HARZA - EBASCO
Return to HENRY CHEN

SUSITNA HYDROELECTRIC PROJECT

DRAFT

SUPPLEMENT TO THE FEASIBILITY REPORT

Prepared by:

ACRES

FEBRUARY 1983

ALASKA POWER AUTHORITY

APA 614

Supplement to the Feasibility Report

Prepared by Acres

Draft

This copy is incomplete. The beginning of the table of contents is missing. Section 10.6(c) is blank (perhaps intentionally). The document ends with Figure 10.6 although the table of contents lists chapter 11, chapter 12, and volume 2 (plates).

Revision Page Missing

TABLE OF CONTENTS (Cont'd)

. BLE OF CONTENTS (Cont'd)

1 - INTRODUCTION

1.1 - General

This supplement to the Feasibility Report has been prepared by Acres American Incorporated (Acres) for the Alaska Power Authority (the Power Authority) under the terms of Revision 4 to the Agreement, dated December 19, 1979, to conduct a feasibility study and preparation of a license application to the Federal Energy Regulatory Commission (FERC).

The original feasibility study was undertaken in accordance with the Plan of Study (POS) for the Susitna Hydroelectric Project, which was first issued to the Authority in February, 1980 and subsequently revised four times since the original issue to account for scope changes and public, federal and state agency comments and concerns.

A draft of the FERC license application was filed with FERC on November 15, 1982. Similarly a draft of Exhibit E - Environmental Studies for the FERC license was submitted to the various State and Federal agencies for review and comment. Comments regarding this draft were received during the month of December and January with the final submittal of the FERC license application in February 1983.

The Feasibility Report was issued for public review and comment on March 15, 1982 (Acres 1982a). Subsequent to that time ongoing work continued in the areas of:

- hydrology
- environmental studies
- survey and site facilities
- geotechnical exploration
- design development
- transmission line
- cost estimates and schedules
- FERC licensing
- marketing and financing

As a result of this ongoing work, changes, additions and modifications have been made to the original Feasibility Report. This Supplemental Report is intended to provide an update of information through January 1983. A comprehensive environmental study has been submitted as Exhibit E to the FERC license. Since extensive ongoing studies continue to be done in this area, no supplement to Volume 2 - Environmental Studies of the original Feasibility Report has been prepared for this submittal. Readers interested in the environmental studies to include environmental impacts and recommended mitigation measures are requested to consult Exhibit E to the FERC license.

This report is intended as a supplement to the March Feasibility Report and should be used in reference to that document.

1.2 - Objectives - Scope

The objective of the work performed from March 15 through December 1982, was to continue ongoing studies and submit the draft FERC license application. The work has been undertaken in a series of tasks which are:

Task 72 - Access Plan
Task 73 - Hydrologic Studies
Task 75 - Geotechnical Studies
Task 76 - Design Development
Task 77 - Environmental Studies
Task 78 - Transmission
Task 79 - Construction Cost Estimates and Schedule
Task 80 - Licensing
Task 81 - Marketing & Finance
Task 82 - Public Participation Program

These ongoing studies have resulted in some modifications to the design and development schemes for the Susitna Hydroelectric Project as set forth in the March Feasibility Report. Details of these changes are presented in the preceeding section. The principal changes to the Feasibility Report are in the areas of access, environmental and transmission. In addition, changes have also been made in the hydrologic flow regime of the dams to minimize downstream environmental impacts. These modifications have resulted in redesign of the intake structures which are presented in Volume 2 of this submittal.

1.3 - Organization of the Supplemental Report

The supplement to the Feasibility Report is presented in 12 sections.

Section 1 - Introduction
A brief summary of the project background and a general introduction to the report

Section 2 - Summary
This section provides a summary of the results of Sections 4 thru 10

Section 3 - Scope of Work
This section outlines the scope of work undertaken in each of the tasks

Section 4 - Access Roads
Section 4 is a detailed discussion of the access road alternative studies and the final access recommendation

Section 5 - Refinement of Susitna Development
This section presents the refinement to the Susitna Development based on work carried out from March to December, 1982

Section 6 - Transmission Facilities
Section 6 addresses the recommended transmission routing for the Susitna Development

Section 7 - Project Operation
This section presents the revised flow regime for the Susitna Development

Section 8 - Estimates of Costs
This section presents the revised project cost estimate which incorporates the changes in the design scheme

Section 9 - Development Schedules
Section 9 presents the revised project schedule to reflect principally the changes in access routing

Section 10- Economic, Marketing and Financial Evaluation
This section presents the revised economic and financial evaluation for the Susitna Development

Section 11- Response to Comments
This section addresses comments and responses to various public and private queries regarding this project

Section 12- Conclusion and Recommendations
This section presents the main conclusions of the feasibility study

3 - OBJECTIVES

3.1 - Introduction

The scope of work undertaken from the March 15, 1982 submittal of the Susitna Hydroelectric Feasibility Report to present is set forth in Amendment No. 4, dated September 27, 1982. The principal technical tasks undertaken during this period included:

- Access Plan
- Hydrologic Studies
- Geotechnical Explorations
- Design Development
- Environmental Studies
- Transmission
- Construction Cost Estimates & Schedules
- Licensing
- Marketing and Finance

3.2 - Access Plan

The March 1982 Feasibility Report recommended an access plan which, for reasons of project schedule, would necessitate the construction of a pioneer road prior to the FERC license being issued. Subsequent to the issuance of the Feasibility Report, this concept was found unacceptable by the various reviewing agencies.

Consequently, this study involved the development of a new access criteria and the development of additional access alternatives within the three potential corridors detailed in 1981 studies. The objective was to delineate the most responsive plan in each corrider and to subject these plans to a multi-disciplinary assessment and comparison to ultimately arrive at the most acceptable route. Results of this study are presented in Section 4.

3.3 - Hydrology Studies

Work performed under this subtask involved:

(a) the continued collection of baseline climatic, water quality, sediment, discharge, ice, thermal, groundwater, stage and snow creep data.

(b) preparation of reports on groundwater analyses, sedimentation and post project esturine affects.

(c) further refine energy and minimum flow requirements for downstream fisheries.

(d) prepare groundwater report with groundwater contours of the study sloughs, groundwater sources and groundwater inflow rates.

(f) continue reservoir and instream flow studies to enable the project impacts to be assessed and a mitigation plan to be adopted.

3.4 - Geotechnical Exploration

To perform the following tasks for:

- perform additional soil drilling and testing in the Watana Relict Channel
- prepare an amendment to the 1980-81 Geotechnical Report
- develop the scope of a 1982 winter program and
- prepare necessary contracts to perform the work.

3.5 - Design Development Update

The scope of this subtask involves the continued updating of various design aspects of the project with particular attention directed to those design changes necessary to meet changing environmental criteria and improve application. Particular areas to be addressed are:

- intake structures
- construction haul roads
- transmission line routing
- access roads

3.6 - Environmental Studies

(a) Introduction

The principal objective of the environmental studies were to continue coordination among environmental study subtasks and subcontractors, establish and maintain reporting schedules, continue informal agency contact, and prepare Exhibit E for the FERC license application.

(b) Cultural Resource Investigations

Work under this program involved:

- conducting a reconnaissance Level 1 survey along the proposed transmission corridor from Fairbanks to Healy, Willow to Anchorage, and Watana damsite to the Intertie
- conduct a Reconnaissance Level 1 survey at the "new" segment of the proposed access route on the north side of the Susitna River, from Devil Canyon to the Parks Highway
- conduct archaeological evaluations of areas to be impacted by geotechnical testing

- conduct Reconnaissance Level 2 survey on the Tsusena Creek "cat trail" from the Watana Camp area to the mouth of the Tsusena Creek

- prepare the cultural resource components of the FERC license.

(c) Land Ownership and Acquisition

To further define land ownership and acquisition in connection with access road and transmission line corridor and assist in preparation of Exhibit G for the FERC license application.

(d) Land Use Analysis - Mitigation of Aesthetic Impact

To further assess aesthetic impacts and develop a draft plan for mitigation of impacts of the Project on the aesthetic resources of the Upper Susitna River Basin.

(e) Recreation Planning

To develop specific proposed sites for recreation facilities to include cost and schedules for development of the facilities.

(f) Aquatic Impact Assessment

To analyze and interpret available baseline knowledge of the Susitna River aquatic system and examine and present in models and reports the impacts on fishery resources of hydroelectric development in the Upper Susitna Basin. Work undertaken during this period included:

- coordination with the Alaska Department of Fish and Game, Su Hydro Study Group on the fishery and aquatic habitat studies and other groups and agencies involved in assessing impacts on fishery.

- assemble an information management program to collect and compile available knowledge of the Susitna River aquatic system relating specifically to the examination of project impact on fishery resources.

- construction of a dynamic model of the Susitna River Basin which will be used to develop quantitative relationships between aquatic habitats and resources pursuant to various hydro operational scenarios.

- establish a format, schedule, and content of periodic briefings on aquatic study, analysis and impact assessment efforts to the Alaskan resource agencies.

(g) Fisheries Mitigation Planning

To develop a mitigation plan consisting of quantified mitigation options for each phase of the project as well as to identify deficiencies and prioritize studies needed to fulfill the quantification requirements of the mitigation plan.

(h) Fisheries Mitigation Planning

The primary objective of the fisheries mitigation planning effort was to develop a mitigation plan consisting of quantified mitigation options for each phase of the project with the ultimate goal of providing the mitigation documents required by the FERC for license approval.

(i) Susitna Hatchery Siting Study

To determine if it is appropriate that consideration be given to the feasibility of siting an enhancement hatchery to insure maintenance of the existing stocks at or above their present population levels.

(j) Wildlife and Habitat Impact Assessment & Mitigation Planning

To continue with ongoing data collection, workshop and field studies, prepare supporting reference documents, assess various project impacts, and develop final comprehensive mitigation plans for inclusion in FERC license application.

(k) Transmission Line Survey

To locate the centerline of the transmission lines to include width and location of right-of-way.

- define all points of intersection (P.I.) along the centerline by measuring the station for each P.I. and its bearings

- provide information regarding the transmission equipment and appurtenance

- prepare drawings and documentations as required to meet the FERC requirements for license application

3.7 - Cost Estimate Update

To update project cost estimate in connection with the elimination of the pioneer road and the selected access route, and other planning and design changes for inclusion in the FERC license application.

3.8 - Update Engineering/Construction Schedule

To update construction schedules in connection with the elimination of the pioneer road and the selected access route and other Planning and design changes for inclusion in FERC license application.

3.9 - Preparation of FERC License Application

To prepare and coordinate all engineering and support activities necessary for the preparation of the FERC license application.

3.10 - Marketing and Finance

Marketing and finance work was directed to:

- further review A. Tussing's draft report "Alaska Energy Planning Studies"; hold meeting to resolve outstanding differences between Tussing's and Acres reports on Susitna project risk analysis; and prepare appropriate responses; and

- to resolve issues concerning sources and extent of financing and annual revenues as the basis for preparing applicable portions of Exhibit D

4 - ACCESS PLAN

4.1 - Introduction

This section describes the development of alternative access plans from the original Acres Plan of Study of February 1980 through to the final selection of the proposed access plan as approved by the Alaska Power Authority Board of Directors in September 1982. The main body of this section is concerned with the access planning studies which have taken place subsequent to the issuance of the Susitna Hydroelectric Project Feasibility Report in March 1982 (Acres 1982a). In the latter part of this section, the modifications and improvements that have been made since the selection of the proposed plan in September 1982 are discussed. In addition, the general guidelines that have been developed for roadway construction and mining of borrow sites are described.

4.2 - Background

The original Plan of Study proposed that a single access route would be selected by May 1981, to be followed by a detailed environmental investigation.

Early in the study, three main access corridors were identified. Plans developed within these three corridors were evaluated on the basis of available information, comments and concerns of various state agencies, and recommendations from the Susitna Hydroelectric Steering Committee (SHSC). After an initial evaluation, the decision was made to assess all three alternative corridors in more detail throughout 1981 and recommend a selected route later in the year. This assessment included environmental studies, engineering studies, aerial photography, and geologic mapping of all three alternative routes.

In March of 1982, the Alaska Power Authority presented the results of the Susitna Hydroelectric Feasibility Report to the public, resource agencies and organizations. This report recommended an access plan which, for reasons of project schedule, would have necessitated the construction of a pioneer road prior to the FERC license being issued. The construction of a pioneer road, however, was considered unacceptable by the resource agencies and the plan was discarded.

Consequently, the evaluation criteria were refined and additional access alternatives were developed. The most responsive plan in each of the three corridors was identified and subjected to a multi-disciplinary assessment and comparison. After consideration of these alternatives, the Alaska Power Authority Board of Directors formally adopted the Denali-North plan, Plan 18, as the Proposed Access Plan in September 1982.

4.3 - Objectives

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

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

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

4.4 - Existing Access Facilities

The proposed Devil Canyon and Watana damsites are located approximately 115 miles northeast of Anchorage and 140 miles south of Fairbanks. The Alaska Railroad, which links Anchorage and Fairbanks, passes within 12 miles of the Devil Canyon damsite at Gold Creek. The George Parks Highway (Route 3) parallels the Alaska Railroad for much of its route, although between the communities of Sunshine and Hurricane the highway is routed to the west of the railroad, to the extent that Gold Creek is situated approximately 16 miles south of the intersection of the railroad and highway. At Cantwell, 51 miles north of Gold Creek, the Denali Highway (Route 8) leads easterly approximately 116 miles to Paxson where it intersects the Richardson Highway. To the south, the Glenn Highway (Route 1) provides the main access to Glenallen and intersects the Richardson Highway which leads south to Valdez. A location map with the proposed access route is shown on Figure 4.1.

4.5 - Corridor Identification and Selection

The Acres Plan of Study, February 1980, identified three general corridors leading from the existing transportation network to the damsites. This network consists of the George Parks Highway and the Alaska Railroad to the west of the damsites and the Denali Highway to the north. The three general corridors are identified on Figure 4.2.

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

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

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

The access road studies identified a total of eighteen alternative plans within the three corridors. The alternatives were developed by laying out routes on topographical maps in accordance with accepted road and rail design criteria. Subsequent field investigations resulted in minor modifications to reduce environmental impacts and improve alignment.

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

- Maximum grade of 6 percent;
- Maximum curvature of 5 degrees;
- Design loading of 80^k axle and 200^k total during construction; and
- Design loading of HS-20 after construction.

Railroad design parameters utilized were as follows:

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

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

4.6 - Development of Plans

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

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

This led to the development of eight alternative access plans.

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

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

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

During the evaluation process, the Alaska Power Authority staff formulated a further plan, thus increasing the total number of plans under evaluation to eighteen. This subsequently became the plan recommended by Power Authority staff to the Power Authority Board of Directors, and was formally adopted as the Proposed Access Plan in September 1982 (Acres 1982a).

A description of each of the eighteen alternative access plans, together with a breakdown of costs, is given in Table 4.1

4.7 - Evaluation of Plans

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

- No pre-license construction;

- Provide initial access within one year;

- Provide access between sites during project operation phase;

- Provide access flexibility to ensure project is brought on-line within budget and schedule;

- Minimize total cost of access;

- Minimize initial investment required to provide access to the Watana damsite;

- Minimize risks to project schedule;

- Minimize environmental impacts;

- Accommodate current land uses and plans;

- Accommodate Agency preferences;

- Accommodate preferences of Native organizations;

- Accommodate preferences of local communities; and

- Accommodate public concerns.

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

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

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

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

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

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

The seven remaining plans found to meet the selection criterion were Plans 6, 11, 13, 14, 16, 17 and 18. Of these, Plans 13, 16, and 18 in the North, South, and Denali corridors, respectively, were selected as being the most responsive plan in each corridor. The three plans are described below and the route locations shown in Figures 4.3 through 4.5.

4.8 - Description of Most Responsive Access Plans

Plan 13 "North" (see Figure 4.3)

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

Plan 16 "South (see Figure 4.4)

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

Plan 18 "Denali-North" (see Figure 4.5)

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

4.9 - Comparison of the Selected Alternative Plans

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

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

(a) Costs

The relative cost of the three access alternatives is presented in Table 4.2. This table outlines the total costs of the three plans with the schedule constraint that initial access must be completed within one year of receipt of the FERC license. Costs to complete the access requirement for the Watana development only are also shown. The costs of the three alternative plans can be summarized as follows:

Estimated Total Cost ($\$ \times 10^6$)

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

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

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

(b) Schedule

The schedule for providing initial access to the Watana site was given prime consideration since the cost ramifications of a schedule delay are highly significant. The elimination of pre-license construction of a pioneer access road has resulted in the severe compression of on-site construction activities in the 1985-86 period. With the present overall project scheduling, should diversion not be completed prior to spring runoff in 1987, dam foundation preparation work would be delayed one year, and hence cause a delay to the overall project of one year. It has been estimated that the resultant increase in cost would likely be in the range of 100-200 million dollars. The access route that assures the quickest completion and hence the earliest delivery of equipment and materials to the site has a distinct advantage. The forecasted construction periods for initial access, including mobilization, for the three plans are:

Denali- North	6 months
North	9 months
South	12 months

It is evident that with the Denali-North Plan site activities can be supported at an earlier date than by either of the other routes. Consequently, the Denali-North Plan offers the highest probability of meeting schedule and hence the least risk of project delay and increase in cost. The schedule for access in relation to diversion is shown for the three plans in Figure 4.6.

(c) Environmental Issues

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

(i) Wildlife and Habitat

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

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

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

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

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

5. Denali Highway to Watana: This segment is primarily composed of shrub and tundra vegetation types, with little productive forest habitat present. Although habitat diversity is relatively low along this segment, the southern portion along Deadman Creek contains an important brown bear concentration and browse for moose. This segment crosses a peripheral portion of

the range of the Nelchina caribou herd and there is evidence that as herd size increases, caribou are likely to migrate across the route and calve in the vicinity. Although it is not possible to predict with any certainty how the physical presence of the road itself or traffic will affect caribou movements, population size or productivity, it is likely that a variety of site-specific mitigation measures will be necessary to protect the herd.

These segments combine, as illustrated below, to form the three alternative access plans:

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

Table 4.3 summarizes the three alternative access plans with respect to potential adverse impacts on wildlife and their supporting habitat.

The North route has the least potential for creating adverse impacts to wildlife and habitat for it traverses or approaches the fewest areas of productive habitat and zones of species concentration or movement. The wildlife impacts of the South Plan can be expected to be greater than those of the North Plan due to the proximity of the route to Prairie Creek, Stephan Lake, and the Fog Lakes, which currently support high densities of moose and black and brown bears. In particular, Prairie Creek supports what may be the highest concentration of brown bears in the Susitna Basin. The Denali-North Plan crosses the periphery of the Nelchina caribou range and movement zone between the Denali Highway and Susitna River. In addition, this route has the potential for disturbances to brown and black bear concentrations and movement zones in the Deadman and Tsusena Creek areas. Overall, however, the potential for adverse impacts with the Denali-North Plan is similar to the South Plan.

(ii) <u>Fisheries</u>

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

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

1. <u>Hurricane to Devil Canyon</u>: Seven stream crossings will be required along this route, including Indian River which is an important salmon spawning river. Both the Chulitna River watershed and the Susitna River watershed are affected by this route. The increased access to Indian River will be an important indirect impact to the segment. Approximately 1.8 miles of cuts into banks greater than 30 degress occur along this route requiring erosion control measures to preserve the water quality and aquatic habitat.

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

3. <u>Devil Canyon to Watana (North Side, North Plan)</u>: This segment crosses 20 streams and laterally transits four rivers for a total distance of approximately 12 miles. Seven miles of this lateral transit parallels Portage Creek which is an important salmon spawning area.

4. <u>Devil Canyon to Watana (North Side, Denali-North Plan)</u>: The difference between this segment and segment 3 described above is that it avoids Portage Creek by traversing through a pass four miles to the east. The number of streams crossed is consequently reduced to 12, and the number of lateral transits is reduced to two with a total distance of four miles.

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

6. Denali Highway to Watana: The segment from the Denali Highway to the Watana damsite has 22 stream crossings and passes from the Nenana into the Susitna watershed. Much of the route crosses or is in proximity to seasonal grayling habitat and runs parallel to Deadman Creek for nearly ten miles. If recruitment and growth rates are low along this segment, it is unlikely that resident populations could sustain heavy fishing pressure. Hence, this segment has a high potential for impacting the local grayling population.

7. Denali Highway: The Denali Highway from Cantwell to the Watana access turnoff will require upgrading. The upgrading will involve only minor realignment and negligible alteration to present stream crossings. The segment crosses 11 streams and laterally transits two rivers for a total distance of five miles. There is no anadromous fish spawning in this segment and little direct or indirect impact is expected.

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

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

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

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

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

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

(d) Cultural Resources

A level one cultural resources survey was conducted over a large portion of the three access plans. The segment of the Denali-North Plan between the Watana damsite and the Denali Highway traverses an area of high potential for cultural resource sites. Treeless areas along this segment lack appreciable soil desposition, making cultural resources visible and more vulnerable to secondary impacts. Common to both the Denali-North and the North Plan is the segment on the north side of the Susitna River from the Watana damsite to where the road parallels Devils Creek. This segment is also largely treeless, making it highly vulnerable to secondary impacts. The South Plan traverses less terrain of archaeological importance than either of the other two routes. Several sites exist along the southerly Devil Canyon to Watana segment; however, since much of the route is forested, these sites are less vulnerable to secondary impacts.

The ranking from the least to the highest with regard to cultural resource impacts is South, North, Denali-North. However, impacts to cultural resources can be fully mitigated by avoidance, protection or salvage; consequently, this issue was not critical to the selection process.

(e) Socioeconomics/Community Preferences

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

(i) Cantwell

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

(ii) Hurricane

The North Plan would significantly impact the Hurricane area, since currently there is little population, employment, business activity or housing. Changes in socioeconomic indicators for Hurricane would be less under the South Plan and considerably less under the Denali- North plan.

(iii) Trapper Creek and Talkeetna

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

(iv) Gold Creek

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

The responses of people who will be affected by these potential changes are mixed. The people of Cantwell are generally in favor of some economic stimulus and development in their community. Some concern was expressed over the potential effects of access on fish and wildlife resources, but with stringent hunting regulations implemented and enforced, it was considered that this problem could be successfully mitigated. The majority of residents in both Talkeetna and Trapper Creek have indicated a strong preference to maintain their general lifestyle patterns and do not desire rapid, uncontrolled change. The Denali-North Plan would impact these areas the least. The majority of landholders in the Indian River subdivision favor retention of the remote status of the area and do not want road access through their lands. This and other feedback to date indicate that the Denali-North Plan will come closest to creating socioeconomic changes that are acceptable to or desired by landholders and residents in the potentially impacted areas and communities.

(f) Preferences of Native Organizations

Cook Inlet Region Inc. (CIRI) has selected lands surrounding the impoundment areas and south of the Susitna River between the damsites. CIRI has officially expressed a preference for a plan providing road access from the George Parks Highway to both damsites along the south side of the Susitna River. The Tyonek Native Corporation and the CIRI village residents have indicated a similar preference. The South Plan provides full road access to their lands south of the Sutina River and thus comes closest to meeting these desires. The AHTNA Native Region Corporation presently owns land bordering the Denali Highway and they, together with the Cantwell Village Corporation, have expressed a preference for the Denali-North Plan. None of the Native organizations support the North Plan.

(g) Relationship to Current Land Stewardships, Uses and Plans

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

The other land management plans that have a large bearing on access development are the Bureau of Land Management's (BLM) recent decision to open the Denali Planning Block to mineral exploration, and the Denali Scenic Highway Study being initiated by the Alaska Land Use Council. The Denali Highway to Deadman Mountain segment of the Denali-North Plan would be compatible with BLM's plans. During the construction phase of the project, the Denali-North Plan could create conflicts with the development of a Denali Scenic Highway; however, after construction, the access road and project facilities could be incorporated into the overall scenic highway planning.

By providing public access to a now relatively inaccessible, semi-wilderness area, conflict may be imposed with wildlife habitats necessitating an increased level of wildlife and people management by the various resource agencies.

In general, however, none of the plans will be in major conflict with any present federal, borough, or Native management plans.

(h) Recreation

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

4.9 - Summary of Final Selection of Plans

In reaching the decision as to which of the three alternative access plans was to be recommended, it was necessary to evaluate the highly complex interplay that exists between the many issues involved. Analysis of the key issues described in the preceeding pages indicates that no one plan satisfied all the selection criteria nor accommodated all the concerns of the resource agencies, Native organizations and public. Therefore, it was necesary to make a rational assessment of tradeoffs between the sometimes conflicting environmental concerns of impacts on fisheries, wildlife, socioeconomics, land use, and recreational opportunities on the one hand, with project cost, schedule, construction risk and management needs on the other. With all these factors in mind, it should be emphasized that the primary purpose of access is to provide and maintain an uninterrupted flow of materials and personnel to the damsite throughout the life of the project. Should this fundamental objective not be achieved, significant schedule and budget overruns will occur.

(a) Elimination of "South Plan"

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

A further limitation of this route is that, for the first three years of the project, all construction work must be supported solely from the railhead facility at Gold Creek. This problem arises because it will take an estimated three years to complete construction of the connecting road across the Susitna River at Devil Canyon to Hurricane on the George Parks Highway. Limited access such as this does not provide the flexibility needed by the project management to meet contingencies and control costs and schedule.

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

(b) Schedule Constraints

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

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

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

The date the FERC license will be issued cannot be accurately determined at this time, but is forecast to be within the first nine months of 1985. Hence, the interval between licensing and the scheduled date of diversion can vary significantly, as shown graphically in Figure 4.6. This illustrates that the precise time of year the license is issued is critical to the construction schedule of the access route, for if delays in licensing occur, there is a risk of delay to the project schedule to the extent that river diversion in 1987 will be missed. The risk of delays increases:

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

If diversion is not achieved prior to spring runoff in 1987, dam foundation preparation work will be delayed one year, and hence, cause a delay to the overall project of one year.

(c) Cost Impacts

The increase in costs resulting from a one year delay have been estimated to be in the range of 100-200 million dollars. This increase includes the financial cost of investment by spring of 1987, the financial costs of rescheduling work for a one year delay, and replacement power costs.

(d) Conclusion

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

(e) Plan Recommendation

It is recommended that the Denali-North route be selected so as to ensure completion of initial access to the Watana damsite by the end of the first quarter of 1986, for it is considered that the risk of significant cost overruns is too high with any other route.

4.10 - Modifications to Recommended Access Plan

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

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

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

(c) The chief fisheries concern was the proximity of the proposed route to Deadman Creek, Deadman Lake, and Big Lake. For a distance of approximately 16 miles the road parallels Deadman Creek, which contains good to excellent grayling populations. To alleviate the problem of potential increased angling pressure, the road was moved one half to one mile west of Deadman Creek.

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

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

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

(ii) For safety reasons, it is recommended that:

- Speed restrictions be imposed along the above segment;

- A bike path be provided along the same segment, since the school is adjacent to the access road; and

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

(f) The main concern of the Native organizations represented by CIRI is to gain access to their land south of the Susitna River. Under the proposed access plan, these lands will be accessible by both road and rail, the railroad being from Gold Creek to the Devil Canyon damsite on the south side of the Susitna River. After completion of the Watana dam, road access will be provided across the top of the dam to Native lands. Similarly, a road across the top of the Devil Canyon dam will be constructed once the main works at Devil Canyon are completed. In addition, alternative road access will be available via the high level suspension bridge one mile downstream from the Devil Canyon dam.

(g) From an environmental standpoint, it is desirable to limit the number of people in the project area in order to minimize impacts to wildlife habitat and fisheries. In comparison with a paved road, an unpaved road would deter some people from visiting the area and thus create less of an impact to the environment. An unpaved road would also serve to maintain as much as possible the wilderness character of the area. An evaluation of projected traffic volumes and loadings confirmed that an unpaved gravel road with a 24 ft running surface and 5 ft wide shoulder would be adequate.

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

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

Adhering to these grades and curvatures, the entire length of the road would result in excessively deep cuts and extensive fills in some areas, and could create serious technical and environmental problems. From an engineering standpoint, it is advisable to avoid deep cuts because of the potential slope stability problems, especially in permafrost zones. Also, deep cuts and large fills are detrimental to the environment for they act as a barrier to the migration of big game and disrupt the visual harmony of the wilderness setting. Therefore, in areas where adhering to the aforementioned grades and curvatures involve extensive cutting and filling, the design standards will be reduced to allow steeper grades and shorter radius turns.

This flexibility of design standards provides greater latitude to "fit" the road within the topography and thereby enhance the visual quality of the surrounding landscape. For reasons of driver safety, the design standards will in no instance be less than those applicable to a 40 mph design speed.

(i) One of the most important issues associated with the construction of the access road is the development of borrow sites. Potential impacts can be mitigated through selective siting of borrow sites and the use of state-of-the-art gravel removal techniques. After close consultation with fish and wildlife, recreational, aesthetic, and cultural resource specialists, the following guidelines were developed to ensure that any impacts are minimized.

- Active floodplain and streambed locations should be avoided;

- In locating borrow sites, first priority is to be given to well-drained upland locations, and second priority to first-level terrace sites;

- First-level terrace sites should be located on the inactive side of the floodplain and mined by pit excavation rather than by shallow scraping;

- If wet processing is required, water withdrawal and discharge locations should be carefully sited to minimize fish and wildlife disturbance. Drawdown in overwintering pools used by fish or aquatic mammals and any disturbances to spawning areas is to be avoided. In addition, water intake structures should be enclosed in screened boxes;

- All material sites should be developed in phases by aliquots, and portions of the site which are more sensitive from an environmental standpoint should be left until last;

- For rehabilitation purposes, sites should have irregular boundaries, including projections of undisturbed, vegetated terrain into the site. Where ponding will occur, as in first-level terrace sites, islands of undisturbed vegetated terrain should be left within the perimeter of the operational site; and
- Organic overburden, slash, and debris stockpiled during cleaning should be distributed over the excavated area prior to fertilization. The rehabilitation of sites is to be completed by the end of the growing season immediately following last use.

The modifications and improvements to the proposed access plan, together with the general guidelines that have been developed for roadway construction and mining of borrow sites, have been fully incorporated into the draft FERC License Application. A more detailed description of specific mitigation plans is given in the relevant sections of Exhibit E of the Application.

4.11 - Description of Proposed Access Plan

(a) Watana Access

Access to the Watana damsite will connect with the existing Alaska Railroad at Cantwell where a railhead and storage facility occupying 40 acres will be constructed. This facility will act as a transfer point from rail to road transport and as a storage area for a two-week backup supply of materials and equipment. From the railhead facility the road will follow an existing route to the junction of the George Parks and Denali Highways (a distance of two miles), then proceed in an easterly direction for a distance of 21.3 miles along the Denali Highway. A new road, 41.6 miles in length, will be constructed from this point due south to the Watana campsite. On completion of the dam access to Native lands on the south side of the Susitna River will be provided from the Watana campsite, with the road crossing along the top of the dam. This will involve the construction of an additional 2.6 miles of road, bringing the total length of new road to 44.2 miles.

The majority of the new road will traverse relatively flat terrain involving only isolated sections of cut and fill. Where it is not possible to locate the road on sidehill slopes of gentle to moderate steepness, the road will be formed using side borrow techniques; with the crown of the road being two to three feet above the elevation of adjacent ground. By balancing cut and fill and using side borrow techniques, the need for borrow material from pits and consequent disturbance to areas away from the alignment will be minimized.

It has been estimated that it will take approximately six months to secure initial access with an additional year for completion and the upgrading of the Denali Highway section.

(b) Devil Canyon Access

Access to the Devil Canyon development will consist primarily of a railroad extension from the existing Alaska Railroad at Gold Creek to a railhead and storage facility adjacent to the Devil Canyon camp area. To provide flexibility of access, the railroad extension will be augmented by a road between the Devil Canyon and Watana damsites.

(i) Rail Extension

Except for a 2-mile section where the route traverses steep terrain alongside the Susitna River, the railroad will climb steadily for 12.2 miles from Gold Creek to the railhead facility near the Devil Canyon camp. Nearly all of the route traverses potentially frozen, basal till on side slopes varying from flat to moderately steep. Several streams are crossed, requiring the construction of large culverts. However, where the railroad crosses Jack Long Creek, small bridges will be built to minimize impacts to the aquatic habitat. In view of the construction conditions, it is estimated that it will take eighteen months to two years to complete the extension.

(ii) Connecting Road

From the railhead facility at Devil Canyon, a connecting road will be built to a high level suspension bridge approximately one mile downstream from the damsite. The route then proceeds in a north easterly direction, crosses Devil Creek and swings round past Swimming Bear Lake at an elevation of 3500 feet before continuing in a south easterly direction through a wide pass. After crossing Tsusena Creek, the road continues south to the Watana damsite. The overall length of the road is 37.0 miles.

In general, the alignment crosses good soil types with bedrock at or near the surface. Erosion and thaw settlement should not be a problem since the terrain has gentle to moderate slopes which will allow roadbed construction without deep cuts. The connecting road will be built to the same standard and in accordance with the design parameters used for the Watana access road. However, as is the case for the Watana damsite access road, the design standards will be reduced to as low as 40 mph in areas where it is necessary to minimize the extent of cutting and filling. The affected areas are the approaches to some of the stream crossings, the most significant being those of the high level bridge crossing the Susitna River downstream from Devil Canyon.

The 1,790-ft-long, high-level suspension bridge crossing the Susitna River is the controlling item in the construction schedule, requiring three years for completion. Therefore, it will be necessary to begin construction three years prior to the start of the main works at the Devil Canyon damsite.

Figure 4.7 shows the proposed access plan route. Figure 4.8 shows details, for both the Watana and Devil Canyon developments, of typical road and railroad cross sections, railhead facilities, and the high level bridge at Devil Canyon.

Table 4.1 - Access Plan Costs

PLAN	1	2	3	4	5	6
DESCRIPTION	ROADWAY: PARKS HIGHWAY TO DEVIL CANYON & WATANA ON SOUTH SIDE OF SUSITNA.	RAIL: GOLD CREEK TO DEVIL CANYON & WATANA ON SOUTH SIDE OF SUSITNA.	ROADWAY: DENALI HIGHWAY TO WATANA. PARKS HIGHWAY TO DEVIL CANYON ON SOUTH SIDE OF SUSITNA. NO CONNECTING ROAD.	ROADWAY: DENALI HIGHWAY TO WATANA. RAIL, GOLD CREEK TO DEVIL CANYON ON SOUTH SIDE OF SUSITNA. NO CONNECTING ROAD.	ROADWAY: PARKS HIGHWAY TO DEVIL CANYON ON SOUTH SIDE OF SUSITNA. DEVIL CANYON TO WATANA ON NORTH SIDE OF SUSITNA.	ROADWAY: DENALI HIGHWAY TO WATANA. RAIL: GOLD CREEK TO DEVIL CANYON ON SOUTH SIDE OF SUSITNA. CONNECTING ROAD ON NORTH SIDE OF SUSITNA.
Mileage Road	62	-	91*	65*	81	107*
Mileage Rail	-	58	-	16	-	16
Design and Construction Cost ($ x 1,000,000)	170	149	157	123	160	180
Maintenance Cost ($ x 1,000,000)	9	5	7	5	8	12
Logistics Cost ($ x 1,000,000)	214	214	228	228	216	228
Total Cost ($ x 1,000,000)	393	368	392	356	384	420
Construction Schedule for Initial Access (Years)	1	3-4	1	1	2-3	1
Construction Schedule for Full Access (Years)	3-4	3-4	2-3	2-3	3-4	3
Bridges Major (>1000 ft)	3	2	1	0	2	0
Bridges Minor (<1000 ft)	2	0	1	0	1	0

* Includes upgrading 21 miles of the Denali Highway

Revision: E

Table 4.1 - (Cont'd)

PLAN	7	8	9	10	11	12
DESCRIPTION	ROADWAY: DENALI HIGHWAY TO WATANA. PARKS HIGHWAY TO DEVIL CANYON ON SOUTH SIDE OF SUSITNA. CONNECTING ROAD ON NORTH SIDE OF SUSITNA.	ROADWAY: GOLD CREEK TO DEVIL CANYON ON SOUTH SIDE OF SUSITNA. DEVIL CANYON TO WATANA ON NORTH SIDE OF SUSITNA.	RAIL: GOLD CREEK TO DEVIL CANYON ON SOUTH SIDE OF SUSITNA. ROADWAY: DEVIL CANYON TO WATANA ON NORTH SIDE OF SUSITNA.	RAIL: GOLD CREEK TO DEVIL CANYON ON SOUTH SIDE OF SUSITNA. ROADWAY: DEVIL CANYON TO WATANA ON SOUTH SIDE OF SUSITNA.	ROADWAY: DENALI HIGHWAY TO WATANA. CONNECTING ROAD BETWEEN WATANA AND DEVIL CANYON ON NORTH SIDE OF SUSITNA.	ROADWAY: PARKS HIGHWAY TO DEVIL CANYON AND WATANA ON NORTH SIDE OF SUSITNA.
Mileage Road	132*	69	56	36	114*	61
Mileage Rail	-	-	16	16	-	-
Design and Construction Cost ($ x 1,000,000)	215	117	126	136	172	127
Maintenance Cost ($ x 1,000,000)	9	7	6	6	11	7
Logistics Cost ($ x 1,000,000)	228	216	216	214	258	225
Total Cost ($ x 1,000,000)	452	340	348	356	441	359
Construction Schedule for Initial Access (Years)	1	2-3	3	2	1	2
Construction Schedule for Full Access (Years)	3	3	3	3	2-3	3-4
Bridges Major (>1000 ft)	1	0	0	2	0	1
Bridges Minor (<1000 ft)	1	1	1	1	1	2

* Includes upgrading 21 miles of the Denali Highway

Revision: E

Sheet 2 of 3

Table 4.1 - (Cont'd)

PLAN	13	14	15	16	17	18
DESCRIPTION	ROADWAY: PARKS HIGHWAY TO WATANA ON NORTH SIDE OF SUSITNA WITH BRANCH ROAD TO SOUTH BANK AT DEVIL CANYON.	RAIL/ROADWAY: GOLD CREEK RAILROAD EXTENSION. ROADWAY: TO DEVIL CANYON AND WATANA ON SOUTH SIDE OF SUSITNA. CONNECTING ROAD TO PARKS HIGHWAY.	RAIL/ROADWAY: GOLD CREEK RAILROAD EXTENSION. ROADWAY: TO DEVIL CANYON AND WATANA ON SOUTH SIDE OF SUSITNA.	ROADWAY: GOLD CREEK TO WATANA ON SOUTH SIDE OF SUSITNA. CONNECTING ROAD TO DEVIL CANYON AND PARKS HIGHWAY.	ROADWAY: DENALI HIGHWAY TO WATANA. CONNECTING ROAD TO DEVIL CANYON ON SOUTH SIDE OF SUSITNA. RAIL: GOLD CREEK TO DEVIL CANYON ON SOUTH SIDE OF SUSITNA.	ROADWAY: DENALI HIGHWAY TO WATANA. CONNECTING ROAD TO DEVIL CANYON ON NORTH SIDE OF SUSITNA. RAIL: GOLD CREEK TO DEVIL CANYON ON SOUTH SIDE OF SUSITNA.
Mileage Road	59	64	49	69	102*	97*
Mileage Rail	-	7	7	-	14	14
Design and Construction Cost ($ x 1,000,000)	115	174	128	156	200	188
Maintenance Cost ($ x 1,000,000)	7	9	6	10	12	11
Logistics Cost ($ x 1,000,000)	223	215	215	216	227	227
Total Cost ($ x 1,000,000)	345	398	349	382	439	426
Construction Schedule for Initial Access (Years)	1	1	1	1	1	1
Construction Schedule for Full Access (Years)	3	3-4	3	3	3-4	3
Bridges Major (>1000 ft)	1	2	1	2	1	1
Bridges Minor (<1000 ft)	2	2	1	2	1	1

* Includes upgrading 21 miles of the Denali Highway

Revision: E

TABLE 4.2 - ACCESS PLAN COSTS

INITIAL ACCESS WITHIN ONE YEAR

DESCRIPTION	NORTH PLAN 13			SOUTH PLAN 16			DENALI-NORTH PLAN 18		
	WATANA	DEVIL CANYON	COMBINED	WATANA	DEVIL CANYON	COMBINED	WATANA	DEVIL CANYON	COMBINED
Mileage Road Rail	52 0	7 0	59 0	69 0	0 0	69 0	61 * 0	36 14	97 * 14
Construction Cost ($ x 1,000,000)	95	20	115	156	0	156	82	106	188
Logistics Cost ($ x 1,000,000)	118	105	223	115	101	216	127	100	227
Maintenance ($ x 1,000,000)	5	2	7	7	3	10	4	7	11
Subtotal ($ x 1,000,000)	218	127	345	278	104	382	213	213	426
Impact of Accelerated Schedule ($ x 1,000,000)	23	0	23	34	0	34	11	0	11
Total ($ x 1,000,000)	241	127	368	312	104	415	224	213	437
Construction Schedule for Initial Access (Years)		1			1			1	
Construction Schedule for Full Access (Years)		3			3			3	

* Includes upgrading 21 miles of the Denali Highway

Table 4.3

SUMMARY OF WILDLIFE HABITAT ISSUES
ASSOCIATED WITH ACCESS ALTERNATIVES

Issue	North (13)	South (16)	Denali-North (18)
Waterfowl	No water bodies of high relative importance along route.	Stephan Lake is of high relative importance to waterfowl.	No water bodies of high relative importance along route.
Raptor Nests	Avoids known nest sites.	Avoids known nest sites.	One-half mile from bald eagle nest on Deadman Creek.
Breeding Birds	Least amount of productive forest habitat removed.	Greatest amount of productive forest habitat removed.	Amount of forest removed less than South Route but greater than North Route.
Aquatic Furbearers	Avoids Fog Lakes-Stephan Lake wetlands.	Near Fog Lakes-Stephan Lake wetlands.	Avoids Fog Lakes-Stephan Lake wetlands.
	Crosses highly productive habitat in Chulitna Pass area.	Crosses highly productive habitat in Chulitna Pass area.	Avoids Chulitna Pass area.
	Near productive habitat along Portage Creek.	Avoids Portage Creek area.	Avoids Portage Creek area.
	Avoids Jack Long Creek beaver concentration area.	Disturbs Jack Long Creek beaver concentration area.	Disturbs Jack Long Creek beaver concentration area.
Red Fox Den: Concentration Areas	Within 1/4 mile of Swimming Bear Lake den sites.	Avoids red fox den concentration areas.	Within 1/4 mile of Swimming Bear Lake den sites.
	Avoids Deadman Creek and Deadman Lake den areas.		One-half mile from Deadman Creek and Deadman Lake den concentration areas.

Table 4.3 (Cont'd)

Issue	North (13)	South (16)	Denali-North (18)
Brown Bears	Avoids Prairie Creek concentration area.	Near Prairie Creek concentration area; crosses movement corridor between Prairie Creek and Susitna River.	Avoids Prairie Creek concentration area.
	Avoids Deadman Creek concentration area.	Avoids Deadman Creek area.	Crosses Deadman Creek concentration area.
Black Bears	Avoids den sites.	Near several den sites west of Tsusena Creek.	Near several den sites west of Tsusena Creek.
	Traverses important south-facing slopes.	Fewer south-facing slopes are traversed.	Traverses important south-facing slopes.
	Least amount of forest is removed.	Removes greatest amount of forest.	Removes more forest than North Route but less than South Route.
Caribou	Avoids caribou range and movement corridor between Denali Highway and Susitna River.	Avoids caribou range and movement between Denali Highway and Susitna River.	Crosses caribou range and movement corridor between Denali Highway and Susitna River.
	Avoids Fog Lakes-Stephan Lake caribou range.	Near Fog Lakes-Stephan Lake caribou ranges.	Avoids Fog Lakes-Stephan Lake caribou range.
Moose	Traverses important south-facing slopes.	Fewer south-facing slopes are traversed.	Traverses important south-facing slopes.
	Least amount of forest is removed.	Removes greatest amount of forest.	Removes less forest than South Route but more than North Route.
	Avoids Fog Lakes-Stephan Lake area.	Near Fog Lakes-Stephan Lake wetlands.	Avoids Fog Lakes-Stephan Lake wetlands.
Secondary Effects:	Least potential for secondary effects through public access and recreational development.	Potential for secondary effects through public access less than Denali-North Route but greater than North Route. High potential for secondary effects through recreational development of lands south of Susitna River.	Highest potential for secondary effects through public access and recreational development.

5 - REFINEMENT OF SUSITNA DEVELOPMENT

5.1 - 1982 Geotechnical Design Considerations

The purpose of this section is to update the Feasibility Report (Acres, 1982a) based on the results of the geotechnical investigations performed during the 1982 summer field season.

Details of the geotechnical program are provided in the 1980-81 Geotechnical Report (Acres, 1982b) and the 1982 Supplement to the 1980-81 Geotechnical Report (Acres, 1982c). The reader should refer to these reference reports for a comprehensive understanding of the site geotechnical conditions. Infor mation provided in the following sections is a summary of that provided in these referenced reports.

(a) Geotechnical Explorations

The objective of the geotechnical program, was to determine the surface and subsurface geology and geotechnical conditions for the feasiblity studies of the proposed Susitna Hydroelectric Project, including the access roads and the transmission lines. This was accomplished by a comprehensive program of field exploration, geotechnical evaluation, and dam studies over more than three years, commencing in early 1980. The scope of the geotechnical program was increased in 1982 in terms of additional field work under Amendment 3 and 4 to respond to concerns raised by the Power Authority's External Review Board. The following subsections discuss the objectives of the 1982 explorations performed.

(i) 1982 Field Program

Studies performed during the 1980-81 investigations raised a number of questions regarding the Watana Damsite, the Watana Relict Channel, Borrow Site D, and the Fog Lakes Relict Channel. The objective of the 1982 geotechnical exploration program was to supplement the results of the previous investigations by performing additional detailed explorations of the particular areas of concern. These explorations consisted of:

- Watana Damsite

  To map the:

  - Extent of geologic features identified in previous investigations to include shears, alteration, and fracture zones;
  - Bedrock conditions in the upstream and downstream portal areas; and
  - Geology of "The Fins" and "Fingerbuster" shear zones.

- Watana Relict Channel
  To determine:
  . Channel geometry;
  . Stratigraphy of the channel sediments;
  . Continuity of stratigraphic sequence;
  . Material properties;
  . Ground water conditions;
  . Permafrost conditions;

- Borrow Site D
  To determine:
  . Material properties;
  . Stratigraphy;
  . Material quantities;
  . Ground water conditions;
  . Permafrost conditions;

- Fog Lakes Relict Channel
  To determine:
  . Channel geometry;
  . Stratigraphy of the channel sediments;
  . Ground water conditions;
  . Permafrost conditions;

(b) Watana Site

This section summarizes the results of the 1982 geotechnical explorations for the Watana Damsite, Watana Relict Channel/Borrow Site D, and Fog Lakes Relict Channel. Each of these areas is discussed separately below. Detailed descriptions of the geology at the Watana site are given in the 1980-81 Geotechnical Report (Acres, 1982b) and the 1982 Supplement to the 1980-81 Geotechnical Report (Acres, 1982c).

(i) Watana Damsite

The Watana Damsite refers to the main dam area, as well as, the upstream and downstream cofferdam and portal areas.

- Geologic Conditions

. Overburden

The 1982 study found no significant differences in over burden thickness or material types from those previously reported. A map showing the top of bedrock surface contours and the type and distribution of surficial sediments is shown on Figure 5.1. This map is based on additional seismic refraction surveys and geologic mapping.

. Bedrock Lithology

No significant additional information, pertaining to bedrock lithology was found during the 1982 investigation. A geologic map, showing bedrock lithology, is shown on Figure 5.2.

- Bedrock Structures

  . Joints

The addition of more than 500 joint measurements to the statistical joint plots has resulted in minor changes to the average orientations and dips of the four joint sets found at the site. Table 5.1 is a summary of joint orientations for the overall damsite area as well as the specific areas of the proposed upstream and downstream portals. Joint plots of the damsite area are in the 1982 Supplement to the 1980-81 Geotechnical Report (Acres 1982c). Plots for the upstream and downstream portal areas are on Figures 5.3 and 5.4. Sets I and II remain the major sets with Sets III and IV being minor, although locally pronounced. Set I trends northwestward with high angle to vertical dips and is the most prominent set. Set I parallels most discontinuities at the site. Set II trends north eastward and is best developed upstream of the dam center line. Set II is parallel to fracture zones in this area. Set III joints trend northward with moderate to steep dips to east and west. Set III is not present in the upstream portal area; however, it is well developed in the downstream portal area where it parallels shear and fracture zones. Set IV joints are generally discontinuous and appear to be due to stress relief. Orientations are quite variable, but many trend east-west with shallow to moderate dips to the north and south. These joints are discontinuous and appear to be related to stress relief from glacial unloading.

The Susitna River is joint controlled in the damsite area. Upstream of the dam centerline, the river parallels Set II joints. Near the dam centerline it is controlled by both Sets I and II; and in the downstream area it is controlled by shear and fracture zones related to Set I joints.

  . Shears, Fracture Zones, and Alteration Zones

These features are defined in the Acres Reports 1982a and 1982b. A geologic map showing the extent of these features is shown on Figure 5.3. Significant geologic features are discussed below.

Structural Features Three geologic structures previously identified in the damsite as having potential impact on civil design are "The Fins", "Fingerbuster", and a wide, hydrothermally altered zone. "The Fins" and "Fingerbuster" were explored in more detail during the 1982 field season. The following paragraphs are a summary of the findings. No explorations were performed in the area of the left bank alteration zone.

"The Fins" is shown in relation to the damsite on Figure 5.2 and in detail on Figure 5.3 This is located on the north bank near the present planned location for the upstream cofferdam and diversion portals' Reconnaissance mapping in this area indicated major shears underlying a series of deep gullies separated by intact rock ribs. Detailed mapping showed that most structural discontinuities crosscut the gullies rather than lie within them. "The Fins" is an area of major shears, fracture zones, and alteration zones of various orientations. The strongest trend of these discontinuities is northwest-southeast parallel to Set I joints and northeast-southwest parallel to Set II joints. Minor shears were also found trending at various orientations. The northwest trending structures are near-vertical to vertical and consist of shears, fracture zones, and alteration zones from less than 1 foot up to 10 feet wide. The most significant of these features are found upstream of the proposed portal area. The northeast trending structures consist of fracture zones which are discontinuous and only occur downstream of the proposed portal cuts. These features are up to 6 feet wide and dip moderately south eastward, towards the river, to vertical. A series of low angle (less than 45°) shears dipping towards the river were mapped primarily above the portal area. These shears may cause rock stability problems during excavation.

"The Fins" structure trends generally from 300° to 310°. To the southwest, the structure trend across the Susitna River beneath the upstream cofferdam and is exposed to a limited extent on the south bank. To the northwest, "The Fins" is inferred to correlate with a hydrothermally altered zone on Tsusena Creek.

The "Fingerbuster" is an area of shears, fracture zones, and alteration zones which are best exposed on the north bank of the Susitna River in the area of the proposed down stream diversion and tailrace portals (Figure 5.4). Exposure show two strong trends of discontinuities: northwest-southeast and north-south. The northwest trending discontinuities consist primarily of shears and associated alteration zones parallel to Set I joints. These structures are up to 2 feet wide. Related to the northwest trending structures are areas of open joints and loose unstable rock. Large blocks of detached rock are slumping along the intersection of Sets I, III, and IV joints. The most significant of these areas occurs in the proposed excavation area for the spillway flip- bucket.

The north trending discontinuities are primarily fracture zones with minor shears which parallel Set I joints. An exception to this is a major shear zone labelled GF7Q, which corresponds with the andesite porphyry/diorite contact. This feature is up to 30 feet wide; however, most of the north trending structures are less than 5 feet wide.

The main trend of the "Fingerbuster" is northwest-southeast. To the southeast, the "Fingerbuster" is projected beneath the river and tentatively correlated with shears on the south bank. The extent to the northwest is uncertain due to lack of bedrock exposure.

- Groundwater Conditions

Results of the 1982 geotechnical explorations support the findings and conclusions set forth in the Feasibility Report (Acres 1982a) except for the depth of water levels on the right abutment. The previously reported (Acres 1982b) ground water levels of 110 to 280 feet deep were erroneous and should read 110 to 150 feet. In addition, geologic mapping revealed additional springs on slopes at the overburden/bedrock contacts (Figure 5.2).

- Permafrost Conditions

The interpretation of the permafrost regime at the damsite remains unchanged from that presented in the Feasibility Report.

- Permeability

No additional data pertaining to rock permeability was gathered during 1982. The interpretation presented in the Feasibility Report remains unchanged.

- Reservoir Geology

Geologic mapping in the proposed Watana Reservoir area was undertaken as part of the regional, and Watana and Fog Lakes Relict investigations. The results of this investigation are discussed in Section 5.1(b), 5.1(c)(ii), and 5.1(c)(iii) and are shown on the regional geologic map (Figure 5.5)'

(ii) Watana Relict Channel/Borrow Site D

The 1980"81 geotechnical investigations confirmed the COE's (1978) interpretation of the existence of a buried relict channel on the north side of the damsite. The major potential problems associated with this relict channel are:

- Breaching of the reservoir rim resulting in catastrophic failure of the reservoir; and

- Subsurface seepage resulting in potential downstream piping and/or loss of energy.

As a result of these potential problems a supplemental geotechnical investigation was undertaken in 1982 to define this feature in more detail.

- Location and Configuration

The Watana Relict Channel is located between the present course of the Susitna River and Tsusena Creek and fills an area from the emergency spillway location to Deadman Creek. Borrow Site D is located in the southeast quarter of the channel and overlies the major portion of the inlet area near the Susitna River. The location of the channel is shown on the top of bedrock map (Figure 5.6). The orientation of the relict channel is somewhat irregular but overall it trends northwest southeast. Maximum overburden thickness of 450 feet.

- Geology

Twelve stratigraphic units have been delineated in the Watana Relict Channel/Borrow Site D area (Figure 5.7). These units were differentiated by their physical characteristics, as identified in the field, and by their material properties. These characteristics and properties were used to identify the basic modes of deposition which are described on Figure 5.7. The sediments in the relict channel are interpreted to be Quaternary (Table 5.1) in age and are primarily glacial or glacially related in origin. The oldest sediment in the relict channel are unconsolidated boulders, cobbles and gravels (Unit K) found in the deepest part of the thalweg (Figure 5.8). Following deposition of this Unit K, a major glacial advance deposited the basal till (Unit J). It is likely that during this time the Susitna River was blocked from its old channel and forced south to its present day courses. As this glacier retreated a paraglacial environment of ponded lakes and braided streams developed and deposited Unit J'. Further glacial retreat accompanied by a minor readvance is shown by the deposition of Unit I. Following deposition of Unit I, the area experienced an interglacial stade which resulted in the erosion of the Unit I surface. Stream channels cut into this surface and later became filled with Unit H alluvium. At the close of the interglacial stade, a new ice front advanced across the area depositing the dense basal till of Unit G'. As melting occurred, a proglacial environment developed. Drainage of the meltwaters appears to have been blocked,resulting in the formation of glacial lakes at or near the ice margin. The varied clays and silts of Unit G were deposited in these lakes. Further retreat of the glacier resulted in the draining of the lakes, erosion of the upper Unit G, and the eventual deposition of the outwash silty sands and gravels of Units E and F.

After retreat of the glacier the area was again subjected to an interglacial period. During this time, erosion took place resulting in surface streamflows and inception of lakes in lowland areas. Unit D alluvium and Unit D' lacustrine clays and silts were deposited at this time. During this time a minor readvance of the glacier occurred in the southeastern portion of the Borrow Site D area which resulted in the deposition of the Unit M basal till. At the end of the D/D' interglacial, glaciers again advanced, reworking the upper sediments of Units D, D', E and F. Later, the glacier became stagnated resulting in the in-place mass wasting of the ice and deposition of the ice disintegration Unit C. Meltwater from this ice mass resulted in locally reworking of Unit D. This mass wasting of this last ice mass resulted in the formation of the hummocky knob-and-kettle features which form the present topography. Recent geologic events in the area are confined to post glacial erosion and frost heaving, as represented by Unit A/B.

- Groundwater Conditions

The groundwater regime in the relict channel is complex and poorly understood due to the presence of intermittent permafrost, aquicludes, perched water tables and confined aquifers. Based on drilling it appears that possible artesian or confined water tables exist in Units H and J' while several other units appear to be unsaturated.

A perched water table exists, locally, on top of the impervious Unit G, and possibly on top of Units M, I and J. Permeability testing indicates an average value of 10^{-3} cm/sec for more gravelly materials, and 10^{-4} to 10^{-4} cm/sec for tills and lacustrine deposits.

- Permafrost Conditions

Drillhole samples and ground temperature envelopes from thermistor installations indicate that permafrost in the Watana Relict Channel/Borrow Site D area is primarily freezing temperature water rather than solid phase ice. Maximum observed depth of permafrost is about 40 feet. Most of the visible ice is confined to the annual frost zone (averaging 10 to 15 feet deep) in Units C, D, E and F; and to Units G, G' and H in permafrost zones. Average ground temperature at depth, with the exception of several frozen shallow holes, range 0.5°C to about 1.5°C.

(iii) Fog Lakes Relict Channel

During the 1980-82 geotechnical investigation, a review of the site and regional geology was undertaken to determine if there were any other places in the Watana reservoir where bedrock dropped below maximum pool elevation. The results of that study indicated that bedrock drops below reservoir level in several areas on the south bank of the Susitna River in the area of Fog Lakes (Figure 5.9). Preliminary seismic refraction surveys were undertaken in this area during 1981 with supplemental refraction surveys performed in 1982 (Acres 1982c).

- Location and Configuration

The location of the Fog Lakes Relict Channel is shown on Figure 5.9. The relict channel lies between the bedrock high of the proposed Quarry Site A and the hills of the Mount Watana area approximately seven miles to the east. For discussion purposes, the relict channel can be divided into three sections, the west, central and east sections. The west section lies between the bedrock high of Quarry A and the bedrock high of the central section. The bedrock surface in this area appears to be a series of ridges and valleys. Three of these valleys (from 200 to 800 feet wide) fall below reservoir level.

The central section extends for approximately 4.5 miles east-west. Bedrock in this area is relatively shallow with the majority of the section having bedrock surface above maximum pool level.

The east section of the channel is the largest with a width of from 6000 to 7000 feet wide. This section of the channel consists of a broad area of bedrock above Elevation 2000 flanking a steep sided bedrock gorge trend northeast-southwest.

- Geology

Based on seismic refraction surveys and limited soil outcrops, three types of sediments were delineated in the Fog Lakes Relict Channel:

. Surficial deposits
. Poorly consolidated glacial sediments, and
. Well consolidated glacial sediments

The surficial deposits generally varies from 0 to 40 feet and overlies bedrock and the glacial units. The glacial sediments range up to a maximum thickness of 580 feet with seismic velocities from 4,300 to 10,000 feet per second. The higher velocity material may be partially to completely frozen. Outcrops of glacial sediments are rare. Only till was observed in out crop, however it is likely that other types of glacial and/or glacially-related sediments, similar to the Watana Relict Channel, may be present.

Bedrock in the relict channel area consists of the Cretaceous argillite and graywacke on the west side and Triassic melavolcanic rock to the east (Figure 5.5). The contact between these two units is the Talkeetna Thrust Fault whose location and trend is nearly coincident with the main thalweg of the Fog Lakes Relict Channel.

- Groundwater Conditions

The groundwater table in the area appears to be relatively shallow, as evidenced by poor surface drainage and numerous ponds, lakes and bogs. Drainage of the area is toward the Susitna River to the north and Fog Creek to the south. Groundwater gradients are expected to be steep in the Susitna drainage area and very low toward Fog Creek.

- Permafrost Conditions

Permafrost conditions are likely to be sporadic throughout the area, as evidenced by the existence of typical permafrost features which include black spruce, hummocky tundra, perched ponds on hills and skin flows. Higher seismic velocities of sediments at depth indicate partially to completely frozen material.

(iv) Construction Material Investigation

Investigation of quarry and borrow sites continued during 1982, however the emphasis on this work was in Borrow Site D. Detailed discussion of these sites is presented in Acres Report 1982b.

- Rock Fill Material

Long-term freeze thaw durability testing was completed in 1982. The rock samples from Quarry Site A, consisting of andesite, showed a maximum loss after 150 cycles of just over 2 percent. It is concluded that Quarry A is a good source of thermal and water-deterioration resistant rock, for construction material however, reactivity tests on the andesite should be performed to determine its suitability for concrete aggregate.

No further direct exploration or testing was conducted in Quarry B. However, mapping in the area related to the Watana Relict Channel confirmed the previous conclusions regarding the general unsuitability of this site.

- Core Material

Two potential sources (Borrow Site D and H) of impervious, semi-pervious core material were previously identified (Acres, 1982c). In 1982 exploration of Borrow Site D consisted of geologic mapping, drilling and laboratory testing. Results of this investigation showed that most stratigraphic units above Unit G are suitable borrow material; with Unit E/F exhibiting the most consistent suitable properties. Total volume of borrow material is about 180 million cubic yards over an area of 1130 acres with an excavated depth of 100 feet. The borrow materials consist of nonplastic silty to silty gravelly sands derived from ice disintegration, alluvial outwash deposits (Units C, D, E/F); and local zones of till (Unit M) and lacustrine deposits (Unit D'). Detailed material properties for Borrow Site D are included in Acres Reports 1982 and 1981c.

Thermometer readings indicate that a significant portion of the borrow materials are below freezing in the natural state, however, no temperature below -0.2 C has been detected. In addition, little evidence of ice was observed in the boring. Based on the above, permafrost is not considered to be a problem in borrow site development.

No work with the exception of continued thermistor readings, was performed in Borrow Site H. These readings showed that in all but one hole, the temperatures below the active zone are about +1°C.

- Granular Material

Granular material for filter, shells and concrete aggregate will come primarily from Borrow Sites E and I. Work in these areas consisted of geologic mapping of surficial deposits and completion of laboratory testing. Mapping did not reveal any conditions which would change the data assumptions or reserve calculations presented in Acres Report 1982c.

Freeze-thaw tests performed on aggregate from the Borrow Sites E and I showed losses of 2.3 to 7.8 percent after 140 cycles. The results of the absorption, soundness and abrasion tests show that the aggregate meets the applicable standards for general structural and dam construction. Reactivity test results of the aggregate with cement show negligible adverse reactivity.

(c) Devil Canyon Site

This section summarizes the results of the 1982 geotechnical investigations for the Devil Canyon damsite. The work during this time involved completion of laboratory testing of quarry and concrete aggregate material begun in 1981, and reading of borehole instrumentation installed in 1980-81 for groundwater and temperature monitoring at the damsite. Detailed discussions of the results of this work are in Acres 1982c Report.

(i) Geologic Conditions

No geologic investigations were done at the Devil Canyon damsite in 1982.

(ii) Groundwater Conditions

Groundwater readings during 1982 continued to show a seasonal fluctuation in the two north abutment holes (BH-1 and BH-2) with the level in BH-1 fluctuating from about 50 to 150 vertical feet below the surface, and BH-2 showing water levels equal to or slightly exceeding the collar elevation of the hole. Until failure of the BH piezometer near the lake on the south bank, the readings indicated water levels varying only a few feet from lake level.

(iii) Permafrost Conditions

Thermistor readings in BH-1, BH-2 and BH-3 during 1982 confirm the previous data presented in the 1980-81 Geotechnical Report (Acres 1982b). No permafrost was found in either the bedrock or surficial material at or around the damsite. The depth of annual frost penetration in bedrock is about 10 to 18 feet, with the deepest frost penetration being in May and June. Depth to zero annual amplitude ranges from 40 to 100 feet.

(iv) Permeability

No additional data pertaining to rock permeability was gathered during 1982. The interpretation presented in the Acres 1982b Report remains unchanged.

(v) Devil Canyon Reservoir Geology

Geologic mapping was performed in the upper reaches of the proposed Devil Canyon reservoir as part of the Watana damsite area regional mapping. This area is discussed in Section 5.1(b).

(vi) Construction Material Investigation

Construction material investigation during 1982 was limited to the completion of laboratory testing begun during 1981 of granular materials for filters, shells and aggregate. No further investigation for core material for the saddle dam was undertaken.

- Granular Material

Granular materials will come from Borrow Site G and possibly Quarry Site K (Acres, 1982b). Samples from both areas were tested for suitability as a construction material.

- Borrow Site G

This area was identified as the source for all concrete aggregate, grout sand, and filter gravels and sands. The results of general aggregate suitability tests show that the materials are well within the limits for general construction use in concrete, and the low absorption and high abrasion resistance indicate probable suitability for general aggregate use in roads, filters, and related uses. The freeze-thaw durability tests show only moderate losses up to 150 cycles.

Petrographic analysis of the various material types in Borrow Site G indicate the material near river level to have a more favorable composition and quality than the material in the upper terrace. Chemical reactivity tests to determine the effect of free silicates on concrete were run on this lower level material. Results indicate the aggregate may have an adverse silicate reaction. Based on these test results Borrow Site G appears suitable for all uses at the damsite.

- Quarry Site K

Laboratory testing of granodiorite from Quarry Site K consisted of freeze-thaw durability tests. The tests results showed an 8 percent loss after 150 cycles which is generally considered unacceptable. However, these samples, which were obtained from a surface exposure, were weathered and not representative of clean, fresh quarry rock.

5.4 - Main Dam Alternatives - Watana

(a) Introduction

Assessment between an embankment type and a concrete arch type dam for Watana was presented in Section 9.8 of Acres 1982a Report. Subsequent to the submittal of the Feasibility Report, questions arose regarding the potential feasibility of a concrete faced dam at Watana in lieu of an embankment type. A comparison of these two dam types for Watana are presented in the following section.

(b) Concrete Face Rockfill Type Dam

The selection of a concrete face rockfill dam at Watana would initially appear to offer economic and schedule advantages when compared to a conventional impervious-core rockfill dam. For example, one of the primary areas of concern with the earth-core rockfill dam is the control of water content for the core material and the available construction period during each summer. The core material will have to be protected against frost penetration at the end of each season and the area cleared and prepared to receive new material after each winter. On the other hand, rockfill materials can be worked almost year-round and the quarrying and placing/compacting operations are not affected by rain and only marginally by winter weather.

The concrete face rockfill dam would also require less foundation preparation, since the critical foundation contact area is much less than that for the impervious-core/rock foundation contact. The side slopes for faced rockfill could probably be on the order of 1.5:H to 1: or steeper as compared to the 2.5 and 2.0:H to 1: for the earth-core rockfill. This would allow greater flexibility for layout of the other facilities, in particular the upstream and downstream portals of the diversion tunnels and the tailrace tunnel portals. The diversion tunnels could be shorter, giving further savings in cost and schedule.

However, the height of the Watana Dam as currently proposed is 885 feet, some 70 percent higher than the highest concrete face rockfill dam built to date (the 525-foot high Areia Dam in Brazil completed in 1980). A review of concrete face rockfill dams indicates that increases in height have been typically in the range of 20 percent; for example, Paradela - 370 feet completed in 1955; Alto Anchicaya - 460 feet completed in 1974; Areia - 525 feet completed in 1980. Although recent compacted rockfill dams have generally performed well and rockfill dam is inherently stable even with severe leakage through the face, a one-step increase in height of 70 percent over existing structures is well beyond precedent.

In addition to the height of the dam, other factors which are beyond precedent include the seismic and climatic conditions at in the reservoir which would take many years and involve severe economic penalties from loss of generating capacity.

No concrete face rockfill dam has yet been built in an arctic environment. The drawdown at Watana is in excess of 100 feet and the upper section of the face slab will be subjected to severe freeze/thaw cycles.

Although the face rockfill dam appears to offer schedule advantages, the overall gain in impoundment schedule would not be so significant. With the earth-core rockfill dam, impoundment can be allowed as the dam is constructed. This is not the case for a concrete face rockfill since the concrete face slab is normally not constructed until all rockfill has been placed and construction settlement taken place. The slab is then poured in continuous strips from the foundation to the crest. Most recent high faced rockfill dams also incorporate an impervious earth fill cover over the lower section to minimize the risk of excessive leakage through zones which, because of their depth below normal water level, are difficult to repair. Such a zone at Watana might cover the lower 200 to 300 feet of the slab and require considerable volumes of impervious fill, none of which could be placed until all other construction work had been completed. This work would be on the critical path with respect to impoundment and, at the same time, be subject to interference by wet weather.

The two types of dam were not costed in detail because cost was not considered to be a controlling factor. It is of interest to note, however, that similar alternatives were estimated for the LG 2 project in northern Quebec and the concrete face alternative was estimated to be about 5 per cent cheaper' However, the managers, on the recommendation of their consultants, decided against the use of a concrete face rockfill dam for the required height of 500 feet in that environment.

In summary, a concrete face rockfill dam at Watana is not considered appropriate as a firm recommendation for the feasibility stage of development of the Susitna project because of:

- The 70 percent increase in height over precedent; and
- The possible impacts of high seismicity and climatic conditions.

5.5 - Refinements to General Arrangement

(a) Introduction

This section describes refinements made to the general arrangements of the Watana and Devil Canyon projects since the presentation of the Susitna Hydroelectric Project Feasibility Report (Acres 1982a). Changes have been made in the following areas:

- Watana project power and outlet facilities intakes;
- Devil Canyon project power intake;
- Devil Canyon project main spillway gates;
- Devil Canyon project compensation flow discharge pipe; and
- Devil Canyon main access road.

6 - TRANSMISSION FACILITIES

This section describes the development of transmission facilities from the original Acres American Incorporated Plan of Study of February 1980 through to the filing of the FERC License Application in February 1983.

The major topics covered in the transmission studies include:

- Electric system studies;
- Transmission corridor selection;
- Transmission route selection;
- Transmission towers, foundations and conductors;
- Substations; and
- Dispatch center and communications.

The main body of this section is concerned with the transmission studies that have taken place subsequent to the issuance of the Susitna Hydroelectric Project Feasibility Report in March 1982 (Acres, 1982). These studies included a reassessment of the transmission line corridor within the Central Study Area, and a land acquisition analysis in the Northern, Southern and Central study areas; the purpose of which was to finalize the alignment, and determine the legal descriptions of the rights-of-way. The ways in which these studies have affected each of the six major topics mentioned above are discussed in the following sections.

6.1 PREVIOUS STUDIES

The two previously published reports which contain the most information relevant to the transmission line studies are:

- The Upper Susitna River basin Interim Feasibility Report, prepared by the Corps of Engineers (COE) (U.S. Corps 1975).

- The Economic Feasibility Study for the Anchorage-Fairbanks Intertie, prepared by International Engineering Company, Inc., and Robert Retherford Associates. (IECO/RWRA 1979).

The Corps of Engineers report consisted primarily of an evaluation of alternative corridor locations to aid in the selection of those which maximized reliability and minimized costs. Utilizing aerial photographs and existing maps, general corridors connecting the project site with Anchorage and Fairbanks were selected. This study was general in nature and was intended only to demonstrate project feasibility.

The IECO/RWRA report utilized the COE report as background information for both economic feasibility determination and route selection. The corridor selected by IECO/RWRA was very similar to that selected by the COE with further definition. The route selected was based on shortest length, accessibility and environmental compatibility. The report also presented a detailed economic feasibility study for the Anchorage-Fairbanks transmission intertie.

These two reports together with the various subtask reports published by Acres since the Plan of Study of February 1980 served as the data base for the Susitna Hydroelectric Project Feasibility Report of March 1982, to which this report is a supplement.

6.2 - Electric Systems Studies

Subsequent to the publication of the Feasibility Report in March 1982 (Acres 1982a) the route of the Intertie between Willow and Healy has been finalized. As a result of this the transmission system has undergone the following changes:

At the time the Feasibility Report was published the intertie interconnected with the Susitna transmission system at Devil Canyon. Since then the intertie has been re-routed to the extent that it now passes approximately eight miles to the west of the Devil Canyon damsite. Studies indicated that the optimum arrangement for connecting to the intertie was to construct a switching station on the south bank terraces of the Susitna River at approximately river mile 142. The location of this station, referred to as the Gold Creek Switching Station, together with the location of the intertie and other project features is shown on Figure 6.1. A single line diagram and plan of the switchyard is presented in Figure 6.2.

Following a land acquisition analysis conducted in the latter half of 1982 the transmission line routing was finalized, and the lengths of the various line sections recalculated. Thus Table 14.3 of the Acres Feasibility Report (Acres 1982a) summarizing the transmission system characteristics has been revised to include these updated mileages and the additional switching station at Gold Creek. These revisions are presented sented in Table 6.1

Figure 14.1 of the Feasibility Report, showing the configuration of the recommended system was also changed accordingly and is presented as Figure 6.3.

6.3 - Corridor Identification and Selection

Development of the proposed Susitna project requires a transmission system to deliver electric power to the Railbelt area. The preconstruction of the intertie system will result in a corridor and route for the Susitna transmission lines between Willow and Healy. Therefore three areas were identified as needing further study:

- Northern study area, to connect Healy with Fairbanks;
- Central study area, to connect the Watana and Devil Canyon damsites with the intertie;
- Southern study area, to connect Willow with Anchorage.

The identification of candidate corridors was based on the consideration of previous studies, existing data, aerial reconnaissance and limited field studies. Corridors 3 to 5 miles wide, which met the criteria discussed in paragraph (a) below, were then selected in each of the three study areas.

(a) Selection Criteria

The objective of the corridor selection conducted by Acres was to select feasible transmission line corridors in each of the three study areas, i.e., northern, central and southern. Technical, economic, and environmental criteria were developed to select potential corridors within each of the three areas. These criteria are listed in Table 6.2.

Environmental inventory tables were then compiled for each corridor selected, listing length, number of road crossings, number of river and creek crossings, topography, soils, land ownership/status, existing and proposed development, existing rights-of-way, scenic quality/recreation, cultural resources, vegetation, fish, birds, furbearers, and big game. These tables and a more thorough discussion of the technical, economic, and environmental criteria in Table 6.2 above, are included in the Acres, Transmission Line Corridor Screening Closeout Report of September 1981. (Acres 1981)

Based on this analysis 22 corridors were selected; three in the southern study area, 15 in the central area, and four in the northern study area. Three of the corridors in the southern study area run in a north-south direction, while one runs northeast to Palmer, then northwest to Willow. Corridors in the central area are in two general categories: those running from the Watana damsite west to the intertie, and those running north to the Denali Highway and the Chulitna River. Corridors in the northern study area run either west or east to bypass the Alaskan Range, then proceed north to Fairbanks. The location of these corridors is shown in the Feasibility Report. (Acres 1982a)

(b) Screening Criteria

The selected corridors were then subjected to a further evaluation to determine which ones met the more specific technical, economic, and environmental criteria described in Table 6.3. The rationale for the selection of these criteria is explained in the Closeout Report of September 1981. (Acres 1981)

In addition to these criteria, each corridor was screened for reliability. Six basic factors were considered:

- Elevation: Lines located at elevations below 4000 feet will be less exposed to severe wind and ice conditions which can interrupt service.

- Aircraft: Avoidance of areas near aircraft landing and takeoff operations will minimize the risk of power failures.

- Stability: Avoidance of areas susceptible to land, ice, and snow slides will reduce the chance of power failures.

- Topography: Lines located in areas with gentle relief will be easier to construct, repair, and maintain in operation.

- Access: Lines located in reasonable proximity to transportation corridors will be more quickly accessible and, therefore, more quickly repaired if any failures occur.

The screening criteria and reliability factors for each corridor were evaluated utilizing topographic maps, aerial photos, aerial overflights, and published materials. Each corridor was then assigned four ratings (one each for technical, economic, and environmental considerations, and one overall summary rating). Ratings were defined as follows:

A - recommended
C - acceptable but not preferred
F - unacceptable

From the technical point of view, reliability was the main objective. An environmentally and economically sound corridor was rejected if it would be unreliable. Thus any line which received an F technical rating was assigned a summary rating of F and eliminated from further consideration.

Similarly, because of the critical importance of environmental considerations, any corridor which received an F rating for environmental impacts was assigned a summary rating of F, and eliminated from consideration.

(c) Selected Corridors

In the Feasibility Report (Acres 1982a) the selected transmission corridor consisted of the following segments:

- Southern Study Area   Corridor (2) ADFC
- Central Study Area   Corridor (1) ABCD
- Northern Study Area   Corridor (1) ABC

Descriptions of these corridors and reasons for the rejection of the other corridors are discussed in section 2.F of Exhibit B (Acres 1983). More detail on the screening process and the specific technical, economic and environmental ratings of each alternative is included in Chapter 10, Exhibit E of the FERC License Application (Acres 1983).

However, at the time the Feasibility Report was published the routing of the proposed access road between the damsites was undecided. The location of the access road is of major importance in relation to the transmission line within the Central study area, both in terms of economics and environmental impact. Therefore, following the selection of the Denali-North Plan as the proposed access route in September 1982 the transmission line corridor alternatives in the central study area were reassessed.

- Topography: Lines located in areas with gentle relief will be easier to construct, repair, and maintain in operation.

- Access: Lines located in reasonable proximity to transportation corridors will be more quickly accessible and, therefore, more quickly repaired if any failures occur.

The screening criteria and reliability factors for each corridor were evaluated utilizing topographic maps, aerial photos, aerial overflights, and published materials. Each corridor was then assigned four ratings (one each for technical, economic, and environmental considerations, and one overall summary rating). Ratings were defined as follows:

A - recommended
C - acceptable but not preferred
F - unacceptable

From the technical point of view, reliability was the main objective. An environmentally and economically sound corridor was rejected if it would be unreliable. Thus any line which received an F technical rating was assigned a summary rating of F and eliminated from further consideration.

Similarly, because of the critical importance of environmental considerations, any corridor which received an F rating for environmental impacts was assigned a summary rating of F, and eliminated from consideration.

(c) Selected Corridors

In the Feasibility Report (Acres 1982a) the selected transmission corridor consisted of the following segments:

- Southern Study Area Corridor (2) ADFC
- Central Study Area Corridor (1) ABCD
- Northern Study Area Corridor (1) ABC

Descriptions of these corridors and reasons for the rejection of the other corridors are discussed in section 2.F of Exhibit B (Acres 1983). More detail on the screening process and the specific technical, economic and environmental ratings of each alternative is included in Chapter 10, Exhibit E of the FERC License Application (Acres 1983).

However, at the time the Feasibility Report was published the routing of the proposed access road between the damsites was undecided. The location of the access road is of major importance in relation to the transmission line within the Central study area, both in terms of economics and environmental impact. Therefore, following the selection of the Denali-North Plan as the proposed access route in September 1982 the transmission line corridor alternatives in the central study area were reassessed.

Of the 15 corridors originally considered in the central study area, 11 were found to be unacceptable since they had an overall rating of 'F'. The four remaining corridors were then subjected to a more detailed evaluation and comparison to determine which corridor most closely satisfied the screening criteria.

6.4 - Corridor Reassessment: Central Study Area

The four corridors identified as being acceptable in terms of the technical, economic, and environmental criteria described in the Feasibility Report (Acres 1982a) are corridors one, three, thirteen and fourteen. The four corridors are comprised of the following segments

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

Segments ABC and AJC link Watana with Devil Canyon and, similarly, segments CD and CF link Devil Canyon with the intertie.

In order to more directly compare the four corridors a preliminary route was selected in each of the segments. These routes are shown in Figure 6.4. On closer examination of the two routes between Devil Canyon and the intertie, the route in segment CD was found to be superior to the route in segment CF for the following reasons:

- Economic

  A four wheel drive trail is already in existence on the south side of the Susitna River between Gold Creek and the proposed location of the railhead facility at Devil Canyon. Therefore the need for new roads along segment CD, both for construction and operation and maintenance, is significantly less than for segment CF, which requires the construction of a pioneer road. In addition the proposed Gold Creek to Devil Canyon railroad extension will also run parallel to segment CD. Another primary economic aspect considered was the length of the corridors. However, since the lengths of segments CD and CF are 8.8 miles and 8.7 miles respectively, this was not a significant factor. Amongst the secondary economic considerations is that of topography. Segment CF crosses more rugged terrain at a higher elevation than segment CD and would therefore prove more difficult and costly to construct and maintain. Hence, segment CD was considered to have a higher overall economic rating.

- Technical

  Although both segments are routed below 3000 feet in elevation, segment CF crosses more rugged, exposed terrain with a maximum elevation of 2600 feet. Segment CD on the other hand, traverses flatter terrain and has a maximum elevation of 1800 feet. The disadvantages of segment CF are somewhat offset however by the Susitna River crossing that will be needed at river mile 150 for segment CD. Overall the technical difficulties associated with the two segments may be regarded as being similar.

- Environmental

One of the main concerns of the various environmental groups and agencies is to keep any form of access away from sensitive ecological areas previously inaccessible other than by foot. Creating a pioneer road to construct and maintain a transmission line along segment CF would open that area up to all terrain vehicle and public use, and thereby increase the potential for adverse impacts to the environment. The potential for environmental impacts along segment CD would be present regardless of where the transmission line was built since there is an existing four wheel drive trail, together with the proposed railroad extension in that area. It is clearly desirable to restrict environmental impacts to a single common corridor; for that reason, segment CD is preferable to segment CF.

Because of potential environmental impacts and economic ratings, segment CF was dropped in favor of segment CD. Consequently, corridors Three (AJCF) and Thirteen (ABCF) were eliminated from further consideration.

The two corridors remaining are therefore corridors One (ABCD) and Fourteen (AJCD). This reduces to a comparison of alternate routes in segment ABC on the south side of the Susitna River, and segment AJC on the north side. These routes were then screened in accordance with the criteria set out in the Transmission Line Corridor Screening Closeout Report of September 1981 (Acres 1981). The key points of this evaluation are outlined below:

- Economic

For the Watana development, two 345 kv transmission lines will be constructed from Twatana through to the intertie. When comparing the relative lengths of transmission line, it was found that the southern route utilizing segment ABC was 33.6 miles in total length compared to 36.4 miles for the northern route using segment AJC. Although at first glance a difference in length of 2.8 miles (equivalent to 12 towers at a spacing of 1200 feet) seems significant, other factors were taken into account. Segment ABC contains mostly woodland, black spruce in segment AB. Segment BC contains open and woodland spruce forests, low shrub, and open and closed mixed forest in about equal amounts. Segment AJC, on the other hand, contains significantly less vegetation and is composed predominantly of low shrub and tundra in segment AJ and tall shrub, low shrub and open mixed forest in segment JC. Consequently, the amount of clearing associated with segment AJC is considerably less than with segment ABC, resulting in savings not only during construction but also during periodic recutting. Additional costs would also be incurred with segment ABC due to the increased spans needed to cross the Susitna River (at river mile 165.3) and two other major creek crossings. In summary, the cost differential between the two segments would probably be marginal.

- Technical

The route along segment AJC traverses generally moderately - sloping terrain ranging in height from 2000 feet to 3500 feet with 9 miles of the route being at an elevation in excess of 3000 feet. Route ABC traverses more rugged terrain, crossing several deep ravines and ranges in elevation from 1800 feet to 2800 feet. In general there are advantages of reliability and cost assoicated with transmission lines routed under 3000 feet. The nine miles of route AJC at elevations in excess of 3000 feet will be subject to more severe wind and ice loadings than route ABC, and the towers will have to be designed accordingly. However, these additional costs will be offset by the construction and maintenance problems with the more rugged topography and major river and creek crossings of route ABC. The technical difficulties associated with the two segments are therefore considered similar.

- Environmental

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

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

6.5 - Final Corridor Selection

Table 14.6 of the Feasibility Report (Acres 1982a) which gives the summary of ratings for each of the three corridors was revised following the change to the proposed transmission line corridor in the central study area, the revised table is presented as Table 6.4.

The transmission line corridor presented in the FERC License Application thus changed to:

- Southern Study Area — Corridor (2) — ADFC
- Central Study Area — Corridor (14) — AJCD
- Northern Study Area — Corridor (1) — ABC

A more detailed explanation of the screening and final selection process, with particular reference to environmental constraints is given in Chapter 10 of Exhibit E, of the FERC License Application (Acres 1983).

6.6 - Route Selection

(a) Studies prior to publication of Feasibility Report

The route selection methodology followed in Section 14.3 of the Feasibility Report (Acres 1982a) resulted in the development of recommended routes for each of the three study areas. The data base used in this analysis was obtained from:

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

Many specific routing constraints were identified during the preliminary screening, and others were determined during the 1981 field investigations. These constraints were collated, placed on a base map, and a route of least impact selected.

(b) Studies subsequent to publication of feasibility report

The original corridors which were three to five miles in width were narrowed to a half mile and, after final adjustment, to a finalized route with a defined right-of-way.

As discussed earlier the routing of the transmission line corridor in the central study area was changed so that it shares the same general corridor as the access road between the dams and the railroad extension between Devil Canyon and Gold Creek. The final alignment within this section was chosen to parallel the access road and railroad extension to the maximum extent possible so as to minimize the mileage of new access trail development. It is also desirable to minimize the number of bends in the corridor to keep the number of special structures and therefore the cost to a minimum. With both these objectives in mind the selected alignment, as shown on Figure 6.1 represents the optimum alignment of the transmission line based on existing data.

In the latter half of 1982 a land acquisition analysis was conducted along the length of the transmission line corridor, the purpose of which was to identify areas where land acquisition would present a problem. Additional environmental studies identifying environmentally sensitive areas were also undertaken. These studies have resulted in the alignment being refined along the Northern and Southern corridor stubs to the extent that most of the land acquisition problems, and environmentally sensitive zones have been avoided.

The selected transmission line route for the three study areas is presented in Exhibit G of the FERC License Application (Acres 1983). This route will be subject to some minor revision during the final design phase once the detailed soils investigations and engineering design are completed.

(c) Right-of-way

Preliminary studies have indicated that for a hinged-guyed x-configuration tower the following right-of-way widths should be sufficient.

1 tower	190 feet
2 towers	300 feet
3 towers	400 feet
4 towers	510 feet

These right-of-way widths were developed assuming the following parameters:

- height from tower cross arm to ground 85 feet
- horizontal phase spacing 33 feet
- level terrain (less than 10° slope).

During final design these right-of-way widths may vary slightly where difficult terrain is encountered or the need for special tower structures dictate.

6.7 - Towers, Foundations and Conductors

The types of towers, foundations and conductors to be utilized in the transmission system have not changed since the publication of the Feasibility Report. In general hinged-guyed x-configuration towers, of the type selected for the intertie, will be used. Guyed pole-type structures will be used on larger angle and dead end structures; and a alignment within this section was chosen to parallel the access road and railroad extension to the maximum extent possible so as to minimize the mileage of new access trail development. It is also desirable to minimize the number of bends in the corridor to keep the number of special structures and therefore the cost to a minimum. With both these objectives in mind the selected alignment, as shown on Figure 6.1 represents the optimum alignment of the transmission line based on existing data.

In the latter half of 1982 a land acquisition analysis was conducted along the length of the transmission line corridor, the purpose of which was to identify areas where land acquisition would present a problem. Additional environmental studies identifying environmentally sensitive areas were also undertaken. These studies have resulted in the alignment being refined along the Northern and Southern corridor stubs to the extent that most of the land acquisition problems, and environmentally sensitive zones have been avoided.

The selected transmission line route for the three study areas is presented in Exhibit G of the FERC License Application (Acres 1983). This route will be subject to some minor revision during the final design phase once the detailed soils investigations and engineering design are completed.

(c) Right-of-way

Preliminary studies have indicated that for a hinged-guyed x-configuration tower the following right-of-way widths should be sufficient.

1 tower	190 feet
2 towers	300 feet
3 towers	400 feet
4 towers	510 feet

These right-of-way widths were developed assuming the following parameters:

- height from tower cross arm to ground 85 feet
- horizontal phase spacing 33 feet
- level terrain (less than 10° slope).

During final design these right-of-way widths may vary slightly where difficult terrain is encountered or the need for special tower structures dictate.

6.7 - Towers, Foundations and Conductors

The types of towers, foundations and conductors to be utilized in the transmission system have not changed since the publication of the Feasibility Report. In general hinged-guyed x-configuration towers, of the type selected for the intertie, will be used. Guyed pole-type structures will be used on larger angle and dead end structures; and a

Table 6.1: TRANSMISSION SYSTEM CHARACTERISTICS

Line Section	Length (mi)	Number of Circuits	Voltage (kV)
Watana to Gold Creek	37	2	345
Devil Canyon to Gold Creek	8	2	345
Gold Creek to Willow	79	3	345
Willow to Knik Arm	44	3	345
Knik Arm Crossing*	3	3	345
Knik Arm to University Substation (Anchorage)	19	2	345
Gold Creek to Ester Substation (Fairbanks)	185	2	345

TABLE 6.2 TECHNICAL, ECONOMIC, AND ENVIRONMENTAL CRITERIA USED IN CORRIDOR SELECTION

Type	Criteria	Selection
1. Technical		
- Primary	General Location	Connect with Intertie near Gold Creek, Willow, and Healy. Connect Healy to Fairbanks. Connect Willow to Anchorage.
	Elevation	Avoid mountainous areas.
	Relief	Select gentle relief.
	Access	Locate in proximity to existing transportation corridors to facilitate maintenance and repairs.
- Secondary	River Crossings	Minimize wide crossings.
2. Economical		
- Primary	Elevation	Avoid mountainous areas.
	Access	Locate in proximity to existing transportation corridors to reduce construction costs.
- Secondary	River Crossings	Minimize wide crossings.
	Timbered Areas	Minimize such areas to reduce clearing costs.
	Wetlands	Minimize crossings which require special designs.
3. Environmental		
- Primary	Development	Avoid existing or proposed developed areas.
	Existing Transmission Right-of-Way	Parallel.
	Land Status	Avoid private lands, wildlife refuges, parks.
	Topography	Select gentle relief.
- Secondary	Vegetation	Avoid heavily timbered areas.

TABLE 6.3 TECHNICAL, ECONOMIC AND ENVIRONMENTAL CRITERIA USED IN CORRIDOR SCREENING

Technical

Primary

- Topography
- Climate and Elevation
- Soils
- Length

Secondary

- Vegetation and Clearing
- Highway and River Crossings

Economic

Primary

- Length
- Presence of Right-of-Way
- Presence of Access Roads

Secondary

- Topography
- Stream Crossings
- Highway and Railroad Crossings

Environmental

Primary

- Aesthetic and Visual
- Land Use
- Presence of Existing Right-of-Way
- Existing and Proposed Development

Secondary

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

TABLE 6.4 SUMMARY OF SCREENING RESULTS

Corridor	Env.	Econ.	Tech.	Summary
	RATINGS			
- Southern Study Area				
(1) ABC'	C	C	C	C
*(2) ADFC	A	A	A	A
(3) AEFC	F	C	A	F
- Cental Study Area				
(1) ABCD	C	C	A	C
(2) ABECD	F	C	C	F
(3) AJCF	C	C	C	C
(4) ABCJHI	F	F	F	F
(5) ABECJHI	F	F	F	F
(6) CBAHI	F	C	F	F
(7) CEBAHI	F	F	C	F
(8) CBAG	F	F	C	F
(9) CEBAG	F	F	C	F
(10) CJAG	F	F	C	F
(11) CJAHI	F	C	C	F
(12) JACJHI	F	F	C	F
(13) ABCF	C	C	C	C
*(14) AJCD	A	A	A	A
(15) ABECF	F	C	C	F
- Northern Study Area				
*(1) ABC	A	A	A	A
(2) ABDC	C	A	C	C
(3) AEDC	F	C	F	F
(4) AEF	F	C	F	F

A = recommended
C = acceptable but not preferred
F = unacceptable

*Indicates selected corridor.

8 - ESTIMATES OF COST

This section, originally included as Section 16 in the March 1982 issue of the Feasibility Report, presents estimates of capital and operating costs for the Susitna Hydroelectric Project, comprising the Watana and Devil Canyon developments and associated transmission and access facilities, which have been updated as a result of on-going studies. The costs of design features and facilities incorporated into the project to mitigate environmental impacts during construction and operation are identified. Cash flow schedules, outlining capital requirements during planning, construction, and startup are presented. The approach to the derivation of the capital and operating cost estimates is described.

Changes which have been made in the Watana cost estimate include:

- Access Plan 18 replaced Plan 5 (see Section 4);
- All work leading up to diversion was recosted for an accelerated schedule;
- Storage facilities were provided at Cantwell, and an item for operation and maintenance of these facilities was added to the estimate;
- Material prices were revised to reflect the larger transportation route;
- Quantities were revised for the intake and spillway;
- All work, other than noted above, was estimated on a basis of 10-hour shifts;
- Construction power was re-estimated based on direct generation at site; and
- Contingencies were evaluated for each account.

Changes which have been made in the Devil Canyon cost estimate include:

- Access Plan 18 replaced Plan 5 (see Section 4);
- Intake quantities were revised;
- All work was reestimated on the basis of 10-hour shifts;
- The discussion of operation and maintenance costs was rewritten and Table 8.5 was added to show the breakdown of costs; and
- The cash flow curves were revised and Table 8.6 was added.

The total cost of the Watana and Devil Canyon projects is summarized in Table 8.1. A more detailed breakdown of cost for each development is presented in Tables 8.2 and 8.3.

8.1 - Construction Costs

This section describes the process used for derivation of construction costs and discusses the Code of Accounts established, the basis for the estimates, and the various assumptions made in arriving at the estimates. For general consistency with planning studies, all costs developed for the project are in January 1982 dollars.

(a) Code of Accounts

Estimates of construction costs were developed using the FERC format as outlined in the Federal Code of Regulations, Title 18 (Code of Federal Regulations 1981).

The estimates have been subdivided into the following main cost groupings:

Group	Description
Production Plant	Costs for structures, equipment, and facilities necessary to produce power.
Transmission Plant	Costs for structures, equipment, and facilities necessary to transmit power from the sites to load centers.
General Plant	Costs for equipment and facilities required for the operation and maintenance of the production and transmission plant.
Indirect Costs	Costs that are common to a number of construction activities. For this estimate, only camps and electric power costs have been included in this group. Other indirect costs have been included in the costs under production, transmission, and general plant costs.
Overhead Construction Costs	Costs for engineering and administration.

Further subdivision within these groupings was made on the basis of the various types of work involved, as typically shown in the following example:

- Group:	Production Plant
- Account 332:	Reservoir, Dam, and Waterways
- Main Structure 332.3:	Main Dam
- Element 332.31:	Main Dam Structure
- Work Item 332.311:	Excavation
- Type of Work:	Rock

(b) Approach to Cost Estimating

The estimating process used generally included the following steps:

- Collection and assembly of detailed cost data for labor, material, and equipment as well as information on productivity, climatic conditions, and other related items;

- Review of engineering drawings and technical information with regard to construction methodology and feasibility;

- Production of detailed quantity takeoffs from drawings in accordance with the previously developed Code of Accounts and item listing;

- Determination of direct unit costs for each major type of work by development of labor, material, and equipment requirements; development of other costs by use of estimating guides, quotations from vendors, and other information as appropriate;

- Development of construction indirect costs by review of labor, material equipment, supporting facilities, and overheads; and

- Development of construction camp size and support requirements from the labor demand generated by the construction direct and indirect costs.

The above steps are discussed in detail in the following:

(c) Cost Data

Cost information was obtained from standard estimating sources, from sources in Alaska, from quotes by major equipment suppliers and vendors, and from recent representative hydroelectric projects. Labor and equipment costs for 1982 were developed from a number of sources (Alaska 1982; Caterpillar 1981) and from an analysis of costs for recent projects performed in the Alaska environment.

It has been assumed that most contractors will work an average of two 10-hour shifts per day, 6 days per week. Due to the severe compression of construction activities in 1985-86, it has been assumed that most work in this period will be on two 12-hour shifts, 7 days per week.

The 10-hour work shift assumption provides for high utilization of construction equipment and reasonable levels of overtime earnings to attract workers. The two-shift basis generally achieves the most economical balance between labor and camp costs.

Construction equipment costs were obtained from vendors on an FOB Anchorage basis with an appropriate allowance included for transportation to site. A representative list of construction equipment required for the project was assembled as a basis for the estimate. It has been assumed that most equipment would be fully depreciated over the life of the project. For some activities such as construction of the Watana main dam, an allowance for major overhaul was included rather than fleet replacement. Equipment operating costs were estimated from industry source data, with appropriate modifications for the remote nature and extreme climatic environment of the site; Alaskan labor rates were used for equipment maintenance and repair. Fuel and oil prices have been based upon FOB site prices.

Information for permanent mechanical and electrical equipment was obtained from vendors and manufacturers who provided guideline costs on major power plant equipment..

The costs of materials required for site construction were estimated on the basis of suppliers' quotations, with allowances for shipping to site.

(d) Seasonal Influences on Productivity

A review of climatic conditions, together with an analysis of experience in Alaska and in northern Canada on large construction projects was undertaken to determine the average duration for various key activities. It has been projected that most aboveground activities will either stop or be curtailed during the period of December and January because of the extreme cold weather and the associated lower productivity. For the main dam construction activities, the following assumptions have been used:

- Watana dam fill - 6-month season; and
- Devil Canyon arch dam - 8-month season.

Other aboveground activities are assumed to extend up to 11 months depending on the type of work and the criticality of the schedule. Underground activities are generally not affected by climate and should continue throughout the year.

Studies by others (Roberts 1976) have indicated a 60 percent or greater decrease in efficiency in construction operations under adverse winter conditions. Therefore, it is expected that most contractors would attempt to schedule outside work over a period of 6 to 10 months.

Studies performed as part of this work program indicate that the general construction activity at the Susitna damsite during the months of April through September would be comparable with that in the northern sections of the western United States. Rainfall in the general region of the site is moderate between mid-April and mid-October ranging from a low of 0.75 inch precipitation in April to a high of 5.33 inches in August. Temperatures in this period range from 33°F to 66°F for a twenty-year average. In the five-month period from November through March, the temperature ranges from 9.4°F to 20.3°F with snowfall of 10 inches per month.

(e) Construction Methods

The construction methods assumed for development of the estimate and construction schedule are generally considered as normal and in line with the available level of technical information. A conservative approach has been taken in those areas where more detailed information will be developed during subsequent investigation and engineering programs. For example, normal drilling, blasting, and mucking methods have been assumed for all underground excavation. Also, conventional equipment has been considered for major fill and concrete work. Various construction methods were considered for several of the major work items to determine the most economically practical method. For example, a comprehensive evaluation was made of the means of excavating material from Borrow Site E and the downstream river for the Watana dam shells. A comparison of excavation by dragline, dredge, backhoe, and scraper bucket methods was made, with consideration given to the quantity of material available, distance from the dam, and location in the river or adjacent terraces.

(f) Quantity Takeoffs

Detailed quantity takeoffs were produced from the engineering drawings using methods normal to the industry. The quantities developed are those listed in the detailed summary estimates in Appendix C of the Feasibility Report (Acres 1982a).

(g) Indirect Construction Costs

Indirect construction costs were estimated in detail for the civil construction activities. A more general evaluation was used for the mechanical and electrical work.

Indirect costs included the following:

- Mobilization;
- Technical and supervisory personnel above the level of trades foremen;
- All vehicle costs for supervisory personnel;
- Fixed offices, mobile offices, workshops, storage facilities, and laydown areas, including all services;
- General transportation for workmen onsite and offsite;
- Yard cranes and floats;
- Utilities including electrical power, heat, water, and compressed air;

- Small tools;
- Safety program and equipment;
- Financing;
- Bonds and securities;
- Insurance;
- Taxes;
- Permits;
- Head office overhead;
- Contingency allowance; and
- Profit.

In developing contractor's indirect costs, the following assumptions have been made:

- Mobilization costs have generally been spread over construction items;

- No escalation allowances have been made, and therefore any risks associated with escalation are not included;

- Financing of progress payments has been estimated for 45 days, the average time between expenditure and reimbursement;

- Holdback would be limited to a nominal amount;

- Project all-risk insurance has been estimated as a contractor's indirect cost for this estimate, but it is expected that this insurance would be carried by the owner; and

- Contract packaging would provide for the supply of major materials to contractors at site at cost. These include fuel, electric power, cement, and reinforcing steel.

8.2 - Mitigation Costs

As discussed in previous sections, the project arrangement includes a number of features designed to mitigate potential impacts on the natural environment and on residents and communities in the vicinity of the project. In addition, a number of measures are planned during construction of the project to mitigate similar impacts caused by construction activities. The measures and facilities represent more costs to the project than would normally be required for safe and efficient operation of a hydroelectric development. These mitigation costs have been estimated at $153 million and have been summarized in Table 8.4. In addition, the costs of full reservoir clearing at both sites have been estimated at $65 million. Although full clearing is considered good engineering practice, it is not essential to the operation of the power facilities. These costs include direct and indirect costs, engineering, administration, and contingencies.

A number of mitigation costs are associated with facilities, improvements, or other programs not directly related to the project or located outside the project boundaries. These would include the following items:

- Caribou barriers;
- Fish channels;
- Fish hatcheries;
- Stream improvements;
- Salt licks;
- Recreational facilities;
- Habitat management for moose;
- Fish stocking program in reservoirs; and
- Land acquistion cost for recreation.

It is anticipated that some of these features or programs will not be required during or after construction of the project. In this regard, a probability factor has been assigned to each of the above items, and the estimated cost of each reduced accordingly. The estimated cost of these measures has been covered in the construction contingency.

A number of studies and programs will be required to monitor the impacts of the project on the environment and to develop and record various data during project construction and operation. These include the following:

- Archaeological studies;
- Fisheries and wildlife studies;
- Right-of-way studies; and
- Socioeconomic planning studies.

The costs for the above work have been estimated to be included in the owner's costs under project overheads.

8.3 - Engineering and Administration Costs

Engineering has been subdivided into the following accounts for the purposes of the cost estimates:

- Account 71
  - Engineering and Project Management
  - Construction Management
  - Procurement
- Account 76
  - Owner's Costs

The total cost of engineering and administrative activities has been estimated at 12.5 percent of the total construction costs, including contingencies. This is in general agreement with experience on projects similar in scope and complexity. A detailed breakdown of these costs is dependent on the organizational structure established to undertake design and management of the project, as well as more definitive data relating to the scope and nature of the various project components. However, the main elements of cost included are as follows:

(a) Engineering and Project Management Costs

These costs include allowances for:

- Feasibility studies, including site surveys and investigations and logistics support;
- Preparation of a license application to the FERC;
- Technical and administrative input for other federal, state, and local permit and license applications;
- Overall coordination and administration of engineering, construction management, and procurement activities;
- Overall planning, coordination, and monitoring activities related to cost and schedule of the project;
- Coordination with and reporting to the Power Authority regarding all aspects of the project;
- Preliminary and detailed design;
- Technical input to procurement of construction services, support services, and equipment;
- Monitoring of construction to ensure conformance to design requirements;
- Preparation of startup and acceptance test procedures; and
- Preparation of project operating and maintenance manuals.

(b) Construction Management Costs

Construction management costs have been assumed to include:

- Initial planning and scheduling and establishment of project procedures and organization;
- Coordination of onsite contractors and construction management activities;
- Administration of onsite contractors to ensure harmony of trades, compliance with applicable regulations, and maintenance of adequate site security and safety requirements;
- Development, coordination, and monitoring of construction schedules;
- Construction cost control;
- Material, equipment, and drawing control;
- Inspection of construction and survey control;
- Measurement for payment;
- Startup and acceptance test for equipment and systems;
- Compilation of as-constructed records; and
- Final acceptance.

(c) Procurement Costs

Procurement costs have been assumed to include:

- Establishment of project procurement procedures;
- Preparation of nontechnical procurement documents;
- Solicitation and review of bids for construction services, support services, permanent equipment, and other items required to complete the project;
- Cost administration and control for procurement contracts; and
- Quality assurance services during fabrication or manufacture of equipment and other purchased items.

(d) Owner's Costs

Owner's costs have been assumed to include the following:

- Administration and coordination of project management and engineering organizations;
- Coordination with other state, local, and federal agencies and groups having jurisdiction or interest in the project;
- Coordination with interested public groups and individuals;
- Reporting to legislature and the public on the progress of the project; and
- Legal costs (Account 72).

8.4 - Operation, Maintenance, and Replacement Costs

The facilities and procedures for operation and maintenance of the project are described in Section 15 of the Feasibility Report (Acres 1982a). Assumptions for the size and extent of these facilities have been made on the basis of experience at large hydroelectric developments in northern climates. The annual costs for operation and maintenance for the Watana development have been estimated at $10 million. When Devil Canyon is brought on-line, these costs increase to $15.2 million per annum. Interim replacement costs have been estimated at 0.3 percent per annum of the capital cost.

The breakdown in Table 8.5 is provided in support of the allowance used in the finance/economic analysis of Susitna Hydroelectric Power Development. It is based on an operating plan involving full staffing of power plant and permanent town site support with a total of 105 personnel at Watana with another 25 when Devil Canyon comes on-line. This provides manned supervisory staff on a 24-hour, 3-shift basis and maintenance crews to handle all but major overhauls. Overhauls would involve contracted labor for which a nominal allowance has been allowed. It recognized that major overhauls are normally unlikely in the first 10 years or more of plant life. In earlier years, this allowance was a prudent provision for unexpected startup costs over and above those covered by warranty.

The allowance for contracted services also covers helicopter operations and access road snow clearing/maintenance.

Allowances have also been made for environmental mitigation as well as for a contingency for unforeseen costs.

Estimates for Susitna have been based both on original estimate and actual experience at Churchill Falls. It should be realized that alternative operating plans are possible which eliminate the need for permanent townsite facilities and rely on more remote supervisory systems and/or on operations/maintenance crews transported to the plant on rotating shift basis. Cost implications of these alternatives have not yet been examined.

8.5 - Allowance for Funds Used During Construction

At current high levels of interest rates in the financial marketplace, AFDC will amount to a significant element of financing cost for the lengthy periods required for construction of the Watana and Devil Canyon projects. However, in economic evaluations of the Susitna project, the low real rates of interest assumed would have a much reduced impact on assumed project development costs. Furthermore, direct state involvement in financing of the Susitna project will also have a significant impact on the amount, if any, of AFDC. For purposes of the feasibility study, therefore, the conventional practice of calculating AFDC as a separate line item for inclusion as part of project construction cost has not been followed. Provisions for AFDC at appropriate rates of interest are made in the economic and financial analyses described in Section 18 of the Feasibility Report (Acres 1982a)

8.6 - Escalation

All costs presented in this section are at January 1982 levels, and consequently include no allowance for future cost escalation. Thus, these costs would not be truly representative of construction and procurement bid prices because provision must be made in such bids for continuing escalation of costs and the extent and variation of escalation that might take place over the lengthy construction periods involved. Economic and financial evaluations discussed in Section 18 of the Feasibility Report take full account of such escalation at appropriately assumed rates.

8.7 - Cash Flow and Manpower Loading Requirements

The cash flow requirements for construction of Watana and Devil Canyon are an essential input to economic and financial planning studies. The basis for the cash flow are the construction cost estimates in January 1982 dollars and the construction schedules presented in Section 9, with no provision being made as such for escalation. The cash flow estimates were computed on an annual basis and do not include adjustments for advanced payments for mobilization or for holdbacks on construction contracts. The results are presented in Table 8.6 and Figures 8.1 through 8.3. The manpower loading requirements were developed from cash flow projections. These curves were used as the basis for camp loading and associated socioeconomic impact studies.

8.8 - Contingency

An overall contingency allowance of approximately 15 percent of construction costs has been included in the cost estimates. Contingencies have been assessed for each account and range from 10 to 20 percent. The contingency includes cost increases which may occur in the detailed engineering phase of the project after more comprehensive site investigations and final designs have been completed and after the requirements of various concerned agencies have been considered. The contingency estimate also includes allowances for inherent uncertainties in cost of labor, equipment and materials, and for unforeseen conditions which may be encountered during construction. Escalation in costs due to inflation is not included. No allowance has been included for costs associated with significant delays in project implementation.

8.9 - Previously Constructed Project Facilities

An electrical intertie between the major load centers of Fairbanks and Anchorage is currently under construction. The line will connect existing transmission systems at Willow in the south and Healy in the north. The intertie is being built to the same standards as those proposed for the Susitna project transmission lines and will become part of the licensed project. The line will be energized initially at 138 kV in 1984 and will operate at 345 kV after the Watana phase of the Susitna project is complete.

The current estimate for the completed intertie is $130.8 million.

8.10 - Check Estimate by EBASCO

An independent check estimate was undertaken by EBASCO Services Incorporated. The estimate was based on engineering drawings, technical information, and quantities prepared by Acres. Major quantity items were checked. The EBASCO check estimated capital cost was approximately 7 percent above the Acres estimate.

A meeting was held with the Power Authority, EBASCO, and Acres to review differences in the estimates. It was generally possible to reconcile the differences and it was concluded that no major changes were required in the Feasibility Report Estimate.

TABLE 8.1: SUMMARY OF COST ESTIMATE

Category	Watana	Devil Canyon	Total
	January 1982 Dollars $ X 10^6		
Production Plant	$2,293	$1,069	$3,362
Transmission Plant	456	105	561
General Plant	5	5	10
Indirect	429	212	641
Total Construction	3,183	1,391	4,574
Overhead Construction	398	174	572
TOTAL PROJECT	$3,581	$1,565	$5,146

TABLE 8.2

WATANA

ESTIMATE SUMMARY

ACRES

CLIENT: ALASKA POWER AUTHORITY

PROJECT: SUSITNA HYDROELECTRIC PROJECT

TYPE OF ESTIMATE: Feasibility

APPROVED BY: JDL

JOB NUMBER: P5700.00

FILE NUMBER: P5700.14.09

SHEET 1 OF 5

BY ____ DATE ____

CHKD JRP DATE 2/82

No.	DESCRIPTION	AMOUNT	TOTALS	REMARKS
		(x 10^6)	(x 10^6)	
	PRODUCTION PLANT			
330	Land & Land Rights	$ 51		
331	Powerplant Structures & Improvements	74		
332	Reservoir, Dams & Waterways	1,547		
333	Waterwheels, Turbines & Generators	66		
334	Accessory Electrical Equipment	21		
335	Miscellaneous Powerplant Equipment (Mechanical)	14		
336	Roads & Railroads	214		
	Subtotal	1,987		
	Contingency	306		
	TOTAL PRODUCTION PLANT		$ 2,293	

TABLE 8.2

WATANA

ESTIMATE SUMMARY

ACRES

CLIENT ALASKA POWER AUTHORITY

PROJECT SUSITNA HYDROELECTRIC PROJECT

TYPE OF ESTIMATE Feasibility

APPROVED BY JDL

JOB NUMBER P5700.00

FILE NUMBER P5700.14.09

SHEET 2 OF 5

BY DATE

CHKD JRP DATE 2/82

No.	DESCRIPTION	AMOUNT	TOTALS	REMARKS
		(x 10^6)	(x 10^6)	
	TOTAL BROUGHT FORWARD		$ 2,293	
	TRANSMISSION PLANT			
350	Land & Land Rights	$ 8		
352	Substation & Switching Station Structures & Improvements	12		
353	Substation & Switching Station Equipment	131		
354	Steel Towers & Fixtures	131		
356	Overhead Conductors & Devices	100		
359	Roads & Trails	13		
	Subtotal	395		
	Contingency	61		
	TOTAL TRANSMISSION PLANT		$ 456	
			$ 2,749	

ACRES	**ESTIMATE SUMMARY**	TABLE 8.2 WATANA		JOB NUMBER P5700.00
	CLIENT ALASKA POWER AUTHORITY		TYPE OF ESTIMATE Feasibility	FILE NUMBER P5700.14.09
	PROJECT SUSITNA HYDROELECTRIC PROJECT		APPROVED BY JDL	SHEET 3 OF 5
				BY ___ DATE ___
				CHKD JRP DATE 2/82

No.	DESCRIPTION	AMOUNT	TOTALS	REMARKS
		(x 10^6)	(x 10^6)	
	TOTAL BROUGHT FORWARD		$ 2,749	
	GENERAL PLANT			
389	Land & Land Rights	$ -		Included under 330
390	Structures & Improvements	-		Included under 331
391	Office Furniture/Equipment			Included under 399
392	Transportation Equipment			" "
393	Stores Equipment			" "
394	Tools Shop & Garage Equipment			" "
395	Laboratory Equipment			" "
396	Power-Operated Equipment			" "
397	Communications Equipment			" "
398	Miscellaneous Equipment			" "
399	Other Tangible Property	5		
	TOTAL GENERAL PLANT		$ 5	
			$ 2,754	

TABLE 8.2

WATANA

ESTIMATE SUMMARY

ACRES

CLIENT ALASKA POWER AUTHORITY

PROJECT SUSITNA HYDROELECTRIC PROJECT

TYPE OF ESTIMATE Feasibility

APPROVED BY JDL

JOB NUMBER P5700.00

FILE NUMBER P5700.14.09

SHEET 4 OF 5

BY ____ DATE ____

CHKD JRP DATE 2/82

No.	DESCRIPTION	AMOUNT (x 10^6)	TOTALS (x 10^6)	REMARKS
	TOTAL BROUGHT FORWARD		$ 2,754	
	INDIRECT COSTS			
61	Temporary Construction Facilities	$ -		See Note
62	Construction Equipment	-		See Note
63	Camp & Commissary	373		
64	Labor Expense	-		
65	Superintendence	-		See Note
66	Insurance	-		See Note
69	Fees	-		See Note
	Note: Costs under accounts 61, 62, 64, 65, 66, and 69 are included in the appropriate direct costs listed above.			
	Subtotal	373		
	Contingency	56		
	TOTAL INDIRECT COSTS		$ 429	
	TOTAL CONSTRUCTION COSTS		$ 3,183	

ACRES

ESTIMATE SUMMARY

TABLE 8.2

WATANA

CLIENT: ALASKA POWER AUTHORITY

PROJECT: SUSITNA HYDROELECTRIC PROJECT

TYPE OF ESTIMATE: Feasibility

APPROVED BY: JDL

JOB NUMBER: P5700.00
FILE NUMBER: P5700.14.09
SHEET 5 OF 5
BY ____ DATE ____
CHKD JRP DATE 2/82

No.	DESCRIPTION	AMOUNT ($x 10^6$)	TOTALS ($x 10^6$)	REMARKS
	TOTAL CONSTRUCTION COSTS BROUGHT FORWARD		$ 3,183	
	OVERHEAD CONSTRUCTION COSTS (PROJECT INDIRECTS)			
71	Engineering/ Administration	$ 398		
72	Legal Expenses	-		Included in 71
75	Taxes	-		Not applicable
76	Administrative & General Expenses	-		Included in 71
77	Interest	-		Not included
80	Earnings/Expenses During Construction	-		Not included
	Total Overhead		398	
	TOTAL PROJECT COST		$ 3,581	

ACRES

ESTIMATE SUMMARY

TABLE 8.3

DEVIL CANYON

CLIENT ALASKA POWER AUTHORITY

PROJECT SUSITNA HYDROELECTRIC PROJECT

TYPE OF ESTIMATE Feasibility

APPROVED BY JDL

JOB NUMBER P5700.00

FILE NUMBER P5700.14.09

SHEET 1 OF 5

BY DATE

CHKD JRP DATE 2/82

No.	DESCRIPTION	AMOUNT (x 10⁶)	TOTALS (x 10⁶)	REMARKS
	PRODUCTION PLANT			
330	Land & Land Rights	$ 22		
331	Powerplant Structures & Improvements	72		
332	Reservoir, Dams & Waterways	646		
333	Waterwheels, Turbines & Generators	42		
334	Accessory Electrical Equipment	14		
335	Miscellaneous Powerplant Equipment (Mechanical)	12		
336	Roads & Railroads	119		
	Subtotal	927		
	Contingency	142		
	TOTAL PRODUCTION PLANT		$ 1,069	

ACRES

ESTIMATE SUMMARY

TABLE 8.3

DEVIL CANYON

CLIENT: ALASKA POWER AUTHORITY

PROJECT: SUSITNA HYDROELECTRIC PROJECT

TYPE OF ESTIMATE: Feasibility

APPROVED BY: JDL

JOB NUMBER: P5700.00

FILE NUMBER: P5700.14.09

SHEET 2 OF 5

BY ______ DATE ______

CHKD JRP DATE 2/82

No.	DESCRIPTION	AMOUNT	TOTALS	REMARKS
		($x 10^6$)	($x 10^6$)	
	TOTAL BROUGHT FORWARD		$ 1,609	
	TRANSMISSION PLANT			
350	Land & Land Rights	$ -		Included in Watana Estimate
352	Substation & Switching Station Structures & Improvements	7		
353	Substation & Switching Station Equipment	21		
354	Steel Towers & Fixtures	29		
356	Overhead Conductors & Devices	34		
359	Roads & Trails	-		Included in Watana Estimate
	Subtotal	91		
	Contingency	14		
	TOTAL TRANSMISSION PLANT		$ 105	
			$ 1,174	

TABLE 8.3

ESTIMATE SUMMARY

DEVIL CANYON

ACRES

CLIENT: ALASKA POWER AUTHORITY

PROJECT: SUSITNA HYDROELECTRIC PROJECT

TYPE OF ESTIMATE: Feasibility

APPROVED BY: JDL

JOB NUMBER: P5700.00

FILE NUMBER: P5700.14.09

SHEET 3 OF 5

BY ____ DATE ____

CHKD JRP DATE 2/82

No.	DESCRIPTION	AMOUNT	TOTALS	REMARKS
		(x 10⁶)	(x 10⁶)	
	TOTAL BROUGHT FORWARD		$ 1,174	
	GENERAL PLANT			
389	Land & Land Rights	$		Included under 330
390	Structures & Improvements			Included under 331
391	Office Furniture/Equipment			Included under 399
392	Transportation Equipment			" "
393	Stores Equipment			" "
394	Tools Shop & Garage Equipment			" "
395	Laboratory Equipment			" "
396	Power Operated Equipment			" "
397	Communications Equipment			" "
398	Miscellaneous Equipment			" "
399	Other Tangible Property	5		
	TOTAL GENERAL PLANT		$ 5	
			$ 1,179	

ESTIMATE SUMMARY

TABLE 8.3

DEVIL CANYON

ACRES

CLIENT ALASKA POWER AUTHORITY

PROJECT SUSITNA HYDROELECTRIC PROJECT

TYPE OF ESTIMATE Feasibility

APPROVED BY JDL

JOB NUMBER P5700.00

FILE NUMBER P5700.14.09

SHEET 4 OF 5

BY DATE

CHKD JRP DATE 2/82

No.	DESCRIPTION	AMOUNT	TOTALS	REMARKS
		(x 10^6)	(x 10^6)	
	TOTAL BROUGHT FORWARD		$ 1,179	
	INDIRECT COSTS			
61	Temporary Construction Facilities	$ -		See Note
62	Construction Equipment	-		See Note
63	Camp & Commissary	184		
64	Labor Expense	-		See Note
65	Superintendence	-		See Note
66	Insurance	-		See Note
69	Fees	-		See Note
	Note: Costs under accounts 61, 62, 64, 65, 66, and 69 are included in the appropriate direct costs listed above.			
	Subtotal	184		
	Contingency	28		
	TOTAL INDIRECT COSTS		$ 212	
	TOTAL CONSTRUCTION COSTS		$ 1,391	

ACRES

ESTIMATE SUMMARY

TABLE 8.3

DEVIL CANYON

CLIENT ALASKA POWER AUTHORITY

PROJECT SUSITNA HYDROELECTRIC PROJECT

TYPE OF ESTIMATE Feasibility

APPROVED BY JDL

JOB NUMBER P5700.00

FILE NUMBER P5700.14.09

SHEET 5 OF 5

BY DATE

CHKD JRP DATE 2/82

No.	DESCRIPTION	AMOUNT (x 10^6)	TOTALS (x 10^6)	REMARKS
	TOTAL CONSTRUCTION COSTS BROUGHT FORWARD		$ 1,391	
	OVERHEAD CONSTRUCTION COSTS (PROJECT INDIRECTS)			
71	Engineering	$ 174		
72	Legal Expenses	-		Included in 71
75	Taxes	-		Not Applicable
76	Administrative & General Expenses	-		Included in 71
77	Interest	-		Not Included
80	Earnings/Expenses During Construction	-		Not Included
	Total Overhead Costs		174	
	TOTAL PROJECT COST		$ 1,565	

TABLE 8.4: MITIGATION MEASURES - SUMMARY OF COSTS INCORPORATED IN CONSTRUCTION COST ESTIMATES

COSTS INCORPORATED IN CONSTRUCTION ESTIMATES	WATANA $ X 10^3	DEVIL CANYON $ X 10^3	
Outlet Facilities			
Main Dam at Devil Canyon		14,600	
Tunnel Spillway at Watana	47,100		
Restoration of Borrow Area D	1,600	NA	
Restoration of Borrow Area F	600	NA	
Restoration of Camp and Village	2,300	1,000	
Restoration of Construction Sites	4,100	2,000	
Fencing around Camp	400	200	
Fencing around Garbage Disposal Area	100	100	
Multilevel Intake Structure	18,400	NA	
Camp Facilities Associated with trying to Keep Workers out of Local Communities	10,200	9,000	
Restoration of Haul Roads	800	500	
SUBTOTAL	85,600	27,400	
Contingency 20%	17,100	5,500	
TOTAL CONSTRUCTION	102,700	32,900	
Engineering 12.5%	12,800	4,100	
TOTAL PROJECT	115,500	37,000	152,500

TABLE 8.5

SUMMARY OF OPERATING AND MAINTENANCE COSTS

	WATANA ($ 000's Omitted)			DEVIL CANYON ($ 000's Omitted)		
	Labor	Expense Items	Subtotal	Labor	Expense Items	Subtotal
Power and Transmission Operation/ Maintenance	5,330	990	6,320	1,920	500	2,420
Contracted Services	--	900	900	--	480	480
Permanent Townsite Operations	540	340	880	120	80	200
Allowance for Environmental Mitigation	--	--	1,000	--	--	1,000
Contingency	--	--	900	--	--	500
			$10,000			$ 4,600
Additional Allowance from 2002 to Replace Community Facilities			400			200
Total Operating and Maintenance Expenditure Estimate Power Development and Transmission Facilities		WATANA	$10,400		DEVIL CANYON	$ 4,800

TABLE 8.6

SUSITNA HYDROELECTRIC PROJECT

Watana & Devil Canyon
Cumulative & Annual Cash Flow

JANUARY 1982 DOLLARS - IN MILLIONS

	ANNUAL CASH FLOW			CUMULATIVE CASH FLOW (TO END OF YEAR)		
YEAR	WATANA	DEVIL CANYON	COMBINED	WATANA	DEVIL CANYON	COMBINED
1981	27.6		27.6	27.6		27.6
82	12.9		12.9	40.5		40.5
83	28.7		28.7	69.2		69.2
84	48.5		48.5	117.7		117.7
85	198.6		198.6	316.3		316.3
86	282.7		282.7	599.0		599.0
87	294.1		294.1	893.1		893.1
88	367.4		367.4	1260.5		1260.5
89	436.5		436.5	1697.0		1697.0
90	624.9		624.9	2321.9		2321.9
91	606.2	4.9	611.1	2928.1	4.9	2933.0
92	427.2	48.1	475.3	3355.3	53.0	3408.3
93	152.5	68.9	221.4	3507.8	121.7	3629.7
94	73.4	64.6	138.0	3581.2	186.5	3767.7
95		65.2	65.2		251.7	3832.9
96		115.8	115.8		367.5	3948.7
97		204.2	204.2		571.7	4152.9
98		295.1	295.1		866.8	4448.0
99		281.0	281.0		1147.8	4729.0
2000		242.8	242.8		1390.6	4971.8
2001		156.7	156.7		1547.3	5128.5
2002		17.7	17.7		1565.0	5146.2
TOTAL	3581.2	1565.0	5146.2			

11/08/82, REVISED DEVIL CANYON CASH FLOW

9 - DEVELOPMENT SCHEDULES

This section, originally included as Section 17 in the March 1982 issue of the Feasibility Report (Acres 1982a), describes the development schedules prepared for both Watana and Devil Canyon to meet the on-line power requirements of 1993 and 2002, respectively. These schedules have been updated as a result of on-going studies; they span the period from 1983 until 2004. Schedules for the development of both Watana and Devil Canyon are shown in Figures 9.1 and 9.2. The main elements of the project have been shown on these schedules, as well as some key interrelationships. For purposes of planning, it has been assumed that a license will be awarded by December 31, 1984.

Revisions to the Watana schedule include the following:

- The pioneer road was replaced by Denali Access Plan 18. Work prior to receipt of the FERC license was eliminated;
- Activities leading up to diversion were revised for an accelerated schedule; and
- The pre-construction of one circuit of the permanent transmission line from Gold Creek was eliminated.

Revisions to the Devil Canyon schedule include the following:

- Denali Access Plan 18 was incorporated, and the start of access construction was advanced accordingly.

9.1 - Preparation of Schedules

Preliminary schedules were first developed by estimating the durations of the main construction activities and arranging these in logical sequence. Some activity adjustments were then made to reduce excessive demands on resources, such as underground excavation or concrete placing. The preliminary schedules were then used as a basis for the preparation of cost estimates. The schedules were also reviewed for overall compatability with major constraints such as licensing, on-line power requirements, and reservoir filling.

At both sites the period for construction of the main dam is critical; other activities are fitted to the main dam work. A study of the front end requirements of Watana concluded that initial access work should commence immediately after receipt of license and be completed in the shortest possible time to permit a sufficiently rapid buildup of manpower and equipment to meet construction requirements.

During development of the final project arrangement and preparation of the cost estimates (Section 8), the preliminary schedules were modified and refined. As estimating data were developed, the production rates and construction durations were calculated. Networks were developed for the main construction activities and the durations and sequences of activities determined. The overall schedules were modified to suit.

9.2 - Watana Schedule

Commencement of construction:

Initial access road	- April 1985
Site facilities	- April 1985
Diversion	- July 1985

Completion of construction:

Four of six units ready	- January 1994
Six units ready	- July 1994

Commencement of commercial operations:

Four of six units	- January 1994
Six units	- July 1994

The Watana schedules were developed to meet two overall project constraints:

- FERC license would be issued by December 31, 1984; and
- Four units would be on-line by the end of 1993.

The critical path of activities to meet the overall constraints was determined to be through site access, site facilities, diversion and main dam construction. In general construction activities leading up to diversion in 1987 are on an accelerated schedule whereas the remaining activities are a normal schedule. These are highlighted as follows:

(i) Access

Initial road access to the site is required by October 1, 1985. Certain equipment will be transported overland during the preceeding winter months so that an airfield can be constructed by July 1985. This effort to complete initial access is required to mobilize labor, equipment, and materials in 1985 for the construction of site facilities and diversion works.

(ii) Site Facilities

Site facilities must be developed in a very short time to support the main construction activities. A camp to house approximately 1,000 men must be constructed during the first 18 months. Site construction roads and contractors' work area have to be started. An aggregate processing plant and concrete batching plant must be operational to start diversion tunnel concrete work by April 1986. At site, power generating equipment must be installed in 1985 to supply power for camp and construction activities.

(iii) Diversion

Construction of diversion and dewatering facilities, the first major activity, should start by mid-1985. Excavation of the portals and tunnels requires a concentrated effort to allow completion of the lower tunnel for river diversion by October 1986. The upper tunnel is needed to handle the spring runoff by May 1987. The upstream cofferdam must be placed to divert riverflows in October 1986 and raised sufficiently to avoid overtopping by the following spring.

(iv) Main Dam

The progress of work in the main dam is critical throughout the period 1986 through 1992. Mobilization of equipment and start of site work must begin in 1986. Excavation on the right abutment, as well as river alluvium under the dam core, begins in 1986. During 1987 and 1988, dewatering, excavation, and foundation treatment must be completed in the riverbed area and a substantial start made on placing fill. The construction schedule is based on the following program:

Year	Quantity ($yd^3 \times 10^6$)	Accumulated Quantity ($yd^3 \times 10^6$)	Fill Elevation October 15 (feet)	Reservoir Elevation (feet)
1987	3	--	--	--
1988	6	9	--	--
1989	12	21	1660	--
1990	13	34	1810	1460
1991	13	47	1950	1865
1992	12	59	2130	2050
1993	3	62	2210	2185

The program for fill placing has been based on an average six months season. It has been developed to provide high utilization of construction equipment required to handle and process fill materials.

(v) Spillways and Intakes

These structures have been scheduled for completion one season in advance of the requirement to handle flows. In general, excavation for these structures does not have to begin until most of the excavation work has been completed for the main dam.

(vi) Powerhouse and Other Underground Works

The first four units are scheduled to be on line by late 1993 and the remaining two units in early 1994. Excavation of the access tunnel into the powerhouse complex has been scheduled to start in late 1987. Stage I concrete begins in 1989 with start of installation of major mechanical and electrical work in 1991. In general, the underground works have been scheduled to level resource demands as much as possible.

(vii) Transmission Lines/Switchyards

Construction of the transmission lines and switchyards have been scheduled to begin in 1989 and be completed before commissioning of the first unit.

(viii) General

The Watana schedule requires that extensive planning, bid selection and commitments are made before the end of 1984 to permit work to progress on schedule during 1985 and 1986. The rapid development of site activities requires commitments, particularly in the areas of access and site facilities in order that construction operations have the needed support.

The schedule has also been developed to take advantage of possible early reservoir filling to the minimum operating level by October 1992. Should this occur, power could possibly be generated by the end of 1992.

9.3 - Devil Canyon Schedule

Commencement of construction:

Main access - April 1992
Site facilities - June 1994
Diversion - June 1995

Completion of construction:

Four units - October 2002

Commencement of commercial operations:

Four units - October 2002

The Devil Canyon schedule was developed to meet the on-line power requirement of all four units in 2002. The critical path of activities was determined to follow through site facilities, diversion and main dam construction.

(i) Access

It has been assumed that site access facilities built to Watana will exist at the start of construction. A road will be constructed connecting the Devil Canyon site to the Watana access road including a high level bridge over the Susitna River downstream from the Devil Canyon dam. At the same time, a railroad spur will be constructed to permit railroad access to the south bank of the Susitna near Devil Canyon. These activities will be completed by mid-1994.

(ii) Site Facilities

Camp facilities should be started in 1994. It has been assumed that buildings can be salvaged from Watana. Site roads and power could also be started at this time.

(iii) Diversion

Excavation and concreting of the single diversion tunnel should begin in 1995. River closure and cofferdam construction will take place to permit start of dam construction in 1997.

(iv) Arch Dam

The construction of the arch dam will be the most critical construction activity from start of excavation in 1996 until topping out in 2001. The concrete program has been based on an average 8-month placing season for 4-1/2 years. The work has been scheduled so that a fairly constant effort may be maintained during this period to make best use of equipment and manpower.

(v) Spillways and Intake

The spillway and intake are scheduled for completion by the end of 2000 to permit reservoir filling the next year.

(vi) Powerhouse and Other Underground Works

Excavation of access into the powerhouse cavern is scheduled to begin in 1996. Stage I concrete begins in 1998 with start of installation of major mechanical and electrical work in 2000.

(vii) Transmission Lines/Switchyards

The additional transmission facilities needed for Devil Canyon have been scheduled for completion by the time the final unit is ready for commissioning in late 2001.

(viii) General

The development of site facilities at Devil Canyon begins slowly in 1994 with a rapid acceleration in 1995 through 1997. Within a short period of time, construction begins on most major civil structures. This rapid development is dependent on the provision of support site facilities which should be completed in advance of the main construction work.

9.4 - History of Existing Project

An intertie is planned to permit the economic interchange of up to 70 megawatts of power between major load centers at Anchorage and Fairbanks. Connecting to existing transmission systems at Willow in the south and Healy in the north, the intertie will be built to the same standards as those proposed for the Susitna project transmission system. It will be energized initially at 138 kv. Subsequent to construction of the Watana project, the intertie will be incorporated into the Susitna transmission system and will operate at 345 kV.

Construction of the intertie is scheduled to begin in March 1983. Completion and initial operation is planned for September 1984, well in advance of the anticipated date for receipt of a FERC license on December 31, 1984.

10 - ECONOMIC, MARKETING, AND FINANCIAL EVALUATION

10.1 - Introduction

The purpose of this section is to document the changes and further studies which have taken place since the publication of the Feasibility Report (Acres 1982). There have been few changes in the financial studies presented. For the FERC license application, a calculation for the cost of power was made and a financing plan was selected as the most probable.

In August, a report reviewing the Feasibility Study from a financial purview was published by Arlon Tussing and Associates. The findings of this report prompted a reassessment and update of several underlying factors in the financial and risk analyses. The results of those considerations are presented in Subsection 10.5.

The third area of update is in the generation planning studies which formed the basis of the project economic analysis. One critical factor of change is in the change in the cost of the projects. The impact of the cost change on the economic and financial analyses has been addressed.

Similar to project costs, a change in the proposed project operation has been made since the Feasibility Report. The change resulted from mitigation studies involving the maintenance of downstream flows for fishery spawning. As a result of the operation change, the energy produced by the plant and the monthly distribution has changed. The impacts of this shift on project economics have been reviewed.

The primary tool used for generation planning studies is the General Electric Optimized Generation Planning (OGP) simulation model. Version 5 of the model was used for the feasibility report analysis. In May 1982, GE released Version 6 of the program. The changes in the program and its impacts on study results have been checked and documented in Subsection 10.6.

Finally, there were several issues raised in reviews of the Feasibility Report. These issues included the assessment of Watana, Devil Canyon, and Chakachamna as single projects and an alternative staging from the recommended plan. They are:

- The impact of changing probabilities in the multivariate sensitivity analysis;

- A discussion of percent reserve margins;

- Annual system cost components; and

- Delay of the project.

The following subsections address each of the areas mentioned individually.

10.2 - Cost of Power

One requirement of Exhibit D of the FERC license application was for an annual cost to be presented. As a two-stage (Watana and Devil Canyon) development with varying levels of energy output and the assumption of ongoing inflation (at 7 percent per annum), the real cost of Susitna power will be continually varying. As a consequence, no simple, single-value real cost of power can be used. For the purposes of the application, the following cost was adopted.

Table D.7 in Exhibit D (Acres 1983) gives the projected year-by-year projection energy levels on the first line and on the second, the year-by-year unit cost of power in 1982 dollars. Costs are based on power sales at cost assuming 100 percent debt-finance at 10 percent interest. This is seen to result in a real cost of power of 122 mills in 1994 (first "normal" year of Watana) falling to 73.95 mills in 2003 (the first "normal" year of Watana and Devil Canyon). The real cost of power would then fall progressively for the whole remaining life.

The cost of power given in Table D.8 in Exhibit D (Acres 1983) is designed to reflect as fully as possible the economic cost of power for purposes of broad comparison with alternative power options. It is, therefore, based on the capacity cost which would arise if the project were 100 percent debt-financed at market rates of interest. It does not reflect the price at which power will be charged into the system.

10.3 - Financing Plan

In the Feasibility Report, several plans were presented for financing the Susitna project. At this time, one plan has emerged as the most likely. This plan is presented in the FERC license application (Acres 1983).

The financing of the Susitna project is expected to be accomplished by a combination of direct state of Alaska appropriations and revenue bonds issued by the Power Authority. It is expected that project costs for Watana through early 1991 (estimated at $3.0 billion in 1982 dollars) will be funded from such state appropriations. Thereafter, completion of Watana is then expected to be financed by issuance of approximately $0.9 billion (1982 dollars) of revenue bonds. On the assumption of 7 percent annual inflation from 1982 to the end of construction, the $0.9 billion in 1982 dollars will have a then current money value of approximately $1.8 million as detailed in Table 10.1. These annual par amounts do not exceed the Authority's estimated annual addition debt capacity for the period 1991 to 1995.

The revenue bonds are expected to be secured by project power sales contracts, other available revenues, and by a Capital Reserve Fund (funded by a state appropriation equal to a maximum annual debt service) and backed by the "moral obligation" of the state of Alaska. At the issuance of the first revenue bonds for Watana, expenditures of state appropriations are expected to have funded sufficient construction progress so that subsequent construction risks will be relatively small.

The completion of the Susitna project by the building of Devil Canyon is expected to be financed on the same basis requiring (as detailed in Table 10.1) the issuance of approximately $2.2 billion of revenue bonds (in 1982 dollars) over the years 1994 to 2202.

Summary financial statements based on the assumption of 7 percent inflation and bond financing at a 10 percent interest rate and other estimates in accordance with the above economic analysis are given in Table 10.2.

The actual interest rates at which the project will be financed in the 1990s and the related rate of inflation evidently cannot be determined with any certainty at the present time.

A material factor will be securing tax exempt status for the revenue bonds. This issue has been extensively reviewed by the Power Authority's financial advisors, and it has been concluded that it would be reasonable to assume that by the operative date the relevant requirements of Section 103 of the IRS code would be met. On this assumption, the 7 percent inflation and 10 percent interest rates used in the analysis are consistent with authoritative estimates of Data Resources (U.S. Review July 1982) forecasting a CPI rate of inflation 1982-1991 of approximately 7 percent and interest rates of AA Utility Bonds (nonexempt) of 11.43 percent in 1991 dropping to 10.02 percent in 1995.

10.4 - Change in the Cost Estimate

As discussed in Section 8, the cost estimate has been revised to reflect adjustments to the project made since the feasibility report. The following summarizes those estimate changes.

January 1982 $ x10^6

	Feasibility Study Estimate	License Application Estimate	Change	Percent Change
Watana	3,647	3,581	(66)	(1.8)
Devil Canyon	1,480	1,565	85	5.7
Total	5,127	5,146	19	0.37

Due to the relatively minor changes in the cost estimate, no changes have been made in the financial analysis. Since the Watana project cost has decreased and it is the more critical project to finance, and, since it is the first to be constructed, the change would in theory make financing easier. However, due to the minimal change in numbers, the impact on the financial projections is insignificant.

10.5 - Comments from "Review Report"

After publication of the Feasibility Report, a report entitled "Alaska Energy Planning Studies - Substantiative Issues and the Effects of Recent Events", a review by A. R. Tussing and G. K. Ericson, was prepared for the Division of Policy Development and Planning, Office of the Governor of the State of Alaska.

This document, "Alaska Energy Planning Studies - Substantiative Issues and Effects of Recent Events" (the review), covered four reports submitted to Alaska state agencies including the draft Susitna Hydroelectric Project Feasibility Report.

After publication of the review, a commentary responding to comments was prepared. This subsection is a summary of the key comments and responses.

This summary confines itself to the review only of the feasibility report study and related data. It does not respond to the comments made in the Review on data developed by Battelle and the Institute of Social and Economic Research, University of Alaska.

The review commentary deals with:

- World Oil Prices: long-term future of world oil prices.
- Alaskan Fossil Fuel Prices: market prices versus opportunity values, linkage between coal and oil prices, and linkage between gas and oil prices.
- Reliability of Susitna Construction Cost Estimate: construction cost estimates, and risk analysis.
- Financing Issues: real discount and interest rates.

These issues are identified as those requiring further treatment to deal with apparent misunderstandings and need for further comment arising from the review. The summary here presents the issue and commentary in support of the feasibility report relative to the issues.

(a) World Oil Prices, Long Term

The review asserts that oil price forecasts are too high and suggests that real (inflation-adjusted) prices will continue to be below 1982 levels for the remainder of the century.

Price forecasts used in the feasibility report were adopted from the Battelle Alternatives Study. Nonetheless, an updated check of forecasting was done to confirm or indicate the necessity for changes in the oil price base used in the feasibility report. The results of the survey of forecasts is presented in Table 10.3.

The forecasts used in the report are in close agreement with those of all the major forecasting organizations shown in Table 10.3. The forecasts are all of recent date and take into account all recent trends.

Thus, one piece of evidence cited in the review is that Data Resources, Inc. (DRI) now forecasts a decline in Europe's oil consumption during the rest of this century, while today there is an excess oil-producing capacity in the world. Such partial analysis cannot lead to the conclusion that oil prices will decline over the next 20 years. This requires consideration of the future levels of oil demand outside Europe: worldwide supply/demand conditions, etc. DRI, taking all such factors into account, supports the position taken in the report with a forecast of 2.8 percent growth in real terms.

A second factor cited by the review is the scaling down of oil price projections by the Alaska Department of Revenues in its Petroleum Production Revenue Forecast. The state's forecasts made in the spring of 1982 point to declining real oil prices through 1998. Of the numerous eminent authorities engaged in long-term energy forecasting, this alone is cited by the review.

Table 10.3 summarizes all the major forecasts for comparison with the report's base case scenario of 2 percent real escalation, bounded by low and high scenarios of 0 percent and 4 percent, respectively. Of the 16 authorities surveyed, only one presented a case with long-term declining real oil prices.

Although a wide range of oil prices is reflected in these projections, it is clear that with the single qualification already noted they are all calling for positive real growth in world oil prices over the long-term horizon required for power planning studies. The Report did not, however, exclude the possibility of zero real growth in oil prices; it merely assigned it a lower possibility of 25 percent compared with the 50 percent probability assigned to the 2 percent growth case. It is Acres' assessment that the review does not present a case for rejecting this assessment (and the similar forecasts shown in Table 10.3) and effectively assigning 100 percent probability to the zero growth scenario.

(b) Alaskan Fossil Fuel Prices

(i) Market Prices Versus Opportunity Values

An issue raised by the review was the assessment of probable future costs of fossil fuels for generation in the Railbelt from local coal or gas supply conditions.

Both the Feasibility Study and the Battelle study reviewed the prior studies made of Beluga coal costs and worldwide coal production cost estimates. The use of production costs for natural gas and coal would be wholly appropriate and desirable for the financial analysis of a power project from the narrow perspective of private investors or owners. As a public project, however, Susitna should be, and was, appraised from the point of view of the state as a whole and valued the fossil fuels at its opportunity cost in terms of potential exports.

It is for this reason that Acres supported the net-back approach in which the value of coal and natural gas in Alaska was determined as the c.i.f. (landed) price in the most likely (East Asian) market less the cost of transportation from Alaska to that market.

(ii) Linkage Between Coal and Oil Prices

The review is critical of the approach whereby "both contractors have deduced their price assumptions for Railbelt coal and gas wholly from forecasts of oil prices in Japan."

The statement may be misleading as, in fact, it is the real growth rates in coal and gas export prices that are estimated, in the most likely case, to equal real rates of world oil price escalation. Base period (1982) opportunity values of coal and gas were determined (as shown above) independently of oil prices. In the most likely (base) case, it forecasts that there would be no change in relative prices; that is, the 1982 price ratios among oil, gas, and coal would be maintained during the planning period. This estimation is supported by forecasts of coal and natural gas prices provided in the report. A moving average of coal/oil price ratios exhibits relatively little fluctuation over the 8-year period. (There is an estimated probability of over 65 percent that the ratio is 0.42 $\pm$0.04.)

(iii) Linkage Between Gas and Oil Prices

The emphasis of the criticism of Feasibility Report assumptions relating to natural gas is centered on the fact that the current price of Cook Inlet natural gas is significantly below the "opportunity value" suggested in the report, and that this price is not expected to increase to levels in line with the opportunity value. It is maintained that "Cook Inlet gas prices will be established largely on the basis of factors local to the region," and thus, these prices will be insulated from the effects of world price movements.

Regardless of whether Cook Inlet gas prices do or do not equal opportunity values, the results of the Susitna public benefit-cost analysis would not be altered. In fact, it is only the opportunity values which are of relevance, and the Cook Inlet domestic gas prices at any point in time should not be an issue of any concern in an analysis of net economic benefits.

This results solely from the fact that, if export markets exist for LNG at the prices which have been determined in the Report, then it must be assumed that the rational gas producer in Alaska would select the opportunity to receive the highest price that is offered for the gas.

(c) <u>Reliability of Susitna Construction Cost Estimates</u>

(i) <u>Construction Cost Estimates</u>

A third area of concern expressed in the review was the reliability of the project capital cost estimate. The concern appears to be based on generalizations stemming from the "mega project" experience of the last decade.

This questioning does not appear to be founded on any detailed data or experience of hydroelectric power development engineering and construction. The only specific mega projects cited to justify allegations of "misplaced specificity, subjectivity, and over-optimism, institutional blind spots, and underallowance for noncompletion" in the Acres construction cost estimate are the Trans Alaska oil pipeline and the Washington Public Power Supply System nuclear reactor program. It is Acres' view that neither of these projects has any practical bearing on a site-specific, basically conventional engineering hydroelectric power development such as Susitna where the project estimate has been as extensive, evaluated and assigned as high a confidence level as in the Susitna case.

Cost-estimate review on a risk basis was conducted in the Feasibility Report by relating to a list of projects compiled by an external source. It is recognized that this approach did not include major hydroelectric projects in northern areas, nor did it reflect the Acres experience in project cost-estimating. To provide further support for the project cost-estimate, Acres' experience on a project similar to Susitna was reviewed. Table 10.4 provides in detail a review of Acres' Churchill Falls Hydroelectric Power Project estimate versus outcome.

Two estimates of costs are given. The first, for 1963, is in the nature of an early stage feasibility estimate, while the second, for 1968, is a final pre-contract estimate broadly comparable in confidence level to that produced in the Susitna Feasibility Report. It is seen that, reduced to comparable purchasing power (1963 dollars), the 1963 estimate is at variance from the final cost by 4.2 percent. This favorable (negative) variance has to be viewed, furthermore, in light of the fact that between 1963 and 1968 there was an increase from 10 to 11 in the number of hydroelectric units and an increase in the rating of all generators from 450 MW to 475 MW.

TABLE 10.4

COMPARISON OF ACRES ESTIMATE AND ACTUAL COST REDUCED TO COMMON (1963) LEVEL

	$ Millions Current Dollars	1963 Dollars	Percent of 1963 Estimate
1963 Estimate (incl. contingency) (1)	488.2	488.2	100.0
1966 Estimate (incl. contingency) (2)	563.3	489.5	100.3
Completion Cost	665.6	467.8	95.8

NOTE: (1) 1963 Estimate was for 10 x 450 MW Units; 1966-68 Estimate and Actual was for 11 x 475 MW Units.

(2) The project budget provided for a contingency allowance of $41 million, i.e., approximately 8 percent of the base construction cost estimate and a provision for escalation of $102 million based on a rate of 4.5 percent per annum, constant over the construction period.

The Churchill Falls Power Development in Labrador, Newfoundland, is a 5,225 MW development in a remote area. It is comparable to Susitna as a giant hydroelectric project. It will be noted that in place of the single large dam which creates the operating head and storage reservoir for Watana, a large number of fill structures were constructed at Churchill Falls with an aggregate length of over 42 miles and volume of more than 40 million cubic yards. Construction work spread out over 2,500 square miles of reservoir area was inherently more difficult to control than a concentrated development area such as Watana.

Other examples of estimate/final cost comparisons uphold Acres record of performance on major hydroelectric power projects in northern latitudes and at remote sites.

(d) Real Discount and Interest Rates

The review took issue with the standard methodology by which Acres derived the 3 percent real discount rate used in the cost/benefit analysis in the feasibility report (Section 18.3 to 18.21) and argues for 4.5 percent as the appropriate rate.

The 3 percent discount rate was derived from two sources. First, it was given as a guideline for economic evaluation by the Department of Commerce of the State of Alaska. The second source was the generally accepted studies summarized on page 18.4 of the Feasibility Report.

It is clearly possible to question the standard methodology giving rise to this parameter. Here, as in other parts of the study, however, it was study policy to avoid unnecessary controversy by not questioning accepted methodology or guidelines unless the alternative approaches materially affected Acres' conclusions.

A more precise approach is that of determining the Project Specific Rate (PSR). This is done by first estimating the weighted average interest cost of project borrowing and the opportunity interest cost of any funds provided by the state of Alaska, with the weightings being the proportions of these two types of capital. This weighted average is then converted into a real discount rate (approximately) by deducting the relevant rate of inflation. The interest rates used would be those obtained at the time that the capital is to be raised and the rate of inflation, the long-term rate expected over the life of the borrowing.

On the basis of the DRI forecasts and on the assumption that the opportunity cost of state-provided funds is the interest rate forecast for federal government securities while the project borrowing is in the form of tax-exempt bonds (see Table 18.22 in the Feasibility Report), the weighted averaged interest rate with the state appropriation of $2.3 billion can be determined. The DRI forecast interest rate on federal funds and on tax-exempt bonds, both over the relevant capital raising periods and unweighted, are 10.4 percent and 8.1 percent, respectively. This gives a weighted average PSR of 9.1 percent in money terms.

The long-term forecast rate of CPI inflation from 1985 to 1995 (again as given by DRI) varies between 7.1 (1985-90) and 6.5 percent (1990-95). No forecast is given for the post-1995 period. The implied real rate of interest relevant to the cost benefit at a long-term inflation rate of 6.5 percent is, therefore, approximately 9.1 - 6.5 = 2.6 percent. At these rates of inflation, therefore, this alternative methodology, using DRI data, does not support a higher discount rate than the 3 percent discount rate used in cost/benefit analysis carried out for the feasibility study and dealt with in the report.

The position taken in the review is that the discount rate should be that at which the project is financed. This is the PSR approach just described. As such, it produces a lower (not higher) rate than that used in the Acres analysis.

The review suggests, however, that the appropriate rate is 4.5 percent on the grounds that this is the DRI forecast of real interest rates on corporate bonds* in 1992. Since the project is not being financed by corporate bonds but by tax-exempt bonds and by the state of Alaska, it cannot be argued that this 4.5 percent has any relevance. The relevant tax-exempt and federal bond rates consistent with the 4.5 percent corporate bond rate give the result outlined above.

We would also note that the DRI 4.5 percent real interest rate on corporate bonds is very much higher than the Wharton or Chase forecasts or indeed any of the other main forecasting agencies. These are generally in the range of 3-2.4 percent. If these forecasts, rather than the DRI forecast used above, are accepted then, taking into account the advantages of tax exemption, the 3 percent discount rate used for the Susitna cost/benefit analysis is conservative in that the appropriate PSR should be significantly lower. This became apparent in the course of the Acres analysis but was not pursued, since it merely had the effect of reinforcing rather than controverting the conclusions reached.

In summary, it appears to Acres that the review is mistaken as to the outcome of the methodology which it proposes and that, correctly stated, this methodology (which Acres stresses is only an approximation) gives a result which would argue that the discount rate promulgated by the Alaskan Department of Commerce and used by Acres is too high, not too low.

10.6 - Generation Planning

After circulation of the feasibility report, several items of work were accomplished in response to questions and comments. These involved the following areas of analysis:

- Multivariate analysis - sensitivity of load probability;
- Changes to the generation planning model;
- Impacts of project changes; and
- Other issues.

Each of these areas is explored individually in the following text.

(a) Multivariate Analysis - Sensitivity of Load Probability

To account for variance in forecasting, the economic analysis was approached on a probabilistic basis. Several key variables were chosen; a range of low, medium, and high variable values were

*Using the CPI and not IPD the rate is 4.0 percent.

estimated; and probabilities were assigned to each value. A probability tree was constructed with each combination of variables assigned a resultant probability. The original analysis is discussed in more detail in Section 18 of the feasibility report.

The mulitvariate sensitivity analysis analyzed the four variables: load forecast, alternatives capital cost, fuel cost escalation and Susitna capital cost; assigning a range of probabilities to each. Some concern has been expressed regarding the likelihood of the probability distribution being different from the assumed "base case" of 0.20, 0.60, and 0.20 for the low, medium, and high load forecast scenarios. A recalculation of the probabilities was made using the distribution 0.60, 0.30, and 0.10. Tables 10.5 and 10.6 summarize the calculation for the non-Susitna and Susitna trees.

The results of the analysis show that the expected value of net benefits is $971 million. This is a result of the difference in the non-Susitna and Susitna plans ($7,624 - $6,653 = $971). Compared to the base case multivariate analysis, the $971 million expected value is approximately 33 percent less than the base case value of $1,450 million. Figure 10.1 plots the net benefit curves.

(b) <u>Changes to the Generation Planning Model</u>

In May 1982, General Electric released Version 6 of the OGP Program. Version 5 of the program was used as the primary tool for the generation planning studies for the feasibility report.

Several changes were made to the program in Version 6 in response to user comments. These include a possible 30-year study period (replacing 20), more options for maintenance scheduling, and increased program flexibility. Two changes particularly relevant to the Susitna analysis are the possibility of economic overbuilding (adding units on an accelerated schedule) and carryover of excess hydropower from wet months to dry months. The latter gives a more favorable (and accurate) value to the potential hydro energy produced by the project.

In order to test the impact of these terms on the results of the generation planning, the base case, with and without Susitna, was reanalyzed with OGP-6. Table 10.7 summarizes the results. The results were reduced to a long-term cost in a manner identical to the feasibility report.

The revisions in the program had no impact on the non-Susitna case. For the with-Susitna case, the increased value of the hydro energy increased net benefits by about 5 percent.

(c) Impact of Project Changes

(d) Other Issues

After completion of the Feasibility Report, several comments were raised which required additional study or explanation. Those issues are presented in the following paragraphs.

(i) Discussion of Percent Reserve Margin

In planning system electrical need, there are a number of methods that can be used to measure a system's reliability and determine the need for the addition of capacity. It is common utility practice to plan to a statistical measure of reliability: loss of load probability (LOLP) in conjunction with some minimum percent reserve margin. Computation of LOLP involves probabilistic forced outage rates, planned maintenance, peak load, and reliable energy considerations. LOLP is commonly expressed as a loss in days per year or, in some systems, hours per year depending on the size of individual units in the operating system. Percent reserve margin can also be calculated in a variety of ways relating capacity, load, contracts for power exchange, and the largest units on the system to a single measure of available capacity.

In modeling the Alaskan Railbelt System for generation planning studies, the LOLP criteria of 0.1 day per year was used as the "trigger point" for capacity additions. In other words, in every year, the OGP model calculates the system reliability LOLP without any additions. If the system as it exists violates the LOLP criterion of 0.1 day/year, the model then examines combinations of available alternative unit capacity additions that would meet this reliability criterion. From these alternative system mixes, the least cost (or production cost optimal choice) is selected and the system is operated for the following year. At this time, the percent reserve margin is calculated for that year using the equation:

$$\text{percent reserve} = \frac{\text{capacity - load}}{\text{load}}$$ in the peak month (December in the Railbelt System)

Therefore, the calculation of percent reserve in this context is independent of the "need" for capacity which is determined by the LOLP criterion.

Alternatively, the OGP model can plan to a percent reserve margin and calculate LOLP after expansion has been made. However, this option was not exercised due to the variety of methods for computing percent reserve and the difficulty in arriving at a consensus on a reliable percent reserve due to the system size.

An alternative method of calculating reserve margins involves subtracting the largest unit of capacity out of the total available system capacity. Other methods subtract the largest "string" of intertied units from the total capacity to arrive at a reserve margin. In any case, the percent reserve is merely a simple statistic of available capacity to meet load regardless of "acts of God" and forced outages.

Table 10.8 summarizes the two sets of statistics for the medium load forecast base non-Susitna and Susitna plans. The planning criteria were LOLP less than 0.10 days per year, and percent reserve was calculated using the noted equation. Figure 10.2 plots percent reserve versus time for the two plans. The following paragraphs discuss the variations among plans.

As previously mentioned, the system model examines the available units for addition in a year when reliability is not met. In the first year of the study, 1993, the units available for the non-Susitna plan are 200-MW coal, 200-MW combined cycle, 70-MW gas turbine, and 10-MW diesel units. Of these, a single 200-MW unit meets the LOLP criterion in the most cost-effective manner. In the Susitna plan, the Watana project added in a single stage is 680-MW, which is considerable for that particular year; however, as load grows and existing units retire, percent reserve decreases. No other units are needed in the system. In year 2002, additional capacity is needed. The Susitna plan adds the 600-MW Devil Canyon project which again raises the percent reserve.

The non-Susitna plan has the capability to add only small increments of capacity relative to the Susitna project. The addition of 200-MW or smaller units meets reliability criteria with a smaller reserve margin. As Susitna is added in 600+ MW increments to take advantage of its full energy potential, the reserve margin becomes very large. Much of the reserve margin capacity sets idle from 1993 on.

In year 2010, the non-Susitna plan has a calculated LOLP of 0.099 indicating that criterion is nearly violated in that year. This LOLP corresponds to a percent reserve of 32.5 percent, which indicates the level of capacity installation over LOLP needs. In both plans the percent reserve is always above this level, varying as the various size units are installed.

(ii) Annual System Costs

Each year the OGP model dispatches available energy generation to meet load. Table 10.9 shows the annual energy dispatch in GWh by generating unit type for the two plans. Figure 10.3 shows the annual system costs plotted for the two plans. This figure represents the initial cost of the Watana project having higher system cost during the first few years, remaining about the same during the years 1996 to 2001, and showing significant savings in the years 2003 to 2010.

(iii) Annual System Cost Components

The annual system costs consist of a number of components:

	Non-Susitna	Susitna
Investment Costs:	Coal NGGT	Susitna NGGT
O&M:	Coal Combined Cycle NGGT Other Hydro Diesels	Susitna Combined Cycle NGGT Other Hydro Diesels

Fuel Costs:	Coal GT Natural Gas CC Natural Gas Oil	GT Natural Gas CC Natural Gas

Tables 10.10 and 10.11 list the annual yearly costs by components for the non-Susitna plan and the Susitna plan. Figures 10.4 and 10.5 depict the components graphically. The most dramatic comparison is the portion of Susitna investment cost versus the coal investment and fuel cost components in the non-Susitna plan.

Figure 10.6 plots the annual system long-term costs for both plans during the 1993 to 2010 system modeled period and the 2011 to 2051 economic extension period.

(iv) Discussion of Delay of Project

The Railbelt system technically needs capacity installation in December 1992 to meet the LOLP reliability criteria. However, Acres has started the study in 1993, suggesting that the December 1992 peak would be met by extending one or two retiring units until major new units are on line in January of 1993. Delaying Watana Stage One to 1994, therefore, poses a problem, since it is necessary to have some type of capacity in 1993.

Two impacts occur when a Susitna project stage is delayed. First, there is an increase in fuel costs during the year of delay to make up generation not provided by Susitna. For example, with Watana, in 1993, fuel costs are $25 million. Without Watana and using two new natural gas turbines, fuel costs are $128 million in 1993. Second, there is a decrease in Susitna investment cost present worth. For example, $100 invested in 1993 is $76 in 1982 dollars. One hundred dollars invested in 1994 is $74 in 1982 dollars at a 3 percent discount rate.

The lowest production cost alternative in 1993 is a 200-MW coal unit. However, this unit followed by the large Watana project in 1994 is only used one year, hardly a justification for building a large plant. Alternatively, two 70-MW gas turbines can be installed in 1993, run to meet peak until Watana comes on line, then used as standby until the later years. This system plan (C3) is shown in Table 10.14. This plan reduces net benefits approximately 4 percent to $1,133 million.

Delaying both stages of the Susitna plan one year results in essentially the same net benefit as the previous case. This plan C4 has a long-term cost of $7,165 million. However, it must be compared to a without-Susitna plan which has been extended to year 2053 rather than 2052, since the Susitna project life is 50 years from the year Devil Canyon is installed. This modification makes the non-Susitna plan LTC $8,299 million; therefore, net benefits are $1,134 million.

Delaying both stages of the project two years (plan C5) increases fuel costs in years 1993, 1994, 2002, and 2003 due to dispatching of thermal units to meet load. Again, the net impact is partially offset by the decrease in present worth of Susitna costs and the net benefits are $1,130 million, 4 percent less than the base case.

(v) Watana Project Alone

Pursuing only the Watana projections examined in the medium- and low-load forecast cases. Table 10.13 summarizes these plans.

Under the medium-load forecast, the Watana only project was tested at two installed capacities: 680 MW and 1,020 MW. Although the larger capacity plan displaced some additional capacity and since no additional average or firm energy is associated with these units, the net effect is a negative benefit of $102 million. The second stage of Watana was capital cost of the $58.8 million.

The low-load forecast plan shows a negative net benefit of $96 million for the Watana-only scheme.

Two notes on the calculation of net benefits and long-term cost:

(1) When comparing Watana-only project plans with the base case alternative plan, it is necessary to compute the long-term cost to year 2043 when Watana is installed in 1993 (medium-load case) and 2045, when Watana is installed in 1995 (low-load case).

(2) When a Susitna plan installs a 200-MW coal plan in the planning horizon, it is necessary to add in the cost of a Beluga transmission tie in the year it is added, calculated in 1982 dollars. This cost was estimated as $53.5 million (from the upper limit capital cost report, July 1981), and is added to the long-term cost.

(vi) Alternative Railbelt Hydro Assessment

Previously, the Development Selection Report (DSR) examined various alternative developments of the Susitna Basin. The Watana/Devil Canyon selection was chosen as the least-cost, long-term generation plan. This assessment reviews some of the possible alternatives, using the same criteria as the Susitna feasibility study and updated data on the hydropower alternatives. Generation plans were developed for the following scenarios and long-term costs compared to the base case without-Susitna plan.

- Devil Canyon - Watana
- Chakachamna - Devil Canyon
- Chakachamna - Watana
- Watana only
- Devil Canyon only
- Chakachamna only

- Devil Canyon - Watana

Reverse staging of the Susitna project has some unique cost implications. First, the possibility exists that the Devil Canyon project could be on line sooner than 1993, perhaps as early as late 1991. This situation was not modeled; however, in the without-Bradley Lake case it may reduce the long-term cost and increase net benefits over the value presented here. Secondly, the interim years between Devil Canyon (1993) and Watana (2002) require additional capacity to be added. Five 70-MW gas turbines are needed to supply energy to the system.

Capital Cost (including IDC) impacts of Devil Canyon first followed by Watana are summarized below:

1982$ x 10^6			
Watana	$4,094	Devil Canyon	$2,203
Devil Canyon	1,631	Watana	3,558
Total	$5,725		$5,761

Building Devil Canyon first increases the cost compared to a later staging because of additional adjustments of transmission, intakes, diversions, cofferdams, access roads, and site facilities.

Total energy impacts of Devil Canyon first compared to Watana/Devil Canyon are as follows:

Available Energy, GWh					
Watana	3,459	2,631	Devil Canyon	2,585	2,264
Devil Canyon	3,334	2,763	Watana	4,208	3,130
Total	6,793	5,394		6,793	5,394

Note that this is a tally of available energy which is slightly greater than usable energy by year 2010.

The results of the generation plans for the base case - Watana/Devil Canyon and the reverse staging Devil Canyon/ Watana are summarized in Table 10.12. Long-term costs in the latter increase by 4 percent over the Watana first case reducing net benefits to $896 million.

- Chakachamna - Susitna

The 330 MW Chakachamna hydroelectric project was also examined in the DSR. Two updated generation plans-- one with the Chakachamna project in 1993 followed by Devil Canyon, the other Chakachamna followed by Watana-- were analyzed under the same parameters as the feasibility study base case. Capital costs and energies were provided by Bechtel, Alternative "B" with average annual energy of 1,492 GWh, firm energy of 1,374 GWh and a capital cost of $1,450 million including IDC and transmission costs.

With the addition of Chakachamna in 1993, Devil Canyon can most effectively be staged in 1997 with further expansion of Beluga coal units in 2003 and 2010. Six 70-MW gas turbines are added in the post-2000 period. The total long- term cost (1993-2051) of this plan is $8,186 million as shown in Table 5.

The Chakachamna - Watana generation plan was staged as 1993-2000 respectively, since Watana alone is a larger energy project than Devil Canyon. Additional capacity added are three 70-MW gas turbines and a 200-MW combined cycle unit. This plan has a 1993-2051 long-term cost of $8,241 million, with negative net benefits of $4 million when compared to the base case non-Susitna plan.

The possibility of a Chakachamna-Devil Canyon-Watana or Chakachamna-Watana-Devil Canyon plan was examined; however, the excess capacity and energy provided in these scenarios, given the medium load forecast, are over 1,000 GWh and were, therefore, not modeled as such.

- Single Hydro Project Developments

Three single development cases were examined under this topic: Watana, Devil Canyon, or Chakachamna alone.

Table 10.15 summarizes energies, capital costs, and long-term costs for each of these scenarios. Long-term costs are computed for 50 years of the project.

TABLE 10.1: FINANCING REQUIREMENTS - $ MILLION FOR $3.0 BILLION STATE APPROPRIATION

$ Million

Interest Rate 10%
Inflation Rate 7%

	Actual	1982 Purchasing Power
1985 State Appropriation	403.7	318.6
86 "	472.7	348.2
87 "	479.7	330.9
88 "	499.5	321.8
89 "	938.3	564.9
90 "	1550.4	872.3
91 "	462.4	243.3
Total State Appropriation	4806.7	3000.0
1990 Revenue Bonds	--	--
1 "	784.7	412.6
2 "	754.9	371.1
3 "	294.6	139.0
Total Watana Bonds	1834.2	922.7
1994 Revenue Bonds	211.6	90.8
5 "	368.9	148.0
6 "	427.7	160.3
7 "	395.4	138.5
8 "	1163.0	380.8
9 "	1432.3	438.6
2000 "	1604.7	458.8
1 "	1473.5	393.9
2 "	137.8	34.5
Total Devil Canyon Bonds	7214.9	2244.2
Total Susitna Bonds	9049.1	3166.9

TABLE 10.3

SUMMARY OF MAJOR FORECASTS OF OIL PRICE TRENDS

Source	Date of Forecast	Forecast Trend (percent)
Date Resources Inc.	Summer 1982	+2.8
International Energy Agency	Spring 1982	
- Low		-0.5
- High		+2.0
US Energy Information Administration	Spring 1982	above +3
Energy Mines and Resources Canada	Summer 1982	+1.7
Ontario Hydro	Spring 1982	+1.8
Energy Modeling Forum, World Oil Report*	February 1982	
- average of 10 models		+3.4
- range of 10 models		+1.9 +5.3
Dr. F. Fesharaki, Resource Systems Institute East-West Centre, Honolulu	Spring 1982	+1.7

* The 10 models are: Gately-Kyle-Fischer (New York Univ.), IEES - OMS (U.S. Dept. of Energy), IPE (M.I.T.), Salant-ICF (U.S. Federal Trade Commission and ICF, Inc.), ETA-MARCO (Stamford Univ.), WOIL (U.S. Dept. of Energy and Environmental Analysis, Inc), Kennedy-Nehring (Univ. of Texas and the Rand Corp.), OILTANK (Chr. Michelsen Institute), Opeconomics (BP Co. Ltd.), OILMAR (Energy and Power Subcommittee, U.S. House of Representatives).

TABLE 10.5

MULTIVARIATE SENSITIVITY ANALYSIS, LONG-TERM COSTS AND PROBABILITY, NON-SUSITNA TREE

Rank (Low-High)	ID	(1982$) $ x 10⁶ Long-Term Cost	Probability	Cumulative Probability	Incremental LTC 1/	Cumulative LTC
1	T27	4412	.03	.03	132.36	132
2	T24	4590	.09	.12	413.10	545
3	T21	4856	.03	.15	145.68	691
4	T18	5489	.015	.165	82.34	773
5	T15	5661	.045	.21	254.75	1,028
6	T12	5991	.015	.225	89.87	1,118
7	T26	6101	.06	.285	366.06	1,484
8	T23	6878	.18	.465	1,238.04	2,722
9	T09	7184	.005	.47	35.92	2,758
10	T06	7313	.015	.485	109.70	2,868
11	T20	7460	.06	.545	447.60	3,315
12	T03	7624	.005	.55	38.12	3,354
13	T17	7915	.03	.58	237.45	3,591
14	T14	8238	.09	.67	741.42	4,332
15	T25	8492	.03	.70	254.76	4,587
16	T22	8746	.09	.79	787.14	5,374
17	T11	8858	.03	.82	265.74	5,640
18	T19	9253	.03	.85	277.59	5,918
19	T16	10321	.015	.865	154.82	6,072
20	T08	10503	.01	.875	105.03	6,177
21	T13	10637	.045	.92	478.67	6,656
22	T05	10859	.03	.95	325.77	6,982
23	T10	11272	.015	.965	169.08	7,151
24	T02	11569	.01	.975	115.69	7,267
25	T07	13742	.005	.980	68.71	7,335
26	T04	14194	.015	.995	212.91	7,548
27	T01	15058	.005	1.000	75.29	7,624
			1.000			

1/ LTC - long-term costs

Using probability distributions:

Low Load Forecast	0.60
Medium Load Forecast	0.30
High Load Forecast	0.10
	1.00

TABLE 10.6: MULTIVARIATEA SENSITIVITY ANALYSIS LONG-TERM COSTS AND PROBABILITY, SUSITNA TREE

Rank (Low-High)	ID	(1982$) $ x 10^6 Long-Term Cost	Probability	Cumulative Probability	Incremental LTC 1/	Cumulative LTC
1	S45	5543	.09	.09	498.87	499
2	S42	5757	.18	.27	1,036.26	1,535
3	S36	5827	.045	.315	262.22	1,797
4	S39	6097	.09	.405	548.73	2,346
5	S33	6151	.09	.495	553.59	2,900
6	S44	6437	.0375	.5325	241.39	3,141
7	S30	6477	.045	.5775	291,47	3,432
8	S41	6650	.075	.6525	498.75	3,931
9	S35	6738	.01875	.67125	126.34	4,058
10	S38	6991	.0375	.70875	262.16	4,320
11	S32	7062	.0375	.74625	264.83	4,585
12	S27	7087	.003	.74925	21.26	4,606
13	S18	7108	.009	.75825	63.97	4,670
14	S09	7151	.003	.76125	21.45	4,691
15	S43	7331	.0225	.78375	164.95	4,856
16	S29	7388	.01875	.8025	138.53	4,995
17	S40	7543	.045	.8475	339.44	5,334
18	S34	7650	.01125	.85875	86.06	5,420
19	S37	7884	.0225	.88125	177.39	5,598
20	S31	7974	.0225	.90375	179.42	5,777
21	S26	7986	.00125	.905	9.98	5,787
22	S17	8008	.00375	.90875	30.03	5,817
23	S08	8050	.00125	.91	10.06	5,827
24	S24	8326	.006	.916	49.96	5,877
25	S15	8347	.018	.934	150.25	6,027
26	S28	8371	.01125	.94525	94.17	6,121
27	S06	8390	.006	.95125	50.34	6,172
28	S25	8886	.00075	.952	6.66	6,17[illegible]
29	S16	8908	.00225	.95425	20.04	6,199
30	S07	8951	.00075	.955	6.71	6,205
31	S23	922[illegible]	.0025	.9575	23.06	6,228
32	S14	9247	.0075	.9650	69.35	6,297
33	S05	9290	.0025	.9675	23.23	6,321
34	S21	9614	.003	.9705	28.84	6,350
35	S12	9758	.009	.9795	87.82	6,437
36	S03	9784	.003	.9825	29.35	6,467
37	S22	10126	.0015	.9840	15.19	6,482
38	S13	10147	.0045	.9885	45.66	6,528
39	S04	10190	.0015	.99	15.29	6,543
40	S20	10514	.00125	.99125	13.14	6,556
41	S11	10658	.00375	.995	39.97	6,596
42	S02	10683	.00125	.99675	13.35	6,609
43	S19	11414	.00075	.997	8.56	6,618
44	S10	11558	.00225	.99925	26.01	6,644
45	S01	11584	.00075	1.00000	8.69	6,653
			1.00000			

1/ Using probability distributions:

Low Load Forecast	0.60
Medium Load Forecast	0.30
High Load Forecast	0.10
	1.00

TABLE 10.7
COMPARISON OF BASE CASES
REVISED OGP-5 PROGRAM

OGP-5	Cumulative Costs 1993-2010	2010 Annual 1/	1982 Present Worth of System Costs $ x 10^6 Estimated 2011-2051	Long-Term Cost 1993-2001	Net Benefit
Non-Susitna	3,213	491	5,025	8,238	---
Susitna	3,19	385	3,943	7,062	1,176
OGP-6					
Non-Susitna	3,213	491	5,025	8,238	---
Susitna	3,066	384	3,929	6,995	1,243

1/ 2010 annual cost is projected 41 years at 3% and present worth 26 years to 1982 at 3% to arrive at the 2011-2051 estimated present worth.

TABLE 10.8: PERCENT RESERVE - MEDIUM LOAD FORECAST[1/]

		Non-Susitna			Susitna		
Year	Peak Load (MW)	Total Capability (MW)	% Reserve	LOLP days/years	Total Capability (MW)	% Reserve	LOLP days/year
1993	947	1373	45.0	0.063	1853	95.7	0.000
1994	965	1542	59.8	0.027	1822	88.8	0.000
1995	983	1495	52.0	0.077	1774	80.5	0.000
1996	1003	1624	61.9	0.059	1704	69.9	0.000
1997	1023	1620	58.4	0.084	1630	59.4	0.000
1998	1044	1635	56.6	0.092	1575	50.8	0.001
1999	1064	1635	53.6	0.055	1575	48.0	0.002
2000	1084	1591	46.8	0.059	1531	41.2	0.015
2001	1121	1661	48.2	0.038	1531	36.6	0.032
2002	1158	1608	38.9	0.062	2079	79.5	0.000
2003	1196	1625	35.9	0.087	2026	69.4	0.001
2004	1233	1695	37.5	0.057	2027	64.4	0.001
2006	1323	1794	35.6	0.049	1939	52.7	0.017
2006	1323	1794	35.6	0.052	1917	44.9	0.068
2007	1377	1994	44.8	0.023	1987	44.3	0.025
2008	1430	1968	37.6	0.066	2032	42.1	0.029
2009	1484	2037	37.3	0.051	2031	36.9	0.050
2010	1537	2037	32.5	0.099	2102	36.8	0.025

1/ As calculated in peak month: $\% \text{ reserve} = \frac{\text{capacity} - \text{load}}{\text{load}}$

TABLE 10.9: ANNUAL ENERGY DISPATCH 1/

NON-SUSITNA PLAN (GWh)

Year	Coal	NG GT	NG CC	OIL	HYDRO	TOTAL
1993	1758	610	1733	4.0	631	4736
1995	2887	226	1177	0.6	631	4922
2000	3983	68	787	0	631	5469
2002	4236	95	891	0	631	5853
2005	4283	300	1214	0	631	6428
2010	5486	434	1240	0	631	7791

SUSITNA PLAN (GWh)

Year	COAL	NG GT	NG CC	OIL	OTHER HYDRO	SUSITNA	TOTAL
1993	140	0	578	0	631	3387	4736
1995	183	2	719	0	631	3387	4922
2000	239	83	1129	0	631	3387	5469
2002	0	0	0	0	631	5222	5853
2005	3	0	0	0	631	5539	6428
2010	53	6	616	0	631	6485	7791

1/ Medim Load Forecast.

TABLE 10.10: COMPONENTS OF ANNUAL COSTS - NON-SUSITNA PLAN 1/

(Millions $)

Year	Coal INV	Coal O/M	Coal Fuel	NGGT INV	NGGT O/M	NGGT Fuel	NGCC O/M	NGCC Fuel	OIL O/M&Fuel	TOTAL
1993	44.2	6.6	36.7	0	5.1	26.2	6.4	47.0	3.9	176.1
Cum.	44.2	50.8	87.5	87.5	92.6	118.8	125.2	172.2	176.1	
1995	73.9	12.1	61.6	0	2.7	10.4	5.5	37.3	3.4	206.9
Cum.	73.9	86.0	147.6	174.6	150.3	160.7	166.2	203.5	206.9	
2000	114.2	18.4	100.5	6.4	-2.2	4.6	5.1	40.4	3.2	295.0
Cum.	114.2	132.6	233.1	239.5	241.7	246.3	251.4	291.8	295.0	
2002	114.2	19.3	109.0	9.8	2.6	6.7	5.6	45.8	3.3	316.4
Cum.	114.2	133.5	242.5	252.3	254.9	261.0	267.2	313.0	316.3	
2005	114.2	20.0	111.4	24.3	5.0	25.2	6.8	62.0	3.5	372.4
Cum.	114.2	134.2	254.6	269.9	274.9	300.1	306.9	368.9	372.4	
2010	152.8	29.1	150.8	32.0	7.1	38.3	7.5	69.5	3.9	491.0
Cum.	152.8	181.9	332.7	364.7	371.8	410.1	417.6	487.1	491.0	

1/ Medium Load Forecast

TABLE 10.11: COMPONENTS OF ANNUAL COSTS - SUSITNA PLAN 1/

(Million $)

Year	Susitna Investment	Susitna O/M	Other Hydro O/M	NGGT Inv	Thermal O/M	Coal Fuel	NG Fuel	Total
1993	199.1	12.2	2.8	0	7.3	4.7	20.4	246.5
Cum.	199.1	211.3	214.1	214.1	221.4	226.1	246.5	
1995	199.1	12.7	2.9	0	7.7	6.4	26.9	255.9
Cum.	199.1	211.8	214.7	214.7	222.4	228.8	255.9	
2000	199.1	14.1	3.2	0	8.8	7.8	59.6	292.6
Cum.	199.1	213.2	216.4	216.4	225.2	233.0	292.6	
2002	294.0	22.4	3.3	0	5.3	0	0	325.0
Cum.	294.0	316.4	319.7	319.7	325.0	325.0	325.0	
2005	294.0	23.8	3.5	0	5.2	0.7	16.0	343.2
Cum.	294.0	317.8	321.3	321.3	326.5	327.2	343.2	
2010	294.0	26.2	3.9	11.9	7.7	1.9	39.7	385.3
Cum.	294.0	320.2	324.1	336.0	343.7	345.6	385.3	

1 Medium Load Forecast

TABLE 10.12: SUSITNA PROJECT DELAYED

	Base Case Non-Susitna A	Base Case Susitna C	Susitna Delayed C3	Susitna Delayed C4	Susitna Delayed C5
OGP ID	L9J9	L9K3	LOW9	L2W5	L2W7
DATES: 1/ WATANA/DC	--	93/2002	94/2002	94/2003	95/2004
ADDITIONS	4 Coal 9 GT's	3 GT's 2007 2008 2010	3 GT's 1993* 1993* 2010	3 GT's 1993* 1993* 2010	3 GT's 1993* 1993* 2010
$ x 10^6 (198 2 PW)					
1993 - 2010	$3,212.8	$3,199.4	$3,140.1	$3,137.9	$3,099.2
2010 Cost	491.0	385.3	387.4	388.7	394.1
2010 to 20XX Cost 2/	5,024.7	3,943.0	3,964.5	4,026.9	4,131.1
Long-Term Cost	8,238 8,299 C4 8,360 C5	7,062	7,105	7,165	7,230
Net Benefit	--	$1,176	$1,133	$1,134	$1,130

1/ Dates modeled are from 1993 through 2010 in all cases.

2/ Factors: 2010-2051 = 10.2336 (A, C, C3)
2010-2052 = 10.3598 (C4)
2010-2053 = 10.4824 (C5)

TABLE 10.13: WATANA PROJECT ALONE

	Medium Load Forecast				Low Low Forecast		
	Non-Susitna	1280 MW Susitna	680 MW Watana	1020 MW Watana	Non-Susitna	1280 MW Susitna	680 MW Watana
OGP ID	~~L919~~ L9J9	L9K3	L189	L671	L195	L9K7	L4R7
System	600 MW B 200 MW N 630 MW GT	680 MW 93 600 MW 02 210 MW GT	680 MW 93 400 MW B 420 MW GT	680 MW 93 340 MW 02 400 MW B 350 MW GT	400 MW B 200 MW N 560 MW GT	680 MW 95 600 MW 04	680 MW 95 200 MW B 280 MW GT
	1430	1490	1500	1770	1160	1280	1160
$ Millions							
2010 yearly 1/	491.0	385.3	479.8	485.5	404.3	359.5	394.2
1993-2010	3,212.8	3,119.4	3,295.3	3,344.4	2,639.9	2,881.9	2,805.9
LTC $82	8,238	7,062	7,571	8,313	6,878	6,650	6,447
Transmission 2/	--	--	27	27	--	--	23
Totals	8,238(A)	7,062	8,232	8,340	6,878(C)	6,650	--
	7,589(B)	--	7,598	--	6,374 (D)	--	6,470
Net Benefit	--	1,176(A)	(9) (B)	(102)(A)	--	228(C)	(96)(D)

1/ Economic Factors: Medium Load:
to 2051 10.2336
to 2043 8.9119

Low Load:
to 2054 10.4824
to 2045 9.2367

2/ $53.5 in 2005 = $27 1982 PW
2010 = $23 1982 PW

TABLE 10.14: ALTERNATIVE GENERATION PLANS

Case	Non-Susitna Plan	Watana Devil Canyon	Devil Canyon Watana	Chakachamna DC	Chakachamna Watana
ID	L9J9	L9K3	L5Z[illegible]	L2Z3	L309
System Mix (Added capacity only)	800 Coal 560 GT	W/93 DC/02 210 GT	DC/93 W/02 350 GT	C/93 DC/97 400 Coal 420 GT	C/93 W/00 200 CC 210 GT
$ x 10⁶ (1982)					
1993-2010	$3,121.8	$3,119.4	$3,168.3	$3,206.6	$3,259.9
2010	491.0	385.3	407.8	486.6	486.7
2011-2051	5,024.7	3,943.0	4,173.3	4,979.7	4,980.7
Long-term cost (1993-2051)	$8,237	$7,062	$7,341	$8,186	$8,241
Net Benefit	---	$1,176	$ 986	$ 51	($4)

TABLE 10.15: SINGLE HYDRO PROJECT DEVELOPMENTS

Case	Watana	Devil Canyon	Chakachamna
ID	L189	L6I1	L9E1
Capacity	680 MW	600 MW	330 MW
Available	1993	1993	1993
Average Energy	3459 GWh	2589 GWh	1492 GWh
Firm Energy	2631 GWh	2264 GWh	1374 GWh
$\$ \times 10^6$ (1982)			
Capital Cost (including IDC and transmission)	$4,094	$2,203	$1,450
Long-term costs (1993-2042)	$7,571	$7,656	$7,271
Net Benefits compared to non-Susitna plan LTC (1993-2042) of $7,589 million	$17	($67)	$317)

REFERENCES

Acres American Incorporated. 1981. Susitna Hydroelectric Project. Transmission Line Corridor Screening Closeout Report. Prepared for the Alaska Power Authority.

______. 1982a. Susitna Hydroelectric Project, Feasibility Report. Prepared for the Alaska Power Authority.

______. 1982a. Susitna Hydroelectric Project, Transmission Line Corridor Screening Closeout Report. Prepared for the Alaska Power Authority.

______. 1982b. Susitna Hydroelectric Project. 1980-81 Geotechnical Report. Prepared for the Alaska Power Authority.

______. 1982c. Susitna Hydroelectric Project. 1982 Supplement to the 1980-81 Geotechnical Report. Prepared for the Alaska Power Authority.

______. 1982d. Susitna Hydroelectric Project. Subtask 2.10 - Access Route Selection Report. Prepared for the Alaska Power Authority.

______. 1982e. Susitna Hydroelectric Project. Access Plan Recommendation Report. Prepared for the Alaska Power Authority.

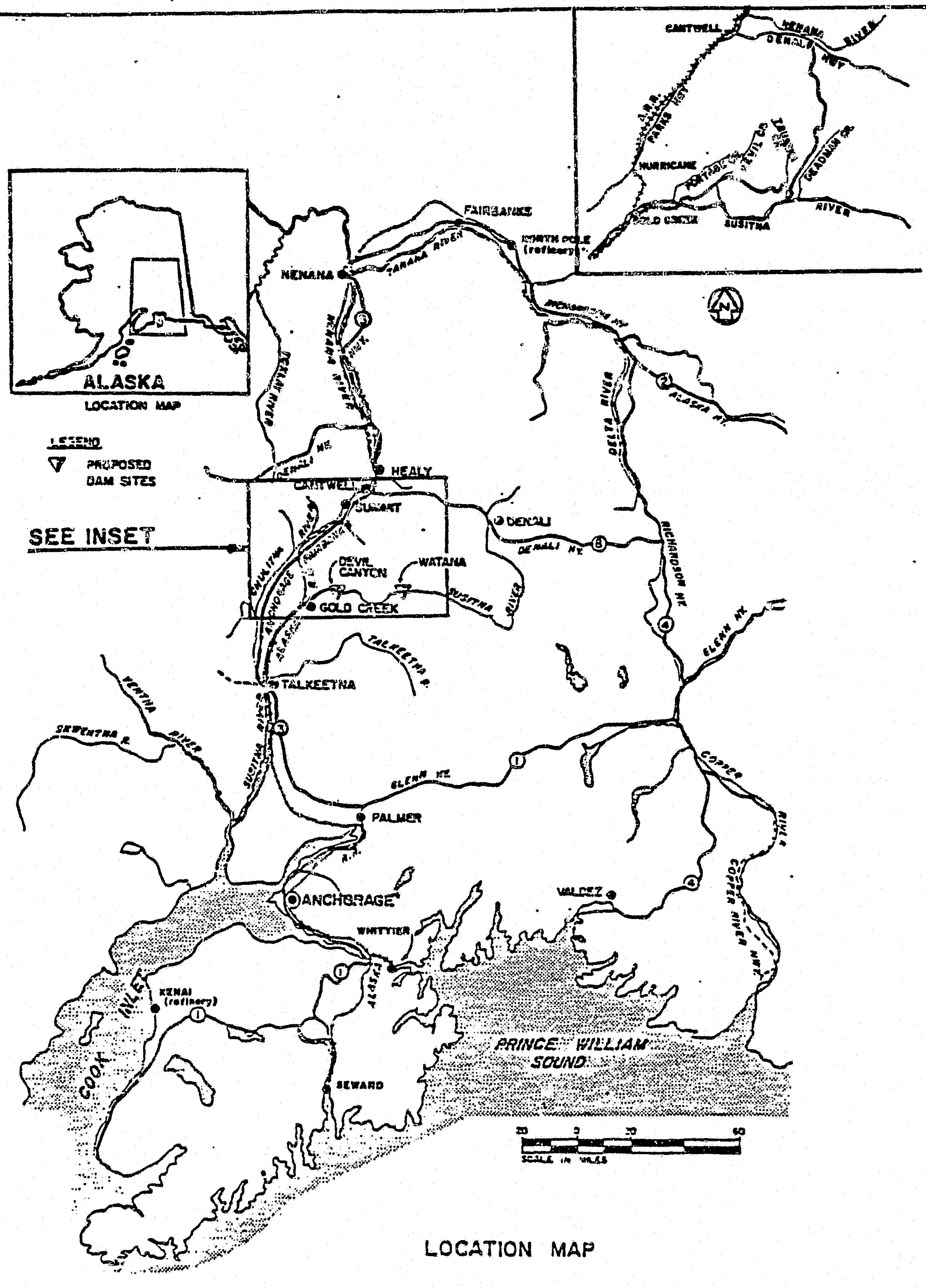
______. 1983. Susitna Hydroelectric Project. FERC License Application. Prepared for the Alaska Power Authority.

Alaska Agreements of Wages and Benefits for Construction Trades. January 1982.

Caterpillar Tractor Co., Caterpillar Performance Handbook. 1981.

Code of Federal Regulations, Title 18. 1981. Conservation of Power and Water Resources, Part 1 and 2. Washington, D.C., Government Printing Office.

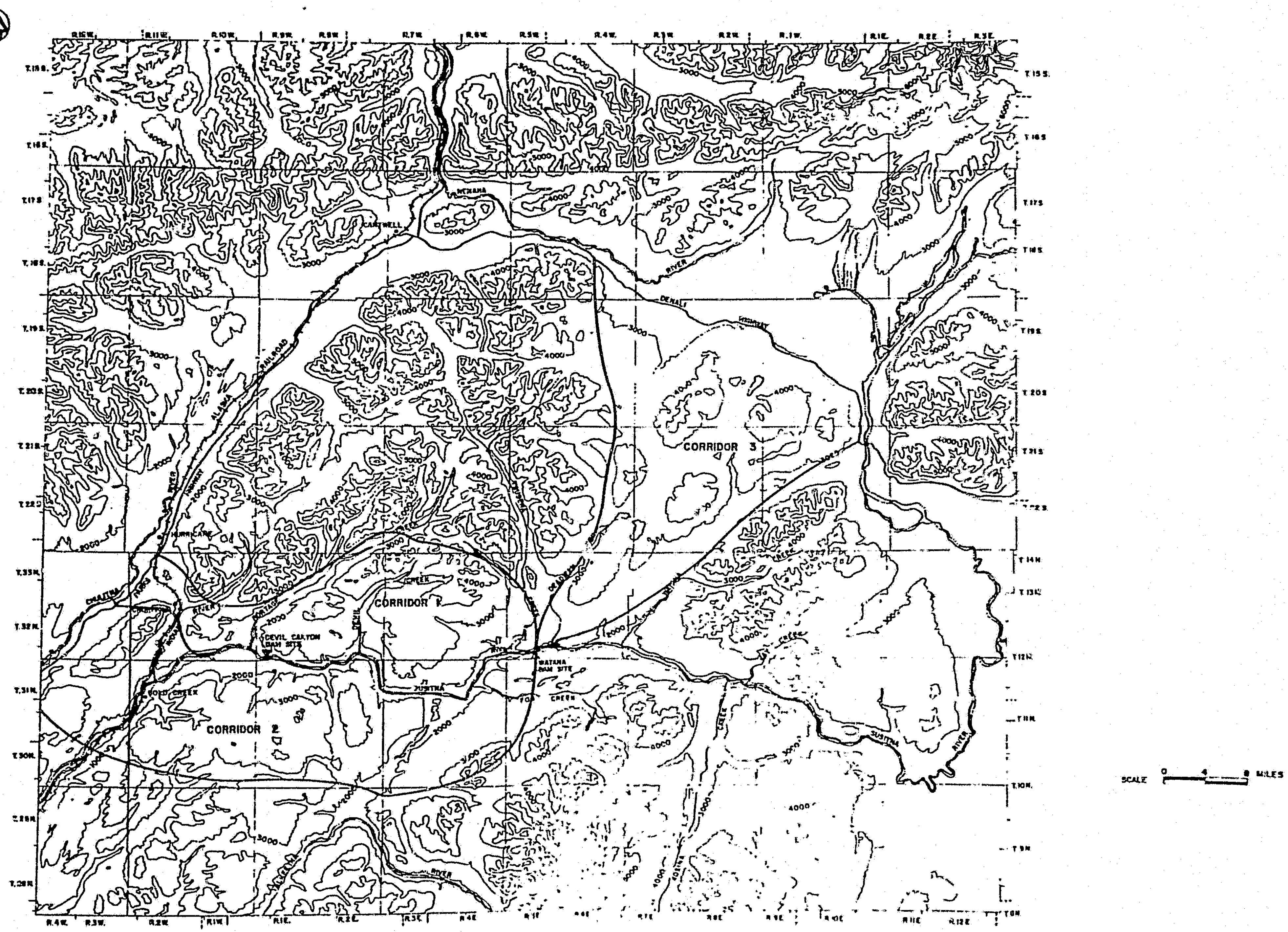
International Engineering Company, Inc. 1979. Robert Retherford Associates. Economic Feasibility Study. Prepared for the Alaska Power Authority.



LOCATION MAP

FIGURE 4.1

ACRES

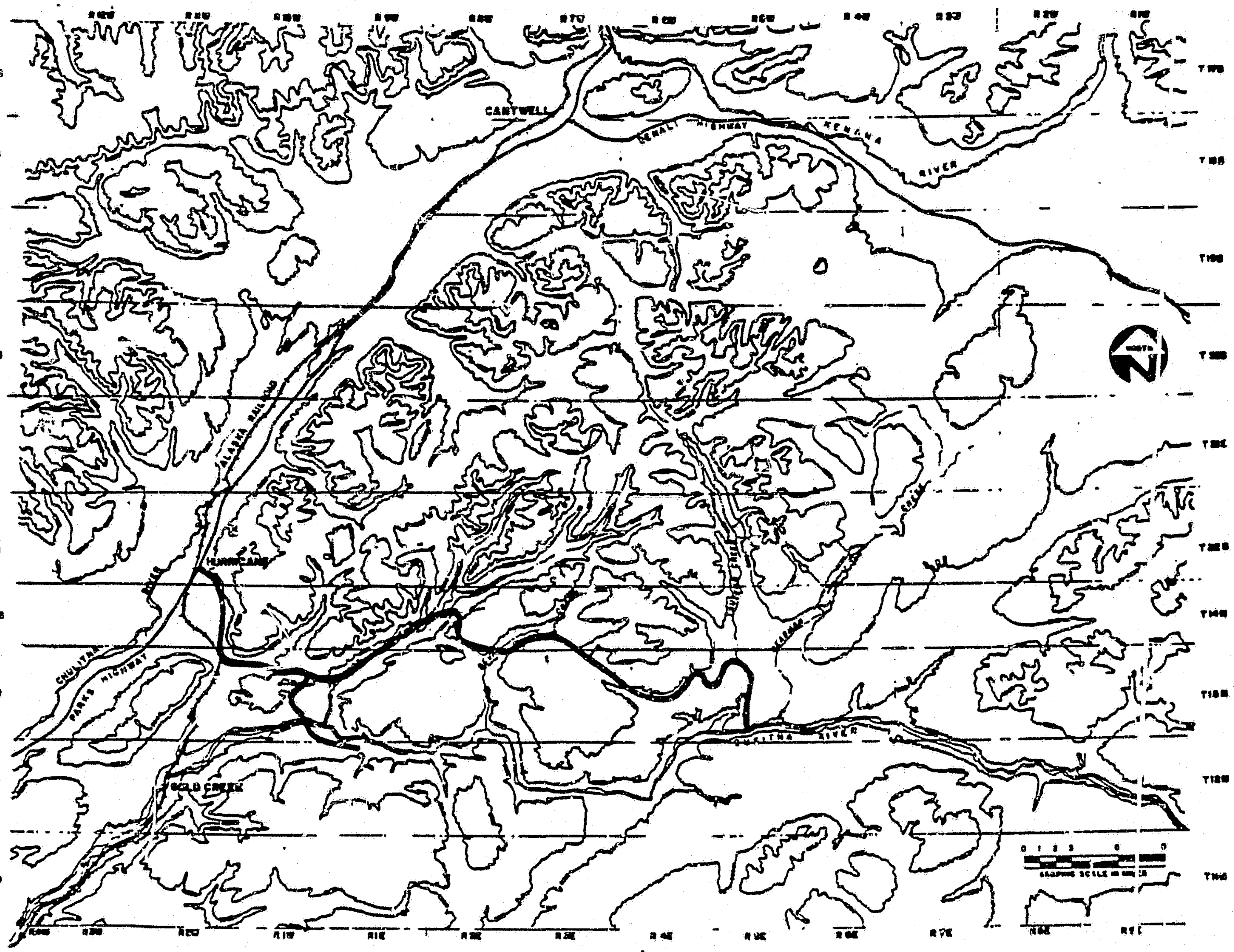


REFERENCE: BASE MAP FROM USGS, 1:250,000
HEALY, ALASKA
TALKEETNA MOUNTAINS, ALASKA

ALTERNATIVE ACCESS CORRIDORS

FIGURE 4.2

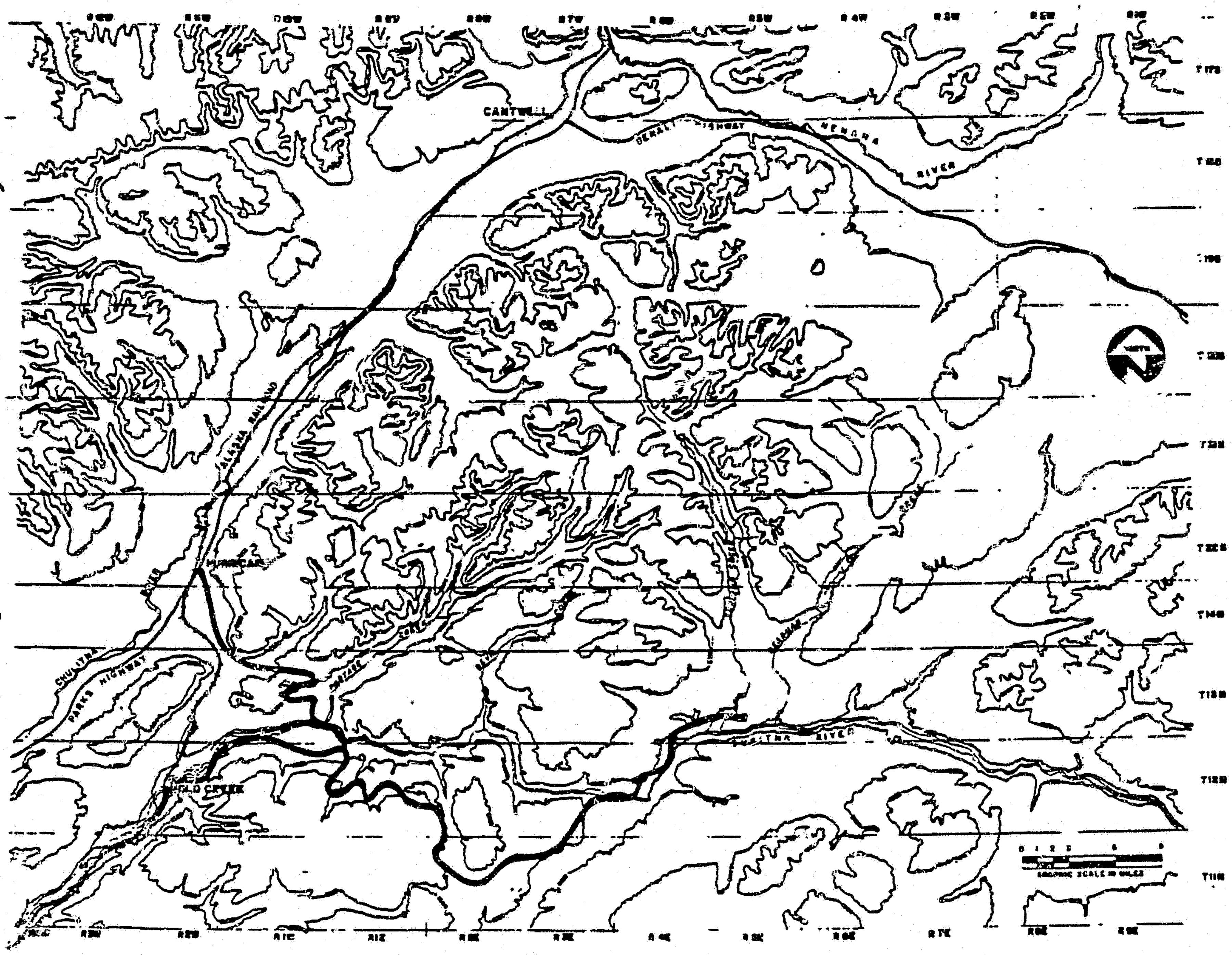
ACRES



ACCESS PLAN 13 (NORTH)
"SUSITNA HYDROELECTRIC PROJECT
ALTERNATIVE ACCESS PLAN"

ACRES

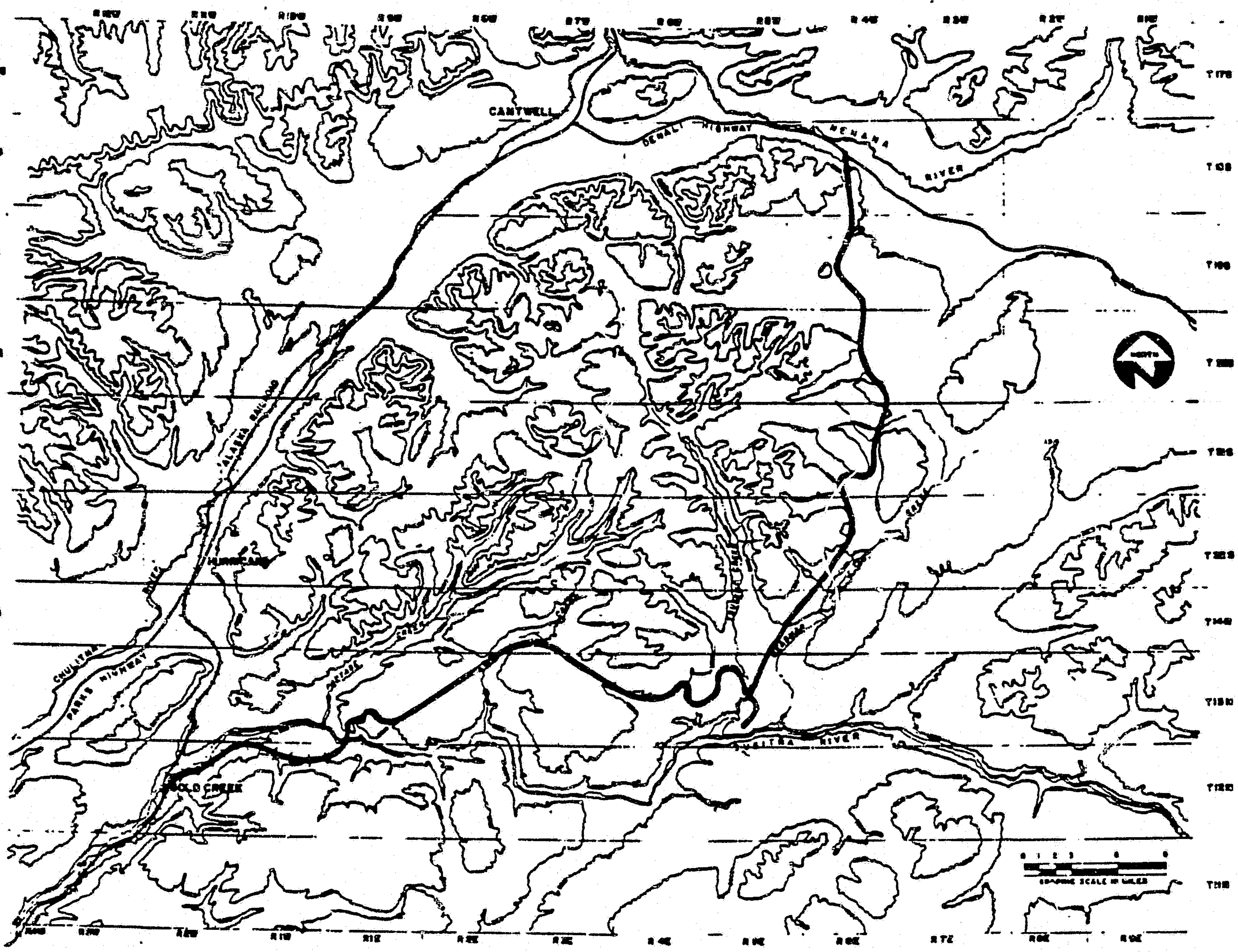
FIGURE 4.3



ACCESS PLAN 16 (SOUTH)
"SUSITNA HYDROELECTRIC PROJECT
ALTERNATIVE ACCESS PLAN"

ACRES

FIGURE 4.4

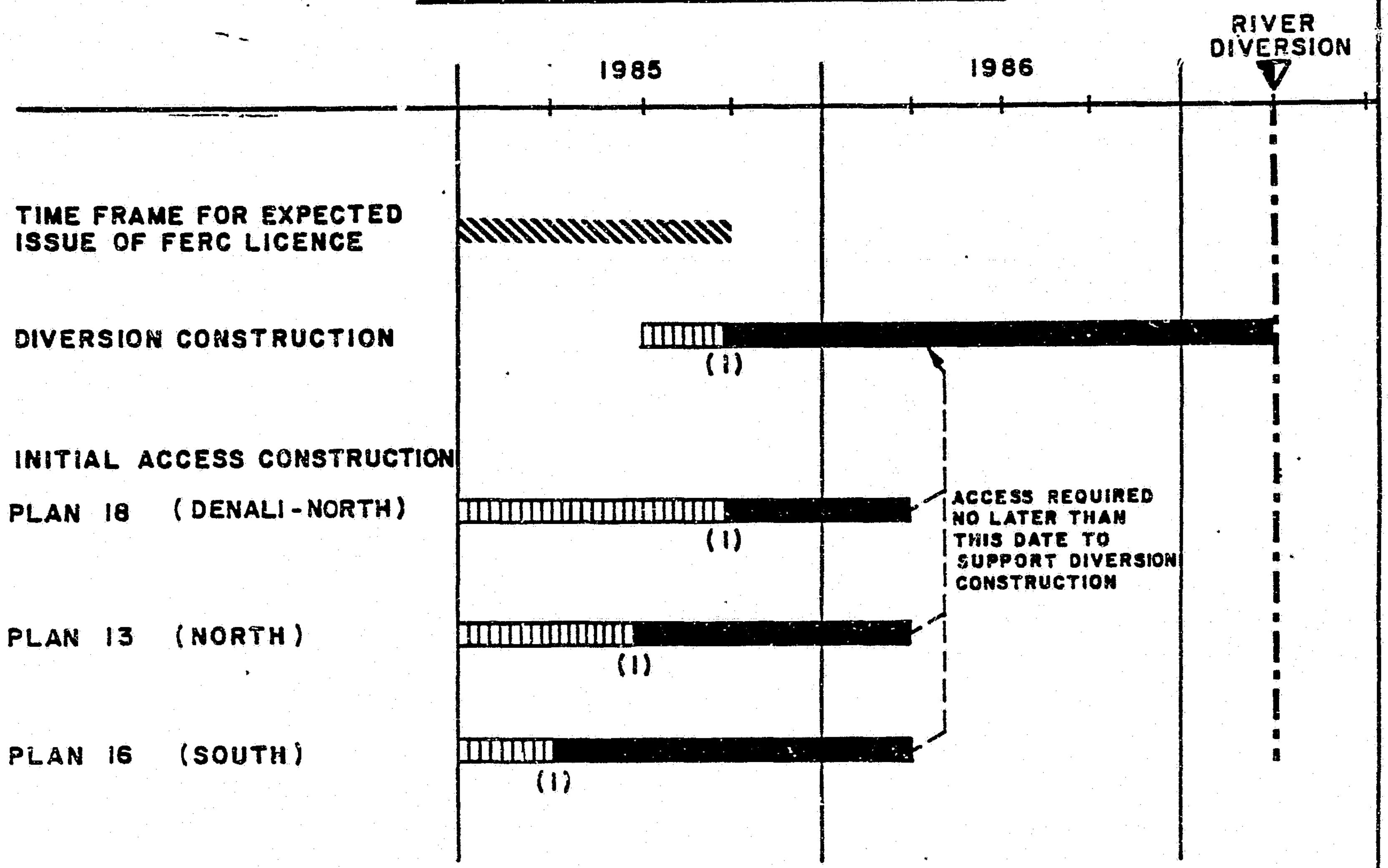


ACCESS PLAN 18 (PROPOSED)
"SUSITNA HYDROELECTRIC PROJECT
ALTERNATIVE ACCESS PLAN"

FIGURE 4.5

ACRES

SCHEDULE FOR ACCESS AND DIVERSION



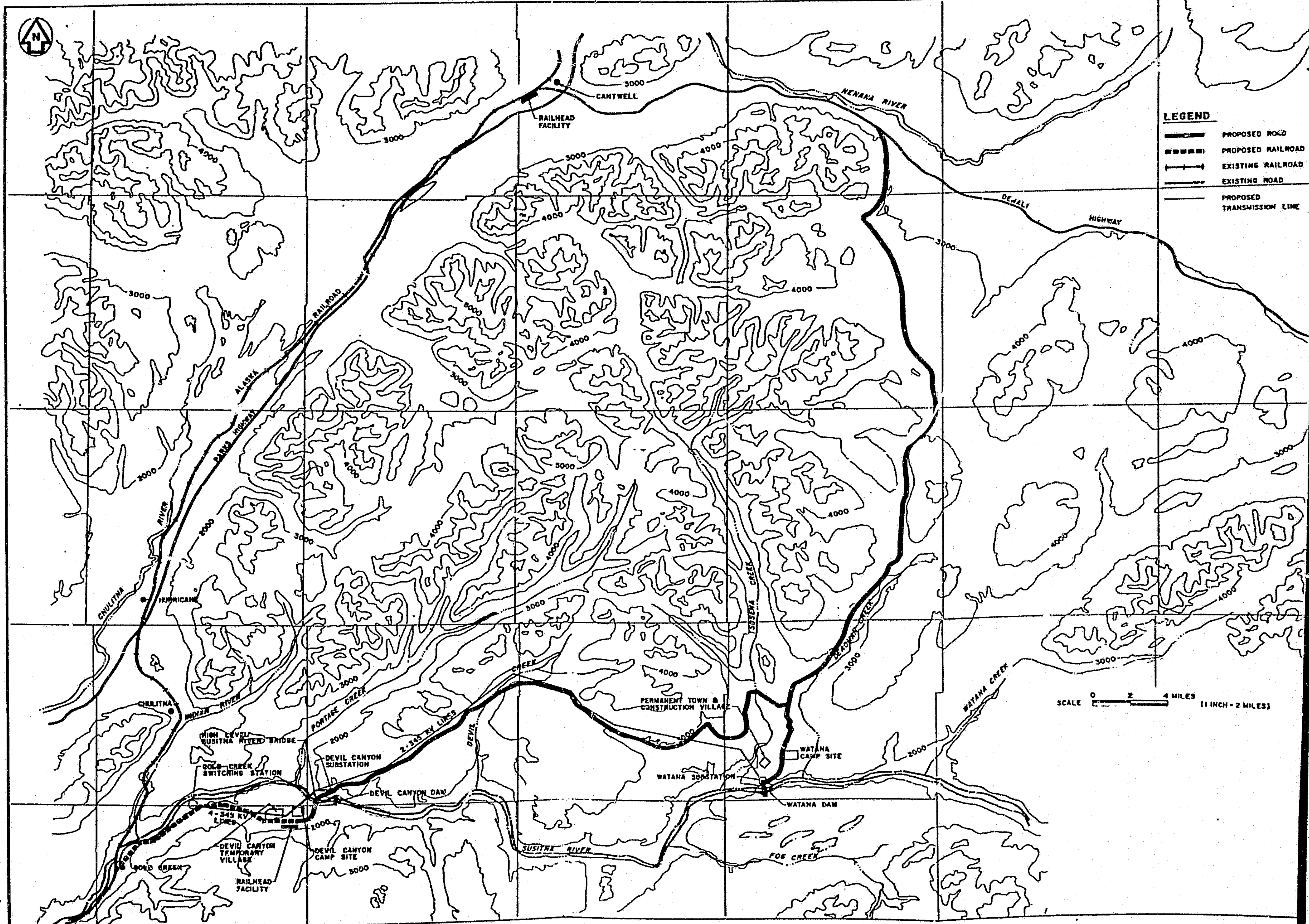
NOTES:

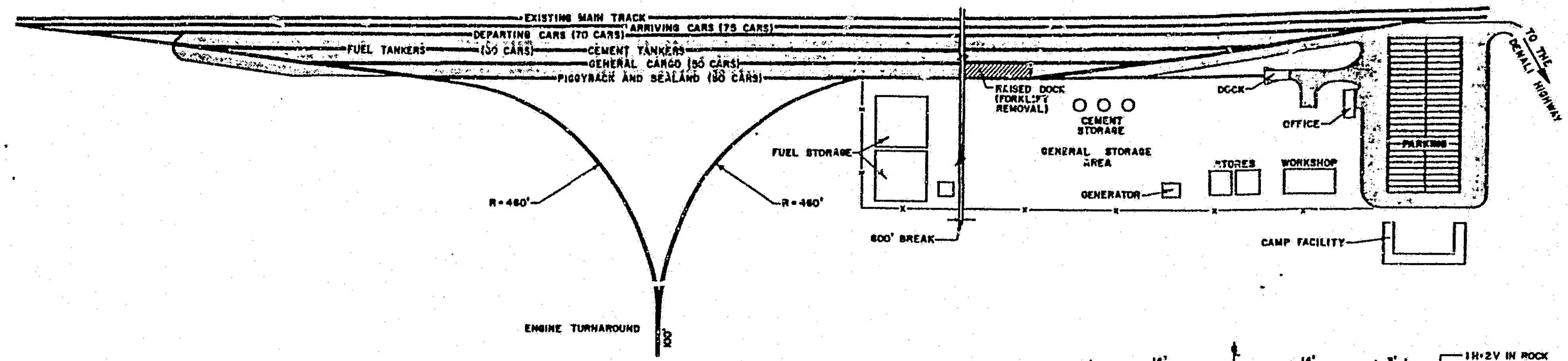
[hatched bar] ACTIVITY START COULD BE DELAYED AND DIVERSION STILL MET.

(1) LATEST START DATE OF CONSTRUCTION ACTIVITY.

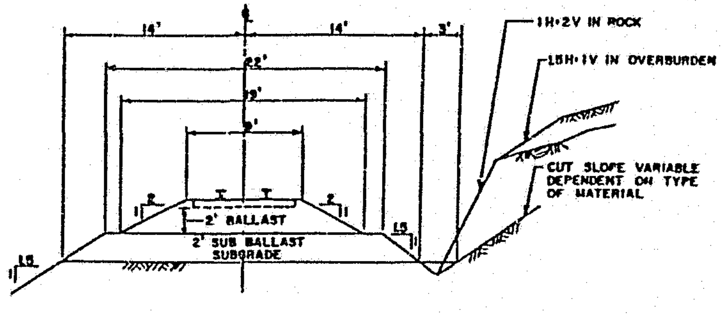
FIGURE 4.6

ACRES

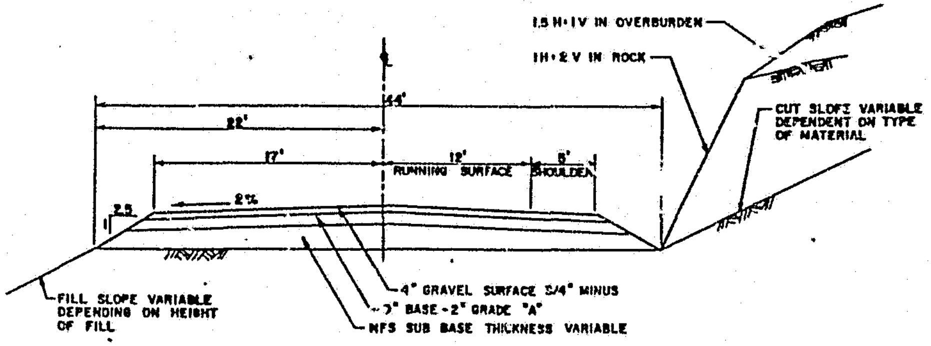

LEGEND
PROPOSED ROAD
PROPOSED RAILROAD
EXISTING RAILROAD
EXISTING ROAD
PROPOSED TRANSMISSION LINE
SCALE 0 2 4 MILES (1 INCH = 2 MILES)
CANTWELL
RAILHEAD FACILITY
NENANA RIVER
DENALI HIGHWAY
ALASKA RAILROAD
PARKS HIGHWAY
CHULITNA RIVER
HURRICANE
CHULITNA
INDIAN RIVER
PORTAGE CREEK
HIGH LEVEL SUSITNA RIVER BRIDGE
GOLD CREEK SWITCHING STATION
DEVIL CANYON SUBSTATION
2-345 KV LINES
DEVIL CANYON DAM
4-345 KV LINES
DEVIL CANYON TEMPORARY VILLAGE
DEVIL CANYON CAMP SITE
RAILHEAD FACILITY
GOLD CREEK
DEVIL CREEK
SUSITNA RIVER
FOG CREEK
TSUSENA CREEK
DEADMAN CREEK
WATANA CREEK
PERMANENT TOWN & CONSTRUCTION VILLAGE
WATANA CAMP SITE
WATANA SUBSTATION
WATANA DAM



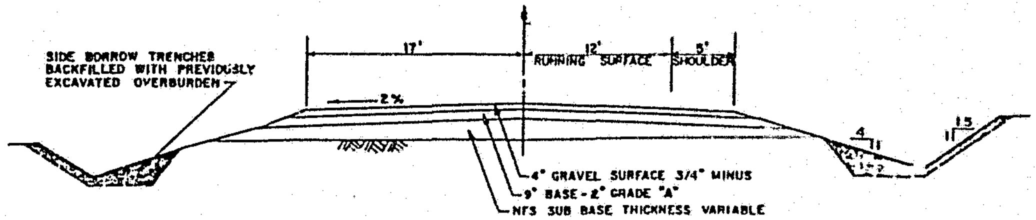
RAILHEAD FACILITY AT CANTWELL - PLAN
SCALE A



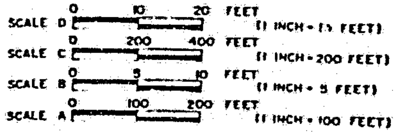
TYPICAL RAILROAD CROSS SECTION
SCALE B

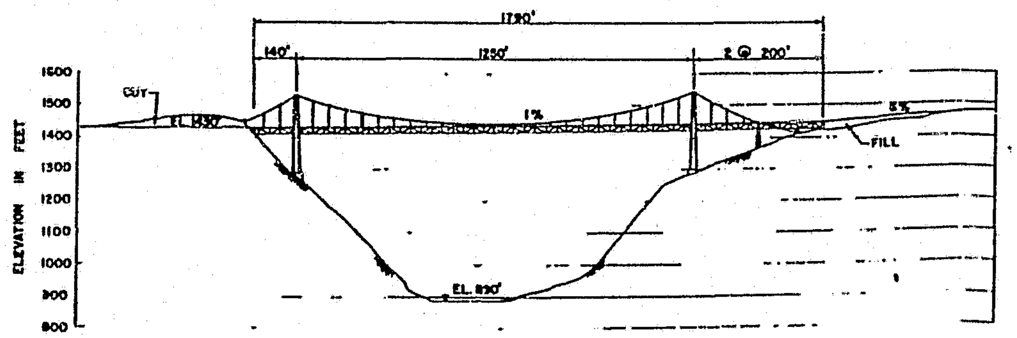


TYPICAL 'SIDEHILL CUT' SECTION
SCALE B

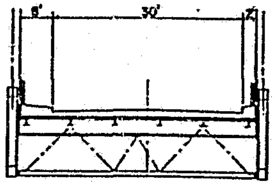


TYPICAL 'SIDE BORROW' SECTION
SCALE B

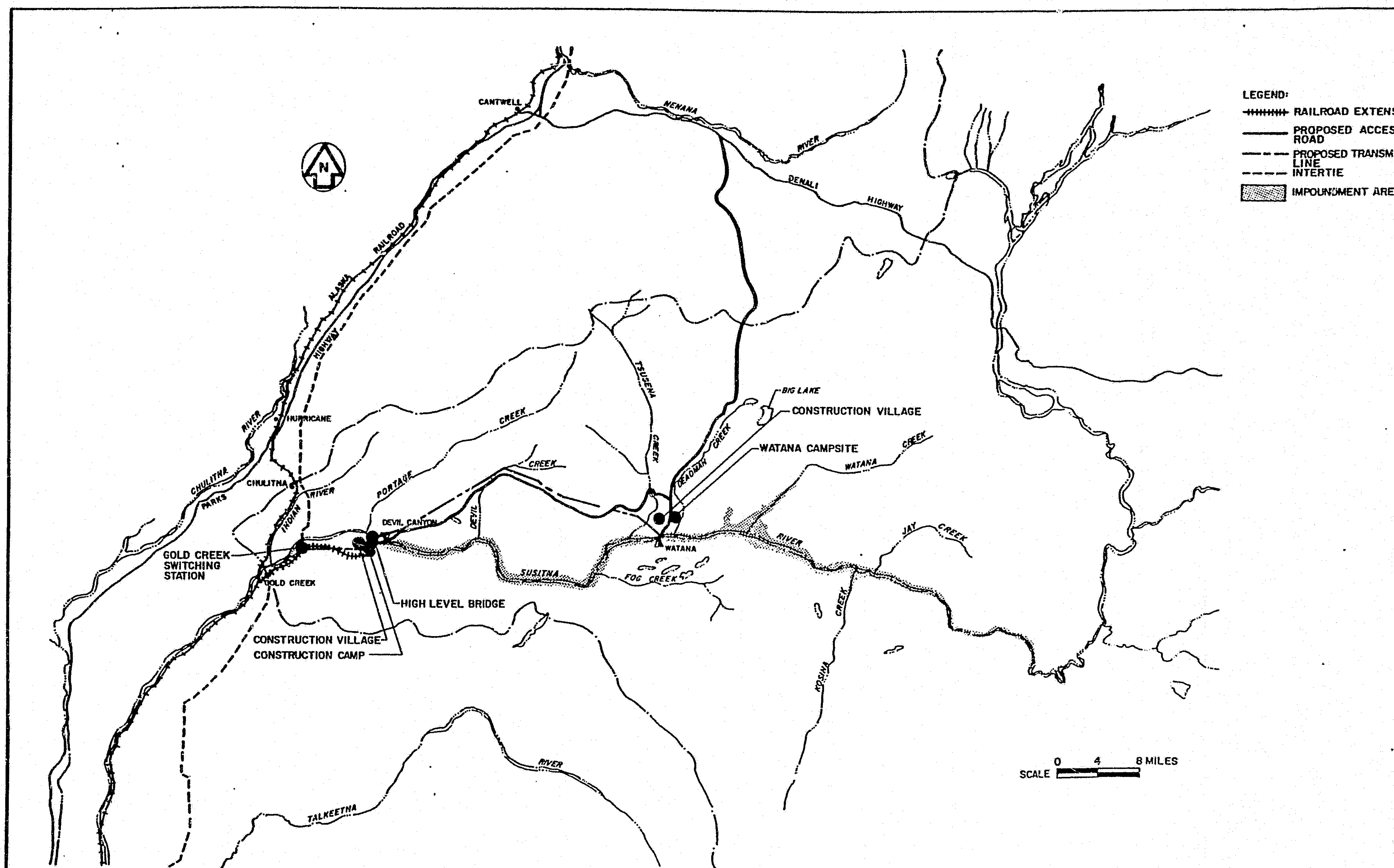




HIGH LEVEL SUSITNA RIVER BRIDGE
SCALE C

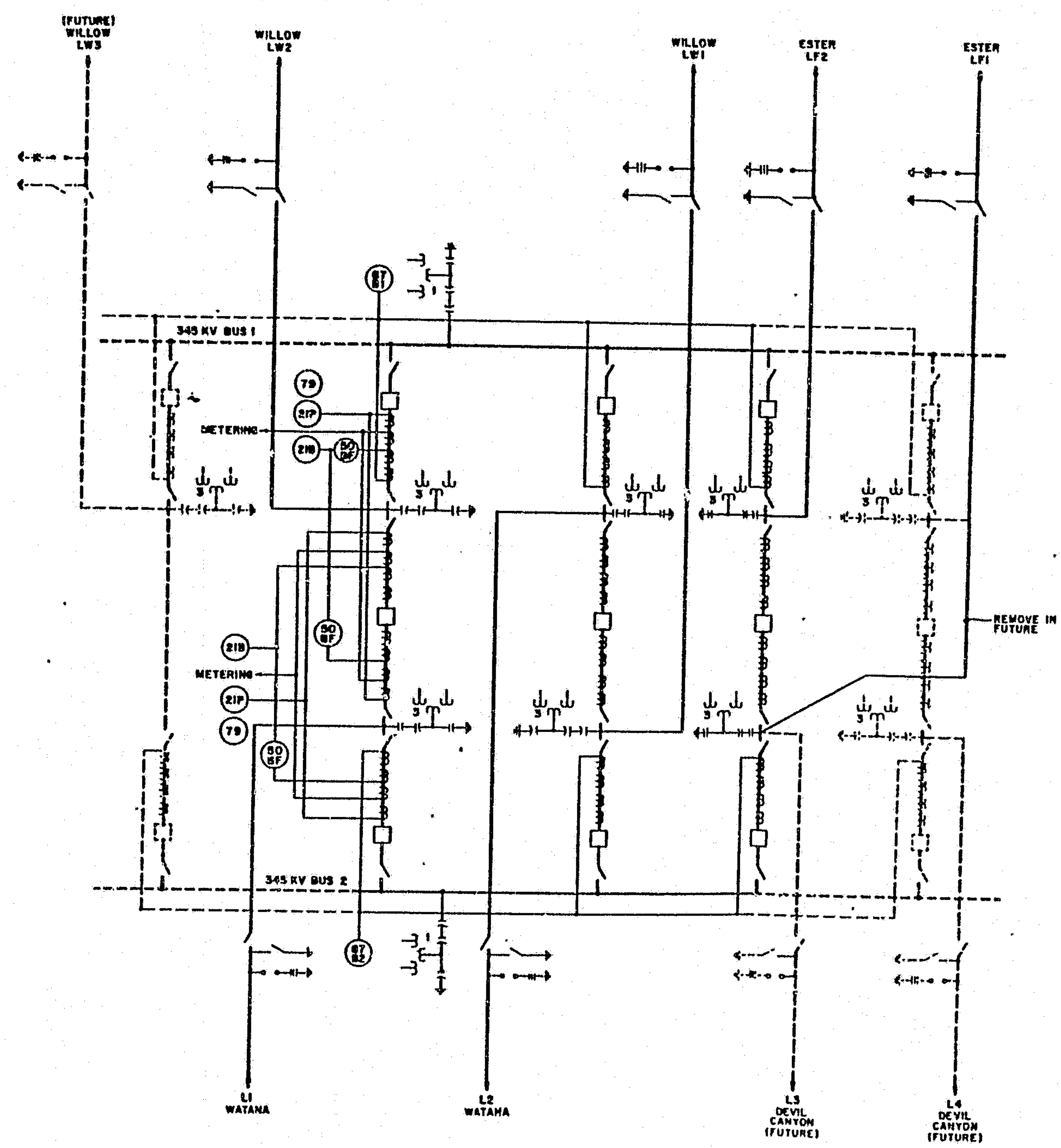


TYPICAL CROSS SECTION
HIGH LEVEL SUSITNA RIVER BRIDGE
SCALE D

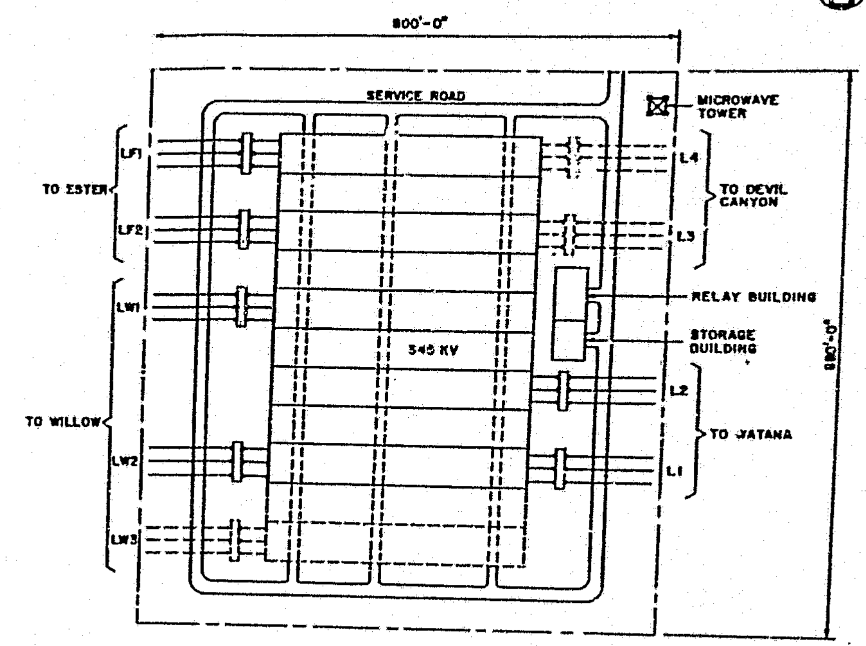


PROPOSED PROJECT FEATURES

FIGURE 6.



SINGLE LINE DIAGRAM

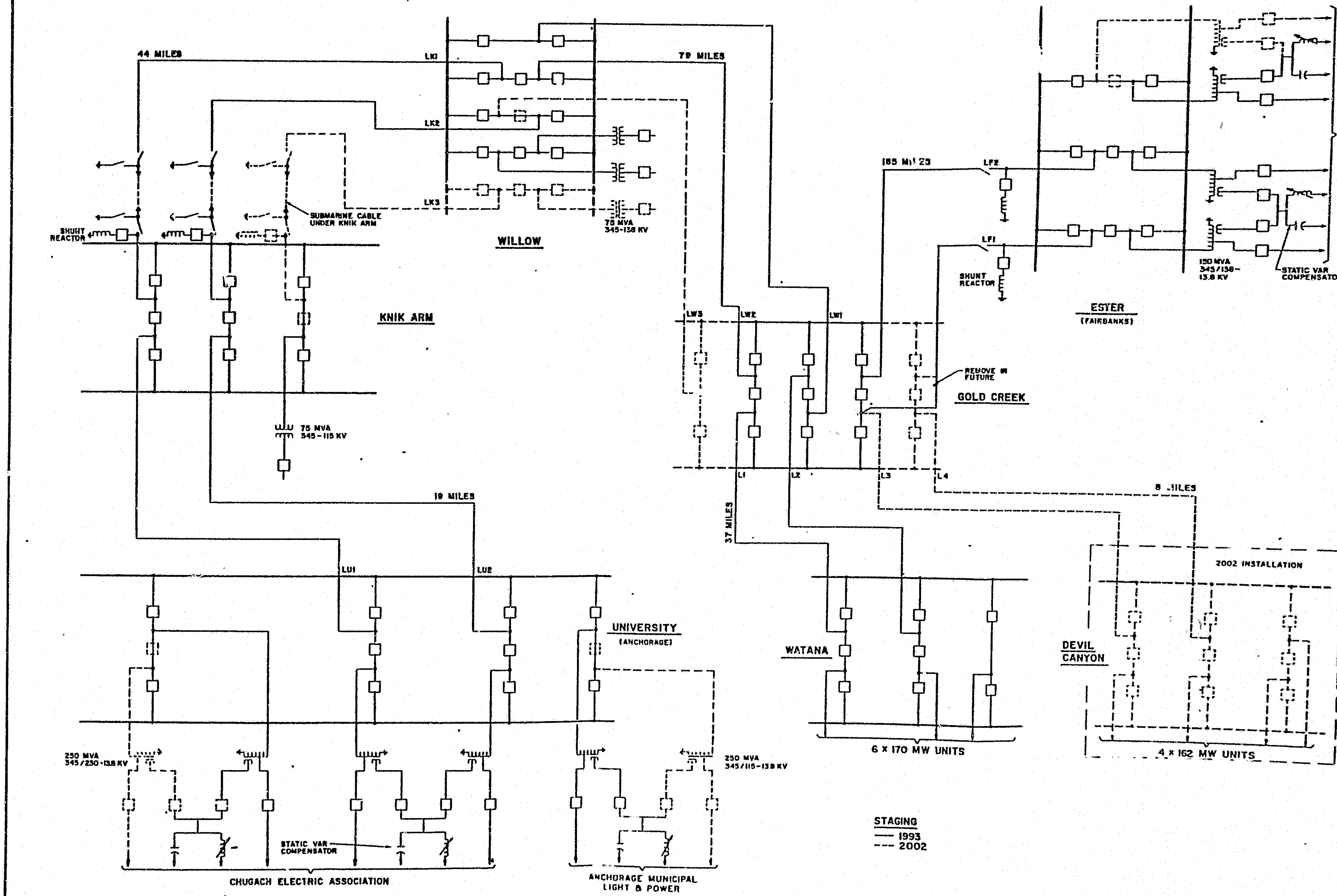


SWITCHYARD PLAN
SCALE A

SCALE A 0 100 200 FEET (1 INCH = 100 FEET)

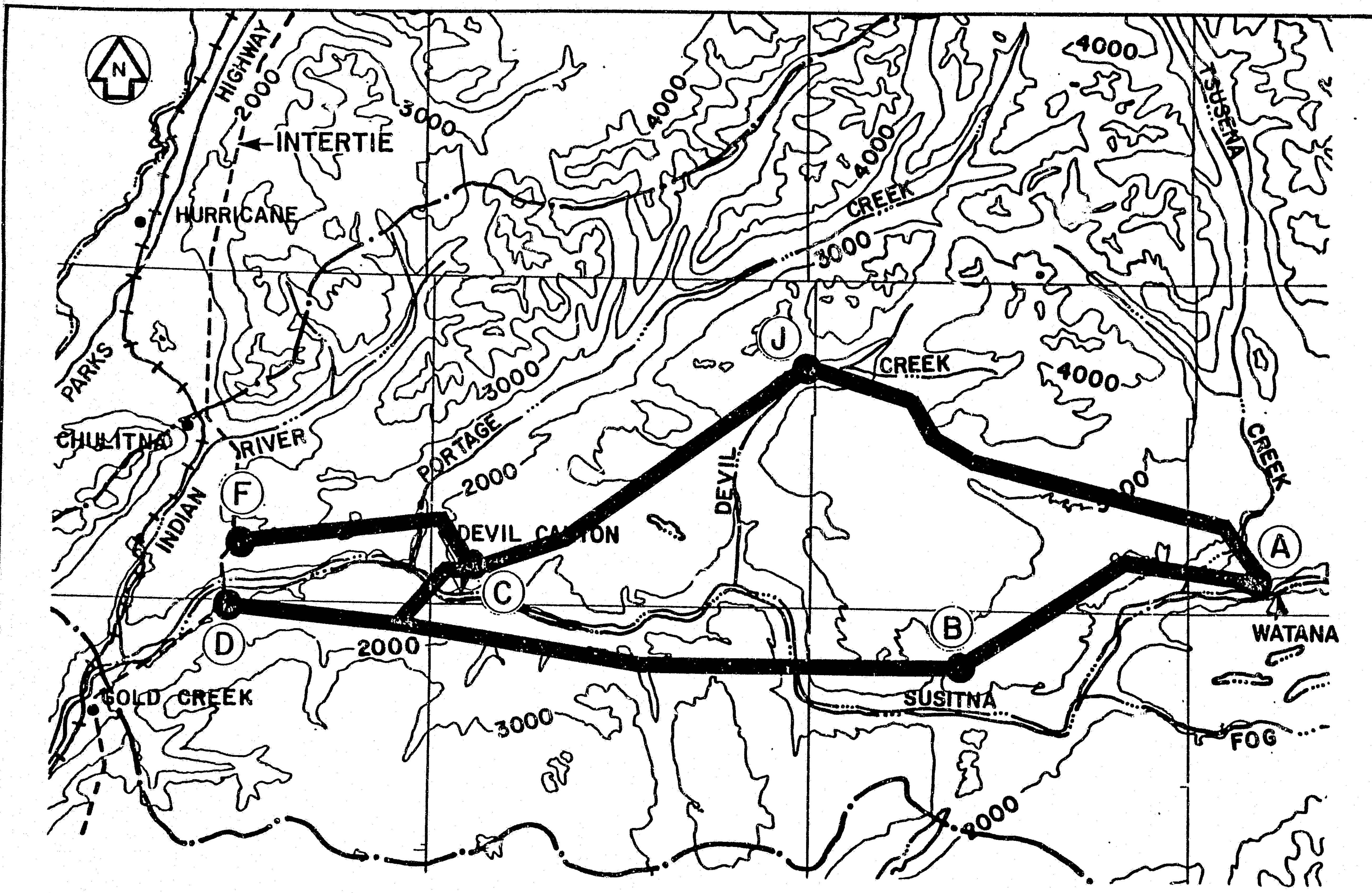
GOLD CREEK SWITCHYARD SINGLE LINE DIAGRAM AND PLAN

FIGURE 6.2



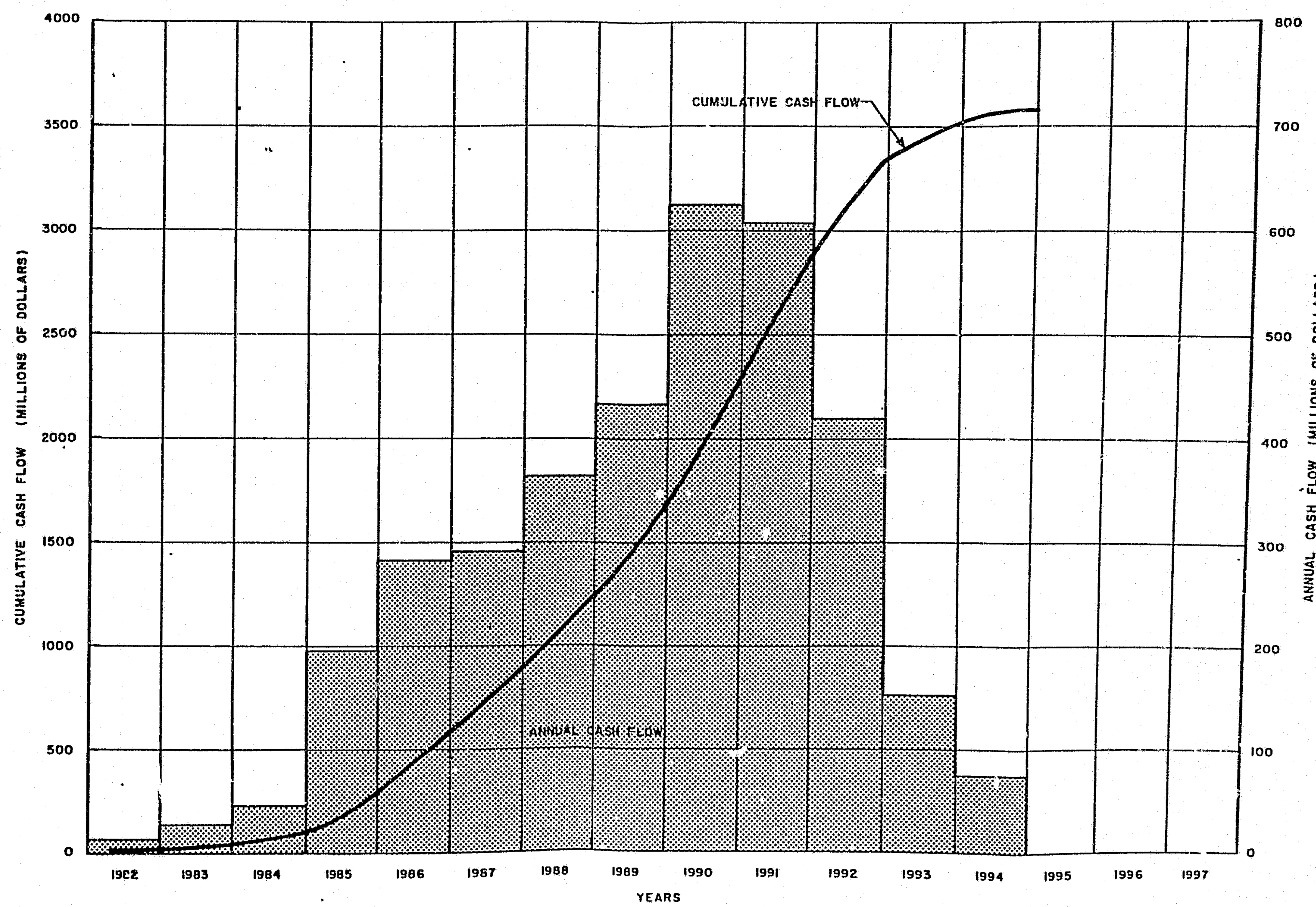
RAILBELT 345 KV TRANSMISSION SYSTEM SINGLE LINE DIAGRAM

FIGURE 6



CENTRAL STUDY AREA ALTERNATIVE TRANSMISSION ROUTES

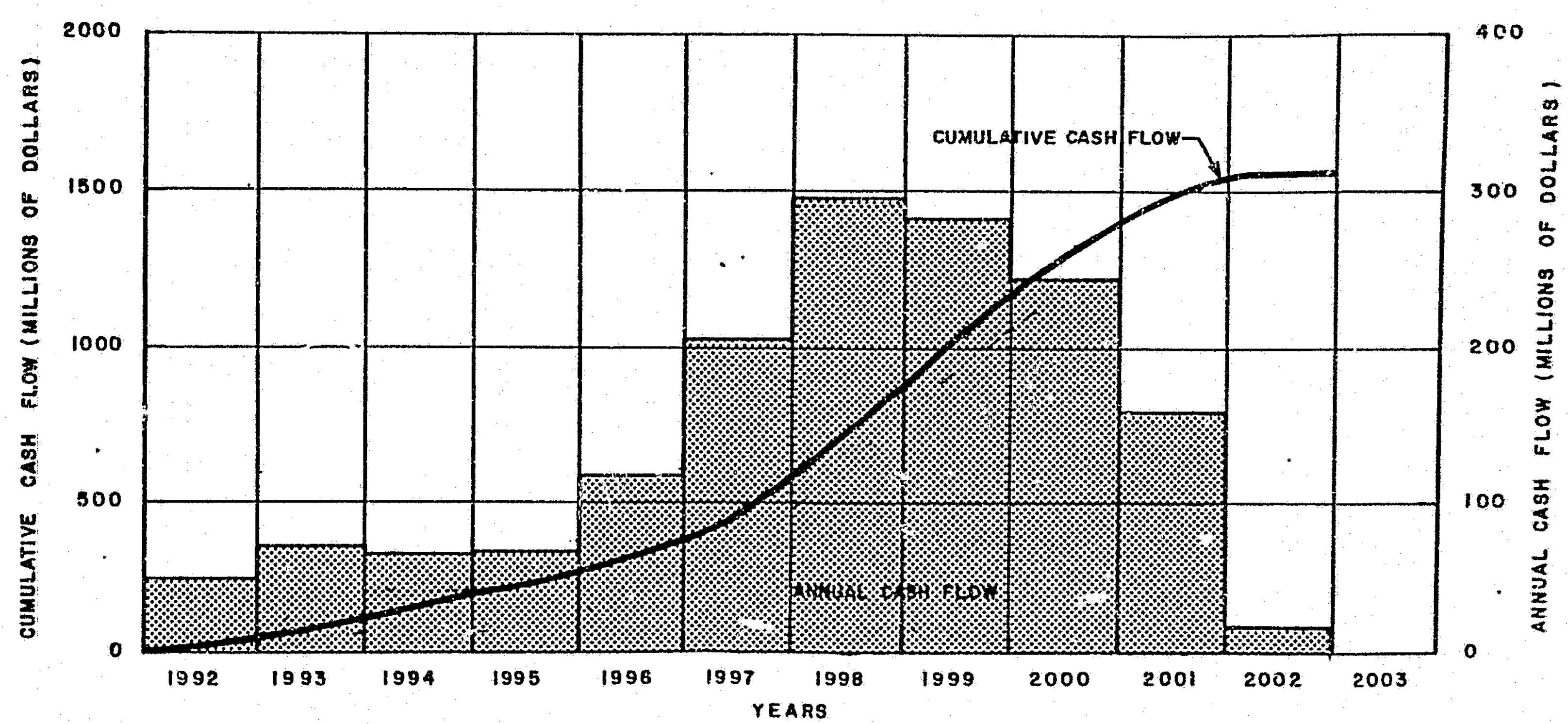
FIGURE 6.4



WATANA DEVELOPMENT
CUMULATIVE AND ANNUAL CASH FLOW
JANUARY, 1982 DOLLARS

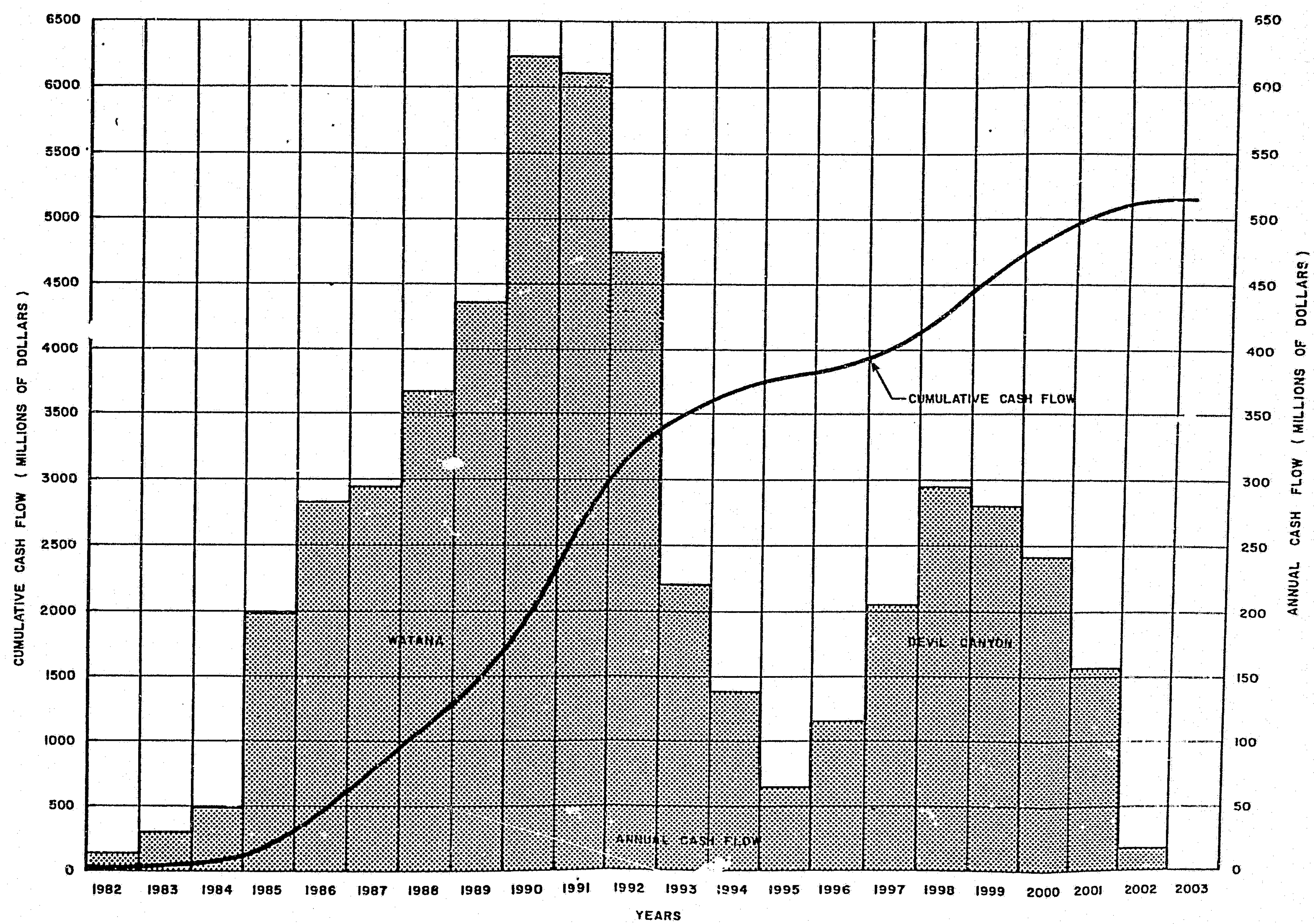
FIGURE 8.1

ACRES



DEVIL CANYON DEVELOPMENT
CUMULATIVE AND ANNUAL CASH FLOW
JANUARY, 1982 DOLLARS

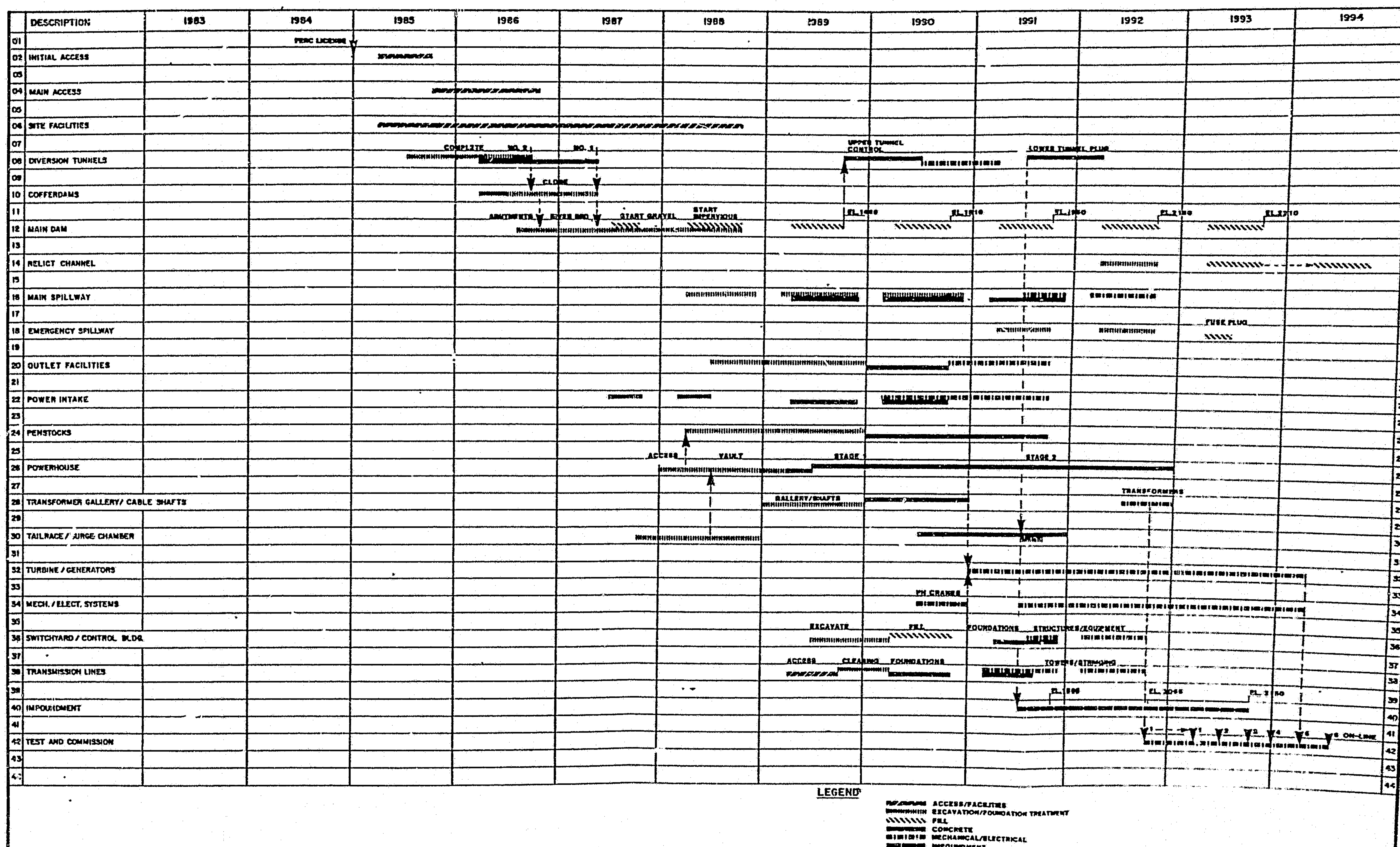
FIGURE 8.2



SUSITNA HYDROELECTRIC PROJECT
CUMULATIVE & ANNUAL CASH FLOW ENTIRE PROJECT
JANUARY, 1982 DOLLARS

FIGURE 8.3

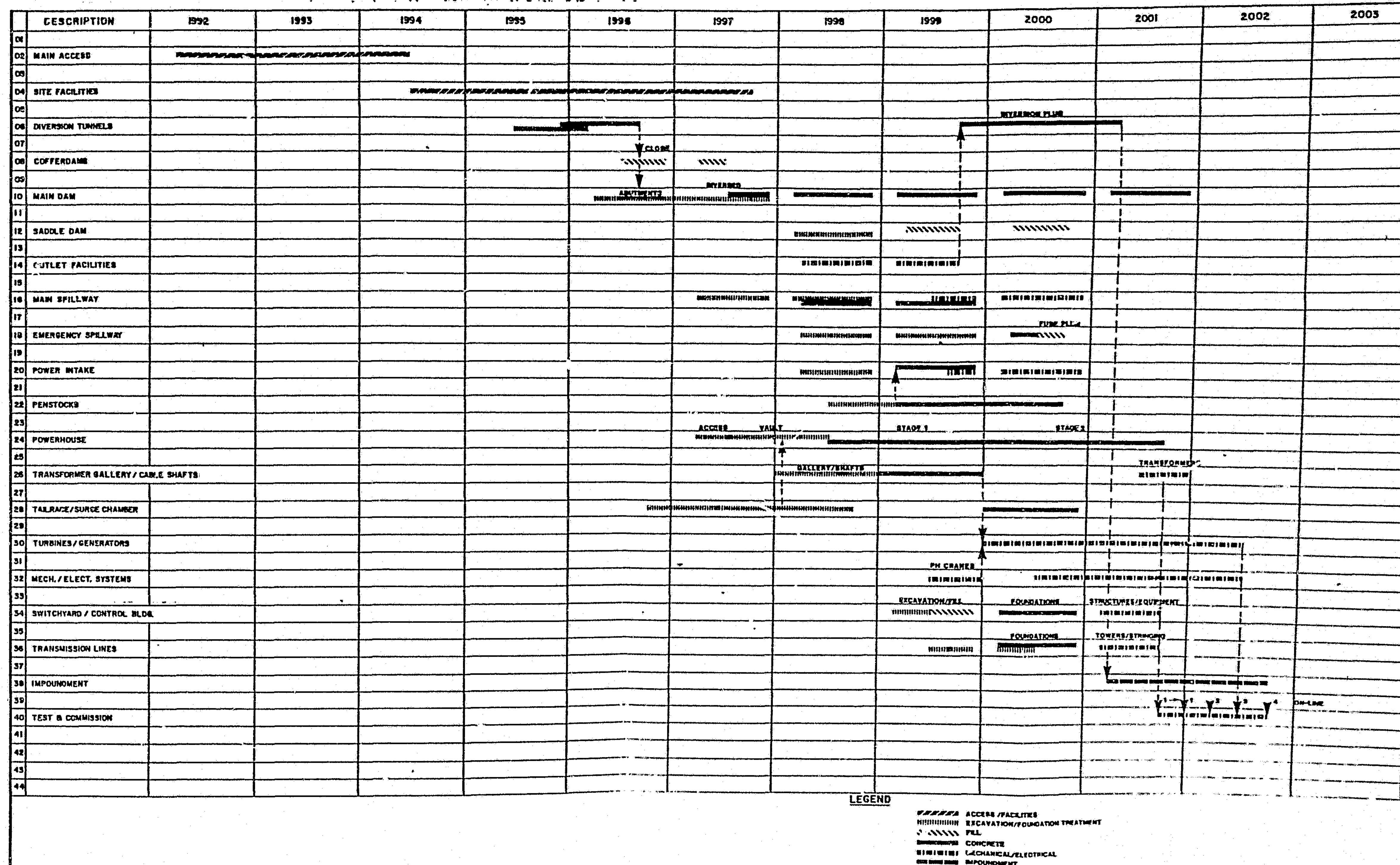
ACRES



WATANA
CONSTRUCTION SCHEDULE

FIGURE 9.1

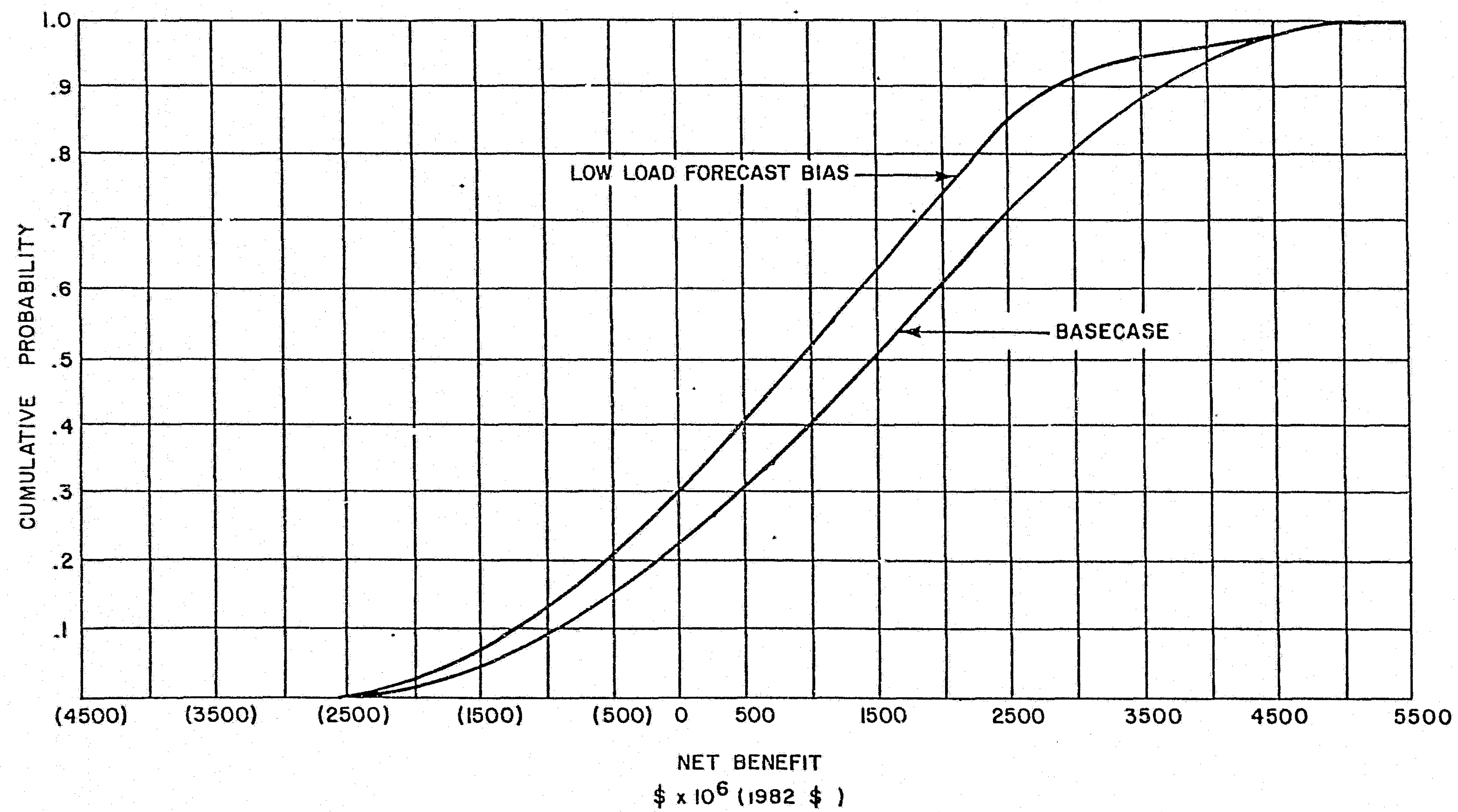
ACRES



DEVIL CANYON
CONSTRUCTION SCHEDULE

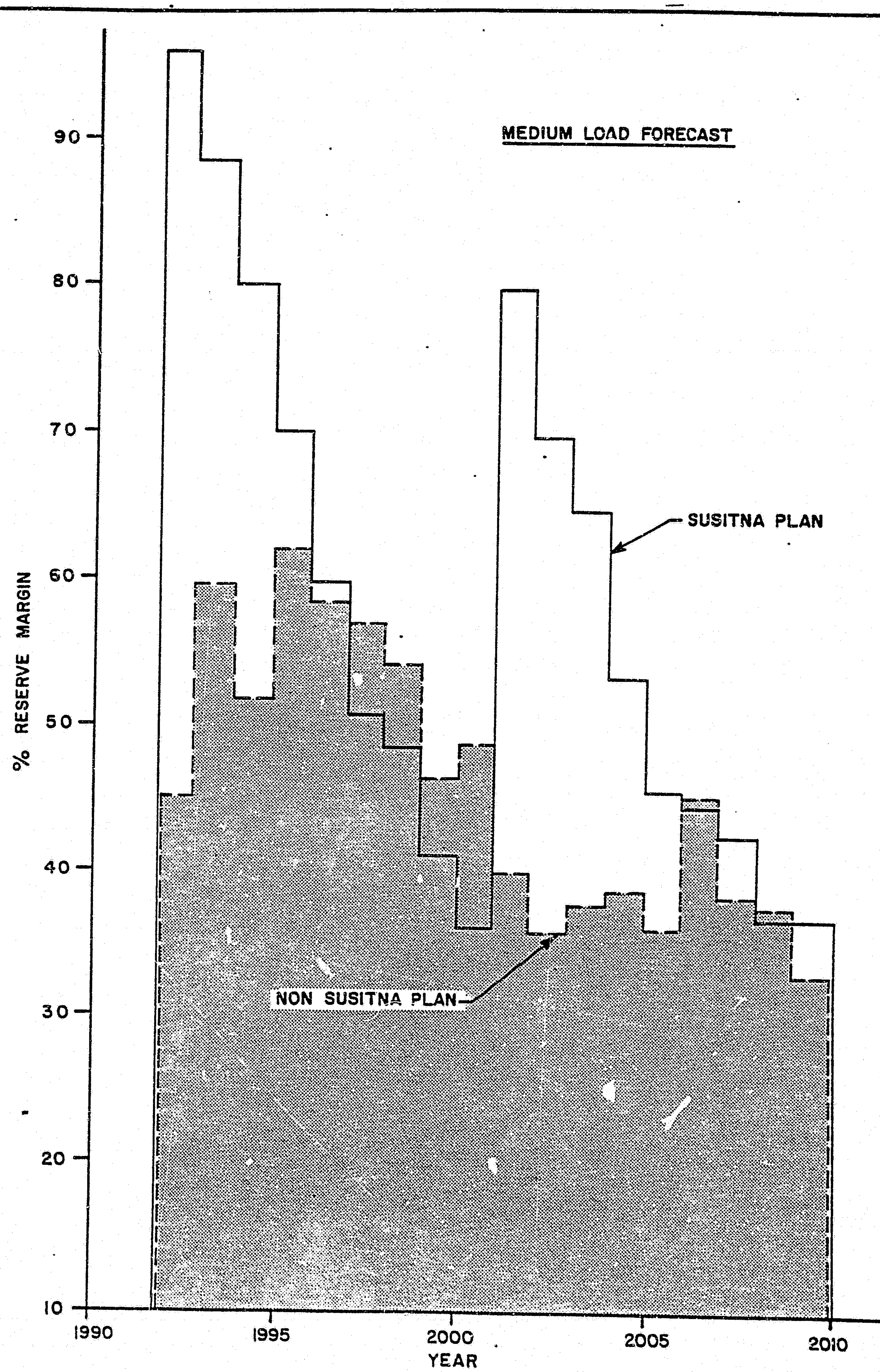
FIGURE 9.2

ACRES



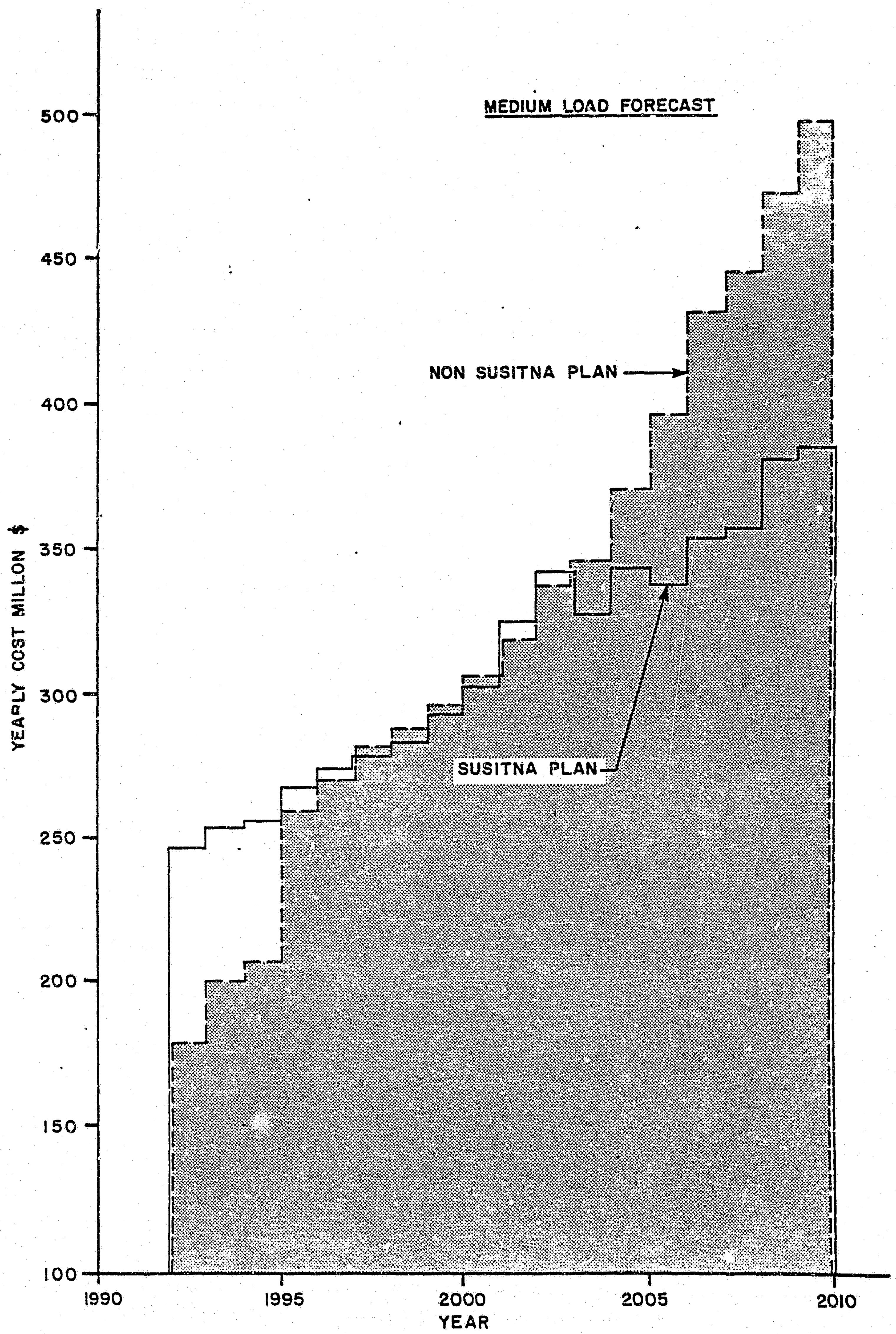
SUSITNA MULTIVARIATE SENSITIVITY ANALYSIS
CUMULATIVE PROBABILITY VS. NET BENEFITS

FIGURE 10.1



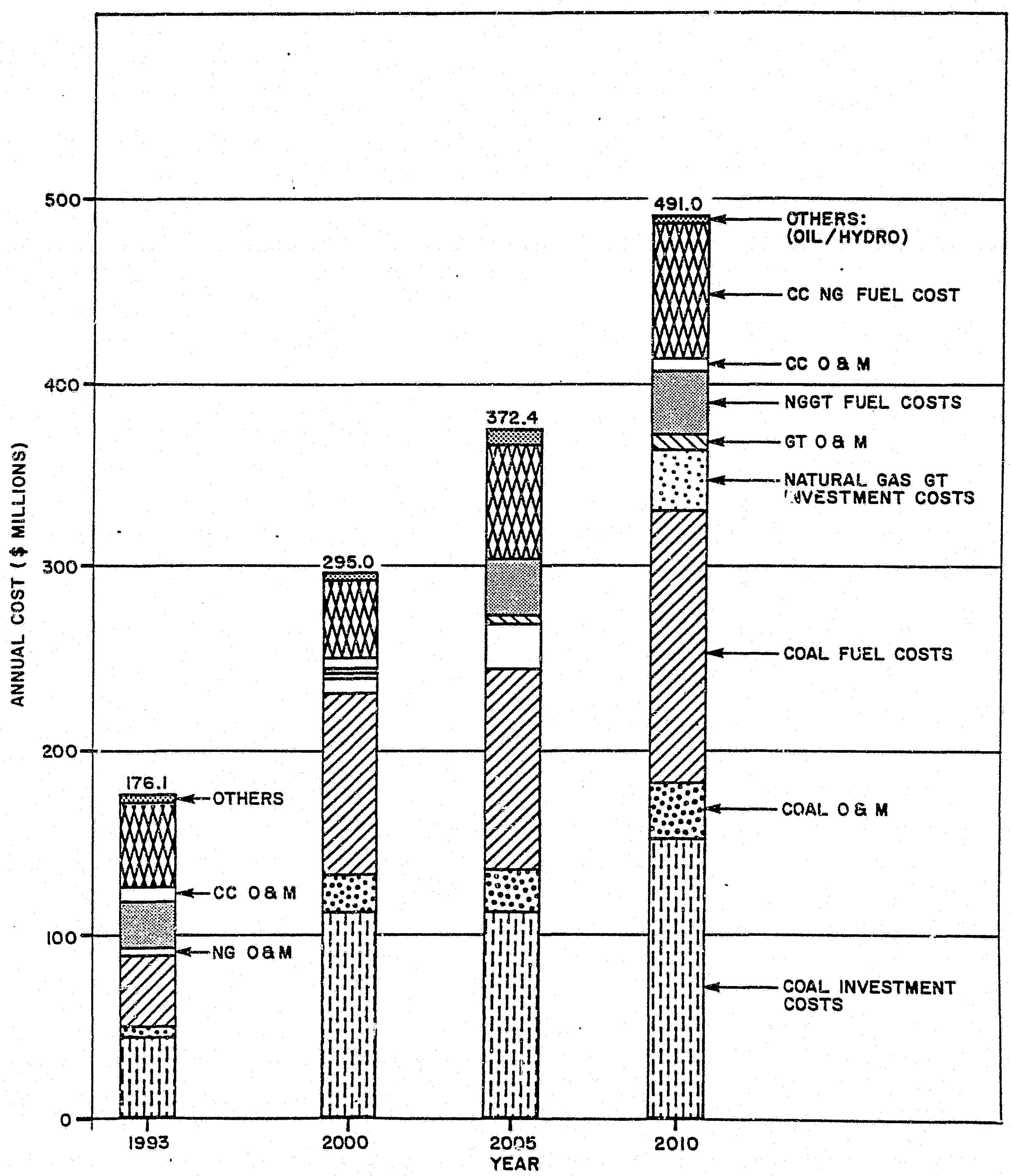
PERCENT RESERVE VS. TIME

FIGURE 10.2



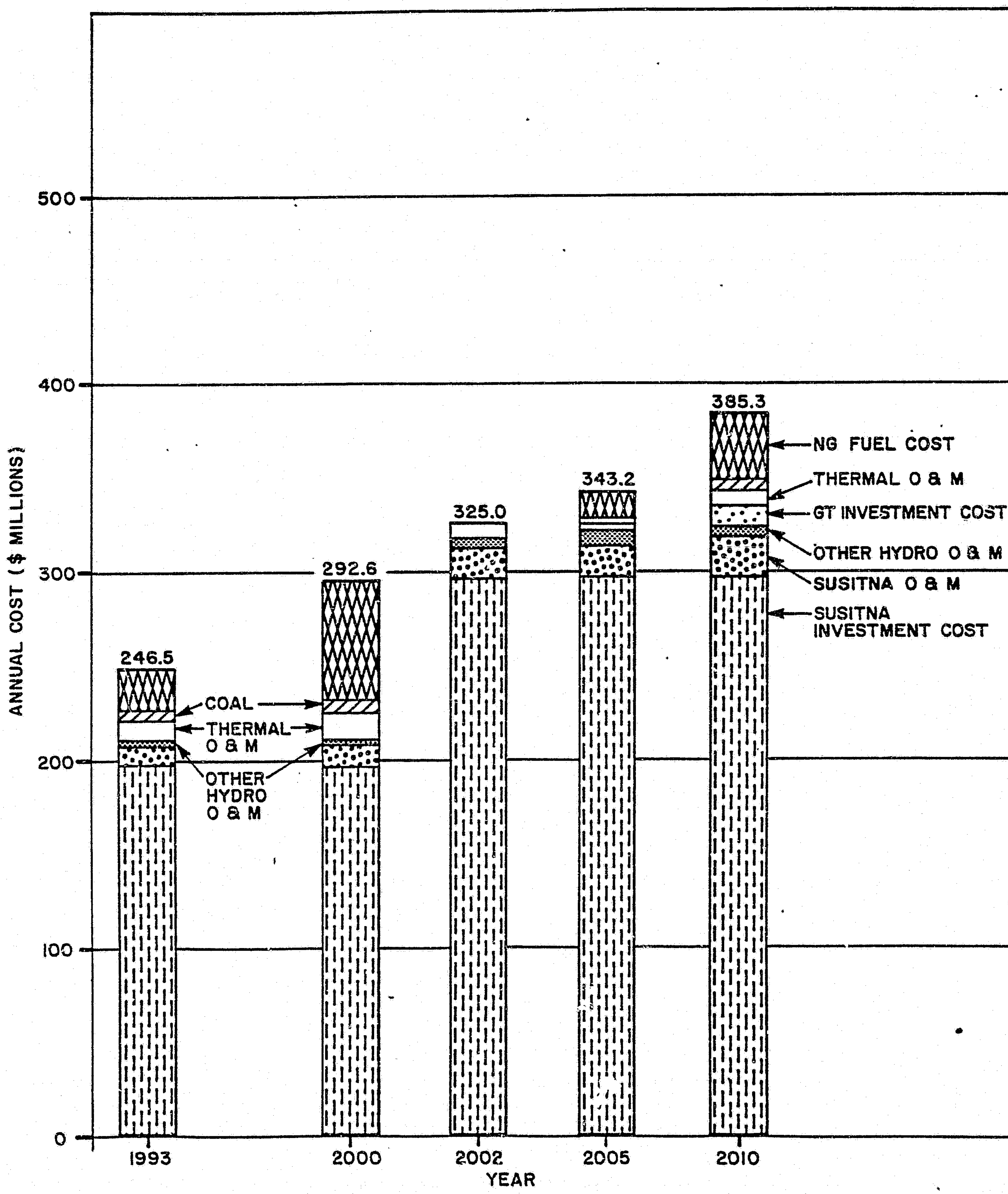
YEARLY ANNUAL COSTS

FIGURE 10.3



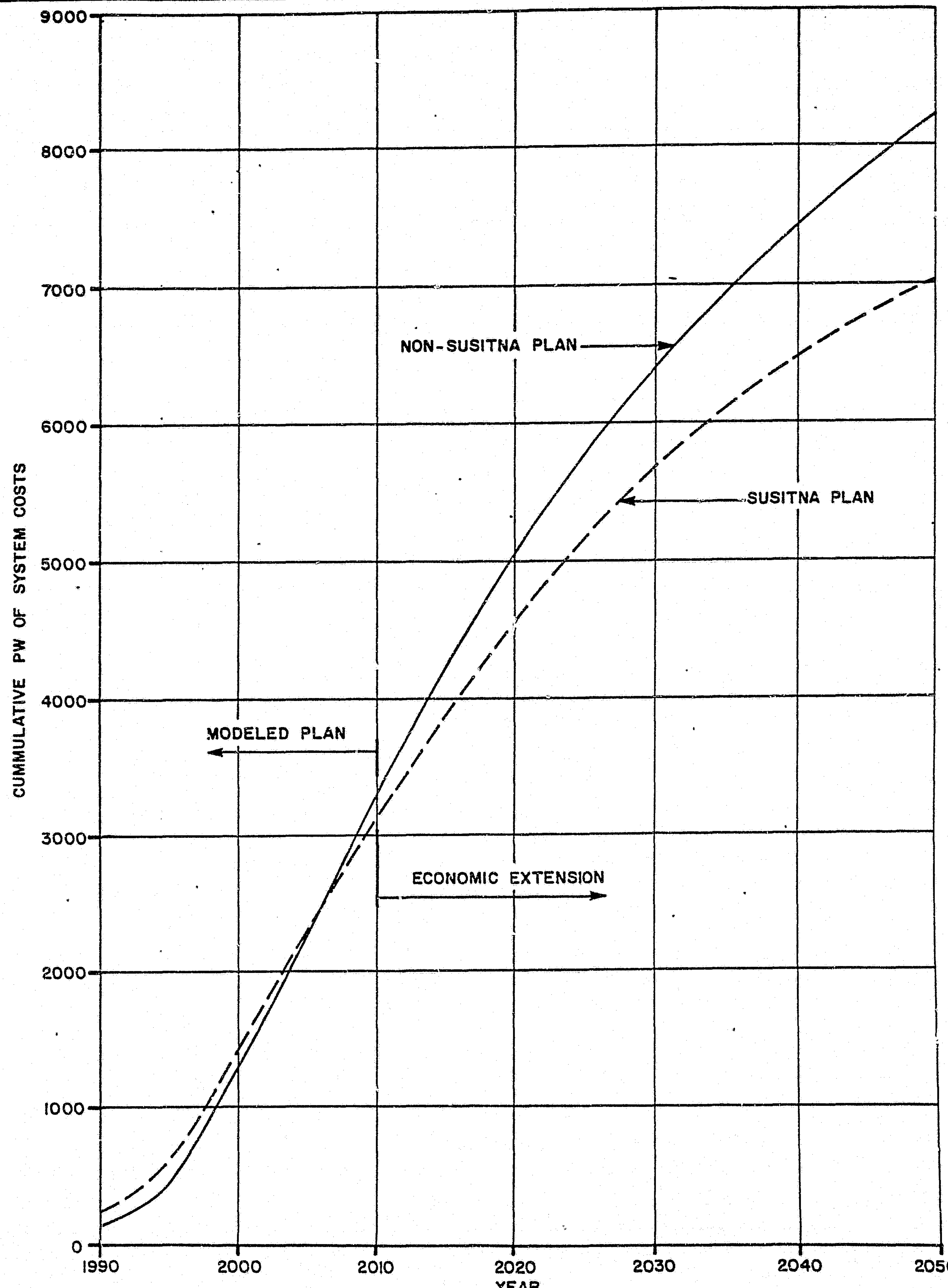
NON-SUSITNA PLAN MEDIUM LOAD FORECAST

FIGURE 10.4



SUSITNA PLAN MEDIUM LOAD FORECAST

FIGURE 10.5



MEDIUM LOAD FORECAST - LONG TERM COSTS

FIGURE 10.6