ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

REVIEW OF PREVIOUS STUDIES AND REPORTS
SUBTASK 6.01

CLOSE OUT REPORT

AUGUST 1980

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 - INTRODUCTION

The development of hydropower in the Susitna Basin has been under consideration for the last 30 years. It is therefore essential that the Task 6 design development consider important findings of these past studies. Hence the first subtask has been to review these past studies from civil, geotechnical, hydrological, environmental, hydropower, planning and economic viewpoints.

The objective of this subtask as stated in the Plan of Study was to "Assemble and review all available engineering data, siting, and economic studies relating to the Susitna hydropower development and to alternative potential sites". Alternative potential sites has been taken to include only sites above Gold Creek in the Upper Susitna Basin.

Other sites and developments both in the lower Susitna basin and other rivers are included in Subtask 6.33 - Hydroelectric Generation Resources. Collection of geotechnical and hydrological data is the subject of Subtasks 3.01 and 5.01, respectively; however, those parameters as related to specific developments are included briefly herewith.

This report represents a brief review of the previous studies and significant findings. Section 2 is a summary of the report. Section 3 gives a chronological review of the previous studies. Section 4 deals with civil, hydrological, geotechnical, environmental, hydropower and planning parameters associated with each of the previously identified sites. Cost comparison between alternatives is given in Section 5. Discussions and conclusions are included in Section 6.

2 - SUMMARY

2.1 - Previous Studies

The hydroelectric potential of the Upper Susitna Basin has been the subject of several studies during the past 30 years. The major studies have included the following:

(a) Potential water resources in the Susitna River Basin, United States Bureau of Reclamation (USBR) - 1952 and updated in 1953;

(b) Devil Canyon Project - USBR 1960;

(c) An alternative to the Devil Canyon Project - Kaiser Engineers, 1974;

(d) Interim Facility Study by the Corps of Engineers in 1975; and

(e) Supplemental Feasibility Study by the Corps of Engineers in 1979.

Other studies have dealt specifically with environmental issues and geotechnical investigations.

The [illegible] study by the USBR identified a total of 10 sites in the Susitna Basin above Gold Creek. Preliminary schemes of development including dam types and heights were presented for seven of the sites. From these studies it was proposed that the ultimate development consist of dams at Olson, Devil Canyon, Watana, Vee and Denali with a total installed capacity of 1010 MW.

The first stage of this development was the subject of the 1960 USBR study on the Devil Canyon Project. This study developed a design for the Devil Canyon Dam and the Denali Dam. Devil Canyon was to have an installed capacity of 580 MW and Denali would be used only for regulation of downstream flow.

The Kaiser Study suggested the construction of a dam approximately five miles upstream of the Devil Canyon site known as Susitna I or High Devil Canyon (in later studies) in place of the Devil Canyon development. This had the advantage that unlike the Devil Canyon Site, sufficient storage would be available for utilization of the potential at Devil Canyon without a separate upstream reservoir. Ultimately three other dams would be constructed for full basin development.

The Interim and Supplemental Feasibility Studies by the Corps of Engineers represents the most extensive work performed on developing the Upper Susitna potential. Several schemes of development were considered with dams at Watana and Devil Canyon being selected as the most economical development as well as the best environmentally. It was shown that the Benefit Cost Ratio for these developments would be approximately 1.42 over the alternative coal-fired plant alternative.

2.2 - Design Parameters

Information has been gathered for a total of eleven sites identified in previous studies (see Figure 1) above Gold Creek. Some of these sites are mutually exclusive sites. Table 5 lists the sites, alternative dam heights and which sites are eliminated by a development at a given site. This information is also given in graphic form in Figure 2.

Available information has ranged from detailed layouts to merely identification of a potential site. Table 4 summarizes the extent of engineering layout information available for these sites.

Design parameters for the various developments are given in Section 4. Tables 6, 7, 8, and 10 give the civil, hydrological, environmental, and hydropower design parameters which have been collected from previous studies. Available drawings are included in Appendix A.

2.3 - Cost Comparisons

The most extensive cost information for alternative developments is found in the 1975 Corps of Engineers Interim Feasibility Report. This is based on adjustments to bid prices in the Pacific Northwest and Canada to 1975 price

levels for Alaska labor rates, and for transportation costs to the site. Table 11 gives a cost for the alternative developments escalated to 1980 price levels using the Whitman Index. Cost data extracted from the Corps of Engineers 1975 report is given in Appendix C.

2.4 - Discussion and Conclusions

The following major items were identified in this review of previous studies:

(a) The Devil Canyon site appears to be one of the best sites for development; however, this requires upstream regulation for effective operation.

(b) The Kaiser plan proposes a single dam located in the Devil Canyon region which would provide both the high head and storage required. It would appear this should be studied in more detail.

(c) The economics of the proposed project is more dependent on forced retirements of existing plants than future load growth. The viability of this assumption should be checked.

3 - PREVIOUS STUDIES

Hydroelectric potential of the Susitna River Basin has been studied by different agencies at various times in the last 30 years. The first reports were general in nature, the earliest of which was made by the Corps of Engineers in 1950. Several potential sites for hydroelectric power development on the Susitna were identified as part of a survey of Cook Inlet and tributaries. The report identified three sites on the main stem Susitna (Denali, Watana and a site 2.5 miles upstream of Portage Creek confluence), all upstream from Gold Creek. A second study, the Bureau of Reclamation Reconnaissance Study on the Potential Development of Water Resources in Alaska was completed in January 1952. This study identified three alternative sites for the full development of Susitna hydro potential.

Subsequently, the feasibility of hydropower development of the Susitna River has been the subject of several more detailed studies. The most significant of these studies are:

(a) U.S. Bureau of Reclamation - 1952, 1953
(b) U.S. Bureau of Reclation - 1960
(c) Kaiser Engineers - 1974
(d) U.S. Corps of Engineers - 1975
(e) U.S. Corps of Engineers - 1979

The final reports of each of these general studies, as well as other reports dealing with the geology and environmental issues at specific sites, have been reviewed. Significant parameters extracted from these studies are included in Section 4.

The first major study was completed in 1953 by the USBR. In this study a total of ten sites were identified above the railroad crossing at Gold Creek (see Figure 1). These sites were:

(a) Gold Creek
(b) Olson
(c) Devil Canyon
(d) Devil Creek
(e) Watana
(f) Vee
(g) Maclaren
(h) Denali
(i) Butte Creek
(j) Tyone (on Tyone Creek)

An additional 15 dam sites were identified with the remainder of the Susitna Basin downstream of the Gold Creek railroad crossing. A review of these sites will be part of Subtask 6.33 - Hydroelectric Generation Resources and has not been included as part of this subtask.

Some of the sites were eliminated from detailed study solely on the basis of field examination. For example, Butte Creek site was eliminated because Denali was considered to be better and was only a short distance downstream. The plan of ultimate development was selected based on the criteria that the maximum energy output be obtained at least cost. This plan included the development of the following sites:

(a)	Olsen:	Pool elevation = 920 ft	Installed capacity = 50 MW
(b)	Devil Canyon:	Pool elevation = 1,417 ft	Installed capacity = 390 MW
(c)	Watana:	Pool elevation = 1,900 ft	Installed capacity = 310 MW
(d)	Vee:	Pool elevation = 2,330 ft	Installed capacity = 260 MW
(e)	Denali:	Pool elevation = 2,590 ft	No power generation facilities

The first stage of development was to consist of a dam at Devil Canyon with the initial installation of 195 MW of capacity. To meet further increases in demand, the dam at Denali would be built. This would provide sufficient regulation to allow doubling the capacity at Devils Canyon to 390 MW.

It should be emphasized that this USBR study was very preliminary in nature. At the time of the study only two or three years of hydrological records were available for the Susitna River.

In 1960 a more detailed feasibility study was completed dealing specifically with the Devil Canyon-Denali Development. It was recommended that a five-stage construction scheme be used to match the load growth curve. The first stage would consist of a 635 ft high arch dam constructed at Devil Canyon. Initially, three 72.5 MW units would be installed for a capacity of 217.5 MW. The second stage would be to build an earthfill dam and reservoir at Denali and thereby increase the dependable energy available at Devil Canyon. Stages 3,4 and 5 would involve adding two units, two units and one unit respectively to the Devil Canyon powerhouse giving a total installed capacity of 580 MW.

The increase in installed capacity over the previous study is due to several reasons. The level of detail in which the development at Devil Canyon was studied was significantly greater than the previous study. The full pool elevation of the Devil Canyon Reservoir was increased by 33 feet to 1,450 feet. Flow records were available for approximately 10 years as opposed to two years available for the previous study.

A study completed in 1974 by Kaiser Engineers suggested an alternative to the USBR scheme of development. It was proposed that the initial development consist of a single dam known as Susitna I located at a site approximately five miles upstream of the USBR Devil Canyon site. A 810 ft high rockfill dam at this site with a maximum pool elevation of 1,750 feet would provide sufficient storage for a 600 MW of dependable capacity without an additional upstream reservoir. One of the factors favoring this development was the questionable foundation conditions at Denali.

Kaiser suggested an ultimate development consisting of Susitna II located downstream at approximately the USBR Olson Site and Susitna III located upstream at the end of the Susitna I reservoir. The Susitna III site was identified only as a point at which a head of 600 feet could be obtained. Information available for Susitna II or Susitna III is limited essentially to an estimate of energy available at these sites. The future addition of Denali, if foundation conditions proved to be adequate, would increase the energy generation potential of the other three sites.

The most comprehensive study of the hydroelectric potential of the Upper Susitna Basin was completed in 1975 by the Corps of Engineers. In this study several schemes of development were considered including combinations of dams of various heights at the following sites:

(a) Olson;
(b) Devil Canyon;
(c) High Devil Canyon (Susitna I from the Kaiser Plan);
(d) Watana;
(e) Vee; and
(f) Denali.

A total of 23 alternative developments were identified and evaluated using a scoping type economic analysis. The results of this analysis are shown in Table I. Alternatives were selected for final evaluation based on "maximizing net benefits consistant with engineering judgement". The most promising of these alternatives are listed in Table 2 with firm annual energy, dependable capacity, and reasons for or against further study.

Four possible alternatives were selected for meeting the future power needs of the Railbelt Area. These were:

(a) Coal (considered to be the "without" condition);
(b) Devil Canyon - Watana (2200);
(c) Devil Canyon - Watana (2200) - Denali; and
(d) Devil Canyon - Watana (1905) - Vee - Denali.

Each of these alternatives were evaluated in light of:

(a) Technical criteria;
(b) National economic development criteria;
(c) Environmental quality criteria; and
(d) Social well-being and regional development consideration.

These criteria are listed in Appendix B. Table 3 gives a summary comparison of the four alternatives.

The selected Devil Canyon - Watana alternative was selected by the Corps as that which maximizes the National Economic Development and also minimizes environmental effects. This scheme involves the initial construction of an earthfill dam at the Watana site with a height of 810 feet. This would result in a full pool elevation of 2200 feet. Three 264 MW units would be installed giving a total capacity of 792 MW. At Devil Canyon, a 635 foot high thin arch dam (pool elevation = 1450) would be constructed as the load growth requires. The Devil Canyon site would have an installed capacity of 776 MW. Firm annual energy would be 3.1×10^9 kW-hr and 3.0×10^9 kW-hr at Watana and Devil Canyon, respectively. This development had a benefit-cost ratio of 1.3 with power benefits based on the cost of the coal alternative.

In 1979 the Corps of Engineers issued their Supplemental Feasibility Report which primarily answered questions raised by the Office of Management and Budget (OMB) on the 1975 report. Highlights of this study included:

(a) Substitution of a gravity dam at the Devil Canyon site in place of the thin arch dam previously proposed. This was to provide a more conservative basis for benefit-cost calculations in the event that the arch dam became technically infeasible during final design. This was not necessarily indicating that the Corps considered an arch dam infeasible.

(b) Results of a geotechnical exploration program at the Watana site performed in 1978 were included.

(c) An increase in the total construction period to more nearly reflect historical construction rates.

(d) New cost estimates were completed on the basis of the gravity dam at Devil Canyon and exploratory work at Watana. The new benefit-cost ratio was found to have increased to 1.4 because the value of power had increased faster than construction costs plus design changes.

(e) A sensitivity analysis to the rate of load growth showed that this rate would have to fall below 0.8 percent annually before costs exceed benefits. This was due to the large number of fossil-fuel plants with planned retirements close to the on-line date for the Susitna development.

4 - DESIGN PARAMETERS

4.1 - General

Information has been gathered and placed in tabular form for each of the eleven sites mentioned above. Figure 1 shows the locations of those sites. Dams of various heights have been studied for several of the sites. Since the alternative damsites have been studied at different levels of details for certain sites, some of the parameters are unavailable. For example, the Susitna III site was identified simply as a point upstream of the Susitna I (High Devil Canyon) reservoir where a head of 600 feet might be obtained. Table 4 lists layout and topographical information available for each site and the source of such information.

Table 5 gives a list of alternative sites and pool elevations with the head that could be developed at that site. Also listed for each site are upstream sites which would be flooded by the dam and downstream sites which, if developed, would prevent development at that site. Figure 2 also gives this information in graphic form.

Table 5 lists information available for each site.

4.2 - Civil

Preliminary layout drawings are available for the following alternative developments:

Site	Pool Elevation	Dam Type
Devil Canyon	1417	Arch
Devil Canyon	1450	Thin Arch
Devil Canyon	1450	Concrete Gravity
Susitna I (High Devil Canyon)	1750	Concrete Faced Rockfill
Watana	2200	Earthfill
Vee	2350	Earthfill
Denali	2535	Earthfill

These drawings have been included as Appendix A.

For ther sites and developments, information is limited to descriptions available in the text of the reports.

Civil parameters for each site, including dam type, height, length, length-to-height ratio, reservoir area, gross storage, spillway type, and whether or not a low level outlet is provided are given in Table 6.

The following is a brief description of the civil aspects of each of the dam sites identified in the Upper Susitna Basin:

4.2.1 - Gold Creek

An earthfill dam 135 feet high constructed at this stie would back water up to the Olson site. A spillway and power plant could be constructed along either abutment. Diversion of the Chulitna River through two tunnels and the Indian River would considerably increase the energy generating potential of this site.

4.2.2 - Olson

A concrete gravity dam at the Olson site would raise the water level 50 feet without invading the High Devil Canyon site. The spillway would be a gated overflow section in the center of the dam.

4.2.3 - Devil Canyon

At the Devil Canyon site, three dam designs have been proposed in previous studies. Each of these designs has had a full pool elevation of 1,450 feet with a dam height of approximately 650 feet. These designs have each consisted of:

(a) A main concrete section;

(b) An earthfill section 200 feet high and 950 feet long at the south end of the main dam.

Originally as proposed by the USBR, the main concrete section was to be an arch-type dam. In 1975, the Corps of Engineers proposed a double curved thin arch design. Concern over possible seismic problems that might be encountered during final design led to the calculation of the economic feasibility of the project based on a concrete gravity section for the 1979 study. It should be emphasized that this was not a decision that the arch dam could not be constructed but rather a more conservative cost approach.

Plans and typical sections for all three of these dam types are included in Appendix A.

The USBR design included a tunnel spillway through the north abutment. The thin arch dam design had a chute-type spillway with a flip bucket located on the south canyon wall. The gravity dam design had a spillway incorporated in the center of the dam.

4.2.4 - High Devil Canyon (Susitna I)

An 810 foot high concrete-faced rockfill dam was proposed for the High Devil Canyon site. The crest elevation is 1755 feet giving a full pool elevation of 1,750 feet. Upstream and downstream slopes of the rockfill dam were proposed to be 1.4 and 1.3 to 1 respectively. It is likely that these slopes would require to be flattened during final design.

The spillway would be located on the south abutment and wuld be a channel type with a series of steps excavated in rock. Plans and sections are included in Appendix A.

4.2.5 - Devil Creek

Located just below the mouth of Devil Creek, the Devil Creek site is favorable for a low dam. The maximum height would be limited to 350 feet by the right abutment. No layouts are available for this site.

4.2.6 - Watana

Rockfill dams of various heights have been proposed at the Watana site. The most recent Watana Dam design presented in the Corps of Engineers 1979 report proposed a rockfill dam with a crest elevation of 2,195 feet and a maximum pool elevation of 2,189 feet. This was essentially the same dam as proposed in 1975 with a pool elevation of 2,200 feet. The discrepancy was due to corrections in topography made during field investigations. The dam would be 810 feet high and have a sloping impervious core.

A saddle spillway would be provided across the left abutment and into the Tsusena Creek. Twin diversion tunnels would also be located in the left abutment. These tunnels would be converted to a high and low level outlet before completion of the project. The powerhouse would be located underground below the right abutment. Plans and typical sections are provided in Appendix B.

4.2.7 - Susitna III

The Susitna site was defined by Kaiser as a point above the headwaters of Susitna I reservoir where a head of 600 feet could be obtained. This is the only civil information available at this site.

4.2.8 - Vee

At the Vee site, any structure higher than 350 feet will require a saddle dam. A height over 480 feet would be prohibited as water would spill out into the Copper River Basin. The USBR originally proposed a arch-gravity structure with a crest elevation of 2,340 feet. Further work by the USBR, as well as the Corps of Engineers, including some site investigation, resulted in the consideration of an earthfill dam with a height of 410 feet and a full pool elevation of 2,300 feet. A layout for the proposed earthfill dam is included in Appendix A. No reference has been found detailing the rationale for this design. A geotechnical investigation report for the Vee Canyon site refers to a tunnel to be used for the spillway; however, this is not shown on the plan.

4.2.9 - Maclaren

An earth and concrete dam with a height of not more than 100 feet was considered by the USBR in the initial studies. The concrete river section would include an overflow spillway.

4.2.10 - Denali

The primary purpose of the Denali reservoir would be to provide storage for regulated releases for downstream power generation. Since there would be several months with no water releases, it has not been considered feasible to install a powerhouse at this site. This may be reconsidered. A 260 foot high earthfill dam has been proposed at the Denali site. The spillway would be a 19 foot diameter Glory Hole type with a conduit through the embankment. Plans of the general arrangement are included in Appendix A.

4.2.11 - Butte Creek

A dam at the Butte Creek site was considered by the USBR. Field examination led to the rejection of this site in favor of the Denali site with better foundation conditions.

4.2.12 - Tyone

An earth dam with a height of 35 feet was considered on the Tyone River at the outlet of a series of three large lakes. Like Denali, this was to be used for regulation and a power plant was not proposed at this dam.

4.3 - Hydrology

Hydrological parameters have been determined from flow records available from the following gaging stations:

Station	Records Available
Gold Creek	1949 - present
Vee	1961 - 1972
Denali	1957 - present
Maclaren	1958 - present
Talkeetna	1964 - present

Obviously, the earlier studies were based on very limited flow records. In particular, the initial USBR studies had at most two years of record.

The most comprehensive study in which hydrological parameters are given for the various site is the 1975 Corps of Engineers report. Flow data for the Devil Canyon and Watana sites were generally prorated from the Gold Creek. Table 7 gives a list of pertinent hydrological parameters for each of the sites above Gold Creek.

Detailed hydrological information is to be gathered under Subtask 3.01 - Review of Available Hydrology Material.

4.4 - Geotechnical

A varied degree of geotechnical investigations have been completed at the various sites. Investigations have ranged from a fly over for some sites to drilling programs at Watana, Devil Canyon, Vee and Denali. Available geological and geotechnical information will be gathered and reported in Subtask 5.01 - Data Collection and Review. The following is a brief review of geotechnical considerations for each site.

4.4.1 - Gold Creek

Limited information is available; however, it is known that a very deep cut off wall will be required and construction material suitable for the earth-fill dam may be difficult to obtain.

4.4.2 - Olson

Very good abutments consist of a rounded, hard, sound graywacke formation.

4.4.3 - Devil Canyon

Exploration performed by the Bureau of Reclamation in 1957 consisted of 22 borings, 19 trenches and test pits and geologic mapping. The Corps of Engineers did a limited amount of additional seismic work in 1979. The significant features include:

(a) About 35 feet of alluvium overlying bedrock in the channel;
(b) The abutments will require extensive dental work;
(c) The foundation will require grouting;
(d) Shear zones exist in both abutments;
(e) A buried stream channel or shear zone exists near the saddle dam location;
(f) The Maximum Credible Earthquake is 8.5 Richter magnitude at 40 miles or 7.0 at 10 miles;
(g) Materials for a concrete dam are available in sufficient quantity but the aggregate shows marginal freeze-thaw resistance; and
(h) Sporadic permafrost may exist in the left (south) abutment.

4.4.4 - Watana

Exploration at Watana occurred in several stages:

Agency	Time	Scope
Bureau of Reclamation	1950 - 1953	Reconnaissance
USGS	1974	Reconnaissance and mapping
Corps of Engineers	1975	Reconnaissance
Dames and Moore	1975	Right abutment seismic
Corps of Engineers	1978	28 borings, 27 test pits, 18 auger holes
Shannon & Wilson	1978	Seismic

The significant features include:

(a) Overburden thicknesses of 40 feet to 80 feet in the valley bottom and 10 feet to 20 feet on the abutments.

(b) River channel alluvium 48 feet to 78 feet thick.

(c) A buried stream channel near the spillway location with one aquifer under an artesian head.

(d) A possible slide block in the right abutment.

(e) The Finns and the Finger buster shear zones.

(f) Deep permafrost in the left abutment.

(g) Sufficient borrow materials available but fine-grained materials are very water content sensitive.

(h) "Warm" permafrost in the reservoir may slump after thawing.

(i) A possible fault, tentatively named the Susitna fault, is about 2.5 miles west of the site.

4.4.5 - Susitna III

The location of this site has not been firmly fixed and therefore no geotechnical information is available.

4.4.6 - Vee

Investigations consisting of thirteen borings and 16 dozer trenches were performed by the USBR in 1960 - 1962. Deposits in the river bottom are approximately 125 feet deep. A buried streambed in the location of the saddle dam is expected to be deeper than the present Susitna River channel. Considerable amounts of talus and loose rock must be removed from abutment areas to expose good quality rock. Permafrost is present at the saddle dam location.

4.4.7 - Maclaren

Bedrock outcrops indicate a good dam site.

4.4.8 - Denali

In 1958-1959 the USBR performed investigations consisting of five borings and 14 test pits. Significant features include:

(a) Deep permafrost in both abutments;
(b) Pervious sand and gravel in right abutment;
(c) Low density, potentially liquifiable, fine grained sands in river section;
(d) Layers of compressible silt in both abutments;
(e) Maximum Credible Earthquake at 8.5 at 40 miles;
(f) A deep cutoff excavation and excessive foundation treatment will be required; and
(g) Impervious materials may be difficult to obtain.

4.4.9 - Butte Creek

Limited information is available. Glacial silts on the right abutment will require removal.

4.4.10 - Tyone

No available information.

4.5 - Environmental

In our assessment of the various Upper Susitna potential sites being considered (Figure 8), the following approach has been taken to incorporate environmental factors.

4.5.1 - Task 1

Through review of existing information, a data base for the Upper Susitna Basin has been prepared. Much of the information contained in this data base is preliminary in nature, however, certain key areas of concern have been identified which will aid in the assessment of the various sites.

4.5.2 - Task 2

Using the information acquired under Task 1, potential impacts associated with development in various sections of the river upstream of Talkeetna will be outlined. Only information that is deemed pertinent to site selection will be included. For information relating to the broader impacts associated with the development of any of the Susitna schemes, the original reports will need to be consulted.

4.5.3 - Task 3

Following site(s) selection, it will be necessary to assess various potential development schemes associated with these sites. As part of this process, environmental areas of concern will be outlined under the headings of:

(a) Area of inundation;
(b) Dam site;
(c) Downstream; and
(d) Regional and state wide.

Although this approach covers more than Subtask 6.01, the current status of the Task 6 work is contained within and is as follows:

4.5.3.1 - Task 1

The majority of baseline environmental information for the Upper Susitna River was acquired from U.S. Corps of Engineers "Final Environmental Impact Statement - Upper Susitna River Basin, Southcentral Railbelt Area, Alaska, 1977; and

"The Upper Susitna River - Alaska - An Inventory and Evaluation of the environmental, aesthetic and recreational resources" performed by Jones and Jones in March, 1975.

The information contained in these reports has been reviewed and summarized in Table 8. Only information that can be directly utilized in site selection has been incorporated.

4.5.3.2 - Task 2

Potential environmental impacts and concerns are outlined for sections of the Susitna River upstream of Talkeetna. In addition these sections are rated relative to each other under the headings of biological, social and physical concerns (Table 9).

(a) River Section A - Talkeetna to Devil Canyon

Under existing conditions, salmon migrate as far as Devil Canyon, utilizing Portage Creek and Indian River for spawning. The development of any dam downstream of Devil's Canyon would thus result in a direct loss of salmon habitat. The development of any site in this area is not recommended. In fact, government approval for such a scheme would be difficult if not impossible to acquire.

(b) River Section B - Devil Canyon to Watana

The concerns associated with development in this section of the river relate mainly to the inundation of Devil Canyon, a unique scenic and white water reach of the river, and safety aspects associated with the occurrence of major geological faults. In addition, the Nelchina caribou heard has a general migration crossing in the area of Fog Creek.

(c) River Section C - Watana to Vee

Minor concerns in this area relate to the loss of some moose habitat and the inundation of sections of Deadman River and Kosina Creek. Of more significance is the effect on caribou crossing in the Jay Creek area, the potential for extensive shoreline erosion and the occurrence of major geological faults.

(d) River Section D - Vee to Maclaren

Inundation of moose winter range, waterfowl breeding areas, the scenic Vee Canyon and the downstream portions of the Oshetna and Tyone Rivers are all potential environmental impacts associated with this reach of the river. In addition, caribou crossing occurs in the area of the Oshetna River. The area surrounding this section of the river is relatively inaccessable and development would open large areas to hunters.

(e) River Section E - Maclaren to Denali

Environmentally, this area appears to be more sensitive than Sections B and C. Inundation could affect Grizzly bear denning areas, moose habitat, waterfowl breeding areas and moist alpine tundra vegetation. Improved access would open large wilderness areas to hunters and unstable slopes could result in extensive shoreline erosion.

(f) River Section F - Upstream of Denali

This area is similar to Section E with the exception of Grizzly bear denning areas. Access to this area would not be as critical as in Section D and F, however, due to the proximity to the Denali highway, the inflow of people could be greater.

4.5.3.3 - Task 3

In progress.

4.6 - Hydropower

The hydroelectric potential at a given site is not only dependent upon the site characteristics but also upon upstream regulation. As a result, the hydropower parameters are related to the scheme of development.

The Devil Canyon site has the highest degree of dependency on upstream regulation. With a full pool elevation of 1,450 feet, there is almost no storage at the Devil Canyon site. As a result, Devil Canyon has been proposed for development with either Denali or Watana either of which would give the requisite upstream regulation.

Table 10 gives hydropower parameters which are available for each of the sites as well as the parameters for the combinations of sites by the Corps of Engineers in 1975.

4.7 - Planning

A substantial portion of each of the previous studies has been devoted to planning studies and how the Susitna development would fit in with the system load growth. The initial USBR report showed that Susitna power would be required to meet load growth in the 1960's. As the Susitna project was delayed, fossil fuel plants were built to meet the demand. This together with a lower than expected rate of growth delayed considerably the rate of load growth.

In 1979 the Corps of Engineers showed the need for Watana in 1994 followed by Devil Canyon in 1998. Figures 3 and 4 give the medium and low range expected load growth rates respectively.

It should be noted that the mid-range 1980 ISER expected load growth rate is lower than the low range rated predicted in the 1979 Corps of Engineers Report.

As can be seen from these figures, it is as much or more dependent upon planned retirement of the existing plants as it is on future growth. For this reason, the Corps found that for load growth rates as low as 0.8 percent annually, the Susitna development would still be economical. Preliminary calculations indicate that without the planned retirement, the benefit-cost ratio for the low range growth curve would reduce to .75 as opposed to 1.42 with the planned retirement.

5 - COST COMPARISON

5.1 - Available Data

The most recent cost estimates for development of the Susitna were performed in October 1978 by the Corps of Engineers. Detailed engineering type estimates are given for the Watana (2200) and the Devil Canyon Concrete Gravity alternative only.

A more significant amount of cost information is found in the 1975 Corps of Engineers report. This includes detailed quanity take-off and unit costs for the Watana (2200) and Devil Canyon thin arch alternative. Also included are cost estimates with the same basis for the following developments:

(a) Olson (1020) Constructed Second[1]
(b) Devil Canyon (1450) Constructed First
(c) High Devil Canyon (1750)[2] Constructed First
(d) Low Watana (1905) Constructed First
(e) Low Watana (1905) Constructed Second
(f) Mid Watana (2050) Constructed First
(g) Mid Watana (2050) Constructed Second
(h) High Watana (2200) Constructed Second
(i) Vee (2300) Constructed Second
(j) Vee (2350) Constructed Second[1]
(k) Denali (2535) Constructed Second

These costs are given as summary costs for the individual accounts such as Reservoir, Dams, Power Plant, Roads, etc.

Since the 1975 data has the most alternatives compared in the same base year costs, this information is included in Appendix C. For information the summary sheets for the 1978 estimates are also included.

---

1) Reconnaissance Grade Estimate
2) Susitna I

Some limited cost information is available for developments at other sites. This is based on crude estimates performed between 1953 and 1968 and therefore even with escalation factors should not be used for comparison.

5.2 - Basis

Both the 1975 and 1978 Corps of Engineers estimates use unit prices derived from bid prices of other major hydroelectric projects in the Pacific Northwest and Canada. These bid prices were adjusted to reflect the following:

(a) January 1975 price levels;
(b) Alaska labor costs; and
(c) Transportation costs for material and equipment to the site.

Costs have been converted to equivalent 1980 costs using the Whitman Index.

5.3 - Ranking of Sites

Table 11 gives costs for the various alternative developments as well as the year of the estimate. All estimates are brought to 1980 basis using the Whitman Index for comparison and approximate costs per kilowatt and costs per kilowatt hour are calculated.

System studies of the Anchorage-Fairbanks power grid have shown that capacity benefits are approximtely 2.5 times energy benefits from the selected plan. Thus for rough comparison purposes only, a ranking of sites may be based on a cost per kilowatt of dependable capacity. For the initial development, the following is a ranking of single dams on a cost of dependable capacity basis:

(a) High Watana (2200)
(b) Mid Watana (2050)
(c) High Devil Canyon (1750)
(d) Low Watana (1905)
(e) Devil Canyon (1450)

The ranking of dams for subsequent developments on the same basis would be as follows:

(a) Devil Canyon (1450)
(b) High Watana (2200)
(c) Mid Watana (2050
(d) Vee (2300)
(e) Low Watana (1905)

Of course a true comparison of alternatives must be on a cost-benefit basis with adequate consideration of load growth forecasts and environmental concerns.

6 - DISCUSSION AND CONCLUSIONS

All previous studies recommend the construction of a dam in Devil Canyon as part of the initial development. One disadvantage of the Devil Canyon site is its lack of storage capacity. Consequently, most schemes have relied on a simultaneous development of one of the upstream sites. Initially, the Denali site was selected to provide the storage required for controlled release for power generation at the Devil Canyon site.

The concern over foundation conditions at Denali led to the selection of the Watana site to provide the storage required for release to Devil Canyon. This results in a significantly larger generation capacity for the initial development, and thus larger capital costs.

The one exception to the two dam concept for initial development is the Kaiser plan in which only the High Devil Canyon Dam is constructed. The High Devil Canyon (Susitna I) development would have sufficient storage so that the firm annual energy at that site would be approximately equal to that obtained from the Devil Canyon site with upstream regulation. In the Corps of Engineers comparison of full basin development, the Vee Canyon development was used rather than the Susitna III site proposed by Kaiser. This plan would appear to have significant advantages and therefore should be investigated further.

FIGURES

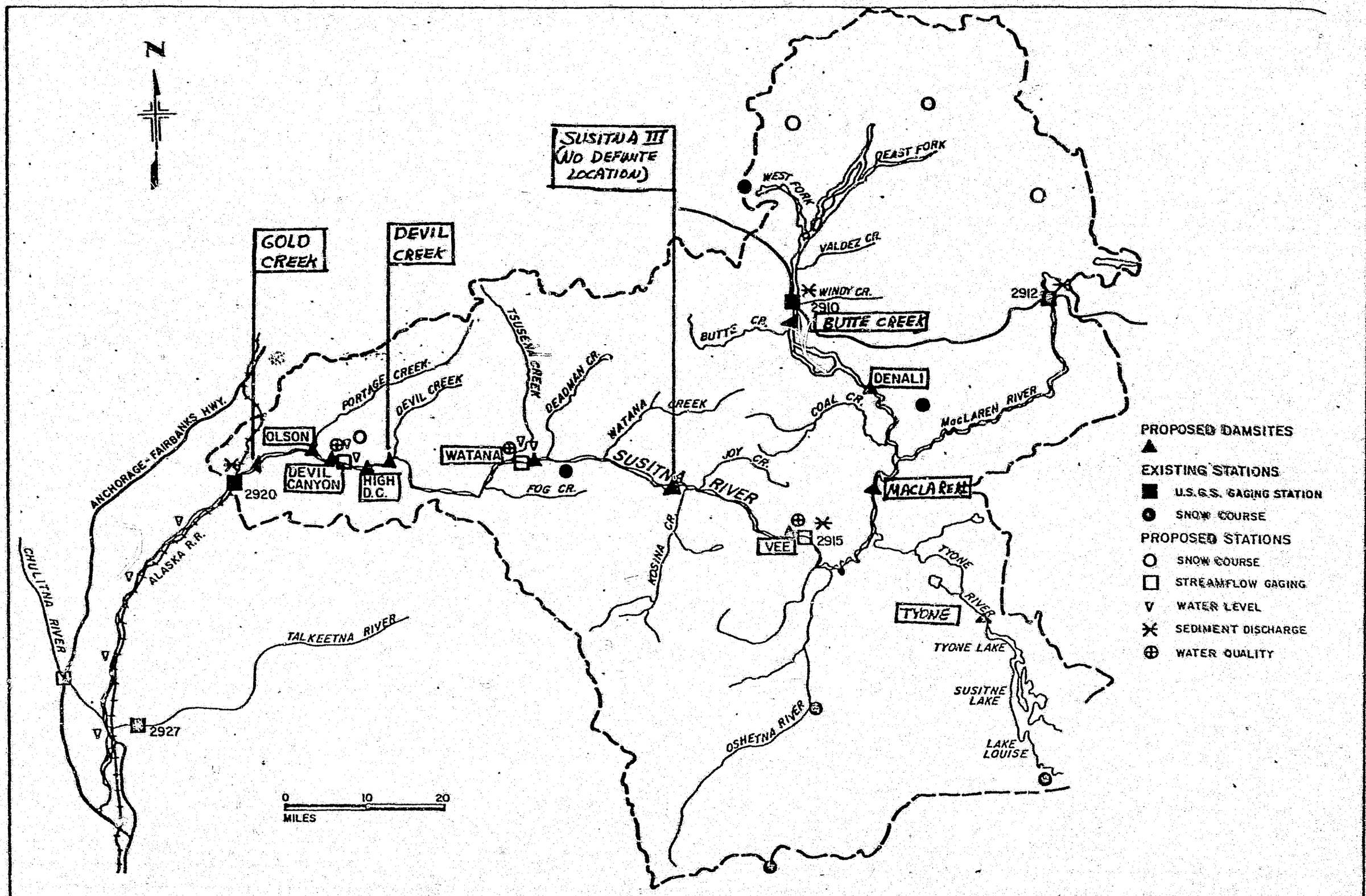


FIGURE 1 LOCATION OF PROPOSED DAMSITES

5-75/5-76

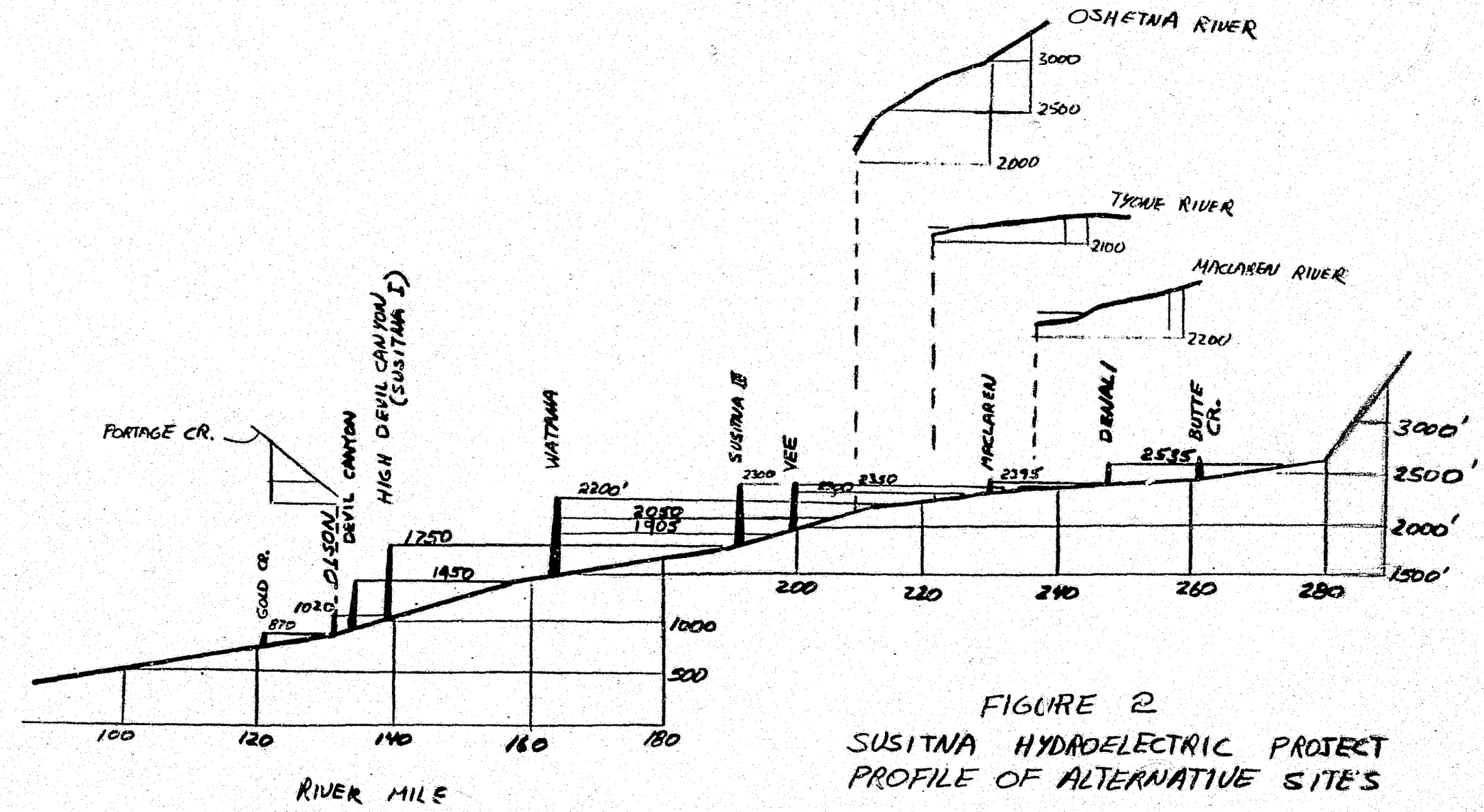


FIGURE 2
SUSITNA HYDROELECTRIC PROJECT
PROFILE OF ALTERNATIVE SITE'S

FIGURE 3

SOUTHCENTRAL RAILBELT
LOADS & RESOURCES
MEDIUM LOAD FORECAST
INTERTIE 1991, WATANA 1994

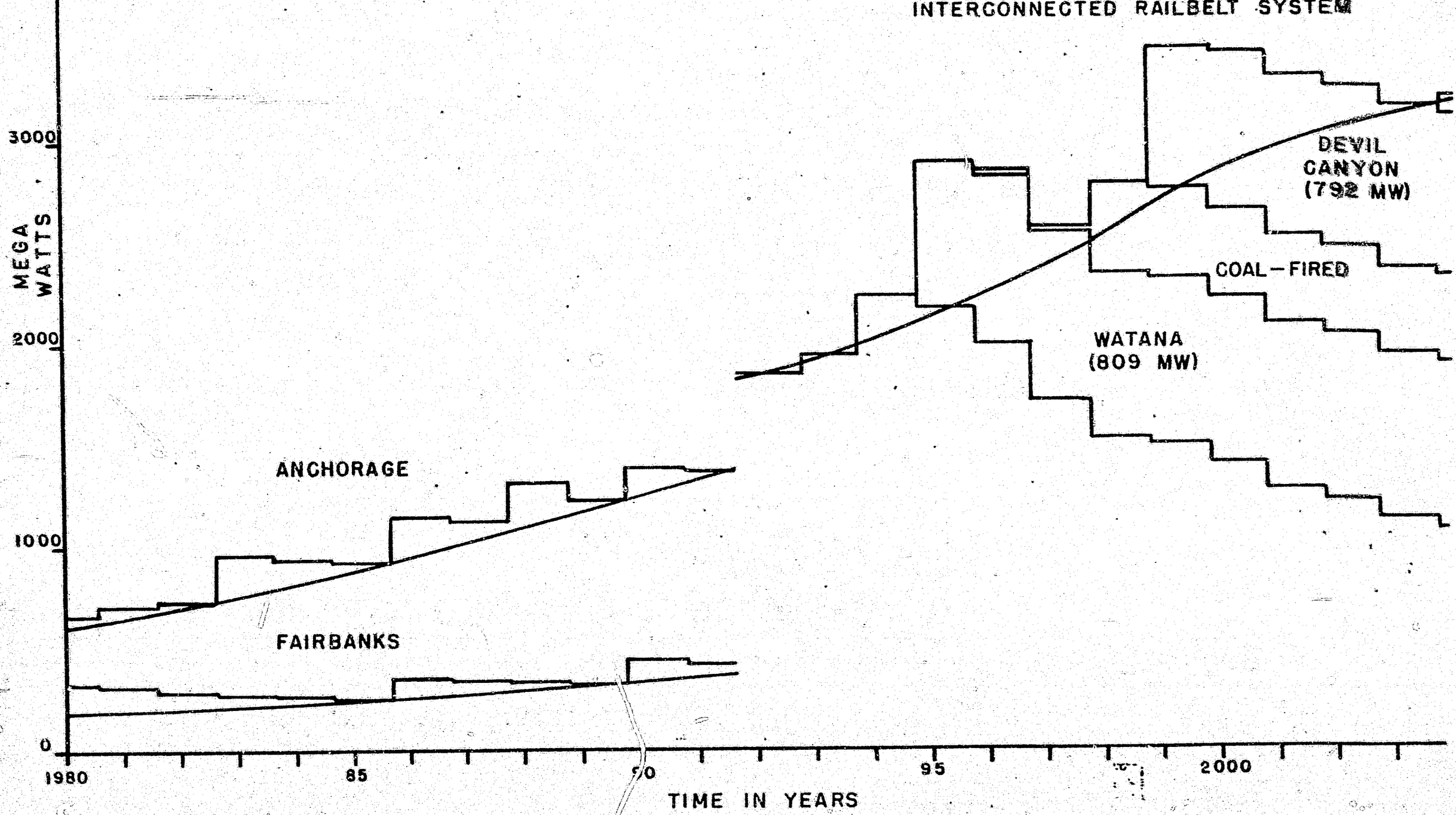
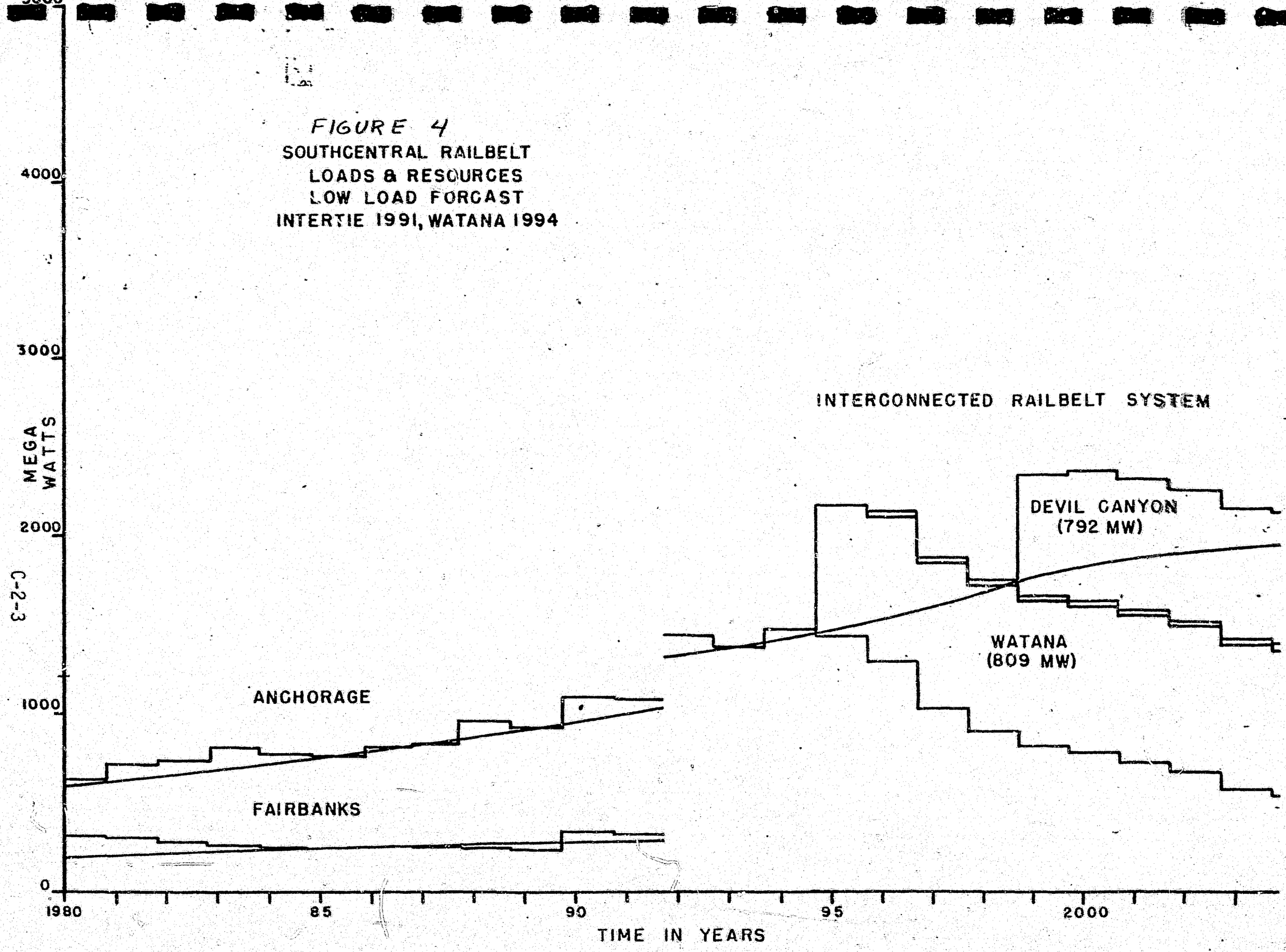


FIGURE 4

SOUTHCENTRAL RAILBELT
LOADS & RESOURCES
LOW LOAD FORCAST
INTERTIE 1991, WATANA 1994



TABLES

Table 1

CORPS OF ENGINEERS

SCOPING ECONOMIC ANALYSIS

System of Development	Total Average Annual Costs ($1,000)	Total Average Annual Benefits ($1,000)	NET BENEFIT ($1,000)
Devil Canyon, Denali, Vee (2300), Watana (1905)	102,491	109,461	6,970
Devil Canyon, Denali, Vee (2350), Watana (1905)	104,445	112,407	7,962
High D. C., Olson, Denali, Vee (2300)	139,984	113,654	- 26,330
Devil Canyon, Watana (2200), Denali	110,091	133,188	23,097
Devil Canyon, Watana (2050), Denali	99,094	118,615	19,521
Devil Canyon, Watana (1905), Denali	88,150	98,727	10,577
Devil Canyon, Watana (2250)	104,336	126,262	21,926
Devil Canyon, Watana (2200)	96,600	126,188	29,588
Devil Canyon, Watana (2050)	85,604	103,193	17,589
Devil Canyon, Watana (1905)	74,660	78,222	3,562
Watana (2250), Devil Canyon	106,379	127,147	20,768
Watana (2200), Devil Canyon	101,776 3/	126,523	24,747
Watana (2050), Devil Canyon	86,834	102,547	15,713
Watana (1905), Devil Canyon	72,034	77,168	5,134
Devil Canyon, Denali	69,651	63,858	- 5,793
Devil Canyon	51,561	29,644	- 21,917
High D. C.	90,651	67,397	- 23,254
Watana (2200)	78,046	73,029	- 5,017
Watana (2050)	63,104	54,741	- 8,363
Watana (1905)	48,304	31,574	- 16,730

1. Number in parenthesis represents the normal maximum pool elevation of the project.
2. Project staging in sequence as shown and each project was assumed to have a five-year construction time.
3. Six year Watana construction and IDC based on annual expenditures would have resulted in an Annual Cost of $103,920,000 (See Table 30).

Table 2

CORPS OF ENGINEERS
PROMISING SUSITNA DEVELOPMENTS

	F. A. E.	D. C.	CORPS OF ENGINEERS COMMENTS
Devil Canyon	0.9×10^9 kW-hr	205	Not economic by itself
High Devil Canyon	2.6×10^9 kW-hr		Not economic by itself
Watana	3.1×10^9 kW-hr	706	Economic, however, same environmental impact as project twice its size
Devil Canyon - Denali	2.5×10^9 kW-hr	571	Not economically feasible
Devil Canyon-Watana*	6.1×10^9 kW-hr	1,568	Economic - should be studied further
Devil Canyon - Denali*	6.8×10^9 kW-hr	1,578	Economic - environmental affects greater than Devil Canyon - Watana
Devil Canyon - Watana - Vee - Denali	6.1×10^9 kW-hr	1,570	95 percent of full basin potential
High Devil Canyon - Olson - Vee - Denali	5.9×10^9 kW-hr		Develops less than basin potential - Not economically justified

*Selected for further study

Table 3

CORPS OF ENGINEERS - EVALUATION OF ALTERNATIVES

	PLAN A	PLAN B	PLAN C	PLAN D
	WITHOUT CONDITION	NATIONAL ECONOMIC DEVELOPMENT (NED) ENVIRONMENTAL QUALITY (EQ) PLANS	MAXIMUM POWER DEVELOPMENT PLAN	PREVIOUSLY RECOMMENDED PLAN
	Conventional Coal Thermal Plant	Devil Canyon-Watana Dams	Devil Canyon-Watana-Denali Dams	USBR Four-Dam System
A. PLAN DESCRIPTION	Non-Federal financing of a 300-mw coal-fired generating plant at Healy and a 1,200-mw coal-fired plant at Beluga. The plants would have 35-year service lives. Project would include costs for coal mining and separate Healy-to-Fairbanks and Beluga-to-Anchorage transmission systems.	Federal financing of the total system to include a thin-arch dam and underground powerplant at the Devil Canyon site, and an earthfill dam and underground powerplant at the Watana site. Both projects would provide at-site power generation. Watana would provide the seasonal storage for the system. Plan would also include transmission system between projects and to the Anchorage and Fairbanks load centers.	This plan is basically the same as the Plan B, but with the addition of the Denali Project would have no at-site power generation and would be used only for low flow augmentation of the two downstream projects.	This is the system proposed by the Bureau of Reclamation in its 1952 report on hydropower resources of the Upper Susitna River Basin. Federal financing, of the total system to include a thin-arch dam and powerplant at the Devil Canyon site, a low head earthfill dam and powerplant at the Watana site, an earthfill dam and powerplant at the Vee site, and a flow augmentation reservoir at the Denali site Plan would also include transmission system between projects and to the two load centers.
1. Dam Heights	No Dams	1. Devil Canyon - 635 feet 2. Watana - 810 feet	1. Devil Canyon - 635 feet 2. Watana - 810 feet 3. Denali - 260 feet	1. Devil Canyon - 635 feet 2. Watana - 515 feet 3. Vee - 455 feet 4. Denali - 250 feet
2. Dependable Capacity	1,500,000 kilowatts	1,394,000 kilowatts	1,552,000 kilowatts	1,404,000 kilowatts
B. SIGNIFICANT IMPACTS	(Included in Relationship to Four Accounts)	(Included in Relationship to Four Accounts)	(Included in Relationship to Four Accounts)	(Included in Relationship to Four Accounts)
C. PLAN EVALUATION				
1. Contribution to Planning Objective				
a. Firm Annual Energy	6,800,000,000 kilowatt-hours	6,910,000,000 kilowatt-hours	6,800,000,000 kilowatt-hours	6,350,000,000 kilowatt-hours
b. Average Annual Energy	6,910,000,000 kilowatt-hours	6,910,000,000 kilowatt-hours	6,910,000,000 kilowatt-hours	6,380,000,000 kilowatt-hours
c. Percent of Basin Potential	Not Applicable	36%	36%	35%
d. System Dependability	No grid intertie of major load centers. Reduced dependability.	Provides grid intertie of major load centers.	Provides grid intertie of major load centers.	Provides grid intertie of major load centers.
2. Relationship to Four Accounts				
a. National Economic Development (NED)				
NET NED BENEFITS	0	$33,856,000	$29,611,000	$16,795,000
BENEFIT-TO-COST RATIO	1.0	1.3	1.3	1.2
b. Environmental Quality (EQ)				
Acreage Inundated or Destroyed	20,000	50,550	104,550	84,950
Drawdown Zone Acreage	0	13,000	45,000	45,000
Stream Mileage Inundated or Degraded	110-120	32	116	138
Whitewater Mileage Inundated	0	9	9	9
Major Ecosystems, Acreage Inundated or Destroyed				
Important Moose Habitat	18,000	4,000	4,000	38,000
Important Caribou Habitat	2,000	0	52,000	52,000
Important Waterfowl Habitat (number of potnole lakes)	2,000 acres	0	400	400
Archaeological Zones Precluded from Post-Construction Studies	Unquantified area has very high potential	40	60	45
Prehistoric Sites Inundated or Destroyed	0	0	0	1
Historic Sites Inundated or Destroyed	0	1	4	4
c. Social Well-Being (SWB)				
Energy Resources Conserved in Tons per Year		5,850,000	5,850,000	5,830,000
d. Regional Development (RD)				
Cost of Power in Mills/Kwhr	26.4 - 31.4	21.)	21.0	24.3
3. Plan Response to Associated Evaluation Criteria				
a. Acceptability	This plan is the worst from the standpoint of conservation of nonrenewable resources. It has large adverse EQ effects in that it requires strip-mining of 20,000 acres of important wildlife habitat, it degrades water quality by chemical inputs and suspended sediments, and it degrades air quality by inputs of particulates and chemical pollutants. Its NED performance is acceptable. It provides no flood control or recreational opportunity.	Maximum beneficial impacts of options studied in NED and EQ accounts. Supported by consensus of most publics. Plan has drawn some concern because of possibility for induced population growth associated with initial power on line, as well as the adverse impact on fish and wildlife values. Would provide flood control and recreation potential.	Greater adverse EQ effects than in recommended plan. Ranks second to the recommended plan in the NED account. Would provide maximum firm power of hydro development plans. Would provide flood control and recreation potential.	Beneficial impacts in NED, SWB, and EQ accounts. Has good potential for stage development of hydro projects and is also favored by Alaska Power Administration. Ranks low in the EQ account in comparison to other alternatives. Would provide flood control and recreation potential.

	PLAN A	PLAN B	PLAN C	PLAN D
	WITHOUT CONDITION	NATIONAL ECONOMIC DEVELOPMENT (NED) ENVIRONMENTAL QUALITY (EQ) PLANS	MAXIMUM POWER DEVELOPMENT PLAN	PREVIOUSLY RECOMMENDED PLAN
	Conventional Coal Thermal Plant	Devil Canyon-Watana Dams	Devil Canyon-Watana-Denali Dams	USBR Four-Dam System
C. PLAN EVALUATION (Cont.)				
3. Plan Response to Associated Evaluation Criteria (Cont.)				
b. Certainty	This appears to be an implementable plan which could be pursued to meet energy needs for the near and long range future. It is the most flexible plan in terms of incremental development and operation potentials.	Foundation conditions appear adequate for construction of both projects. Transmission system is within the means of present technology. Least flexible of alternatives to changes in projected power demand.	Same evaluation as for Plan B except for storage control project at Denali site. Additional exploration required before this structure could be recommended. More flexible than Plan B.	Same evaluation as for Plan C except for the power project at the Vee site. Additional exploration of abutment material required before this dam could be recommended for the structure height stated above. Most flexible of hydro alternatives.
c. Completeness	Could match the energy output of any plans evaluated herein as long as fuel source is available.	Provides adequate power to satisfy projected demand growth until mid-1990's. Little potential for expansion. Demand beyond the project capability will have to be met by other development.	Provides adequate power to satisfy projected demand growth until mid-1990's. Little potential for expansion. Demand beyond the project capability will have to be met by other development.	Provides adequate power to satisfy projected demand growth until mid-1990's. Little potential for expansion. Demand beyond the project capability will have to be met by other development.
d. Effectiveness	Could be expanded indefinitely to limits of fuel.	Would develop 96 percent of basin development potential.	Develops greatest firm power - equal to Plan B in average annual power.	Would develop 93 percent of basin development potential.
D. IMPLEMENTATION RESPONSIBILITY				
1. Financial Responsibility	Private and/or semi-public entities coordinated with Federal and State regulatory agencies.	Federal Government with power marketed through the Alaska Power Administration.	Federal Government with power marketed through the Alaska Power Administration.	Federal Government with power marketed through the Alaska Power Administration.
2. Recreation Sponsorship	None	State of Alaska	State of Alaska	State of Alaska

Table 4

AVAILABLE LAYOUT INFORMATION

SITE (Pool El.)	TOPO MAPPING	LAYOUTS	DRILLING	AERIAL PHOTOS
Gold Creek				
Olson (920)				
Olson (1020)		? - COE (1975)		
Devil Canyon (1450)	? - COE ? - USBR	Y - COE (1975) Y - COE (1979)* Y - APAd (1974)	Y - USBR	1:30,000 B&W
High Devil Canyon (1750)		Y - Ka (1974) ? - COE (1975)		1:30,000 B&W
Devil Creek				1:30,000 B&W
Low Watana (1905)	Y - COE*	? - COE (1975)	Y - COE	1:30,000 B&W
Mid Watana (2050)	Y - COE*	? - COE (1975)	Y - COE	1:30,000 B&W
High Watana	Y - COE*	Y - COE (1975) Y - COE (1979)*	Y - COE	1:30,000 B&W
Susitna III	No	No	No	
Vee (2300)	? - COE	Y - COE (1975)	Y - USBR	
Vee (2350)	? - COE	? - COE (1975)		
Maclaren				
Denali (2535)	? - COE	Y - COE (1975) Y - USBR	Y - USBR	
Denali (2552)			Y - USBR	
Denali (2590)			Y - USBR	
Butte Creek				
Tyone				

KEY:

NO: No information is available
?: This information may be available, however, we do not have it in Buffalo
Y: Information available in Buffalo
APPd: Alaska Power Authority Administration
COE: Corps of Engineers
USBR: United States Bureau of Reclamation
Ka: Kaiser Engineers
*: Reproducible drawings

Table 5

DAM SITES ABOVE GOLD CREEK

Site (Pool El.)	Head	Upstream Sites Flooded	Downstream Sites Which Drown Out this Site
Gold Creek (870)	190 ft	None	None
Olson (920)	45 ft	None	None
Olson (1020)	145 ft	Devil Canyon	None
Devil Canyon (1450)	570 ft	High Devil Canyon Devil Creek	Olson (1020)
High Devil Canyon (1750)	720 ft	Devil Creek Watana	Devil Canyon (1450)
Devil Creek	(approx)	---	Devil Canyon High Devil Canyon
Low Watana (1905)	425 ft	None	High Devil Canyon
Mid Watana (2050)	570 ft	Vee	High Devil Canyon
High Watana (2200)	720 ft	Vee	High Devil Canyon
Susitna III	≈600 ft	Vee	Low, Mid & High Watana
Vee (2300)	375 ft	None	Watana (2050 & 2200)
Vee (2350)	425 ft	Maclaren	Watana (2050 & 2200)
Maclaren (2395)	--	None	Vee (2350)
Denali (2535))	No	Butte Creek	None
Denali (2552))	Power	Butte Creek	None
Denali (2590))	Generation	Butte Creek	None
Butte Creek	--	---	Denali
Tyone	--	None	None

Table 6

CIVIL DESIGN PARAMETERS

Site (Pool El.)	Dam Type	Height (ft)	Length (ft)	Length / Height	Reservoir Area (acres)	Gross Storage x 10^6 Ac-ft	Spillway Type	Low Level Outlet
Gold Creek	Earthfill	135	4,900	36	--	7.3	--	--
Olson (920)	Concrete Gravity	50	400	7	--	.01	Overflow Section of Dam	--
Olson (1020)	Concrete Gravity	145	--	--	--	--	--	--
Devil Canyon (1450)	Thin Arch) 74	635	1,370	2	7,550	1.1	Chute w/Flip Bucket	Yes
	Thrust Block) Alternative	110	155	1.4	--	--	--	--
	Earthfill	200	950	4.2	--	--		
	Gravity &) 79	650	1,590	2.4	7,550	1.1	Center Section of Dam	Yes
	Earthfill) Alternative	200	720	3.6	--	--		
High Devil Canyon (1750)	Concrete-faced Rockfill	810	3,050	3.8	24,200	4.7	Channel Cut Into South Abutment	--
Devil Creek	Concrete	350 Max	--	--	--	2.5	--	--
Low Watana (1905)	Earthfill	515	1,650	3.2	--	5.2	Channel Cut In Saddle Into Tsusena Creek	--
Mid Watana (2050)	Earthfill	660	2,600	3.9	--	9.4	" " "	--
High Watana (2200)	Earthfill	810	3,450	4.3	43,000	2.1	" " "	--
Susitna III	--	--	--	--	--	--	--	--
Vee (2300)	Earthfill	455	--	--	--	3.4	--	--
Vee (2350)	Earthfill	--	--	--	--	--	--	--
Maclaren (2395)	Earth & Concrete	100	2,300	23	--	0.2	--	--
Denali (2535)	Earthfill	260	--	--	--	3.9	19' Dia. Glory Hole w/Conduit Through Embankment	--
Denali (2552)	Earthfill	219*	2,000	9.4	51,000	5.4	--	--
Denali (2590)	Earthfill	205*	1,900	9.3	--	5.7	--	--
Butte Creek	--	100	500	5	--	--	--	--
Tyone	Earthfill & Concrete	35	500	14		--	--	--

*Discrepancy must be due to better information in the 1961 study - Denali (2552)

Table 7

HYDROLOGICAL DESIGN PARAMETERS

Site (Pool El.)	Years of Record	Mean Annual Flow Ac-ft/year (cfs)	Min. Avg. Monthly Flow (March) (cfs)	Max. Avg. Monthly Flow (June) (cfs)	Avg. Reg. Flow March	Avg. Reg. Flow June	Spillway Design Flood (cfs)	Reservoir Storage Gross (Ac-ft)	Reservoir Storage Net (Ac-ft)	Remarks
Gold Creek	29	6,967,000 (9616)	713	50,580	N/A	N/A	A	N/A	N/A	at Gaging Station
Olson (920)	(29)	6,819,727 (9413)	698	49,510	N/A	N/A	A	6,600	NIL	(1)
Olson (1020)	(29)	6,819,727 (9413)	698	49,510	N/A	N/A	A	N/A	N/A	(1)
Devil Canyon (1450)	(25)	6,717,000 (9280)	670	48,120	9,020	8,324	228,000	1,050,000	280,000	(1)
High D.C. (1750)	(25)	6,639,000 (9,170)	662	47,561	Avg = 6,000		A	5,760,000	3,930,000	(1)
Devil Creek	(25)	6,639,000 (9,170)	662	47,561	N/A	N/A	A	N/A	N/A	Assumed same as High Devil Canyon
Watana (1905)	(25)	5,905,000 (8,160)	579	43,031	N/A	N/A	A	2,480,000	2,310,000	
Watana (2050)	(25)	5,905,000 (8,160)	579	43,031	N/A	N/A	A	5,300,000	4,575,000	
Watana (2200)	(25)	5,905,000 (8,160)	579	43,031	8,883	5,528	165,000	9,624,000	3,100,000	(1)
Susitna III	(25)	4,484,000 (6,194)	429	34,630	N/A	N/A	A	--	820,000	Assumed location at Vee Canyon as below
Vee (2300)	(25)	4,484,000 (6,194)	429	34,630	N/A	N/A	A	--	820,000	at Gaging Station
Vee (2350)	(25)	4,484,000 (6,194)	429	34,630	N/A	N/A	A	--	N/A	" " "
Maclaren	(2)	2,910,000 (4,019)	N/A	N/A	N/A	N/A	A	210,000	N/A	USBR Report 1953

Table 7 (Cont'd)

HYDROLOGICAL DESIGN PARAMETERS

Site (Pool El.)	Years of Record	Mean Annual Flow Ac-ft/year (cfs)	Min. Avg. Monthly Flow (March) (cfs)	Max. Avg. Monthly Flow (June) (cfs)	Avg. Reg. Flow March	Avg. Reg. Flow June	Spillway Design Flood (cfs)	Reservoir Storage Gross (Ac-ft)	Reservoir Storage Net (Ac-ft)	Remarks
Denali (2535)	(25)	2,386,000 (3,292)	98	14,109	N/A	N/A	A	N/A	3,770,000	Corps of Engineers - 1975
Denali (2552)	(10)	2,545,000 (3,515)	N/A	N/A	N/A	N/A	A	5,400,000	5,300,000	USBR (1961)
Denali (2590)	(2)	1,650,000 (2,280)	N/A	N/A	N/A	N/A	A	N/A	5,400,000	USBR (1953)
Butte Creek	19[B]	2,064,200 (2,849)	44	12,000	N/A	N/A	A	N/A	B	Assumed DA 1000 sq. mi. prorated from Denali gage up-to-date Denali gage
Tyone (2385)	(2)	222,000	N/A	N/A	N/A	N/A	A	700,000	N/A	USBR

NOTES

(1) Gold Creek flow records prorated.
Years of record in parenthesis indicate number of years of record used for correlation.
A -Figure to be estimated after regional flood flow analysis (Subtask 3.05(i)) is complete.
B -Prorated from Denali gaging station.

TABLE 8
UPPER SUSITNA ENVIRONMENTAL DATA BASE FOR INPUT INTO THE SELECTION OF DEVELOPMENT SITES
(Includes only information that varies among sites)

	Talkeetna to Devil Canyon (Section A)	Devil Canyon to Watana (Section B)	Watana to Vee (Section C)	Vee to Maclaren (Section D)	Maclaren to Denali (Section E)	Upstream of Denali (Section F)
Biological						
Fisheries	- Resident & migratory salmon - Provides salmon access to Portage Creek and Indian River	- No anadromous fish	- Inundation of part of Deadman River & Kosina Creek	- Inundation of part of Oshetna and Tyone River		
Wildlife	- Moose habitat in river valley downstream of Portage Creek	- Nelchina Caribou herd - Summer range north of Susitna River - Summer & winter range south of Susitna River - Migration in the area of Fog Creek	Caribou - Calving area south of Susitna River in the area of Kosina Creek - Migration in the Jay Creek area - Ranges as stated for Section B	- Inundation of posible moose winter range - Medium waterfowl density - Caribou migration in the area of Oshetna River	- Brown Grizzly bear denning adjacent to reservoir area - Good moose habitat - Medium waterfowl density	- Waterfowl nesting area - Good moose habitat - Medium waterfowl density
Vegetation	- Mainly upland or lowland spruce-hardwood forest		- Some moose habitat Watana Creek		- Fragile moist & alpine tundra	- Fragile moist & alpine tundra
Social						
Aesthetic		- Unique Devil Canyon		- Moderately unique Vee Canyon		
Recreation		- White water kayaking Class IV Devil Canyon				
Access	- Present access from lower river	- Access road would open moderate area of wilderness	- Access road would open moderate area of wilderness	- Access road would open large areas of wilderness presently inaccessible	- Access road would open large areas of wilderness presently inaccessible	- Reservoir could have access from the Denali Highway
Physical		- Occurrence of major geological faults - Potential for earthquake	- Unstable slopes - for potential for earthquake	- Occurrence of major geological faults	- Unstable slopes potential shoreline erosion	- Unstable slopes - potential shoreline erosion

Table 9

INITIAL RATING OF ENVIRONMENTAL CONCERNS

River Section	Biological		Social	Physical
	Fish	Wildlife		
A	X	M	L	L
B	L	M	H	H
C	L	M	M	H
D	L	H	H	H
E	L	M	M	M
F	L	M	L	M

Initial Rating of Environmental Concern:

L: Low
M: Medium
H: High
X: Unacceptable

Table 10

HYDROPOWER PARAMETERS

Site (Pool El.)	Head	Mean Annual Flow	Installed Capacity	Dependable Capacity	Average Annual Energy	Firm Energy	Secondary Energy	% of River Potential (1)	Remarks
	(ft)	(cfs)	(MW)	(MW)	($x10^9$ kWh)	($x10^9$ kWh)	($x10^9$ kWh)		
Gold Creek	190	9,616	260			1.139		≈17%	With U/S Regulation
Olson (920)	45	9,413							
Olson (1020)	145	9,413		187	0.915	0.821		13%	With U/S Regulation
Devil Canyon(1450)	570	9,280	776	206	1.489	0.900	0.750	21%	
High D.C. (1750)	720	9,170	700	609	3.350	2,628	0.600	47%	Data from Corps - 1975
Devil Creek		9,170							
Low Watana (1905)	425	8,160	≈420	252	1.550	1.104	0.750	22%	
Mid Watana (2050)	570	8,160	≈500	457	2.601	1.997	0.550	36%	
High Watana (2200)	720	8,160	792	686	3.346	3.004	0.350	47%	
Susitna III	600	6,194	445			1.840		≈28%	
Vee (2300)	375	6,194		300	1.450	1.310		20%	With U/S Regulation
Vee (2350)	425	6,194							
Maclaren									
Denali									
Butte Creek									
Tyone									
Devil Canyon Denali	N/A	N/A		571	3.300	2.500	0.700	46%	
Devil Canyon Low Watana	N/A	N/A		731	4.485	3.200	1.270	62%	
Devil Canyon Mid Watana	N/A	N/A		1,062	5.730	4.650	1.000	78%	
Devil Canyon High Watana	N/A	N/A		1,427	6.850	6.250	0.550	95%	

NO POWER GENERATION

Table 10 (Cont'd)

HYDROPOWER PARAMETERS

Site (Pool El.)	Head	Mean Annual Flow	Installed Capacity	Dependable Capacity	Average Annual Energy	Firm Energy	Secondary Energy	% of River Potential (1)	Remarks
	(ft)	(cfs)	(MW)	(MW)	($x10^9$ kWh)	($x10^9$ kWh)	($x10^9$ kWh)		
Devil Canyon High Watana Denali	N/A	N/A		1,552	6.911	6.800	0.111	96%	
Susitna I Susitna II Susitna III	N/A	N/A	1,308		6.309			88%	
Devil Canyon Watana Vee Denali	N/A	N/A		1,427	6.881	6.252	0.629	96%	
Olson High Devil Canyon Vee Denali	N/A	N/A		1,347	6.511	5.900	0.611	91%	
Devil Canyon Watana Vee Denali Olson					7.181+	6.552		100%	

(1) Percent of Maximum Average Annual Energy with Devil Canyon, Watana, Vee, Denali; Olson assumed to be 100%

Table 11

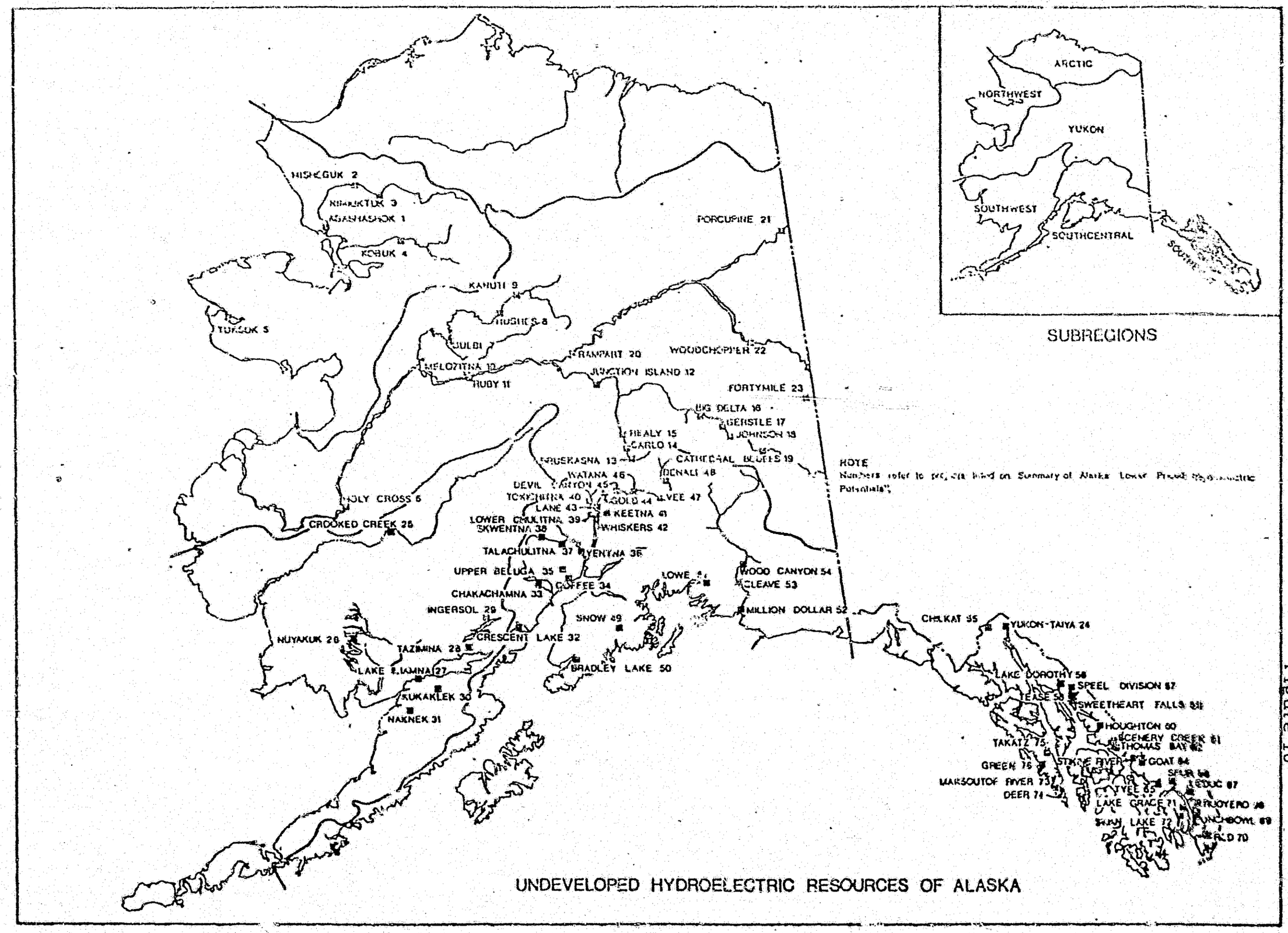
COST COMPARISON

Site (Pool El.)	Estimated Cost (1)	Year of Estimate	Escalation Factor (Whitman Index)	1980 Cost	Dependable Capacity	Cost/ kW	Avg. Annual Energy	Cost/kW-hr 15% Annual Charge	Notes
	$ x 10^6			$x10^6$	MW		10^6 kW-hr	Mills	
Gold Creek	338	1968	550/210	885	260 (4)	3,404	1,139 (5)	117	(3)(6)
Olson (920)									
Olson (1020)	380	1975	550/377	554	187	2,964	915	91	*(3)(6)
Devil Canyon Arch	714	1975	550/377	1,042	206	5,056	1,489	105	*(2)
(1450)	432	1975	550/377	630	594	1,062	3,235	29	*(3)(6) with M. Watana
Devil Canyon Gravity (1450)	823	1978	550/495	914	594	1,539	3,235	42	(3)(6) with M. Watana
High Devil Canyon (1750)	1,266	1975	550/377	1,846	600	3,078	3,350	83	*(2)
Devil Creek									
Low Watana (1905)	668	1975	550/377	975	252	3,868	1,550	94	*(2)
	420	1975	550/377	613	252	2,431	1,550	59	*(3)
Mid Watana (2050)	677	1975	550/377	1,279	457	2,800	2,601	74	*(2)
	628	1975	550/377	916	457	2,004	2,601	53	*(3)
High Watana (2200)	1,088	1975	550/377	1,587	686	2,313	3,346	71	*(2)
	837	1975	550/377	1,221	686	1,780	3,346	55	*(3)
	1,765	1978	550/495	1,961	686	2,859	3,346	88	*(2) Revised Estimate
Vee (2300)	477	1975	550/377	696	300	2,320	1,450	72	*(3)
Vee (2350)	527	1975	550/377	769					*(3)
Maclaren									
Denali (2335)	340	1975	550/377	496	None		None		*(3)
Denali (2552)	134	1960	550/170	433	None		None		
Denali (2590)	80	1953	550/122	331	None		None		
Butte Creek									
Tyone									

* Estimated in same or a year therefore best for comparison
(1) Generally includes contingencies but not IDC
(2) Constructed first (i.e. includes main access road and transmission line)
(3) Later development
(4) Installed capacity
(5) Firm energy
(6) With U/S Regulation

APPENDIX A -

DRAWINGS



NOTE
Numbers refer to [illegible] listed on Summary of Alaska Lower Proved [illegible] Potentials".

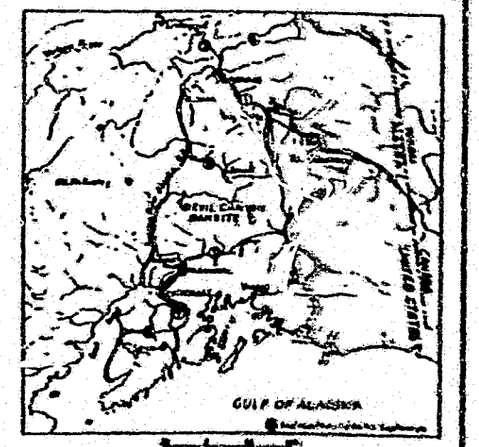
UNDEVELOPED HYDROELECTRIC RESOURCES OF ALASKA

Figure 10

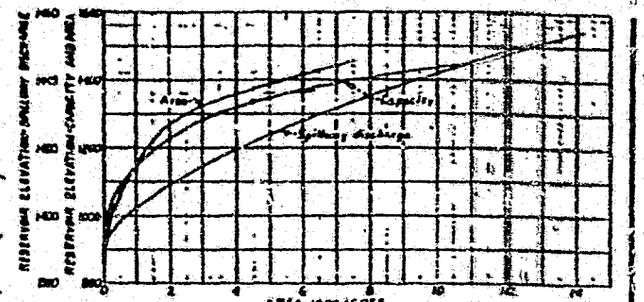
RESERVOIR STORAGE ALLOCATIONS

Purpose	Elevation	Storage-A.F.
Conservation	1450 to 1715	2610000
Inactive	1175 to streambed	230000
		2700000

Surcharge of 3 feet (approximately 48,000 A.F. at Max. W.S.El. 1455) was considered only as contributing to the spillway capacity of 142,000 c.f.s. which in combination with powerplant releases of 18,000 c.f.s. (2 units operating) provides protection against the inflow design flood having a peak of 320,000 c.f.s. and a 15 day volume of 2,000,000 A.F.



LOCATION MAP

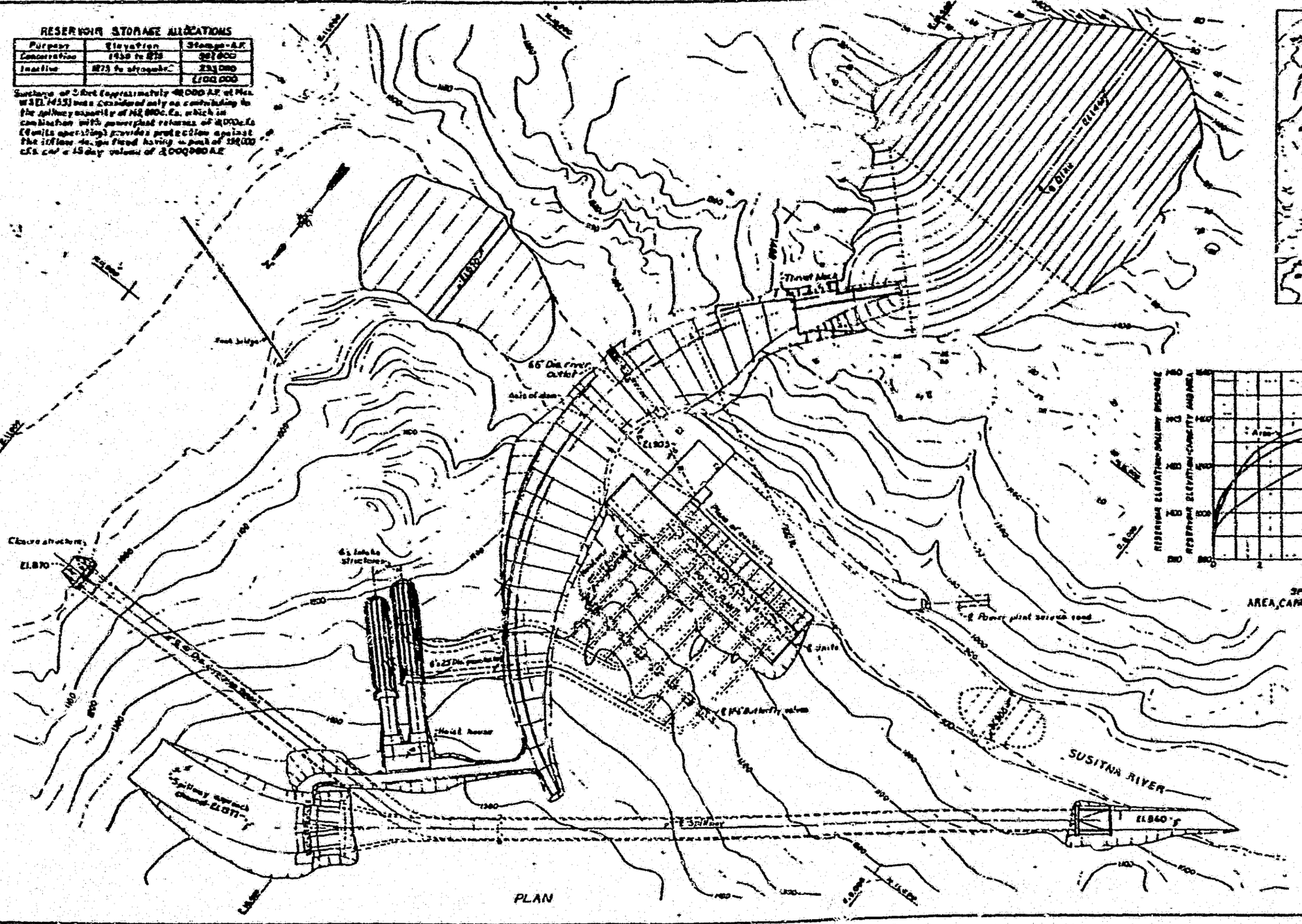


AREA, CAPACITY, AND SPILLWAY DISCHARGE CURVES

NOTE

Topography taken from Dwg. 8-352-D-5.

SCALE OF FEET



PLAN

6-28-CON REVISED NOTE UNDER RESERVOIR STORAGE & ALLOCATIONS CHART

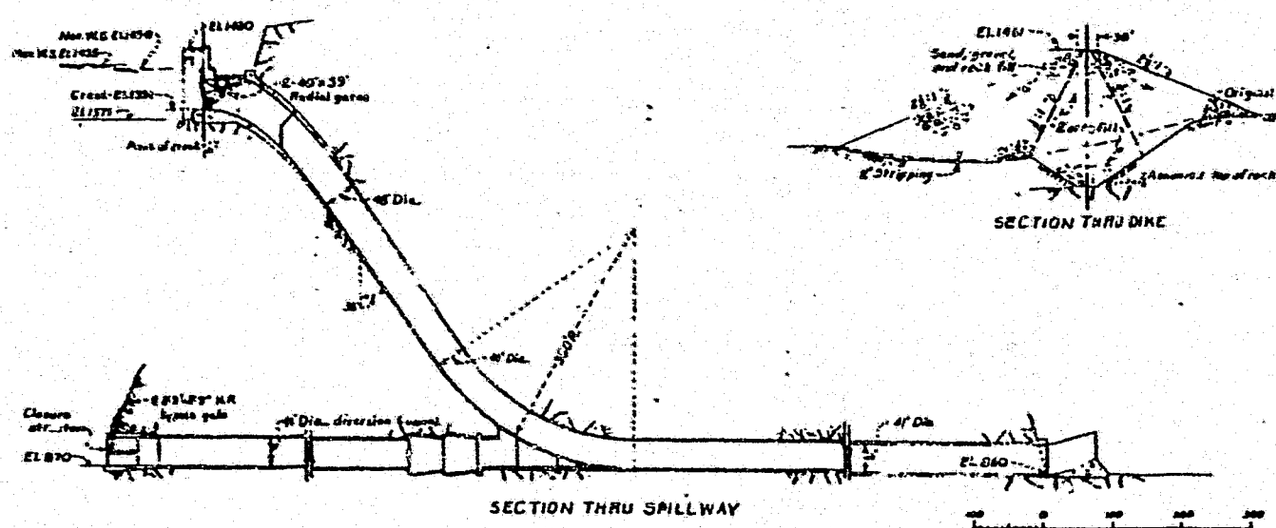
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
DEVIL CANYON PROJECT, ALASKA

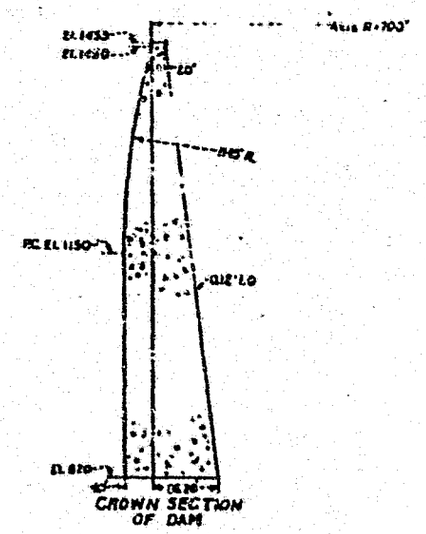
DEVIL CANYON DAM AND POWER PLANT
FEASIBILITY ESTIMATE DRAWING

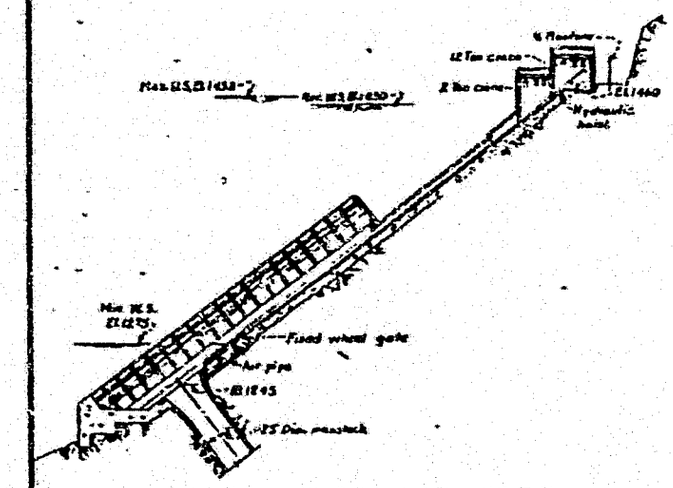
DESIGNED	E.A.L.	SUBMITTED	
DRAWN	E.L.V., E.A.L.	RECOMMENDED	
TRACED		APPROVED	
QUANTITIES CHECKED			

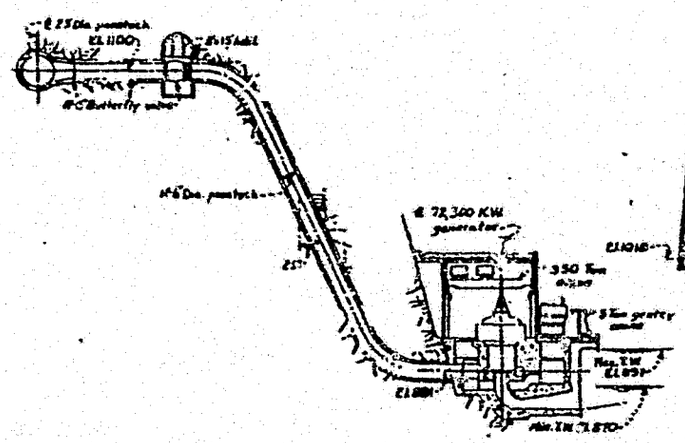
DENVER, COLORADO, JUNE 1958

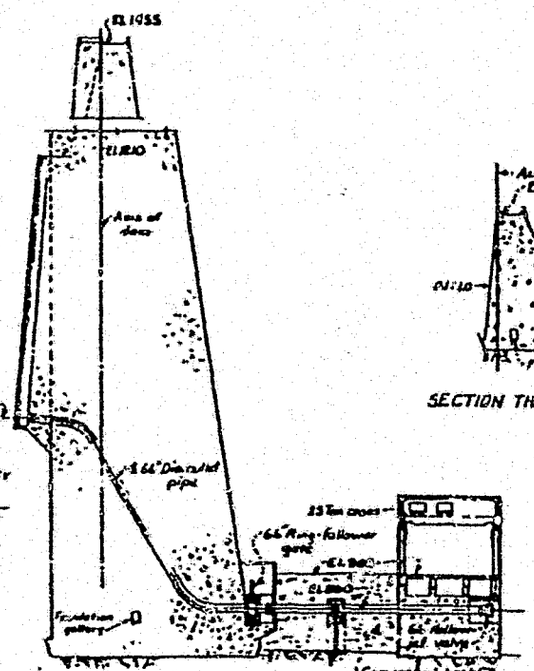
852-D-6

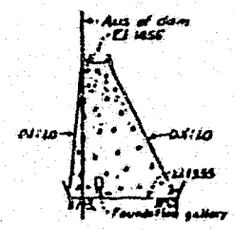












UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
DEVIL CANYON PROJECT - ALASKA

DEVIL CANYON DAM AND POWER PLANT
FEASIBILITY ESTIMATE DRAWING

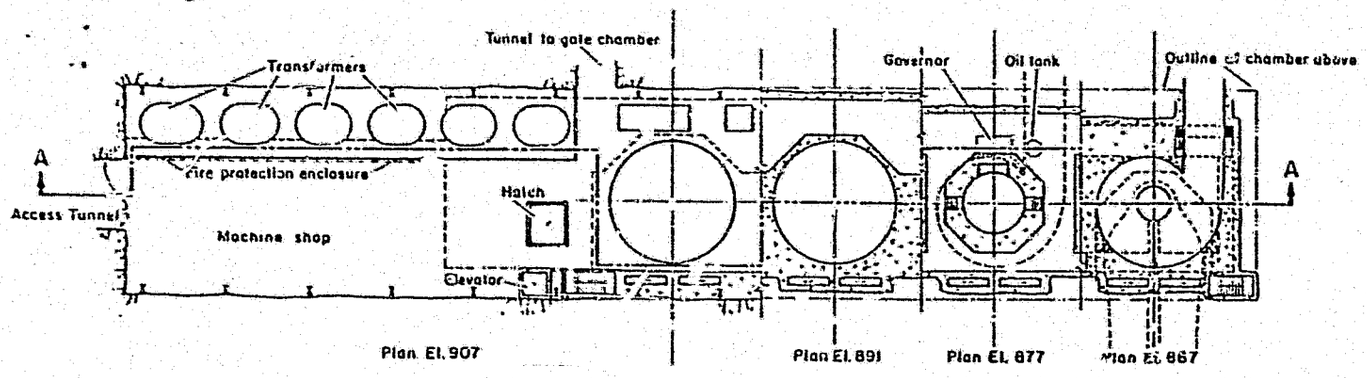
855-D-7

107

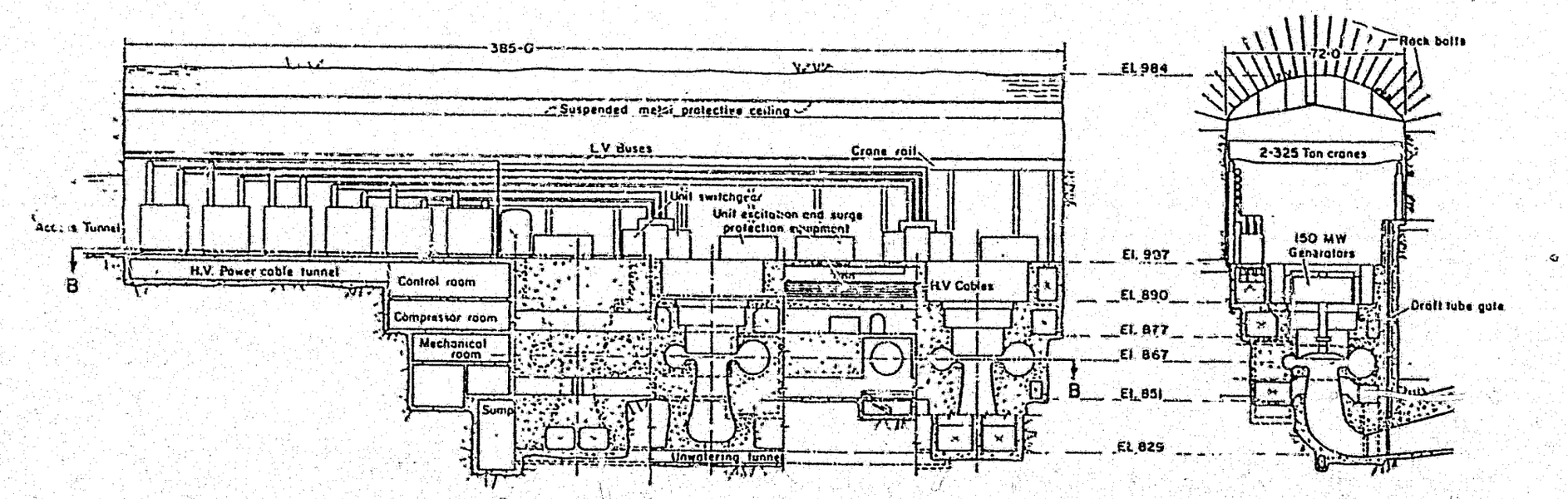
DEVIL CANYON DAM AND POWERPLANT

POWERPLANT PLAN AND SECTIONS

SCALE
0 20 40 60 80 100 120 FT.



General plan



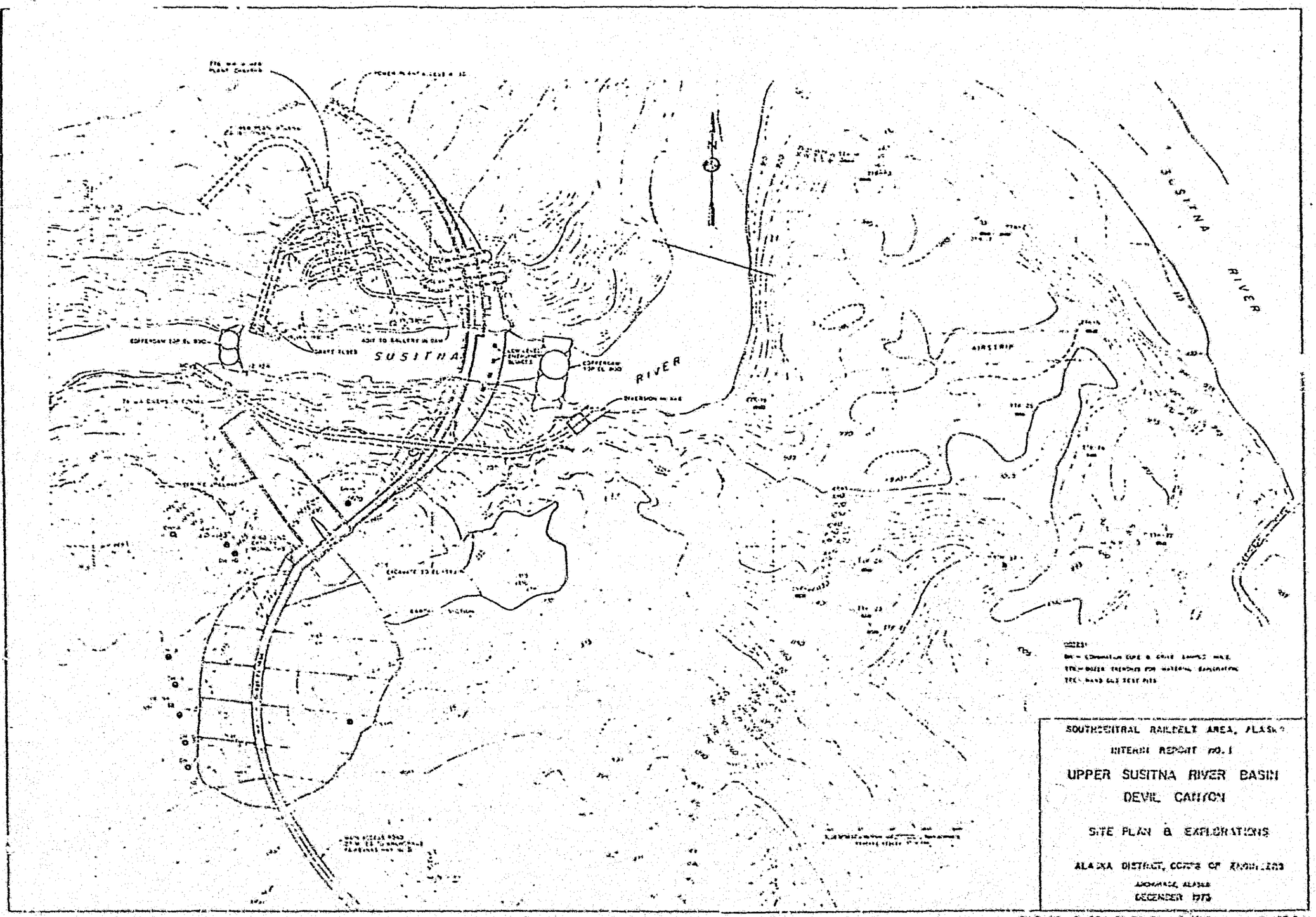
Section B-B

Longitudinal section

Section A-A

Transverse section

through ℄ of units



SOUTHCENTRAL RAILBELT AREA, ALASKA

INTERIM REPORT NO. 1

UPPER SUSITNA RIVER BASIN

DEVIL CANYON

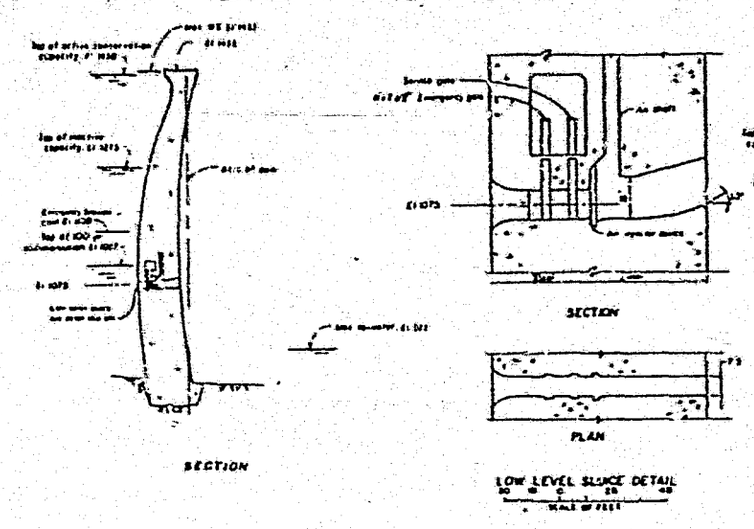
SITE PLAN & EXPLORATIONS

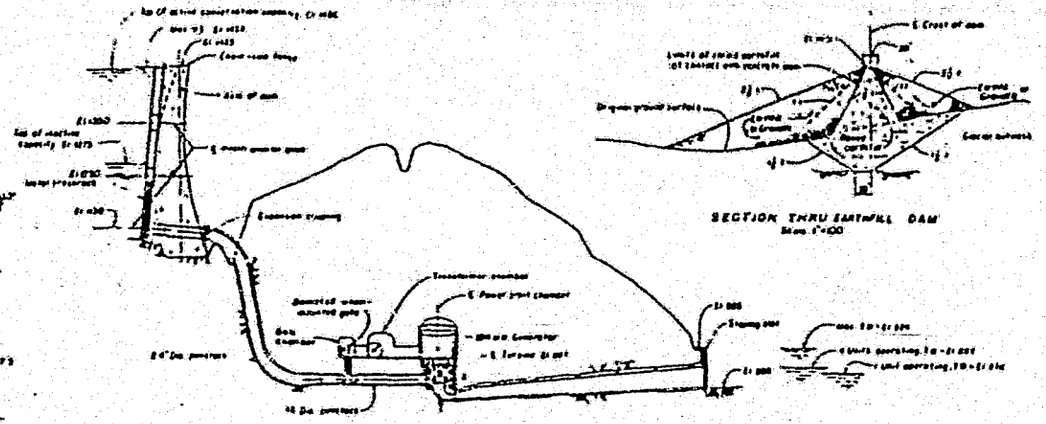
ALASKA DISTRICT, CORPS OF ENGINEERS

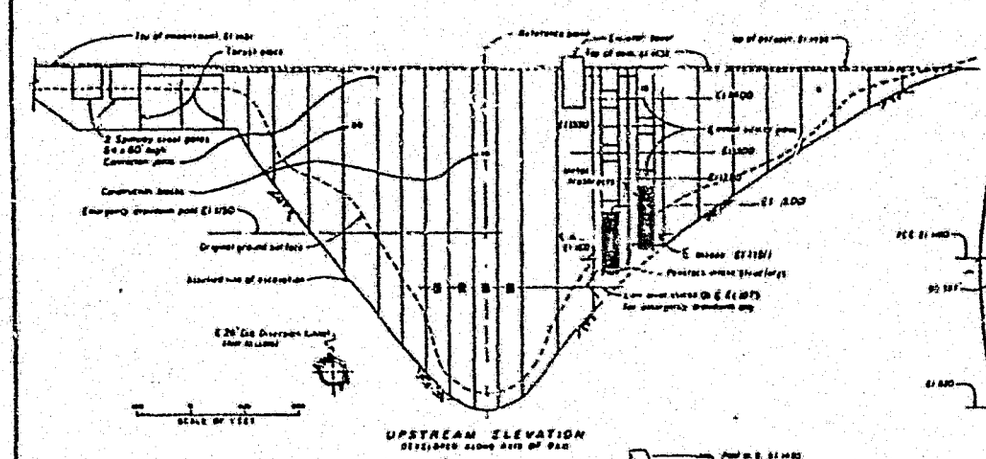
ANCHORAGE, ALASKA

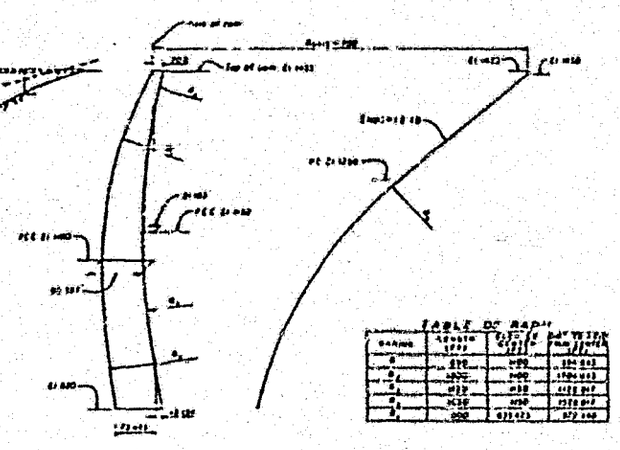
DECEMBER 1975

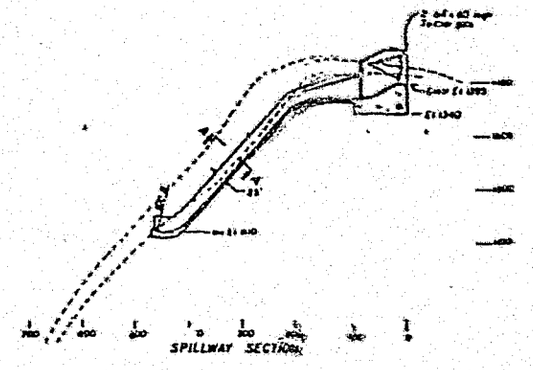
FILE NO 2-503-92-04-01 APPENDIX I PLATE D-1

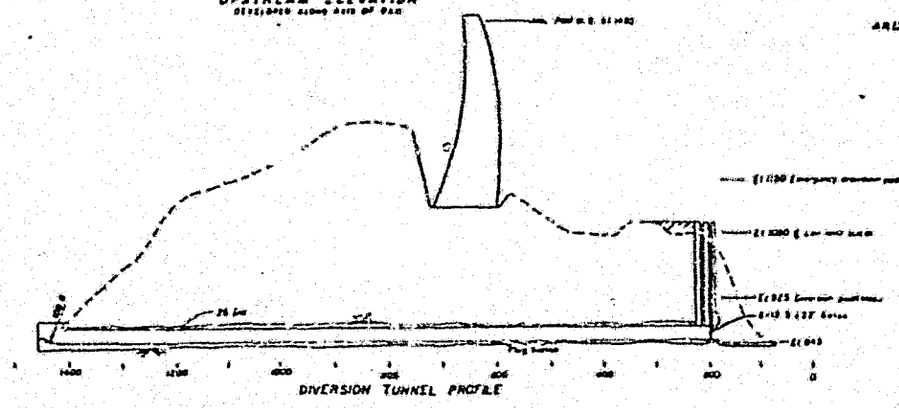


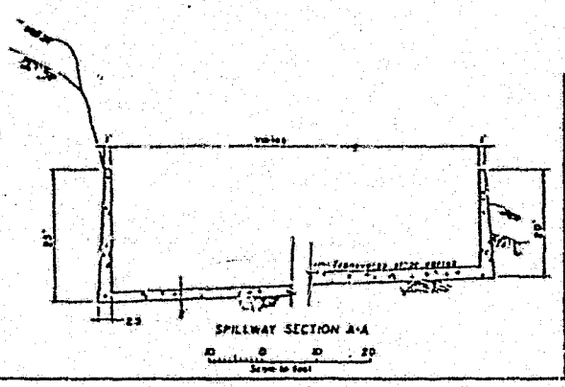












SOUTHCENTRAL RAILBELT AREA, ALASKA

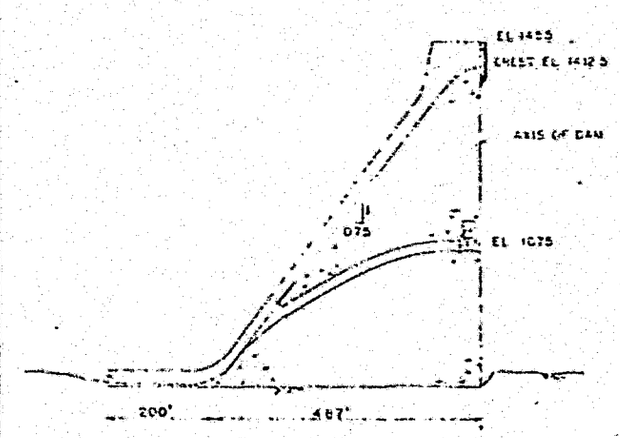
INTERIM REPORT NO. 1

UPPER SUSITNA RIVER BASIN
DEVIL CANYON DAM

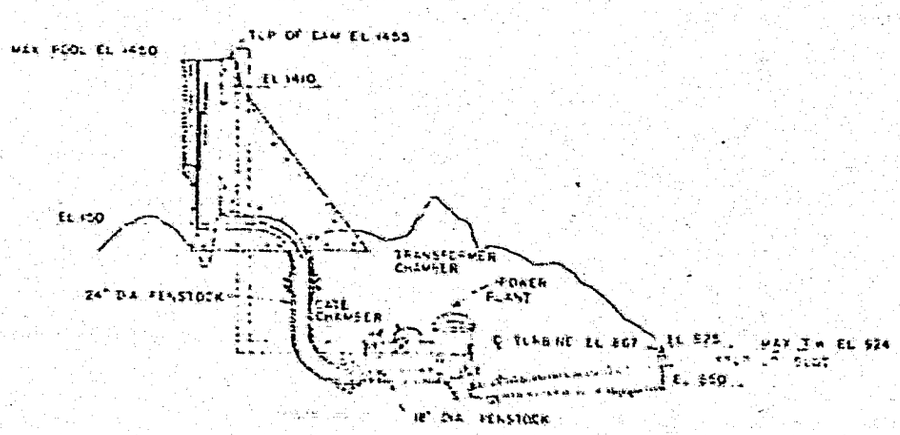
ELEVATION AND SECTIONS

ALASKA DISTRICT, CORPS OF ENGINEERS
ANCHORAGE, ALASKA
DECEMBER 1975

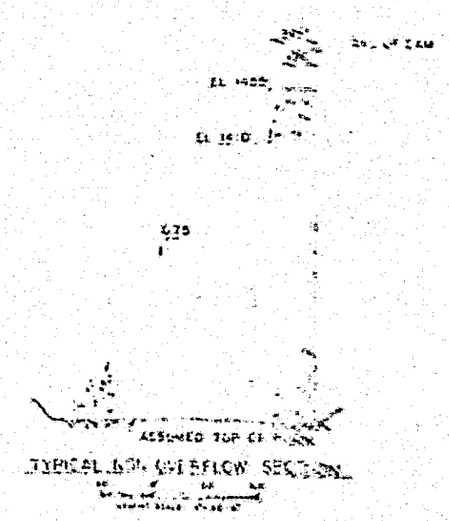
FILE NO. 2-SOU-92-04-01 APPENDIX I PLATE B-0



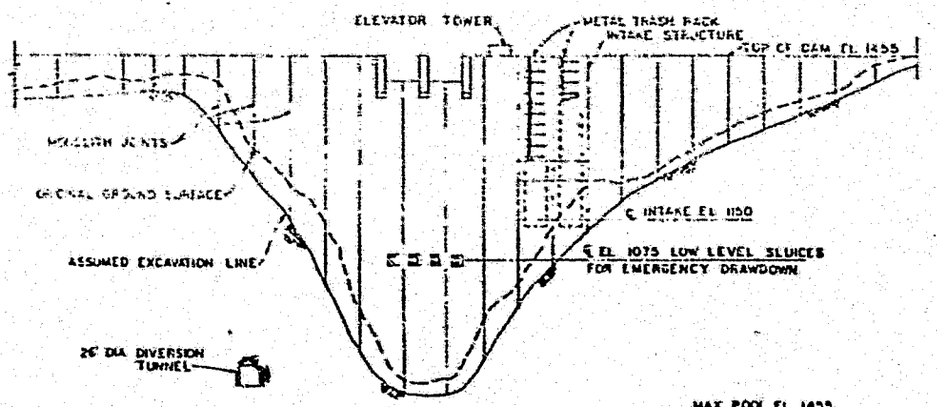
SPILLWAY SECTION



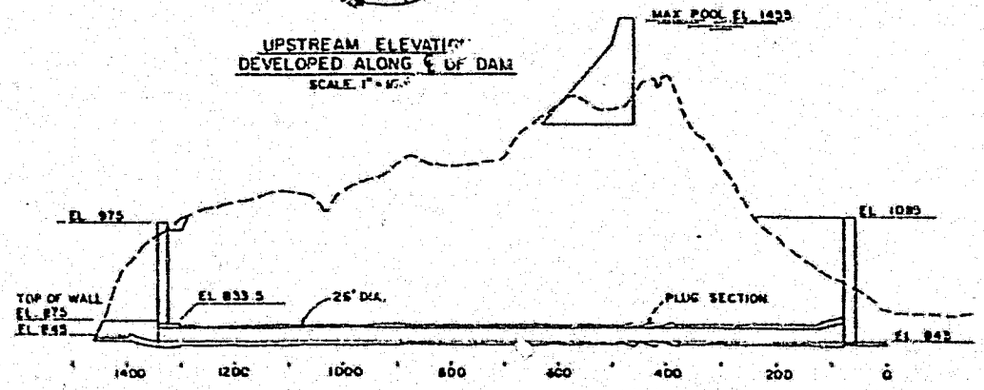
SECTION THRU PENSTOCK AND POWER PLANT
SCALE 1"=100'



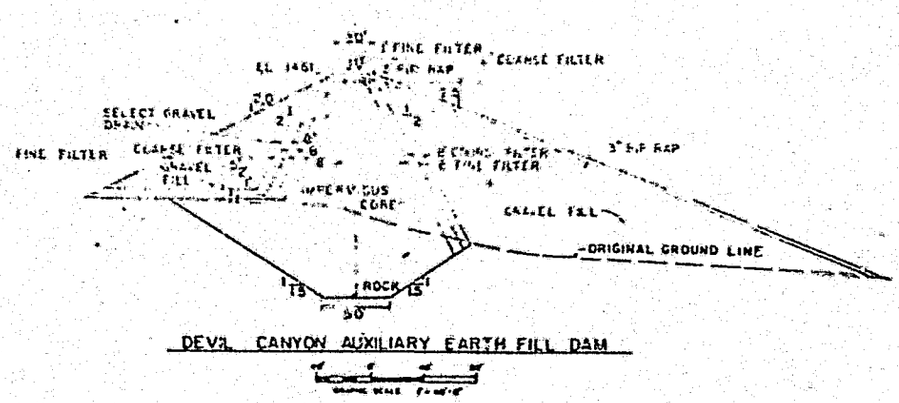
TYPICAL NON-OVERFLOW SECTION



UPSTREAM ELEVATION
DEVELOPED ALONG ℄ OF DAM
SCALE 1"=100'



DIVERSION TUNNEL PROFILE
SCALE 1"=100'



DEVIL CANYON AUXILIARY EARTH FILL DAM

SOUTHCENTRAL RAILBELT AREA, ALASKA
SUPPLEMENTAL FEASIBILITY STUDY
UPPER SUSITNA RIVER BASIN
DEVIL CANYON DAM
CONCRETE GRAVITY DAM
ELEVATION AND SECTIONS
ALASKA DISTRICT, CORPS OF ENGINEERS
ANCHORAGE, ALASKA
FEBRUARY 1979

PLATE

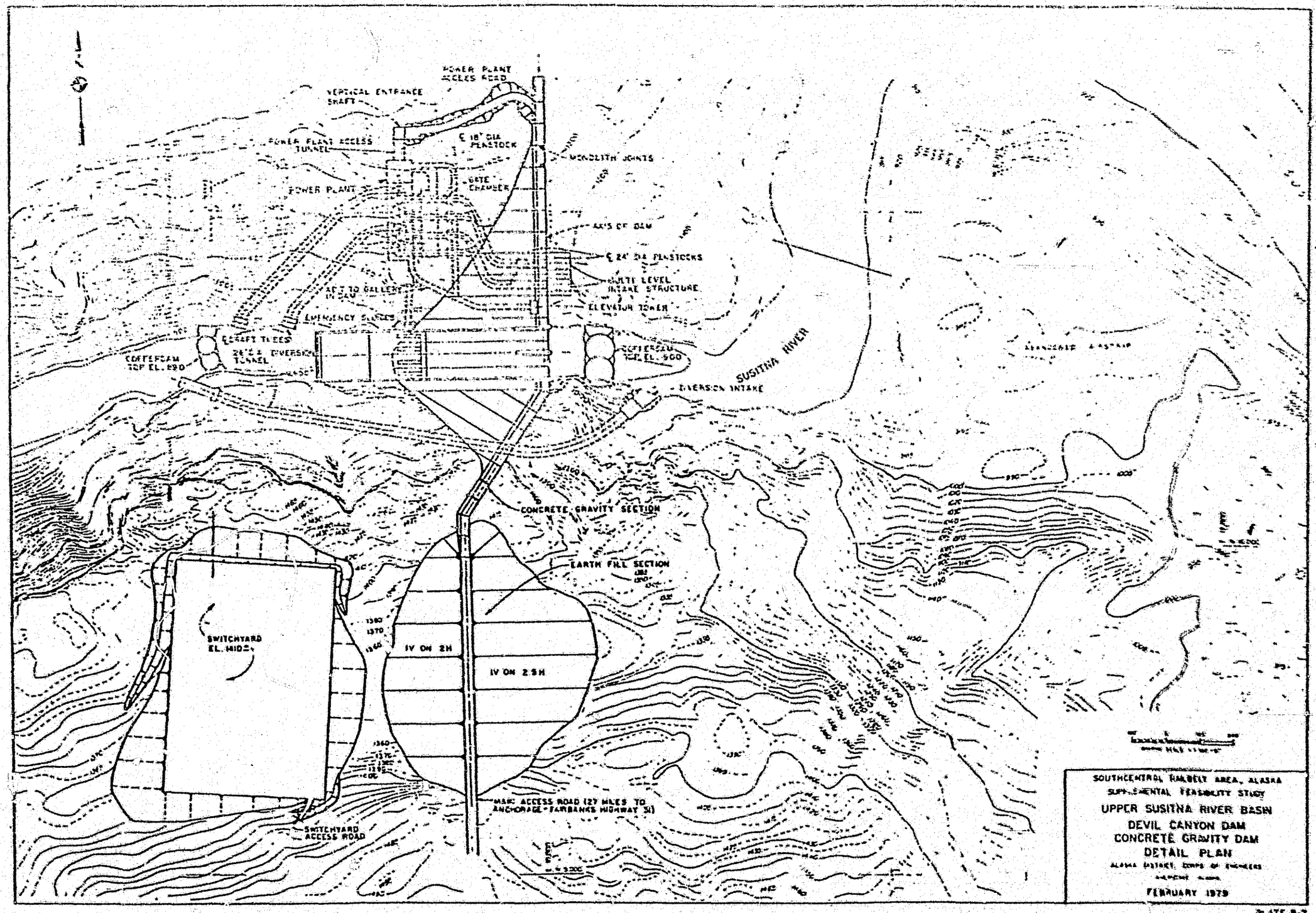
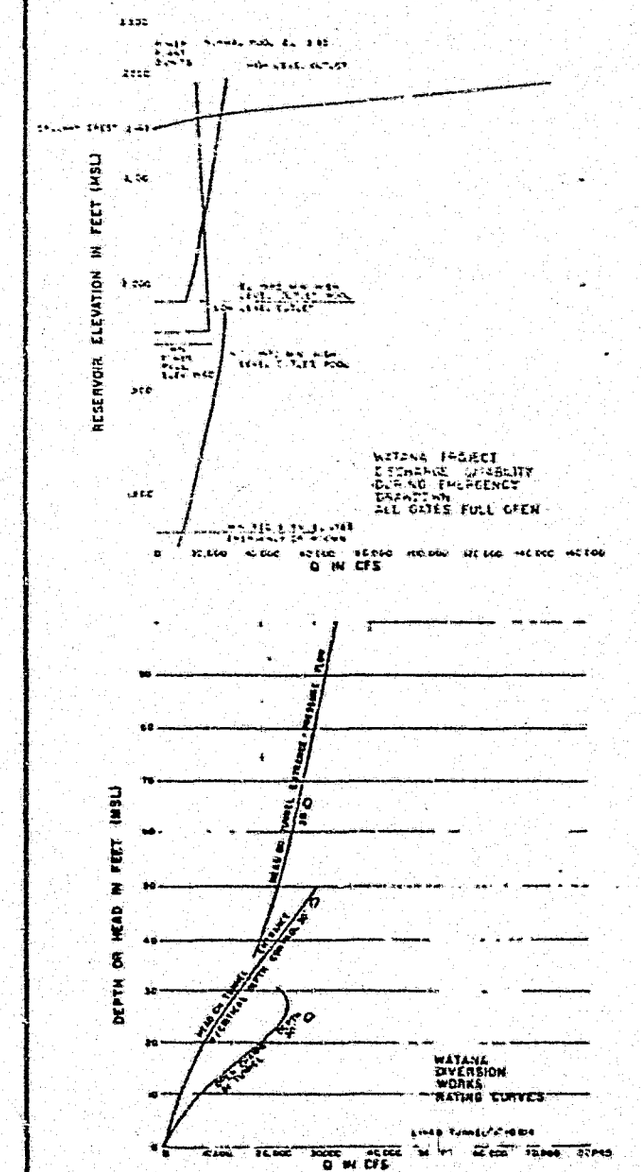

POWER PLANT ACCESS ROAD
VERTICAL ENTRANCE SHAFT
POWER PLANT ACCESS TUNNEL
ϵ 18' DIA PENSTOCK
MONOLITH JOINTS
GATE CHAMBER
POWER PLANT
AXIS OF DAM
ϵ 24' DIA PENSTOCKS
SUITE LEVEL INTAKE STRUCTURE
ELEVATOR TOWER
EMERGENCY GATES
DRAFT TUBES
COFFERDAM TOP EL. 880
COFFERDAM TOP EL. 900
SUSITNA RIVER
DIVERSION INTAKE
CONCRETE GRAVITY SECTION
EARTH FILL SECTION
SWITCHYARD EL. 1100±
IV ON 2H
IV ON 2.5H
MAIN ACCESS ROAD (27 MILES TO ANCHORAGE-FAIRBANKS HIGHWAY SI)
SWITCHYARD ACCESS ROAD
SOUTHCENTRAL RAILBELT AREA, ALASKA
SUPPLEMENTAL FEASIBILITY STUDY
UPPER SUSITNA RIVER BASIN
DEVIL CANYON DAM
CONCRETE GRAVITY DAM
DETAIL PLAN
ALASKA DISTRICT, CORPS OF ENGINEERS
FEBRUARY 1979

PLATE B-7

NOTES

1. TOPOGRAPHIC CONTOURS ARE BASED ON AERIAL PHOTOGRAPHY DATED 15 JUNE 1978. VERTICAL DATUM IS MEAN SEA LEVEL (MSL).



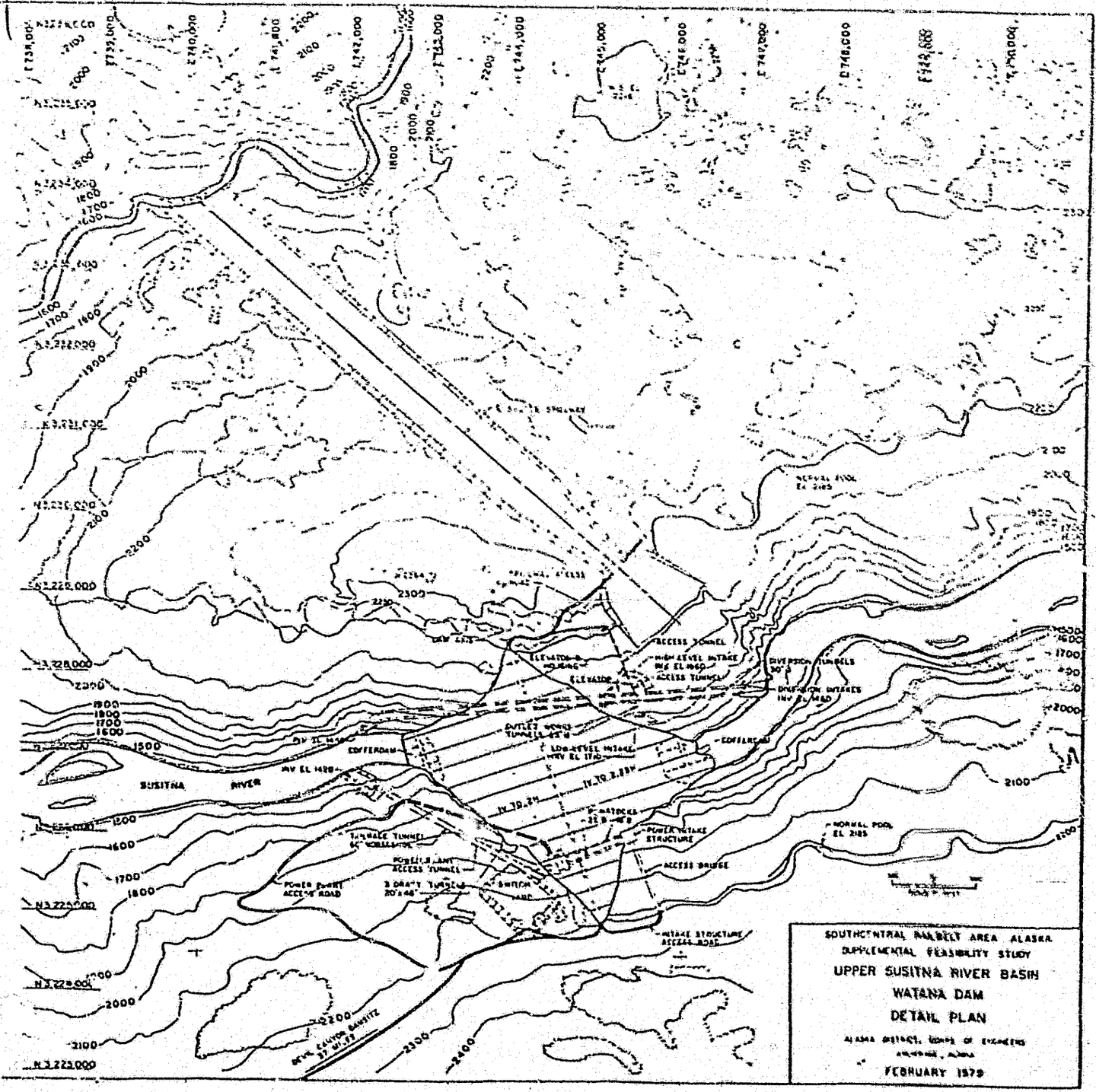
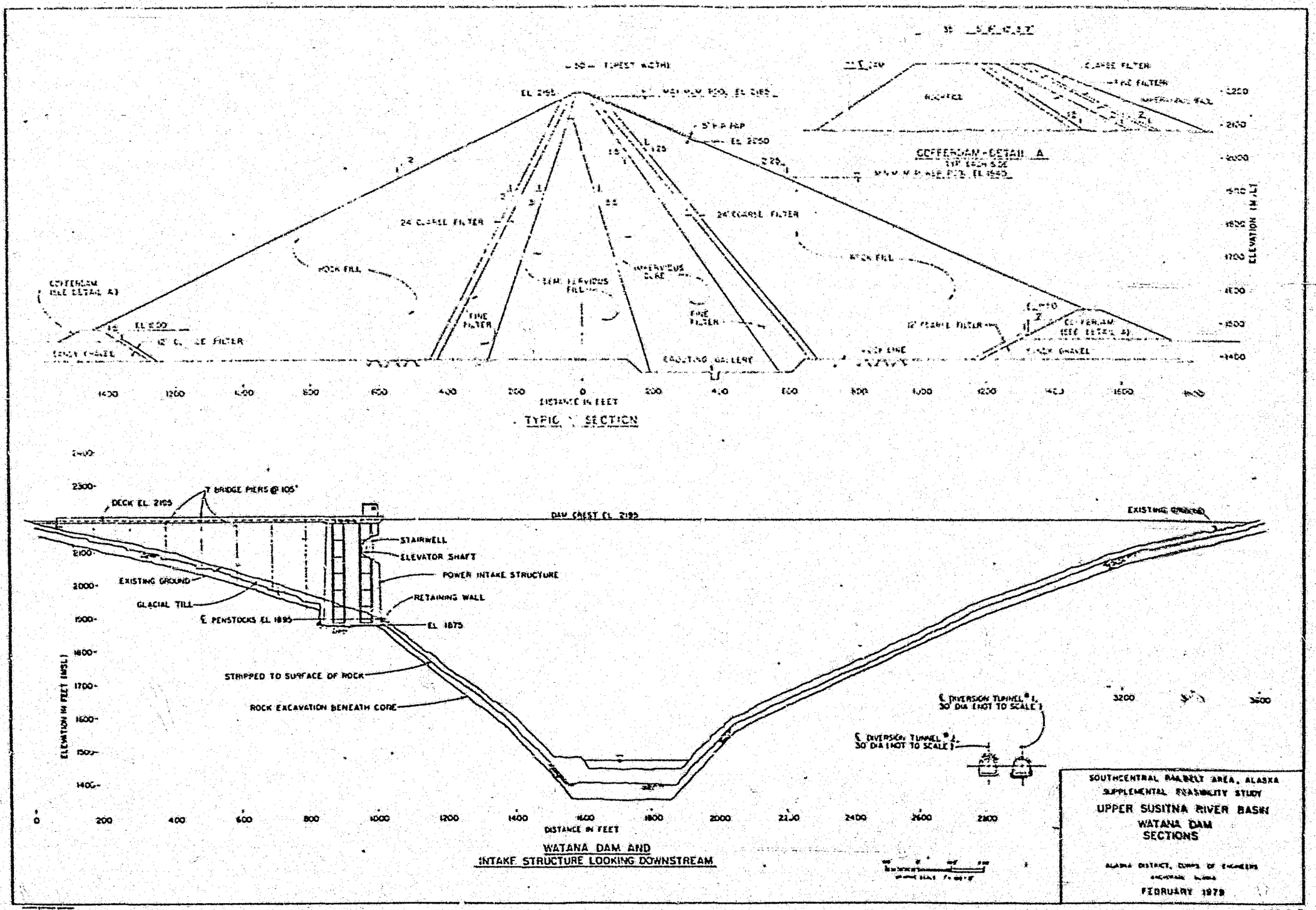


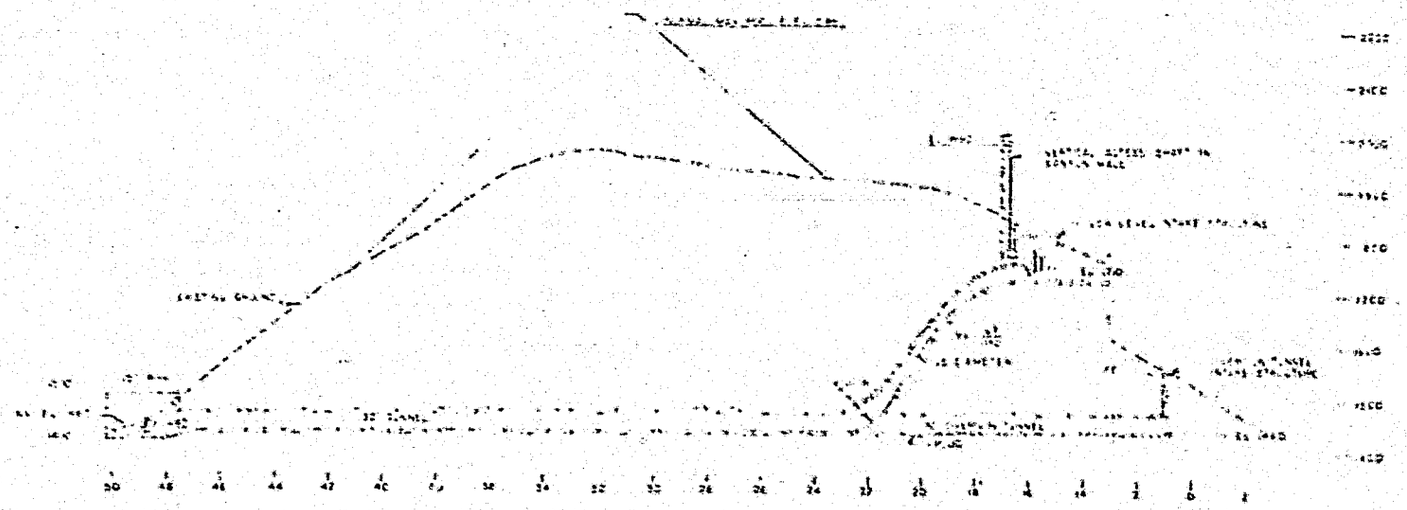
PLATE B-2



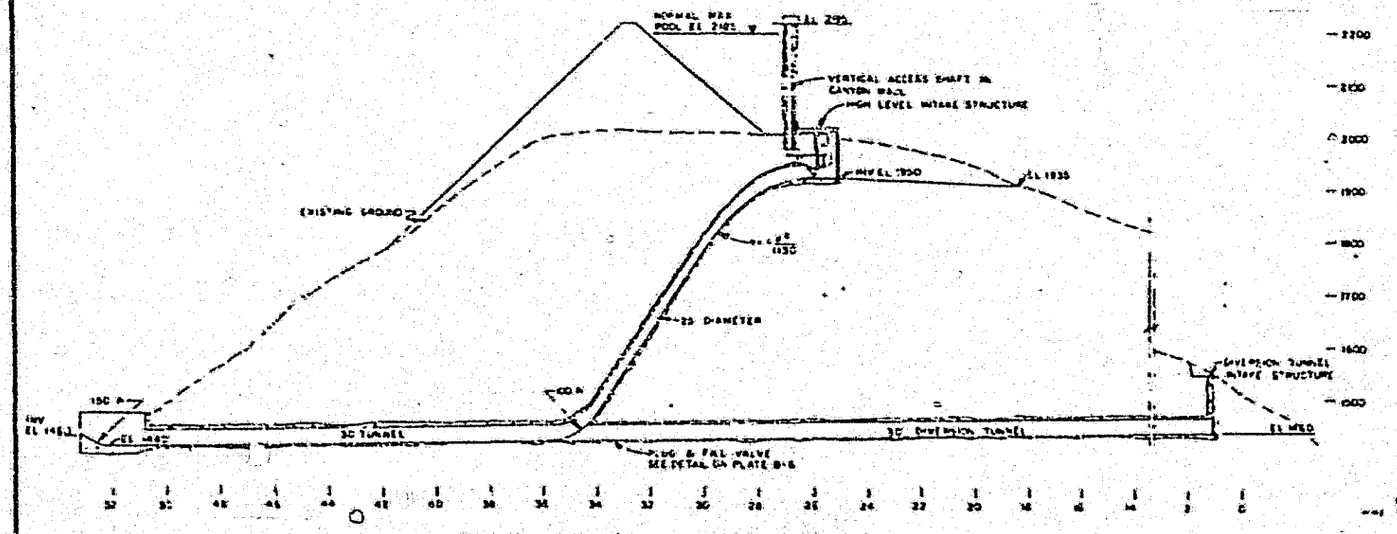
SOUTHCENTRAL RAILBELT AREA, ALASKA
SUPPLEMENTAL FEASIBILITY STUDY
UPPER SUSITNA RIVER BASIN
WATANA DAM
SECTIONS

ALASKA DISTRICT, CORPS OF ENGINEERS
ANCHORAGE, ALASKA
FEBRUARY 1979

PLATE B-3



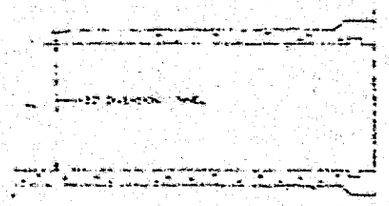
PROFILE LOW LEVEL OUTLET & DIVERSION TUNNEL #2



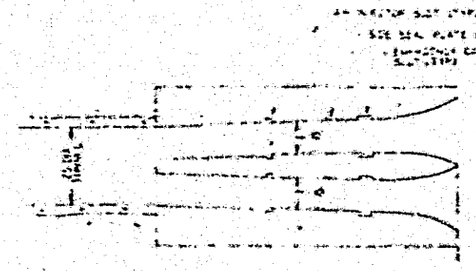
PROFILE HIGH LEVEL OUTLET & DIVERSION TUNNEL #1

SOUTHCENTRAL RAILBELT AREA, ALASKA
SUPPLEMENTAL FEASIBILITY STUDY
UPPER SUSITNA RIVER BASIN
WATANA DAM
PROFILES
ALASKA DISTRICT, CORPS OF ENGINEERS
ANCHORAGE, ALASKA
FEBRUARY 1979

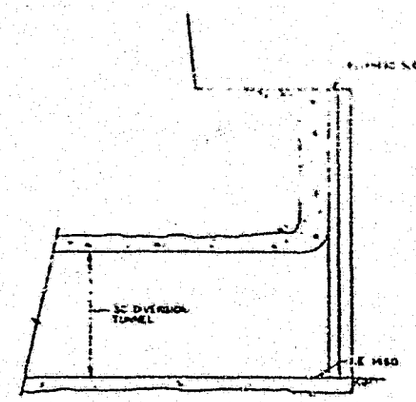
PLATE B-6



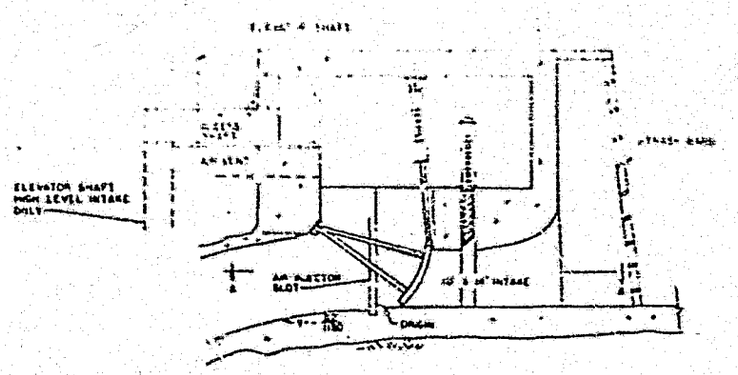
DIVERSION TUNNELS #1 AND #2 INTAKE STRUCTURE
PLAN



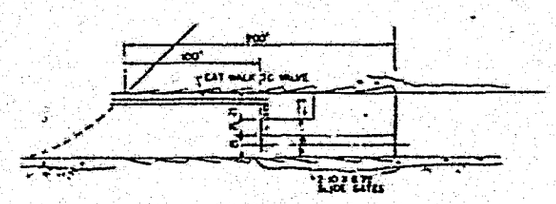
HIGH AND LOW LEVEL INTAKE
PLAN & A-A



DIVERSION TUNNELS #1 AND #2 INTAKE STRUCTURE
SECTION



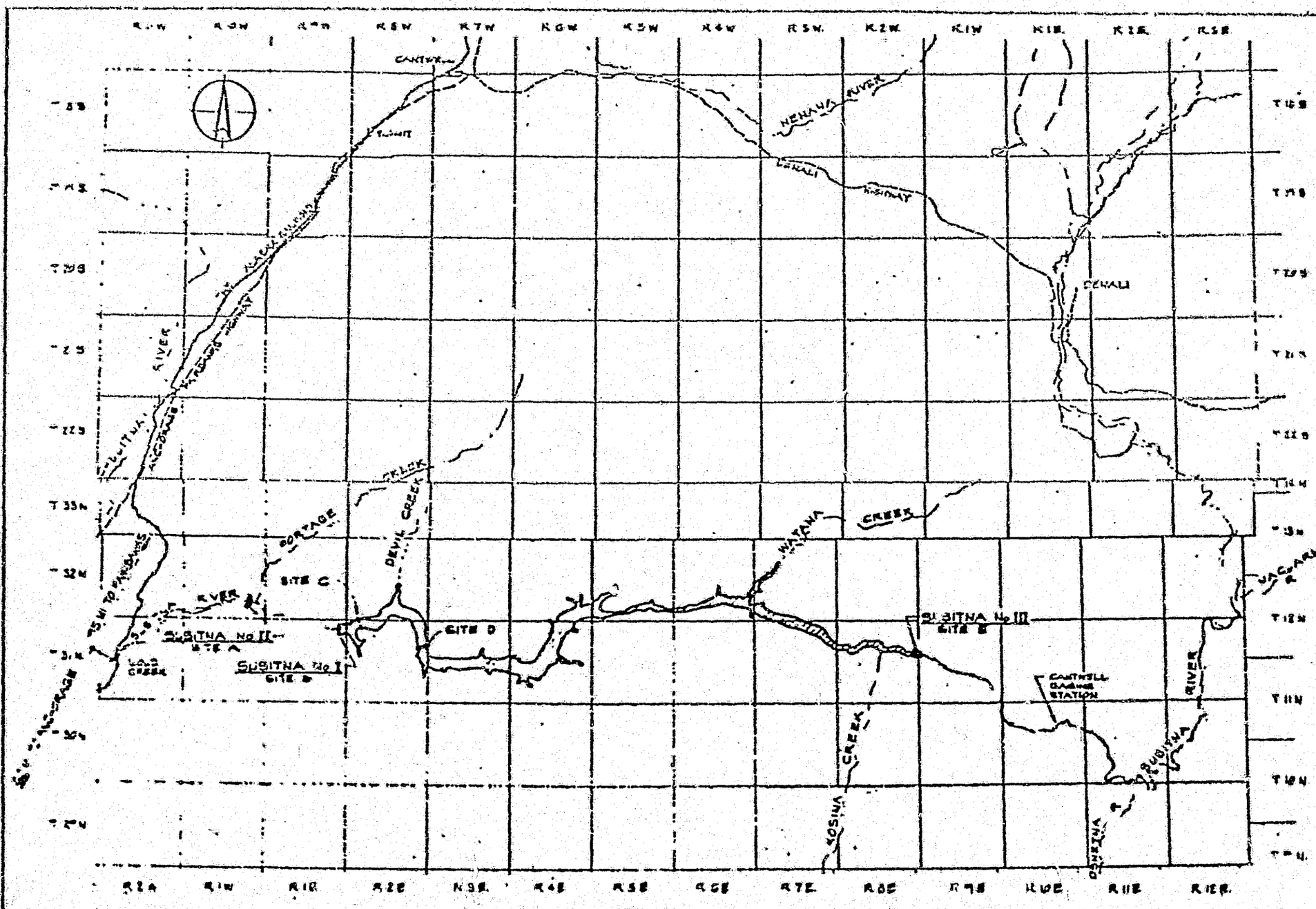
HIGH AND LOW LEVEL INTAKES
SECTION



PLUG AND FILL VELVE DETAIL
NOT TO SCALE

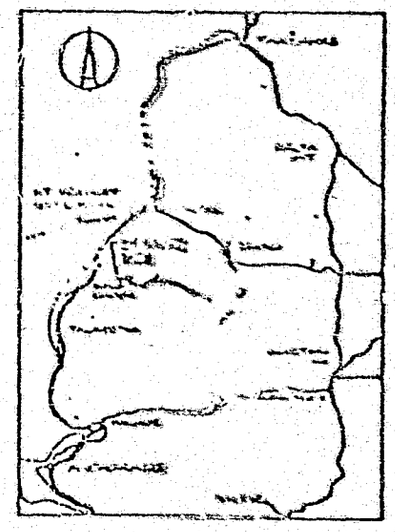
SOUTHCENTRAL RAILBELT AREA, ALASKA
SUPPLEMENTAL FEASIBILITY STUDY
UPPER SUSITNA RIVER BASIN
WATANA DAM
DETAILS
ALASKA DISTRICT, CORPS OF ENGINEERS
ANCHORAGE, ALASKA
FEBRUARY 1979

PLATE 3-6



SITE LOCATION PLAN

0 5 10 20 MILES



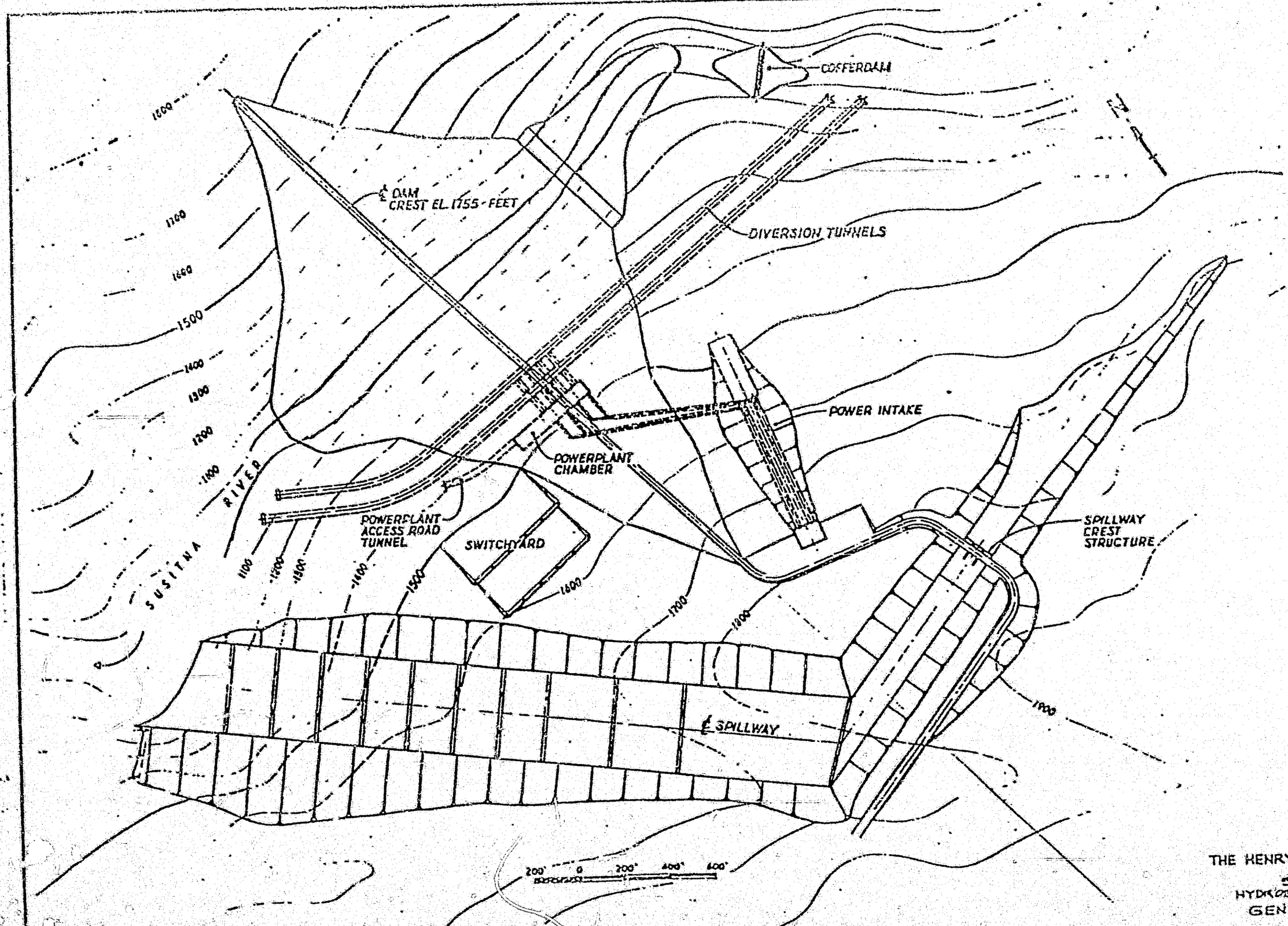
VICINITY PLAN

0 0 50 100 MILES

THE HENRY J. KAISER COMPANY

SUSITNA I
HYDROELECTRIC PROJECT
SITE LOCATION PLAN

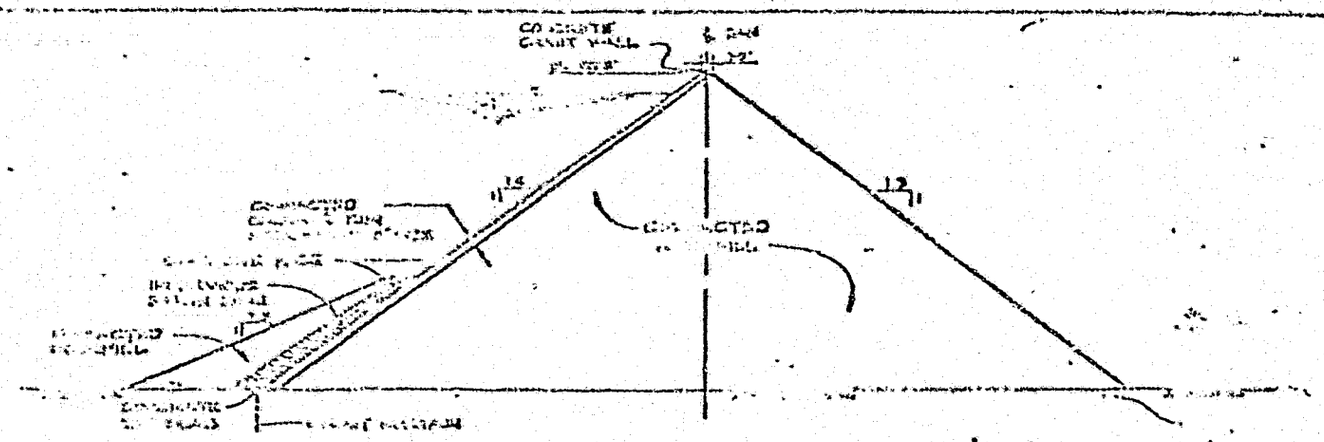
FIGURE VII-1



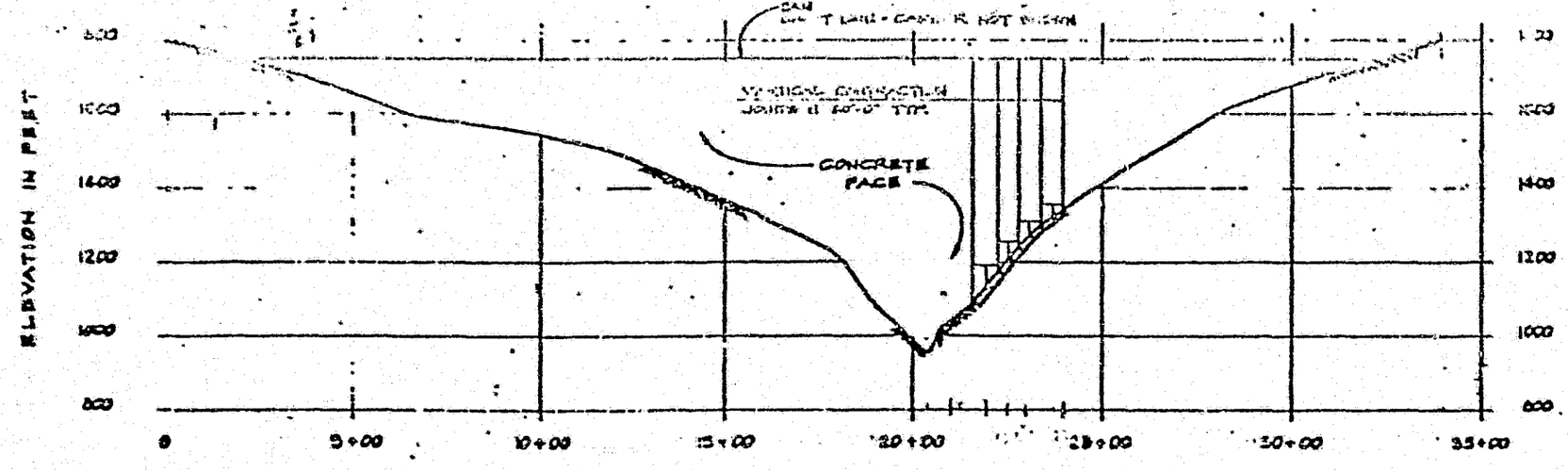
THE HENRY J. KAISER COMPANY

SUSITNA 1
HYDROELECTRIC PROJECT
GENERAL LAYOUT

FIGURE 2-1

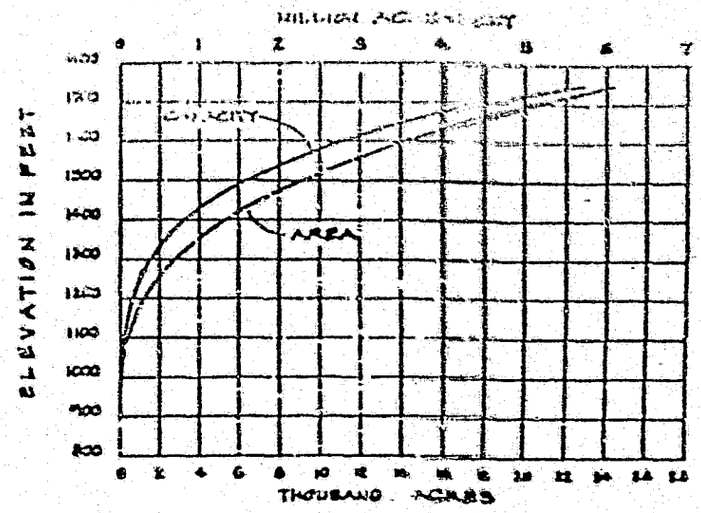


TYPICAL DAM SECTION

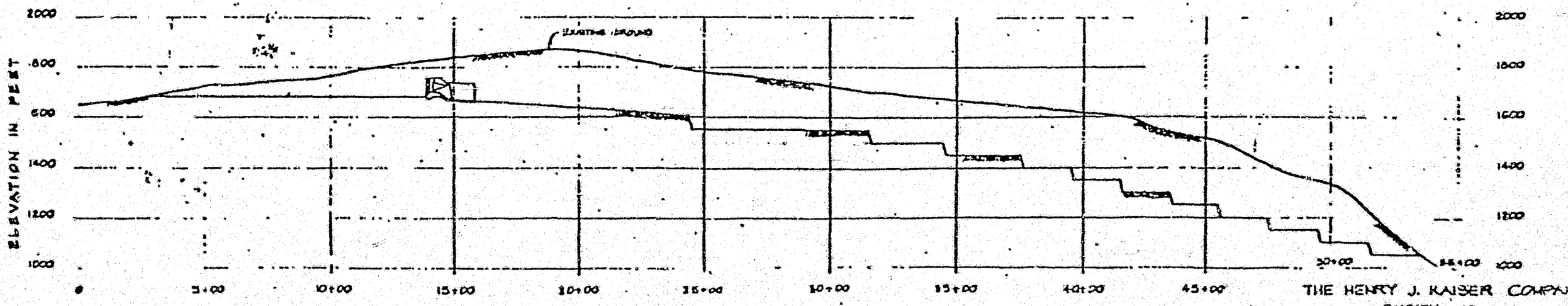


UPSTREAM ELEVATION OF DAM

SCALE: 1" = 200' HORIZONTAL & VERTICAL



RESERVOIR AREA - CAPACITY CURVE



SPILLWAY & PROFILE

SCALE: 1" = 200' HORIZONTAL & VERTICAL

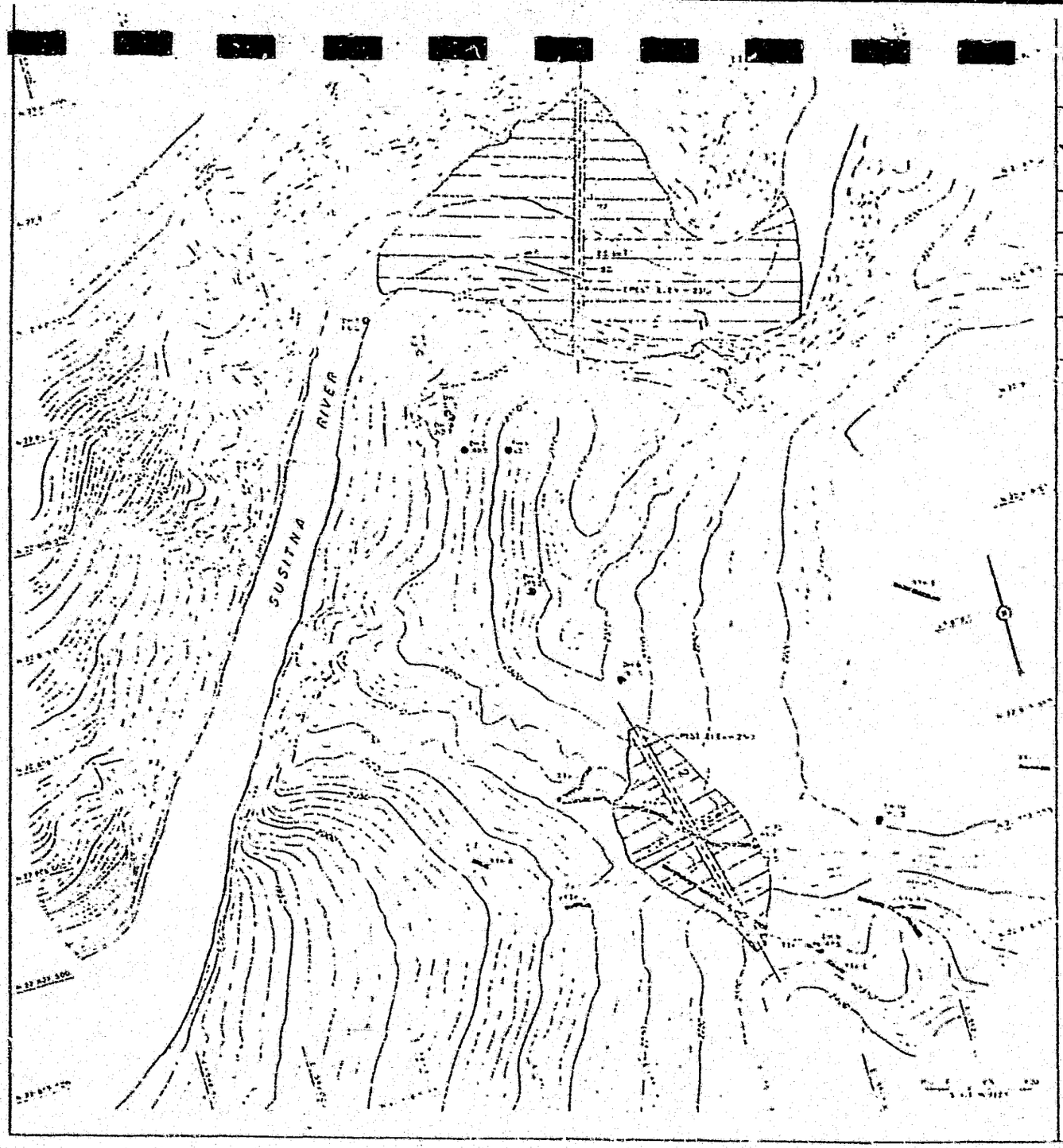
THE HENRY J. KAISER COMPANY

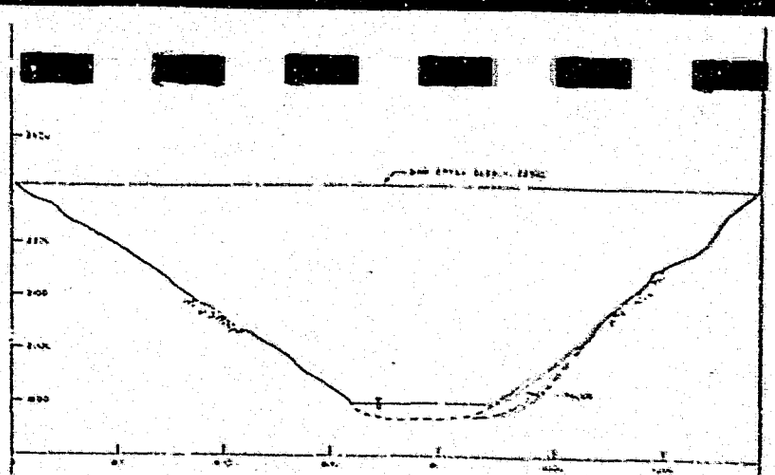
SUSITNA I

HYDROELECTRIC PROJECT

SECTIONS

FIGURE V-2





SCHEMATIC PROFILE

LEGEND

NOTES

1. CONTOUR INTERVAL

SOUTHCENTRAL RAILBELT AREA, ALASKA

INTERIM REPORT NO. 1

UPPER SUSITNA RIVER BASIN

VEE CANYON

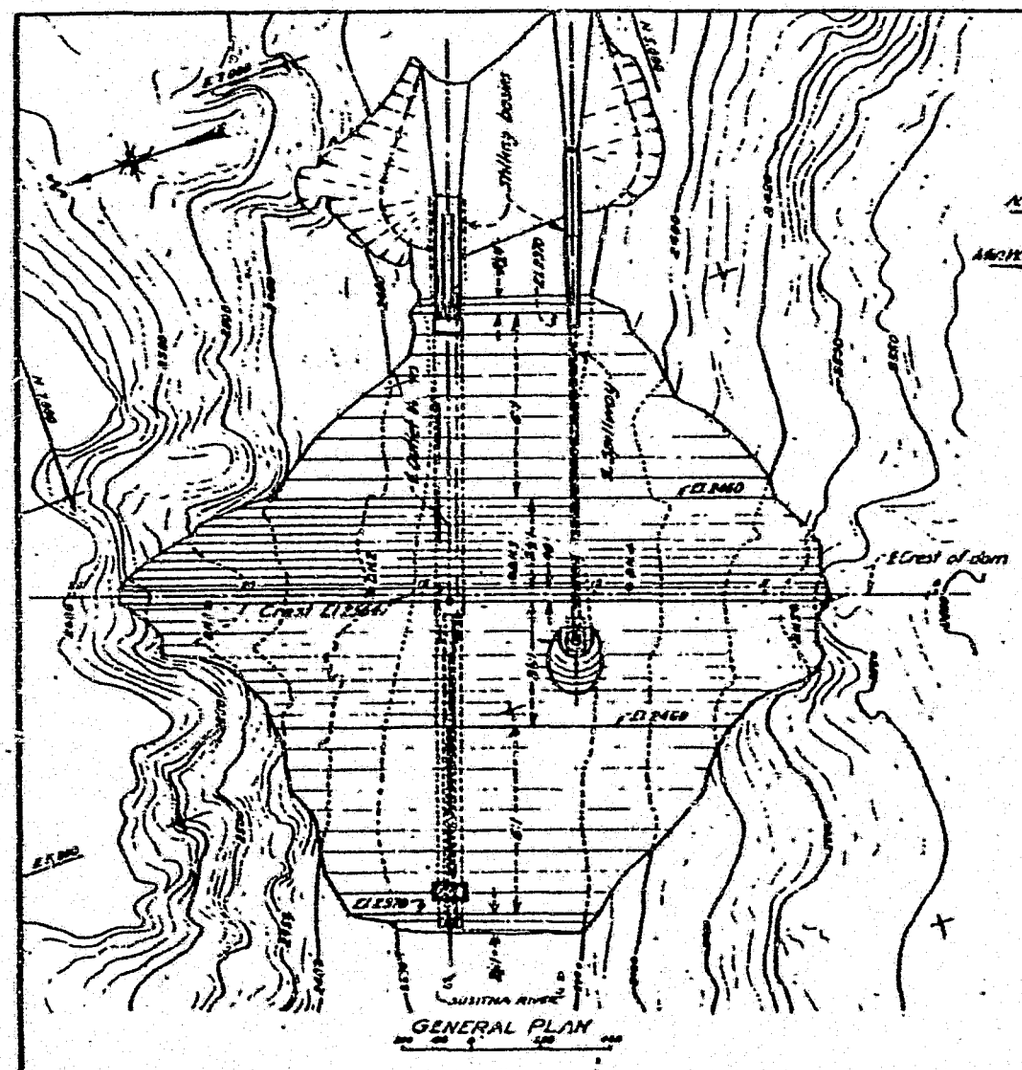
SITE PLAN & CENTERLINE PROFILE

ALASKA DISTRICT, CORPS OF ENGINEERS

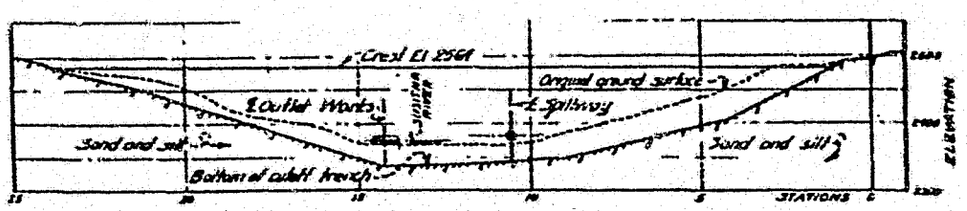
ANCHORAGE, ALASKA

DECEMBER 1975

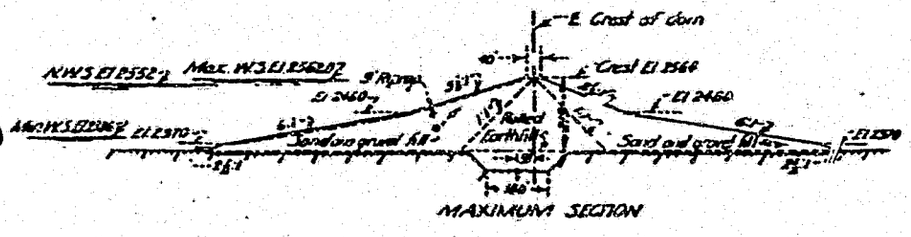
FILE NO 2-SOU-32-C4+D ANNEX I PLATE D4



GENERAL PLAN



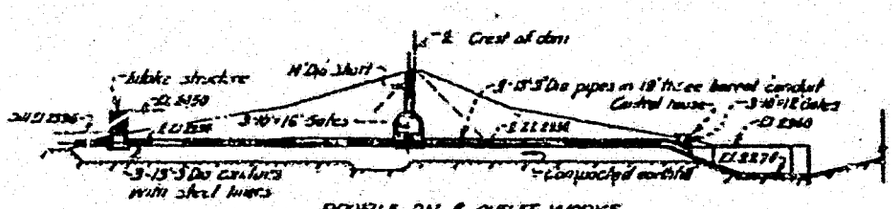
PROFILE ON E OF DAM



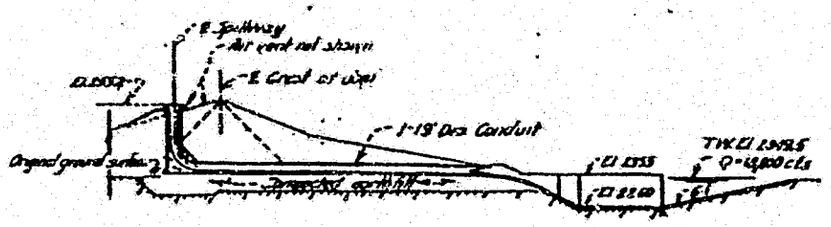
RESERVOIR ALLOCATION

PURPOSE	ELEVATION	STORAGE ACRE FEET
Conservation	2386 to 2552	3,904,000
Dead	2370 to 2386	180,000
Total storage capacity		3,930,000*

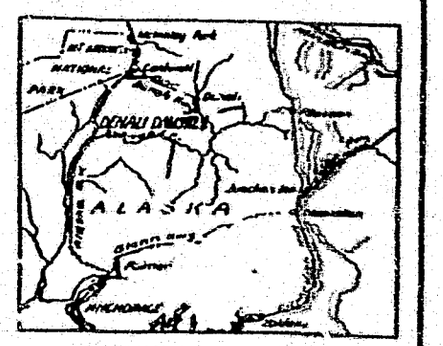
* Includes 140,000 a.f. for sediment
A surcharge of 815,300 a.f. (Max. W.S El. 2562.8) with a spillway discharge of 79,600 c.f.s. protects against the million year flood (peak 90,000 cfs., 7 month volume 3,788,000 a.f.)



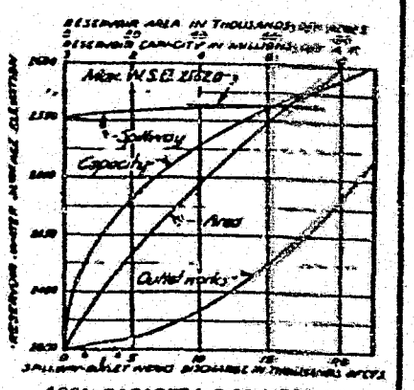
PROFILE ON E OUTLET WORKS



PROFILE ON E OF SPILLWAY



LOCATION MAP



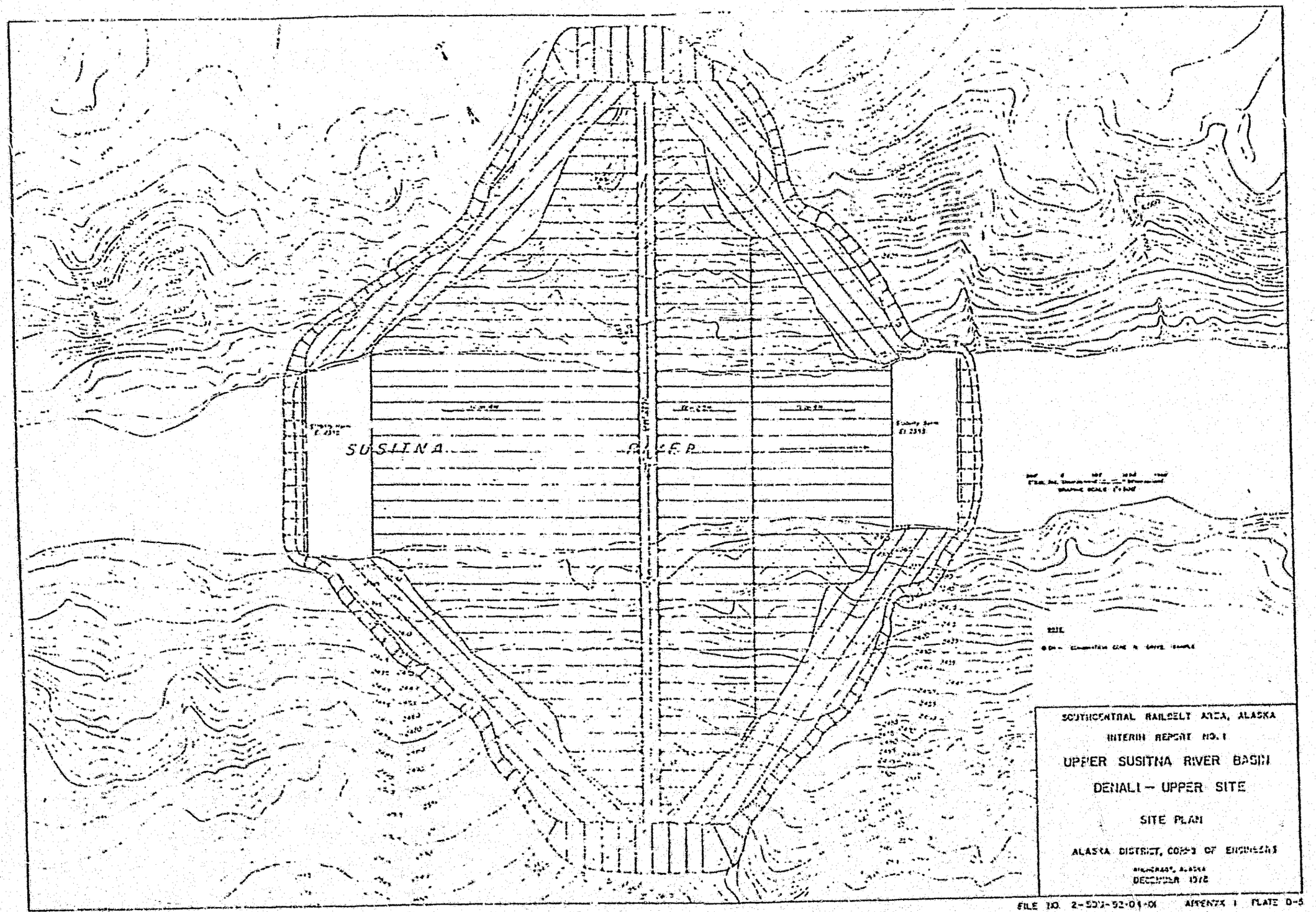
AREA-CAPACITY-DISCHARGE CURVES

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
BERL CANYON PROJECT ALASKA

DENALI DAM
(ALTERNATE POWER)
RECONNAISSANCE DESIGN DRAWING

DESIGN NRE SUBMITTED D.S.E.
TRACED RECOMMENDED
CHECKED APPROVED
DENVER, COLORADO FILE NO. 952-D-4

117



SOUTHCENTRAL RAILBELT AREA, ALASKA

INTERIM REPORT NO. 1

UPPER SUSITNA RIVER BASIN

DENALI – UPPER SITE

SITE PLAN

ALASKA DISTRICT, CORPS OF ENGINEERS

ANCHORAGE, ALASKA

DECEMBER 1978

FILE NO. 2-502-52-01-01 APPENDIX I PLATE D-5

APPENDIX B -

CORPS OF ENGINEERS
CRITERIA FOR EVALUATION OF ALTERNATIVES

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

EVALUATION OF ALTERNATIVES

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

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

Technical Criteria:

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

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

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

National Economic Development Criteria:

Tangible benefits must exceed project economic costs.

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

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

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

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

Environmental Quality Criteria:

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

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

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

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

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

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

Social Well-Being and Regional Development Considerations:

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

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

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

The effects on educational and cultural opportunities;

The conservation of nonrenewable resources.

APPENDIX C -

CORPS OF ENGINEERS
COST DATA FROM 1975 INTERIM FEASIBILITY REPORT

SUMMARY COST ESTIMATE
JANUARY 1975 PRICE LEVEL

WATANA DAM AND RESERVOIR
2200 FEET NORMAL POOL ELEVATION
(FIRST-ADDED)

ACCOUNT NO.	ITEM		FEATURE COST ($1,000)
01	LANDS AND DAMAGES		16,392
03	RESERVOIR		9,180
04	DAMS		479,775
	Main Dam	194,172	
	Spillway	57,665	
	Outlet Works	44,544	
	Power Intake	123,298	
	Construction Facilities	60,096	
07	POWERPLANT		439,238
	Powerhouse	67,229	
	Turbines and Generators	50,649	
	Accessory Electrical and Powerplant Equipment	11,121	
	Tailrace	47,287	
	Switchyard	15,717	
	Transmission Facilities	219,600	
	Construction Facilities	27,635	
08	ROADS AND BRIDGES		48,875
14	RECREATIONAL FACILITIES		39
19	BUILDINGS, GROUNDS, AND UTILITIES		3,565
20	PERMANENT OPERATING EQUIPMENT		1,800
30	ENGINEERING AND DESIGN		39,638
31	SUPERVISION AND ADMINISTRATION		49,498
	TOTAL PROJECT COST		1,088,000

Table B-1
Appendix I
B-20

SUMMARY COST ESTIMATE
JANUARY 1975 PRICE LEVEL

DEVIL CANYON DAM AND RESERVOIR
1450 FEET NORMAL POOL ELEVATION
(SECOND-ADDED)

ACCOUNT NO.	ITEM		FEATURE COST ($1,000)
01	LANDS		1,444
03	RESERVOIRS		3,456
04	DAMS		219,543
	Main Dam	140,971	
	Spillway	19,792	
	Power Intakes	42,136	
	Auxiliary Dam	3,897	
	Construction Facilities	12,747	
07	POWERPLANT		147,977
	Powerhouse	42,702	
	Turbines and Generators	,808	
	Accessory Electrical and Powerplant Equipment	10,475	
	Tailrace	13,921	
	Switchyard	19,518	
	Construction Facilities	3,553	
08	ROADS AND BRIDGES		8,528
14	RECREATIONAL FACILITIES		512
19	BUILDINGS, GROUNDS, AND UTILITIES		2,519
20	PERMANENT OPERATING EQUIPMENT		1,800
30	ENGINEERING AND DESIGN		26,962
31	SUPERVISION AND ADMINISTRATION		19,259
	TOTAL PROJECT COST		432,000

SUMMARY COST ESTIMATE
JANUARY 1975 PRICE LEVEL

WATANA DAM AND RESERVOIR
2200 FEET NORMAL POOL ELEVATION
(SECOND-ADDED)

ACCOUNT NO.	ITEM		FEATURE COST ($1,000)
01	LANDS AND DAMAGES		16,392
03	RESERVOIR		9,180
04	DAMS		479,775
	Main Dam	194,172	
	Spillway	57,665	
	Outlet Works	44,544	
	Power Intake	123,298	
	Construction Facilities	60,096	
07	POWERPLANT		232,305
	Powerhouse	67,229	
	Turbines and Generators	50,649	
	Accessory Electrical and Powerplant Equipment	11,121	
	Tailrace	47,287	
	Switchyard	15,717	
	Transmission Facilities	12,667	
	Construction Facilities	27,635	
08	ROADS AND BRIDGES		26,137
14	RECREATIONAL FACILITIES		39
19	BUILDINGS, GROUNDS, AND UTILITIES		3,565
20	PERMANENT OPERATING EQUIPMENT		1,800
30	ENGINEERING AND DESIGN		30,142
31	SUPERVISION AND ADMINISTRATION		37,665
	TOTAL PROJECT COST		837,000

Table B-3
Appendix I
B-22

SUMMARY COST ESTIMATE
JANUARY 1975 PRICE LEVEL

DEVIL CANYON DAM AND RESERVOIR
1450 FEET NORMAL POOL ELEVATION
(FIRST-ADDED)

ACCOUNT NO.	ITEM		FEATURE COST ($1,000)
01	LANDS		1,444
03	RESERVOIRS		3,456
04	DAMS		236,728
	Main Dam	140,971	
	Spillway	19,792	
	Power Intakes	42,136	
	Auxiliary Dam	3,897	
	Construction Facilities	29,932	
07	POWERPLANT		359,700
	Powerhouse	42,702	
	Turbines and Generators	57,808	
	Accessory Electrical and Powerplant Equipment	10,475	
	Tailrace	13,921	
	Switchyard	19,518	
	Transmission Facilities	206,933	
	Construction Facilities	8,343	
08	ROADS AND BRIDGES		31,266
14	RECREATIONAL FACILITIES		512
19	BUILDINGS, GROUNDS, AND UTILITIES		2,519
20	PERMANENT OPERATING EQUIPMENT		1,800
30	ENGINEERING AND DESIGN		44,648
31	SUPERVISION AND ADMINISTRATION		31,927
	TOTAL PROJECT COST		714,000

Table B-4
Appendix I
B-23

DETAILED COST ESTIMATE

WATANA DAM AND RESERVOIR ELEVATION 2200

JANUARY 1975 PRICE LEVEL

(FIRST-ADDED)

Cost Account Number	Description or Item	Unit	Quant	Unit Cost ($)	Total Cost ($1,000)
01	LANDS AND DAMAGES				
	Reservoir				
	Public domain	AC	18,600	323.00	(6,008)
	Private land	AC	30,000	317.00	9,510
	Site and other	AC	1,080	500.00	540
	Access road	AC	780	615.00	480
	Transmission facilities				
	Public domain	AC	4,400	300.00	(1,320)
	Private land	AC	3,795	620.00	2,352
	Recreation	AC	90	500.00	45
	Subtotal				20,255
	Contingencies 20%				4,051
	Government administrative costs				880
	TOTAL LANDS AND DAMAGES				(25,186)
	Construction cost				16,392
	Economic cost				(8,794)
03	RESERVOIR				
	Clearing	AC	5,100	1,500.00	7,650
	Contingencies 20%				1,530
	TOTAL, RESERVOIR				9,180
04	DAMS				
04.1	MAIN DAM				
	Mobilization and preparatory work	LS			23,000
	Clearing	AC	860	1,500.00	1,290
	Foundation preparation	SY	105,000	10.00	1,050
	Excavation				
	Foundation	CY	1,800,000	3.50	6,300
	Borrow and quarry areas	LS			3,000
	Embankment				
	Gravel fill	CY	39,200,000	1.65	64,680
	Sand filter	CY	1,100,000	8.00	8,800
	Second filter	CY	1,000,000	4.00	4,000
	Impervious core	CY	9,250,000	3.75	34,688
	Riprap	CY	280,000	10.00	2,800
	Select drain	CY	1,800,000	4.00	7,200

TABLE B-5 --DETAILED COST ESTIMATE--Continued

WATANA DAM AND RESERVOIR

Cost Account Number	Description or Item	Unit	Quant	Unit Cost ($)	Total Cost ($1,000)
04	DAMS				
04.1	MAIN DAM (Cont'd)				
	Drilling and grouting	LF	145,000	18.75	2,719
	Drainage system	LS			283
	Right abutment seepage control	LS			2,000
	Subtotal				161,810
	Contingencies 20%				32,362
	TOTAL, MAIN DAM				194,172
04.2	SPILLWAY				
	Clearing and stripping	AC	150	1,500.00	225
	Foundation preparation	CY	8,500	16.00	136
	Excavation	CY	10,530,000	3.00	31,590
	Concrete				
	Mass	CY	97,000	50.00	4,850
	Structural	CY	15,100	325.00	4,908
	Cement	Cwt	240,000	4.00	960
	Reinforcing steel	Lbs	1,510,000	.60	906
	Anchor bars	Lbs	37,000	1.25	46
	Drilling and grouting	LF	6,200	21.50	133
	Drainage system	LS			250
	Tainter gates (3), complete	LS			3,250
	Stoplogs (1 set)	LS			300
	Electrical and mechanical work	LS			500
	Subtotal				48,054
	Contingencies 20%				9,611
	TOTAL, SPILLWAY				57,665
04.3	OUTLET WORKS				
	Intake structure				
	Excavation rock	CY	41,000	15.00	615
	Foundation preparation	SY	8,000	10.00	80
	Concrete				
	Mass	CY	20,400	50.00	1,020
	Structural	CY	18,500	325.00	6,013
	Cement	Cwt	82,000	4.00	328
	Reinforcing steel	Lbs	3,055,000	.60	1,833

TABLE B-5 -DETAILED COST ESTIMATE--Continued

WATANA DAM AND RESERVOIR

Cost Account Number	Description or Item	Unit	Quant	Unit Cost ($)	Total Cost ($1,000)
04	DAMS				
04.3	OUTLET WORKS (Cont'd)				
	Electrical and mechanical work	LS			100
	Gate bonnets	EA	4	133,000.00	532
	Gate frames	EA	4	130,000.00	520
	Gates (slide)	EA	4	285,000.00	1,140
	Trash racks	EA	4	96,000.00	384
	Tainter gates	EA	4	395,000.00	1,580
	Excavation				
	Tunnels	CY	95,300	125.00	11,913
	Concrete	CY	21,700	300.00	6,510
	Cement	Cwt	100,000	4.00	400
	Reinforcing steel	Lbs	4,790,000	.60	2,874
	Elevator	LS	1		200
	Stairs	LS	1		100
	Steel sets & lagging	Lbs	349,000	1.00	349
	Rock bolts	EA	3,700	170.00	629
	Subtotal				37,120
	Contingencies 20%				7,424
	TOTAL, OUTLET WORKS				44,544
04.4	POWER INTAKE WORKS				
	Intake structure				
	Excavation	CY	222,000	15.00	3,330
	Foundation preparation	SY	3,700	10.00	37
	Mass concrete	CY	39,500	50.00	1,975
	Structural concrete	CY	69,200	325.00	22,490
	Cement	Cwt	376,000	4.00	1,504
	Resteel	Lbs	4,839,000	.60	2,904
	Emb. metal	Lbs	35,000	3.00	105
	Trash rack	LS	1		2,000
	Stairs	LS	1		75
	Elevator	LS	1		200
	Bulkhead gates	LS	1		1,500
	Stoplogs	LS	1		1,500
	Electrical and mechanical work	LS	1		1,600
	Truck crane	LS	1		225
	Bridge	LS	1		2,500
	Trash boom	LS	1		300
	Tunnel excavation	CY	79,000	125.00	9,875

TABLE B-5 --DETAILED COST ESTIMATE--Continued

WATANA DAM AND RESERVOIR

Cost Account Number	Description or Item	Unit	Quant	Unit Cost ($)	Total Cost ($1,000)
04	DAMS				
04.4	POWER INTAKE WORKS (Cont'd)				
	Concrete	CY	16,650	300.00	4,995
	Cement	Cwt	84,000	4.00	336
	Resteel	Lbs	3,745,000	.60	2,247
	Steel liner	Lbs	21,000,000	2.00	42,000
	Bonnetted gates	LS			900
	Electrical and mechanical work	LS			150
	Subtotal				102,748
	Contingencies 20%				20,550
	TOTAL POWER INTAKE WORKS				123,298
	TOTAL DAMS				419,679
07	POWERPLANT				
07.1	POWERHOUSE				
	Mobilization and preparatory work	LS	1		3,500
	Excavation, rock	CY	202,000	110.00	22,220
	Concrete	CY	57,600	325.00	18,720
	Cement	Cwt	261,000	4.00	1,044
	Reinforcing steel	Lbs	5,228,000	.60	3,137
	Architectural features	LS			1,000
	Elevator	LS			200
	Mechanical and electrical work	LS			3,300
	Structural steel	Lbs	1,250,000	1.50	1,875
	Miscellaneous metalwork	Lbs	150,000	3.00	450
	Draft tube bulkhead gates	LS			380
	Rock bolts	EA	563	170.00	96
	Steel sets	Lbs	102,000	1.00	102
	Subtotal				56,024
	Contingencies 20%				11,205
	TOTAL, POWERHOUSE				67,229

TABLE B-5 --DETAILED COST ESTIMATE--Continued

WATANA DAM AND RESERVOIR

Cost Account Number	Description or Item	Unit	Quant	Unit Cost ($)	Total Cost ($1,000)
07	POWERPLANT (Cont'd)				
07.2	TURBINES AND GENERATORS				
	Turbines	LS			20,608
	Governors	LS			765
	Generators	LS			20,834
	Subtotal				42,207
	Contingencies 20%				8,442
	TOTAL, TURBINES AND GENERATORS				50,649
07.3	ACCESSORY ELECTRICAL EQUIPMENT				
	Accessory Electrical Equipment	LS			4,065
	Contingencies 20%				813
	TOTAL, ACCESSORY ELECTRICAL EQUIPMENT				4,878
07.4	MISCELLANEOUS POWERPLANT EQUIPMENT				
	Miscellaneous Powerplant Equipment	LS			5,202
	Contingencies				1,041
	TOTAL, MISCELLANEOUS POWERPLANT EQUIPMENT				6,243
07.5	TAILRACE				
	Excavation, tailrace tunnel	CY	223,000	125.00	27,875
	Concrete, tailrace tunnel lining	CY	21,000	300.00	6,300
	Cement	Cwt	104,000	4.00	416
	Reinforcing steel	Lbs	5,202,000	.60	3,122
	Rock bolts	EA	3,400	170.00	578
	Steel sets	Lbs	1,115,000	1.00	1,115
	Subtotal				39,406
	Contingencies 20%				7,181
	TOTAL, TAILRACE				47,287
07.6	SWITCHYARD				
	Transformers	LS			5,826
	Insulated cables	LS			1,030

TABLE B-5 --DETAILED COST ESTIMATE--Continued

WATANA DAM AND RESERVOIR

Cost Account Number	Description or Item	Unit	Quant	Unit Cost ($)	Total Cost ($1,000)
07	POWERPLANT				
07.6	SWITCHYARD (Cont'd)				
	Switchyard	LS			6,241
	Subtotal				13,097
	Contingencies 20%				2,620
	TOTAL, SWITCHYARD				15,717
07.8	TRANSMISSION FACILITIES				
	Transmission Facilities	LS			183,000
	Contingencies 20%				36,600
	TOTAL, TRANSMISSION FACILITIES				219,600
	TOTAL, POWERPLANT				411,603
08	ROADS AND BRIDGES				
	Permanent Access Road - 27 miles (Highway No. 3 to Devil Canyon)				
	Clearing	AC	135	1,500.00	203
	Excavation	CY	210,000	0.20	1,302
	Embankment	CY	885,000	2.00	1,770
	Riprap	CY	2,700	30.00	81
	Road surfacing (crushed)	CY	216,000	12.00	2,592
	Bridges	LS	1		10,000
	Culverts and guardrail	LS	1		3,000
	Permanent Access Road - 37 miles (Devil Canyon to Watana)				
	Clearing	AC	195	1,500.00	293
	Excavation	CY	360,000	6.20	2,232
	Embankment	CY	1,244,000	2.00	2,488
	Riprap	CY	3,800	30.00	114
	Road surfacing (crushed)	CY	304,000	12.00	3,648
	Bridges	LS			3,700
	Culverts and guardrail	LS	1		1,585
	Permanent on-site roads				
	Power plant access tunnel	LS	1		5,096
	Power plant access road	LS	1		1,515
	Dam crest road	LS	1		80

TABLE B-5 --DETAILED COST ESTIMATE--Continued

WATANA DAM AND RESERVOIR

Cost Account Number	Description or Item	Unit	Quant	Unit Cost ($)	Total Cost ($1,000)
08	ROADS AND BRIDGES (Cont'd)				
	Spillway access road	LS	1		380
	Switch yard access road	LS	1		200
	Road to operating facility	LS	1		200
	Power intake structure access road	LS	1		250
	Subtotal				40,729
	Contingencies 20%				8,146
	TOTAL, ROADS AND BRIDGES				48,875
14	RECREATION FACILITIES				
	Site D				
	Camp units (tent camp)	EA	10	1,800.00	18
	Vault toilets	EA	2	2,000.00	4
	Subtotal				22
	Contingencies 15%				3
	Total Site D				25
	Site E				
	Trail system	MI	12	1,000.00	12
	Contingencies 15%				2
	Total Site E				14
	TOTAL, RECREATION FACILITIES				39
19	BUILDINGS, GROUNDS, AND UTILITIES				
	Living quarters and O&M facilities	LS			1,631
	Visitor facilities				
	Visitor building	LS			100
	Parking area	SF	12,000	3.00	36
	Boat ramp	LS			200
	Vault toilets	EA	2	2,000.00	4
	Runway facility	LS	1		1,000
	Subtotal				2,971
	Contingencies 20%				594
	TOTAL, BUILDINGS, GROUNDS, AND UTILITIES				3,565

TABLE B-5 --DETAILED COST ESTIMATE--Continued

WATANA DAM AND RESERVOIR

Cost Account Number	Description or Item	Unit	Quant	Unit Cost ($)	Total Cost ($1,000)
20	PERMANENT OPERATING EQUIPMENT				
	Operating Equipment and Facilities	LS	1		1,500
	Contingencies 20%				300
	TOTAL, PERMANENT OPERATING EQUIPMENT				1,800
50	CONSTRUCTION FACILITIES				
	Diversion tunnels				
	Excavation	CY	281,000	115.00	32,315
	Concrete	CY	48,750	275.00	13,407
	Cement	Cwt	244,000	4.00	976
	Resteel	Lbs	11,544,000	.60	6,927
	Steel sets and lagging	Lbs	1,404,000	1.00	1,404
	Rock bolts	EA	7,800	170.00	1,326
	Diversion outlet works				
	Excavation	CY	14,000	15.00	210
	Concrete	CY	7,500	325.00	2,438
	Cement	Cwt	30,000	4.00	120
	Resteel	Lbs	1,500,000	.60	900
	Anchors	LS	1		500
	Diversion inlet works				
	Excavation	CY	43,000	15.00	645
	Concrete	CY	16,500	325.00	5,363
	Cement	Cwt	58,000	4.00	232
	Resteel	Lbs	2,475,000	.60	1,485
	Gate frames and gates	LS	1		861
	Diversion tunnel plug	LS	1		3,000
	Care of water	LS	1		1,000
	Subtotal				73,109
	Contingencies 20%				14,622
	TOTAL, CONSTRUCTION FACILITIES				87,731
	TOTAL CONSTRUCTION COST				998,864
30	ENGINEERING AND DESIGN				39,638
31	SUPERVISION AND ADMINISTRATION				49,498
	TOTAL PROJECT COST WATANA DAM AND RESERVOIR ELEVATION 2200 (First-Added)				1,088,000

DETAILED COST ESTIMATE

DEVIL CANYON DAM AND RESERVOIR, ELEVATION 1450

JANUARY 1975 PRICE LEVEL

(SECOND-ADDED)

Cost Account Number	Description or Item	Unit	Quant	Unit Cost ($)	Total Cost ($1,000)
01	LANDS AND DAMAGES				
	Reservoir				
	Public domain	AC	8,350	300.00	(2,505)
	Private land	AC	850	300.00	255
	Site and other	AC	250	600.00	150
	Recreation	AC	740	600.00	440
	Subtotal				3,350
	Contingencies 20%				670
	Government administrative cost				430
	TOTAL, LANDS AND DAMAGES				(4,450)
	Construction cost				1,444
	Economic cost				(3,006)
03	RESERVOIR				
	Clearing	AC	1,920	1,500.00	2,880
	Contingencies 20%				576
	TOTAL, RESERVOIR				3,456
04	DAMS				
04.1	MAIN DAM				
	Mobilization and preparatory work	LS			24,300
	Prevention of water pollution	LS			500
	Sealing of canyon walls	CY	21,000	75.00	1,575
	Excavation				
	Exploratory tunnels	CY	3,500	190.00	665
	Dam	CY	327,000	15.00	4,905
	Foundation treatment	CY	3,000	60.00	180
	Drilling line holes for rock excavation	LF	34,000	4.60	156
	Drilling and grouting	LF	64,000	22.00	1,408
	Drainage holes	LF	29,570	15.30	452
	Concrete				
	Dam	CY	994,000	50.00	49,700
	Thrust block	CY	25,600	60.00	1,536
	Foundation treatment	CY	3,000	125.00	375

TABLE B-6 --DETAILED COST ESTIMATE--Continued

DEVIL CANYON DAM AND RESERVOIR

Cost Account Number	Description or Item	Unit	Quant	Unit Cost ($)	Total Cost ($1,000)
04	DAMS				
04.1	MAIN DAM (Cont'd)				
	Foundation, mass	CY	15,250	50.00	763
	Structural	CY	10,240	325.00	3,328
	Cooling concrete	LS			2,000
	Contraction joint and cooling system grouting	LS			1,135
	Cement	Cwt	3,779,000	4.00	15,116
	Pozzolan	Cwt	922,000	3.00	2,766
	Reinforcing steel	Lbs	1,200,000	.60	720
	Gates				
	Slide gates, frames, guides, and operators	EA	4	345,000.00	1,380
	Miscellaneous				
	High strength steel strands	Lbs	290,000	2.00	580
	Earthquake anchorages	LS			500
	Gantry crane	LS			385
	Gantry crane rails	Lbs	39,000	1.00	39
	Elevators	LS			280
	Stairways	Lbs	105,500	5.20	549
	Instrumentation	LS			115
	Rock bolts	LF	50,000	10.70	535
	Chain-link fence	LF	1,535	15.00	23
	Electrical and mechanical work	LS			1,000
	Miscellaneous metalwork	LS	170,000	3.00	510
	Subtotal				117,476
	Contingencies 20%				23,495
	TOTAL, MAIN DAM				140,971
04.2	SPILLWAY				
	Excavation, all classes	CY	239,000	15.00	3,585
	Foundation preparation	SY	7,520	10.00	75
	Drilling and grouting	LF	8,000	25.00	200
	Anchor bars	LF	48,000	1.25	60
	Drainage system	LS	1		500
	Concrete				
	Mass	CY	37,000	50.00	1,850
	Structural	CY	12,000	325.00	3,900
	Cement	Cwt	152,000	4.00	608

TABLE B-6 --DETAILED COST ESTIMATE--Continued

DEVIL CANYON DAM AND RESERVOIR

Cost Account Number	Description or Item	Unit	Quant	Unit Cost ($)	Total Cost ($1,000)
04	DAMS				
04.2	SPILLWAY (Cont'd)				
	Reinforcing steel	Lbs	1,191,000	.60	715
	Tainter gates and hoists, complete	EA	2	2,000,000.00	4,000
	Stoplogs, complete	Set	1		500
	Miscellaneous Electrical and mechanical work	LS			500
	Subtotal				16,493
	Contingencies 20%				3,299
	TOTAL, SPILLWAY				19,792
04.4	POWER INTAKE WORKS				
	Excavation				
	Open cut	CY	7,200	15.00	108
	Tunnels	CY	34,400	125.00	4,300
	Concrete				
	Mass	CY	7,300	55.00	402
	Structural and backfill	CY	10,430	325.00	3,390
	Cement	Cwt	74,000	4.00	296
	Reinforcing steel	Lbs	1,070,000	.60	642
	Penstocks	Lbs	8,175,000	2.00	16,350
	Bonnetted gates and controls	EA	5	1,375,000.00	6,875
	Stoplogs, complete	LS			914
	Trashracks	Lbs	1,224,000	1.50	1,836
	Subtotal				35,113
	Contingencies 20%				7,023
	TOTAL, POWER INTAKE WORKS				42,136
04.5	AUXILIARY DAM (EARTH FILL)				
	Excavation				
	Dam foundation	CY	110,000	3.50	385
	Foundation preparation	LS	1		40
	Dam embankment	CY	760,000	2.25	1,710
	Drilling and grouting	LF	8,800	46.60	410
	Concrete	CY	5,400	120.00	648

TABLE B-6 --DETAILED COST ESTIMATE--Continued

DEVIL CANYON DAM AND RESERVOIR

Cost Account Number	Description or Item	Unit	Quant	Unit Cost ($)	Total Cost ($1,000)
04	DAMS				
04.5	AUXILIARY DAM (EARTH FILL) Cont'd)				
	Cement	Cwt	13,500	4.00	54
	Subtotal				3,247
	Contingencies 20%				650
	TOTAL, AUXILIARY DAM				3,897
	TOTAL, DAMS				206,796
07	POWERPLANT				
07.1	POWERHOUSE				
	Mobilization and preparatory work	LS	1		5,000
	Excavation, rock	CY	120,000	110.00	13,200
	Concrete	CY	20,000	325.00	6,500
	Cement	Cwt	100,000	4.00	400
	Reinforcing steel	Lbs	4,600,000	.60	2,760
	Architectural features	LS			1,000
	Elevator	LS			75
	Mechanical and electrical work	LS			4,400
	Structural steel	Lbs	1,200,000	1.50	1,800
	Miscellaneous metalwork	Lbs	150,000	3.00	450
	Subtotal				35,585
	Contingencies 20%				7,117
	TOTAL, POWERHOUSE				42,702
07.2	TURBINES AND GENERATORS				
	Turbines	LS			22,575
	Governors	LS			2,546
	Generators	LS			23,052
	Subtotal				48,173
	Contingencies 20%				9,635
	TOTAL, TURBINES AND GENERATORS				57,808

TABLE B-6 --DETAILED COST ESTIMATE--Continued

DEVIL CANYON DAM AND RESERVOIR

Cost Account Number	Description or Item	Unit	Quant	Unit Cost ($)	Total Cost ($1,000)
07	POWERPLANT				
07.3	ACCESSORY ELECTRICAL EQUIPMENT				
	Accessory Electrical Equipment	LS			6,600
	Contingencies 20%				1,320
	TOTAL, ACCESSORY ELECTRICAL EQUIPMENT				7,920
07.4	MISCELLANEOUS POWERPLANT EQUIPMENT				
	Miscellaneous Powerplant Equipment	LS			2,129
	Contingencies 20%				426
	TOTAL, MISCELLANEOUS POWERPALNT EQUIPMENT				2,555
07.5	TAILRACE				
	Excavation tunnel	CY	37,000	125.00	4,625
	Concrete	CY	13,800	300.00	4,140
	Cement	Cwt	69,000	4.00	276
	Resteel	Lbs	3,163,000	.60	1,898
	Draft tube bulkhead gates	LS	1		378
	Draft tube stoplogs	LS	1		284
	Subtotal				11,601
	Contingencies 20%				2,320
	TOTAL, TAILRACE				13,921
07.6	SWITCHYARD				
	Transformers	LS			5,967
	Insulated cables	LS			1,372
	Switchyard	LS			8,926
	Subtotal				16,265
	Contingencies 20%				3,253
	TOTAL, SWITCHYARD				19,518
	TOTAL, POWERPLANT				144,424
08	ROADS AND BRIDGES				
	On-site road				
	Clearing and earthwork	Mile	2.3	200,000.00	460
	Paving	Mile	2.3	72,000.00	166

TABLE B-6 --DETAILED COST ESTIMATE--Continued

DEVIL CANYON DAM AND RESERVOIR

Cost Account Number	Description or Item	Unit	Quant	Unit Cost ($)	Total Cost ($1,000)
08	ROADS AND BRIDGES (Cont'd)				
	Culverts	LF	850	39.00	33
	Tunnel	LF	2,100	2,975.00	6,248
	Road to operating facility	Mile	2	100,000.00	200
	Subtotal				7,107
	Contingencies 20%				1,421
	TOTAL, ROADS AND BRIDGES				8,528
14	RECREATION FACILITIES				
	Site A				
	(Boat access only)				
	Boat dock	EA	1	25,000.00	25
	Camping units	EA	10	1,800.00	18
	Two-vault toilets	EA	2	2,000.00	4
	Subtotal				47
	Contingencies 15%				7
	Total Site A				54
	Site B				
	Access road	Mile	0.5	100,000.00	50
	Overnight camps	EA	50	2,500.00	125
	Comfort stations	EA	2	35,000.00	70
	Power	LS		25,000.00	25
	Sewerage	LS		50,000.00	50
	Subtotal				320
	Contingencies 15%				48
	Total Site B				368
	Site C				
	Trailhead picnic area access road	Mile	0.2	100,000.00	20
	Picnic units w/parking	EA	12	2,000.00	24
	Trail system	Mile	30	1,000.00	30
	Two-vault toilets	EA	2	2,000.00	4
	Subtotal				78
	Contingencies 15%				12
	Total Site C				90
	TOTAL, RECREATION FACILITIES				512

TABLE B-6 --DETAILED COST ESTIMATE--Continued

DEVIL CANYON DAM AND RESERVOIR

Cost Account Number	Description or Item	Unit	Quant	Unit Cost ($)	Total Cost ($1,000)
19	BUILDINGS, GROUNDS, AND UTILITIES				
	Living quarters and O&M facilities	LS			1,700
	Visitor facilities				
	Visitor building	LS			200
	Parking area	SF	15,000	3.00	45
	Boat ramp	LS			150
	Vault toilets	EA	2	2,000.00	4
	Subtotal				2,099
	Contingencies 20%				420
	TOTAL, BUILDINGS, GROUNDS, AND UTILITIES				2,519
20	PERMANENT OPERATING EQUIPMENT				
	Operating Equipment and Facilities	LS	1		1,500
	Contingencies 20%				300
	TOTAL, PERMANENT OPERATING EQUIPMENT				1,800
50	CONSTRUCTION FACILITIES				
	Coffer dams				
	Sheet pile	Ton	1,024	1,000.00	1,024
	Earthfill	CY	38,000	5.00	190
	Diversion works				
	Tunnel				
	Excavation	CY	32,000	115.00	3,680
	Concrete	CY	5,750	275.00	1,582
	Cement	Cwt	29,000	4.00	116
	Resteel	Lbs	1,323,000	.60	794
	Steel sets	Lbs	157,000	1.25	197
	Rock bolts	EA	1,150	170.00	196
	Diversion intake structure				
	Rock excavation	CY	6,800	15.00	102
	Structural concrete	CY	3,800	325.00	1,235
	Cement	Cwt	150,000	4.00	60
	Resteel	Lbs	750,000	.60	450
	Gates and frames	LS	1		860
	Diversion outlet structure				
	Rock excavation	CY	6,800	15.00	102
	Concrete	CY	3,800	325.00	1,235
	Cement	Cwt	15,000	4.00	60

TABLE B-6 --DETAILED COST ESTIMATE--Continued

DEVIL CANYON DAM AND RESERVOIR

Cost Account Number	Description or Item	Unit	Quant	Unit Cost ($)	Total Cost ($1,000)
10	CONSTRUCTION FACILITIES (Cont'd)				
	Resteel	Lbs	750,000	.60	450
	Anchors	LS	1		250
	Care of water	LS	1		1,000
	Subtotal				13,583
	Contingencies 20%				2,717
	TOTAL, CONSTRUCTION FACILITIES				16,300
	TOTAL, CONSTRUCTION COST				38,779
30	ENGINEERING AND DESIGN				26,962
31	SUPERVISION AND ADMINISTRATION				19,259
	TOTAL PROJECT COST DEVIL CANYON DAM AND RESERVOIR ELEVATION 1450 (SECOND-ADDED)				432,000

Table B-/
Appendix I
R-40

SUMMARY COST ESTIMATES--OTHER PROJECTS STUDIED
JANUARY 1975 PRICE LEVEL
(Costs in $1,000)

ACCOUNT NO.	PROJECT FEATURE	DENALI 2535 (Second)	VEE 2300 (Second)	VEE 2350 (Second)	HIGH D.C. 1750 (First)	WATANA 1905 (First)	WATANA 1905 (Second)	WATANA 2050 (First)	WATANA 2050 (Second)
	PROJECT FULL POOL ELEV. (Ft., m.s.l.) CONST. SEQUENCE (Added)								
01	LANDS AND DAMAGES	7,000	2,550	3,495	8,400	4,381	4,381	12,050	12,050
02	RELOCATIONS	13,000							
03	RESERVOIR	4,800	3,165	5,160	7,650	5,100	5,100	7,920	7,920
04	DAM	237,017	203,170	225,500	574,900	165,058	165,058	287,229	287,229
07	POWERPLANT		143,788	159,600	450,478	313,076	106,143	368,721	153,788
08	ROADS AND BRIDGES	1,500	19,968	20,748	34,511	47,587	24,849	48,231	25,493
14	RECREATIONAL FACILITIES	39	39	39	512	39	39	39	39
19	BUILDINGS, GROUNDS, AND UTILITIES	3,565	3,565	3,565	3,565	3,565	3,565	3,565	3,565
20	PERMANENT OPERATING EQUIPMENT	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800
30-31	ENGINEERING AND DESIGN - SUPERVISION AND ADMINISTRATION	36,279	48,855	53,093	104,184	62,638	44,309	79,419	60,090
50	CONSTRUCTION FACILITIES	35,000	50,100	54,000	80,000	64,756	64,756	76,026	76,026
	TOTAL PROJECT COST	340,000	477,000	527,000	1,266,000	668,000	420,000	877,000	628,000

APPENDIX D -

LIST OF REFERENCES

SUSITNA MATERIALS COLLECTION - LOCATED IN HYDRAULICS DEPARTMENT

Alaska Dept. of Commerce	ALASKA POWER & ECONOMIC DEVELOPMENT PROGRAM 2 Vol.	(798) 621.22.3 Al
	JOBS AND POWER FOR ALASKANS: A PROGRAM FOR POWER & ECONOMIC DEVELOPMENT 2 copies	"
Alaska Power Adm. *	INVENTORY TYPE CALCULATIONS FOR SOME POTENTIAL HYDROELECTRIC PROJECTS IN ALASKA	"
Alaska Power Authority	ANCHORAGE-FAIRBANKS TRANSMISSION: ECONOMIC FEASIBILITY STUDY REPORT. DRAFT.	(798) 621.22.1 Al
	FUTURE POWER REQUIREMENTS - REPORT OF THE TECHNICAL ADVISORY COMMITTEE ON ECONOMIC ANALYSIS & LOAD PROJECTIONS	(798) 621.22.3 Al
	FUTURE ALASKA POWER SUPPLIES - REPORT OF THE TECHNICAL ADVISORY COMMITTEE ON RESOURCES & ELECTRIC POWER GENERATION	"
	REPORT OF THE TECHNICAL ADVISORY COMMITTEE ON ENVIRONMENTAL CONSIDERATION & CONSUMER AFFAIRS 2 copies	(798) 621.22.1 :581.57 Al
	SUSITNA HYDROELECTRIC PROJECT: A DETAILED PLAN OF STUDY 2 copies	(798) 621.22.3 Al
	SUSITNA HYDROELECTRIC PROJECT: PLAN OF STUDY FOR PROJECT FEASIBILITY AND FERC LICENSE APPLICATION	"
Arctic Environmental Information & Data Center	CLIMATOLOGICAL DATA	(798) 621.22.1 Al
Bacon, Glenn	ARCHEOLOGY IN THE UPPER SUSITNA RIVER BASIN	(798) 621.22.1 B.

Behlke, Dr. Charles E.	AN INVESTIGATION OF SMALL TIDAL POWER PLANT POSSIBILITIES ON COOK INLET, ALASKA	(798) 621.22.3 Be
Bishops, Daniel M.	A HYDROLOGIC RECONNAISSANCE OF THE SUSITNA RIVER BELOW DEVIL'S CANYON	(798) 621.22.1 (282.41) Bi
Burrows, Robert L.	SEDIMENT TRANSPORT IN THE TANANA RIVER IN THE VICINITY OF FAIRBANKS, ALASKA	"
Carlson, Robert F.	EVALUATION OF THE NATIONAL WEATHER SERVICE RIVER FORECEASE SYSTEM MODEL FOR USE IN NORTHERN REGIONS.	(798) 621.22.1 Ca
Federal Power Commission	*ALASKA POWER SURVEY	(798) 621.22.3 Fe
	THE 1976 ALASKA POWER SURVEY, VOL. I & II 2 copies	"
Gray, T.J.	TIDAL POWER (COOK INLET)	(798) 621.22.3 Gr
Hartman, Charles W.	ENVIRONMENTAL ATLAS OF ALASKA	(798) 621.22.1 Ha
Henry, J. Kaiser Co.	* REASSESSMENT REPORT ON UPPER SUSITNA RIVER HYDROELECTRIC DEVELOPMENT FOR THE STATE OF ALASKA	(798) 621.22.1 (282.4) He
Inst. of Water Resources Univ. of Alaska	STUDY OF THE BREAKUP CHARACTERISTICS OF THE CHENA RIVER BASIN USING ERTS IMAGERY	(798) 621.22.1 (282.41) In
Johnson, Roy W.	HARNESSING COOK INLET'S TIDAL ACTIVITY	(798) 621.22.3 Jo
Jones & Jones	UPPER SUSITNA RIVER, ALASKA: AN INVENTORY & EVALUATION OF ENVIRONMENTAL, AESTHETICS & RECREATIONAL RESOURCES	(798) 621.22.1 [illegible].57

Lamke, R.D.	FLOOD CHARACTERISTICS OF ALASKAN STREAMS	(798) 621.22.1 La
Naske, Claus M.	THE POLITICS OF HYDROELECTRIC POWER IN ALASKA: RAMPART & DEVIL CANYON, A CASE STUDY	(798) 621.22.3 Na
Project Software & Development Inc.	PROJECT/2: SAMPLE RUN ACTIVITY-ON-ARROW	(798) 621.22.1 Pr
Salomon Brothers	NORTH CAROLINA MUNICIPAL POWER AGENCY, No. 3. PROPOSAL	621.22.3 (756) Sa
Scully, David R.	SURFACE WATER RECORDS OF COOK INLET BASIN, ALASKA, THROUGH SEPT. 1975 3 copies	(798) 621.22.1 (282.4) Sc
Shira, Donald L.	HYDROELECTRIC POWER PLANT SITING IN GLACIAL AREAS OF ALASKA	(798) 621.22.3 Sh
U.S. ARmy Corps of Engineers	COOK INLET & TRIBUTARIES, HARBORS & RIVERS IN ALASKA. URVEY REPORT	(798) 621.22.1 (282.4) Un
	COPPER RIVER & GULF COAST. HARBORS & RIVERS IN ALASKA SURVEY REPORT	(798) 621.22.1 (282.41) Un
*	DRAFT & REVISED DRAFT ENVIRONMENTAL IMPACT STATEMENT. (HYDROELECTRIC POWER DEVELOPMENT - SUSITNA RIVER BASIN, SOUTHCENTRAL RAIL BELT AREA	(798) 621.22.1 :581.57 Un
	FINAL ENVIRONMENTAL IMPACT STATEMENT (as above)	"
	HARBORS & RIVERS IN ALASKA. SURVEY REPORT, YUKON & KUSKOKWIN RIVER BASINS	(798) 621.22.1 U.
*	HYDROELECTRIC POWER & RELATED PURPOSES - INTERIM FEASIBILITY REPORT SOUTH CENTRAL RAILBETL AREA, ALASKA UPPER SUSITNA RIVER BASIN (1975)	(798) 621.22.3 Un

.S. Army Corps of Engineers	INTERIM REPORT NO. 2, COOK INLET & TRIBUTARIES, PART NO. 1 - HYDROELECTRIC POWER, BRADLEY LAKE, ALASKA	(798) 621.22.1 (282.4) Un
*	NATIONAL HYDROELECTRIC POWER RESOURCES STUDY - PRELIMINARY INVENTORY OF HYDRO POWER RESOURCES, PACIFIC NORTHWEST	(798) 621.22.3 Un
	1978 SEISMIC REFRACTION SURVEY. SUSITNA HYDROELECTRIC PROJECT, WATANA DAMSITE, DEVIL'S CANYON DAMSITE	(798) 621.22.2 .006 Un
	REPORT ON RAMPART CANYON DAM & LAKE YUKON RIVER BASIN	(798) 621.22.1 Un
	REVIEW OF REPORTS: COOK INLET & TRIBUTARIES, COPPER RIVER & GULF COAST, TANANA RIVER BASINS, YUKON & KUSKOKWIN BASINS, SOUTHCENTRAL RAILBELT AREA. PUBLIC HEARING - FAIRBANKS, ALASKA 1974	(798) 621.22.3 Un
	REVIEW OF REPORTS...as above ANCHORAGE & FAIRBANKS PUBLIC MEETING 1975 tw copies	(798) 621.22.1 (282.4) Un
	REVIEW OF SOUTHCENTRAL ALASKA. HYDRO POWER POTENTIAL, ANCHORAGE 2 copies	(798) 621.22.3 Un
	SOUTHCENTRAL-RAILBELT AREA, ALASKA. (HYDROELECTRIC POWER STUDY-PUBLIC HEARING, ANCHORAGE ALASKA.) 1974	"
*	SOUTHCENTRAL RAILBELT AREA, ALASKA UPPER SUSITNA RIVER BASIN. INTERIM FEASIBILITY REPORT. Appendix 1 & 2.	(798) 621.22.1 (282.4) Un
*	SOUTHCENTRAL RAILBELT AREA, ALSKA UPPER SUSITNA RIVER BASIN. MAIN REPORT	(798) 621.22.3 Un
	SUBSURFACE GEOPHYSICAL EXPLORATION, PROPOSED WATANA DAMSITE ON THE SUSITNA RIVER	(798) 621.22.2 006 Un

SUSITNA MATERIALS continued

U.S. Army Corps of Engineers		TANANA RIVER BASIN, HARBORS & RIVERS IN ALASKA SURVEY REPORT	(798) 621.22.1 (282.41) U
		TRANSCRIPT OF COORDINATION CONFERENCE FOR SOUTHCENTRAL RAILBELT AREA, ALASKA INVESTIGATION	(798) 621.22.3 U
U.S. Bureau of Reclamation	*	DEVIL CANYON PROJECT, ALASKA FEASIBILITY REPORT	(798) 621.22.2 .006 Un
		ENGINEERING GEOLOGY REPORT, FEASIBILITY STAGE, DEVIL CANYON DAM	"
	*	REPORT ON THE POTENTIAL DEVELOPMENT OF WATER RESOURCES IN THE SUSITNA RIVER BASIN OF ALASKA. DISTRICT MANAGER'S RECONNAISSANCE REPORT	(798) 621.22.1 (282.4) Un
	*	VEE CANYON PROJECT, SUSITNA RIVER ALASKA _ ENGINEERING GEOLOGY OF VEE CANYON DAMSITE	(798) 621.22.2 .006.1 Un
U.S. Dept. of Commerce		ALASKA ECONOMY: YEAR END PERFORMANCE REPORT 1978	(798) 621.22.1 U
		CLIMATE OF ALASKA: CLIMATOGRAPHY OF THE U.S.	"
U.S. Dept. of Energy		ANALYSIS OF IMPACT ON HYDROELECTRIC POTENTIAL OF THE ADMINISTRATION' RECOMMENDATIONS FOR THE ALASKA D-2 LANDS	(798) 621.22.3 U
		HYDROELECTRIC ALTERNATIVES FOR THE ALASKA RAILBELT 2 copies	"
		UPPER SUSITNA RIVER PROJECT: POWER MARKET ANALYSES	(798) 621.22.1 (282.4) Un
U.S. Dept. of the Interior		ALASKA NATURAL RESOURCES & THE RAMPART PROJECT VOL. I & II 2 copies	(798) 621.22.1 U

SUSITNA MATERIALS continued

U.S. Dept. of the Interior	ALASKA - RECONNAISSANCE REPORT ON THE POTENTIAL DEVELOPMENT OF WATER RESOURCES IN THE TERRITORY OF ALASKA	(798) 621.22.1 Un
	ANALYSIS OF IMPACT H.R. 39 ON THE HYDROELECTRIC POTENTIAL OF ALASKA	(798) 621.22.3 Un
	DEVIL CANYON PROJECT, ALASKA REPORT OF THE COMMISSION OF RECLAMATION	(798) 621.22.2 .006 Un
	* DEVIL CANYON PROJECT -ALASKA STATUS REPORT 2 copies	"
	FUTURE POWER REQUIREMENTS : REPORT OF THE TECHNICAL ADVISORY COMMITTEE ON ECONOMIC ANALYSIS & LOAD PROJECTIONS	(798) 621.22.3 Un
	SUSITNA RIVER BASIN: A REPORT ON THE POTENTIAL DEVELOPMENT OF WATER RESOURCES IN SUSITNA RIVER BASIN	(798) 621.22.1 (282.4) Un
U.S. Fish & Wildlife Service	SUBSTANTIATING REPORT ON THE FISH & WILDLIFE RESOURCES OF THE YUKON AND KUSKOKWIN RIVER BASINS	(798) 621.22.1 :581.57 Un
U.S. Geological Survey	WATER RESOURCES DATA FOR ALASKA WATER YEAR 1977 2 copies	(798) 621.22.1 Un
	WATER RESOURCES (SURFACE & SUBSURFACE) OF THE COOK INLET BASIN - ROUGH FINAL DRAFT	(798) 621.22.1 (282.4) Un