area at higher elevations.

Both black and brown bear den in the Beluga area and utilize the Selvon fishery as a food source (CIRI/Placer 1981). 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, and they are found throughout the area during other times of the year (CED 1980). Active nesting sites of bald eagles and trumpeter swans occur on the Chuitna River, and peregrine falcons also have been sighted in the area (CIRI/Placer 1981). The coastal areas are heavily utilized by waterfowl.

The combined four power plants envisioned for the Beluga area would cause long-term disruption of significant land areas. Additional long-term disruption would be caused by the access roads and other site improvements. The Beluga coal mine would permanently disrupt a large area. Potential impacts on the terrestrial ecology could be a major constraint on plant siting.

(iii) Aquatic Ecology (***)

The running water of the Chuitna River and other streams in the area support both resident and anadromous fisheries. The Chuitna River supports all five species of Pacific salmon plus rainbow trout, Dolly Varden, and round whitefish (CED 1980). Nikolai Creek, Jo's Creek, Pitt Creek, and Stedatana Creek are also known to support anadromous fish populations.

The offshore marine environment is also important to commercial and sport fisheries. Four species of salmon and halibut utilize the area and are harvested on a commercial basis, as are herring, shrimp, and crab. Subsistence fishing is also conducted by local Natives, particularly by those from the Tyonek area. Species harvested include clams, bottomfish, salmon, and smelt. Marine mammals present in Cook Inlet include seals, whales, and dolphins. Only the harbor seal and Beluga whale are known to occur in upper Cook Inlet.

Potential impacts of the coal-fired plants and coal mine on portions of the aquatic ecology of the Beluga area would be significant. Short-term construction-related impacts and long-term impacts associated with coal mining operations and power plant discharges could adversely affect streams and the nearshore marine environment.

(iv) Socioeconomics (***)

The only substantial settlement on the west coast of Cook Inlet is Tyonek, inhabited by approximately 270 Tanana Indians. The village is typical of many small villages in Alaska, with high unemployment. Available employment on the west side of Cook Inlet is supplied by three commercial developments: the Chugach gas-fired 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 a 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. A medical center is located in the village of Tyonek. Water is supplied from a nearby lake and wastewater is disposed via septic systems (CIRI/Placer 1981; CED 1980). Transportation facilities in the area are limited to gravel logging roads and small airstrips. Land ownership in the Beluga area is by the State of Alaska, Cook Inlet Region, Inc., Tyonek Native Corporation, and the Kenai Peninsula Borough. Most of the state land in the Beluga coal district is resource management land. One of the designated uses of this land is coal prospecting and leasing and mining permits.

For the Beluga area, the socioeconomic impacts associated with the development of the coal mine and power plants could be significant. The settlements in this area will be faced with the need for more educational facilities, medical services, and social services to cope with short- as well as long-term impacts of new workers associated with mine and plant construction and operation. The Tyonek village has adopted policies and taken actions with the objective of maintaining the Native character of the village with minimal dilution from non-native inhabitants. An extensive development in the area will require special consideration of the character and location of its work force if Tyonek is to retain its Native distinction.

4.1.3 - Environmental Controls (***)

(a) Air Quality (***)

Coal-fired power plant emissions must comply with Federal New Source Performance Standards (NSPS) (40 CFR 60, Subpart Da). The maximum allowable emissions for power plants burning low sulfur, subbituminous coal are as follows:

- Particulates: 0.03 lbs/10^6 Btu heat input
- SO_2: 70 percent SO_2 removal
- NO_x: 0.50 lbs/10^6 Btu heat input.

The power plants would also be subject to Prevention of Significant Deterioration (PSD) review by the ADEC. The PSD review would consist of the following steps:

1. PSD increments represent the difference between background air quality conditions and the Alaska ambient air quality standards. In effect, the PSD increment for each pollutant represents the amount of air quality deterioration that can be tolerated. Very little deterioration is tolerable in pristine Class I) areas such as national parks whereas a higher level of deterioration would generally be tolerated in less sensitive areas. The Applicant must conduct a detailed air quality analysis to show that the worst-case emissions would not cause exceedences of either the PSD increments or the Alaska ambient air quality standards (see Table E.10.4.3). The only PSD Class I areas that could be affected by power plants in the Nenana and Beluga

areas are Denali National Park and the Tuxedni National Wildlife Refuge.

2. A Best Available Control Technology (BACT) analysis must be conducted to show that the facility will include the most efficient pollutant control devices that are economically feasible. Although no BACT analyses have been conducted for coal-fired power plants in Alaska, the BACT emission rate may be well below the NSPS limit for SO_2. For those areas currently within the Alaskan ambient air quality standards ("attainment" areas), the BACT analyses will consider the type of source, past BACT analyses for comparable sources, and energy and economic penalties associated with the emissions control measures. It should be noted that an individual BACT analysis must be conducted for each pollutant, and that BACT requirements can be quite different for individual pollutants from the same source. For facilities to be located in areas which currently exceed the Alaska ambient air quality standards ("nonattainment" areas), no consideration is given to the energy or economic penalties associated with pollution control. In these nonattainment areas, Lowest Achievable Emission Rate (LAER) control technology will be required for new sources. LAER is more stringent and costly than the NSPS or BACT, and additional costs may be incurred to reduce emissions from current pollution sources to provide offsets for the new source emissions. Due to the very high costs of achieving compliance in nonattainment areas, it is generally most cost-effective to locate new sources in attainment areas.

3. The National Park Service (NPS) has the authority to conduct an independent review of potential visibility reduction in Denali National Park that would be caused by emissions from any proposed industrial facility. The NPS can advise the state agency to deny the PSD permit for any proposed facility based solely upon predicted visibility degradation. The NPS is currently drafting their own guidelines for evaluating visibility impacts in the national parks. The NPS evaluation procedures could prove to be a major constraint on power plant siting.

4. Fugitive dust emissions from the power plants would be subject to PSD review. Fugitive dust impacts could not exceed the allowable PSD increments. The fugitive dust would be considered to be "secondary

emissions" associated with the power plant operations. Since the power plants would be PSD sources, their fugitive dust emissions would also be a PSD source. The fugitive dust emissions from the Nenana coal field mine would probably not be subject to PSD review, so the mine dust emissions would have to satisfy only the Alaska ambient air quality standards. The mine operations would only be subject to PSD review if there were a major stationary point emission source such as a diesel generator. It is likely that the Nenana field mine would use line electrical power; however, the Beluga field mine may use its own electric generation plant. If so, this mine would be subject to PSD review.

Although exact requirements for control of air emissions cannot be established at this time, a very high level of control was assumed. The sulfur content of the coal to be fed to these units is very low (0.2 percent). Nevertheless, an SO_2 removal efficiency of 75 percent has been assumed through the use of dry scrubbers. This removal efficiency is the highest possible removal achievable with current technology (Schweiger and Hayes 1985). A high efficiency baghouse with a removal efficiency of 99.9 percent would also be employed. Again, this unit approaches the highest removal rates possible with current technology (Schweiger and Hayes 1985). The capital costs for these air emission controls are projected to amount to nearly 10 percent of the total plant cost or over $50 million for each 200 MW unit. It is assumed that these technologies will be capable of meeting the emissions limits established by the above procedures. Emission rates, both uncontrolled and controlled, for each 200 MW power plant are estimated to be as follows:

200 MW POWER PLANT EMISSIONS

	Particulates	SO_2	NO_x
Uncontrolled			
lb/Btu x 10^6	9.05	0.528	0.502
lb/hr	37,200	2,168	2,064
tons/year[1/]	130,000	7,600	7,230
ppm	13,200	769	732
Controlled			
lb/Btu x 10^6	0.0091	0.132	0.502
lb/hr	37.2	542	2,064
tons/year[1/]	130	1,900	7,230
ppm	13.2	192	732

One additional air quality consideration not addressed by these regulations is the potential for the formation of ice fog caused by water vapor emissions from the stack or cooling tower of the power plant. As shown in Table E.10.4.4, ice fog is a frequent problem in the Fairbanks area. It might be difficult to obtain permits for a power plant in locations where ice fog would affect local communities. The coal-fired plants described could use wet/dry cooling towers. During winter conditions when the potential for ice fog formation is greatest, the cooling towers could have a minimum of water vapor emissions. Additionally, the stack gas will be reheated as necessary and practical to reduce ice fog formation from the flue gas plume. Contending with this problem may impose a significant additional fuel cost on winter operation. In any event, in order to obtain an Alaska air quality permit, the plant operator would have to demonstrate that the water vapor emissions would not frequently cause ground level fogging near critical areas such as airports and highways.

1/ Assumes design capacity factor of 80 percent.

(b) Water Quality and Quantity (***)

It can be expected that all point source discharges will meet federal New Source Performance Standards and other regulations of the federal Water Pollution Control Act. However, due to the high quality of water in the streams in the impacted areas, even permitted discharges may result in noticeable impacts. Also, due to the seasonal fluctuation of flows in these areas, the impacts of sedimentation and other water quality effects may be increased (Battelle 1978).

The use of wet/dry cooling towers will reduce the quantities of water needed for plant processes. Despite this fact, consumptive water use will increase due not only to direct plant requirements but also due to the increased water consumption associated with construction activities and population increases. It is anticipated that these additional water needs will be met using groundwaters and that there will be little impact upon surface water hydrology.

(c) Noise (***)

Noise emissions from the mining and power plant activities would be controlled to meet the U.S. EPA noise guideline levels.

(d) Solid Waste (***)

All solid wastes generated at the coal-fired power plants would be disposed of at an off-site landfill in compliance with all applicable Alaska waste management regulations and Federal Resource Conservation and Recovery Act requirements. To ensure compliance with the regulations, the disposal area will be lined with an impermeable synthetic liner. Once an area has been completed, it will be covered with topsoil and reseeded to minimize leachate and dust related problems.

Surface mine spoils will be regraded to restore the mine site to approximate original contours. Restored areas will be reseeded to minimize the potential for wind and water erosion and to reduce percolation of precipitation through the spoils.

(e) Terrestrial Impacts (***)

Although it will be impossible to avoid all adverse impacts associated with land use changes, many impacts can be controlled through proper development and implementation of appropriate sediment and erosion control plans for access roads, site drainage, coal pile runoff, and other similar activities.

4.1.4 - Resulting Environmental Impacts (***)

The expected environmental impacts of the proposed two 200 MW coal-fired plants at Nenana and four 200 MW coal-fired plants in the Beluga area, together with associated mining impacts, were studied. It was assumed that the control technologies or policies outlined in the previous section would be employed.

Hypothetical power plant sites near Healy and Beluga were assumed to show the impacts that would be caused by power plants in the area. The impacts of the Nenana field and Beluga field mine operations were also investigated.

(a) Nenana (***)

(i) Air Quality (***)

The plant location assumed for the air quality modeling study was hypothetical and was selected only to demonstrate the possible air quality impacts of a plant located in this area. No actual siting studies were conducted to establish the optimum plant locations. Maximum 24-hour and 3-hour air quality impacts were assessed in the elevated terrain surrounding the hypothetical site. The simplified VALLEY screening calculation was used to estimate the worst case impacts (Environmental Protection Agency 1977). That screening calculation assumes that the wind blows directly towards the elevated terrain at 2.5 meters/sec wind speed during poor atmospheric dispersion conditions, and with a persistence of 6 hours per day. The methodology used here provides only a preliminary estimate for planning purposes. A much more detailed study would be required for regulatory purposes. Projected emissions characteristics from the Nenana units are shown in Table E.10.4.5.

The annual average concentrations at Nenana were calculated using the wind rose for the Nenana airport. The COMPLEX I computer model was utilized to perform the calculations.

The calculated worst case air quality impacts of the hypothetical Nenana plant are summarized in Table

E.10.4.6. Calculated SO_2 isopleths (lines of equal concentration) for the plants are shown graphically in Figure E.10.4.1. Because the existing background pollutant concentrations are very low, compliance with PSD increments would be much more constraining than would compliance with ambient air quality standards. Based upon the assumed control of particulate, SO_2, and NO_x emissions, the Nenana plants would not cause exceedences of any air quality parameters. Particulate levels are very low in comparison to the allowable PSD Class II increments, and the calculated worst-case 24-hour SO_2 impact is 38 ug/m^3 compared to the allowable PSD Class II increment of 91 ug/m^3. In addition, emissions from the Nenana plants would probably not cause exceedences of the PSD Class I increments in Denali National Park.

Fugitive dust emissions from the power plant operations could be a significant siting constraint. Worst-case 24-hour dust emissions were calculated assuming a dry, windy day with BACT fugitive dust controls being applied as appropriate. It was assumed that the winds blew down-valley for six hours during the day at 2.5 meters/sec, with F-class stability. The fugitive dust was assumed to be generated in a 200 m x 200 m area. Results were adjusted to account for dust fallout based on measurements at coal loading facilities. The calculated emission rate for the 400 MW power station was 940 lbs/day. Assuming natural dust mitigations by snow cover and rainfall, the overall annual fugitive dust emission rate should be approximately 172 tons per year. The calculated worst case fugitive dust impacts near the Nenana power plants are shown in Figure E.10.4.2. Under the assumed worst case conditions, the maximum 24-hour fugitive dust emissions would exceed the allowable Class II increment for all locations within approximately 1.0 km of the center of the facility. As shown in the figure, the worst case annual dust concentrations are not expected to exceed the allowable PSD increment.

The coal mine would probably not be a PSD source and would therefore not have to meet the PSD Class I or Class II increments; however, as shown in Figure E.10.4.3, the calculated annual average dust concentrations would exceed the allowable Alaska 24-hour ambient limit of 150 ug/m^3 for all areas within approximately 1.0 km of the mine center. The annual standard of 60 ug/m^3 would not be exceeded beyond the hypothetical 1.0 km limit of the mine. Assumptions were similar to those for the power plant modeling, except that the fugitive dust was assumed to be generated in a 1 km x 1 km area. These calculations were based upon a worst case 24-hour fugitive dust emission rate of 2,240 lbs/day. Assuming natural mitigations by snow cover and rainfall, the calculated overall annual average fugitive dust emission rate is 250 tons per year. Because of the high expected rate of particle fallout, the fugitive dust concentrations from the Nenana area mine at the Denali National Park boundary are expected to be well below the Alaska ambient air quality limits.

(ii) Noise (***)

The noise impacts of the coal mine blasting, continuous mining operations, coal unit trains, and the power plants were estimated using realistic worst case assumptions. An existing background noise level of 30 decibels was assumed, with an EPA noise guideline level of 55 decibels assumed to represent the area of greatest impact. All calculations were based upon flat terrain, with no noise attenuation by topography or foliage. Considering the complex terrain around the mine site, these assumptions should result in conservatively high calculated noise levels; however, extreme meteorological conditions could affect the levels presented by as much as 20 decibels in either direction. The results of the analyses are as follows:

- Blasting noise from the Nenana field coal mine could be audible in some parts of Denali National Park under worst-case conditions, but this impact is not expected to be severe. The blasting noise would occur daily, but would be limited to durations of only a few seconds and recurrence intervals of several hours. Assuming a source noise level of 83dBA at 5,000 feet distance (Foch 1980) with winter conditions of 10°F and 70 percent humidity and summer conditions of 70°F and 70 percent humidity, the 55dBA noise level would occur at a distance of about 6 miles from the mine center under winter conditions or 5 miles from the mine center under summer conditions.

- The continuous mining noises would affect a large area in the immediate vicinity of the existing mine. The 55dBA level would occur at about 2 miles from the mine center under worst-case winter conditions assuming a source noise level of 104 dBA at 50 feet distance.

- The power plants would create long-term local noise impacts, but the noise level would be low and the impact area small. The calculated noise levels are below the 55dBA limit at all locations beyond 900 meters (about 1/2 mile) from the plant center.

(iii) Aesthetics (***)

The potential aesthetic impacts of the coal mine and the power plants were considered. The results of the aesthetic impacts evaluations are as follows:

- Although exact locations for the coal-fired plants have not been established, the high visual absorption capabilities of the Nenana landscapes are likely to lessen the visibility of the plant structures. The effectiveness of the landscape's visual absorption capabilities will be directly related to the proximity of the plant facilities and ancillary structures to important viewpoint locations. Much of the visual impact can be controlled through proper plant siting; however, the sunlight reflective capabilities of some of the plant structures will contribute significantly to the degree of visual impact experienced by potential viewers of the plant site. Also, the visibility potential of the stacks, transmission lines, and possibly cooling towers is likely to be very high.

- Visual impacts created by plume emissions are less restricted to site-specific parameters and are likely to be experienced by a greater number of viewers and for longer periods of time than visual impacts relating to actual plant structures and associated facilities. Visibility analyses showed that, based upon comparison of calculated visibility impairment indicators with the "significance levels" established by the EPA for specific indicators, the plume from the Nenana power plants would not cause any significant degradation in Denali National Park. The vista looking north or south (along the plume) would not be significantly discolored by emissions from the plant. The integral vista from Savage River looking toward Mt. Deborah would not be significantly affected.

(iv) Water Quantity and Quality (***)

The water quality impacts of the coal mining operations and the power plants would be long term. The predicted effluents from a typical 200-MW power plant are shown in Table E.10.4.7. The estimated impacts are as follows:

- The power plants would require long-term water supply sources, but these sources would most likely be groundwater-based; therefore, there will be little or no measurable impact of these withdrawals on surface water hydrology.

- The power plants would continually discharge treated wastewater to receiving streams, but these discharges would be controlled through compliance with applicable state and federal regulations. As a result, although there may be measurable long-term changes in water quality, these changes would not be expected to have a substantial adverse impact. More site specific information is needed to accurately predict the precise impacts of the power plant discharges on stream quality. Residues from the treatment of process and waste waters would be disposed in an off-site landfill.

- Although surface runoff from the coal mining operations can alter the hydrology, chemistry, and sediment load of receiving waters, technologies are available and will be used to control these impacts. Nevertheless, some minor impacts can be expected. Again, until more site specific information is developed, the precise extent of these minor impacts cannot be determined.

- The coal mining operations would cause long-term and possibly irreversible groundwater impacts in the immediate vicinities of the mines due to disruptions of geohydrologic conditions. Aquifer flow patterns and chemistry would be likely to be affected, but the significance of these impacts cannot be assessed without detailed hydrologic studies of the specific mine sites. It is unlikely that these groundwater resources would be tapped for future use.

(v) Terrestrial Ecology (***)

The predicted disruption caused by the Nenana power plants is shown in Table E.10.4.8. The two coal-fired power plants and associated mines would create long-term disruption of approximately 1,200 acres. Additional long-term terrestrial disruption would be caused by the access roads and other associated improvements. Potential impacts on the terrestrial ecology would be a major constraint on the power plant and mine siting at this location.

(vi) Aquatic Ecology (***)

The potential short and long-term impacts of the access roads, coal mine, and the power plants would be a major constraint on the thermal power alternatives, but the facilities could be designed to avoid potential significant impacts on endangered or sensitive species, anadromous fish spawning grounds, and benthic organisms.

(vii) Socioeconomic Impacts (***)

Construction and operation of the power plants could cause significant socioeconomic impacts in the small communities near the power plant sites. The communities could be faced with the need for more educational facilities, medical services, and social services due to the influx of temporary workers during the power plant construction and to the presence of permanent employees once the plants are operational. On the other hand, the construction projects, mines, and operating plants will provide stable long-term employment for the affected communities.

(b) Beluga (***)

(i) Air Quality (***)

For this study, the Beluga units were assumed to be roughly one mile north of Carlson Lake. The plant location assumed for the air quality modeling study was hypothetical and was selected only to demonstrate the possible air quality impacts of a plant located in this area. No actual siting studies were conducted to establish the optimum plant locations. Maximum 24-hour and 3-hour air quality impacts were assessed in the elevated terrain surrounding the hypothetical sites. The simplified VALLEY screening calculation was used to estimate the worst case impacts (EPA 1977). That screening calculation assumes that the wind blows directly towards the elevated terrain northeast of the site at 2.5 meters/sec wind speed during poor atmospheric dispersion conditions, and with a persistence of 6 hours per day. The methodology used here provides only a preliminary estimate for planning purposes. A much more detailed study would be required for regulatory purposes. Projected emissions characteristics from these units are shown in Table E.10.4.5.

For the Beluga site, wind data and stability classes for Anchorage were used to approximate conditions at the plant. It should be noted that the hypothetical Beluga plant site is located at an elevation of about 1,000 feet whereas Anchorage is nearly at sea level. Use of Anchorage meteorological data will not, therefore, yield highly accurate results; however, this is the closest weather station for which long-term data are available. The use of this information is expected to yield more conservative ("worse") results than would actual field data collected at the hypothetical power plant site. A modified gaussian dispersion model was utilized to perform the calculations.

The calculated worst case air quality impacts of the hypothetical Beluga plant are summarized in Table E.10.4.9. Calculated SO_2 isopleths for the plants are shown graphically in Figure E.10.4.4. Again, due to the low background pollutant concentrations, compliance with PSD increments would be much more constraining than would compliance with the ambient air quality standards. Based upon the assumed plant locations, environmental factors, and emissions controls for particulates, SO_2, and NO_x, the Beluga plants would not cause exceedences of any air quality parameters. However, the calculated SO_2 impacts would be significant. For example, the calculated worst-case 24-hour SO_2 impact is 91 ug/m^3, which is roughly equal to the allowable PSD Class II increment. The calculated worst-case 3-hour SO_2 impact of 196 ug/m^3 is over 38 percent of the allowable PSD Class II increment, and the calculated worst-case annual average impact of 4.5 ug/m^3 amounts to 23 percent of the allowable PSD Class 11 increment. A more detailed modeling effort, with better emissions and plant configuration data as well as better atmospheric data, will likely allow a reduction in this impact.

As with the Nenana area plants, fugitive dust emissions from the power plant operations could be a significant siting constraint. Worst-case 24-hour dust emissions were calculated assuming a dry, windy day with BACT fugitive dust controls being applied as appropriate. Assumptions similar to those for the Nenana plant were utilized. The calculated emission rate for the four 200 MW power plants was 1,880 lbs/day. Assuming natural dust mitigations by snow cover and rainfall, the overall annual fugitive dust emission rate should be approximately 340 tons per year. The calculated worst case fugitive dust impacts near the Beluga power plants are shown in Figure E.10.4.5. Under the assumed worst case conditions, the maximum 24-hour fugitive dust emissions would exceed the allowable Class II increment for all locations within approximately 2.0 km of the center of the facility. As shown in the figure, the worst case annual dust concentrations are not expected to exceed the allowable PSD increment.

The coal mine would probably not be a PSD source and would therefore not have to meet the PSD Class I or Class II increments; however, as shown in Figure E.10.4.6, the calculated annual average dust concentrations would not exceed the allowable Alaska annual ambient limit of 60 ug/m^3 for areas outside beyond 2.0 km of the mine center.

The 24-hour limit of 150 ug/m^3 would be exceeded within about 3.0 km of the mine center. These calculations were based upon a worst-case 24-hour fugitive dust emission rate of 4,670 lbs/day.

Assuming natural mitigations by snow cover and rainfall, the calculated overall annual average fugitive dust emission rate is about 524 tons per year.

(ii) Noise (***)

The noise impacts of the coal mine blasting, continuous mining operations, coal unit trains, and the power plants are comparable to those described for the Nenana site:

- The continuous mining noises would affect a large area in the immediate vicinity of the existing mine.

- The power plants would create long-term, low-level local noise impacts, affecting a limited area around each facility.

(iii) Aesthetics (***)

The potential aesthetic impacts of the coal mine and the power plants were considered. The results of the aesthetic impacts evaluations are as follows:

- Although exact locations for the coal-fired plants have not been established, the high visual absorption capabilities of the Beluga landscapes are likely to lessen the visibility of the plant structures. The effectiveness of the landscape's visual absorption capabilities will be directly related to the proximity of the plant facilities and ancillary structures to important viewpoint locations. Much of the visual impact can be controlled through proper plant siting; however, the sunlight reflective capabilities of some of the plant structures will contribute significantly to the degree of visual impact experienced by potential viewers of the plant site. Also, the visibility potential of the stacks, transmission lines, and possibly cooling towers is likely to be very high given the high intrinsic visual quality of the Beluga landscapes.

- Visual impacts created by plume emissions are less restricted to site-specific parameters and are likely to be experienced by a greater number of viewers and for longer periods of time than visual impacts relating to actual plant structures and associated facilities.

(iv) Water Quantity and Quality (***)

The water quality impacts of the coal mining operations and the power plants would be long term. The predicted effluents from a typical 200 MW power plant were shown in Table E.10.4.7. The estimated impacts are expected to be similar to those delineated for the Nenana plants.

(v) Terrestrial Ecology (***)

As was shown in Table E.10.4.8, the Beluga area coal mine, power plants, access roads, and other improvements would permanently disrupt as much as 2,400 acres. Potential impacts on the terrestrial ecology would be a major constraint on the power plant and mine siting at each location.

(vi) Aquatic Ecology (***)

The potential short and long-term impacts of the access roads, coal mine, and the power plants would be a major constraint on the thermal power alternatives, but the facilities could be designed to avoid potential significant impacts on endangered or sensitive species, anadromous fish spawning grounds, and benthic organisms.

(vii) Socioeconomic Impacts (***)

Socioeconomic impacts similar to those described for the Nenana site will be experienced in the Beluga area; however, the impacts would be likely to be more severe due to the limited transportation facilities and smaller population of the Beluga area. The addition of permanent employment to this area will, however, provide positive socioeconomic impacts.

4.2 - Thermal Alternatives Other Than Coal (***)

There are a wide variety of alternate fuel sources that can be used in thermal power stations including petroleum-related fuels, nuclear, biomass, geothermal, and solar. Due to their similarities, thermal alternatives using petroleum-related fuels will be discussed in this report section. Other thermal and nonthermal alternatives will be discussed separately.

4.2.1 - Natural Gas-Fired Thermal Alternatives (***)

(a) Natural Gas Supply (***)

Natural gas resources currently or potentially available to the Railbelt region include the Cook Inlet reserves and the North Slope (Prudhoe Bay) proven resources. The Cook Inlet reserves are estimated to be 4.5 Tcf, with a total field size of 8 Tcf proven plus unquantified, undiscovered reserves. Gas reserves in the Kenai Peninsula and Cook Inlet region presently exceed demand since no major transportation system to export markets currently exists; however, there is one operating liquified natural gas (LNG) terminal exporting LNG to Japan. A second facility converts gas to urea for export to the U.S. west coast and foreign markets. The facilities consume 115 billion cubic feet per year. A complete discussion of natural gas availability in Alaska is contained in Appendix D-1.

(b) Description of Alternatives (***)

There are two related natural gas-fired technologies considered feasible for the Railbelt region of Alaska. These are simple cycle combustion turbines and combined cycle combustion turbines. These two alternatives are described below in summary form. A more detailed description may be found in Exhibit D, Section 2.4.

(i) Simple Cycle Combustion Turbine Plants (***)

Simple cycle gas combustion turbines added to the Railbelt's generating capacity as part of the thermal alternative will be constructed at existing partially developed plant sites.Each Simple Cycle Combustion Turbine (SCCT) plant will consist of three large-frame, industrial-type gas-fired combustion turbine generators with a total plant output of 262 MW. The plant will have a net operating range from 26 MW (30 percent load for a single unit) to 262 MW. The plant will require approximately a five-acre site, not including the transmission line right-of-way.

The plant major and auxiliary systems include the natural gas fuel system, water injection system, lubrication system, starting and cooldown system, inlet and exhaust system, waste control system, and fire protection system.

Specific factors which will be of environmental concern are:

During construction (short-term):

- o Clearing, grading, and excavation
- o Potential effluents of operating equipment such as fuel, oil, and engine exhaust
- o Water runoff
- o Noise

During operation (long-term):

- o Turbine exhaust
  - SO_2
  - NO_x
  - CO
- o Liquid and water pollutants
  - Storm drains
  - Building and equipment drains
  - Demineralizer backwash
  - Sewage
  - Water treatment effluent
- o Solid waste disposal
  - Demineralizer effluent
- o Noise
- o Visual impacts

(ii) Combined Cycle Combustion Turbine Plants (***)

Like the single cycle plants, combined cycle plants added to the Railbelt system will be located at existing generating sites. The Combined Cycle Combustion Turbine (CCCT) 230 MW power plant incorporates two large-frame, industrial-type natural gas-fired combustion turbine generator sets each exhausting into a waste heat recovery steam generator (HRSG) to generate high pressure steam for the steam turbine generator set. The plant's major equipment consists of two combustion turbine generators, two heat recovery steam generators, one steam turbine generator, switchyard and transmission line, an air-cooled condenser, and a complete feedwater system.

Specific factors of environmental concern will include all of those listed for the SCCT plant in Section 4.2.1(b)(i) as well as the following:

- o Boiler blowdown
- o Increased demineralizer effluents.

(c) Existing Environment and Potential Impacts (***)

Although the simple and combined cycle gas-fired thermal units could be sited in a variety of locations throughout the Railbelt, it is assumed for the purposes of this analysis that all of the gas-fired units will be located at existing sites such as the Chugach Electric Association's Beluga plant or on the Kenai Peninsula.

The Beluga area was chosen as being typical of the potential location for the gas-fired power plant sites. The topography of this area is dominated by high glaciated mountains dropping rapidly to a glacial moraine/outwash plateau which slopes gently to the sea. The lowland areas are mantled with glacial deposits and overlaid by silt loam. Soils in the southern portion of the area are generally 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. Vegetative cover consists principally of upland spruce-hardwood forest, lowland spruce-hardwood forest, and high brush communities, although about 10 percent of the area is occupied by wet tundra and alpine tundra communities.

(i) Air Quality (***)

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

Light winds and extended periods of calm would be major siting constraints for gas-fired thermal units in this area. Table E.10.4.1 illustrates the light wind conditions prevailing at Anchorage. Although very little data are available, it is expected that temperature inversions could exacerbate the stagnant conditions. Conditions are not, however, expected to be as severe as the Nenana site.

(ii) Terrestrial Ecology (***)

Upland and lowland spruce-hardwood forests account for much of the vegetative cover in the areas envisioned for siting the gas-fired power plant. High brush and tundra are also present to a significant degree. Black bear and brown bear den in these areas and utilize the existing fisheries as a major food source (CIRI/Placer 1981). A major fall and winter concentration of moose occurs in the high brush community in the west central portion of the Beluga area near the Chuitna River, and they are found throughout the area during other times of the year (CED 1980). Active nesting sites of bald eagles and trumpeter swans occur in these areas, and peregrine falcons also have been sighted (CIRI/Placer 1981). The coastal areas are heavily utilized by waterfowl. The gas-fired power plants will each occupy sites of about 5 acres in size, but will impact far larger areas due to transportation requirements, transmission line rights-of-way, and plant emissions.

(iii) Aquatic Ecology (***)

The running water of the Chuitna River and other streams in the area support both resident and anadromous fisheries. The Chuitna River supports all five species of Pacific salmon plus rainbow trout, Dolly Varden, and round whitefish (CED 1980). The offshore marine environment is also important to commercial and sport fisheries. Four species of salmon and halibut utilize the area and are harvested on a commercial basis, as are herring, shrimp, and crab. Subsistence fishing is also conducted by local Natives, particularly by those from the Tyonek area. Species harvested include clams, bottomfish, salmon, and smelt. Marine mammals present in Cook Inlet include seals, whales, and dolphins. Only the harbor seal and Beluga whale are known to occur in the upper Cook Inlet.

Potential impacts of the gas-fired plants on the aquatic ecology of the Beluga area are not likely to be significant. Short-term construction related impacts and long-term impacts associated with power plant discharges could adversely affect streams and the nearshore marine environment, although discharges from gas-fired generating units are normally minimal. The long-term operating emissions may even be zero if required.

(iv) Socioeconomics (***)

The only substantial settlement on the west coast of Cook Inlet is Tyonek. The village and its socioeconomic characteristics were previously described in Section 4.1.2(b)(iv).

The socioeconomic impacts associated with the construction of the gas-fired power plants could be significant, but since these plants will be located near existing facilities, these impacts will be less significant than if the plants were built at greenfield sites. The settlements in this area will still be faced with the need for more educational facilities, medical services, and social services to cope with short- as well as long-term impacts of new workers associated with plant construction and operation, but these impacts are not expected to be severe.

(d) Environmental Controls (***)

(i) Air Quality (***)

Emissions from gas-fired power plants must comply with the NSPS in 40 CFR 60, Subpart GG, Section 60.332(a)(1). That section limits NO_x emissions to a variable limit that is based on fuel nitrogen and the heat rate of the turbine. For the simple cycle combustion turbine plant with a heat rate of 12,000 Btu/kWh, the allowable NO_x emissions can vary from 0.0085 to 0.0135 percent by volume of the exhaust gases, depending upon the fuel-bound nitrogen content of the feed gas. For the combined cycle plant with a heat rate of 9,200 Btu/kWh, the allowable NO_x emission can vary from 0.0111 to 0.0161 percent by volume of the exhaust gases. The natural gas expected to be used for the Beluga area plants is estimated to have a nitrogen content of 2.1 percent, so the higher of the emission limits listed above would apply. The NSPS also allows the water injection NOx controls to be discontinued during periods of ice fog, provided that the increased NO_x emissions would not cause exceedences of the air quality standards.

The gas-fired power plants would, like the coal-fired plants, also be subject to Prevention of Significant Deterioration (PSD) review by the ADEC. The PSD review would consist of the following steps:

1. The applicant must conduct a detailed air quality analysis to show that the worst-case emissions would not cause exceedences of either the PSD increments or the Alaska ambient air quality standards (see Table E.10.4.3). The only PSD Class I areas that could be affected by power plants in the Nenana and Beluga areas are Denali National Park and the Tuxedni National Wildlife Refuge.

2. A Best Available Control Technology (BACT) analysis must be conducted to show that the facility will include the most efficient pollutant control devices that are economically feasible. The BACT analysis must address site specific economic and engineering aspects of each individual facility. BACT for NO_x control for gas-fired turbine generators in Alaska is currently considered to be by steam injection. There are indications that more stringent NO_x controls could be required in the future. The BACT analysis can also include consideration of carbon monoxide (CO) emissions. This may be important if the gas-fired units are located near Anchorage because Anchorage is an existing nonattainment area. If, once precise locations for the plants are established, it is determined that CO would adversely affect the nonattainment area, then the plants might have to be relocated. Alternately, the plant owners could develop CO emission offsets.

   Although ozone could also be considered in a BACT analysis, there are presently no ozone nonattainment areas in Alaska. The gas-fired units would not emit significant levels of ozone, so no controls would be anticipated.

3. The National Park Service (NPS) has the authority to conduct an independent review of potential visibility reduction in Denali National Park that

would be caused by emissions from any proposed industrial facility. The NPS can advise the state agency to deny the PSD permit for any proposed facility based solely upon predicted visibility degradation. The NPS is currently drafting their own guidelines for evaluating visibility impacts in the national parks. The NPS evaluation procedures be a major could prove to constraint on power plant siting.

4. Few fugitive dust emissions would be associated with the operation of a natural gas-fired power plant, except those occurring during construction of the plants and pipelines. The activities would not be subject to PSD review unless there were a major stationary point emission source.

Although exact requirements for control of air emissions cannot be established at this time, it can be stated that, in general, gas-fired plants are very clean burning and that existing technologies are fully capable of meeting the anticipated emissions limitations.

The formation of ice fog caused by water vapor emissions from the stack of the power plant could be a major siting constraint for these power stations. Although the NSPS allows water injection NO_x controls to be discontinued during periods of ice fog, the ADEC will probably not issue an air quality permit until the plant operator demonstrates that the water vapor emissions would not cause frequent ground level fogging near critical areas. While it might be difficult to obtain permits for a power plant in locations where ice fog would affect local communities, the CCCT gas-fired plants described would use an air-cooled condenser and the SCCT would have no cooling needs, thereby minimizing the potential for ice fog formation.

(ii) Water Quality and Quantity (***)

It can be expected that all point source discharges will meet federal New Source Performance Standards and other regulations of the federal Water Pollution Control Act. It should also be noted that, since gas-fired plants generate such small quantities of wastewater, it may be possible, especially for the SCCT plants, to truck all wastewaters off-site for treatment at municipal waste treatment facilities, thereby eliminating any surface water discharges at the power plant sites. Short-term construction-related impacts can be well controlled using available technologies to detain stormwaters and remove sediment from runoff.

The use of an air cooled condenser and no cooling towers for the SCCT plants will reduce the quantities of water needed for plant processes. Despite this fact, consumptive water use will increase due not only to direct plant requirements but also due to the increased water consumption associated with construction activities and population increases. It is anticipated that these additional water needs will be met using groundwaters. There should be little impact upon surface water hydrology.

(iii) Noise (***)

Noise emissions from the power plant activities are expected to meet the U.S. EPA noise guideline levels.

(iv) Solid Waste (***)

Solid wastes generated at the gas-fired power plants would be minimal and would be removed to an approved disposal site in compliance with all applicable Alaska waste management regulations and federal Resource Conservation and Recovery Act requirements.

(v) Terrestrial Impacts (***)

Although it will be impossible to avoid all adverse impacts associated with land use changes, many impacts can be controlled through proper development and implementation of appropriate sediment and erosion control plans for access roads, site drainage, and other similar activities.

(e) Resulting Environmental Impacts (***)

(i) Air Quality (***)

Gas-fired power plants emit particulate matter in the form of unburned carbon; however, the particulate emission rates from gas-fired power plants are significantly less than the allowable regulatory emission limits. Pollution control devices to limit particulate emissions from those types of power plants are not usually required. Similarly, the sulfur content of the natural gas is below the level where pollution control devices are effective or required.

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. The principal strategy involves control of combustion temperatures (lower combustion temperatures retard formation of NO_x) through steam or water injection.

The controlled NO_x emissions from the gas-fired units are reduced through water injection to a point where they will not exceed the ambient air quality standard for NO_x. Projected emission rates for the units would be 0.0115 percent by volume versus an allowable emission rate of 0.016 percent by volume. However, if any of the power plants were located near industrial areas, then NO_x emissions could increase ambient NO_x concentrations enough to limit future industrial growth near the power plant.

As noted earlier, the Anchorage CO nonattainment area could influence the locations of the gas-fired power stations if a BACT analysis reveals that the plant emissions will have a significant adverse effect upon this area. Alternately, the plant owners could develop CO emission offsets by paying for CO emission reductions at other industrial facilities so as to balance the increased CO emissions caused by operation of the new power plants. It is anticipated that the final locations for the plants will be established to avoid the need for CO emission offsets.

(ii) Noise (***)

The noise impacts of the gas-fired thermal plants would be restricted to the vicinity of the plant except for short-term impacts associated with construction of the plant and the electric and gas transmission lines. Since the new plants would be located near existing facilities, adverse impacts would be minimized.

(iii) Aesthetics (***)

Location of the new power plants near existing facilities will reduce the aesthetic impacts of the power plant structures. The most visible features of these units are likely to be the stacks, the transmission lines and corridor, and the plumes emitted from the stacks. Impacts of the structures will be localized, but the plumes could be visible from a number of viewpoints in and around the Anchorage area. The effectiveness of visual absorption capabilities will be directly related to the proximity of the plant facilities to important viewpoint locations.

Visibility analyses conducted for a Beluga area plant location revealed that emissions from the gas-fired power plants would cause insignificant visibility impacts. Based upon the results of these analyses, the plume would not be perceptible to an Anchorage observer looking down Cook Inlet.

(iv) Water Quantity and Quality (***)

Only minimal water quantity or quality impacts would be associated with the SCCT plant. Since this is not a steam cycle plant, water use requirements are small, and wastewater generation is minimal. It may be possible to eliminate the direct discharge of any wastewaters from the SCCT plant by hauling the wastes to a municipal wastewater treatment facility for treatment and disposal. The CCCT plants would use more water and generate more wastewater due to the introduction of a steam cycle unit (exhaust gas heat recovery boiler). However, these additional wastes could be readily treated to achieve compliance with state and federal regulations. While there may be some measurable impact upon water quality, the impact of these gas-fired units on water quality would be small. Since groundwater would be used as a feed source for these plants, hydrologic impacts would not be significant. Exploration and drilling for gas supplies could affect groundwater quality as well as surface water quality, but these impacts can be well controlled through proper well design, installation, and operation.

(v) Terrestrial Ecology (***)

The gas-fired power plants would cause long-term disruption of about 5 acres for the power generating facility itself plus additional disruptions for the electric and gas transmission lines, access roads, and other improvements. It is expected that only the short-term construction-related impacts would be significant, even though they will be controlled through implementation of appropriate technology.

(vi) Aquatic Ecology (***)

Although construction activities could produce significant adverse effects upon fish spawning grounds, benthic organisms, and other areas, the facilities can be designed to avoid or lessen these impacts. Over the long term, the minimal wastewater discharges from the power plants would not be expected to create significant adverse impacts upon freshwater aquatic resources; however, drilling activities could have a significant impact upon both fresh and marine water systems. These impacts can be controlled through proper well design and operation.

(vii) Socioeconomic Impacts (***)

Construction of the power plants would cause significant short-term socioeconomic impacts if the plants were built near small communities such as Tyonek. These communities would be faced with the need for more educational facilities, medical services, and social services due to the influx of temporary construction workers. Permanent employees at the power station would cause a low level, long-term impact upon these resources; however, the plants will also provide stable, long-term employment for the affected communities.

4.2.2 - Oil-Fired Thermal Alternative (***)

Alaska has very large crude oil reserves relative to its internal needs, and the technology for generating electricity from oil via direct combustion or via a steam cycle plant is well established. Refining capacity is currently about 25,000 barrels per day, with home heating oils, diesel, and jet fuels, the primary products. Much of the installed generating capacity of the Fairbanks Municipal Utility Systems is fueled by oil. Thermal generating stations in Anchorage use oil as a standby fuel only. The chief constraint to the use of oil as a fuel is not availability but price. The price of oil dictates that Alaska may receive greater economic benefits through export of this high priced commodity with internal consumption of lower cost fuels or energy sources.

There are a number of short- and long-term impacts associated with the use of oil-fired thermal systems. Air emissions could include particulates, sulfur dioxide, nitrogen oxides, carbon monoxide, unburned hydrocarbons, water vapor, noise, and odors. most of these emissions can be controlled through proper plant siting and design, as well as the use of appropriate pollution control technologies. Potential sources of water quality impacts are the cooling system blowdown, demineralizer wastes, fuel oil releases, and miscellaneous cleaning wastes, as well as sulfur and nitrogen oxides which have the potential to affect the acidity of rain, snow, and dry fallout. Again, these impacts can be minimized or eliminated through use of technologies. Additional impacts would be similar to those described for other thermal alternatives, e.g., construction activity impacts, hydrologic impacts, land use, and aesthetic impacts. More details may be found in the February, 1983 License Application (APA 1983b).

4.2.3 - Diesel-Fired Thermal Alternative (***)

There are a number of diesel-fired generation plants in use, but nearly all are standby (emergency) units or peaking generation equipment.As with fuel oil, the major restriction to the use of diesel as a fuel source is cost rather than availability, although refining capacity is currently limited.

Environmental considerations for the diesel-fired thermal alternative would be the same as those for the fuel oil-fired thermal alterative. Short-term construction-related impacts, air and water emissions, and impacts upon hydrology, land use, and aesthetics would be the primary considerations. The February, 1983 License Application contains more details concerning this alternative power generation scheme (APA 1983b).

4.3 - Tidal Power Alternatives (***)

Tidal power generation basically involves impounding water at high tide level and converting the head difference between the corresponding basin and the ebbing tide to electricity via low head hydraulic turbines. The most appropriate and available sites for supplying tidal power to the Railbelt occur along Cook Inlet. Initial studies of Cook Inlet tidal power development (Acres 1981b) have concluded that generation from tide fluctuation is technically feasible, and numerous conceptual schemes ranging in estimated capacity from 50 MW to 25,900

MW have been developed. Studies conducted for the Governor's office (Nebesky 1980) have indicated that three sites in particular are best suited for tidal power development. These sites are Rainbow, Point MacKenzie/Point Woronzof, and Eagle Bay/Goose Bay, and they cross either the Turnagain Arm (Rainbow) or Knik Arm. The key problem with these and other tidal power schemes is that the power generation is cyclic (corresponding to the 12 hour 25 minute lunar cycle) that, without some means of retiming the energy output via pumped storage or some other means, only a fraction of the potential energy production could be used and the costs of power produced by such developments would not be competitive.

Environmental effects of a tidal power scheme would be both short- and long-term and would involve impacts associated with construction activities and alteration of the tidal regime and estuarine hydrology. Indirect effects related to site access and, potentially, to the construction of a causeway across the tidal barrier may also be significant. The short-term effects associated with construction activities would include the following:

- Changes in topography and in rates of erosion and sedimentation due to site development and development of construction materials sources;
- Disturbance of benthic habitats due to dredge and fill activities;
- Wildlife disturbance due to noise-producing equipment and human activities; and
- Water quality impacts due to construction and dredging activities.

Long-term effects would be primarily related to changes in hydrologic characteristics and would include the following:

- Reduction of both high and low tidal extremes within the basin;
- Increase in the mean tide level within the basin;
- Changes in mud flats and marshlands within the basin due to water level effects;
- Backwater and flooding effects due to imposition of the tidal barrier;
- Altered salinity patterns within the basin;
- Changes in current patterns and velocities within and outside of the tidal barrier;

- o Changes in rates of sedimentation and erosion within and outside of the tidal barrier;
- o Changes in turbidities and, indirectly, in biological productivity due to the net decrease in mixing energy within the basin; and
- o Increased traffic noise and human access to wetland areas due to improved site access.

If a causeway were built across the tidal barrier, additional long-term impacts would be expected due to the improved access to areas now separated by the inlet. A more complete discussion of tidal power alternatives and their effects can be found in the February, 1983 License Application (APA 1983b).

4.4 - Nuclear Steam Electric Generation (***)

Nuclear steam power generation involves the use of a highly refined form of enriched uranium as a heat source to produce steam, which is in turn used to drive steam turbines to generate electricity. Available nuclear units are large (ca. 1,000 MW) and as such are not well suited to the extended modest demand growth rates expected for the Railbelt. Despite the well-developed nature of this technology in the U.S. and throughout the world, nuclear power is presently suffering from a number of social and political problems that may affect its viability. 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 (APA 1983b). The State of Alaska's policy on nuclear power is expressed in legislation establishing the Alaska Power Authority. The Power Authority may not develop nuclear power plants.

Due to their large size, nuclear stations would have a number of short-term and long-term environmental effects. The short-term effects would be those associated with the construction of a large power station. Long-term impacts would include those related to the large amounts of heat rejected by a 1000 MW plant. Once through cooling of such a facility would almost certainly dictate a coastal site, whereas closed cycle cooling would allow siting along a major river. In either case, site access will be critical due to the need to transport large quantities of construction materials, including some heavy and bulky equipment. Additional long-term impacts associated with nuclear steam power generation include spent fuel storage, reprocessing, or disposal activities, routine low-level discharge of radionuclides, aesthetic impacts if closed cycle cooling towers are employed, and the low probability risk of accidenta release of higher level radionuclides.

The February, 1983 License Application (APA 1983b) contains a more detailed discussion of the nuclear power alternative.

4.5 - Biomass Power Alternatives (***)

Biomass in various forms can be used as a fuel for a steam cycle electric generating plant. Biomass plants are distinct from fossil-fired units in that maximum plant capacities are relatively small. In addition, biomass plants have specialized fuel handling requirements. The generally accepted capacity range for biomass-fired power plants is approximately 5 to 60 MW (Bechtel 1983). The moisture content of the fuel, as well as the scale of operation, introduces thermal inefficiencies into the power plant system (APA 1983b). Biomass fuels that may be available in the Railbelt include municipal solid waste from the cities of Fairbanks and Anchorage, wood residue from small sawmills, and peat. Volumes of municipal waste have been estimated for the Anchorage area (Nebesky 1980), but little information is available concerning the availability of wood residue. Peat deposits are substantial, but many other fuels are available which compete economically with peat. The estimated supply of both wood and municipal waste in greater Anchorage would only be sufficient to support a 19 MW power plant operating 24 hr/day. This represents only about 1 percent of the projected future power needs of the region.

The environmental effects of a biomass plant would be similar to those from other comparably sized steam cycle plants. Significant impacts on ambient air quality could occur, largely due to the emission of particulates and nitrogen oxides. Particulates could, however, be controlled through use of techniques such as baghouses or electrostatic precipitators. Short-term impacts associated with construction activities can generally be well controlled. Long-term impacts, aside from air emissions, would be associated with cooling water usage and habitat loss, as well as aesthetic considerations. Additional details of the biomass option may be found in the February, 1983 License Application (APA 1983b).

4.6 - Geothermal Power Alternatives (***)

Only two types of geothermal resources which could be used for electric power generation have been identified in the Railbelt. These are hot dry rock and low temperature, liquid-dominated hydrothermal convection. 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 (APA 1983b). Hydrothermal liquid-dominated systems may be subdivided into two types, low enthalpy and high enthalpy. Low enthalpy systems may be useful for direct high applications, but only high enthalpy systems can be seriously considered for use in power generation. Steam recovered from the high enthalpy fluid is used to drive turbines to produce electricity. Geothermal plants must be located near the geothermal resource. No detailed information is available concerning the geothermal properties of those systems which have been identified. The environmental effects of geothermal resource development an particularly of hydrothermal resource development will depend to a large extent upon the characteristics of the geothermal fluid and the disposal method for this fluid. These fluids are typically saline and can contain carbon dioxide, hydrogen sulfide, ammonia, methane, boron, mercury, arsenic compounds, fine rock particles, and radioactive elements. Control of the contaminants can be achieved through reinjection, but it may not be possible to reinject all fluids that are extracted. Other impacts associated with development of geothermal resources are similar to those for other steam cycle plants. Short-term construction-related impacts, improved access to remote areas, habitat loss, and socioeconomic impacts can be expected. In addition, although the geothermal plant site would be comparable in size to other steam cycle plants, the lands needed for the well field may be much larger due to the diffuse location of the wells. Also, these lands would tend to be located in more remote areas than other steam cycle plants, so wildlife disturbances could be greater. The February 1983 License Application contains a more detailed discussion of the potential for geothermal exploitation (APA 1983b).

4.7 - Wind Conversion Alternatives (***)

Electrical energy may be extracted from wind using small or large wind systems. Small systems have rated outputs≡7 per machine of 100 kW or less, and they are typically sited in a dispersed manner to provide power to individual residences or small communities. Large wind turbines have rated capacities in excess of 0.1 MW and are typically assembled into "wind farms" to provide sufficient energy to be useful in a regional power supply system. Siting is critical to the success of wind energy conversion systems. The most important site characteristics are average wind speed and variability. The University of Alaska conducted a preliminary assessment of wind power potential in Alaska. The results of these studies identified several potentially favorable sites, but a significant database and much more detailed information would be needed to properly assess wind energy resources in the Railbelt. The Anchorage and Fairbanks areas are specifically not suitable for wind conversion systems due to the generally calm winds experienced by them.

Wind turbines generate no air or water emissions, so the key environmental effects of such systems would be related to construction activities (short-term impacts) and habitat loss or disruption. Most potential wind energy sites are located in remote areas, so there is a potential for significant disturbance of wildlife populations. Microclimate impacts will be similar to those noted around large isolated trees or tall structures. The rotation of the turbine blades could cause radio, TV, or microwave interference, but these impacts can be avoided through judicious siting. Because these systems are often located on ridgetops and other high visibility areas, they can have a major impact upon aesthetics. A more detailed discussion of wind energy conversion systems may be found in the February, 1983 License Applicants (APA 1983b).

4.8 - Solar Energy Alternatives (***)

The two methods available for converting solar energy to electrical energy are photovoltaic systems and solar thermal conversion. Photovoltaic systems convert sunlight directly to electricity by the activation of electrons in photosensitive substances. Solar thermal systems convert solar radiation to heat in a working fluid, and the working fluid is then used to drive a turbine. Both technologies are advancing rapidly, but at the present time neither system is cost-competitive with more conventional technologies except in isolated cases. In Alaska, both systems suffer from the seasonal and diurnal variation in solar flux. Cloud cover and precipitation add uncertainties even when the solar flux is at a maximum. The diurnal and annual cycles are out of phase with the Railbelt energy demand, which peaks in winter and at night; therefore, solar energy resources can only be viewed as a "fuel saving" option or they must be installed with adequate energy storage capacity.

Photovoltaic systems have little or no impacts on air or water resources. The chief environmental considerations associated with their use are habitat loss, wildlife disruption, and aesthetics. Solar thermal systems have the same considerations for the collectors. In addition, considerations similar to those for any other steam cycle plant can be important. Solar thermal systems may also be operated with a working fluid other than water, and such fluids could, through normal system flushing or accidental releases, adversely affect water quality. One additional consideration that could be applicable to either system is the water resource impacts associated with pumped storage facilities if they were used for energy storage. More details on the potential use of solar energy to meet Railbelt power needs may be found in the February, 1983 License Application (APA 1983b).

4.9 - Conservation Alternatives (***)

Energy conservation involves the reduction in the use of energy rather than the generation of additional energy. In 1980 the Alaska State Legislature promulgated A.S. 42.05.141(7)(c) which requires the Alaska Public Utilities Commission (APUC) to promote conservation in establishing electric rates. Since this provision was enacted in 1980, the APUC has attempted to promote conservation when establishing a new rate design for an electric utility. The APUC did tentatively adopt regulations in March of 1984 which established pricing objectives which include conservation as one of five objectives. Conservation was given no greater nor lesser weight than the other four pricing objectives set out in the tentative regulations. Historically, the APUC has not approved radical conservation measures which would have a pronounced impact on consumer usage.

Although significant savings can be realized through use of appropriate conservation strategies, there will remain a need for additional energy sources over the long term due to the projected growth in the population and economy of the State of Alaska. It has been estimated (Battelle 1978) that for a combined Railbelt region, between 1,950 and 3,230 MW of new generating resources may be required before the turn of the century.

Energy conservation is an environmentally attractive alternative for reducing the magnitude of future energy needs. It has generally positive effects upon air and water resources since they are used or degraded less than would be the case without conservation. Similarly, impacts upon terrestrial and aquatic ecosystems as well as upon the socioeconomic fabric of the region would be lessened through use of conservation alternatives.

5 - ENVIRONMENTAL CONSEQUENCES OF LICENSE DENIAL (***)

As detailed in Exhibit B of this License Application, demand for power in the railbelt area will increase over the foreseeable future. Thus, should this License Application be denied, either the State of Alaska or the private and investor-owned utilities would have to pursue other power development projects. As previously detailed in this chapter, these projects would likely include some combination of thermal power projects and other hydroelectric developments. The FERC identified a combination of thermal and hydroelectric power developments in the Draft Environmental Impact Statement of May 1984 (FERC 1984) as being the most likely alternative. These are:

- o One 200-MW coal-fired unit,
- o Three or four 200-MW combined-cycle gas units,
- o Three 70-MW gas-fired combustion turbine units,
- o The Johnson Hydroelectric Site,
- o The Browne Hydroelectric Site,
- o The Keetna Hydroelectric Site,
- o The Snow Hydroelectric Site, and
- o The Chakachamna Hydroelectric Site.

Sections 1 and 4 of this chapter present a detailed analysis of the environmental consequences of the development of these alternatives. This analysis clearly demonstrates that the combined environmental impacts of these alternatives would be substantially greater than those predicted for the Susitna Project and would be spread over a much larger portion of the state, thus contributing to the incremental and cumulative impacts in a number of river basins undergoing other development and/or resource use stress. This includes the critically important Kenai River Basin, perhaps the state's most important recreation river.

To reiterate briefly, the major environmental impacts associated with development of these alternative projects include:

- o Inundation of almost 125,000 acres of habitat (versus 60,860 for Susitna);

- o Disruption of the migratory paths of chum, sockeye and coho salmon by placement of dams and reservoirs on the Snow, Johnson, Browne, Keetna and Chakachamna sites;

- o Complete inundation of two small rural communities (Dot Lake and The Living Word) at the Johnson site, necessitating forced relocation of over 260 people;

- o Disturbance of nesting sites of the endangered peregrine falcon;

- Inundation of approximately 29 miles of major highway, 10 miles of railroad and 16 miles of transmission line at the Browne and Johnson sites;

- Potential disruption of navigation and commerce on the Tanana and possibly the Yukon Rivers;

- Air quality degradation from coal-fired thermal units and aesthetic impacts due to highly visible smokestacks at Denali National Park, one of the United States' premier wilderness areas; and

- An increase in ice fog problems associated with any thermal units located in the interior region of the state.

In Exhibits B and D, the Applicant has measured the economics of the Susitna Project against the long-term, least-cost alternative. In that analysis the least-cost alternative is shown to be a combination of coal-fired facilities and gas-fired facilities. The major environmental impacts associated with development of this alternative generation scenario include:

- Air quality degradation through increased SO_2 and No_x emissions, even after the Best Available Control Technology has been applied;

- Increased fugitive dust and particulate emissions, potentially in areas adjacent to Denali National Park;

- Visibility impacts at national parks and monuments from fugitive dust, particulates and emissions' stack and cooling tower plumes;

- Water quality degradation from surface runoff at coal mines which will negatively impact anadromous fish streams;

- Increased noise emissions from coal mining operations in fragile ecosystems;

- Solid waste disposal problems for hazardous combustion and emissions' control facility by-products;

- Visual impacts from surface mining scarring and power plant siting;

- Irreversible groundwater impacts at coal mine locations;

- Ice fog impacts from locating thermal facilities in northern areas; and

- Terrestial, wildlife and aquatic impacts attributable to right-of-way construction for transmission lines, coal-haul roadways, or gas pipelines to and from remotely located facilities. (Air quality and ice fog constraints will generally require remote siting of large thermal facilities).

The cumulative, and often irreversible and unmitigable, environmental impacts of development of the least-cost alternative generation scenarios are believed to be much greater than the impacts of the Susitna Project.

Furthermore, the Susitna Project would cost $2 billion less than the combined thermal/hydroelectric alternative and would have substantially more capacity than would this alternative.

In contrast, the environmental benefits gained from not building the Susitna Project are largely confined to the upper Susitna Basin where the impoundment areas, access road, and transmission line corridors would remain in their natural state. These largely wilderness areas, although not heavily utilized for any purpose except big game hunting at present, and otherwise not particularly exceptional by Alaskan standards, do include substantial wildlife habitat (see Chapter 2). This area would remain in an unaltered state for the immediate future should Susitna not be developed. Public access would remain limited and established wildlife patterns would remain undisturbed.

Similarly, the flow alterations and thermal regime modifications to the river downstream of the Susitna Project would not occur should the license not be granted. However, the fisheries benefits to be gained from this retention of natural conditions are less obvious than is the case for wildlife. As detailed in Chapters 2 and 3 of this Exhibit, tradeoffs exist for the anadromous fish resource, as the Susitna Project would provide warmer winter water temperatures, reduced summer turbidities and flood flows, and increased flow stability, all beneficial to the fish populations downstream of the project. When combined with protective mitigation measures for the critical slough habitats in the middle river, improvement in the quality of fish habitat resulting from the project can, in fact, be demonstrated. Thus, the main fisheries benefits to be gained from not building Susitna would be accrued by the resident populations of grayling and rainbow trout in the tributary streams draining into the Susitna River in the impoundment area. These stream habitats would not be lost by inundation by the reservoir. Additionally, other stream habitats in the basin would be protected from impacts associated with access road and transmission line construction, and access to and use of the fish populations in these streams would be reduced.

Few, if any, socioeconomic benefits would occur if the Susitna Project is not built. Without the project, the related population in-migration forecast for Local Impact Area communities would not occur. The community having the greatest population growth removed, as a percentage increase over baseline, would be Cantwell. The subsequent project-related demand for public facilities and services in this and other communities would be avoided.

However, the hydro and thermal alternatives that would be built instead of Susitna would have greater socioeconomic impacts. The alternatives' impacts would be greatest for the small communities of Healy and Nenana (Browne site), Tok, Tanacross, Dot Lake, The Living Word, and Delta Junction (Johnson site), Seward (Snow site), Tyonek (Chakachamna site), and Talkeetna and Trapper Creek (Keetna site). Construction of the alternatives would produce impacts in each of these 11 communities that would be at least as great as those experienced in the single community of Cantwell with the Susitna Project. In addition, as previously mentioned, the communities of Dot Lake and The Living Word would be inundated by the Johnson Reservoir.

Denial of the License Application for the Susitna Hydroelectric Project would avoid impacts to the 248 cultural resource sites identified within or adjacent to the Susitna Basin inundation and construction areas as well as to a number of cultural resources expected to occur along the rights-of-way for project transmission lines, access roads, and railroad. Alternate scenarios for power generation, however, involve inundation of almost twice as much land at the Susitna Project. While the number of cultural resources located in these areas is not presently known, the abundance of biological resources, particularly anadromous fish, combined with ethnohistoric and prehistoric dependence on these resources suggest that a large number of cultural resource sites would be impacted.

Furthermore, cultural resource studies during the past five years in the Susitna Basin area have established a firm foundation for identifying significant sites and planning for proper treatment to mitigate adverse effects on them, benefitting the scientific study of these resources as well as making contribution to Native heritage. Without additional time to study lands involved in alternate scenarios, adverse effects to cultural resources would be significant.

6 - REFERENCES

Acres American Inc. 1980. Plan of Study. Susitna Hydroelectric Project. Prepared for the Alaska Power Authority.

_____. 1981a. Susitna Hydroelectric Project, Development Selection Report. Prepared for the Alaska Power Authority.

_____. 1981b. Preliminary Assessment of Cook Inlet Tidal Power, Phase 1 Report. Prepared for the State of Alaska, Office of the Governor.

_____. 1982a. Susitna Hydroelectric Project, 1980-81 Geotechnical Report, Appendix F. Prepared for the Alaska Power Authority.

_____. 1982b. Access Route Recommendation Report. Prepared for the Alaska Power Authority.

_____. 1982c. Susitna Hydroelectric Project, Feasibility Report Volume 1. Prepared for the Alaska Power Authority.

Acres American Inc./Terrestrial Specialist Inc. 1982. Transmission Line Selected Route. Prepared for the Alaska Power Authority.

Alaska Department of Fish and Game. 1983a. Anadromous Waters Catalogue. Division of Habitat Protection.

_____. 1983b. Annual Management Report 1983 - Yukon Area. Division of Commercial Fisheries.

_____. 1984a. Susitna Hydro Aquatic Studies Report No.1: Adult Anadromous Fish Investigations, May-October, 1983. Prepared for Alaska Power Authority, Anchorage, Alaska.

_____. 1984b. Susitna Hydro Aquatic Studies Report No. 2: Resident and Juvenile Anadromous Fish Investigations, May-October, 1983. Prepared for Alaska Power Authority, Anchorage, Alaska .

_____. 1984c. Susitna Hydro Aquatic Studies Report No.4: Access and Transmission Corridor Aquatic Investigations, July-October 1983. Prepared for the Alaska Power Authority.

_____. 1985. Susitna Hydro Aquatic Studies, Report No. 6: Adult Salmon Investigations (May-October 1984). Prepared for Alaska Power Authority, Anchorage, Alaska. 157 pp.

Alaska Department of Natural Resources. 1985. Susitna Area Plan. Anchorage, Alaska.

Alaska Power Authority. 1983a. Susitna Hydroelectric Project FERC License Application, Project No. 7114-000. Vol. 6a, Exh. E, Chapter 3. 190 pp.

_____. 1983b. Susitna Hydroelectric Project, FERC License Application. Project No. 7114-000. Vol. 9, Exh. E. Chapter 10, Alternative Locations, Designs, and Energy Source.

_____. 1984. Alaska Power Authority Comments on the Federal Energy Regulatory Commission Draft Environmental Impact Statement of May 1984, Volume 4, Appendix II, Evaluation of Non-Susitna Hydroelectric Alternatives.

_____. 1985. Susitna Hydroelectric Project, Staged Construction Pre-Filing Consultation Package. Filed with FERC May, 1985. FERC Project No. 7114.

Battelle Memorial Institute. 1966. Joint Frequency Data Summarized from Tape Deck TD1440 (NOAA) by Pacific Northwest Laboratory, Richland, WA.

Battelle Pacific Northwest Laboratories. 1978. An Analysis of Future Requirements and Supply Alternatives for the Railbelt Region. Prepared for the Alaska Division of Energy and Power Development, Department of Commerce and Ecomonic Development, and the Alaska Power Authority, Anchorage, Ak.

Bechtel Civil and Minerals Inc. 1983a. Chakachamna Hydroelectric Project. Interim Feasibility Assessment Report. Prepared for Alaska Power Authority.

_____. 1983b. Chakachamna Hydroelectric Project, Interim Feasibility Assessment Report. Vol. II, Appendix to Section 6.0, and Environmental Appendices A1-A5. Alaska Power Authority, Anchorage, Alaska.

Bell, M.C. 1984. Personal communication. Private Consultant. Letter to D. Beyer, Harza-Ebasco, June 25, 1984.

Bethel, J., D. Briggs, L. Garay, S. Gessel, W. Kitto, W. Lake, A. Rossi, G. Schreuder, D. Tillman, L. Zuller. 1979. Energy from Wood. A report to the U.S. Congress, Office of Technology Assessment. College of Forest Resources. University of Washington, Seattle, Washington.

Billelo, M.A. 1966. Survey of Arctic and Subarctic Temperature Inversion. U.S. Army Material Command, Cold Regions Research and Engineering Laboratory. October, 1966.

Bowling, S. and C. Benson. 1978. Study of the Subarctic Heat Island at Fairbanks, Alaska.

Commerce and Economic Development, Division of Energy and Power Development. 1980. Alaska Regional Energy Resources Planning Project Phase 2 - Coal, Hydroelectric and Energy Alternatives Volume 1. Beluga Coal District Analysis.

Cook Inlet Region Inc. and Placer Amex Inc. 1981. Coal to Methanol Project, Final Report, Vol IV. Environmental.

Environmental Protection Agency. 1977. Guidelines for Air Quality Maintenance, Planning and Analysis. Vol. 10. EPA 450/4-77-001. October 1977.

E.W. Trihey & Associates. 1985. Susitna Hydroelectric Project, Response of Aquatic Habitat Surface Areas to Mainstem Discharge in the Talkeetna to Devil Canyon Reach of the Susitna River, Alaska. Prepared for Harza/Ebasco Susitna Joint Venture, Anchorage, Alaska.

Frank Orth & Associates. 1985. Documentation Report for the Susitna Hydroelectric Project. Socioeconomic Impact Model. Prepared for the Alaska Power Authority, Anchorage, Ak.

Federal Energy Regulatory Commission. 1984. Susitna Hydroelectric Project, FERC No. 7114-Alaska. Draft Environmental Impact Statement.

Foch, J.D. 1980. Technical Report on Sould Levels in Bryce Canyon National Park and the Noise Impact on the proposed Alton Coal Mine. Noise Technical Center, University of Colorado, October 1980.

Harza-Ebasco Susitna Joint Venture. 1984. Evaluation of Alternative Flow Requirements. Final Report. Prepared for Alaska Power Authority, Anchorage, Alaska. 55 pp.

_____. 1985. Household Survey Report. Prepared for the Alaska Power Authority, Anchorage, Alaska.

International Conference of Building Officials. 1980. Plan Review Manual. Whittier, California. 269pp.

International Engineering Company and Robert W. Retherford Associates. 1979. Anchorage-Fairbanks Transmission Intertie, Economic Feasibility Report.

Mosley, M.P. 1982. Analysis of the Effect of Changing Discharge on Channel Morphology and Instream Uses in a Braided River, Ohau River, New Zealand. Water Resources Research. 18(4): 800-812.

National Oceanic and Atmospheric Administration. 1979. Climatography of the United States No. 90 (1965-1974) Airport Climatological Summary for the Anchorage and Fairbanks International Airports. National Climatic Center, Ashville NC.

Nebesky, W. 1980. An Economic Evaluation of the Potential for Recycling Waste Materials in Anchorage, Alaska. Prepared for the Institute of Social and Economic Research.

Post, A. and L.R. Mayo. 1971. Glacier Dammed Lakes and Outburst Floods in Alaska.

R & M Consultants Inc. 1982a. Subtask 2.10 - Access Planning Studies. Prepared for Acres American Inc.

_____. 1982b. Subtask 2.10 - Supplementary Access Planning Studies. Prepared for Acres American Inc.

Schweiger, Bob and A. Hayes (ed.) 1985. Reliability Concerns, Regulations Lead to Virtual Standardization of Air Pollution Control Systems. Power, 129(4): 81-93 (April 1985).

Selkregg, L.L. (editor). 1974. Alaska Regional Profiles - South-Central Region. Arctic Environmental Information and Data Center, Anchorage, Alaska. 255 pp.

State of Alaska. 1972. Knik Arm Highway Crossing. Department of Highways, Anchorage, Alaska.

U.S. Air Force. 1983. Revised Uniform Summary of Surface Weather Observations. Environmental Technical Applications Center, Natioanl Weather Service, Scott Air Force Base, Ill.

U.S. Army Corps of Engineers. 1975. Hydroelectric Power and Related Purposes: Southcentral Railbelt Area, Alaska, Upper Susitna River Basin Interim Feasibility Report.

U.S. Bureau of Reclamation. 1977. Design of Small Dams. U.S. Government Printing Office, Washington, D.C.

Paul Weir Company. 1984. Hypothetical Mining Studies and Coal Price Estimates for Beluga and Nenana Coal Fields. Prepared for Harza-Ebasco Susitna Joint Venture, Anchorage, Alaska.

Woodward-Clyde Consultants Inc. 1984. Fish Mitigation Plan. Prepared for Harza-Ebasco Susitna Joint Venture, Anchorage, Alaska.

TABLES

TABLE E.10.1.1 SUMMARY OF RESULTS OF SCREENING PROCESS

Site[1]	Elimination Iteration				Site[1]	Elimination Iteration				Site[1]	Elimination Iteration				Site[1]	Elimination Iteration			
	1	2	3	4		1	2	3	4		1	2	3	4		1	2	3	4
Allison Creek					Fox	*				Lowe				*	Talachulitna River	*			
Beluga Lower			*		Gakona		*			Lower Chulitna				*	Talkeetnna 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		*			Kiliey 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.10.1.2 SUSITNA DEVELOPMENT PLANS

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 %
			Stage/Incremental Data				Cumulative System Data		
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.10.1.2 (Page 2 of 3)

			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.10.1.2. (Page 3 of 3)

			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 %
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.10.1.3 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.10.1.4: 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.10.1.5 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.				Essentially no difference between plans/schemes.
Impact on local economy	--					
Seismic exposure	Risk of major structural failure	All projects designed to similar levels of safety.				
	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.10.1.6 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
	<u>Tradeoffs made:</u>
	Economic advantage of dam scheme is judged to outweigh the reduced environmental impact associated with the tunnel scheme.

TABLE E.10.1.7: 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.10.1.7 (Page 2 of 2)

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.10.1.8 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.10.1.9: COMPARISON OF INDIVIDUAL HYDROELECTRIC ALTERNATIVES[1/]

	Project	Total Construction Cost[a] Jan. 1985 Level ($ x 10^6)	Installed[ac] Capacity (MW)	Average Annual Output[d] (GWh)	Cost per Installed MW ($ x 10^6/MW)	Cost Per GWh ($ x 10^6/GWh)	Maximum Reservoir Surface Area (Acres)	Active Reservoir Volume (Acre-Ft)	Cost per Acre-Ft of Active Storage ($/Acre-Ft)	Required Reservoir Area per GWh (Acre/GWh)	Total Cost (x10^6$)	Total Installed Capacity (MW)	Total Reservoir Surface Area (Acres)	Total Cost per Installed Capacity (x10^6$/MW)	Total Acres Inundated Per MW (Acres/MW)
ALTERNATIVES	BROWNE	2,561.58	100	440	25.62	5.82	12,500	760,000	3,371	28.4	7,643.35	773	115,700[f]	9.89	150
	JOHNSON	1,839.47	210	950	8.76	1.94	94,500	5,300,000	347	99.5					
	KEETNA	977.55	100	430	9.78	2.27	5,500	500,000	1,955	12.8					
	SNOW	522.17	63	270	8.29	1.93	3,200	173,000	3,018	11.9					
	CHAKACHAMNA	1,742.58[b]	300	1,250	5.81	1.39	17,280[e]	1,105,000	1,577	13.8					
SUSITNA	WATANA I	2,682.00[c]	360	2,470	7.45	1.02	21,000	800,000	829	8.5	5,790.00	1,620	45,800[g]	3.57	28
	DEVIL CANYON	1,394.00[c]	600	3,120	2.32	0.48	7,800	350,000	4,263	2.5					
	WATANA III	1,319.00[c]	600	1,310	2.00	0.97	38,000	3,740,000	340	29.0					

1/ Operation and Maintenance, and mitigation costs have not been included.

a APA 1984b; Browne Cost corrected, and all alternatives updated to 1985 level costs.

b Bechtel 1983b, Cost for Alternative D.

c APA 1985.

d Output as determined by reservoir operations program for Year 2010 Load conditions assuming project is first alternative constructed.

e Existing lake

f Does not include Chakachamna which is an existing, natural lake

g Stages II and III

TABLE E.10.2.1

SUSITNA HYDROELECTRIC PROJECT
FLOW CONSTRAINTS FOR ENVIRONMENTAL
FLOW REQUIREMENT CASE E-VI

Water Week	Period	Gold Creek Flow (cfs) Minimum	Gold Creek Flow (cfs) Maximum	Water Week	Period	Gold Creek Flow (cfs) Minimum	Gold Creek Flow (cfs) Maximum
14	31 Dec. - 06 Jan.	2,000	16,000	40	01 July - 07 July	9,000*	35,000
15	07 Jan. - 13 Jan.	2,000	16,000	41	08 July - 14 July	9,000*	35,000
16	14 Jan. - 20 Jan.	2,000	16,000	42	15 July - 21 July	9,000*	35,000
17	21 Jan. - 27 Jan.	2,000	16,000	43	22 July - 28 July	9,000*	35,000
18	28 Jan. - 03 Feb.	2,000	16,000	44	29 July - 04 Aug.	9,000*	35,000
19	04 Feb. - 10 Feb.	2,000	16,000	45	05 Aug. - 11 Aug.	9,000*	35,000
20	11 Feb. - 17 Feb.	2,000	16,000	46	12 Aug. - 18 Aug.	9,000*	35,000
21	18 Feb. - 24 Feb.	2,000	16,000	47	19 Aug. - 25 Aug.	9,000*	35,000
22	25 Feb. - 03 Mar.	2,000	16,000	48	26 Aug. - 01 Sep.	9,000*	35,000
23	04 Mar. - 10 Mar.	2,000	16,000	49	02 Sep. - 08 Sep.	8,000	35,000
24	11 Mar. - 17 Mar.	2,000	16,000	50	09 Sep. - 15 Sep.	7,000	35,000
25	18 Mar. - 24 Mar.	2,000	16,000	51	16 Sep. - 22 Sep.	6,000	35,000
26	25 Mar. - 31 Mar.	2,000	16,000	52	23 Sep. - 30. Sep.	6,000	35,000
27	01 Apr. - 07 Apr.	2,000	16,000	1	01 Oct. - 07 Oct.	6,000	18,000
28	08 Apr. - 14 Apr.	2,000	16,000	2	08 Oct. - 14 Oct.	6,000	17,000
29	15 Apr. - 21 Apr.	2,000	16,000	3	15 Oct. - 21 Oct.	5,000	16,000
30	22 Apr. - 28 Apr.	2,000	16,000	4	22 Oct. - 28 Oct.	4,000	16,000
31	29 Apr. - 05 May	2,000	16,000	5	29 Oct. - 04 Nov.	3,000	16,000
32	06 May - 12 May	4,000	16,000	6	05 Nov. - 11 Nov.	3,000	16,000
33	13 May - 19 May	6,000	16,000	7	12 Nov. - 18 Nov.	3,000	16,000
34	20 May - 26 May	6,000	16,000	8	19 Nov. - 25 Nov.	3,000	16,000
35	27 May - 02 June	6,000	16,000	9	26 Nov. - 02 Dec.	3,000	16,000
36	03 June - 09 June	9,000*	35,000	10	03 Dec. - 09 Dec.	2,000	16,000
37	10 June - 16 June	9,000*	35,000	11	10 Dec. - 16 Dec.	2,000	16,000
38	17 June - 23 June	9,000*	35,000	12	17 Dec. - 23 Dec.	2,000	16,000
39	24 June - 30 June	9,000*	35,000	13	24 Dec. - 30 Dec.	2,000	16,000

* Minimum summer flows are 9,000 cfs except in dry years when the minimum will be 8,000 cfs. A dry year is defined by the one-in-ten year low flow.

TABLE E.10.2.2: ENVIRONMENTAL CONSTRAINTS - SOUTHERN STUDY AREA (WILLOW TO ANCHORAGE/POINT MACKENZIE)

Corridor	Length (Miles)	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 parelleling 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 River 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.10.2.3: ENVIRONMENTAL CONSTRAINTS - CENTRAL STUDY AREA (DAMSITES 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 damsite,	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 tributary to Susitna; passes through, habitat for: raptors, furbearers, wolves, wolverine, brown bear, caribou	A
2 (AVECD)	45	Crosses several deep ravines; about 2000' change in elevation; some steep slopes; some wet soils	Little existing ROW except Corps rd. and at D; rec. and resid. areas; float plane areas; mostly Village Selection and Private Lands	Fog Lakes; Stephan Lake; proposed acces road; high country (Prairie & Chulitna Creek 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. and rec. development in area of Otter L. and old sled rd.	Viewshed of Alaska Range and High Lake; proposed access road	Archeologic sites by Watana damsite, and near Portage Creek/ Susitna River confluence; possible sites along Susitna River; Historic sites near communities of Gold Creek and Canyon	Forest-clering needed in western half	14 creek crossings; valuable spawning areas, especially grayling and salmon: Indian River Portage Creek Data Void	Golden eagle nest along Devil Creek near High Lake; active raven nest on Devil Creek; passes through habitat for: raptors, furbearers, wolves, brown bear	C
4 (ABCJHI)	77	Crosses several deep ravines; about >2000' change in elevation; routing above 4000'; steep slopes; some wet soils; shallow bedrock in mountains	No existing ROW; recreation areas and isolated cabins; lakes used by float planes; much Village Selection Land	Fog Lakes; Stephan Lake; proposed access road; viewshed of Alaska Range	Archeologic sites near Watana damsite, Stephan Lake 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 Creek near High Lake; caribou movement area; passes through habitat for: raptors, waterfowl, furbearers, wolves, wolverine, brown bear	F

a A = recommended
C = acceptable but not recommended
F = unacceptable

TABLE E.10.2.3 (Page 2 of 4)

Corridor	Length (Miles)	Topography/Soils	Land Use	Aesthetics	Cultural Resources	Vegetation	Fish Resources	Wildlife Resources	Environmental Rating[a]
5 (ABECJHI)	82	Crosses several deep ravines; changes in elevation >2000'; routing above 4000'; steep slopes; some wet soils; shallow bedrock in mountains	Same as Corridor 4	Fog Lakes; Stephan Lake; High Lake; proposed access road; 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 migrting swan habitat at Stephan Lake	F
6 (CVAHI)	68	Crosses several deep ravines; changes in elevation of about 1600'; routing above 4000'; steep slopes; some wet soils; shallow bedrock in mountains	No known existing ROW; recreation areas and isolated cabins, float plane area; Susitna area and near I are Village and Selection Land	Fog Lakes and Stephan Lake; proposed access road; Tsusena Butte; viewshed of Alaska Range	Archeologic sites near Watana damsite, Fog Lakes and Stephan Lake; 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 southeast of Tsusena Butte; area of caribou movement; passes through habitat for: raptors, waterfowl, furbearers, wolves, wolverine, brown bear	F
7 (CEBAHI)	73	Crosses several deep ravines; changes in elevation of about 1600'; routing above 3000'; steep slopes; some wet soils; shallow bedrock in mountains	Same as Corridor 6	Fog Lakes; and Stephan Lake; proposed access road; high country (Prairie-Chunilna Creeks); Tsusena Butte; viewshed of Alaska Range	Same as Corridor 6	Extensive wetlands in Stephan Lake, Fog Lakes, Tsusena Butte areas; extensive forest-clearing needed	45 creek crossings; valuable spawning areas, especially grayling: data void	Same as Corridor 6 with important waterfowl and migrting 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 mountains	No existing ROW; recreation areas and isolated cabins, float plane areas; air strip and airport; much Village Selection and Federal Land	Fog Lakes; Stephan Lake; access road; scenic area of Deadman Creek; viewshed of Alaska Range	Archeologic sites near Watana damsite, Fog Lakes, Stephan Lake and along Deadman Creek	Wetlands between B and mountains; extensive forest-clearing needed	1 river and 43 creek crossings; valuable spawning areas, especially grayling: data void	Important bald eagle habitat by Denali Hwy. and Deadman Lake; unchecked bald eagle nest near Tsusena Butte; passes through habitat for: raptors, furbearers, wolves, wolverine, brown bear	F

TABLE E.10.2.3 (Page 3 of 4)

Corridor	Length (Miles)	Topography/Soils	Land Use	Aesthetics	Cultural Resources	Vegetation	Fish Resources	Wildlife Resources	Environmental Rating[a]
9 (CEBAG)	95	Crosses several deep ravines; changes in elevation of about 1600'; routing above 3000'; steep slopes; some wet soils; shallow bedrock in mountains	Same as Corridor 8	Fog Lakes; Stephan Lake; proposed access road; high country (Prairie and Chunilna Creeks); Deadman Creek; viewshed of Alaska Range	Same as Corridor 8	Wetlands in Stephan Lake/Fog Lake areas; extensive forest-clearing needed	1 river and 48 creek crossings; valuable spawning areas, especially grayling: data void	Same as Corridor 8 with important waterfowl and migrating swan habitat at Stephan Lake	F
10 (CJAG)	68	Same as Corridor 8	No existing ROW; recreation areas and isolated cabins, float plane areas; air strip and airport; mostly Village Selection and Federal Land	High Lakes area; proposed access road; Deadman Creek drainage; viewshed of Alaska Range	Archeologic sites near Watana damsite, and along Deadman Creek	Small wetlands in JA area; extensive forest-clearing needed	36 creek crossings; valuable spawning areas, especially grayling and salmon: data void	Golden eagle nest along Devil Creek near High Lake; bald eagle nest southeast of Tsusena Butte; passes through habitat for: raptors, furbearers, brown bear	F
11 (CJAHI)	69	Crosses several deep ravines; changes in elevation of 1000'; routing above 3000'; steep slopes; some wet soils; shallow bedrock in mountains	No existing ROW; recreation areas and isolated cabins; float plane area; mostly Village Selection and Private Land	High Lakes area; proposed access road; viewshed of Alaska Range	Archeologic sites Watana damsite	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 Creek near High Lake; bakd eagle nest southeast of Tsusena Butte; passes through habitat for: raptors, furbearers, brown bear	F
12 (JA-CJHI)	70	Same as Corridor 11	No existing ROW; recreation areas and isolated cabins; float plane area; mostly Village Selection and Private Land	High Lakes area; proposed access road; Tsusena Butte; viewshed of Alaska Range	Archeologic site near Watana damsite; 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 Creek near High Lake; pases through habitat for: raptors, furbearers, wolves, brown bear	F
13 (ABCF)	41	Crosses several deep ravines; about 1000' change in elevation; some wet soils	No known existing ROW except at F; recreation areas; float plane areas; resident and recreaction use near Otter Lake and Old Sled Road; isolated cabins; mostly Village Selection Land and some Private Land	Fog Lakes; Stephan Lake; proposed access road	Archeologic sites near Watana damsite; Portage Creek/Susitna River confluence, Stephan Lake, and Fog Lakes; historic sites; near communities of Canyon and Gold Creek	Wetlands in eastern third of corridor; extensive forest-clearing needed	15 creek crossings; valuable spawning areas, especially grayling and salmon: Indian Creek Portage Creek data void	Unidentified raptor nest on tributary to Susitna; passes through habitat for: raptors, furbearers, wolves, wolverine, brown bear, caribou	A

TABLE E.10.2.3 (Page 4 of 4)

Corridor	Length (Miles)	Topography/Soils	Land Use	Aesthetics	Cultural Resources	Vegetation	Fish Resources	Wildlife Resources	Environmental Rating[a]
14 (AJCD)	41	Crosses deep ravine at Devil Creek; about 2000' change in elevation; routing above 3000'; some wet soils	Little existing ROW except Old Corps Road and at D; recreation areas; isolated cabins; much Village Selection Land; some Private Land	Viewshed of Alaska Range and High Lake; proposed access road	Archeologic sites by Watana damsite, possible sites along Susitna River; historic sites near communities of Canyon and Gold Creek	Forest-clearing needed in western half	1 river and 16 creek crossings; valuable spawning areas, especially grayling: data void	Golden eagle nest in Devil Creek/High Lake area; active raven nest on Devil Creek; passes through habitat for: raptors, furbearers, brown bear, caribou	C
15 (ABECF)	45	Crosses several deep ravines; about 2000' change in elevation	No known existing ROW except at F; recreation areas; float plane areas; resident and recreation use near Old Sled Road; isolated cabins; mostly Village Selection Land with some Private Land	Fog Lakes; Stephan Lake; proposed access road; high country (Prairie and Chunilna Creeks drainages); viewshed of Alaska Range	Same as Corridor 13	Wetlands in eastern half of corridor; extensve 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 Lake; passes through habitat for: raptors, waterfowl, furbearers, wolves, wolverine, brown bear, caribou	F

TABLE E.10.2.4: ENVIRONMENTAL CONSTRAINTS - NORTHERN STUDY AREA (HEALY TO FAIRBANKS)

Corridor	Length (Miles)	Topography/Soils	Land Use	Aesthetics	Cultural Resources	Vegetation	Fish Resources	Wildlife Resources[a]	Environmental Rating[b]
1 (ABC)	90	Some wet soils with severe limitations to off-road traffic	Air strip; residential areas and isolated cabins; some U.S. Military Withdrawal and Native Land	3 crossings of Parks Hwy.; Nenana River - scemoc 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 (ABCD)	86	Severe limitations to off-road traffic on wet soils of the flats	No known existing ROW north 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 north 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 (ABEDC)	115	Change in elevation of about 2500'; steep slopes; shallow bedrock in mountains; severe limitations to off-road traffic in the flats	No existing ROW beyond Healy/Cody Creek 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 mountains; data void	Probably extensive wetlands between Wood and Tanana Rivers; extensive forest-clearing needed north 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	Air strips; 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	Probable 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 habitat for: golden eagles, brown bear	F

a Prime habitat = minimum amount of land necessary to provide a substantial 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.10.2.5: SUMMARY OF SCREENING RESULTS[a]

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
- Central Study Area				
(1) ABCD	A (C)	A (C)	A (A)	A (C)
(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	F	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	A	F
(13) ABCF	A (C)	C (C)	A (C)	C (C)
(14) AJCD	C (A)	A	A	C (A)
(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

(a) Ratings in parentheses are those which resulted from re-evaluation following access road decision. See Section 2.4.10.

Table E.10.3.1: RESERVOIR OPERATION LEVEL CONSTRAINTS

Reservoir	Normal Minimum Water Surface Elevation (ft, msl)	Normal Maximum Water Surface Elevation (ft, msl)	Maximum Flood Surcharge Elevation (ft, msl)
Watana Stage I	1,850	2,000	2,014
Devil Canyon Stage II	1,405	1,455	1,456
Watana Stage III	2,065	2,185	2,193

TABLE E.10.3.2: INFLUENCE OF MAINSTEM FLOW AND WATER QUALITY ON CHARACTERISTICS OF AQUATIC HABITAT TYPES

	Physical Characteristics					
Habitat Type	Hydraulic[1/]	Hydrologic	Temp.	Turbidity	Ice	Total
Mainstem (MS)	4	4	4	4	4	20
Side Channel (SC)	3	4	4	3	4	18
Tributary Mouth (TM)	3	3	2	2	3	13
Side Slough (SS)	2	2	2	2	2	10
Upland Slough (US)	1	1	0	0	0	2
Tributary (T)	0	0	0	0	0	0
Lake (L)	0	0	0	0	0	0

0 - no influence
1 - small, limited influence
2 - moderate, occasional influence
3 - moderate, frequent influence
4 - direct, extensive influence

1/ Depth, velocity, wetted area, etc.

TABLE E.10.3.3: IMPORTANT USES OF HABITAT TYPES BY EVALUATION SPECIES

Evaluation Species	Habitat Type					
	MS[1/]	SC	TM	SS	US	T
Chinook Salmon						X
Migrate	X		X			X
Spawn-incubate						X
Rear		X		X		
Coho Salmon						
Migrate	X		X			X
Spawn-incubate						X
Rear					X	X
Chum Salmon						
Migrate	X	X	X	X		X
Spawn-incubate		X		X		X
Rear	X			X		X
Sockeye Salmon						
Migrate	X			X		
Spawn-incubate				X		
Rear				X	X	
Pink Salmon						
Migrate	X		X			X
Spawn-incubate						X
Rear						
Arctic Grayling						
Migrate	X		X			X
Spawn-incubate						X
Rear	X		X			X
Rainbow Trout						
Migrate	X		X			X
Spawn-incubate						X
Rear	X		X			X
Burbot						
Migrate	X		X			
Spawn-incubate						
Rear	X					
Dolly Varden						
Migrate	X	X				X
Spawn-incubate						X
Rear	X					

1/ MS=Mainstem, SC=Side Channel, TM=Tributary Mouth, SS=Side Sloughs, US=Upland Sloughs, T=Tributary

Source: HE 1985c

TABLE E.10.3.4: PRIMARY UTILIZATION OF SENSITIVE HABITAT TYPES BY EVALUATION SPECIES

Evaluation Species	Habitat Types			
	Mainstem	Side Channel	Side Slough	Tributary Mouth
Chinook Salmon		R	R	
Chum Salmon	R	S	S,R	
Coho Salmon				
Sockeye Salmon			S,R	
Pink Salmon				
Arctic Grayling	R			R
Rainbow Trout	R			R
Dolly Varden	R			R
Burbot	S,R			

S - spawning/incubation
R - rearing

TABLE E.10.3.5: STANDARD WATER WEEKS FOR ANY WATER YEAR N

WEEK NUMBER	FROM day	FROM month	FROM year	TO day	TO month	TO year	WEEK NUMBER	FROM day	FROM month	FROM year	TO day	TO month	TO year
1	1	Oct	n-1	7	Oct	n-1	27	1	Apr	n	7	Apr	n
2	8	Oct	n-1	14	Oct	n-1	28	8	Apr	n	14	Apr	n
3	15	Oct	n-1	21	Oct	n-1	29	15	Apr	n	21	Apr	n
4	22	Oct	n-1	28	Oct	n-1	30	22	Apr	n	28	Apr	n
5	29	Oct	n-1	4	Nov	n-1	31	29	Apr	n	5	May	n
6	5	Nov	n-1	11	Nov	n-1	32	6	May	n	12	May	n
7	12	Nov	n-1	18	Nov	n-1	33	13	May	n	19	May	n
8	19	Nov	n-1	25	Nov	n-1	34	20	May	n	26	May	n
9	26	Nov	n-1	2	Dec	n-1	35	27	May	n	2	Jun	n
10	3	Dec	n-1	9	Dec	n-1	36	3	Jun	n	9	Jun	n
11	10	Dec	n-1	16	Dec	n-1	37	10	Jun	n	16	Jun	n
12	17	Dec	n-1	23	Dec	n-1	38	17	Jun	n	23	Jun	n
13	24	Dec	n-1	30	Dec	n-1	39	24	Jun	n	30	Jun	n
14	31	Dec	n-1	6	Jan	n	40	1	Jul	n	7	Jul	n
15	7	Jan	n	13	Jan	n	41	8	Jul	n	14	Jul	n
16	14	Jan	n	20	Jan	n	42	15	Jul	n	21	Jul	n
17	21	Jan	n	27	Jan	n	43	22	Jul	n	28	Jul	n
18	28	Jan	n	3	Feb	n	44	29	Jul	n	4	Aug	n
19	4	Feb	n	10	Feb	n	45	5	Aug	n	11	Aug	n
20	11	Feb	n	17	Feb	n	46	12	Aug	n	18	Aug	n
21	18	Feb	n	24	Feb	n	47	19	Aug	n	25	Aug	n
22	25	Feb	n	3	Mar	n	48	26	Aug	n	1	Sep	n
23	4	Mar	n	10	Mar	n	49	2	Sep	n	8	Sep	n
24	11	Mar	n	17	Mar	n	50	9	Sep	n	15	Sep	n
25	18	Mar	n	24	Mar	n	51	16	Sep	n	22	Sep	n
26	25	Mar	n	31	Mar	n	52	23	Sep	n	30	Sep	n

TABLE E.10.3.6: FLOW CONSTRAINTS FOR ENVIRONMENTAL FLOW REQUIREMENT CASE E-I

Water Week	Gold Creek Flow (cfs)		Water Week	Gold Creek Flow (cfs)	
	Minimum	Maximum		Minimum	Maximum
14	2,000	14,000	40	14,000	
15	2,000	14,000	41	14,000	
16	2,000	14,000	42	14,000	
17	2,000	14,000	43	14,000	
18	2,000	14,000	44	14,000	40,000
19	2,000	14,000	45	14,000	40,000
20	2,000	14,000	46	(2)	40,000
21	2,000	14,000	47	(3)	40,000
22	2,000	14,000	48	14,000	40,000
23	2,000	14,000	49	12,000	14,000
24	2,000	14,000	50	10,000	14,000
25	2,000	14,000	51	8,000	14,000
26	2,000	14,000	52	6,000	14,000
27	2,000	14,000	1	6,000	14,000
28	2,000	14,000	2	6,000	14,000
29	2,000	14,000	3	5,000	14,000
30	2,000	14,000	4	4,000	14,000
31	2,000	14,000	5	3,000	14,000
32	2,000	14,000	6	3,000	14,000
33	2,000	14,000	7	3,000	14,000
34	2,000	14,000	8	3,000	14,000
35	2,000	14,000	9	2,000	14,000
36	10,000		10	2,000	14,000
37	(1)		11	2,000	14,000
38	14,000		12	2,000	14,000
39	14,000		13	2,000	14,000

(1) Base minimum flow of 10,000 cfs. 45,000 cfs spike; 3 days up, 3 days down.

(2) Base minimum flow of 14,000 cfs. 23,000 cfs spike; 1 day up, 1 day down.

(3) Base minimum flow of 14,000 cfs. 18,000 cfs spike; 1 day up, 1 day down.

TABLE E.10.3.7: FLOW CONSTRAINTS FOR ENVIRONMENTAL FLOW REQUIREMENT CASE E-II

Water Week	Gold Creek Flow (cfs) Minimum	Gold Creek Flow (cfs) Maximum	Water Week	Gold Creek Flow (cfs) Minimum	Gold Creek Flow (cfs) Maximum
14	2,000	16,000	40	6,000	
15	2,000	16,000	41	6,000	
16	2,000	16,000	42	6,000	
17	2,000	16,000	43	6,000	
18	2,000	16,000	44	11,000	
19	2,000	16,000	45	12,000	30,000
20	2,000	16,000	46	12,000	30,000
21	2,000	16,000	47	12,000	30,000
22	2,000	16,000	48	12,000	30,000
23	2,000	16,000	49	(2)	30,000
24	2,000	16,000	50	9,000	16,000
25	2,000	16,000	51	9,000	16,000
26	2,000	16,000	52	8,000	16,000
27	2,000		1	6,000	16,000
28	2,000		2	6,000	16,000
29	2,000		3	6,000	16,000
30	2,000		4	6,000	16,000
31	2,000		5	3,000	16,000
32	4,000		6	3,000	16,000
33	6,000		7	3,000	16,000
34	8,000		8	3,000	16,000
35	8,000		9	3,000	16,000
36	10,000		10	2,000	16,000
37	10,000		11	2,000	16,000
38	(1)		12	2,000	16,000
39	6,000		13	2,000	16,000

(1) Base minimum flow of 6,000 cfs. 35,000 cfs spike; 3 days up, 3 days down.

(2) Base minimum flow of 12,000 cfs. 18,000 cfs spike; 1 day up, 1 day down.

TABLE E.10.3.8: FLOW CONSTRAINTS FOR ENVIRONMENTAL FLOW REQUIREMENT CASE E-III

Water Week	Gold Creek Flow (cfs) Minimum	Gold Creek Flow (cfs) Maximum	Water Week	Gold Creek Flow (cfs) Minimum	Gold Creek Flow (cfs) Maximum
14	5,000	14,000	40	14,000	
15	5,000	14,000	41	14,000	
16	5,000	14,000	42	14,000	
17	5,000	14,000	43	14,000	
18	5,000	14,000	44	14,000	
19	5,000	14,000	45	14,000	
20	5,000	14,000	46	14,000	
21	5,000	14,000	47	14,000	
22	5,000	14,000	48	14,000	
23	5,000	14,000	49	12,000	
24	5,000	14,000	50	10,000	
25	5,000	14,000	51	8,000	
26	5,000	14,000	52	6,000	
27	5,000	14,000	1	6,000	14,000
28	5,000	14,000	2	6,000	14,000
29	5,000	14,000	3	6,000	14,000
30	5,000	14,000	4	6,000	14,000
31	5,000	14,000	5	5,000	14,000
32	5,000	14,000	6	5,000	14,000
33	6,000	14,000	7	5,000	14,000
34	7,000	14,000	8	5,000	14,000
35	8,000	14,000	9	5,000	14,000
36	10,000		10	5,000	14,000
37	10,000		11	5,000	14,000
38	14,000		12	5,000	14,000
39	14,000		13	5,000	14,000

TABLE E.10.3.9: FLOW CONSTRAINTS FOR ENVIRONMENTAL FLOW REQUIREMENT CASE E-IV

Water Week	Gold Creek Flow (cfs)		Water Week	Gold Creek Flow (cfs)	
	Minimum	Maximum		Minimum	Maximum
14	2,000	16,000	40	9,000	35,000
15	2,000	16,000	41	9,000	35,000
16	2,000	16,000	42	9,000	35,000
17	2,000	16,000	43	9,000	35,000
18	2,000	16,000	44	9,000	35,000
19	2,000	16,000	45	9,000	35,000
20	2,000	16,000	46	9,000	35,000
21	2,000	16,000	47	9,000	35,000
22	2,000	16,000	48	9,000	35,000
23	2,000	16,000	49	8,000	35,000
24	2,000	16,000	50	7,000	35,000
25	2,000	16,000	51	6,000	35,000
26	2,000	16,000	52	6,000	35,000
27	2,000	16,000	1	6,000	18,000
28	2,000	16,000	2	6,000	17,000
29	2,000	16,000	3	5,000	16,000
30	2,000	16,000	4	4,000	16,000
31	2,000	16,000	5	3,000	16,000
32	4,000	16,000	6	3,000	16,000
33	6,000	16,000	7	3,000	16,000
34	6,000	16,000	8	3,000	16,000
35	6,000	16,000	9	3,000	16,000
36	9,000	35,000	10	2,000	16,000
37	9,000	35,000	11	2,000	16,000
38	9,000	35,000	12	2,000	16,000
39	9,000	35,000	13	2,000	16,000

TABLE E.10.3.10: FLOW CONSTRAINTS FOR ENVIRONMENTAL FLOW REQUIREMENT CASE E-IVa

Water Week	Gold Creek Flow (cfs)		Water Week	Gold Creek Flow (cfs)	
	Minimum	Maximum		Minimum	Maximum
14	2,000	16,000	40	9,000	35,000
15	2,000	16,000	41	9,000	35,000
16	2,000	16,000	42	9,000	35,000
17	2,000	16,000	43	9,000	35,000
18	2,000	16,000	44	9,000	35,000
19	2,000	16,000	45	9,000	35,000
20	2,000	16,000	46	9,000	35,000
21	2,000	16,000	47	9,000	35,000
22	2,000	16,000	48	(2)	35,000
23	2,000	16,000	49	(3)	35,000
24	2,000	16,000	50	(3)	35,000
25	2,000	16,000	51	7,000	35,000
26	2,000	16,000	52	6,000	35,000
27	2,000	16,000	1	6,000	18,000
28	2,000	16,000	2	6,000	17,000
29	2,000	16,000	3	5,000	16,000
30	2,000	16,000	4	4,000	16,000
31	2,000	16,000	5	3,000	16,000
32	4,000	16,000	6	3,000	16,000
33	6,000	16,000	7	3,000	16,000
34	6,000	16,000	8	3,000	16,000
35	6,000	16,000	9	3,000	16,000
36	9,000	35,000	10	2,000	16,000
37	9,000	35,000	11	2,000	16,000
38	(1)	35,000	12	2,000	16,000
39	9,000	35,000	13	2,000	16,000

(1) Base minimum flow of 9,000 cfs. 30,000 cfs spike; 1 day up, 1 day hold, 1 day down.

(2) Base minimum flow of 9,000 cfs. 18,000 cfs spike; 1 day up, 1 day hold, 1 day down.

(3) Base minimum flow of 8,000 cfs 18,000 cfs. spike; 1 day up, 1 day hold, 1 day down.

TABLE E.10.3.11: FLOW CONSTRAINTS FOR ENVIRONMENTAL FLOW REQUIREMENT CASE E-IVb

Water Week	Gold Creek Flow (cfs) Minimum	Gold Creek Flow (cfs) Maximum	Water Week	Gold Creek Flow (cfs) Minimum	Gold Creek Flow (cfs) Maximum
14	2,000	16,000	40	9,000	35,000
15	2,000	16,000	41	9,000	35,000
16	2,000	16,000	42	9,000	35,000
17	2,000	16,000	43	9,000	35,000
18	2,000	16,000	44	9,000	35,000
19	2,000	16,000	45	9,000	35,000
20	2,000	16,000	46	9,000	35,000
21	2,000	16,000	47	9,000	35,000
22	2,000	16,000	48	(2)	35,000
23	2,000	16,000	49	(2)	35,000
24	2,000	16,000	50	(3)	35,000
25	2,000	16,000	51	7,000	35,000
26	2,000	16,000	52	6,000	35,000
27	2,000	16,000	1	6,000	18,000
28	2,000	16,000	2	6,000	17,000
29	2,000	16,000	3	5,000	16,000
30	2,000	16,000	4	4,000	16,000
31	2,000	16,000	5	3,000	16,000
32	4,000	16,000	6	3,000	16,000
33	6,000	16,000	7	3,000	16,000
34	6,000	16,000	8	3,000	16,000
35	6,000	16,000	9	3,000	16,000
36	9,000	35,000	10	2,000	16,000
37	9,000	35,000	11	2,000	16,000
38	(1)	35,000	12	2,000	16,000
39	9,000	35,000	13	2,000	16,000

(1) Base minimum flow of 9,000 cfs. 25,000 cfs spike; 1 day up, 1 day hold, 1 day down.

(2) Base minimum flow of 9,000 cfs. 14,000 cfs spike; 1 day up, 1 day hold, 1 day down.

(3) Base minimum flow of 8,000 cfs. 14,000 cfs spike; 1 day up, 1 day hold, 1 day down.

TABLE E.10.3.12: FLOW CONSTRAINTS FOR ENVIRONMENTAL FLOW REQUIREMENT CASE E-V

Water Week	Gold Creek Flow (cfs)		Water Week	Gold Creek Flow (cfs)	
	Minimum	Maximum		Minimum	Maximum
14	2,000	16,000	40	9,000	35,000
15	2,000	16,000	41	9,000	35,000
16	2,000	16,000	42	9,000	35,000
17	2,000	16,000	43	9,000	35,000
18	2,000	16,000	44	11,000	35,000
19	2,000	16,000	45	12,000	30,000
20	2,000	16,000	46	12,000	30,000
21	2,000	16,000	47	12,000	30,000
22	2,000	16,000	48	12,000	30,000
23	2,000	16,000	49	(2)	30,000
24	2,000	16,000	50	9,000	16,000
25	2,000	16,000	51	9,000	16,000
26	2,000	16,000	52	8,000	16,000
27	2,000	16,000	1	6,000	16,000
28	2,000	16,000	2	6,000	16,000
29	2,000	16,000	3	5,000	16,000
30	2,000	16,000	4	4,000	16,000
31	2,000	16,000	5	3,000	16,000
32	4,000	16,000	6	3,000	16,000
33	6,000	16,000	7	3,000	16,000
34	6,000	16,000	8	3,000	16,000
35	6,000	16,000	9	3,000	16,000
36	9,000	35,000	10	2,000	16,000
37	9,000	35,000	11	2,000	16,000
38	(1)	35,000	12	2,000	16,000
39	9,000	35,000	13	2,000	16,000

(1) Base minimum flow of 9,000 cfs. 35,000 cfs spike; 3 days up, 3 days down.

(2) Base minimum flow of 12,000 cfs. 18,000 cfs spike; 1 day up, 1 day down.

TABLE E.10.3.13 FLOW CONSTRAINTS FOR ENVIRONMENTAL FLOW REQUIREMENT CASE E-VI

Water Week	Gold Creek Flow (cfs)		Water Week	Gold Creek Flow (cfs)	
	Minimum	Maximum		Minimum	Maximum
14	2,000	16,000	40	9,000 *	35,000
15	2,000	16,000	41	9,000 *	35,000
16	2,000	16,000	42	9,000 *	35,000
17	2,000	16,000	43	9,000 *	35,000
18	2,000	16,000	44	9,000 *	35,000
19	2,000	16,000	45	9,000 *	35,000
20	2,000	16,000	46	9,000 *	35,000
21	2,000	16,000	47	9,000 *	35,000
22	2,000	16,000	48	9,000 *	35,000
23	2,000	16,000	49	8,000	35,000
24	2,000	16,000	50	7,000	35,000
25	2,000	16,000	51	6,000	35,000
26	2,000	16,000	52	6,000	35,000
27	2,000	16,000	1	6,000	18,000
28	2,000	16,000	2	6,000	17,000
29	2,000	16,000	3	5,000	16,000
30	2,000	16,000	4	4,000	16,000
31	2,000	16,000	5	3,000	16,000
32	4,000	16,000	6	3,000	16,000
33	6,000	16,000	7	3,000	16,000
34	6,000	16,000	8	3,000	16,000
35	6,000	16,000	9	3,000	16,000
36	9,000 *	35,000	10	2,000	16,000
37	9,000 *	35,000	11	2,000	16,000
38	9,000 *	35,000	12	2,000	16,000
39	9,000 *	35,000	13	2,000	16,000

* Minimum summer flows are 9,000 cfs except in dry years when the minimum will be 8,000 cfs. A dry year is defined by the one-in-ten year low flow.

Table E.10.3.14: ECONOMIC ANALYSIS OF ENVIRONMENTAL FLOW CASES COMPOSITE FORECAST

Case	Cumulative Present Worth of System Costs[1] (1996-2054) (million 1985$)	Cumulative Present Worth of Differential Mitigation Costs (1996-2054)[2] (million 1985$)	Cumulative Present Worth of Net System Costs (1996-2054) (million 1985$)	Total Railbelt Installed Capacity in 2025 (MW)
P-1	4,811	25	4,836	2,105
A	4,813	25	4,838	2,105
E-VI	4,823	0	4,823	2,192
E-IV	4,830	0	4,830	2,192
C	5,120	11	5,131	2,279
E-V	5,490	-4	5,486	2,453
E-I	6,570	-7	6,563	2,855

1/ Costs include production costs and costs for mitigation measures for E-VI flow requirements.

2/ Costs represent the differences in mitigation costs between those required for E-VI and those required for the specific flow requirement.

TABLE E.10.3.15: SUSITNA DEPENDABLE CAPACITY AND ENERGY PRODUCTION COMPOSITE FORECAST

	Watana Stage I	Watana I and Devil Canyon II		Watana III and Devil Canyon II		Ultimate Project, Not Limited by Load
	1999 - 2004	2005	2011	2012	2025	
Average Energy (GWh)	2390	4200	4750	5130	6690	6900
Firm Energy (GWh)	1990	4200	4500	5130	5720	5720
Dependable Capacity (MW)	300	790	805	1500	1520	1620

TABLE E.10.4.1: COMPARISON OF WIND DATA FOR LOCATIONS IN THE ALASKA RAILBELT

	Fairbanks[1]		Nenana[2]		Talkeetna[3]		Anchorage[1]	
Month	Mean Wind Speed (mph)	Calms (%)	Mean Wind Speed (mph)	Calms (%)	Mean Wind Speed (mph)	Calms (%)	Mean Wind Speed (mph)	Calms (%)
January	2.5	48.2	6.5	29.2	6.23	12.9	6.1	34.1
February	4.1	28.9	6.0	33.4	6.1	11.0	5.4	33.7
March	5.4	21.3	5.8	30.1	6.7	8.5	6.0	29.6
April	7.1	10.3	4.9	34.6	7.2	4.9	6.7	20.5
May	8.3	5.9	4.9	33.3	8.2	4.4	6.7	20.5
June	7.6	3.9	4.7	28.8	8.5	3.9	7.0	23.4
July	6.9	4.8	4.5	33.6	7.1	6.5	5.3	26.9
August	6.7	6.4	3.6	42.5	6.8	8.0	8.5	28.9
September	6.4	7.7	3.4	44.9	6.1	12.3	10.4	25.0
October	5.5	14.0	4.2	39.2	6.6	8.6	10.6	25.8
November	4.1	28.6	5.6	31.8	6.1	8.2	5.5	33.5
December	3.6	35.6	5.6	35.3	5.9	12.3	4.9	40.4
Annual Average	5.63	18.0	4.9	34.8	6.8	8.5	5.8	28.5

1/ NOAA 1979.
2/ USAF 1983.
3/ Battelle 1966.

TABLE E.10.4.2: STATISTICAL SUMMARY OF ATMOSPHERIC INVERSIONS BASED AT SURFACE[1/] FAIRBANKS AIRPORT

Month	PCT Frequency of Occurrence		Average Thickness(m)		Average Temperature Gradient (C/100m)	
	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon
January	81	84	690	640	2.6	3.4
February	56	83	480	560	1.8	3.0
March	30	86	190	420	1.3	3.0
April	6	80	120	310	0.8	1.9
May	-	72	-	240	-	1.5
June	1	62	150	280	1.1	1.4
July	1	62	180	320	0.6	1.3
August	1	69	170	310	0.7	1.3
September	5	71	130	290	0.7	1.5
October	28	67	230	350	1.4	2.1
November	66	78	440	500	2.6	2.7
December	82	82	680	610	2.6	3.2

1/ Billelo 1966.

TABLE E.10.4.3: ALASKA AMBIENT AIR QUALITY REGULATIONS

	PSD Class I Increment (ug/m3)	PSD Class II Increment (ug/m3)	Alaska Ambient Standard (ug/m3)
Particulates			
1. Annual	5	19	60
2. 24-hr	10	37	150
Sulfur Dioxide			
1. Annual	2	20	80
2. 24-hr	5	91	365
3. 3-hr	25	512	1,300
Nitrogen Oxides			
1. Annual	--	--	100
Carbon Monoxide			
1. 8-hr	--	--	10,000
2. 1-hr	--	--	40,000
Ozone			
1. 1-hr	--	--	235

TABLE E.10.4.4: OCCURRENCE OF ICE FOG AT FAIRBANKS AIRPORT

Month	Average Number of Days with Observed Ice Fog
November	9
December	12
January	12
February	9

Source: USAF (1984). "Observed ice fog" indicates that fog (less than 7 miles visibility) was observed at any time during the day.

TABLE E.10.4.5: PROJECTED EMISSION CHARACTERISTICS FOR COAL FIRED POWER PLANTS

	400 MW Nenana Coal-Fired Power Plant	800 MW Beluga Coal-Fired Power Plant
Stack Gas Temperature, C	88	88
Stack Diameter, meters	5.49	4.5
Stack Gas Velocity, m/sec	20.1	20.1
Ambient Temperature, C	0	0
Stack Height (meters)1/	134	134
Pollutant Emissions, lb/hr		
1. Particulates	37.2	74.4
2. SO2	542	1,084
3. NOx	2,064	4,127

1/ Actual stack height is a function of the tallest structure on site. Hence, the predicted value may vary from that shown here.

TABLE E.10.4.6: WORST CASE AIR QUALITY IMPACTS OF THE 400 MW NENANA POWER PLANT

Pollutant and Averaging Time[1/]	Allowable PSD Class II Increment (ug/m3)	Allowable Ambient Standard (ug/m3)	Calculated Worst Case Impact (ug/m3)
Sulfur Dioxide			
1. Annual	20	80	0.8
2. 24-hr	91	365	38
3. 3-hr	512	1,300	80
Particles			
1. Annual	19	60	.033
2. 24-hr	37	150	1.7
Nitrogen Dioxide			
1. Annual	--	100	4.1

1/ Annual average values calculated using COMPLEX I computer model. Other averaging times were based on simplified VALLEY/F/2.5 screening calculations (EPA 1977).

TABLE E.10.4.7: ESTIMATED 200 MW COAL-FIRED POWER PLANT WASTEWATER FLOWS

Wastewater	Frequency of Occurrence	Flow or Volume
Cooling Water and Auxiliary Cooling Water	Continuous	Seasonally variable; maximum 200 gpm
Makeup Water Treatment System	Continuous	75 gpm
- Condensate Polisher Waste	Intermittent	regen 24 gpm (daily avg)
- Boiler Blowdown	Intermittent	Max 20 gpm Avg 4 gpm
Floor Drainage and Oily Wastewater	Intermittent	500 gpm (wet) 100 gpm (dry)
Sanitary Wastes	Variable	5,000 gpd
Coal Pile Runoff	Intermittent	5 x 106 gpd
Metal Cleaning Wastes		
- Boiler Cleaning Organic Phase	Intermittent, once per 3 years	500,000 gallons
Inorganic Phase	Intermittent, once per 9 years	750,000 gallons
- Boiler Fireside Cleaning - Furnace Wall Wash	Intermittent, once per year	200,000 gallons
- Air Heater Wash	Intermittent, twice per year	1,000 gpm for 12 hours
Laboratory and Battery Room Wastes	Intermittent	2 gpm average daily flow
Dust Suppression Systems	Intermittent	10,000 gal./week

TABLE E.10.4.8: COAL-FIRED POWER GENERATION SCENARIO SURFACE AREA LOST OR DISTURBED

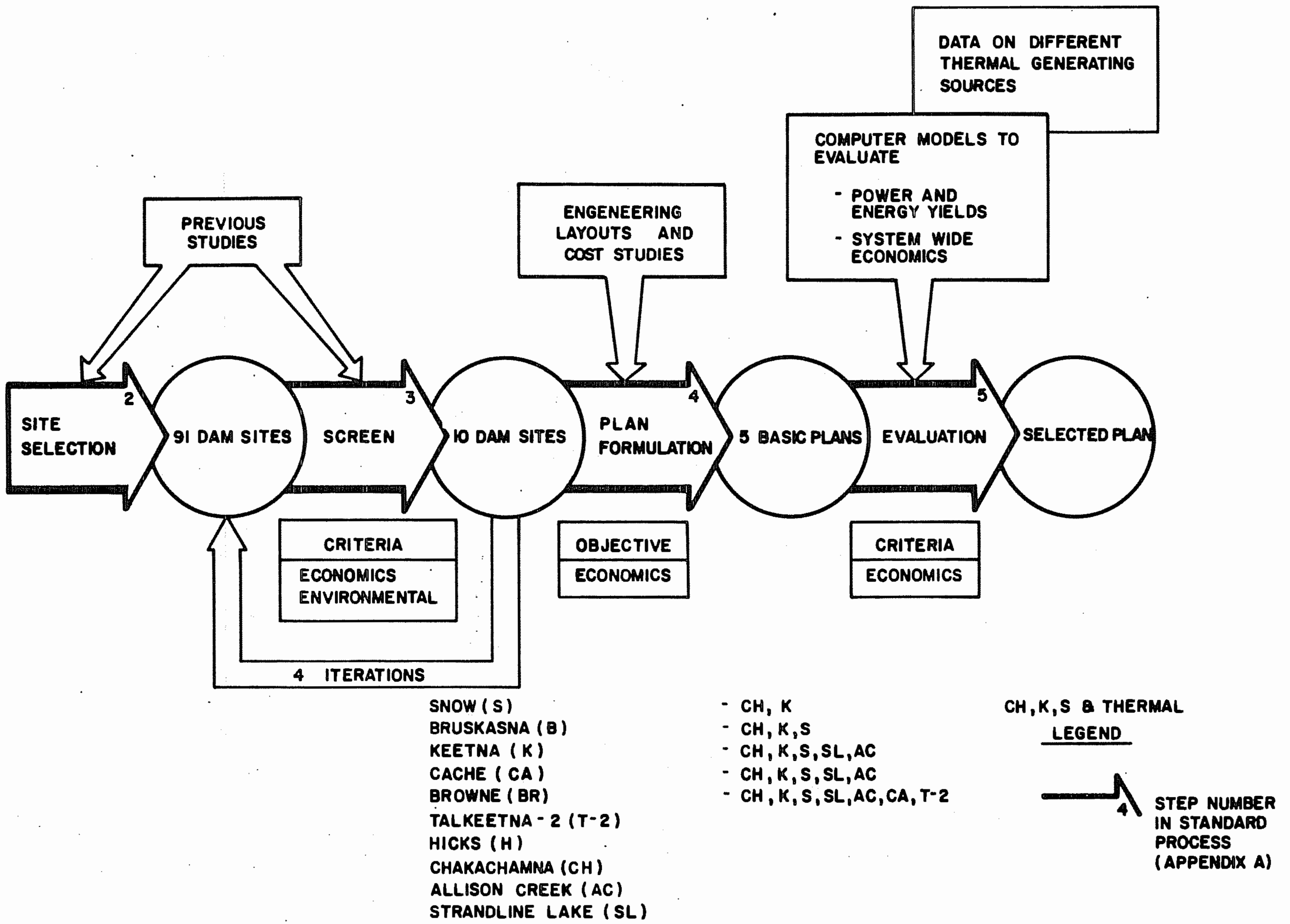
Lost or Disturbed Area (Acres) Type of Disturbance	Nenana Area	Beluga Area
Plant and Associated Structures, Coal Unloading Facilities, and Coal Storage Piles	300	550
Waste Disposal Sites	30	60
Mine Expansion. One 200 MW Facility Would Require 450 Acre of Land be Mined Over the 30-Year Life of the Facility	900	1,800
Area Total	1,230	2,410
GRAND TOTAL	3,640	

TABLE E.10.4.9: WORST CASE AIR QUALITY IMPACTS OF THE 800 MW BELUGA POWER PLANT

Pollutant and Averaging Time 1/	Allowable PSD Class II Increment (ug/m3)	Allowable Ambient Standard (ug/m3)	Calculated Worst Case Impact (ug/m3)
Sulfur Dioxide			
1. Annual	20	80	4.5
2. 24-hr	91	365	91
3. 3-hr	512	1,300	196
Particles			
1. Annual	19	60	0.3
2. 24-hr	37	150	6.2
Nitrogen Dioxide			
1. Annual	--	100	17

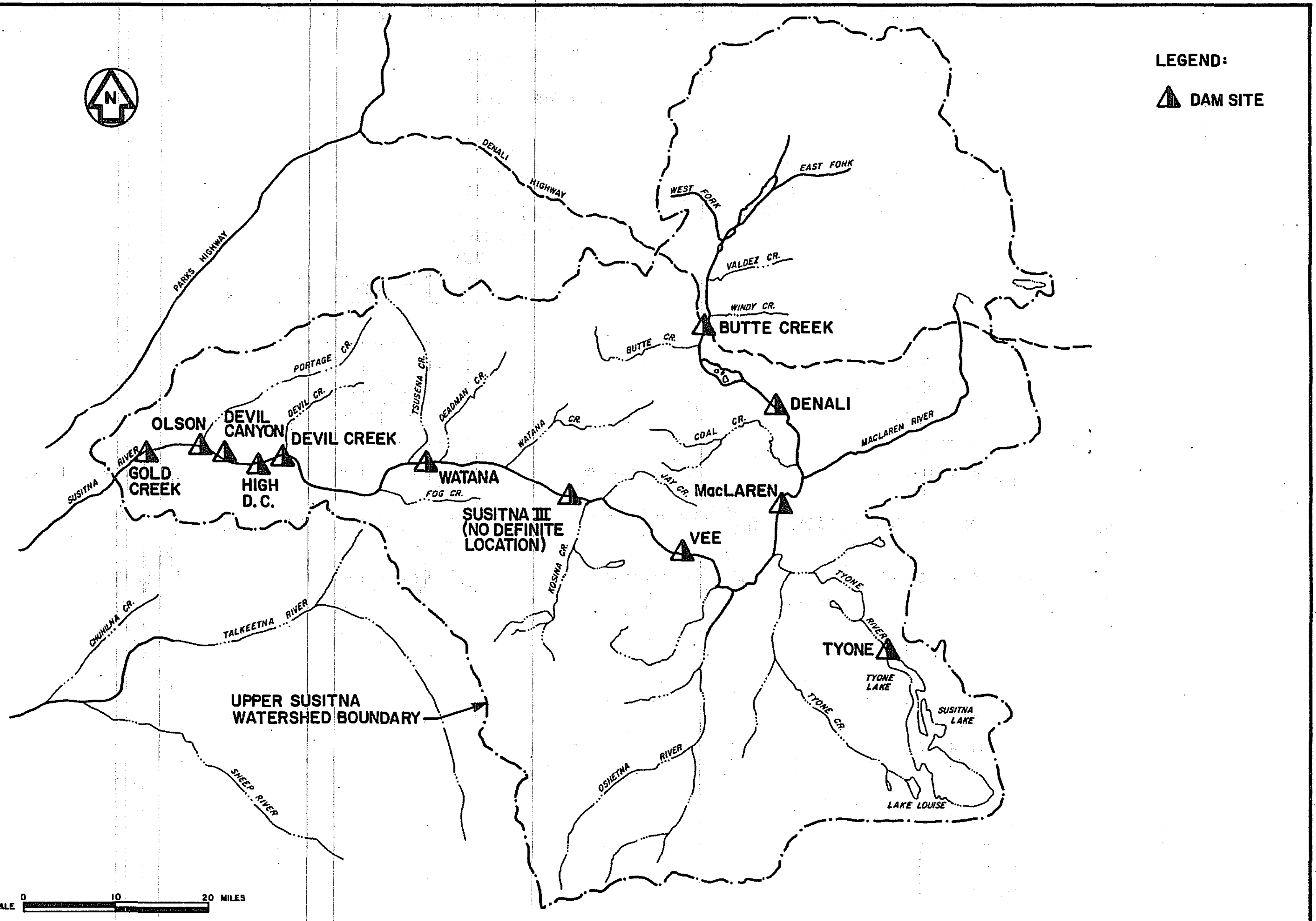
1/ Annual average values calculated using COMPLEX I computer model. Other averaging times were based on simplified VALLEY/F/2.5 screening calculations (EPA 1977).

FIGURES



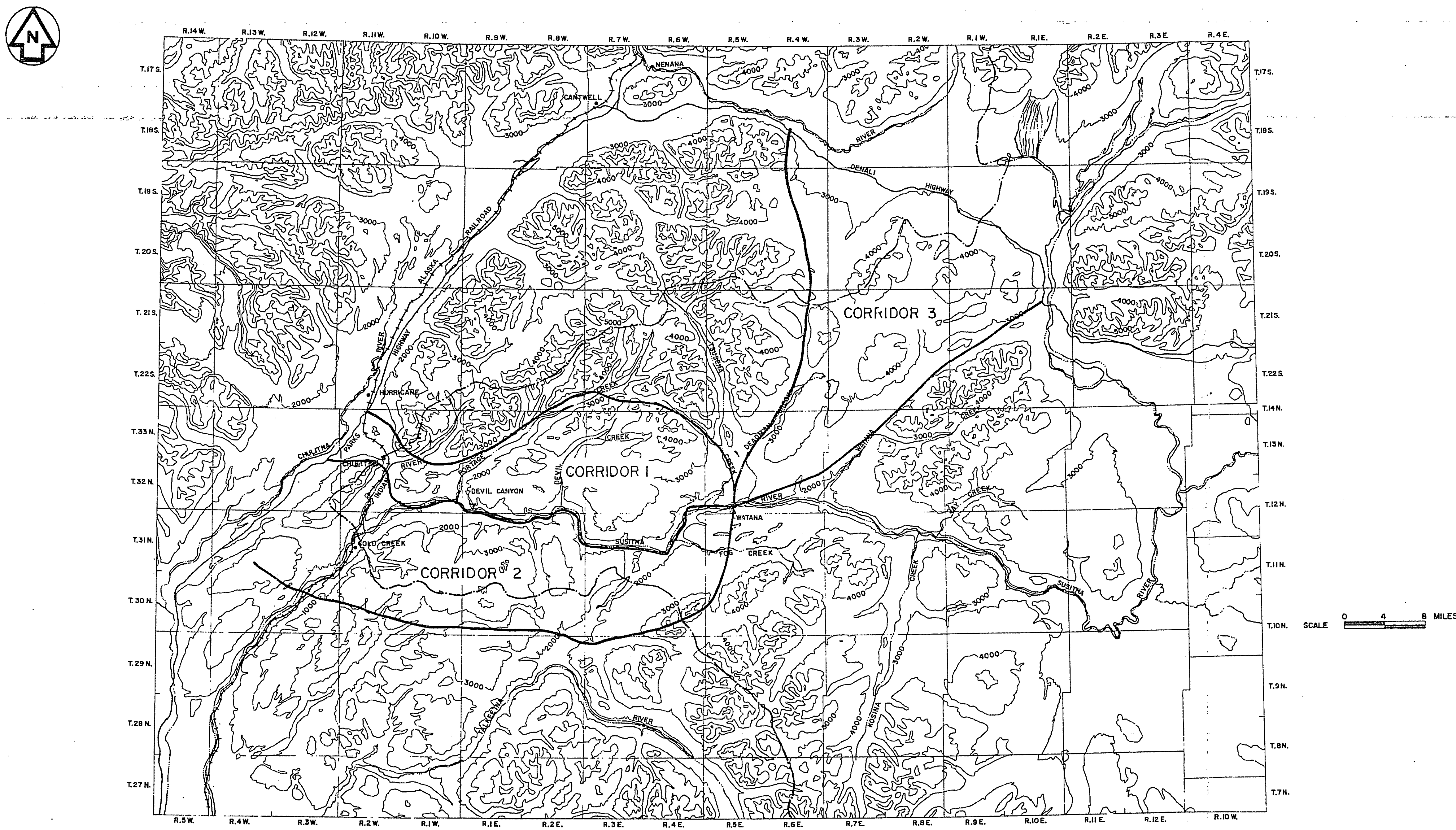
FORMULATION OF PLANS INCORPORATING NON-SUSITNA HYDRO GENERATION

FIGURE E.10.1.1



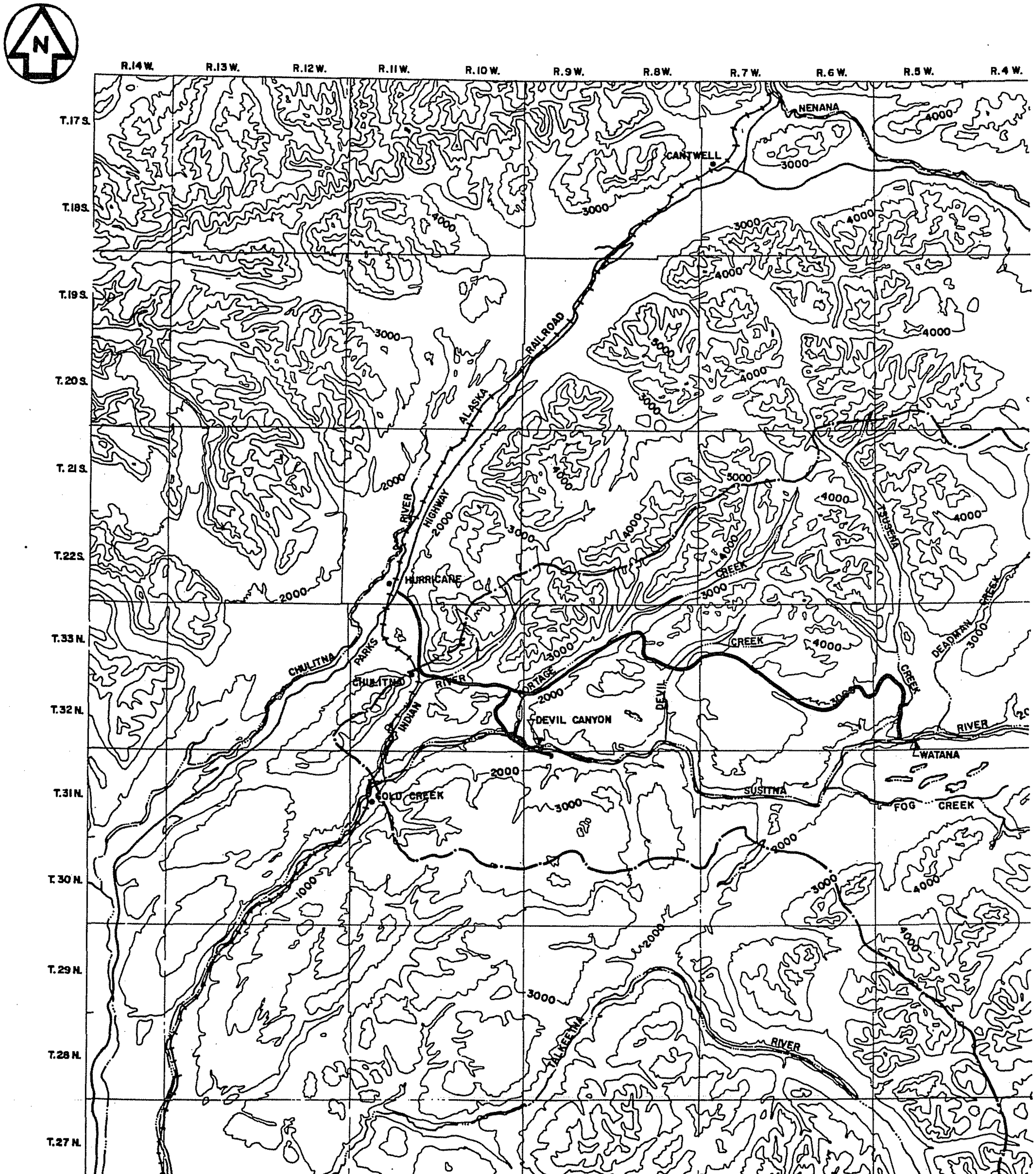
DAMSITES PROPOSED BY OTHERS

FIGURE E.10.1.2



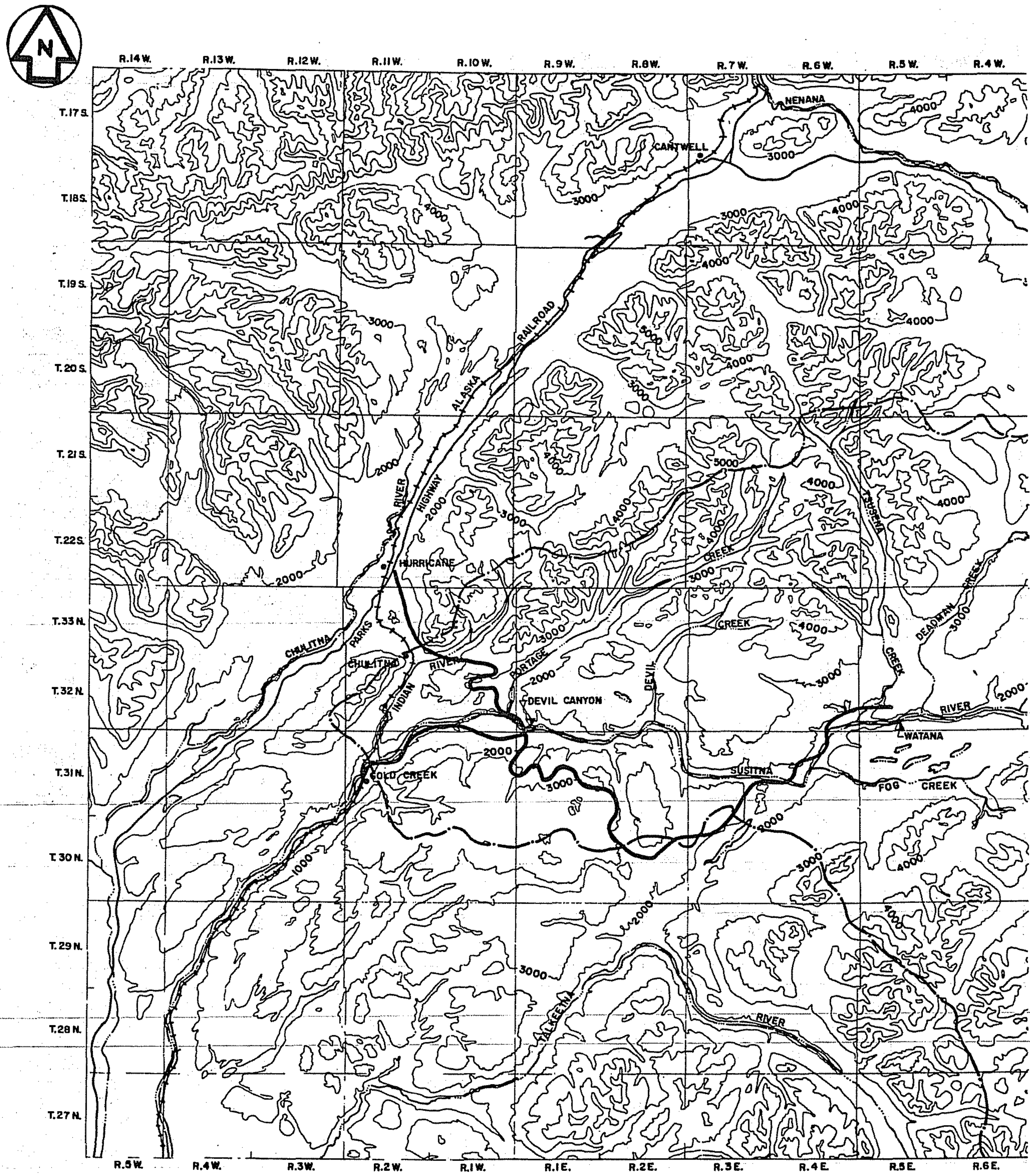
ALTERNATIVE ACCESS CORRIDORS

FIGURE E.10.2.1



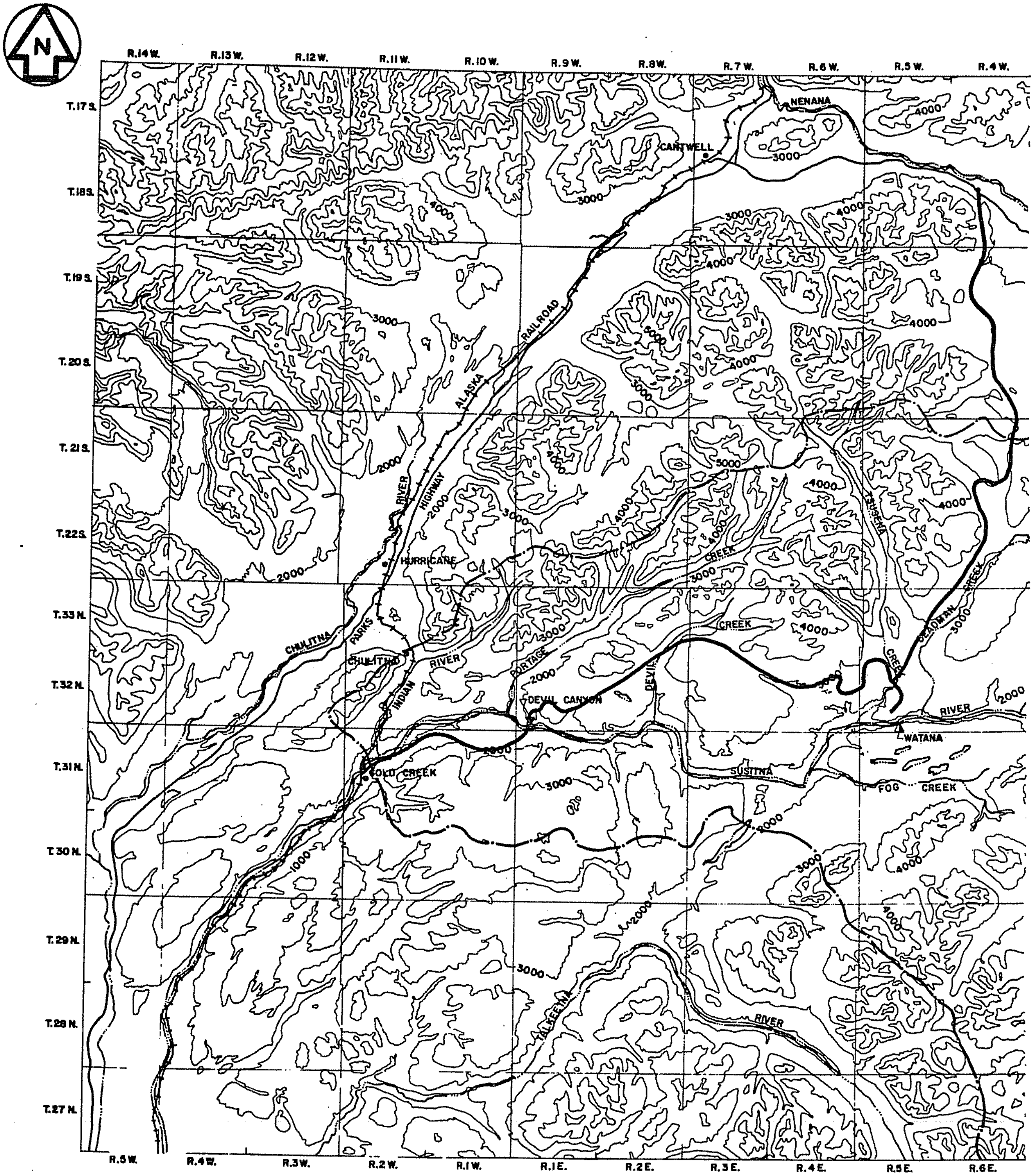
ALTERNATIVE ACCESS PLAN 13 (NORTH)

FIGURE E.10.2.2



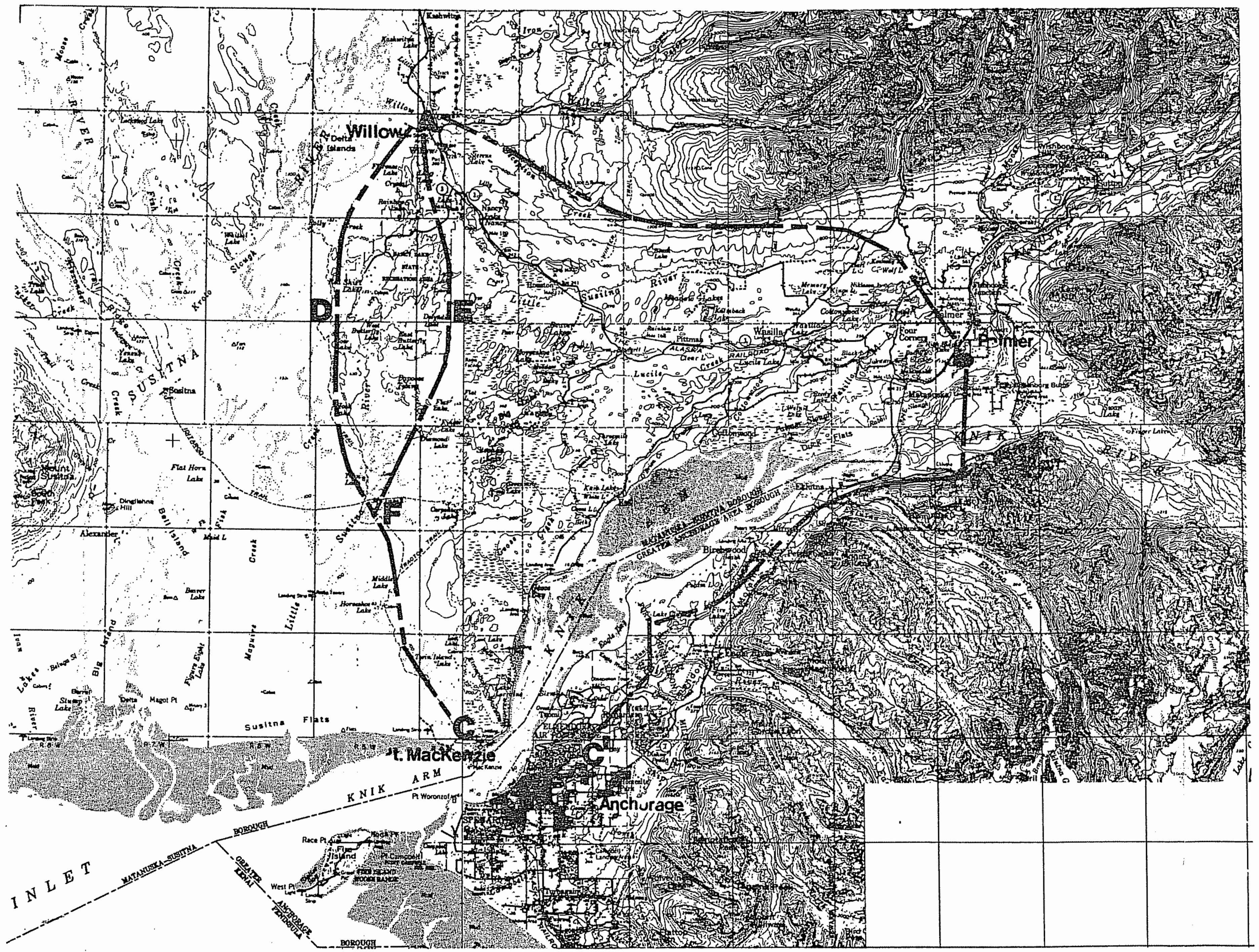
ALTERNATIVE ACCESS PLAN 16 (SOUTH)

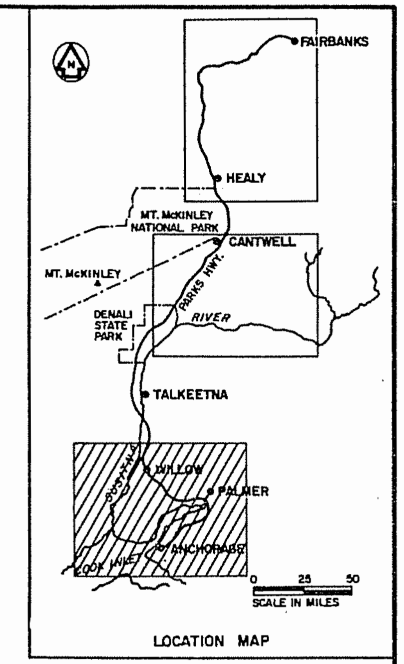
FIGURE E.10.2.3



ALTERNATIVE ACCESS PLAN 18 (PROPOSED)

FIGURE E.10.2.4





LEGEND

STUDY CORRIDOR

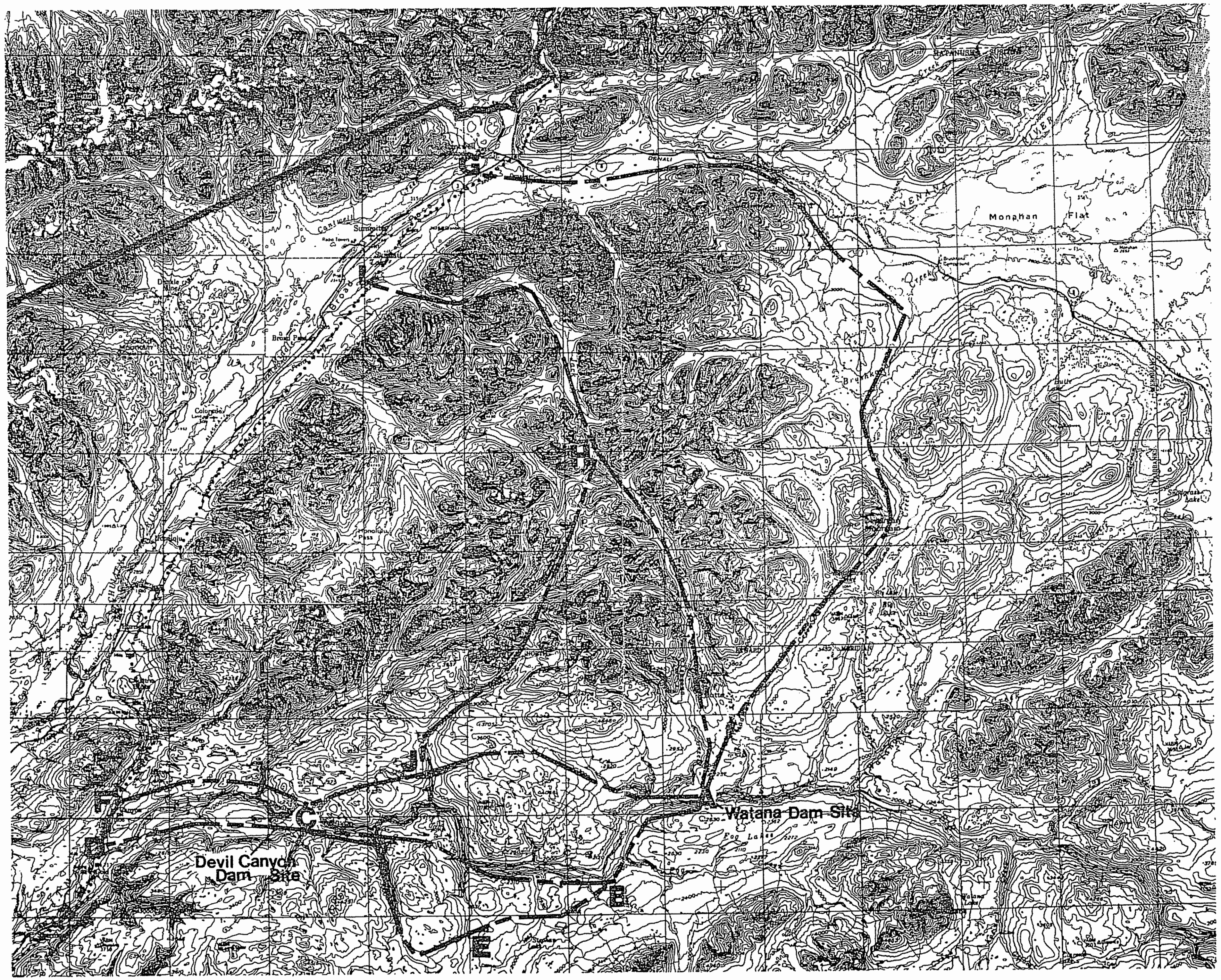
INTERTIE (APPROXIMATE)

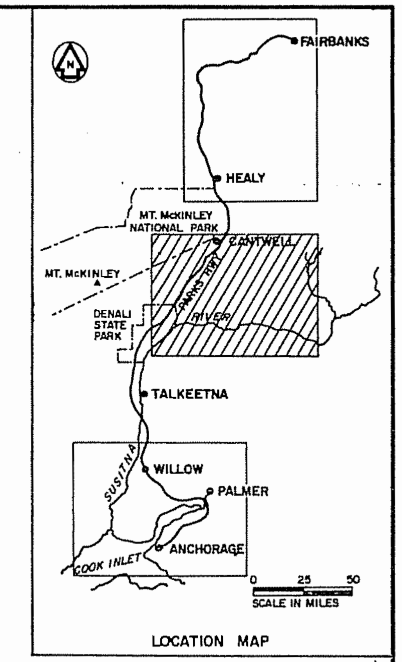
0 5 10

SCALE IN MILES

ALTERNATIVE TRANSMISSION LINE CORRIDORS
SOUTHERN STUDY AREA

FIGURE E.10.2.5





LEGEND

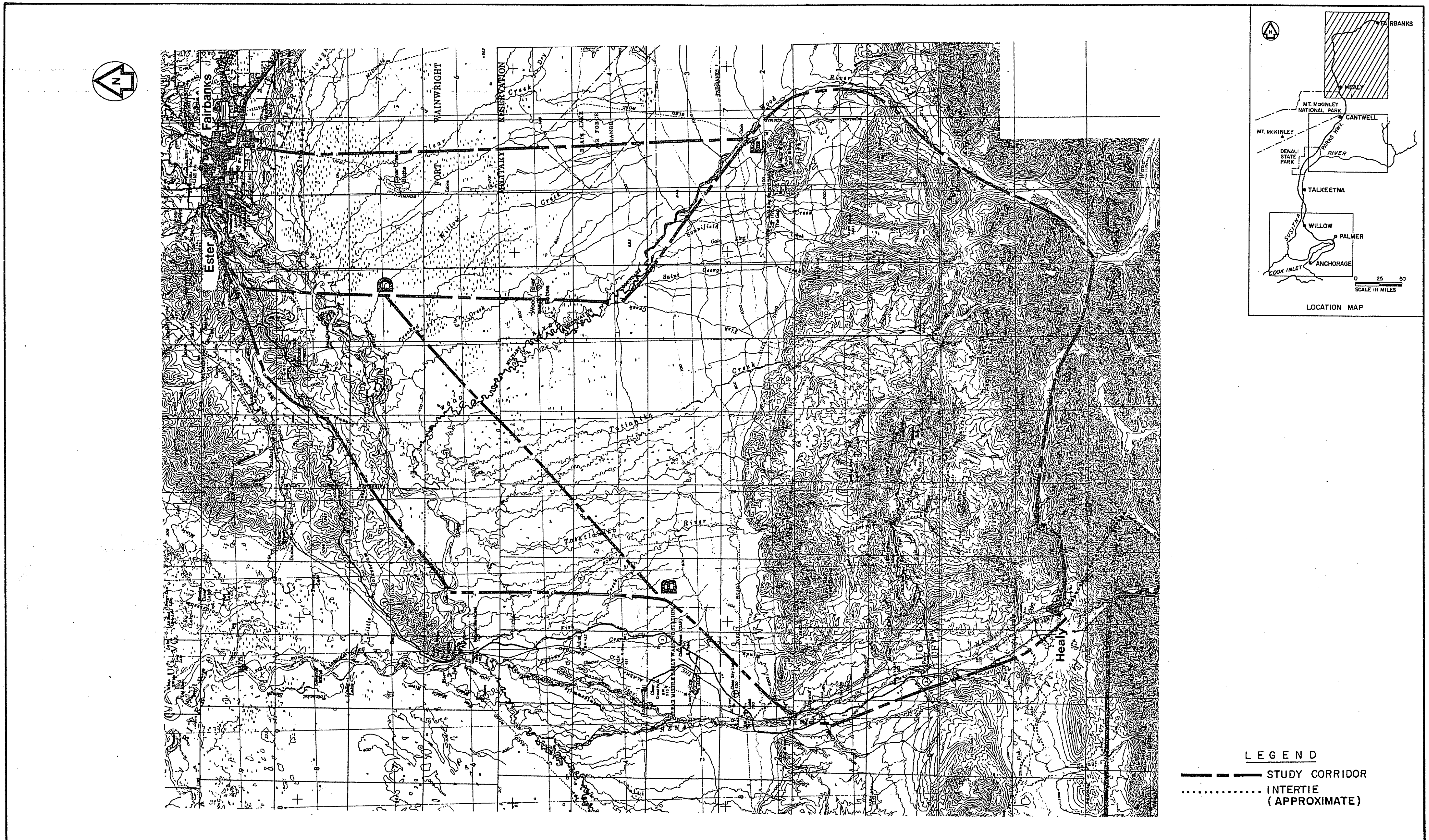
— — — STUDY CORRIDOR

.... INTERTIE (APPROXIMATE)

0 5 10
SCALE IN MILES

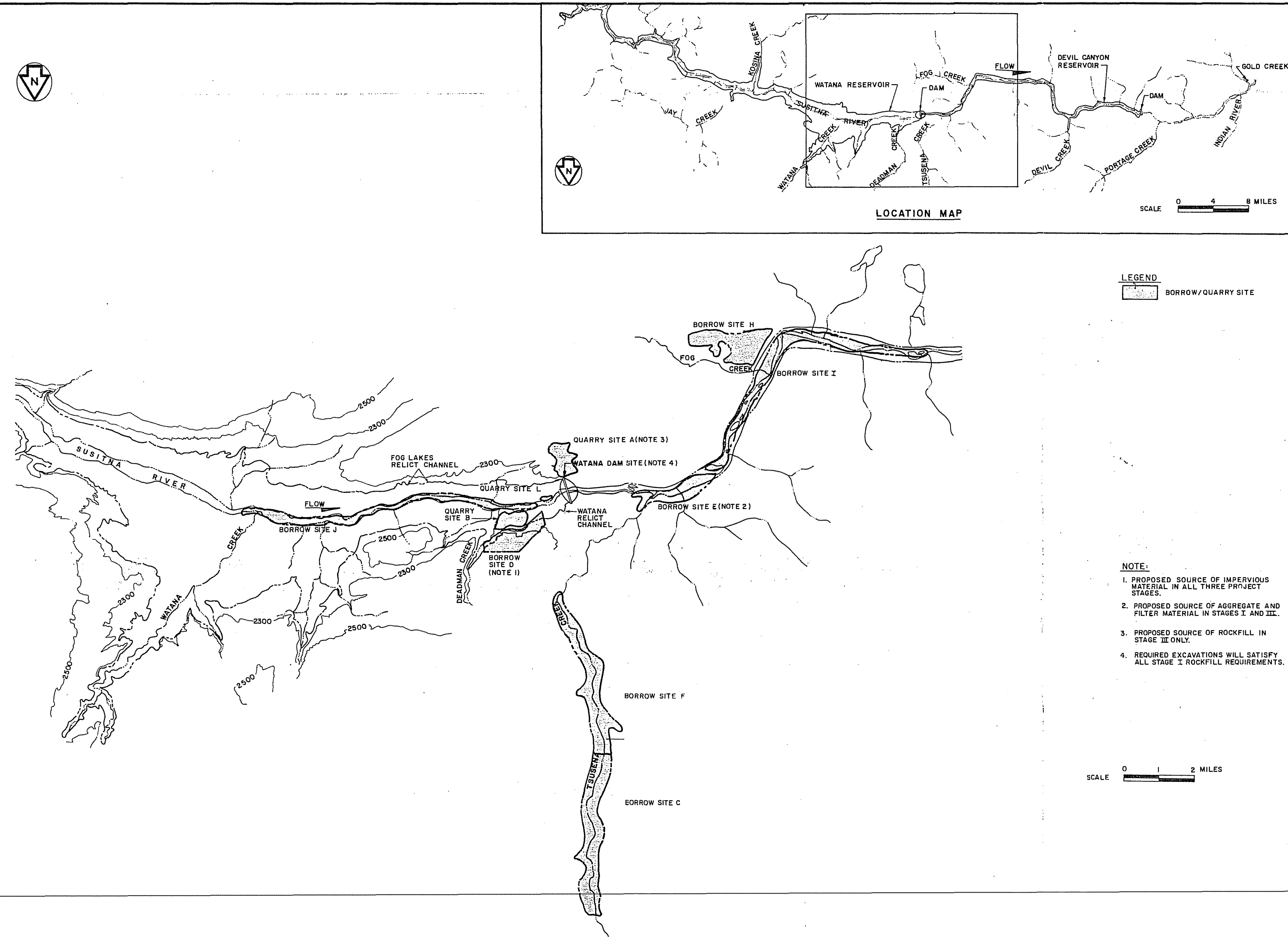
ALTERNATIVE TRANSMISSION LINE CORRIDORS
CENTRAL STUDY AREA

FIGURE E.10.2.6



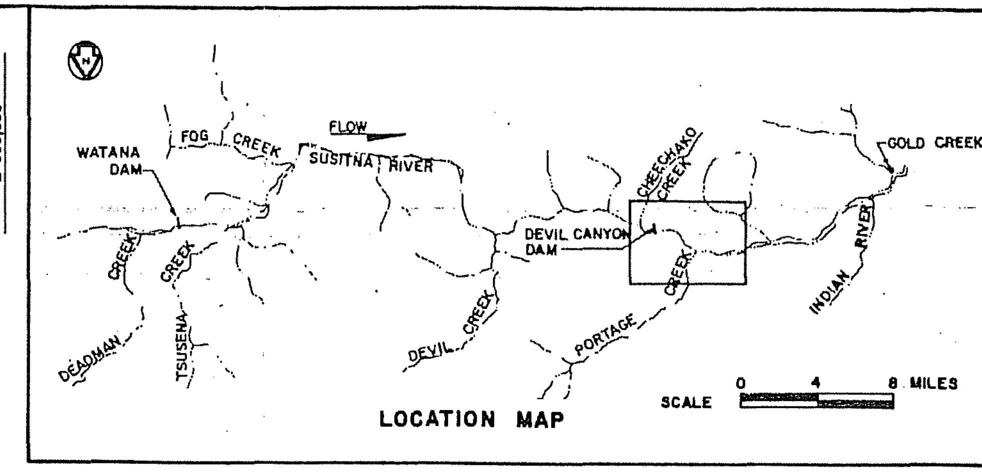
ALTERNATIVE TRANSMISSION LINE CORRIDORS
NORTHERN STUDY AREA

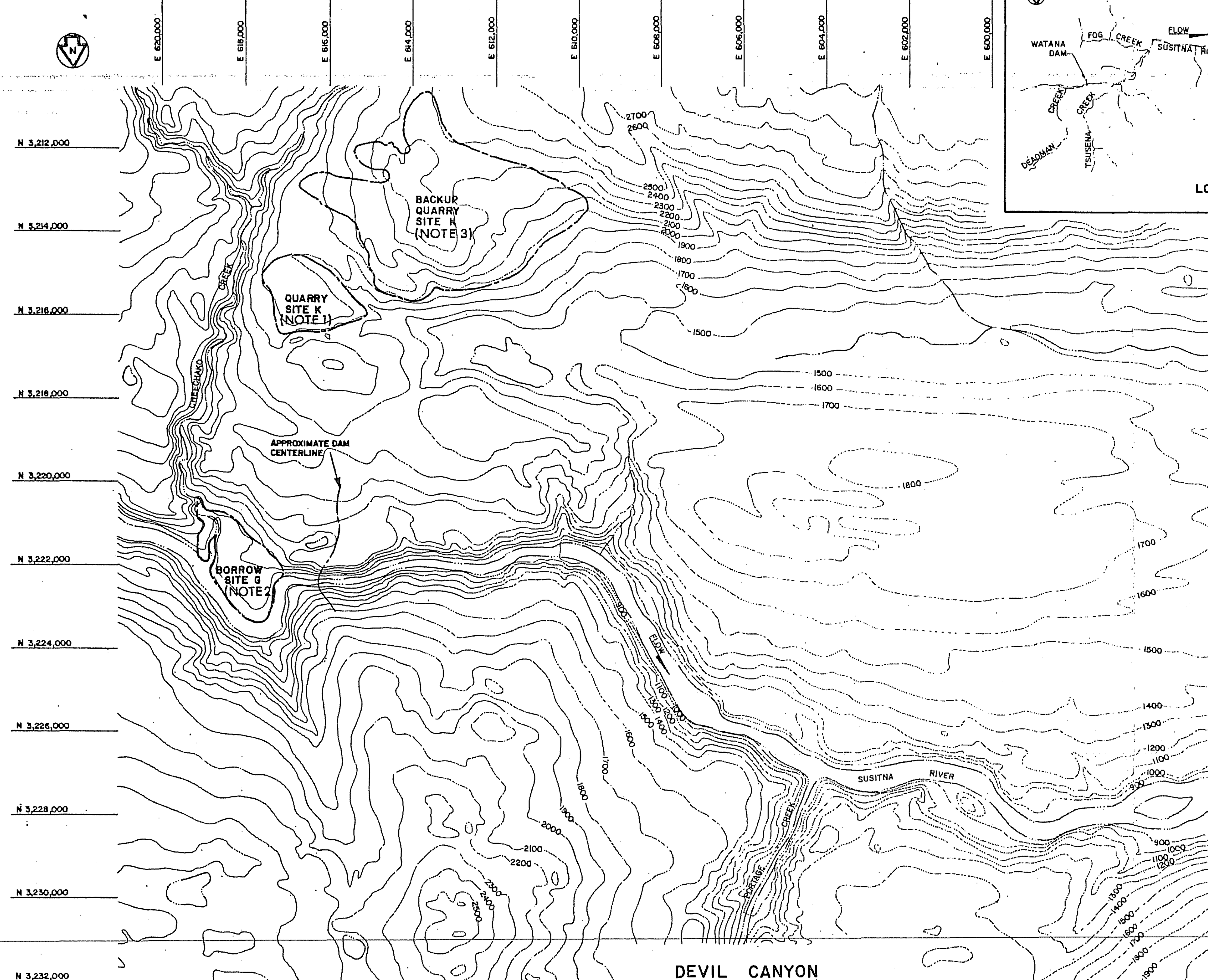
FIGURE E.10.2.7



WATANA BORROW SITE MAP

FIGURE E.10.2.8





LEGEND

BORROW/QUARRY SITE LIMITS

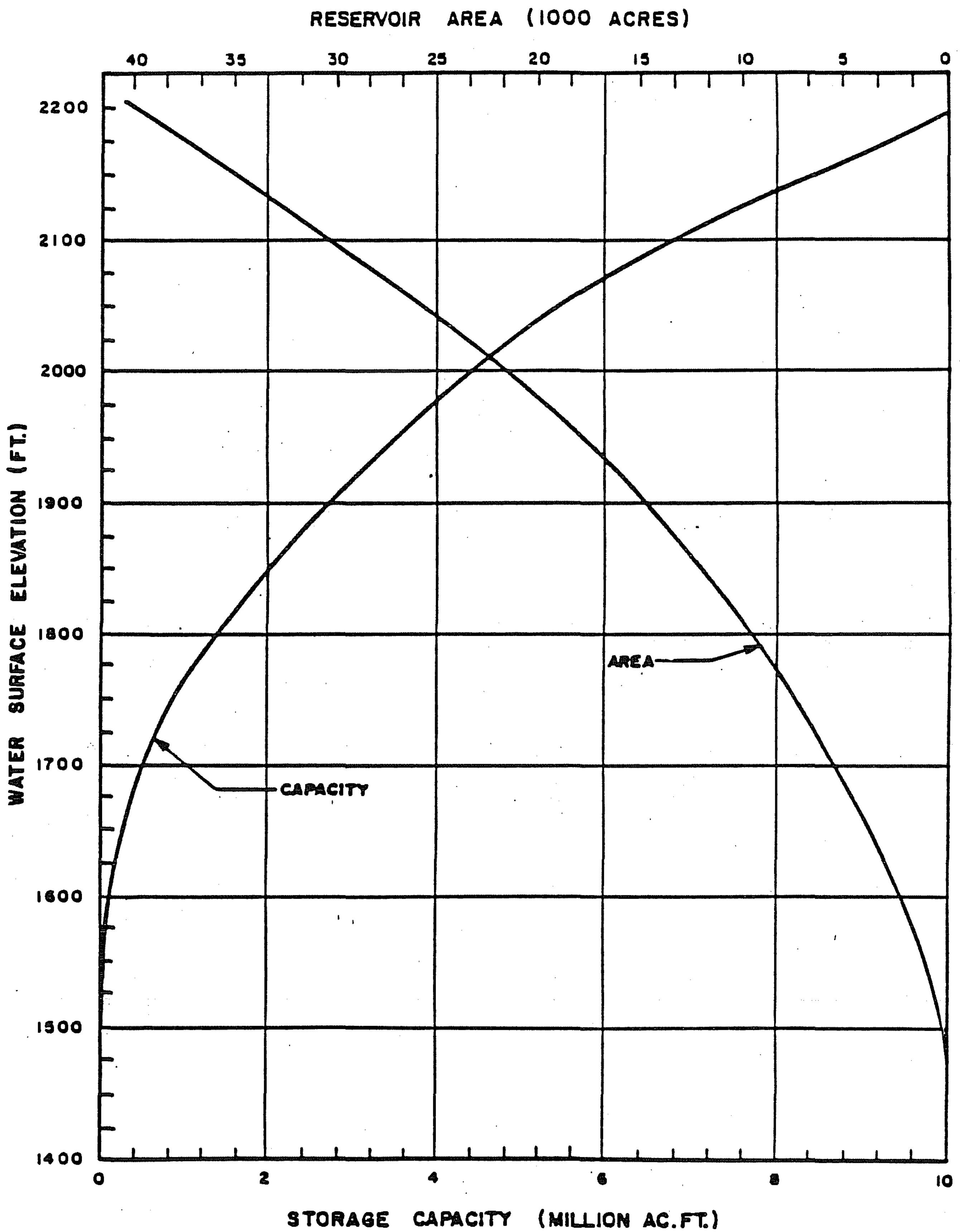
NOTES

1. WATANA BORROW SITE D IS THE PROPOSED SOURCE OF IMPERVIOUS MATERIAL (See Figure E-10-2.5.1-1).
2. PROPOSED SOURCE OF AGGREGATE AND FILTER MATERIAL.
3. PROPOSED SOURCE OF ROCKFILL.

REFERENCE: BASE MAP FROM R&M, 1981 - 1"=200'
DEVIL CANYON TOPOGRAPHY.
COORDINATES IN FEET, ALASKA STATE PLANE (ZONE 4)

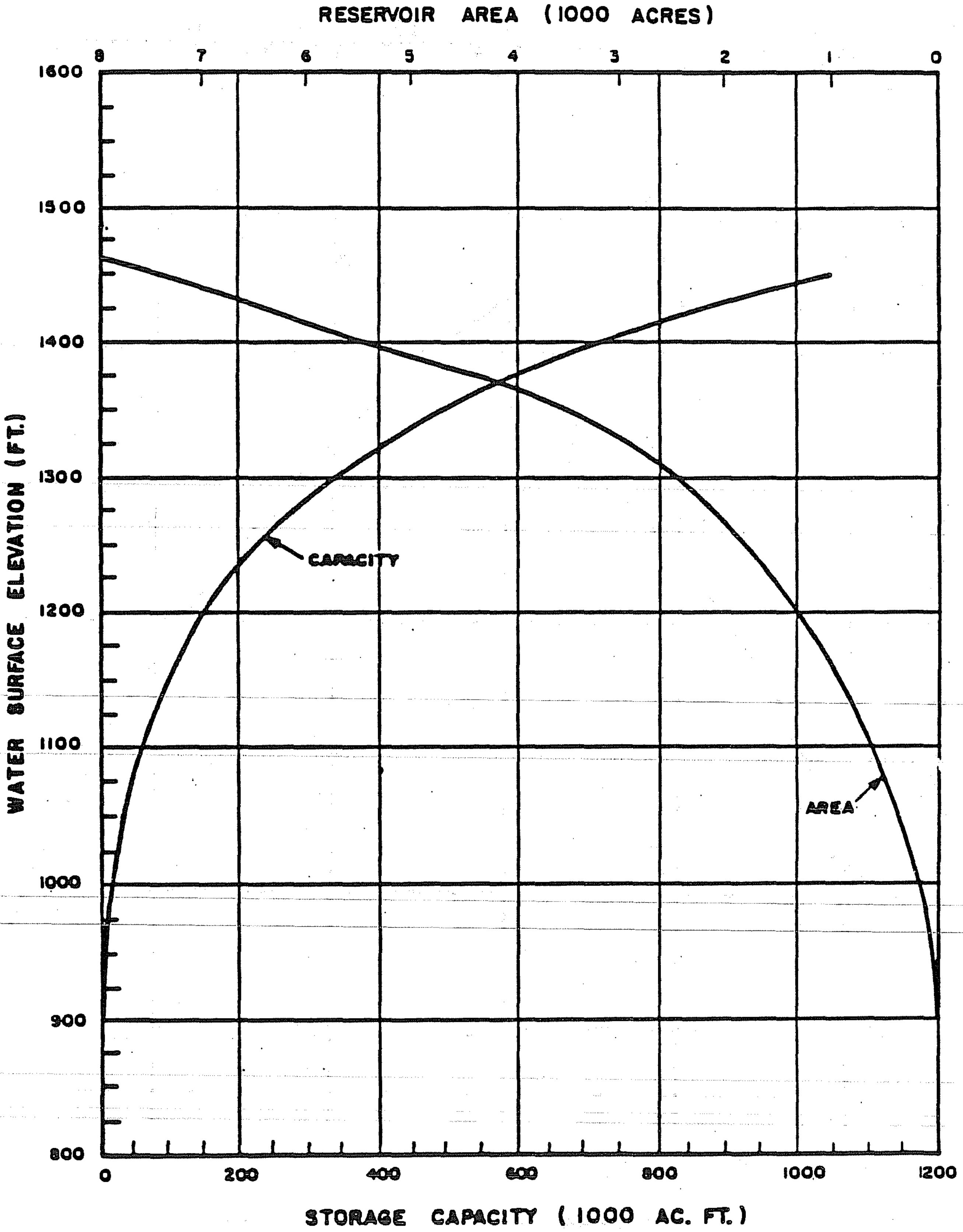
DEVIL CANYON
BORROW SITE MAP

FIGURE E.10.2.9



AREA AND CAPACITY CURVES
WATANA RESERVOIR

FIGURE E.10.3.1



AREA AND CAPACITY CURVES
DEVIL CANYON RESERVOIR

FIGURE E.10.3.2

ENVIRONMENTAL FLOW REQUIREMENTS CASE E I

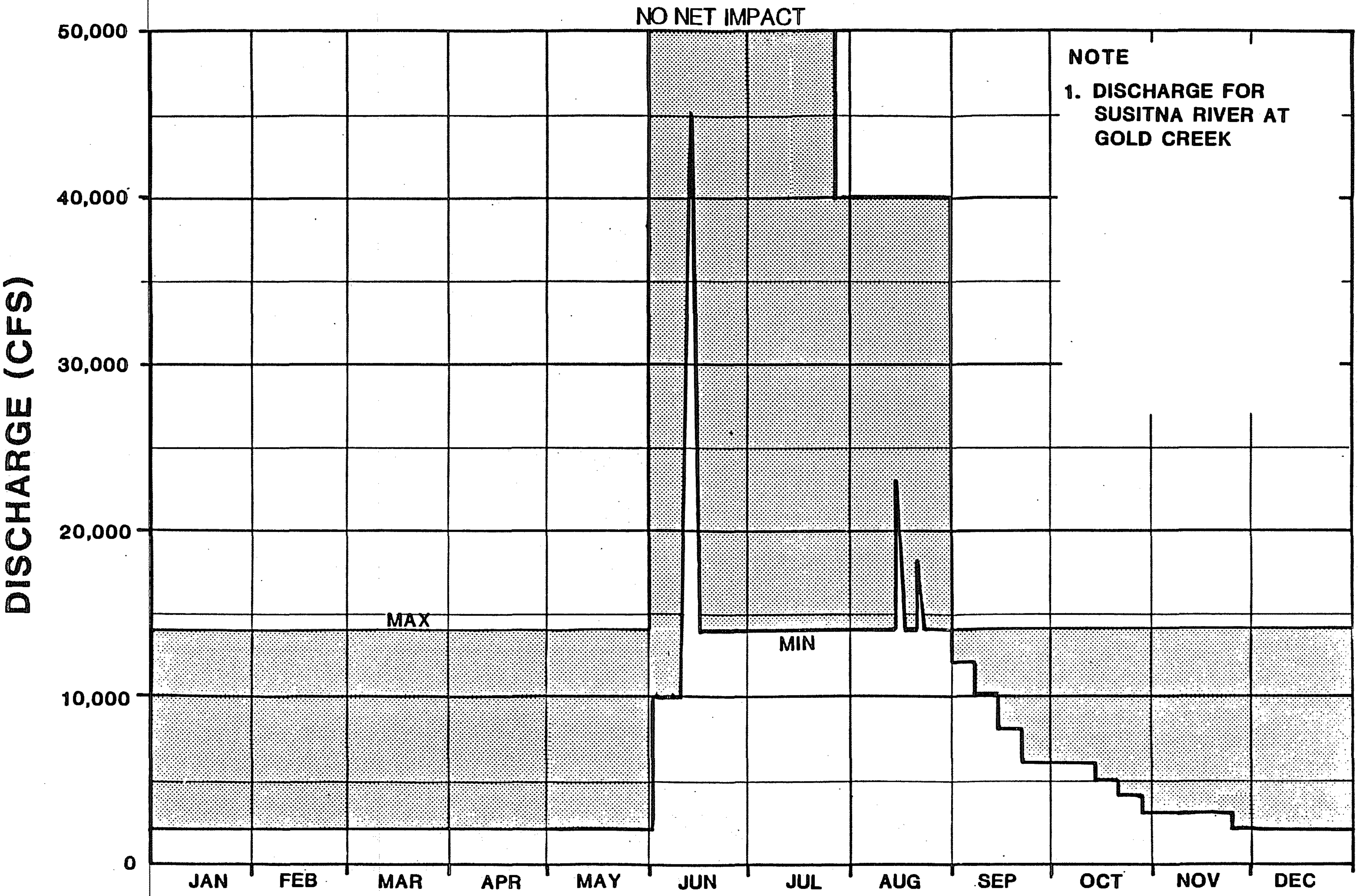


FIGURE E.10.3.3

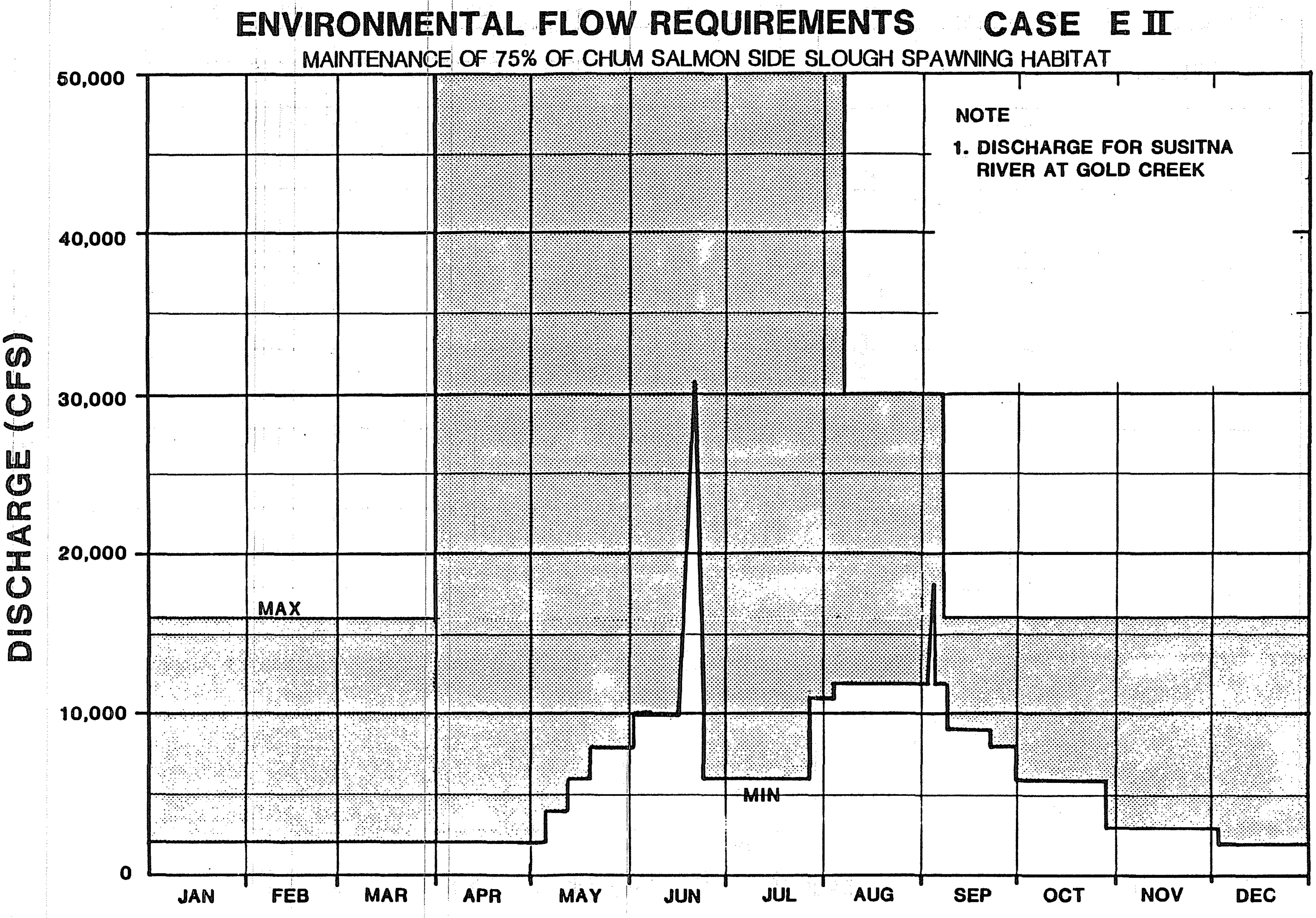


FIGURE E.10.3.4

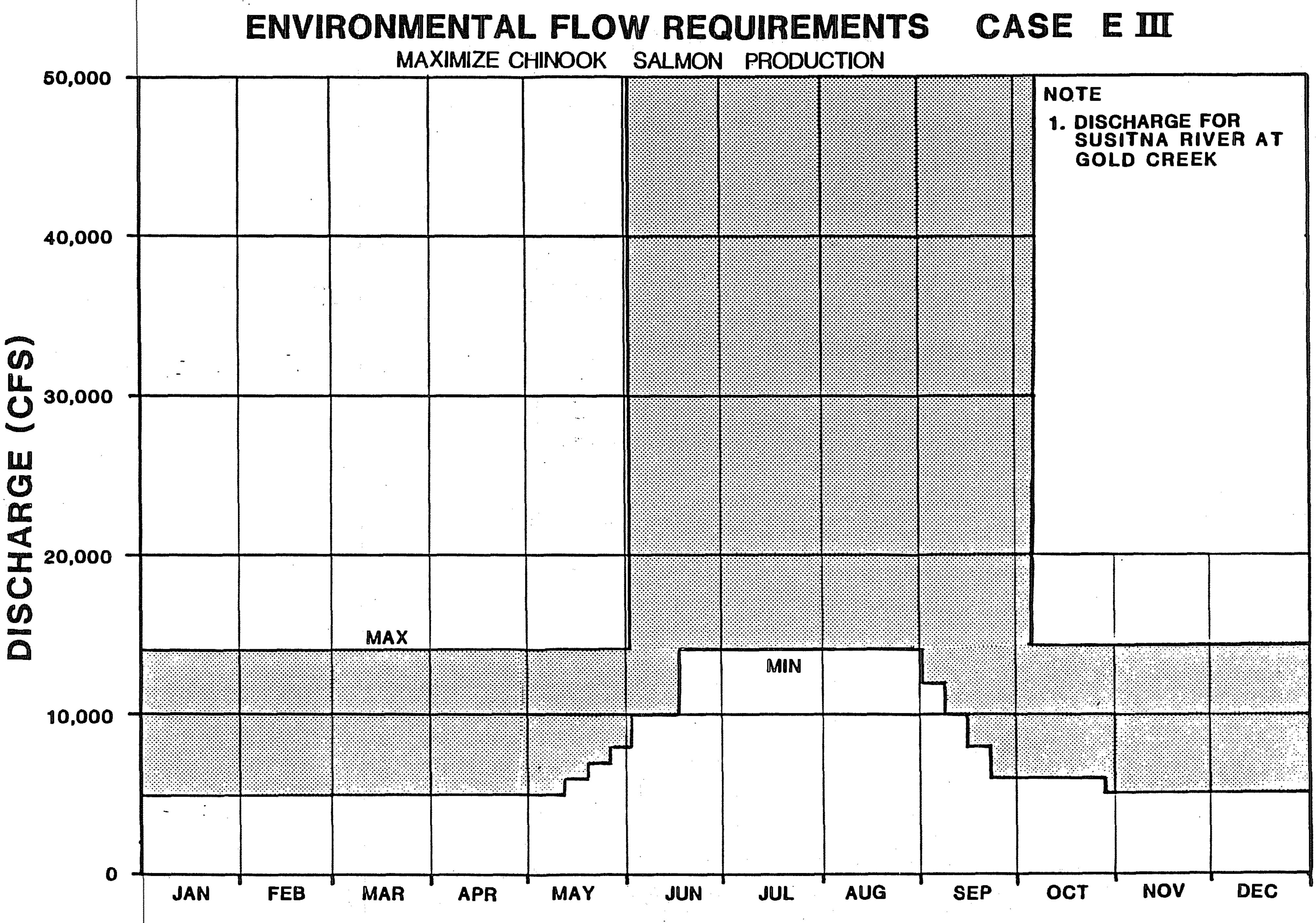
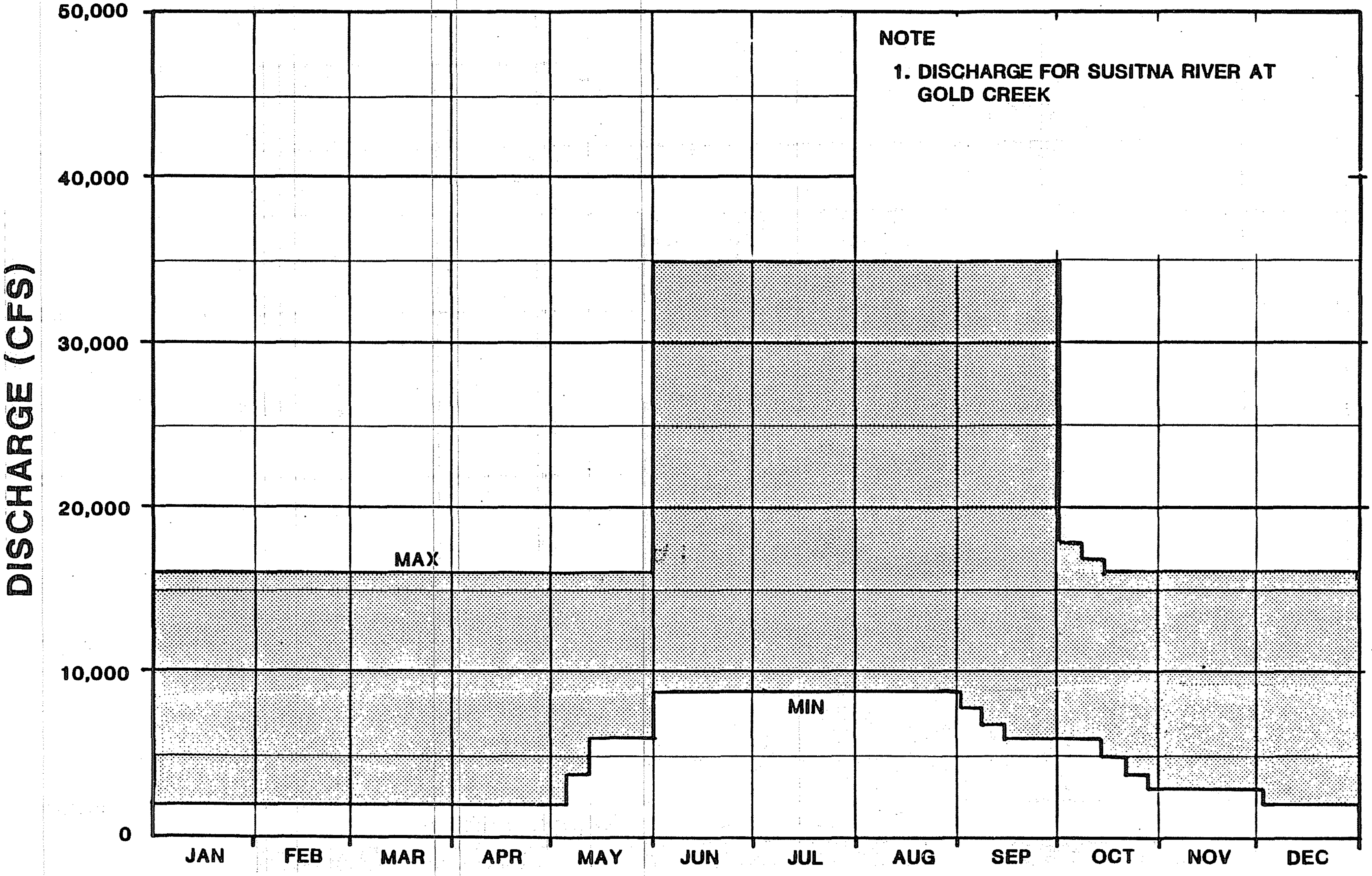


FIGURE E.10.3.5

ENVIRONMENTAL FLOW REQUIREMENTS CASE E IV

MAINTENANCE OF 75% CHINOOK SALMON SIDE CHANNEL REARING HABITAT



GUR 0.3.

ENVIRONMENTAL FLOW REQUIREMENTS CASE E IV a

MAINTENANCE OF 75% OF CHINOOK SALMON SIDE CHANNEL REARING

HABITAT-MAINTAIN CHUM SALMON SIDE SLOUGH SPAWNING WITH MINOR HABITAT MODIFICATION

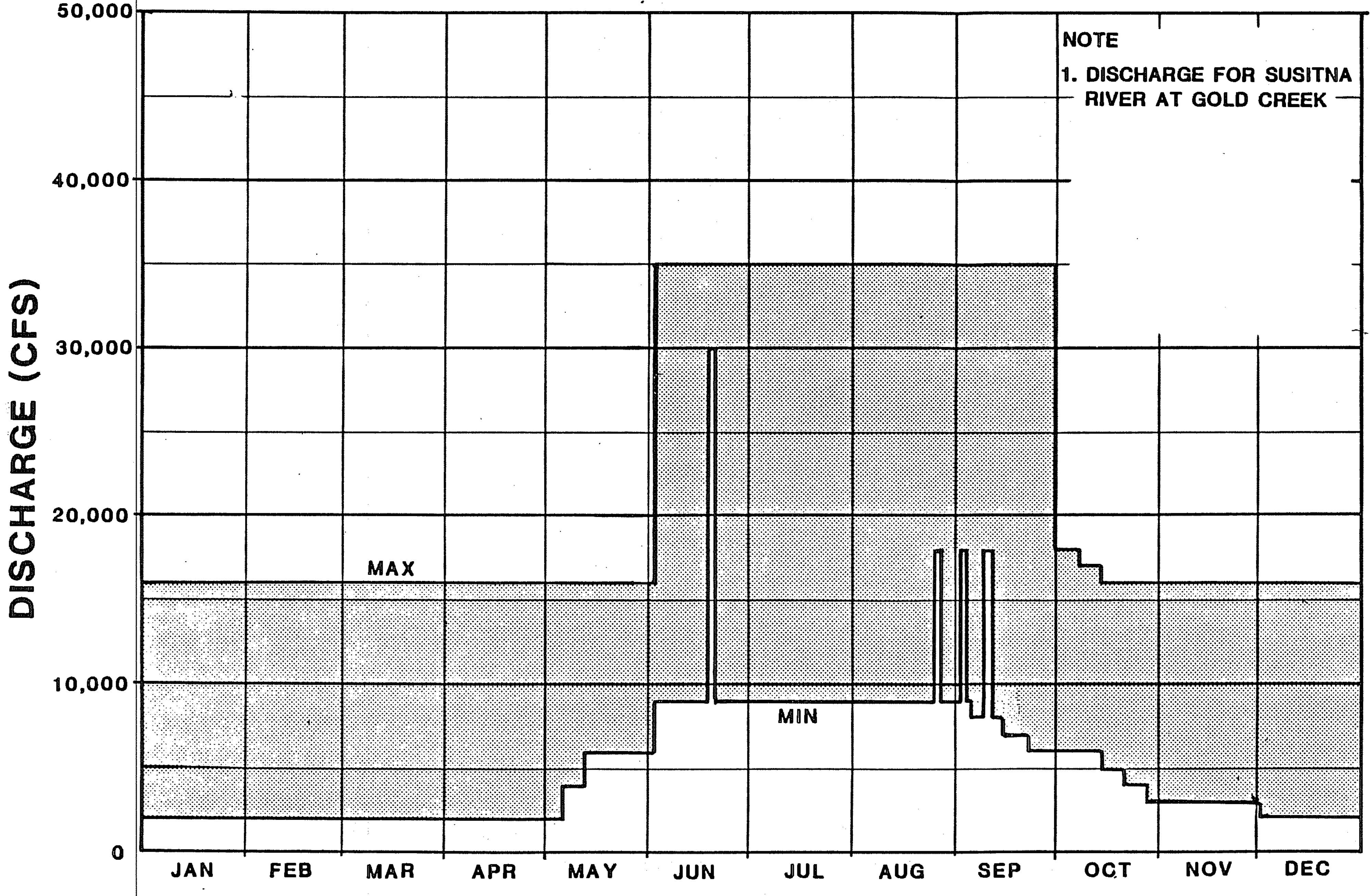


FIGURE E.10.3.7

ENVIRONMENTAL FLOW REQUIREMENTS CASE E IV b

MAINTENANCE OF 75% OF CHINOOK SALMON SIDE CHANNEL
REARING HABITAT- MAINTAIN CHUM SALMON SIDE SLOUGH SPAWNING WITH MODERATE HABITAT MODIFICATION

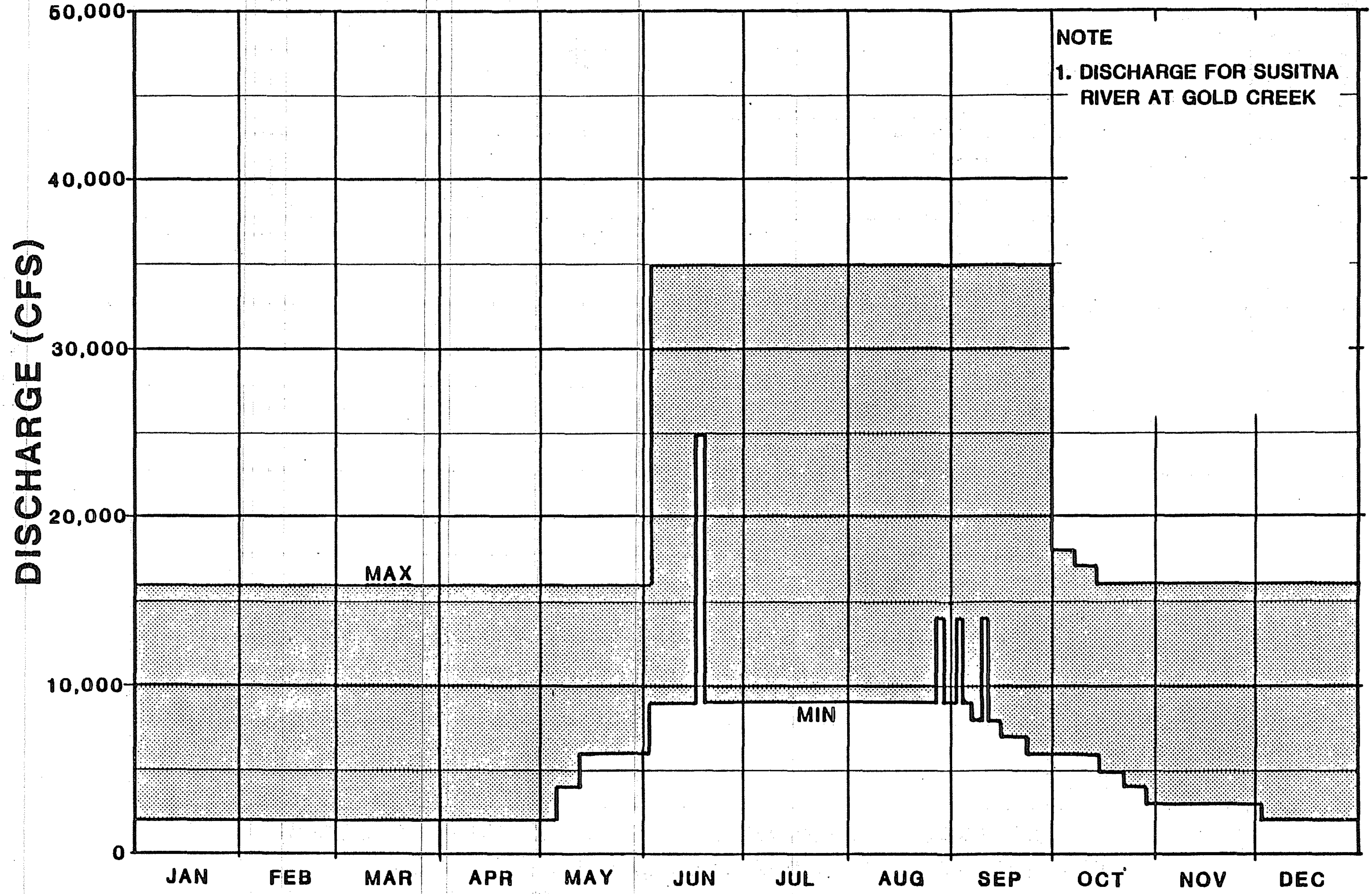


FIGURE E.10.[illegible]

ENVIRONMENTAL FLOW REQUIREMENTS CASE E V

MAINTENANCE OF 75% OF CHINOOK
SALMON SIDE CHANNEL REARING HABITAT AND75% OF CHUM SALMON SIDE SLOUGH SPAWNING HABITAT

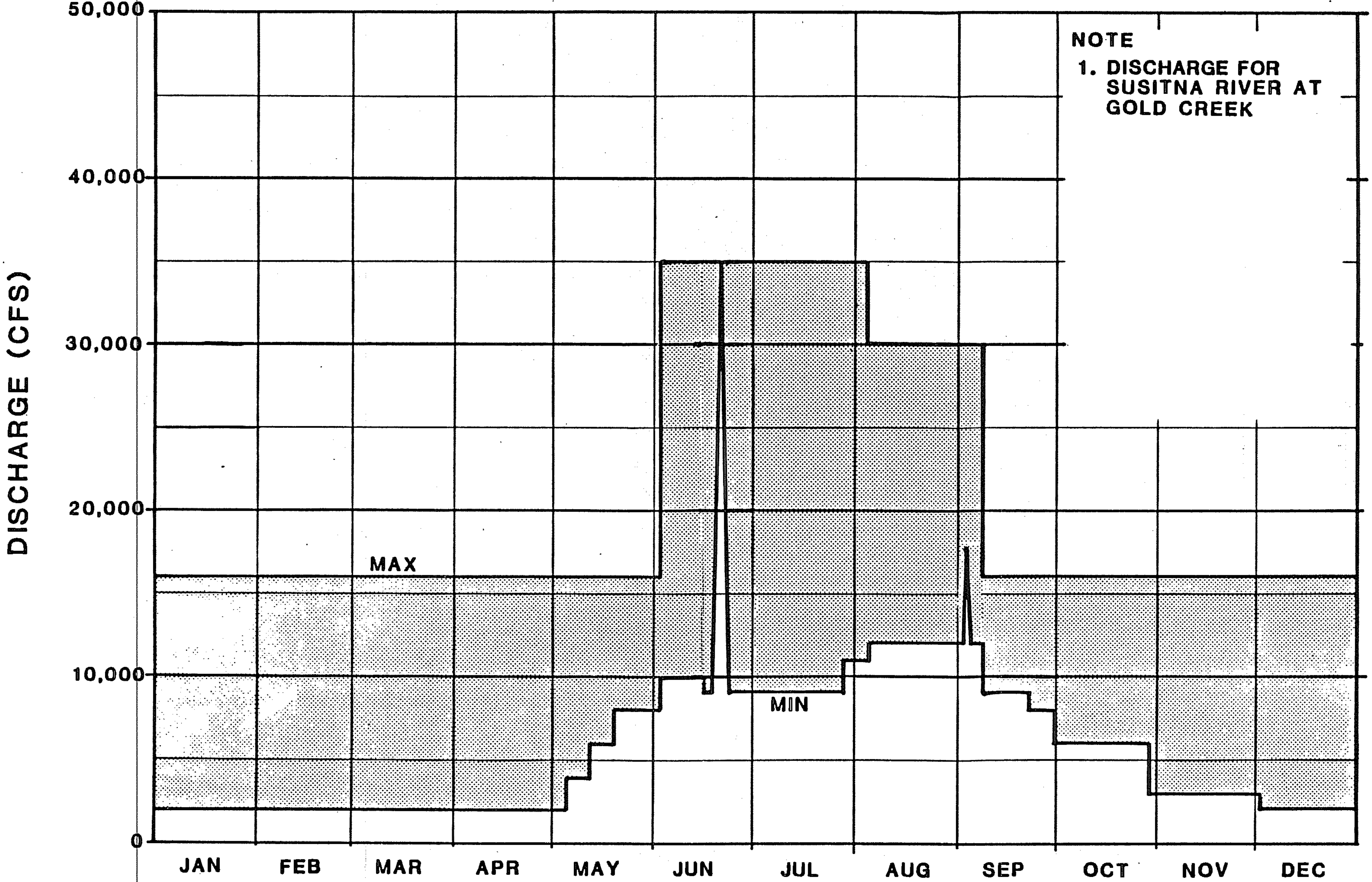


FIGURE E.10.3.9

ENVIRONMENTAL FLOW REQUIREMENTS CASE E VI

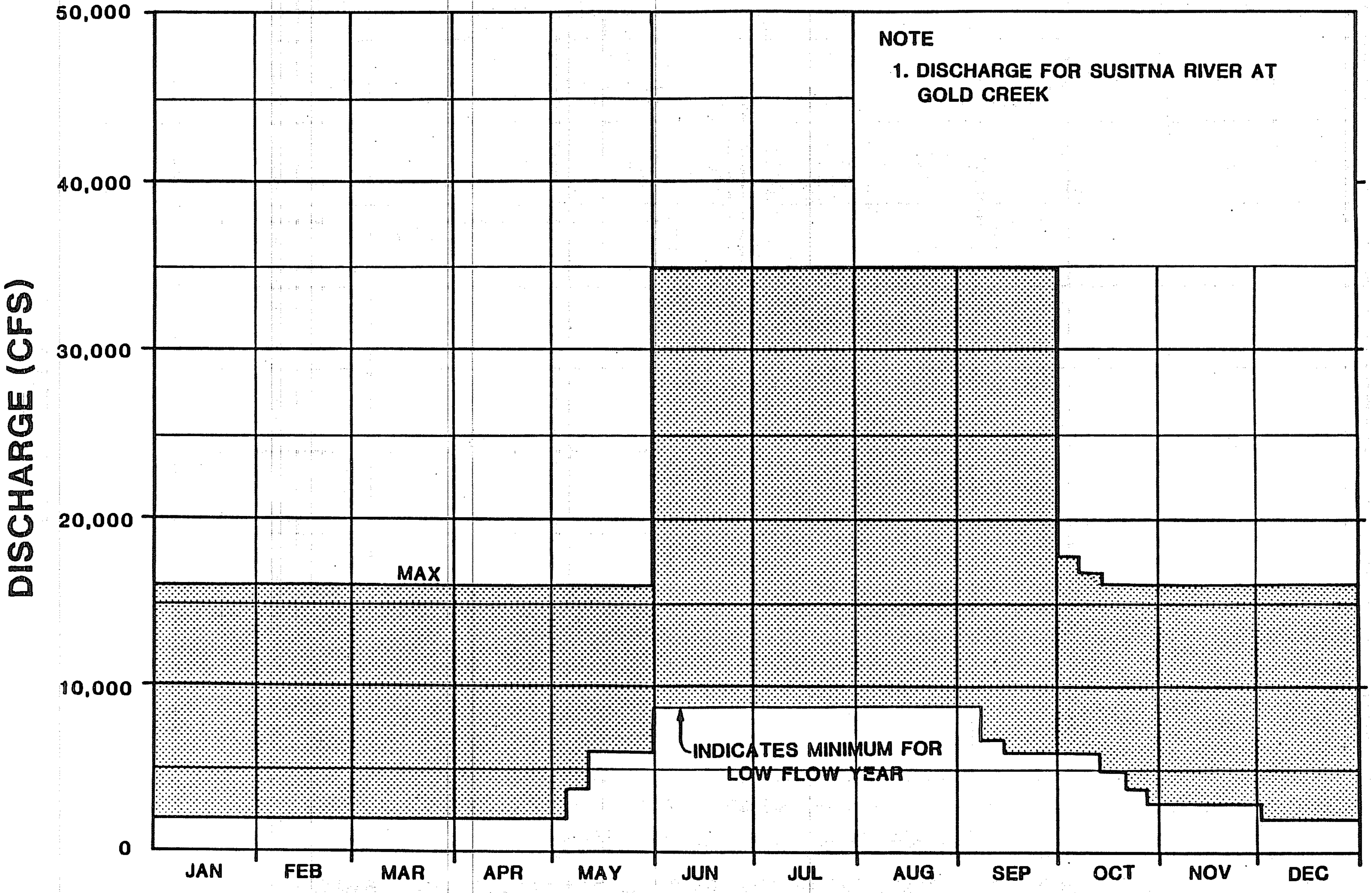
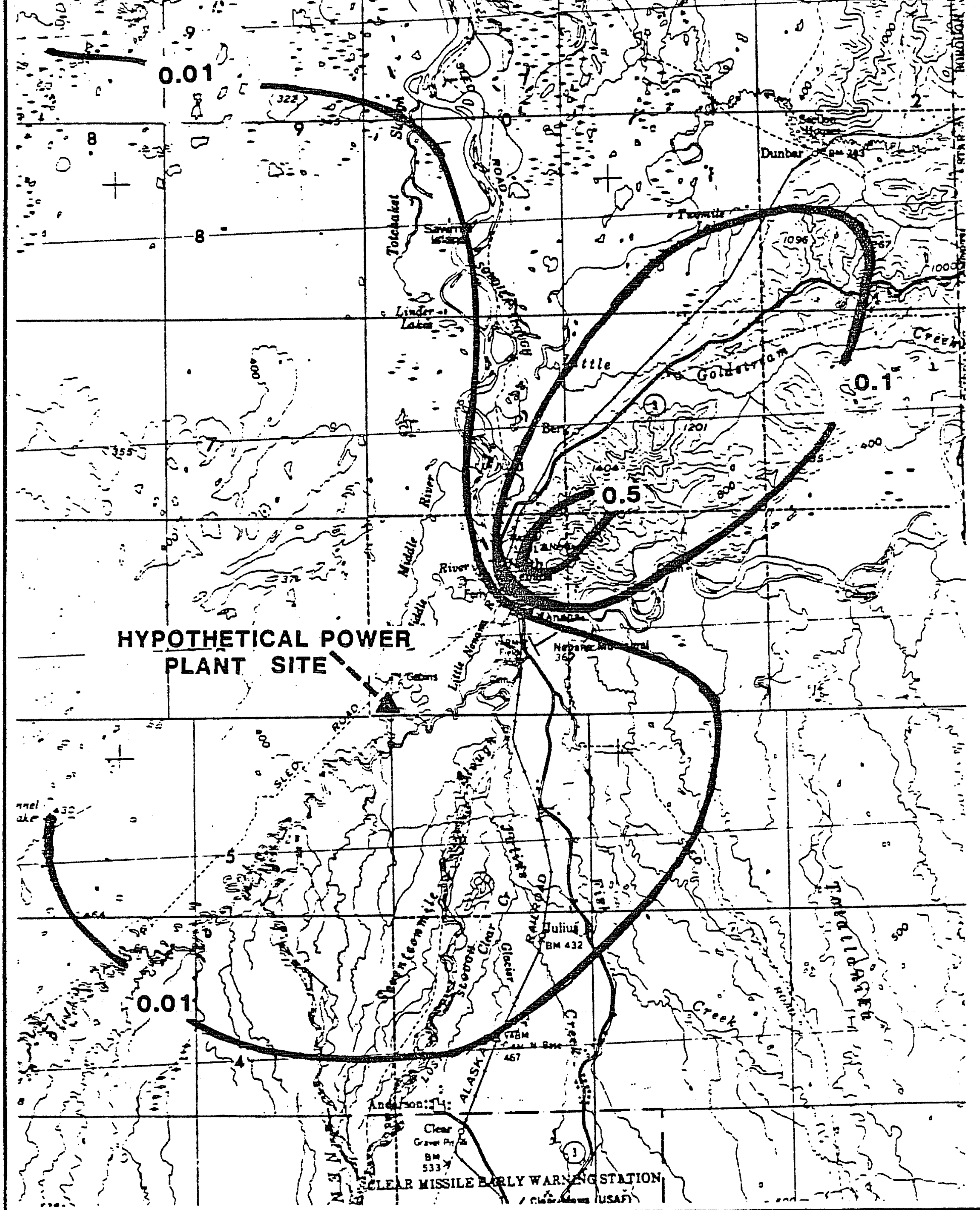


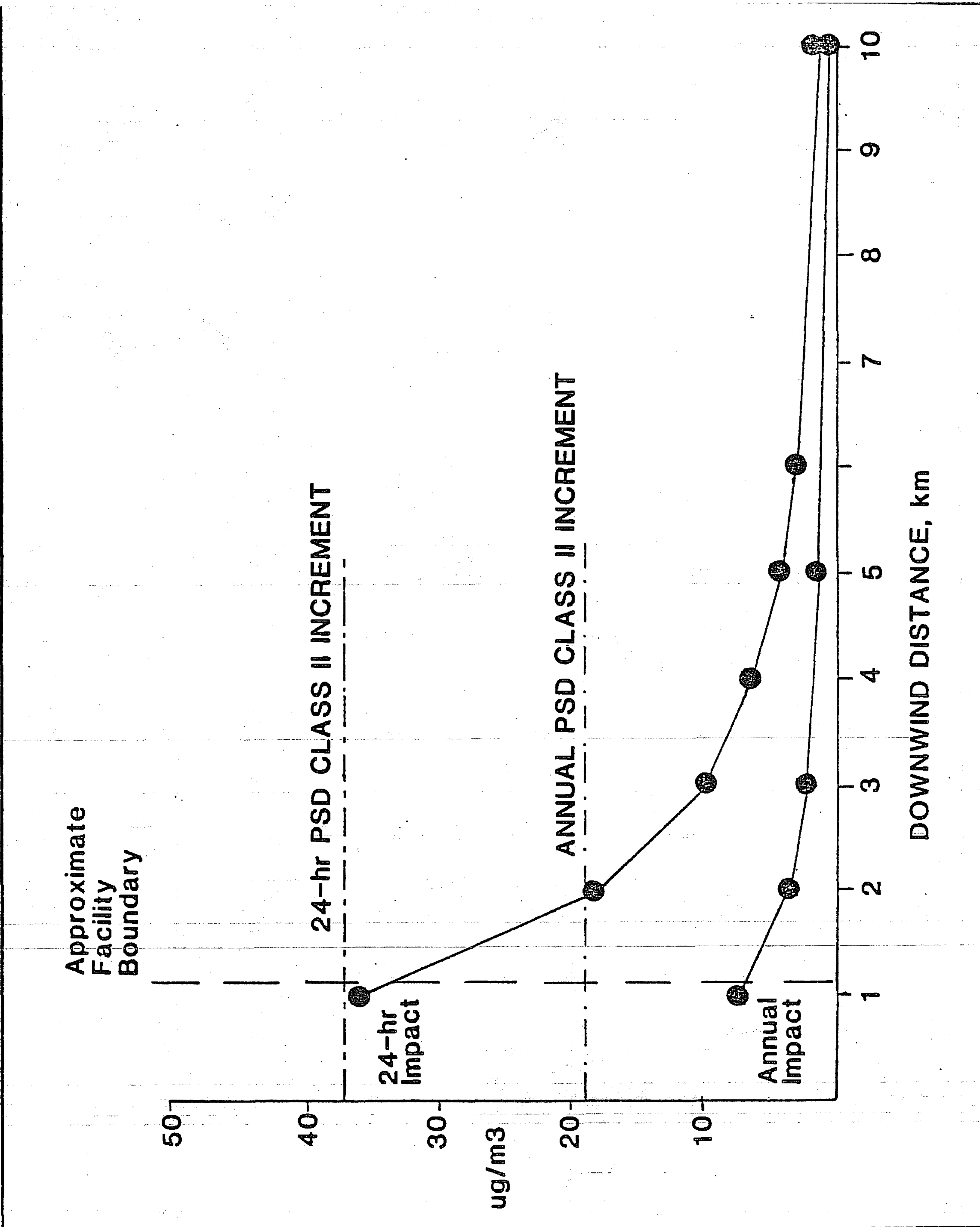
FIG. E.1[illegible]0



HARZA-EBASCO
SUSITNA JOINT VENTURE

Calculated SO_2 Isopleths Around the 400 MW Nenana Power Station (ug/m^3)

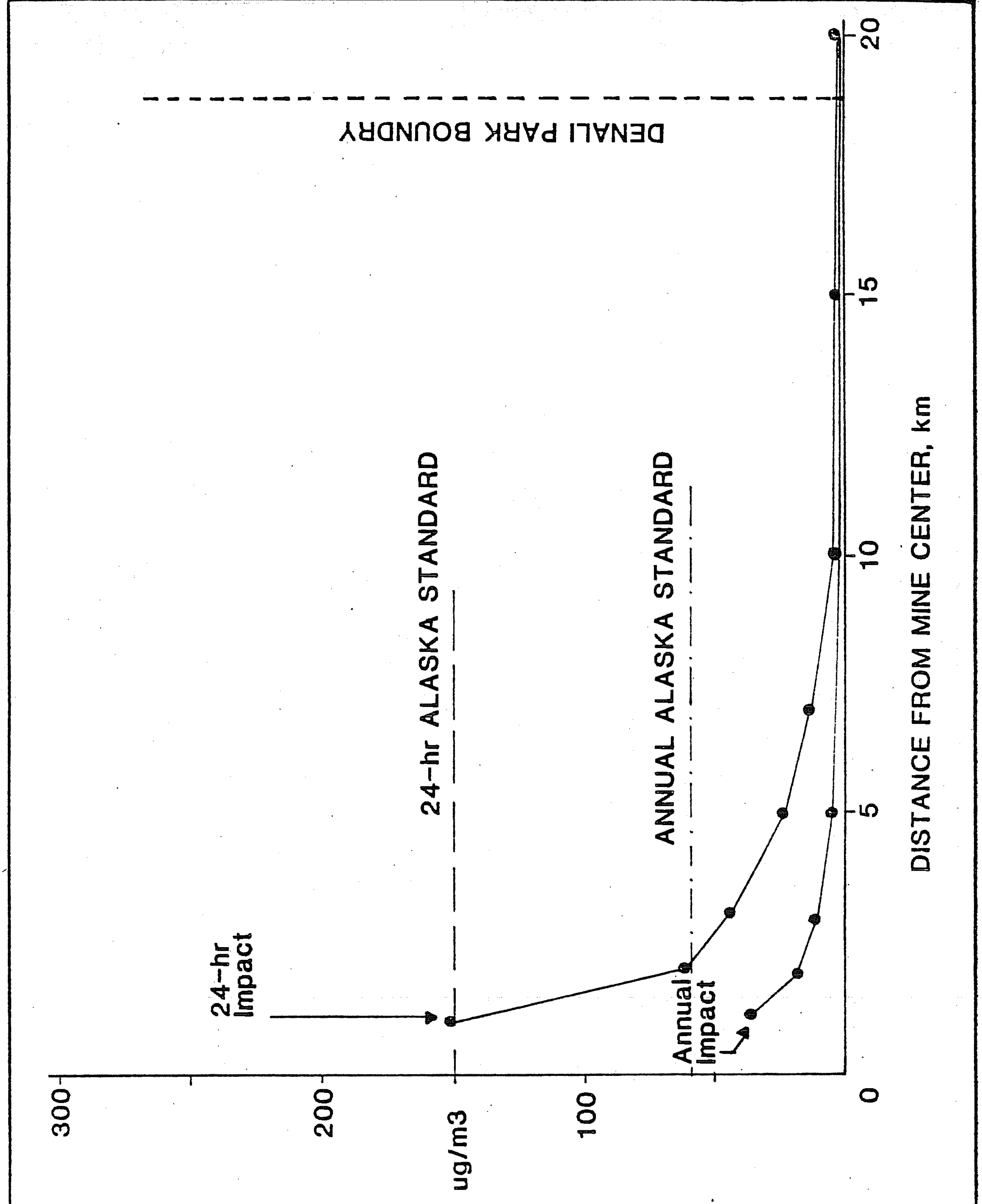
FIGURE E.10.4.1



HARZA-EBASCO
SUSITNA JOINT VENTURE

Calculated 400 MW
Nenana Power Station
Fugitive Dust Impacts

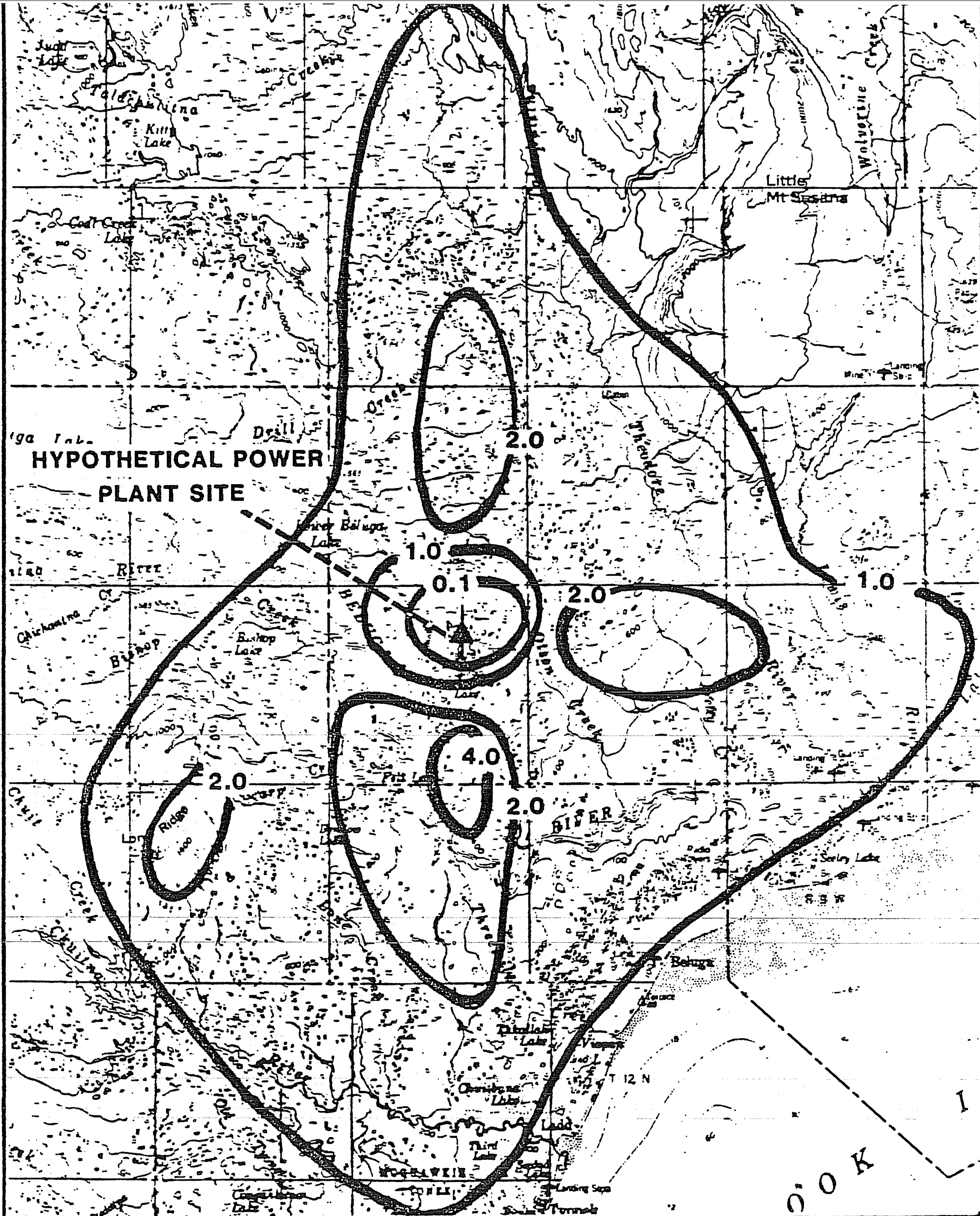
FIGURE
E.10.4.2



HARZA-EBASCO
SUSITNA JOINT VENTURE

Calculated Nenana Coal Mine
Fugitive Dust Impacts

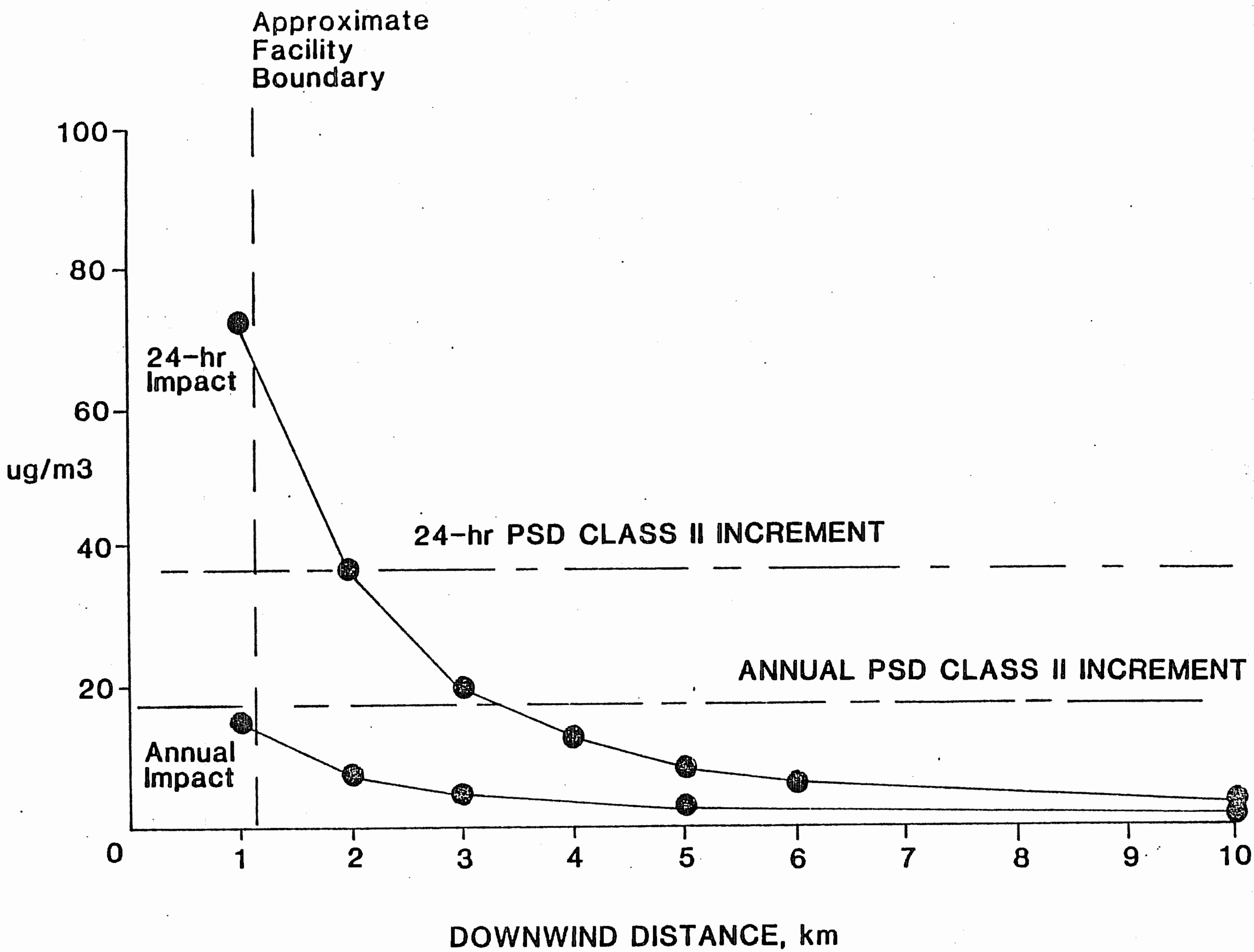
FIGURE
E.10.4.3



HARZA-EBASCO
SUSITNA JOINT VENTURE

Calculated SO_2 Concentrations around the Beluga Power Plant (ug/m^3)

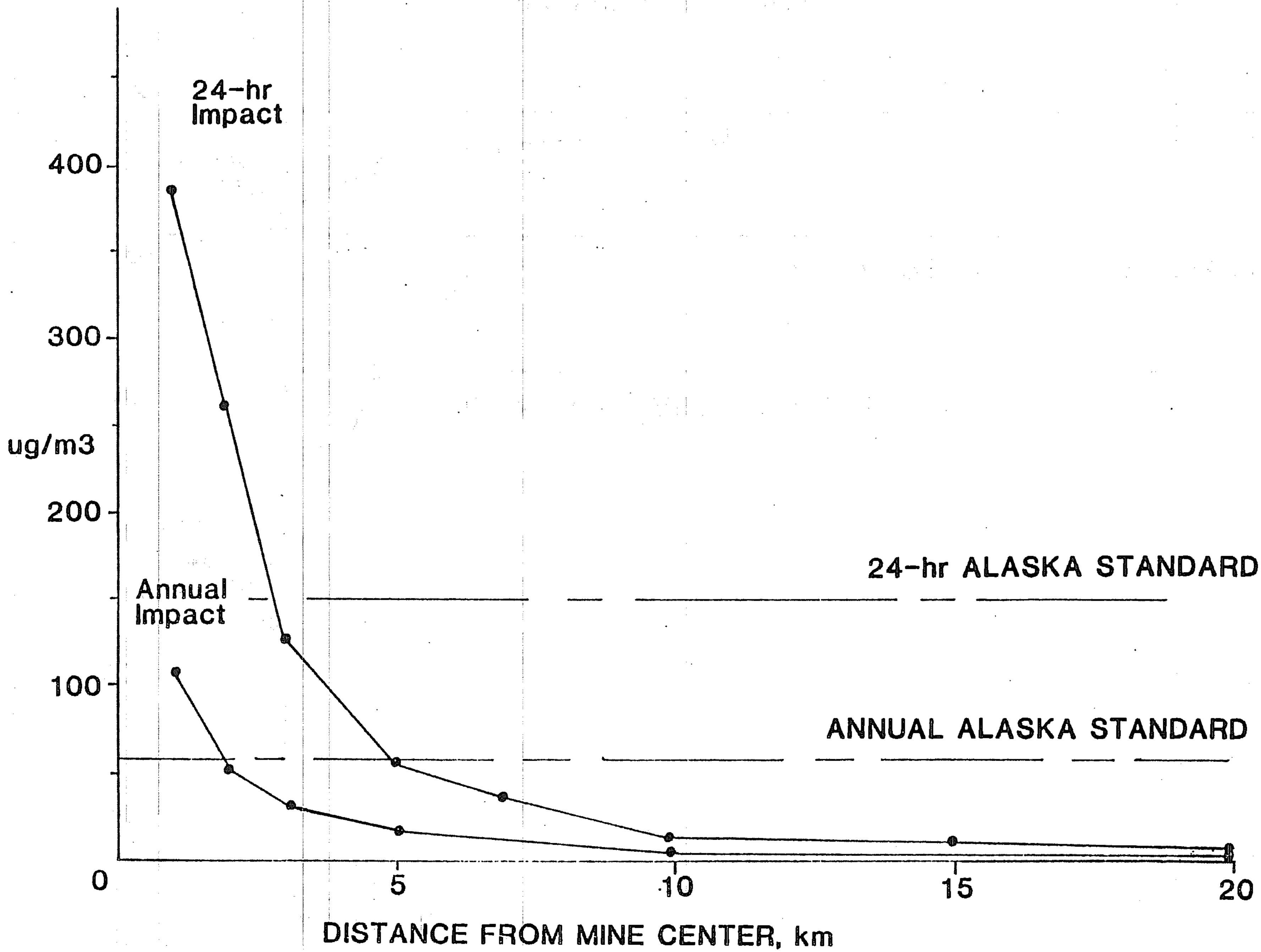
FIGURE E.10.4.4



HARZA-EBASCO
SUSITNA JOINT VENTURE

Calculated 800 MW
Beluga Power Station
Fugitive Dust Impacts

FIGURE
E.10.4.5



HARZA-EBASCO
SUSITNA JOINT VENTURE

Calculated Beluga Coal Mine Fugitive Dust Impacts

FIGURE E.10.4.6

CHAPTER 11

AGENCY CONSULTATION

EXHIBIT E - CHAPTER 11
AGENCY CONSULTATION

LIST OF TABLES

EXHIBIT E - CHAPTER 11
AGENCY CONSULTATION

1 - ACTIVITIES PRIOR TO FILING THE INITIAL APPLICATION (1980 - FEBRUARY 1983) (***)

The Applicant conducted extensive agency consultation, beginning with a request for review of the Plan of Study in the spring of 1980 and carrying through to a request for review and comment on the Draft Exhibit E on November 15, 1982. Detailed discussion of agency consultation during this period was presented in Exhibit E Chapter 11 (Volumes 10A and 10B) of the original License Application filed before the Federal Energy Regulatory Commission (FERC) in February, 1983.

Principal items for which agency comment and review were requested included:

- Plan of Study - circulated for review in March 1980, with subsequent public and agency meetings in 1980.
- Project Assessment Reports - annual environmental reports, access road reports, transmission line siting reports, Mid-Study report.
- Development Selection Report - circulated in March 1981.
- Mitigation Planning - fish and wildlife mitigation policy development and mitigation option papers were discussed with the agencies in 1981 and 1982.
- Feasibility Report - distributed for agency review and comment in March 1982, and provided to FERC in April 1982.
- Testimony before the Power Authority Board of Directors - a public hearing was held in April 1982 to receive testimony from resource agencies, power utilities, and the public.
- Draft License Application Exhibit E - distributed to appropriate federal, state, and local agencies for review and comment November 15, 1982 and discussed at a workshop in Anchorage November 29 - December 2, 1982. The draft Exhibit E was also submitted to FERC November 15, 1982.

2 - ADDITIONAL FORMAL AGENCY AND PUBLIC CONSULTATION (***)

The Applicant has engaged in extensive information dissemination and agency consultation since it filed the original application before the FERC in February, 1983. The goal of the Applicant has been to involve interested agencies in extensive consultations regarding the project's environmental impacts, both with a view towards improving project design and operation, and for the purpose of cooperatively resolving as many issues as possible.

2.1 - Technical Workshops (***)

In addition to regular meetings regarding formulation of environmental plans of study, the Alaska Power Authority in 1984 began holding a series of technical workshops to enable federal, state, and local resource agency personnel, as well as interested citizens, to discuss the results of technical studies conducted by the Applicant, its contractors, and subcontractors with regard to environmental issues. Each workshop is aimed at discussing newly released project environmental reports or documents. To date the Applicant has conducted twelve workshops; seven on aquatic environmental studies analysis and mitigation; three on terrestrial environmental studies analysis and mitigation; and two on social science programs, including cultural resources, socioeconomic studies, recreation studies, esthetic planning and land use.

Each workshop is proceeded by a mailing which includes the documents to be discussed at the workshop. Review of the documents and comments are encouraged. Minutes and a formal transcript have been prepared for each of the technical workshops for use by those unable to attend the workshops. Table E.11.1 lists the twelve technical workshop topics and the documents discussed. Comments reviewed and information exchanged during these conferences are incorporated throughout this Exhibit E.

2.2 - Ongoing Consultation (***)

Immediately after original FERC filing in February, 1983, the Applicant sought to identify environmental issues relating to known and potential project impacts. By March of 1984, 56 issues ranging from very minor concerns to significant resource utilization issues were identified by the Applicant in conjunction with state, federal, and local resource agencies. These 56 issues comprised what became known in the context of an extensive cooperative consultation effort as "the issues list" which was disseminated to all interested parties for comment. The list was derived in order to enable the Applicant and the appropriate resource agencies and concerned citizens to focus environmental studies and mitigation planning on specific and important issues.

The Applicant embarked upon a program to produce succinct compilation of information regarding each of the 56 issues and to share that information and the Applicant's views with regard to the significance of each issue and its proposals to deal with the issue with all interested agencies and citizens. Information compiled through this process includes numerous specific topic discussion meetings and opportunities to comment, and has been incorporated in to the appropriate sections of Exhibit E. (Transcripts of these meetings are available as are compilation of the relevant information on each issue.) In addition, it is the Applicant's intent to continue intensive consultation after finalization of this Amended Application for the purpose of cooperatively resolving as many of the issues as possible to the satisfaction of all interested entities.

2.3 - Further Comments and Consultation (***)

An extensive presentation of comments received from resource agencies and others during the course of the preparation of this License Amendment will be provided in the Final Amendment to be filed with the Federal Energy Regulatory Commission.

TABLES

TABLE E.11.1: SUSITNA HYDROELECTRIC PROJECT TECHNICAL WORKSHOPS HELD IN ANCHORAGE, ALASKA

Workshop and Date	Topic	Documents
Aquatic 1 February 15, 1984	Aquatic Modeling Approaches	o AEIDC's January 1984 report on Aquatic Impact Assessment
Aquatic 2 March 30, 1984	FY85 Aquatic Studies Workscope	o Draft FY85 Aquatic Plan of Study
Terrestrial 1 April 10, 1984	FY85 Terrestrial Studies Workscope	o Draft FY85 Terrestrial Plan of Study
Social Sciences 1 April 17, 1984	FY84 and FY85 Social Sciences Studies Workscopes	o Household, business, public sector surveys o Draft FY85 Social Science Program Study Tasks o Updated Socioeconomic Impact Projections Summary Report (March 1984)
Aquatic 3 May 15, 1984	Instream Temperature and Ice Conditions	o Effects of Water Temperature on Chum and Sockeye Salmon Incubation o SuHydro Winter Aquatic Data Report (Oct. 82 - May 83) o 1982-83 Susitna River Ice Study o Discharge and Temperature Changes due to the Proposed Project o Stream Flow and Temperature Modeling in the Susitna Basin o Instream Ice Calibration of Computer Model

TABLE E.11.1 (Page 2 of 3)

Workshop and Date	Topic	Documents
		o Eklutna Lake Temperature and Ice Study and Watana Reservoir Simulation
		o Information Summary for Temperature Criteria Development
Aquatic 4 June 15, 1984	Studies on Physical Processes	o Sediment Discharge Data for Susitna Basin Sites
		o Reservoir and River Sedimentation
		o Preliminary Assessment of Salmon Access into Portage Creek and Indian River
Terrestrial 2 June 26, 1984	Terrestrial Impact Assessment and Mitigation Plan Refinement	
Aquatic 5 August 6, 1984	Water Quality	o Susitna River Sedimentation and Water Clarity Study
		o Water Quality Effects from Impoundment
		o 1982 Water Quality Annual Report
Social Sciences 2	Cultural Resources Research Priorities	o Site Significance Criteria Report
		o Summary of Cultural Resource Investigations

TABLE E.11.1 (Page 3 of 3)

Workshop and Date	Topic	Documents
		o Annotated Bibliography of Selected UAM Project Reports
		o Archeology Study Area Map
		o Site Record Form
		o Susitna River Tephrochronology Chart
		o Geological Terrain Unit Map
Aquatic 6 October 29, 1984	Aquatic Habitat and Instream Flow	o Aquatic Habitat Surface Areas Response to Mainstem Discharge
		o Slough Geohydrology Studies
		o Resident and Juvenile Anadromous Fish Investigations (May-Oct 83)
		o Aquatic Habitat and Instream Flow Investigations
		o Adult Anadromous Fish Investigations (May-Oct 83)
Aquatic 7 December 4, 1984	Fisheries Mitigation	o Fish Mitigation Plan (Nov 84)
Terrestrial 3 January 30, 1985	Big Game and Furbearer Field	o Eight Big Game Studies Annual