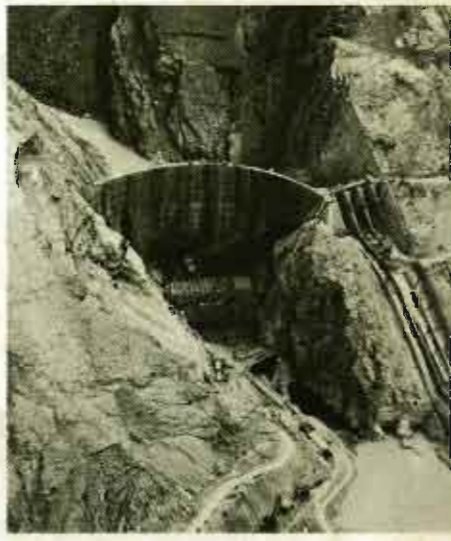
ALASKA POWER AUTHORITY
ANCHORAGE, ALASKA

PLAN OF STUDY

FOR
PROJECT FEASIBILITY AND
FERC LICENSE APPLICATION

VOLUME II - DETAILED PROGRAM

SUSITNA HYDROELECTRIC PROJECT



HARZA ENGINEERING COMPANY

SEPTEMEBER 1979

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INTRODUCTION

The activities described here will be undertaken to definitively assess the feasibility of development of the Upper Susitna River Basin for hydroelectric power and allied purposes. As described in Part A, Section 2, of Volume I, a three-phase approach will be employed. Phase I will consist of a Basin Planning Study to identify the plan of optimum development of the Upper Susitna River and select the most favorable Initial Project. Phase II will consist of a Feasibility Study of the initial project and Phase III will be the preparation and support of an FERC license application for this Initial Project. The work programs for these phases are described below.

This Plan of Study constitutes a detailed work program by disciplines, but we expect that some modifications may be necessary after review by APA and subsequent discussion with other agencies and members of the public as called for by APA. Some modifications also will be required on the basis of results obtained in the course of the study. The detailed work program for each phase and item of study will be presented in a series of investigation memoranda for approval by APA. These will be working documents subject to revision as may be required by the course of the study.

This volume has been divided into four parts, as follows:

Part A - Public Information and Participation Program

Part B - Planning and Engineering Studies

Part C - Environmental Studies

Part D - Detailed Budget Estimates

PART A

PUBLIC INFORMATION AND PARTICIPATION PROGRAM

Summary of Approach

The Susitna Valley is perceived as a significant wilderness area by many groups and individuals in Alaska. Hydroelectric development in the basin has generated considerable interest and concern since it was first seriously considered in the 1950's. As knowledge of the current intensification of project planning spreads, this interest in the project, potential project impacts, and in the project planning process will increase greatly.

Public concerns regarding the project, in particular Alaska energy needs and development, environmental sensitivities, and prospective economic growth, were discussed at the meeting held July 19, 1979 at the APA offices. Representatives of several environmental groups assisted in the identification of key issues related to the project and the project planning process. Although public participation is built into the EIS process, we believe it is highly desirable that public involvement go considerably beyond the conduct of meetings to solicit comments and reactions to information and proposals that are in an advanced state of planning. To that end, the program should solicit public involvement at the earliest possible date and, if possible, prior to finalization of the Plan of Study (POS), promote public awareness throughout the course of the studies, and provide channels for input and workshops for participation, together with a vehicle for specific and continuing feedback.

The public will be very interested in the determination of need for, and the economics and technical feasibility of, the project, and in the consideration of alternative energy sources. The Public Information and Participation Program (PIPP) discussed below has been developed specifically to provide an organized focus for public opinion and feedback so that public inputs and concerns can be integrated into all phases of the POS. Key objectives of the program are:

1) to present factual information and data relative to the project and project background and to inform the public of the proposed planning process as a basis for facilitating public understanding,

2) to make the entire planning process easily accessible, to the public, and to actively encourage broad, informed participation by all sectors of the communities to be affected,

3) to ensure that public inputs are fully considered along with technical information in the planning and decision -making process, and

4) to document public participation as fully as possible for future reference by APA, FERC, and other organizations and agencies.

We suggest that the organization to manage the public information and participation program be simple and direct. We propose to engage an Alaskan resident as manager of the program. The manager will report directly to the Resident Manager and will work in close cooperation with all key project personnel and with the APA staff. The qualifications of the position will dictate that the person have a thorough background of Alaskan attitudes, customs, and viewpoints and is familiar with local issues. The manager of the PIPP should also have an appreciation for the environmental values that are at stake in the project, and should have, or develop, creditability with the environmental community and the public at large.

The principal tasks of the PIPP will be to facilitate a two-way flow of information between the project team (APA and the Engineer) and the public and to keep the entire planning procedure open and accessible. The manager of PIPP, as well as other key project personnel, should expect to devote significant amounts of time to public meetings, workshops, and conversations with interested individuals. In the Anchorage office, they will be assisted by a resident staff as required by frequency of public contacts, meetings, and preparation of informational releases. The PIPP director will also maintain coodination with the Engineer's Home Office to ensure that public inputs are considered in all aspects of project planning.

It is anticipated that as the PIPP director will become known through public and media contact, and that enquiries will come directly to him regarding the project. In addition, enquiries directed to other members of the project team will be referred to him so that he can ensure that full and accurate information is obtained from the proper sources and provided to the inquirer. The director will also actively seek out opinions and reactions to the project from segments of the population who may have an interest but are not prone to take an active position.

Specific Tasks

The following specific tasks are indicative of the type of activities to be undertaken by the Public Information and Participation Program.

Task P-1

Identify organizations and individuals to receive information materials and meeting notices. The staff of the PIPP will prepare a list of names and addresses of organizations and individuals who are interested in receiving information about the study or who may wish to provide specific inputs to certain aspects of the study. Names will be obtained from public officials, community leaders, environmental groups, previous Corps of Engineers EIS respondees, and by advertising in the local media. The lists will be started at the initiation of the project and will remain open throughout its course, with periodic major efforts at expanding its scope.

Task P-2

Assist APA in organizing an initial public meeting(s) to introduce the engineer and discuss the study program. As soon as the POS is finalized following selection of an engineer, a presentation should be made to the public to explain the study objectives and procedures. The PIPP personnel will assist the APA in preparation for, and conduct of this program. It may be desirable that this presentation be made in more that one location (e.g., Anchorage, Fairbanks, Palmer, Talkeetna, etc.). This presentation should be supplemented, both before and after, by a broad-scale public awareness campaign to announce the presentation, describe the objectives of the study, and to solicit public response.

Task P-3

Prepare and disseminate a series of fact sheets or newsletters to advise the public of the progress of the study and its findings as a basis for facilitating informed public discussion. The fact sheets will summarize current information and indicate the availability of more detailed data. This should be supplemented by information provided to the news media relating to the purpose and design of the overall study, study findings, and proposed future steps to be taken. This information dissemination will facilitate informed public participation and attendance at public meetings and workshops.

Task P-4

Organize and conduct small group workshops to exchange information, identify public concerns, and propose corrective actions for consideration. Following the initial public meeting(s), the staff of the PIPP and other project personnel will organize and conduct small workshops in the Susitna Valley communities and with interested groups in Anchorage, Fairbanks, Palmer and elsewhere to actively work in an informal manner with individuals and groups interested in participating in the study. Topics for these workshops may range from general interchange of ideas to in depth consideration of specific areas of interest or concern (e.g., social impacts on Talkeetna, potentials for recreation development, or alternative energy sources). If desired on the part of individual workshop groups, they could be encouraged and assisted in development of their own background research.

Task P-5

Attend meetings of local service organizations and special interest groups to discuss project activities and objectives. The PIPP will actively seek opportunities to speak before service organizations and special interest groups. Special interest groups may take the lead in presenting their views. Other groups may be less prone to do so, but the director of PIPP will attend their meetings and will request opportunities to discuss the study.

Task P-6

Assist APA in presenting key study findings throughout the study. At various times throughout the planning process (e.g., during final evaluation of project alternatives) the APA may wish to seek public comment in the more formalized setting of official meetings. The PIPP staff will assist in the preparation, advertising, and conduct of such meetings and will follow up with smaller meetings and workshops to obtain an in-depth cross section reaction or public viewpoint.

Task P-7

Document the results of public participation throughout the planning process. The PIPP staff will prepare monthly reports on their activities and the nature of their contacts with the public. Summaries will also be prepared for all public meetings and workshops. The summaries will describe the purpose of the meeting, a characterization of the group participating (including signature sheets with name and address of all participants), the information presented, and the ideas and concerns expressed by

the public. These reports and summaries should be factual, and will be routinely made available to the APA, key project personnel, participating groups, and upon request, to the public. An official file will also be maintained to be submitted as documentation to state and federal regulatory agencies.

Technical Advisory Committee

In addition to the Public Information and Participation Program, a Technical Advisory Committee should be established in cooperation with APA to provide specific lines of two-way communication between project planners and interested state and federal agencies. Our experience has shown that such an organization, as long as it would not conflict with the existing Governor's Devil Canyon Task Force, could serve many of the same functions by opening lines of communication and resolving potential questions or conflicts at an early stage rather than waiting for formal submission and response. The committee would also consider technical issues (e.g., review initial study programs for adequacy and completeness, periodically review results) and advise the APA as to any expansion or alteration of the study effort that might be justifiable in their view.

It is recommended that this committee be composed of representatives of at least the following groups and agencies:

Alaska Power Authority
Engineer (including Resident Manager and Director of PIPP)
Alaska Governor's Office
Alaska Department of Environmental Conservation
Alaska Department of Fish and Game
Alaska Department of Natural Resources
Alaska Department of Commerce and Economic Development
Alaska Department of Community and Regional Affairs
U.S. Fish and Wildlife Service
U.S. Bureau of Land Management
U.S. Army Corps of Engineers
Cook Inlet Region, Inc.
Matanuska - Susitna Borough

One of the first tasks of this committee should be a thorough review of the final Plan of Study following selection of the Engineer. Subsequently they should have periodic informational meetings, and special meetings for review and comment at key decision points.

PART B

PLANNING AND ENGINEERING STUDIES

PHASE I - BASIN PLANNING STUDY

A Basin Plan for hydropower development of the Upper Susitna Basin will be developed during this phase and be compared with non-basin alternatives for meeting power system load requirements. In so far as possible, the planning studies will be based on available data that have been collected and used in previous reports, primarily by the Corp of Engineers. It will be necessary to review and evaluate the data to assure full development of the Upper Susitna River resource, while at the same time providing projects that are scaled to meet market requirements and are environmentally acceptable. Where necessary, additional information will be collected; particularly geotechnical data, aerial photos, and topographic maps relating to the project layouts that will be prepared for the potential sites along the Susitna River. It will also be necessary to update basic information that is available for power markets and other aspects. Environmental data collection programs will be required to adequately address the issues raised by the Governor's Devil Canyon Task Force. The Phase I work program, shown on Exhibit 6-1, of Part A, Volume I, is scheduled to be accomplished between January and November 1980, with a draft report ready for public discussion by October 15.

Phase I will include the definitive studies of power market and alternative sources of generation. This scheduling will contribute to the evaluation of alternatives in Phase I but is intended primarily to assure the availability of these completed studies at the beginning of Phase II. Power market projections, alternative sources of generation, and alternative fuels are expected to be among the areas of interest and comment by the public. A related item to be included in Phase I is the development of the detailed methodology for the Phase II studies of power system expansion and operation, which will include the economic dispatch program and estimates of system generation cost.

The Phase I studies will culminate in the preparation of a Basin Plan Report which will identify the plan of development best adapted to make optimum use of the Susitna resource, and to select an initial project which is economically and financially feasible.

MOBILIZATION AND LOGISTICS

Initiation of Phase I activities will include mobilization of Harza and subcontractor staff and organization of the field operations. The logistical effort has been described in Part A, Section 4, of Volume I.

DATA COLLECTION AND REVIEW

Available data and reports will be collected, organized, and analyzed at the beginning of Phase I for use as a basis for planning studies. Discussions will be held with local officials. The data will be reviewed carefully with particular emphasis on additional data requirements for completion of Phase I studies, to the desired level of detail, as described previously in Part A, Section 2. Much of the identification of available data has been accomplished during preparation of this Plan of Study. Specific items of data collection and review are discussed under individual work items as appropriate.

PHOTOGRAPHY, MAPPING AND SURVEYS

A program of aerial photography, mapping, and surveys will be undertaken to provide a basis for the planning studies. The new maps and photos will supplement existing data. USGS quadrangle maps with a scale of 1 inch = 1 mile and 100-foot contour interval are available for the entire basin. Photos taken in 1949-50, to prepare the quadrangle maps, are available at a scale of 1:40,000. High-altitude photography (1:120,000) and LANDSAT imagery are also available from various sources. The photography, mapping, and survey program has been planned to accommodate seasonal constraints, as shown on Exhibit 6-1 of Volume I.

The major components include (1) reconnaissance mapping, (2) dam site mapping, (3) river valley mapping, (4) channel surveys, and (5) additional mapping. These are described separately below.

Reconnaissance Mapping

An initial step in the planning studies will be to prepare reconnaissance maps of the Susitna River valley. These maps will be prepared using color infrared photographs recently taken by NASA and standard photogrammetric methods. The map scale will be about 1" = 1000 feet, with a 25-foot contour interval. These maps will be used in developing preliminary area and capacity curves, etc., for potential dam sites.

Dam Site Mapping

It is anticipated that about six potential dam sites will be identified in the basin planning studies. Low-altitude aerial photos will be taken in early spring, as soon as the snow cover has melted. Dam site photo mosaics will be prepared for each site.

At these sites, existing ground control will be used and the control will be brought to each site using a level. Dam site maps of a scale 1 inch = 100 feet or 1 inch = 200 feet with a contour interval of 5 feet will be prepared using photogrammetric methods. These maps will be used for making dam and appurtenant structures layouts.

River Valley Maps

Aerial photos of the Susitna River Valley will be taken from Talkeetna to Denali Highway, a distance of 180 river miles, during the spring of 1980. River valley maps will be prepared using the aerial photography and photogrammetric methods. The horizontal ground control would be obtained from existing USGS quadrangle maps. The vertical ground control would be established using a precise altimeter. The river valley maps will be prepared for the reach from Talkeetna to just upstream from the confluence with the MaClaren River, which is near the upstream end of a possible Vee Canyon Reservoir. These maps will cover a distance of about 120 river miles and probably average two miles wide, enough to encompass any planned reservoir rim. Additional width may be specified in local areas of interest for off-channel storage. The maps will be prepared at a scale of 1 inch = 800 feet with a 20-foot contour interval.

Channel Surveys

A limited program of channel surveys will be undertaken in selected reaches to define the channel geometry for estimation of water surface profiles. Channel surveys will be taken in the fall of 1980 downstream from the selected dam site, in order to estimate the tailwater conditions and predict downstream degradation. Additionally, channel surveys may be required in selected reaches between Talkeetna and the selected dam site to define pre-project and post-project water surface profiles. These profiles will be used in environmental studies to assess the project impacts on moose feeding grounds. Additionally, channel surveys will be taken in the downstream reaches to provide input to water quality river system modeling to assess the effects of any proposed reservoir.

Additional Mapping

It is anticipated that additional aerial photos and mapping will be required during Phase II, during May - June 1981, possibly along critical reaches of the transmission line or access road or extensions of the damsite areas to assist in making final plan layouts and cost estimates. The extent of work required will be determined during the Phase II studies.

HYDROLOGIC AND RIVER HYDRAULIC STUDIES

The climate of the Upper Susitna Basin is basically subarctic, and can be characterized as transitional between the maritime climate of the southern coasts and continental climate of northern inland Alaska. Orographic effects are also pronounced so that hydrologic conditions in the basin vary considerably depending on time of the year and location in the basin.

The hydrologic analysis during the Phase I study will emphasize maximum utilization of results of the previous studies made by the U.S. Army Corps of Engineers, U.S. Bureau of Reclamation and Kaiser Engineers. This will allow the meteorological and hydrologic information required for the site selection and primary layouts to be prepared in time for use by all project personnel. More detailed studies may be needed for the site or sites selected for feasibility study and license application. These studies will be made in phase II.

In both Phase I and Phase II studies, careful considerations will be given to the unique characteristics of the subarctic

climate, permafrost and glacial sediment. The Phase I Study includes the following major items.

Data Collection and Field Investigation

Hydrologic data for all stream gaging stations in the Susitna River have been collected from the U.S. Geological Survey (USGS) through the WATSTORE System. These data include daily and monthly streamflows as well as flow duration curves and flood and low flow frequency curves. Considerable climatological data for stations in the project basin and its vicinity have been collected from National Weather Service (NWS) and other agencies including U.S. Bureau of Land Management (BLM).

An aerial and ground reconnaissance of the project basin and streams will be made by a senior hydrologist. The field investigation will emphasize observation of basin and stream characteristics, and distribution of basin erosion sedimentation, as affected by the glaciers and permafrost. Local authorities in meteorology and hydrology, including NWS, USGS, and other agencies, will be visited.

An in-depth study will be made of previous experience in the operation of reservoirs under cold regions conditions and previous research studies dealing with the hydraulics of ice covered channels and reservoirs. This study will consist of a detailed survey of the literature, direct contacts with agencies and individuals knowledgeable on this subject, and formulation of a continuing program with the concurrence of APA.

Delineation of Baseline Conditions

Collected data will be used to delineate baseline climatological and hydrologic conditions. Many climatological factors such as temperature, precipitation and wind velocity will affect the design, construction and operation of the project including the transmission lines. Permafrost may cause serious engineering problems such as thawing of the foundation for a fill dam due to impoundment of water in the reservoir.

Delineation of the baseline conditions will be oriented toward engineering considerations as well as for evaluating environmental impacts of the project. The baseline conditions to be delineated include: average, high and low flows in the streams; icing conditions; stream sediment concentration and water quality; land use; distribution of permafrost; and

pertinent climatological parameters such as average and extreme precipitation, temperature and wind velocity.

Estimation of Available Water Supply, Floods, and Sedimentation

There may be a large number of potential alternative projects to be considered during Phase I. The estimation of available water supply, floods and sedimentation will primarily be based on results of the previous studies and updated hydrologic data without elaborate analyses.

Updated daily and monthly streamflow data have been collected from the WATSTORE system of USGS. The collected data also includes flow duration curves and flood and low flow frequency curves. Most of these data can be transposed to each potential site with minimum effort. PMF's have been estimated for the Devil Canyon and Watana Sites by the Corps of Engineers. These estimates will be transposed to each potential site to determine preliminary design floods without further analysis until specific projects are selected for further study in Phase II. Sediment rating curves and other sediment data have been collected for all gaging stations on the Susitna River. These data will be used in conjunction with the flow duration curves to estimate average annual sediment load at each potential damsite. Potential reservoir sedimentation will be estimated by applying trap efficiencies to be estimated based on the relative size of the reservoir with respect to the average annual flow. No detailed analysis of sediment distribution in the reservoir will be made in the Phase I Study.

Evaluation of Data Collection Program

Existing meterological and hydrologic data collection networks in and adjacent to the Upper Susitna Basin and along the potential transmission lines will be evaluated for their adequacy for project design and operation as well as proper monitoring of environmental parameters as required by the regulatory agencies. Based on the results of the evaluation, an improved network and observation program will be formulated and recommended to Alaska Power Authority (APA) for execution by appropriate agencies.

GEOTECHNICAL STUDIES

Introduction

The geotechnical work which we anticipate would be carried out as part of Harza's study of hydroelectric power development in the Susitna River Basin is described here. The study will be divided into two phases, Basin Planning Studies - Phase I and Feasbility Studies - Phase II. The geotechnical work associated with each phase is summarized here, followed by the description of Phase I activities. The Phase II activities are described later under that heading.

The Basin Planning Studies will encompass an approximately 100 mile long reach of the Susitna River from near Portage Creek to the previously identified Denali Reservoir. Geotechnical reconnaissance will be carried out on this entire reach in support of engineering planning studies of potential dam and reservoir sites. This will be followed by more detailed geologic mapping of designated potential sites and reservoir areas including most of those previously studied by the U.S. Bureau of Reclamation (USBR), the U.S. Army Corps of Engineers, and others. These field activities, surficial in scope, and concurrent office studies will provide adequate geotechnical basis for evaluation and planning layouts of sites selected for the Basin Development Plan. Most of this work would be accomplished during Spring and Summer of 1980.

Feasibility Studies - Phase II - will be carried out for the site singled out for recommended initial development. Field work will include subsurface boring investigations and testing, geophysical exploration, exploration for construction materials, completion of detailed geologic mapping and laboratory testing programs related to foundation evaluation and materials utilization. Field studies initiated during Phase I will be continued for selection of access road route, transmission line corridor, potential for manufacture of cement in the project area and for evaluation of geologic hazards, in particular, those dealing with seismic exposure and risk and with fault activity.

Geologic and geotechnical evaluation of the field and laboratory data will provide significant input for selection of type of dam, arrangement of project structures, materials source exploitation, and feasibility level design of foundations and foundation treatment for all project structures both above ground and underground. The scope of the field investigations and the level of the geotechnical studies and analyses will be planned and executed so as to demonstrate the feasibility of the initial project and to fulfill the requirements for License Application

to the FERC. The bulk of the geotechnical feasibility work will be done during the Spring and Summer of 1981.

Phase I - Basin Planning Study

Review of Existing Data

This task will include detailed study and review of the reports and data compiled by the Bureau of Reclamation (USBR), the U.S. Army Corps of Engineers (USCE), Kaiser Engineers, and other available information. The information on regional and project geology, foundation conditions, construction materials, drill hole logs and test pits will be reviewed and evaluated to confirm the recommendations and the conclusions of these agencies. The data on depth and distribution of permafrost, ambient ground temperature and thickness of the "active" layer will also be reviewed along with updated piezometer and temperature probe measurements.

Data research will also include sources such as the Alaska Geological Survey, the U.S. Geological Survey, the University of Alaska Department of Geology and the Geophysical Research Insititute, the Cold Regions Research and Engineering Laboratories in Hanover, New Hampshire, and pertinent work of other agencies, universities and researchers.

Studies by the USBR and USCE have also identified areas of landslides and potential instability in proposed reservoirs either under changed thermal regime conditions or seismic event. We will identify these areas in relation to the specific sites and use this information in planning our studies.

The information gathered from seismic refraction surveys for the Watana and the Devil Canyon sites will be reviewed and evaluated. We will seek assistance of a specialist in this task to assure that state-of-the-art techniques are employed. The data will be used to make some judgment on other potential sites with similar geologic and topographic character.

Considerable efforts have already been directed towards a seismic risk evaluation of the area's potential sites. The data reported to date by the USBR, and the USCE and others, is considered to be preliminary. This data will be re-evaluated along with other available published and unpublished literature. This task will be performed by Woodward-Clyde Consultants (WCC) in cooperation with Harza. We believe that along with their expertise in the field of seismicity relating to the geotechnical work, their experience gathered on the Alaska pipeline project

will make positive contributions to the Susitna Basin project studies.

Map Studies of Susitna River Basin

Topographic and geologic maps available from various reports and from the USGS will be studied to aid the selection of potential sites for basin development. The information available in published articles, state or federal documents, and unpublished works will be reviewed. Factors such as surface access to the site, route locations for reconnaissance and detailed investigations will be evaluated. Much information already is available for Watana, Devil Canyon, Vee Canyon and Denali sites and will be used as part of the study.

Aerial photographs and other imagery will be studied to obtain information of surface geologic features, terrain, geologic structure, and permafrost distribution. Discussions with appropriate agencies and individuals will be held to gain access to unpublished data and to benefit from the individual's knowledge and experience regarding the study area. This activity will help identify sites for consideration, thereby keeping the later field reconnaissance activities within reasonable limits. A program for field reconnaissance and the necessary geotechnical investigations will then be planned. A plan of field activities will also be submitted to the BLM or other jurisdictional agencies for approval of access on land under their jurisdiction.

Field Reconnaissance

Field geotechnical reconnaissance will be carried out covering all potential damsites and reservoirs within the reaches of the Susitna River under study. This activity will include overflights supported by helicopter of the valley and ground reconnaissance by senior personnel. The purposes of reconnaissance are several. Stratigraphic and structural relationships and potential geologic hazards reported previously by others will be reviewed and confirmed. The reconnaisssance will extend into areas not reported previously to obtain similar geologic data for additional sites under consideration. Reconnaissance is a means for quickly acquiring a geotechnical overview of areas of interest to fix attention on more specific areas requiring detailed inspection. As such, it will be used to screen damsites proposed from map studies, for preliminary location of sources of construction materials, for initial field identification of geologic hazards within potential reservoirs,

for initial appraisal of access road and transmission line routes and for initial fault and seismicity field investigations, all of which are described in more detail below.

Reconnaissance will be carried out at various times during Phase I. It is planned that an initial reconnaissance would be made during March and April, 1980, when access with helicopters and possibly ground vehicles is permitted and the rivers are frozen. Geologic mapping of rock outcrops along the river banks will be facilitated by working on the river ice while the river is at its lowest seasonal levels and exposure of outcrops is at a maximum. Reconnaissance will be used after the snow cover has gone in conjunction with the other geotechnical field activities mentioned above. It is recognized that the optimum time for reconnaissance activity is during the early summer before trees and brush leaf out.

Damsite Investigations

Phase I site investigations by Harza will be surficial in scope and will consist mainly of geologic mapping and determination of potential sources of construction materials. These activities will be used as part of the screening process of potential sites and for site evaluation to aid in planning studies and preliminary layout of structures at selected sites. Geologic mapping will be done in greater detail for sites selected as part of the basin development, but not in the detail and with the precision which will be required later for feasibility investigations.

Initial site mapping will be carried out during March - April of 1980 while the lower river banks are accessible from the ice as a followup to the initial reconnaissance. Mapping of areas higher on the valley wall will be done when the snow cover has disappeared. The considerable work done previously at the Watana and Devil Canyon sites by the USBR and the USCE and reported by these agencies would be helpful in accelerating surficial investigations at those sites. Other possible sites, including Vee site and Denali site, will require more detailed attention during Phase I.

The geologic features which will be particularly noted are those significant to geotechnical evaluation of the sites bearing on type of dam, arrangement of structures, foundation conditions, foundation treatment, potential for underground powerhouse facilities, potential geologic hazards, and location of suitable rock quarries and borrow areas for pervious and impervious fill materials. Features which will be noted include topography,

rock types and areal and stratigraphic relations of rock units, rock quality, distribution and type of overburden cover, types and structural relationships of bedrock discontinuities. These discontinuities are the bedding planes, joints, fractures, faults and shear zones. Evidence of unstable rock or overburden masses, surficial evidence of permafrost, morphological and surficial evidence of deposits of natural gravels, sands, and clay-silt and sites auspicious for rock quarries will be noted.

Reservoir Investigations

Geological reconnaissance of potential reservoir sites coupled with more detailed inspection of selected reservoir slope areas will be carried out. The primary need is to define areas of potential massive slope failure which could occur so as to create a wave damaging to a dam or auxilliary structure. This will require generalized mapping of bedrock, overburden, and unconsolidated sediments, their distributuion and structural relationships. Bedrock features facilitating slides, such as faults, shear zones and close jointing, under changed hydrologic or seismic condition will be evaluated. Similar attention will be given to areas of unconsolidated sediments or glacial overburden, particularly where thawing of ground ice or saturation under reservoir conditions might weaken the soil mass thus increasing the sliding potential with or without seismic affects.

Previous investigations of the Susitna Basin and our recent overflight of the Basin have noted evidence of past slides and potential areas of future slides. These areas will be included in our study. Any potential slide area deemed a potential geologic hazard will be earmarked for special investigation during Phase II.

Seismicity and Fault Studies

An extensive regional study of faults and seismic risk will be initiated in this phase to augment previous studies of the region. Emphasis would be placed on location of major and related minor faulting and their proximity and potential hazard to the sites under preliminary investigation. The fault studies will be continued during the subsequent feasibility phase.

A fault and seismicity study of the Basin will be initiated also during this phase incorporating all available studies and data recorded to date. Ground surveys and low altitude flights

will be used for studying and identifying geologic structural features such as lineaments and faults and evidence of slumping, landslides, offsets of landforms, and escarpments. This aspect of the study is of great significance because the Susitna River Basin lies within a highly seismic area. Faults of regional significance have been identified and some related smaller faults have been inferred. The potential for activity on any of these faults during the life of the project must be evaluated. The detailed discussion of the attendant tasks is included in Volume IV as prepared by WCC.

Evaluation of Alternative Sites

The information gathered during the previously discussed activities will be evaluated, summarized and used in preparing designs and project layouts for various alternative sites. This will include preliminary plans of dam and spillway, powerhouse, switchyard and diversion features; and location of the transmission line corridor and access roads. The choice for the type of dam for a site will be dictated by the foundation and the topographic conditions, height of the dam, seismic exposure and seismic risk, and the availability of construction materials and environmental constraints. Dam sections and their relative merits will be studied for concrete dams (arch or gravity), rockfill/earthfill dams, and concrete-faced rockfill dams.

Climatic factors for construction and maintenance of a powerhouse, the presence of steep-walled canyons with rockfill and slide potential, and the seismic activity of the region all favor an underground powerhouse. This aspect will be evaluated for each site considering specific site conditions.

Construction material requirements will be estimated for various designs considered for each potential site and the estimates will be compared with available construction material on or near the site. This information will be used in preparing cost estimates and evaluation of project economic feasibility. Close cooperation between various disciplines will be maintained to develop optimum schemes that take into consideration, in addition to geotechnical concerns, factors such as climatic restraints on construction activity, environmental aspects related to the river basin, and ecological considerations.

Alternative sites will be evaluated for their relative technical and economic merits. Concepts of staged development versus initial full height development will be evaluated for each site. This information will be combined with the power, hydrologic, hydraulic and planning considerations. Preferred

sites will be identified that are optimum for both technical and cost consideration and that are compatible with overall Susitna Basin development concepts. A candidate site will be selected and presented to the APA for their consideration for Phase II studies.

Reconnaissance for Project Access Roads and Transmission Line

Project roads will be required for construction and permanent access to the sites. Routes for construction of all weather roads will be chosen from maps and airphotos. The possible routes will be geologically mapped in enough detail to determine problems of excavation, existing and potential landslides, and other geologic and environmental hazards. Drainage requirements and susceptibility to blockage by snow avalanches will be incorporated in the study. Optimum routes will be selected.

Several bridges are required for access to the proposed Watana damsite. The foundations are assumed to be on bedrock which is exposed along the river banks. Geologic mapping, and some exploration and sampling may be required during design studies to confirm foundation conditions and sources for construction materials in the vicinity of the bridges.

Selection of preferred and alternate routes for the transmission line will be studied. A field reconnaissance survey will be undertaken to evaluate the geologic hazards such as poor foundation conditions, and for potential and existing slide masses. These considerations will be integrated with environmental factors in route selection.

Planning of Feasibility Stage Investigation Program

A feasibility level investigation program will be planned for the site designated for the initial development. This program will be directed towards investigations of foundation conditions, construction materials, thermal regime, existence and distribution of permafrost and depth of permafrost table and active layers. We will be assisted by a specialist in frozen ground engineering for developing this program. The program will be developed within the guidelines established by the authorities having jurisdiction over the site area, such as the Bureau of Land Managment or other agency, and it will be submitted for agency approvals. The program will also include instrumentation to obtain information on ambient ground temperatures, subsurface

temperatures, water table depth and fluctuations in ground water level. A general description of the program is presented under Feasibility Studies. The specific details of this program will be dictated by the site conditions and the final program may differ from that envisioned at this time.

Planning of Feasibility Studies

The results of the Basin Planning Study will lead to a recommendation for a candidate site and to some extent the type of dam (rockfill, earthfill, concrete), and the concepts for the powerhouse (surface or underground). On this basis, a feasibility level studies program will be planned. This program will include the type of studies to be performed (such as slope stability, seepage, and rock mechanics), the level of sophistication required (simplified analyses or finite element analysis), and the data required for these studies. This identification will permit timely collection of the necessary geotechnical data. A general description of the studies that might be performed is discussed under Feasibility Studies. The scope of each study will be determined by the site conditions, design philosophy, and the requirements for licensing. The planning of permafrost studies will be done with the assistance of a specialist in frozen soil mechanics to assure the completness and reasonable scope of the program.

POWER MARKET STUDIES

Forecasts of future requirements for electric power and energy will provide the basic framework within which the alternative sources of generation including the Upper Susitna project will be compared. This aspect of the need for Susitna generation or an alternative source has received and is expected to receive considerable public comment. Our approach to the Susitna project is to select an initial project of appropriate size for the load to be met, while preserving the long term development potential of the river. The power market studies, for this purpose, will consist of analysis of historical data, projection of future demand and ranges of demand, and detailed analyses of the market area, its constituent utilities, their generation and transmission facilities, and their plans for expansion of facilities.

A study of existing data and previous forecasts will be performed to provide a better understanding of the historical trends and projected future power demand of the Cook Inlet and

Fairbanks areas, to analyze and to project a high, low, and most probable power and energy demand and corresponding level patterns. Harza will present, and discuss with the APA, parameters that may have a significant influence on the projections and on the determination of the most probable forecast. Contacts and meetings will be held with electric utilities, consumer groups, government agencies, and other interest groups to obtain data, and to determine potential benefits and risks to them. In addition to the Cook Inlet and Fairbanks power market areas the Glennallen-Valdez area will also be analyzed, and interconnections between these three power market areas will be evaluated.

Data Collection and Interviews

A Resource Economist and a Sociologist will collect the information readily available and will survey broadly representative samples of larger consumer groups. They will gather the pertinent reports and projections published by government agencies and other organizations on the energy demand and supply in the market areas. Discussions with representatives from the electric utilities serving the market areas will provide insights on past, actual, and future electricity uses. Contacts will also be made with the National Defense installations, and the self-supplied industries to obtain power market data and forecasts. In addition, the socio-economic studies and the public information meetings will provide insights to the needs and desires of the population.

Among the areas of inquiry will be the trend of economic activity and population growth in the Railbelt area, economic and conservation trends affecting traditional uses of electric power, trends in the competition between electric power and other energy sources for uses such as water and space heating, and plans for industrial and commercial activity including new energy intensive industries.

Market Area Description

Harza will discribe the potential market area that could be served by the Susitna Project. Due to its central position between the Fairbanks and Anchorage areas, the Susitna Project will be planned to provide electric energy to the South Central Railbelt area. In addition, possible interconnections with the

Glennallen-Valdez area will be analyzed. The description will include a presentation of the historical and future growth in population, business, services and industry for each major market area:

- Anchorage - Cook Inlet Area
- Fairbanks - Tanana Valley Area
- Glennalen - Valdez Area

Existing and future developments in coal, oil and gas production and transportation, related industries, agriculture, tourism, and any other major economic activity will also be presented.

Utility and Service Area Descriptions

A description of each electric utility in the Railbelt area and in the Glennalen-Valdez area will be prepared as a basis for the transmission, economic, financial, and institutional studies. These utilities and agencies are:

- Alaska Power Administration
- Anchorage Municipal Light & Power
- Chugach Electric Association
- Matanuska Electric Association
- Homer Electric Association
- Seward Electric System
- Fairbanks Municipal Utility System
- Golden Valley Electric Association
- Copper Valley Electric Association.

The service area of each of these utilities will be identified, and interconnections between these systems will be described. Present plans of these utilities for possible future expansion of generation and transmission facilities, with or without the Susitna Project, will be analyzed. In addition, the National Defense power systems and industrial self-generation power systems will be described.

Inventory of Generation and Transmission Systems

An inventory of the existing generation capacity will be made to evaluate the market area's existing power system, with a description of the capacity and energy generated by electric utilities, National Defense systems, and industrial systems within each area. An evaluation will also be made of the existing facilities in the small villages and remote rural areas within the market area. The plant inventory data will include the plant and unit locations, owner, capacity and production data, age and expected service life, type and source of fuel and heat rate. These and similar data for planned and alternative additions will be used in the economic dispatch studies.

A map of the existing main transmission lines (69 KV and higher) together with the additions planned by the utilities will be presented to evaluate the possible connections between the three market areas. The detailed inventory data on transmission facilities will be obtained by the transmission engineers and will be sufficient for use in the transmission system studies.

Analysis of Load Data

Analysis of historic data and detailed examination of power statistics for the last decade will identify trends and changes in use patterns related to economic development, population growth, and conservation measures. Monthly peak loads, energy demands, and load factors will be analyzed. Summary tables will be prepared presenting the historical and existing power and energy demand for each of the three power market areas. Other tables will present energy consumption by consumer categories: Residential, commercial, industrial, public, municipal, and military. Variations in growth patterns among energy sectors and per capita energy consumption will be analyzed. An attempt will be made to isolate changes in growth trends such as that due to increased use of electric space heating and to evaluate the prospects for continuation or revision of such trends.

Load Forecasts

Forecasts of power and energy demand and load patterns will be made by utility service area for use in the power system expansion, economic and financial studies. Forecasts for the years 1990, 2000, and 2010 will be made for each power market area (Anchorage, Fairbanks, and Glennalen-Valdez), and broken down into demands from electric utilities, national defense, and

self-supplied industries. The forecasts will be made at three levels (high, most probable and low estimates) to reflect various hypotheses of economic development in the Railbelt area, conservation measures, and alternatives to electric power for specific uses.

The forecasts made by the utilities and other agencies will be reviewed and used as a basis to develop the range of growth in demand. The historic energy consumption growth rates by consumer categories will be extrapolated for future years on the basis of projected increase in intensity of use and population growth. Future residential energy forecasts will also be determined based on the socio-economic studies, and a survey of selected households in each utility service area. Commercial and industrial energy use projections will be based on interviews with present customers and forecasts of future levels of economic activity. Direct mail surveys of samples of electric customers of all categories may be undertaken with the cooperation of the electric utilities to clarify questions concerning electric heat and other aspects.

Forecasts of energy for the National Defense and self-supplied industries will be developed from historical data and conditions, consultations with knowledgeable people in the army, government and industry; and from reports on future developments.

Historical trends in load factors adjusted to future economic activities will be used to forecast peak demands from the previously determined energy demands.

Estimation of future load projections will consist of two stages. First, historical consumer demand for electric power will be studied in the Anchorage, Fairbanks, and Glennallen-Valley power market areas. In each area a survey of consumption patterns will identify significant social and economic sectors which are broadly representative or larger consumer groups in the area. In addition, surveys or subsamples utilizing a stratified-cluster sampling method and structured interview techniques will address current energy consumption patterns, current expectations of future energy consumption patterns without the project, and propensity to consume electrical energy in the future with the project. The result of these surveys will be a verification and update of current consumption patterns related to energy use.

The second stage of estimating future load demands will be standard population projections for the market region utilizing cohort-survival projection techniques. Secondary data available from the US Department of Commerce, Bureau of Census, together

with State of Alaska vital statistics (mortality rate, birth rate, fertility rate, infant death rate) and data on net immigration into Alaska will be sufficient. This will give a good idea of the expected population increase, which will permit projection of high, most likely and low load demands for all groups of certain broad consumption patterns.

In order to verify this evaluation of future load demands, the data on propensity to consume for the sample groups will be matched to the broad sectors of the population which they represent and any anomolies will be adjusted.

In this way, load projections can be verified for population sectors, based on our knowledge of the sector propensity to consume and the assumed growth of that sector. This two stage approach will provide not only standardly derived load demand estimates, but also useful data regarding current and expected use patterns for the public information and participation process.

Sensitivity Analysis of Forecasts

Projections of future electric energy consumption are sensitive to many factors such as National and Regional economic activity, population growth, life-style changes, competition of electricity with other forms of energy, price and technological changes, governmental policies, restriction on fuels, etc. Harza will discuss the parameters that may have a significant influence on the projections, and on the determination of the most probable forecast. The sensitivity of demand to population growth and economic growth will be discussed. The influence of legislative and regulatory policies will be analyzed. These policies may influence economic growth as well as fuel prices, and will be taken into account in the projections. Load management will be discussed and its possible influence on power demand and land factors will be outlined.

Develop Seasonal Load Requirements

Estimates of average monthly distribution of energy and power demand will be developed to relate reservoir operations and hydroelectric output to the electric load. Historical monthly load and energy for each power market area will be analyzed. Projections will be made taking in consideration the range of future power requirements, estimates of seasonal activity, and

other factors that could affect the shape of the annual distribution curve.

Develop Load Duration Curves

Future annual, monthly, and weekly load duration curves will be developed as adjusted from the existing load curves to account for changing patterns of energy use. Harza will use the computer program that it has developed for the Corps of Engineers in the National Hydro Study. Representative weekly load curves during the wet and dry seasons will be analyzed. This program analyzes the hourly loads during any week, adjusts the shape of the load duration curve, and gives the energy needs for any increment in peak demand. Load duration curves for calendar months or semi-monthly periods as needed for the economic dispatch studies will be developed from the weekly analyses. The hourly load data from the major electric utilities will be analyzed with respect to coincidence of their load patterns.

ALTERNATIVE SOURCES OF GENERATION

Alternative sources of generation to meet the projected future electric power requirements will be identified and evaluated, and the most favorable alternatives will be studied in detail for use in the alternative power system expansion programs. Harza plans to use the services of at least one and probably two or more independent consultants in this item of study to provide additional expertise and assure objectivity in the treatment of non-hydro alternatives.

Identification of Alternative Sources

The identification of possible alternative sources of generation and their charactistics will be based on existing reports and data and additional investigations. Contacts and meetings will be held with electric utilities, fuel suppliers, governmental agencies, area residents, and environmental and interest groups to identify the full range of generation modes available, and to determine their potential risks and benefits. The identified sources will include the conventional types of generating plants existing in the area such as gas turbine, steam turbine, diesel, nuclear and hydro; alternative conventional fuels such as coal, oil, and gas; and also new sources such as wind, solar, geothermal, pulp, and tide. The new technologies

associated with coal fuel synthetics and energy storage systems will also be reviewed and evaluated. In addition, the possibilities and effects of energy conservation and load management on peak demand will be identified and analyzed. Harza has recently conducted similar studies for the Huntington District U.S. Army Corps of Engineers on "Electric Power Demand and Supply", November 1978; "Preliminary Power Analysis for Sutton, Bluestone, and Summerville Projects", April 1979; and "Alternatives for Peaking Power", May 1979.

Fuel Resources Availability and Costs

Estimates of future fuel availability and costs will be made to insure the feasibility of thermal and nuclear alternatives. Data will be gathered from previously published materials, and various sources, such as Alaska Power Administration, Alaska Division of Energy and Power Development, ISER-University of Alaska, Federal Energy Regulatory Commission, and the U.S. Army Corps of Engineers. If necessary, additional interviews will be held with representatives of petroleum and coal companies in the Railbelt area, and experts on oil, gas, coal, and nuclear fuel.

The level of detail required in the fuel study will be established after a preliminary assessment of the probable generation alternatives and their respective fuels. Should the availability and cost of certain types of fuel such as natural gas, coal or oil appear to be of major consequence to the economic evaluation of the Susitna Project, or open to much public debate, a more detailed study of the availability and cost of these fuels will be made. We propose to use a consultant such as the Stanford Research Institute (SRI) to perform such studies. Should the availablility and cost of certain fuel not be of extraordinary importance the procedures normally employed for feasibility level studies will be used, and Harza personnel will perform the necessary studies.

Conventional Thermal Alternatives

Conventional thermal alternatives will be identified and evaluated for the purposes of comparison with the Susitna Project. The main advantages and drawbacks of each thermal alternative will be described. Different aspects of power supply, that is, cost effectiveness, environmental quality, and assurance of adequate power supply will be rated for each alternative. Special consideration will be given to the environmental impacts: air, water, noise pollution, and any

other related impact. We propose to employ Fluor Power Services Corporation as consultant for these studies. By having an independent specialist evaluate these alternatives and participate in the development of the "without Susitna" system expansion program, we believe impartiality will be assured and the evaluations of the Susitna Project will better stand up to public scrutiny.

The studies would focus on the following types of locations of thermal alternatives:

a) Fairbanks Area (Alaska Pipe Line Oil Supply Fuel, and possibly gas pipeline fuel) Oil, Gas and possibly Coal;

b) Anchorage (Local Gas Fields Supply Fuel) Gas, Coal and possibly Oil;

c) Beluga & Healy Area (Low Btu and Sulfur Coal) Minemouth Coal;

The study by Fluor Power Services will include the following:

1.0 Identify Alternative Sources of Generation

1.1 Gas-Fired Plants

1.2 Oil-Fired Plants

1.3 Coal-Fired Plants

1.4 Combined Cycle Plants

1.5 Nuclear

2.0 Based on Power Market Projection, identify:

2.1 Numbers of Generating Plants (300 to 600 MW, made up of unit sizes of 100 to 150 MW)

2.2 Location of Plants

2.3 Type of Fuel to be Considered

2.4 Transmission Requirements

3.0 Identify Environmental Criteria for Proposed Sites:

3.1 Cooling Water Source

3.2 Particulate Emissions

3.3 SO_x, NO_x and others

3.4 Noise

4.0 Develop Conceptual Cost Estimates for Power Plant, Site, Transmission and other Site-Related Items.

Costs of Conventional Alternatives

The evaluation of thermal plant alternatives will include estimates of the following based on the Fluor Power Services Study: heat rates and fuel costs; added fuel transportation and installation cost; construction cost of the plants; operation and maintenance costs; service life and replacement cost; and transmission cost.

The estimates will be made of a preliminary level in Phase I and in more detail for the selected alternative in Phase II. Site arrangement and preliminary general arrangement drawings of the selected alternative will be made in Phase II.

Alternative Hydro Projects

One of the basic premises of APA's program of development of the Upper Susitna is that it represents the most economical hydroelectric resource for early development to serve the Railbelt area. We think this conclusion probably is valid and supportable but consider it necessary to establish the basis for the selection of Susitna in a form more suitable for public discussion and FERC proceedings.

We propose to review the existing inventories of hydroelectric projects in Alaska, select those within any reasonable distance of the Anchorage and Fairbanks areas, and update those projects for presentation on a common basis. This work will be done, to the extent possible, from the published and unpublished studies by the Bureau of Reclamation, Alaska Power Administration, Corps of Engineers, Alaska Division of Energy, Alaska Power Authority, and possibly other agencies. It appears that many of the inventoried sites have been studied only at the reconnaissance level. The available site data, preliminary layouts and project data, and preliminary estimates of production

and cost will be assembled and the cost estimates will be updated by cost indexing methods for use in preliminary evaluations. For each single large capacity site the evaluation will compare the potential generating capacity, the unit cost of power and energy, the transmission facilities, and the environmental impacts. Combinations of smaller capacity sites will be evaluated by geographic areas and river basins. Special consideration will also be given to small sites which are available and can satisfy a portion of the power market demand. The sites evaluated on the basis of this updated inventory will be described in such detail as the basic sources permit, evaluated in relation to the projected power market requirements and existing environmental and land use restrictions, and compared with the Upper Susitna projects on the basis of economic and other aspects.

The results of this study will be discussed with APA, and any necessary extensions of the work will be agreed upon. It may be that the available data and studies are not sufficient in some cases or that the inventory appears to be incomplete in some areas. In that event the identification of sites and preliminary comparisons could be carried forward by map reconnaissance, parametric estimate, and preliminary screening methods similar to those described below under the Phase I studies of the Susitna hydroelectric project and basin plan.

Other Alternative Sources

To complete the evaluation of alternative sources, an analysis of the new sources such as wind, solar, geothermal, pulp and tide will be performed. Harza will review the latest technical developments as well as the pilot projects that have been developed in the Railbelt area. Various concepts of wind energy installations will be considered. The investigations and data available for an evaluation of solar and geothermal energy will be reviewed. The different concepts that have been developed for the Cook Inlet Tidal potential will be analyzed.

Comparison of Alternative Sources

A selection of the most favorable alternatives to meet the power requirements will be made in Phase I to evaluate the economic and financial feasibility of the Susitna Project. The selected alternative will be evaluated in greater depth in Phase II. Tables will summarize the results of the alternatives evaluations.

RESERVOIR OPERATION AND SYSTEM GENERATION COST STUDIES

The optimization and selection of reservoir capacities, generating capacities and installation schedules and the economic and financial analyses of the Upper Susitna project in comparison with alternative generation expansion plans will require detailed studies of the operation of each alternative, under various conditions and in different time periods. The results will show the capacity and energy available from the project, the amounts useable in the system, the capacity and energy utilized from other plants in the system, the system generation costs, and measures of the adequacy of system reserves for each of a selected series of years. These series of generation costs together with the corresponding construction costs and operation and maintenance costs, will be the input to the economic and financial analyses of the various alternatives.

The operation and generation cost studies will utilize, to a large extent, methodologies and computer programs which now exist or are in the process of development for similar project assignments. These available tools will be assembled during Phase I into a methodology and package of programs specifically designed to meet the needs of the Alaska Power Authority in addressing the economic, financial, and institutional situation in the South-Central Railbelt Area. Some of the principal features of the approach are discussed below.

Hydroelectric Project Operation

The Upper Susitna hydroelectric project will consist, at different times, of one or more main stream reservoir projects, possibly an off-stream storage or pumped storage project, and possibly a diversion of winter season stream flows from outside the Upper Susitna basin. The operation studies will be of the sequential type. The streamflow sequences for each damsite will be long-term stochastic sequences as discussed in the section on hydrology. The initial studies, however, may use the historical sequences of approximately 28 years which are now available. The average net rates of reservoir operation will be estimated for each calendar month. For each hydroelectric project to be included in a Susitna alternative the input data will include the reservoir area and volume curves, tailwater curves for natural conditions and with downstream reservoirs if appropriate, normal reservoir elevation, drawdown limit or other operating rules, installed capacity and rated head, number of units, preliminary plant performance curves, minimum release requirements, as well as the streamflow sequence for the damsite. Where two or more Susitna reservoirs are included in an alternative, the inflow

sequences for the downstream reservoirs will be adjusted for the evaporation and flow regulation effects of the upstream projects.

A maintenance schedule will be incorporated to account for planned outage requirements. Forced outage rates will be used to de-rate each plant for use in the economic dispatch study. A separate probability-type analysis of reserve requirements is discussed in a later section. Transmission loss factors for each plant will be used to estimate the generation delivered at load centers.

The hydroelectric generation study can be used in several ways in the course of the study, both separately and as part of the economic dispatch study. The operation program can be used to estimate the firm and secondary energy and dependable capacity on a monthly basis for a project or group of projects with specified installed capacities and reservoir operating limits. The production can be specified on a uniform basis ("maximum continuous power") or the desired production can be specified on a monthly basis, to reflect the seasonal requirements of the Railbelt system. The operation program also can be used to develop operating rule curves for the reservoir or reservoirs, in which the objectives typically would be to maximize winter season energy and smooth the month to month variations in the production of secondary energy. Both of these approaches will provide operating rules to be used in the economic dispatch study. A complete trial, using a given set of reservoirs, plant capacities, and operating rules and the full streamflow sequence, will provide sequential monthly results and analyzed results including long term averages and duration curve analyses, annually and by calendar months, of firm and secondary energy, plant capability, plant discharges, and spills.

In the definitive project studies the hydro operation program will be used as part of the economic dispatch program. A given Upper Susitna alternative will be operated through the full streamflow sequence to meet the electric loads of a given year in combination with the other generating plants as described below, and the results will include average costs of generation and a duration curve analysis of operating costs by months.

Economic Dispatch Studies

The economic dispatch study will provide estimated system generation costs and other operating data for the electric power system and its major sub-systems. Several alternative expansion programs will be developed as discussed in the section on economic analyses, each expansion program consisting of a

schedule of plant additions and transmission line additions to meet the growth needs of the system for a period between a common beginning and a common ending date. The common expansion period might be approximately 10 years, to allow for full utilization of a series of projects in the Upper Susitna basin; but the required period will be determined during the study on the basis of the load projections and the size of the identified resources.

The principal input data will include projected system loads and load duration curves; generating plant data for the existing and proposed thermal plants, Upper Susitna hydro plants, other existing hydroelectric plants, and other proposed hydro plants if necessary; and estimated data on fuel costs and other operating costs. The typical use will be to test the operation of one expansion alternative during one year of projected system loads, using the full Susitna hydrologic sequence for alternatives which include Susitna projects. The output would include the expected average generation costs to meet the load for that year on an annual basis and, for possible further analyses, on a generation cost-duration curve basis by calendar month. There would be an indication of shortage if the available plants were insufficient to meet the load in any month of the hydrologic sequence. The average generation and operating cost data for the year will be input to the economic and financial analyses. The output also will include the generation for the plants of each operating utility and the corresponding cost of fuel.

The input data for each thermal plant in the system will include its ownership, capacity, number and type of units, heat rate or heat rate curves, type of fuel, cost of fuel, maintenance schedule, forced outage rates, transmission loss factor, and operating rules. The data for existing hydro plants outside the Susitna basin will include the capacity, average generation by calendar month, maintenance schedule, forced outage rate, and transmission loss factor.

The system load data will be represented by an annual peak load and monthly load duration curves in percent of load-percent of time format. The load data can be, if desired, divided into two major components, for the Fairbanks and Cook Inlet areas, to facilitate checking the average transmission line loadings and application of operating rules, if any, such as the minimum percentage of load in each area which must be self-supplied. This approach, which assumes that the loads in the Railbelt area follow a largely coincident pattern, will be confirmed or modified by the detailed power market studies.

The economic dispatch program will rank the available non-hydro plants in order of generation cost per kWh and dispatch all available plants so as to meet the load under the load

duration curve at the lowest total generation cost. This will include the maximum use of the available hydroelectric capacity and energy, subject to the various operating rules. The existing hydro generation will be used as available, and the Upper Susitna generation will be used to the limit of the remaining system requirements.

Institutional Aspects

The methods discussed above will provide the data for the analysis of the net generation or purchases by each operating utility in each year as part of the analysis of financial impacts.

HYDROELECTRIC PROJECT STUDIES

Introduction

The studies described in this section consist of the planning and evaluation of project structures and equipment, evaluation of alternative projects and combinations of projects, and selection of the basin plan of development and the initial project. The closely related items of construction costs and programs and economic analyses are described separately.

The Phase I project studies are divided into four principal steps. A reconnaissance study will consist of site identification and preliminary cost and performance screening, using maps and other data available at the beginning of Phase I in January 1980. This will result in the identification, by the end of April, of a selected group of alternative sites for which new aerial photographs and maps will be made as discussed in the section on Photography, Surveying, and Mapping. The identified sites will be studied in more detail, and cost-height and cost-capacity curves will be prepared for each site based on the new maps and site investigations. Reservoir operation studies will be made to estimate the performance of various projects and groups of projects. The alternative basin plans will be studied using various combinations of projects, reservoir elevations, and installed capacities. These will be evaluated as described in the section on economic analysis and a plan of development, order of development, and an initial project will be selected for study at the feasibility level.

Data Collection and Review

A substantial amount of information has been assembled and evaluated in a preliminary manner during the preparation of the Plan of Study and in connection with Harza's previous discussions with APA relative to the Susitna project. These references, particularly the Corps of Engineers study and supporting materials, and all additional pertinent information will be reviewed with respect to site identification, site characteristics, types of structures, and other aspects of project planning.

Reconnaissance Studies

Map Reconnaissance

Several damsites have been identified and studied by the Corps and others. The objectives of the map reconnaissance will be to acquaint ourselves with these identified sites in detail, identify additional possibilities along the main stream of the river, identify possible sites for off-channel storage on tributaries or for pumped storage projects using the plateaus adjacent to the river, and evaluate the possibilities of transbasin diversion of winter flow into the Upper Susitna. The emphasis will be on the main stream projects, particularly variations of the previously identified sites and the addition of one or more sites for small initial projects such as those described in "Study Approach", Volume I. A principal area of interest will be in the reach of river midway between the Devil Canyon and Watana sites, or between river elevations of approximately 1100 to 1300. A project in this area would fit in well with a plan of development incorporating two small dams downstream from Watana. We believe the site conditions in this reach generally are favorable for a concrete dam and associated structures to create 300 to 400 feet of head. The identification and screening process, however, will cover the full reach of river between Portage Creek and El. 2400, which is above the expected upper limit of the Vee Canyon project. Another principal area of attention will be the previously identified Watana site, with emphasis on possible construction in stages as discussed below.

The Denali project site will not be an area of study for project planning purposes. We consider that the technical and environmental problems associated with this project, as identified in previous studies, effectively preclude its inclusion at this time in any definite plan of development for the basin.

The reconnaissance studies will result in a revised list of sites, a range of possible elevations at each site, and preliminary formulations of plans of development based on these identifications.

Preliminary Screening

The preliminary evaluation or screening of alternative projects and plans of development will consist of preliminary cost estimates; preparation of construction cost curves such as cost of reservoirs versus normal reservoir elevation, cost of

power generating facilities versus capacity and head, and cost of transmission facilities of various lengths and capacities; reservoir operation studies as described below; and evaluation of alternative projects and groups of projects on preliminary bases such as the cost per kilowatt of dependable capacity and cost per kilowatt-hour of production.

The project layouts and costs estimates will be based on the existing USGS quadrangle maps at 1:63,360 and the larger scale damsite maps where available, such as for sections of the Devil Canyon and Watana sites. Desireably, as discussed under Photography, Surveying, and Mapping, it may be practical to prepare larger scale maps (reconnaissance maps) of the entire river valley from existing NASA photos.

The layouts on which the cost curves are based will be of a preliminary type but will take full advantage of the available information and previous studies of each site. Different types of dam, spillway, and project arrangement will be considered at each site and the possibility of construction of the dam in two or more stages will be evaluated on a conceptual basis at selected sites. Underground powerstations will most likely be used in all cases. Spillway and diversion floods will be based on the Corps studies. Cost estimates will be based on all available information. The cost estimates prepared for screening purposes, however, will be for the limited purpose of comparison between alternative hydroelectric projects.

The hydrologic sequence for the screening process will be the existing 28 year historical sequence of monthly streamflow, with adjustment as necessary for intervening damsites. The reservoir operations will be studied using an existing multi-reservoir operation program. The reservoir operating rules will be simple, calling basically for maximum continuous power and, to a limited extent, leveling the production of secondary energy by maximum generation from the beginning of the spring refill period. The program will provide the operating results on a monthly basis and in summary form, assign estimated project costs by interpolation and assembly of the cost curve estimates, and summarize the cost and performance results for the single project or multiple project group under consideration. The procedure is designed to facilitate trials of alternative combinations of projects, reservoir elevations, reservoir drawdown limits, and installed capacities.

Identification of Projects for Study

The reconnaissance studies and screening process will result in the identification of several project sites which would, at various levels of development, form part of two or more alternative plans of development. One pair of sites will be the Devil Canyon and Watana sites as identified by the Corps. A third site will be in the reach between these sites and identified for the second low dam in an alternative plan. The lower reach of Devil Canyon may be identified for study of a low dam with reservoir at El 1150 to El. 1250. The Vee Canyon and Kaiser sites, and others to be considered in the reconnaissance studies, may or may not be identified for further study. We estimate that approximately 6 sites will be identified for new aerial photographs and preparation of new topographic maps. The reconnaissance studies will be essentially completed during the period from January through April using office methods and information currently available, and reconnaissance maps. In the latter part of April or as soon as practicable a general field reconnaissance will be made. The selection of areas for photography, mapping, and detailed site reconnaissance will be made, with the concurrence of APA, by approximately May 1. The larger scale river valley photos and maps will be initiated at the same time. It is possible that additional sites may be identified after these photos and maps are received, but we expect no major additions to the conceptual plans following the reconnaissance studies.

Identified Project Studies

The sites identified by the foregoing procedure will be studied at the prefeasibility level during the period from May to September 1980. The field investigations will begin as soon as weather and access conditions permit. The layouts and cost estimates will begin in May but this effort will be concentrated in July, August, and September after the delivery of the new topographic maps of the sites and the river valley in the latter part of June. The results of the Phase I studies of geology, soils and materials, seismicity, hydrology, power market, and basic cost information will become available during this period and incorporated into the prefeasibility study. The number of individual project layouts to be evaluated will depend largely on the number of elevations necessary for the several alternative basin plans and the types of dam considered suitable at each site. The principal aspects of the project studies are as follows.

Access and Relocations

Existing roads, bridges, utilities, and other important facilities in the study area will be inventoried using the best available maps and data and field reconnaissance. Those facilities, if any, which would be affected by construction of the projects will be identified, and preliminary estimates of the cost of the necessary relocations will be prepared for use in the selection of alternatives. Preliminary studies will be made of the routes and of permanent access to each site.

Dams and Reservoirs

New area and volume curves for each reservoir will be prepared from the new river valley maps.

In general the sites now identified are considered technically suitable for fill dams, gravity or gravity arch dams, and in some cases thin arch dams. We would expect the economic choice to be in favor of the concrete dams at lower elevations, largely because of diversion and spillway excavation costs of fill dam schemes, and in favor of fill dams at higher elevation, subject to the availability of suitable construction materials. In each case the limited construction seasons and high steamflows during the summer months require careful consideration.

Fill Dam Schemes

Fill dam layouts at the prefeasibility stage will be based on the current information from the geotechnical studies including excavation criteria and availability of construction materials. An adequate supply of impervious fill especially for a high Watana dam, is forseen as a potential problem. The most likely type of spillway will be a conventional gated chute spillway, in one abutment of the dam, terminating in a flip bucket and plunge pool. The estimates will reflect a preliminary judgement as to the amount of excavation useable in the dam and the methods and timing affecting that utilization.

Concrete Dam Schemes

Gravity dam, thin arch, and gravity arch schemes will be considered as appropriate. In most cases it will be economical to place the spillway for a concrete dam in the main dam and

river channel. The gravity and gravity arch dams could have either flip bucket or stilling basin energy dissipators. The thin arch could have an overflow spillway with plunge pool, possibly requiring a low dam to maintain the plunge pool elevation, or a separate chute spillway. The concept of staged construction of the concrete dams will be studied in adequate detail for those applications considered to be of importance to a basin plan. A concrete dam could be attractive at the Watana site if the final elevation is somewhat lower than in the Corps scheme and if it is constructed in stages compatible with load requirements. Raising of the Guri dam and spillway in Venezuela, now is progress in accordance with a Harza design, is an example of this approach.

Arch Dam Studies

More specific studies of arch dam geometry and costs will be made at the identified sites which appear to be technically suitable for high arch dams, and one of these sites has been suggested for the initial project. The choice of possible axes will be studied by the geologists and planning engineers, and a preliminary axis and range of elevations will be chosen. An estimate of minimum depths of excavation for the foundations will be made. Arch dam layouts will be made for these specific axes, elevations, and expected excavated contours, with adjustments in the excavations as required with consideration given to the rock contours and jointing downstream from the dam. The shape and thickness of the dam will be analyzed on a preliminary basis by means of a crown-cantilever computer program, estimates of concrete and excavation columns suitable for the purposes of Phase I will be prepared, and sketches of the arch geometry will be made for use in preparation of project schemes.

Diversion

Diversion flood peak inflows and volumes for selected return periods at each dam site will be obtained from the hydrology studies and used to develop preliminary diversion schemes for selected levels of risk during construction of concrete or fill dams. In general the concrete dam schemes probably will pass peak diversion flows over or through the partially completed dam, with resultant cost savings. The situation with the fill dam is different. Harza has designed a project, now successfully completed, where excess wet season flows were passed over the partially completed - and previously protected - fill. This was done during one wet season, when the fill was not yet high enough

to require energy dissipation provisions. In the special circumstances of the Upper Susitna, however, such a procedure would leave very little effective construction season for the fill, and a more conservative approach would be required.

Powerstations and Water Conductors

Specific selections of generating units for the most likely scheme at each site will be made and used in the preparation of layouts and estimates for the underground powerstations. These will be used to refine the powerstation cost curves for each site, from the screening process, for further evaluation of alternative installations and elevations in the selection of the basin plan.

The power intakes and water conductors at this stage will be treated on a more site-specific basis, using the larger scale topography, general project arrangement, and additional knowledge of site characteristics.

Operation Studies

Two types of reservoir operation studies will be made to estimate the production of the identified projects and the alternative basin plan. The initial studies will use a multiple reservoir hydroelectric operation procedure, as described above under "Preliminary Screening," which gives full information on the operation of the hydro projects. The final comparision of basin development plans and initial projects, however, will include estimates of the capacity and energy useable in the Railbelt system in selected future years and the resulting effects on system generation costs. These studies will make use of a combined reservoir operation and system generation cost methodology, which is described below under that heading.

Basin Development Plan

The alternative plans of hydroelectric development for the Upper Susitna Basin will be evaluated on technical, economic, financial and environmental bases and a plan of development best adapted to the needs of the area and utilization of the resource will be selected and described. The initial project in that plan of development, which may be the first stage of a larger project,

will be identified for study at the feasibility level in Phase II.

TRANSMISSION SYSTEM

The transmission system studies in Phase I will provide estimates of the design characteristics, stages of construction, costs, and probable route corridors for several alternative transmission systems developed to meet the needs of the corresponding alternative power system expansion programs.

Data Collection and Review

All pertinent previous studies of the area transmission systems, including the 1979 report on the Railbelt Interconnection proposal for APA, and the transmission studies proposal for the Corps Upper Susitna study by the Alaska Power Administration will be reviewed in detail, together with the available public and agency comments on these transmission plans.

Previous load forecasts will be reviewed, and the load forecast adopted in the Power Market Study will be used to establish the loads expected at each major substation on the system.

All reports and Alaskan and U.S. laws describing the environment in areas affected by the transmission system will be collected to determine applicable constraints. In addition, current and past EPRI and DOC research reports on the effect of extra high voltage (EHV) transmission lines on plant and animal life will be utilized in the pertinent sections of the feasibility report.

Preliminary Studies

Criteria

Criteria for the design and operation of transmission systems in Alaska will be identified and discussed with APA and the local utilities.

A set of basic system dynamic performance reliability criteria will be used with approval of APA. These criteria will

be used as a guide in the review of the reliability requirements for the transmission system alternatives.

Transmission Routes

Receiving substation locations in the Anchorage - Cook Inlet, Fairbanks - Golden Valley, and Glenallen-Valdez areas will be established in cooperation with APA on the basis of existing system configurations, load forecasts, and with the aid of previous studies.

Preliminary routing-studies will be made, beginning with the routes suggested in the Interconnection Study and the Alaska Power Administration Study.

One or more common routes from each load center into the Upper Susitna area and individual routes extending to the dam sites will be identified for each alternative basin development plan. The transmission engineers and environmental specialists will conduct a joint study of methods of minimizing the environmental impact of the transmission lines under the conditions of the project area.

Transmission system characteristics for various routings such as length, altitude, difficulty of terrain, reliability, winter maintenance problems and special environmental problems that may be encountered will be identified. An analysis and prediction will be made of possible radio, television and other electromagnetic interferences that might occur because of the operation of the transmission system.

Preliminary Estimates

Generalized cost and performance relationships will be developed for the Upper Susitna transmission lines for use in the preliminary screening of plans of hydroelectric development.

Transmission System for Alternative Plans

The preliminary hydroelectric project studies will identify approximately six sites for evaluation, at different levels of installed capacity as part of several alternative basin development plans. An alternative transmission system plan, with appropriate stages of development, will be prepared for each basin development alternative. In each case a range of voltage levels (for example, 230 KV, 345 KV, and 500 KV) will be established in relation to the corresponding level of generation and load. The line characteristics for the major alternatives

will be tested for stability in accordance with estabilished criteria.

Power flow calculations will be made to estimate how a power system will react to a specified set of load and generation conditions. Load flows for both normal and abnormal conditions guide the determination of both transmission line and substation requirements. Load flow studies will be made for a number of selected cases among the transmission system alternatives.

Transmission line conductor sizes and configurations determined by previous studies for the Alaska Power Authority (APA) will be reviewed, and revised as necessary, for the basin planning study. Normal and emergency current capacity will be defined for the conductors used in the studies.

For each transmission system alternative, a calculation will be made to estimate the annual transmission system losses. The annual cost of these losses will be estimated based on system average demand and energy. The cost of the losses will be factored into the economic analysis of the overall plan.

The need for reactive compensation for each alternate transmission network will be investigated, using the load flow calculations and preliminary transient stability analysis. The need for shunt reactors, series capacitors and static var compensation will be established.

Cost Estimates

The construction and operating costs of the transmission alternatives will be estimated on the basis of preliminary design and quantity estimates and the cost of work under the conditions of the project area.

For each alternative, the cost of transmission line termination in substations will be estimated. The costs of major equipment such as circuit breakers, will be given as a separate costs. For the purpose of cost estimates, substation bus arrangements will be assumed as either breaker and a half or ring bus. Receiving substation transformer requirements will be estimated according to previous studies, and load center requirements. Generator step-up transformers and hydroelectric plant substation equipment costs will be included in the cost of the hydro project.

Preliminary substation layouts and transmission line configurations, including one-line diagrams, typical structures, and preliminary route studies, will be prepared for inclusion in the Basin Planning Report.

The report will include methods for protection of permafrost during and after construction. All ongoing environmental research will be closely watched and pertinent results will be utilized.

CONSTRUCTION COSTS AND PROGRAMS

The general method of study of construction programs and costs in Phase I will be the contractor's unit price method, similar to that described below under the Phase II methodology. However, the calculation of unit prices will be less detailed in the Phase I studies, and unit prices for a wider range of types and volume of construction quantities will be required.

Costs and unit prices for the reconnaissance studies will be based on multipliers reflecting costs and productivity under Alaskan conditions, Corps of Engineers estimates, and other available information.

A cost estimator will visit the project area as early as practical in Phase I to evaluate the severity of construction conditions and collect, at first hand, data on cost and availability of labor and materials. A basic set of unit prices will be developed for use in the prefeasibility studies, and these will be updated and adjusted for each of the project estimates used in the final comparison of plans of development.

Costs of generating equipment and transmission lines will be based on experienced costs from other, similar projects and confirmed by preliminary quotations from manufacturers of major equipment.

A preliminary constructibility analysis will be made of each of the projects in the alternative plans of development, and a preliminary construction schedule will be prepared for each project.

ECONOMIC AND FINANCIAL ANALYSES

Economic Analyses

The Phase I economic studies will utilize an internal rate of return analysis to rank the alternative basin plans of development on an economic basis and make a preliminary comparison between them and a selected thermal alternative. The analysis compares the present worth of the total expenditure

series for each alternative basin plan with the present worth of a series of annual benefits represented by the annual costs of a selected thermal alternative. The internal rate of return is the discount rate, for each basin plan, at which the present worths of costs and benefits are equal. The Susitna basin development plan with the highest internal rate of return and least environmental impact will be considered for further study in Phase II. All costs used in the study will be at a constant price level, probably as of early 1980, and the alternative expenditure series will be discounted to that date. Since this method of economic analysis omits all effects of escalation, including the foreseeable differential escalation of fuel costs, a suitable low discount rate will be used as a criterion when making the preliminary comparison between hydro and thermal alternatives. The purpose of the preliminary hydro-thermal comparison is to indicate that the initial project and basin development plan are economically viable before proceeding with the Phase II studies.

Financial Analyses

The preliminary financial analyses will estimate the financial requirements of the APA and the local utilities with and without the initial Susitna project and the corresponding financial effects on their electric customers.

BASIN PLAN REPORT

A Basin Plan Report will be prepared to document the selection of the initial project and the basin plan of development at the pre-feasibility level. It will consist of a main report and appendices with detailed information on the major aspects of the study, as follows:

a. Hydrology

b. Geotechnical Studies

c. Power Market Studies

d. Alternative Sources of Generation

e. Transmission

f. Selection of the Basic Plan

PHASE II - FEASIBILITY STUDIES

Phase II studies will be performed to establish the technical, economic, and financial feasibility of the Initial Project selected in Phase I to meet requirements of the FERC License Application. The major work programs of Phase II are described below.

HYDROLOGIC AND RIVER HYDRAULICS STUDIES

The hydrologic analyses for the Phase II study will involve (a) a detailed evaluation of long range water supply through stochastic analyses; (b) the determination of design and diversion floods through refined PMF and flood frequency analyses with proper account given to ice problems; (c) a refined estimation of reservoir sedimentation and an evaluation of potential downstream degradation; (d) the development of the tailwater rating curve for the selected site or sites; (e) development of water surface profiles for affected downstream areas; (f) modeling of selected water quality parameters; and (g) preparation of pertinent exhibits for the license application.

Available Water Supply

The flow of the Susitna River is highly seasonal, with more than 85 percent of average annual streamflow occuring in the five-month-period from May to September due to snowmelt and summer rains. This high concentration of annual flows in the summer suggests the need for large storage capacities to meet the high energy demands in the winter.

The contributions of streamflow from different portions of the Susitna basin also vary considerably. The contributions from the intervening area between the Denali and Vee sites are particularly low (1.0 cfs/mi²) as compared to other portions of the basin (about 2 cfs/mi²). There are several possible reasons, such as less precipitation due to the relatively flat topography and possible migration of groundwater eastward to the Cooper River Basin, that could cause the particularly low yield. These and other possible reasons for the low yield will be investigated to insure that the low flow figure for the intervening area is not due to inaccuracy in recorded data.

The streamflow records for the Susitna River range from 11 to nearly 30 years. These records may or may not include

critical flow sequences that can be expected during the economic life of the project. Therefore, extension of the recorded data for a longer period will be essential. Extensions of streamflow data are generally accomplished by correlation with longer periods of climatological data or by stochastic generation based on the statistics of recorded streamflows. In view of the complex effect of permafrost and snow and glacier melts on precipitation-runoff relationships, the correlation method probably will not be practical except those among the stream gaging stations. Therefore, the extension of streamflow data will be primarily based on stochastic generation based on the statistics of recorded data. The generated data will be tested for conformance with the recorded data before being used for reservoir operation studies. The lowest flow of record in the Susitna River is that of the 1969 drought. The frequency of occurrence of this drought as well as those of more severe droughts will be determined by a frequency analysis using the recorded and generated low flow sequences.

Reservoir evaporation may be greater or smaller than the evapotranspiration-before-construction of the dam. Therefore, a reservoir may cause a net loss or gain in available water supply depending on precipitation, soil and vegetation in the reservoir area. Net gain or loss due to the reservoir evaporation will be estimated and accounted for in the estimation of available water supply.

Flood Analysis

Spring floods of the Susitna River are mostly of low peak and long duration while the summer floods are mostly of high peaks and short duration. Depending on the size of the storage capacity, the critical flood for design purposes may be a summer flood or a spring flood. Summer and spring probable maximum floods (PMF) have been estimated by the Corps of Engineers for the Watana and Devil Canyon sites. The estimates are based on the analysis of probable maxium precipitation (PMP), snowmelt and unit hydrographs. Some analyses were also made by the U.S. Bureau of Reclamation for the Denali and Devil Canyon sites and by Kaiser Engineers for the Devil Canyon site. The basic data and results of these analyses will be carefully reviewed using updated storm and flood data to evaluate the adequacy of the PMF estimates and to refine the estimates if necessary.

Portions of the Susitna Basin are underlain by permafrost, which may reduce or prevent infiltration and hence increase flood runoff. Average depths and seasonal variation to the permafrost

table will be estimated and considered in the review and performance of the PMF analyses.

Floods due to outburst of glacier-dammed lakes also could cause severe floods in the Susitna River as indicated by the studies made by the USGS. Most of the glacial lakes in the Susitna basin are small but even a relatively small lake can cause a severe flood. The flood of 359,000 cfs in July 1958 due to the breakout of Lake George in the Knik River Basin in Southern Alaska and the flood of 110,000 cfs on November 30, 1965 due to drainage off Summit Lake in British Columbia are examples. The potential of major floods in the Susitna River due to drainage of glacier dammed lakes will be evaluated and a comparison made with historical floods of similar lakes. Discussions and consultation also will be held with local authorities, such as the USGS and the Geophysical Insitute of the University of Alaska on this subject.

Ice jams also could cause flood damage and alter the tailwater rating curves. Available information on the Susitna River will be analyzed for the effect of the dam on ice formations and dissipation of the jams.

The release of fresh water from the reservoir during the winter period would increase the ice formation in the estuary of the Susitna River. This potential icing will be evaluated based on the reservoir and stream water temperature study described in the following section on water quality.

Sedimentation

Sediment analyses made in the Phase I studies will be refined for the specific site or sites selected for the feasibility study. The refinement will include a careful review and possible refinement of the sediment rating curves. Sediment distribution in the reservoir will be calculated by the Empirical Area Reduction Method. Channel degradation downstream of the dam may or may not be serious depending on the downstream controls, bed material and flow velocity. Potential natural downstream controls will be identified through field investigations in evaluating the degradation potential. Bed material will be sampled to calculate degradation that will result in adequate armoring.

Tailwater Curves and Water Surface Profiles

Tailwater Rating Curves

The tailwater rating curve for each selected site will be prepared based on stage - discharge rating curve for the nearest downstream gaging station and/or backwater computations and the degradation studies. Tailwater curves under preproject and fully degraded conditions (with project) will be developed.

Water Surface Profiles

Backwater computations covering affected downstream reaches of the river will be performed using the U. S. Army Corps of Engineers Hydrologic Engineering Center Computer Program HEC-2, "Water Surface Profiles." Surveyed channel cross-sections at selected points will provide necessary input to the program. Water surface profiles, with and without the project, will be developed for floods of various recurrence intervals. These profiles will be used to determine downstream effects, on, for example, moose feeding grounds.

Water Quality Studies

The WQRRS Model developed by the Corps of Engineers will be used to analyze the water quality in the reservoir and the Sustina River. The model can simulate up to 18 water quality constituents including temperature, dissolved oxygen and nine chemical and seven biological parameters. It is aniticpated that water temperature, dissolved oxygen and suspended glacier flour will be of major concern but other parameters may be included in the model through discussion with project ecologists.

The model will be calibrated by using existing data and supplemental data to be collected through the monitoring program described under the aquatic ecology section of environmental studies. The calibrated model will be used to simulate the reservoir and stream water quality for summer and possibly spring and fall seasons. During the winter season when the reservoir and stream surfaces are frozen, the WQRRS model will not be applicable. Since there is insufficient knowledge of magnitude of the winter problem at the present time, a simplified analysis using an empirical formula will be made for the winter season to identify the need and formulate the method for further analyses. Harza's experiences on the Burfell - Thorisvant project in Iceland, the Great Lakes - St. Lawrence Seaway Winter Navigation

Project, and the Rock River Ice Flooding Project (Illinois) will be useful in identifying and solving winter ice problems.

The glacier flour (or glacier milk) can not be simulated properly by the WQRRS Model. The magnitude of the problem will be identified through discussion with project ecologists and local authorities. The method for analyzing and solving the problem will be formulated accordingly.

License Application

Most hydrologic information required to prepare the exhibits, expecially Exhibit H (Hydrology) and W (Environmental Quality), would be available from the Phase I and II hydrologic analyses. This information will be used to prepare appropriate sections of the license application if desired by APA. Additional analyses such as reservoir stratification and flood waves due to hypothetical dam failure may be required depending on local regulations and findings during the site selection and feasibility studies. If such analyses are needed they can be effectively carried out with Harza's in-house personnel and facilities in parallel with the feasibility study.

GEOTECHNICAL STUDIES

Introduction

The relationship between the Phase I and Phase II geotechnical studies and the preliminary planning for the Phase II study are described in the Geotechnical section in Phase I. the activities of the Phase II investigations are described in this section.

Relatively few hydroelectric projects have been constructed in permafrost areas of North America, and those installations are of low height, generally less than 80 feet. For example, although Churchill Falls Project (completed 1972) has an active storage of approximately 23,000 acre-feet and almost 40 miles of dikes, these dikes range in height from only a few feet to a maximum of 117 feet. Although relatively high water storage embankments have been constructed by the USSR in deep permafrost areas, no large structure is reported to have been constructed in a discontinuous permafrost region such as the Susitna River Basin. The state of thermal regime in this type of permafrost region is very sensitive to water storage projects and will require special considerations, especially with a moderate to

high structure without precedence. However, the understanding of the technology about the permafrost conditions is now much more advanced than one or two decades ago. The need for projects to develop resources in a subarctic environment has contributed to the understanding of the behavior of the soil and rock to the extent that mathematical models can be used to reliably extend that knowledge to new areas, such as a large hydroelectric development. This technology is available to the practicing engineer through written material, conference proceedings, and performance of engineering structures in permafrost and marginally permafrost regions. Our feasibility studies will address the pertinent problems of permafrost along with other geotechnical and seismic considerations in evaluating the suitability of a site. We will secure the assistance of a specialist experienced in geotechnical problems in permafrost regions.

The activities to be performed during the feasibility stage are described herein. The program is somewhat general in nature at this time and will be tailored to the needs of a specific site selected for the feasibility studies. Further, it is recognized that a considerable amount of work has already been performed on Watana and Devil Canyon damsites, and some work on Vee Canyon and Denali sites. If any of the above sites are selected for initial development, additional work will be planned for the selected site to complete the feasibility stage design.

Geotechnical Investigations

Feasibility stage investigations will be conducted by Harza Engineering Company; with some specific studies, drilling, geophysical work, and laboratory testing, done by subcontractors with direction and review by Harza.

Feasibility studies are a more definitive phase of project investigation. This phase involves completion of detailed geologic surface mapping and preparation of geologic sections to demonstrate the subsurface site conditions inferred from basin planning studies. The exploratory work is carried out to satisfy geotechnical requirements, and the scope will vary depending on the selection of the initial site. The availability of suitable construction materials is also an integral part of this study. A limited amount of geotechnical study will be required for access roads and transmission tower foundations.

The data will be compiled, analyzed and reduced to the format directly applicable to the feasibility level design. The

results of the program will be evaluated as the work progresses and, where deemed necessary, modifications will be made.

It is our intent to staff the senior level positions from our Chicago office, and to hire at least two experienced field geologists from Alaska to complete our field teams for the reconnaissance mapping and site drilling. Consultants and advisors for special studies will be retained where necessary.

Foundation Investigations

A foundation investigation program will be prepared for the site designated for the initial development. The information available on Watana and Devil Canyon sites will be used in planning the work. The program will include detailed geologic mapping, drill holes and test pits for the dam and underground powerhouse, switchyard, tunnels (power, diversion and tailrace), spillway structure, and other appurtenant structures. The results will be supplemented with geophysical tests as described later. Requirements for coring, sampling and testing will be specified. Stratigraphic correlation, presence of major faults and shear zones, depth of weathering, sound rock horizon and ground water conditions will be established. Field tests such as permeability tests, standard penetration tests, and the geophysical tests in the borings for the underground powerhouse will be included in the program. Water pressure tests will be performed to determine the general permeability, seepage potential, grouting, and drainage requirements under the dam and in the abutments and the underground powerhouse. Selected samples will be tested to determine their stress-strain characteristics. Disturbed and undisturbed soil samples will be retrieved for testing in the laboratory to determine the index properties and the other pertinent engineering characteristics. Requirements for these activities will be written and procedures established prior to the beginning of the activities. The location of the borings and the test pits will be dictated by the location of the various structures (dam, powerhouse, switchyard, spillway) and access to the site.

The possibility of encountering permafrost in and above the abutment areas will be examined with the goal of defining the nature and extent of frozen ground that may become unstable when thawed. This will be accomplished by a combination of drilling, sampling, and subsurface temperature measurements.

Test pits and trenches will be planned along the abutment slopes and the valley bottom to collect bulk samples, to expose

rock surface for examination, and to obtain block samples of fine grained material.

Investigations previously performed at Watana and Devil Canyon sites have indicated that the permafrost is in a marginal state. This makes it difficult to obtain representative samples, because the drilling operations change the thermal balance from a frozen to a thawed state. Also, the characteristics of the material are markedly different when they are thawed as compared to when they are frozen or in a transitional state of thawing. This will require special care and techniques in sampling, sample handling, and transportation. The methods and techniques will depend on the type of tests to be performed and the studies planned for the feasibility stage. Portable refrigerators powered by portable electric generators may be required for storage and shipment of samples. Usually the samples are wrapped in cellophane and placed in well-sealed, deaired polyethylene bags. Similarly, the choice of drilling fluids may include diesel fuel, air, brine or some type of antifreeze, depending upon the site conditions, and environmental constraints imposed by the jurisdictional authority. Experience gathered in a subarctic environment on investigation procedures will be evaluated to develop procedures for the Susitna Basin work.

Reservoir Investigations

A program for geologic mapping of reservoir slopes will be prepared to identify the areas of potential instability and distribution and location of frozen overburden that may become unstable when thawed due to reservoir filling. If necessary, these investigations will be supplemented with drilling and sampling and/or geophysical surveying.

In the discontinuous permafrost zone of Alaska, the upper surface of a permafrost layer is sufficiently deep so that the geomorphic and botanical indicators commonly used to locate permafrost farther north may be missing.

Location and extent of these potentially unstable areas will have been identified during reconnaissance mapping, and confirmation may be required by drilling during this phase.

Drilling techniques capable of producing undisturbed samples, and the measurement of deep ground temperatures will be necessary to adequately explore and define large zones of potentially unstable permafrost.

Investigations conducted by the U.S. Bureau of Reclamation and the U.S. Corps of Engineers have indicated locations of various scarps at Devil Canyon reservoir site and Watana site that can be attributed to unstable conditions. In Devil Canyon reservoir site, southerly dipping near vertical joints may create problems of rock stability during a seismic event. At Watana site, many scarps are found paralleling shear planes or prominent jointing and, although the abutments were not examined in as much detail as for Devil Canyon site, these scarps could be the result of rockfall due to thawing and freezing accentuated by tectonic activities. Similar characteristic features may be expected throughout the Susitna River Basin and will have significant impact on site suitability. Investigation programs will be planned to confirm areas of potential instability identified by USBR and USCE during the reconnaissance survey, and to identify additional areas including their state of thermal regime, depth of permafrost table, active layer thickness and existence of Taliks (unfrozen ground within permafrost). It has been noted that permafrost is more evident on north facing slopes and that some icing has been noted on these slopes indicating a source of water seepage; these factors will be considered in planning studies.

Geophysical Investigations

Geophysical investigations will be planned to supplement the information gathered from foundation investigations and to determine the dynamic shear modulus, and shear wave velocity characteristics of the rock units in low strain range. Much geophysical work has already been accomplished for the Devil Canyon and Watana sites. The previous data will be used in planning further activities for these sites and other candidate sites. The program will include seismic refraction surveys, downhole and crosshole velocity surveys, and selected downhole geophysical surveys. The work program will be planned and conducted by others, such as Shannon and Wilson. The program will be designed to be flexible enough so that changes could be made as deemed necessary during the progress of the work.

Seismicity and Fault Investigations

It is known that the Susitna Basin is located within a highly seismic region with identified faults of regional importance. The seismicity and tectonics of the region are not yet well understood. Therefore, considering the importance of the Susitna Basin Development to the region and the large

investments involved, this aspect of the project planning and design deserves special attention. The studies conducted by the USBR, the USCE, the USGS, the University of Alaska Geophysical Institute and the data available in the literature will be used in planning further investigations. The program will be conducted by Woodward - Clyde Consultants as a continuation of their field studies under Phase I.

Construction Materials Investigations

Construction material availability is a very important part of this study because of the large quantities required. Much information is available for the Devil Canyon and Watana sites. Programs will be developed for additional work at these sites and other selected potential sites. This program will include field reconnaissance, drilling of rotary and auger holes, test pits and trenches, retrieval of bulk samples for laboratory testing for embankment and concrete aggregate materials, and use of refraction survey data to estimate the volumes available at particular borrow locations.

Previous studies have identified deposits of river alluvium at the confluence of Cheechako Creek with the Susitna River near Devil Canyon site and at the confluence of Tsusena Creek and the Susitna River for the Watana site. The material from these sources has been reported to be acceptable for concrete aggregate as well as fine filter for an embankment. These findings will be confirmed both as to their quality and quantity if either site is selected for an embankment dam. It has been our experience that use of river alluvium in the embankment requires special considerations, particularly if this alluvium contains more moisture than optimum, for two reasons: (1) the material drying becomes a problem as soon as fines content (passing #200 sieve) of the material exceeds 7 percent by weight, and (2) compaction of this material in the wet state becomes impossible due to pumping action. Therefore, where large quantities of alluvium are expected to be within a reasonable haul distance of an embankment site, a test fill program of limited extent may be desirable and this may be included in the materials investigations program.

At the Watana site, the source of impervious and semi-impervious material was identified to be glacial till deposits. Further, the fine portion of this till deposit was found to exhibit two characteristics that need additional evaluation. First, the material exhibited a rather low optimum moisture content (close to 7.5 percent) which may necessitate drying prior to placement; and secondly, if placed wetter than

optimum moisture content, the material loses strength rather rapidly. Since the origin of fine grained soils suitable for impervious core may be similar throughout the Upper Susitna basin, similar characteristics may be expected at other potential locations. Therefore, this aspect of the material investigations will be given due attention for its impact on design of an economical cross section of the embankment.

Rock cores from potential quarries and bulk samples from gravel and sand deposits and other potential areas will be taken to the laboratory for concrete aggregate and embankment fill suitability tests.

Our discussions at the University of Alaska with personnel engaged in economic, mineral and mining investigations, revealed that occurrence of limestone in the Talkeetna Mountains area may have potential for cement manufacture. A nearby source of cement would impact favorably on project economics, particularly for concrete dams, and on the economic development of the Railbelt Region as well. Our Phase II materials investigations will thoroughly investigate cement production possibilities if our Phase I reconnaissance confirms that such potential exists.

Laboratory Testing Program

A laboratory testing program compatible with field investigations and design studies will be planned. The program will be divided in three categories described as follows:

Index Tests

These tests will be performed by a local laboratory under Harza's direction and supervision. If the scope of investigations dictates, a field laboratory may be set up to reduce the cost of transporting the samples to a distant laboratory. The tests will include grain size analyses, specific gravity, natural moisture content, Atterberg limits (on fine grained soils), and unit weight of block samples (from test pits) from embankment borrow materials, and overburden materials, and acceptance tests for sources of concrete aggregate. We have confirmed that in both Anchorage and Fairbanks, there are well equipped, well staffed laboratories capable of this testing.

Structural Property Tests

These tests will include determination of engineering characteristics of the embankment construction material, foundation rock and overburden, and fill material for the access roads. Undisturbed block and tube samples of foundation soils will be tested to determine the character of in place soils.

In general, testing will include permeability tests, triaxial and simple shear tests, compressibility tests, unconfined compression and confined compression tests to determine elastic properties. Additional tests needed are dispersion on both undisturbed and recompacted samples, moisture density relationship and relative density tests on embankment fill material, and unconfined compression tests on selected rock samples.

Rock samples from potential quarry areas, required excavation areas from powerhouse, spillway and tunnels, and coarse aggregate from alluvium deposits will be tested for suitability as rockfill and slope protection material. Certain tests will require unconventional setups to test soil and rock material under high stress conditions representative of stress conditions within the embankment.

Concrete Aggregate Tests and Rock Durability Tests

Appropriate tests will be performed on potential concrete aggregate and rockfill source materials to determine their suitability characteristics. The tests will be performed on alluvial material, if available in sufficient quantity at a site and on rock core samples. The tests will include Los Angeles abrasion, crushing hardness, reactivity, sulfate soundness, specific gravity and absorption and petrographic analysis for concrete aggregate. The alluvial deposits near Devil Canyon and Watana sites have been identified by previous studies to be acceptable for concrete aggregate; this will be confirmed through additional tests.

Instrumentation Program

An instrumentation program will be planned and executed to include ground water monitoring, ground temperature monitoring, and microseismic and macroseismic network. Open standpipes with special features to prevent freezing will be installed to monitor the ground water level fluctuations in critical areas. Ground

temperature monitoring is necessary to determine the depth of permafrost and the temperature variations within the ground as this information may not be available from drilling operations due to the marginal state of permafrost in some areas. This may include installation of thermo-couples with suitable readout equipment for the site. This information is useful for planning of foundation treatment procedures, overburden stability problems when permafrost is thawed, and construction material considerations.

Feasibility Level Layout and Design Studies

On the basis of the geotechnical investigation results and compatible with economic, hydraulic, power, environmental and other project development considerations, layout and preliminary design of various features of the project will be prepared and evaluated. Possible layout for the powerhouse structures (underground and surface) location, outer slopes and internal geometry of embankment dams, impervious core versus concrete face rockfill dam, layout of concrete arch or gravity dam, location and orientation of spillway structures, diversion and power tunnels and switchyard location will be studied. Quantity estimates and material availability studies will be performed for comparative cost evaluations. Access road layouts will be studied. Foundation treatment concepts will be developed for the dam and the abutments. Rock mechanics studies will be performed to determine the temporary and permanent rock cut slopes for exterior and underground excavations. Preliminary rock support requirements and viable concepts will be studied for underground excavations.

Studies for the dam will begin with axis location and relative suitability for arch, gravity, or embankment dams. For embankment dams, the relative merits of impervious core rockfill versus concrete face rockfill will be studied. A concrete face rockfill dam may be attractive for consideration of short construction, rather wet period, sensitive fine grained soil for core and reduced costs in foundation excavation. Features such as presence of a known or suspected fault that may cause surface rupture will be important in determining the type of dam (concrete versus earth/rockfill). In the event the choice is an earth/rockfill dam, then further studies will be performed to determine stable slopes, freeboard requirements and material requirements. It is realized that a liberal freeboard and use of wide filters upstream and downstream of the core will be preferred due to seismic exposure. Internal geometry and crest details will be developed on the basis of available construction material, internal stress distribution, and environmental

constraints of the sub-arctic region on construction activities. Transient and stabilized thermal regime conditions within the embankment may be studied as discussed under special studies. Construction material optimization studies will be performed to arrive at an optimum cross section. These studies will include availablility of the materials, distance and workability, and construction sequence as far as it affects the material stockpiling and handling requirements.

Alternative layouts for the powerhouse and tunnels will be studied. This will require rock mechanics studies on excavation stability and rock support system and access to the underground facility (vertical shaft, level adit). Spillway excavation slopes will be studied using rock mechanics concepts.

Switchyard and transmission corridor layouts will be studied in view of the foundation conditions. Access road layouts will be studied for construction material availability, susceptibility to permafrost action, stability of slopes along the route, and foundation conditions for structures across rivers, creeks and ravines.

A final layout of facilities and preliminary design will be prepared for presentation to the APA.

An important factor that will be considered during these layout and preliminary design studies is the condition of permafrost that may affect the design considerations. This will depend on a specific site condition location, and the scope and impact may vary considerably. At this time, it is not possible to address these issues except in generalities. A more specific scope will be defined during the basin planning and early stages of feasibility studies.

Geotechnical studies will be conducted to formulate and support feasibility stage design. A brief description of these studies and methodology is presented here.

Foundation Design Studies

This will include development of geologic profiles, bedrock surface, and depth to sound competent rock. Requirements for seepage cutoff and foundation treatment in the form of grouting and drainage under the dam, spillway and abutments will be studied. Alternative treatment concepts will be developed.

Studies may be required to investigate the advisability of accelerating the thawing of the foundation as opposed to

protecting the permafrost conditions. Wherever possible, the advantage of the existence of the permafrost conditions will be taken in planning of foundation treatment. In case, overburden deposits or weathered rock are left under the shells of the embankment, means of protecting the permafrost in the downstream zone will be studied and compared with the hazards of thawing of this material. Also, accelerated thawing of upstream zones may be considered to expedite the change in thermal regime and consolidation. Means of relieving the excess pore pressures caused by a rapidly advancing thermal bulb under the foundation, such as sand drains, will be studied where pertinent. Also the effect of the embankment on the stabilization of the permafrost under the downstream portions will be studied. The scope and level sophistication of these studies will depend on the site conditions as discussed under Special Studies.

Rock Mechanics Studies

These studies will include evaluation and study of rock discontinuities such as joints, shears or faults, their density and orientation, and their influence on stability of rock excavation cuts and underground structures. Preliminary analyses will be done on rock slope stability for permanent excavation slopes, including the considerations for permafrost.

The squeeze potential of the rock during excavation for underground facilities will be studied and possible excavation methods for tunnels and underground powerhouse cavern will be developed. Rock support requirements and systems (rock bolting, guniting, lining) will be studied.

Static Slope Stability Analyses for Embankment Dam Slopes

Preliminary design of the embankment will be based on the material characteristics, previous experience and sound judgment. The slopes will then be analyzed using cost effective techniques. Harza maintains two computer programs i.e. Stephen G. Wright program and Harza-Morgenstern computer program. Analyses will be made for intermediate and ultimate construction conditions, steady state seepage conditions with normal reservoir pool, high reservoir pool conditions and postulated drawdown conditions. It is our practice to check the results of these computer analyses with hand computation to provide a direct check on the accuracy of the results. The analyses will be performed using compatible material characteristics.

The Corps of Engineers, in their studies for Watana site, noted that the shear strength characteristics of the fine grained soils derived from the glacial till were very sensitive to the placement moisture content. Particularly the material was found to lose strength when placed wet of optimum moisture content. We have noted similar behavior for residual soils in tropical regions of Central and South America where the material loses its strength rapidly when placed wet of optimum. The only difference is that the optimum water content for those soils is much higher than that in the continental United States. In such instances, we perform a sensitivity study wherein we study the correlation of changing shear strength with dam cross section for appropriate safety factors. These studies help in establishing the construction control requirements without putting undue restrictions on moisture control and shall have a cost effective structure. This type of study is especially important where a short construction season may preclude the drying of core material. The relationship of thermal regime analysis as it may influence the stability is discussed under Special Studies.

Settlement Analyses

For a high embankment dam, settlement analysis is important in establishing freeboard requirements and study of differential settlements that can cause internal cracking. Settlement analysis will be performed using SEPOL program and compatible soil/rock parameters. The work will be checked using hand computations and comparison with Harza experience on previous jobs and published case histories.

One of the unique features of the settlement analysis for this development is the settlement due to the change in permafrost condition where the embankment or portion of it is to be founded on permafrost soil/rock. This aspect is discussed under Special Studies.

Seepage Studies

These will include seepage studies through the embankment dam, foundations, abutments and reservoir rim. Studies will be performed using conventional flow-net analysis and knowledge of joint frequency, pattern, and orientation within the rock. The results will be used in formulating foundation treatment concepts such as seepage cutoff measures and grouting and drainage curtain. Seepage through the reservoir rim-will also influence the ground water table around the project.

In areas where permafrost may be encountered, seepage will result in degradation of permafrost. Also the permeability of the media (soil or rock) will change with changing thermal conditions. These aspects are discussed under Special Studies.

Reservoir Slope Stability Analyses

The reservoir slopes at each dam site will be examined in detail to locate and define potential landslides or rockslides of sufficient magnitude to damage the dam directly or by wave overtopping, or seriously reducing storage volume of the reservoir. This will require special attention due to the subarctic climate where perennially frozen valley slopes, which are stable under permafrost conditions, may become unstable when thawed due to reservoir filling.

North-facing slopes in the Watana area are known to contain permafrost in many locations. Much surficial evidence of permafrost on south-facing slopes upstream near Vee and Denali sites was observed during the Harza helicopter reconnaissance trip in July 1979. Existence of permafrost in alluvium masses with slide potential when inundated by the reservoir will likely thaw and initiate sliding by release of toe support. Thawing of permafrost in joints and fractures in rock, especially with dip slope into the reservoir, may activate large rock slides. Additional hazards of potential slides are activated by earthquake forces imposed on a toe-saturated alluvial mass, or release due to ice fracture from ground vibration. These potential hazards will need to be identified and evaluated.

The stability of these slopes will be analyzed for both static and seismic conditions. Their effect on dam freeboard requirements against overtopping will be evaluated. Risk versus cost of stabilizing these areas will be studied. The stability of these masses will require attention for the following reasons:

a. The fact that they may have experienced movement in the past is indicative of their limiting state of equilibrium which in many cases may be helped by freeze back and ice inclusions in shear planes. These masses, when submerged under reservoir, will experience thawing and lose the cohesion along the shear planes due to the presence of ice thereby making them more vulnerable to failure.

b. Degradation of the permafrost table in the overburden portion of the reservoir slopes may cause excessive pore pressures in layers along critical planes thereby

reducing shear strength markedly. This may cause a slide of mass above that plane in a slope or undermine the toe of a large mass of soil or rock above reservoir level.

c. Marginally stable soil mass or rock mass may experience large build up of pore pressure due to thawing and when coupled with inertial effects of the earthquake may cause land slides.

These points are discussed under Special Studies.

Seismic Analysis of Embankment

A proper evaluation of behavior of an embankment during postulated seismic event requires use of nonlinear dynamic soil parameters, internal static stress distribution prior to an event, development of site related earthquake time history, and use of finite element program such as FLUSH. Dr. H.B. Seed, in 19th Rankin Lecture delivered this year on "Considerations in the Earthquake-Resistant Design of Earth and Rockfill Dams" stated that the type of analysis and the level of sophistication is dictated by the material of which the dam is constructed. He further stated that for materials that do not lose strength significantly under seismic conditions, pseudostatic or Newmark type analysis is extremely useful. Our recent experiences with the seismic analysis of embankments indicate similar conclusions. Therefore, for feasibility stage, we anticipate a Newmark or simplified Seed type analysis to estimate the level of permanent deformations caused by a postulated earthquake event. For final design, however, a more detailed analysis including finite element techniques may be required.

Special Studies

Previous studies conducted by the USBR and the USCE have identified existence of permafrost within the Basin and permafrost related phenomenon such as solifluction, soil creep and land slips in varying degrees at Watana site and Devil Canyon site. This may require study of the preproject thermal regime, the impact of development (dam and reservoir) on it and the rate of change of the thermal regime. The scope of these studies will depend on the type of problem encountered and the structure selected for a site. We will determine the scope and level of sophistication of these studies during the River Basin study and the planning of feasibility investigations and feasibility studies. The following is a general discussion of the studies that may be required. At this time we have made no provision for

these studies in our cost estimate as it cannot be easily identified.

Studies on thermal regime variation may be required to estimate the rate that a "thawfront" will advance due to seepage from the reservoir or the possible aggradation of permafrost where it is protected. The results of these studies will then be incorporated into other studies such as seepage, slope stability or settlement analyses. Also the behavior of the soil mass while thawing may have to be studied for its relationship to excess pore pressures (static and seismic stability), settlement and other related phenomenon. These studies may require the use of finite element or finite difference techniques. The advance of a thaw front due to seepage is similar to the advance of "saturation front" in a thick impervious core for a high embankment. We have been successful in modelling this phenomenon with finite element techniques. Similar approach will be used in analyzing the advance of "thaw front" in changing thermal regime. The parameters needed for such studies would include heat conductivity and permeability of media both in permafrost condition, and thawed condition, temperature of permafrost condition, average yearly temperature, amount of ice present in the soil/rock and limiting boundary conditions. For preliminary studies, some of these parameters can be estimated on the basis of previous work and general soil conditions.

Settlements caused by degradation of permafrost can be significant. These settlements are caused partly by melting of ice inclusions in soil or rock, and partly by consolidation of soil. The data on performance of two major dikes with maximum height of about 20 feet at Kelsey generating station in Manitoba, where permafrost foundation experienced degradation through underseepage, indicate that reasonable estimates of settlement due to thawing can be made using material characteristics and mathematical models. This requires a careful evaluation of amounts and nature of ice present in the foundation, depth and temperature of permafrost, and heat conductivity of soil/rock during frozen, and unfrozen states. Some insight into this aspect, as far as time rate is concerned, will be possible from thermal regime change analysis as discussed later.

We have experienced similar phenomenon is soils of residual origin where the soil structure undergoes marked readjustment when saturated and experiences rather large settlement (structure collapse) under the same total stress conditions. We have controlled these conditions by designing the dam and the construction activities such that the integrity of the structure and the foundation is maintained.

Thawing of permafrost also changes the permeability of the soil and rock. If the site conditions are such that seepage would influence the economic feasibility of a certain structure, necessary laboratory testing on soil or rock both in frozen and thawed state, and seepage studies may be required.

Thawing of permafrost along pre-existing and potential shear zones will markedly change the state of equilibrium of a potential sliding mass. This is due to the loss of cohesion by melting of ice inclusions and presence of excess pore pressure where drainage may be slow or obstructed. Similarly the thawing of ice inclusions along the joints in a rock mass reduces the friction along the joint to near residual and causes loss of cohesion. This could be very important in rock mechanics studies for underground excavation and for rock slopes along the reservoir rim. This effect is similar, in nature, to the saturation of pre-existing shear planes in rock mass where a joint is filled with soil-like matter. In these cases, we perform cyclic shear load tests to determine the residual strength of the shear plane. A similar approach may be applicable to the thawing of ice inclusions.

The loss of permafrost in foundation soil also influences the stability of the earth/rock embankment through the reduction of shear strength. However, as the thaw front advances slowly, previously thawed areas start regaining strength through the release of excess pore water pressures; and thus if the rate of thawing is known, the stability of the structure can be evaluated at critical points.

The presence of permafrost may also be used to advantage under certain circumstances. For example in planning of grouting operations, the permafrost would act like outer rows of grout curtain and provide a tighter closure under relatively low costs. This however, does require considerations in planning of a thawing scheme for drilling and grouting of holes. Permafrost can also be used to advantage in steep temporary excavation slopes and in quarry areas where existence of permafrost would assist the excavation slopes to remain stable.

In any event, it is recognized that permafrost issue will require attention on Susitna Basin Development. The scope of studies (both laboratory and office) and the level of sophistication of studies will be site related and cannot be determined at this time. We will determine these factors during the Basin planning study and the early phases of the feasibility studies. We will seek assistance from a specialist in the field of frozen soil/rock mechanics to assure the work and studies are performed in the right direction.

Fault Activity and Seismic Risk

This part of the study will include review of seismic field investigations, microseismic and macroseismic network data, and review of all available published and unpublished literature related to the seismic activity in the region. For the feasibility stage analysis and design, it will be sufficient to define a conservatively selected maximum credible earthquake. This data will be used in seismic stability of the embankment dam. This study will be performed by Woodward-Clyde Consultants under Harza's direction. It will also be desirable to conduct preliminary probability studies to determine recurrence period for all earthquakes with magnitude greater than 4.0 on the Richter Scale. Also, the risk of reservoir induced earthquakes will be evaluated. Special attention will be given to studying the potential of surface rupture. The studies will form the basis of seismic design parameters (maximum credible earthquake, design earthquake, magnitude, duration, predominant period, time history, etc.) for the specific site finally selected for development.

Feasibility Report

Activities and studies performed during Phase II will lead to the preparation of a feasibility report on a specific site. The geotechnical portion of this report will include feasibility level design for the recommended dam, powerhouse, spillway, switchyard, transmission lines and access roads and other appurtenant structures in the form of exhibits and drawings. The results of the studies will be summarized and included with the report. A draft report will be submitted to the APA for their review and comments. At the conclusion of the review process, comments will be resolved and a final report submitted.

Federal Energy Regulatory Commission Licensing

The necessary geotechnical reports and exhibits required for the application for licensing by the Federal Energy Regulatory Commission will be prepared for the Alaska Power Authority. Geotechnical data necessary for safety and design adequacy will be incorporated in the Environmental Report. Geologic hazards considerations and their probability of occurrence will be discussed.

HYDROELECTRIC PROJECT STUDIES

The Phase II studies of the project structures and equipment will consist in general of the refinement and preliminary design, at the feasibility level of the initial project selected in Phase I. The detailed content of the Phase II studies will of course depend on the type and size of structures and stages of construction of the selected project. We assume for present purposes that the initial project could be either a fill or concrete dam scheme. The principal areas of study and some of the detailed considerations will be as follows.

Access and Relocations

Access to the sites of the project structures for construction and operation purposes will be studied at the feasibility level, with the aid of additional topographic and geologic studies as required. The route selection, preliminary design criteria, and construction procedures planning will be guided by environmental considerations from the beginning of the study. Relocations of existing facilities, if any, will be planned at a comparable level of detail. A sufficiently detailed study will be made of access for construction equipment and permanent equipment from the port of entry to the construction sites, including considerations of port facilities, road and railroad size and weight limitations, possible additional unloading or special siding facilities, and winter operation and maintenance.

Dams and Reservoirs

The selected project scheme will be developed in greater detail on the basis of the geological, geotechnical, hydrologic, and topographic data as they become available. The use of construction materials from required excavations and quarries will be studied, especially with respect to the sequence of construction operations and possible stockpiling requirements. The overall balance of cut and fill in the project will be developed by types of material, and areas for stockpiles and disposal of excess material will be identified.

The selection of the type of dam and general project arrangement from the pre-feasibility studies in Phase I will be reviewed as necessary. The selection of the type of dam may be quite clear from the Phase I studies in view of the indicated reservoir elevation and the place of the initial project in the

overall development scheme. The initial reservoir elevation may, however, require a height of dam at which two or more types of dam are closely competitive, and the selection also may be affected by the results of the Phase II geotechnical studies. Accordingly, it may be necessary to consider alternative types of dam and general project arrangement well into the feasibility study. Our working assumption, however, is that the selection can be made at the beginning of Phase II.

The normal reservoir elevation will be optimized, within a range of elevations defined by the Phase I studies, on the basis of the power economics of the initial project and its relation to upstream and downstream projects. The use of some encroachment or raising the tailwater level at the upstream project is likely on the basis of overall power system economics. The maximum reservoir elevation during design flood conditions and the resulting height of the dam will be optimized in conjunction with the spillway studies.

Preliminary Design of the Dam

If the selected project includes a concrete arch dam, the preliminary layout studies will be refined in Phase II. The location of the axis will be reviewed with respect to geological considerations and overall project arrangement, and revised excavation plans will be prepared based on the larger scale site maps and results of subsurface exploration. The arch dam will be laid out to best fit the site conditions and feasibility-level stress analyses will be performed by existing computer-based methods.

In the event that the selected project does not include an arch dam the effort would be re-directed toward the necessary studies of the selected type of structure. In the case of concrete gravity or fill type dams the structures would be laid out with respect to assumed excavated foundations and analyzed for stability and foundation schemes by computer assisted methods. A number of trial sections for fill dams would be tested, with alternative geometries based on the availability and characterisitcs of construction materials as discussed in the geotechnical section.

The main cofferdams for both fill and concrete dam schemes will be major structures, possibly with severe cut-off problems resulting from deep buried channels at some sites. The construction requirements and the timing of operations with respect to the construction seasons will be areas of emphasis.

The stability of natural and excavated slopes and the requirements for seepage control will be studied, as discussed in the geotechnical section, in the areas of major project structures and in the reservoir and tailrace areas as required.

Spillway

The spillway layout will be revised to accommodate the project design flood as developed in the Phase II hydrology studies and studied to provide safe operation under all operating conditions. The need for and proper design of reservoir outlet works will be studied. It appears that high powerstation discharges plus some spillage will be required during each normal summer season. Therefore a service spillway or outlet works of adequate capacity may be required in addition to the emergency spillway. The design of the energy dissipators and the effect of their operation of the stability of the foundations of the dam and slopes of the gorge will be examined.

The hydraulic design of the spillway and outlets and selection of gates and other equipment will be based on a long history of successfully operating spillways designed by Harza, with special reference to projects in cold regions such as the Burfell and Hrauneyjafoss projects in Iceland.

Diversion

The scheme for diversion during construction will be developed to provide an economical but adequately safe solution, taking into account the degree of risk associated with the types of structures selected, as between concrete or fill dams and surface or underground powerstations, including the risk of delay in timely completion of the project. The possible use of the diversion tunnels as part of the power facilities, probably in the second stage of power development, or as outlet tunnels will be investigated. The diversion facilities will be planned with particular attention to their functioning during the winter and the spring break up period.

Power Facilities

The power generating facilities, consisting primarly of intakes, water conductors, powerstation, and switchyard, will be studied in detail for a range of plant capacities and initial project reservoir elevations. A preliminary design at the feasibility level will be prepared for the selected initial installation. The planning will include the possible later expansion of the plant when needed. Our concept of the initial project suggests that the initial installation will be large enough to achieve maximum practical utilization of the summer secondary energy. This capacity would then become dependable capacity with the addition of upstream storage, but additional capacity at the initial project may not be required until the system as a whole is substantially larger. Therefore, the adopted project layout will permit considerable flexibility in future expansion with a minimum of initial investment in future provisions.

Powerstation and Switchyard

Detailed layouts will be made of the type of powerstation, probably of the underground type, selected in Phase I. The number, size, and orientation of the underground caverns will be based on the geotechnical characterisitcs of the site, water conductor arrangements, access arrangement, and dimensions of the major items of mechanical and electrical equipment. Selection of the size of generating unit will be based on detailed study of the plant in relation to the power system; transportation, access and construction limitations; and permissible dimensions of the underground caverns.

The transformer and switchyard locations, and design features will be selected on the basis of overall economy and operating consideration such as the possibility of ice fogging near the tailrace channel under some conditions.

Intakes and Water Conductors

The intakes for the underground powerstation scheme may be in the concrete dam or in a separate structure with either type of dam. The latter arrangement may result in some increase in tunnel length but with some advantages in simplicity of design and construction. The intakes will be of the multi-level type, to permit plant discharges to be drawn from selected reservoir elevations in accordance with environmental requirements. The

detailed planning of the intake structures and equipment, with full consideration of seasonal operating factors, will be a major item of study.

The power tunnels and shafts and tailrace tunnels will be of conventional design. They will be designed with full consideration of the special geotechnical characteristics of the site, possibly including permafrost and their relationship to the dam foundation and seepage control system.

Operators' Village

The permanent operating facilities for the project, including control facilities, maintenance and support facilities, and housing and community facilities for the permanent operating staff will be included in the overall plan of development from the beginning of the feasibility study. The location and type of village development will be developed in conjunction with the project access and environmental studies and with special attention to all-season access and maintainability and to overall energy efficiency.

Cold Regions Engineering Aspects

Understanding of the Problem

Engineering hydroelectric projects in cold regions must consider the effects of cold climates on several features of the project. Some of the obvious effects of cold climates are the freezing of lake and river water surfaces, permafrost in some cases, lack of radiant energy during winter, difficulties in ground transportation because of snow and low temperatures and outdoor working conditions.

At the start of planning for a hydroelectic project in a cold region the unique conditions of climate must be recognized. The proposed project must then be planned to be reasonablly free of problems caused by cold climate conditions. Some aspects to be taken into account for example are the following: freezing of reservoir water surface, frazil ice, passage of ice floes, ice loads on structures and costs and schedules of construction work during winter. Operating expenses to deal with ice conditions must also be considered in determining the economic feasibility of a project.

After recognition of the potential problems of cold regions and methods of solution proposed, it may be necessary in certain cases to conduct model tests of the proposed structures. Such testing could include modeling of a portion of the reservoir, ice sluices and ice booms.

During design of a project certain provisions to prevent ice problems can be incorporated. Such provisions can be air bubble de-icing systems, gate seal heaters, heated gate enclosures and insulation of pipe lines.

In order to design a reasonably ice problem free project, it is most useful to have an understanding of the physics of the formation of the various types of ice. Experience with design and operation of hydro projects in cold regions along with knowledge of many other projects such as those in Scandinavia would also be beneficial.

Areas of Study

The following are aspects to be considered in design:

1. Reservoir ice cover formation.
2. Control of ice flow movements.
3. Passage of reservoir ice.
4. Frazil ice formation.
5. Icing of intakes.
   a. trashracks.
   b. gates.
6. Ice formation in penstocks and surge tank.
7. Ice formation from gate leakage at spillway.
8. Ice loads on structures.
   a. dynamic loads such as impact and friction of floating ice against structures.
   b. static loads such as thermal expansion of ice cover and ice accumulations by action of wind

or current and freezing on structures from water level variations.

9. Ice loads on transmission lines from freezing rain.

10. Freezing of water spray on structures.

11. Formation of fog from cold air over warmer water bodies.

12. Ice jams downstream of project.

13. Floods caused by step-burst upstream of project.

14. Ice erosion on hydraulic structures.

Of the above aspects those that are applicable will be studied to determine solutions to potential problems including in certain cases hydraulic model testing before design of the project.

Effect on Selection of Type of Dam

A major item of planning a hydroelectric project and determining the feasibility of the project is selection of the type of dam. Cold region conditions will have an important influence on construction methods and schedules. Construction of earth and rock fill or concrete dams are naturally affected by cold conditions in such ways as permafrost in the foundation, freezing of moisture in fill materials, cost of heating and protecting concrete during winter and length of construction season. The length of construction season can have a profound effect on the selection of type of dam. Construction of a dam of smaller volume should shorten construction time. The time needed for thawing of frozen moisture in fills or removal of fill materials which have been frozen could shorten the available construction season for a fill dam. Freezing of borrow areas can shorten available construction time. Suspension of placement of impervious fill and protection of the fill during the winter may be necessary. It may be possible to continue placement of dam concrete during much of the winter, although more expensive procedures would be required. These and related aspects will be considered in the Phase I and Phase II studies of the type of dam and project arrangement.

Harza Experience

Harza made extensive studies of cold weather aspects concerning design and operation of two hydroelectric projects in Iceland.

These projects as designed by Harza are Burfell on the Thorsa River and Hrauneyjafoss on the Tungna River. Construction of Burfell was completed in 1969 and the project is operating successfully. Construction of Hrauneyjafoss started in 1978 and is scheduled for completion at the end of 1981.

Hydraulic model testing for these projects was conducted at the River and Harbour Laboratory of the Norwegian Institute of Technology in Trondheim, Norway. The model program included testing of ice passing facilities. The Burfell project has extensive facilities for ice passage and glacial sand passage. At Hrauneyjafoss the reservoir is expected to have an ice cover during winter and a one kilometer long diversion canal has been designed for an ice cover to also form.

At a project in Northern Wisconsin, Cornell Hydroelectric Plant which was completed in 1976, Harza designed air bubbler de-icing systems to keep intakes and spillway gates ice free during winter. Also the intake has additional icing protection by receiving waste heat from the generators forced into the intake gate house. Heating of the guides of intake gates and of two of the spillway gates has been provided at Cornell. Also the two spillway tainter gates have heated insulated compartments. These compartments enclosed the entire downstream side of the gates and are provided with electric unit heaters.

Harza has been involved in ice control studies for many hydroelectric and navigation projects. Harza was involved in the design of the facilities to keep navigation locks relatively ice free for ship lockage during cold weather. For Great Lakes Power Co. projects, ice pressures against hydraulic structures were investigated and heated gate guide systems were designed.

Studies on the movement of ice in reservoirs and prevention of ice entering power intakes have been conducted. In addition, studies were made on the prevention of ice formation inside of power penstocks and surge tanks by velocity control, thus eliminating special protection such as sheathings, etc. Field operation indicated that these studies were successful.

Dr. D. S. Louie of Harza serves as consultant to the Great Lakes - St. Lawrence Seaway Winter Navigation Board on the study of extension of winter navigation on its waterway system, which involves principally ice management.

Reservoir Operation Studies

The Phase II operation studies are discussed under Reservoir Operations and System Generation Cost Studies, in Phase I.

TRANSMISSION SYSTEM

The Phase II transmission studies will deal, at the feasibility level, with the transmission lines and substations associated with the initial Upper Susitna Project. This work will consist primarily of the refinement of the studies made in the basin planning study and discussed in that section. The system is assumed for descriptive purposes, to consist of a route from the initial project to a substation in the line between Anchorage and Fairbanks and routes from the substation to those two load centers.

The route selection studies will be reviewed with particular attention to foundation conditions and environmental aspect. Adjustments in the routes will be made as required. The characteristics of the routes such as segment length, altitudes, and climatic conditions will be defined more exactly, with existing maps or specially prepared maps and field reconnaissance as required.

The hydroelectric generator characteristics, the number of units, and the system load and supply data will be defined for each of the series of years to be studied. One of the important functions of the Susitna transmission lines will be to serve as an interconnection between the major load centers in the Railbelt area as well as for the transmission of Susitna power to the two load centers. Load flow studies will be made for various conditions of system load and hydro and thermal generation and for various alternative transmission line configurations. The costs and performance of these alternatives, including reliability and system reserve aspects, will be evaluated and an economical program of transmission line development will be selected. It may be noted here that one of the possibly attractive development plans would have, as the initial project, a relatively small project producing largely secondary energy. The standards of transmission line reliability for such a project need not be as high as for the later, well regulated development with significant firm energy and dependable capacity, and important economies could be realized.

Optional studies, which are not included in the Plan of Study but which APA may want to move up from the design phase, include: a study of system reactive requirements and resulting

generator power factor requirements; transient stability calculations, to establish the range of values for the generators moment of inertia; short circuit calculations to establish circuit breaker interrupting ratings; and studies of possible sub-synchronous resonance if series capacitors are to be used in the transmission networks.

A construction schedule for the electrical facilities will be prepared in CPM form. This schedule will provide for completion of the transmission system, switchyards, and substations to coincide with hydro-generation availability. Other factors such as construction power and usage of the facilities for non-project purposes will be in cooperation with the Alaska Power Authority and included in the schedule.

Detailed estimates of construction cost for the transmission lines and substations will be prepared, generally at the same level of detail as discussed for the hydroelectric project works, under Construction Costs and Programs, and will follow the FERC Uniform System of Accounts. The requirements of construction access, environmental protection during construction, and construction conditions in Alaska will be basic considerations in the development of the construction program and cost estimate. An estimate of annual operation and maintenance costs for the lines and substations will be made, based on industry data and FERC guidelines, with adjustment for Alaskan conditions, and discussions with the local utilities and the Alaska Power Administration.

Single line diagrams, preliminary substation layouts, transmission line routing drawings, and descriptions of the feasibility-level design of the transmission and substation facilities will be prepared for use in the feasibility report and FERC license application.

CONSTRUCTION COSTS AND PROGRAMS

Introduction

A series of cost estimates of selected features and alternative project schemes will be prepared during the feasibility study. These estimates will be used for the optimization of project features and the final selection of the project elevation, capacities, and stages of development. These estimates will be successive refinements of the preliminary estimates in Phase I based on more specific designs, quantity estimates, sources of materials, and knowledge of construction conditions and access limitations. The cost estimates will

follow the format established by the FERC Uniform System of Accounts.

The basic procedure will be as follows. Quantity estimates will be made for each important item of civil construction, such as excavation and fill of various types, reinforcing steel, penstock steel and steel liner plate, and concrete of various types.

Constructibility Analysis

The project will be analyzed from the standpoint of constructibility, with consideration given to access, location of the construction plant, location of construction material sources, types of construction equipment required, and overall construction program. Seasonal considerations will be of particular importance in the construction of the Susitna project, and this aspect will be analyzed in detail. The construction conditions on the Upper Susitna are characterized by severe winter weather and the concentration of the period of high river discharge during the short warm weather construction season. The effects of these and other factors on productivity, equipment and labor requirements, rates of production, and protection of the work in progress against seasonal risks will be studied. Seasonal labor and support requirements of the construction program will be estimated.

Cost Estimates

The unit prices for all significant items of civil works will be estimated by the contractor's cost method. The required labor, equipment, supplies, and rates of production will be estimated on a basis consistent with the constructibility analysis and the adopted construction schedule. These items will be priced using the latest labor, equipment, and materials costs based on prevailing conditions in Alaska or on U.S. or international prices for equipment and materials with allowance for shipping to the project site. Estimated mark-ups for the contractor's indirect costs and profit will be added. The costs of plant equipment will be based on available data and experienced costs from other projects, with confirmation of the most significant costs of major equipment by preliminary quotations from representative manufacturers.

The direct cost estimates obtained on the preceding basis will be increased by allowances for contingencies, engineering,

and owner's overhead costs for the project on the basis of previous experience, in consultation with APA. The estimates for engineering costs will be supported by a detailed analysis of the field investigations and design work which will be required, based on the knowledge of site conditions developed during the feasibility study, the types of structures called for in the adapted initial project design, and the planned construction schedule. The resulting construction cost estimate will be based on the cost levels of a stated date.

Construction Schedule

The construction schedule will be based on detailed analyses of the methods and procedures and required quantities for the major features of the project, taking into account the aspects of cold weather logistics, environmental constraints, materials supply and control, manpower and equipment requirements and availability, and the sequence of construction operations. A network of procedure relationships and time requirements, with seasonal constraints, will be developed for the initial project and analyzed by critial path methods and advanced network methods to provide an estimate of the most probable construction period and an indication of the probability or risk of shorter or longer construction periods.

Expenditure Schedule and Escalation

An expenditure schedule will be developed from the construction cost estimate and construction schedule subdivided as necessary into expenditures by major category of engineering effort and construction labor, materials and equipment. The basic expenditure schedule will be in terms of the cost level as of a stated date, the same as used in the construction cost estimate. This expenditure schedule will then be adjusted to an assumed calendar schedule by application of assumed escalation rates to provide an estimate of construction cost including escalation for use in the financial analyses. This procedure keeps the assumed rates of escalation clearly visible and permits several assumed sets of escalation rates to be used conveniently in sensitivity analyses. The estimated rates of escalation for labor, equipment, and materials will be based in part on a detailed analysis of historical rates of escalation.

In summary, the feasibility-level construction cost estimate, the design and construction schedule and the expenditure schedule will be developed on the common basis of

detailed analysis of all particular aspects of the required construction program.

POWER SYSTEM EXPANSION PROGRAMS

Alternative Expansion Plans

Two principal expansion plans will be developed to meet the future power requirements of the Railbelt area, one with the Susitna Project and the other without. The expansion plans will be developed taking into account projected power demands, construction lead times, possible interconnections between the three power market areas (Anchorage, Fairbanks, and Glennallen-Valdez), and FERC licensing requirements. The timing of the generation and transmission additions will be established so that there will be sufficient energy supply to meet the forecasted demand including reserve requirements at all times. The most probable load forecast will be used for the expansion programs, but the sensitivity of the programs to the high and low load forecasts also will be studied.

Outage Rates and Reserve Requirements

Plant outage rates will be estimated and system reserve requirements will be established to provide an adequate and continuous supply of power and energy. Information on outage rates will be based on existing data obtained from local electric utilities, and on reports on equipment availability such as the Edison Electric Institute Publication N. 75-50: "Report on Equipment Availability for Ten-Year Period, 1965-1974."

The alternative programs of power system expansion will be analyzed by probability methods and the scheduled installation dates will be adjusted so that in each year each expansion program meets established criteria as to loss of load probability. The loss of load probability criteria to be used will be discussed with APA and the operating utilities.

For each expansion plan, tables will summarize the reserve capacity requirements for future years. The reliability of the transmission grid with or without interconnections between the load centers will be evaluated as discussed in the section on Transmission.

Monthly Hydro Availability

The monthly power and energy available from the Susitna Project will be determined on the basis of reservoir operation studies discussed in Phase I, the section on Reservoir Operation and Generation Cost Studies. Information on the production of the Eklutna Project will be obtained from the Alaska Power Authority. Projection data on the other existing hydropower plant (Cooper Lake) will be obtained from Chugach Electric Association Inc.

Expenditure Schedules

The construction cost expenditure schedules and annual operation and maintenance expense costs for each plant addition and transmission line addition will be obtained from the studies described under Construction Costs and Programs, Alternative Sources of Generation, and Transmission. Annual fuel costs by calendar year will be estimated for each expansion program by economic dispatch methods as discussed in the section on Reservoir Operations and Generation Cost Studies in Phase I. These series of construction, operation and maintenance, and fuel cost expenditures will be combined to obtain the annual expenditure schedules required to meet the projected system loads with each alternative power system expansion program.

ECONOMIC ANALYSIS

Criteria for Economic Analysis

The alternative power system expansion plans will be evaluated on the basis of benefit-cost analysis.

In the analyses, "cost": will include all costs associated with the development and operation of the hydroelectric projects; "benefits" will be based on the alternative costs of producing power and energy with alternative generation sources. The benefit-cost ratios are computed using two methods:

(1) a normalized cost analysis based on the annual cost of producing power and energy from the hydroelectric projects and the other alternatives at fixed price levels and

(2) a life-cycle evaluation based on the actual worth of expenditures required for the initial

construction of the projects and alternatives and for their operation over their service life as defined in coordination with Alaska Power Authority.

For the normalized cost analysis, the investment costs of the hydroelectric projects and the alternatives, including transmission lines, will be calculated. The annual revenue required to cover the interest, amortization (or depreciation), interim replacements, insurance, and taxes applicable to these investment costs will be computed by applying a carrying charge based on the type of project and the type of financing available.

Annual operation, maintenance, fuel (where applicable), and adminstrative and general expenses will then be added to the revenue requirements to determine the total annual costs for the hydroelectric projects and the alternatives. The annual costs will be divided into components corresponding to the values of capacity and energy.

For the life-cycle analysis, the annual disbursements required for construction, operation and maintenance, fuel and adminstration of the project will be estimated for the years in which they will be incurred. All costs except fuel will be at a fixed price-level. Fuel is computed to escalate annually at 2 and 4 percent more than inflation. The annual disbursements will be discounted to the beginning of the study period, at discount rates corresponding to the financing available. Annual expenditures will be estimated for the proposed plant life period. At the end of that period the residual value of the hydro project beyond that period will be included.

Under the normalized cost analysis, and the life cycle evaluation, the benefit-cost ratios will be determined from an economic feasibility test where the interest rates are different for hydro and other alternatives, and from a comparability test where the interest rates are the same. Economic parameters such as interest rates, public or private financing, and plant service life will be defined in coordination with Alaska Power Authority, other government agencies, and the local utilities.

This methodology was used with success by Harza in the economic evaluation of the Sutton, Bluestone and Summersville hydropower projects for the Huntington District of the U.S. Army Corps of Engineers.

Expansion Program Cash Flow

For each proposed expansion program, annual cash flow requirements will be computed on the basis of the useful life of the program. These annual cash flows will be computed to cover the cost of the invested capital and operation maintenance and fuel costs determined as a result of the load dispatch studies.

Economic Analysis

The economic analysis will be performed to determine the economic viability of each expansion program. Based on the economic assumptions and criteria previously described. The economic analysis will compare the costs including investment costs, operation and maintenance costs, and fuel costs for each expansion program. Tables will summarize these costs, and present the benefit-cost ratio based on the economic criteria previously defined.

Sensitivity Analysis

The sensitivity analysis will compare the effects of various interest rates and differential rates of cost escalation. It will also review the assumptions made on the investments, and operation and maintenance costs of the generation sources. The effects of the range in price forecasts will be analyzed. The sensitivity of the cost comparison to different annual revenue requirements will also be developed.

FINANCIAL ANALYSIS

Criteria for Financial Analysis

Determination of the number of years to recover the investments for the hydroelectric projects and the alternatives will be defined with Alaska Power Authority. The means of financing the Susitna Project, and the alternatives will be reviewed and determined. The interest rates of both state and private financing that will be used in the financial analysis will be determined in coordination with Alaska Power Authority, government agencies, local electric utilities, and private interest groups.

Expansion Program Financial Requirements

Tables will present the financial requirements for each expansion program, with or without the Susitna Project. Public or private financing, or a combination of both, will be analyzed, depending upon the expansion program.

Development and Analysis of Financing Plans

All financing plans available for the development of the Susitna Project or any other alternative will be reviewed and rated. Contacts and meetings will be held with Alaska Power Authority, government agencies, local electric utilities, and private interest groups to obtain up to date data on their financing abilities, and the related benefits and risks for them. An analysis of the various plans will be performed.

Selection of Financing Plans

Among the various financing possibilities, the most advantageous plans will be selected for each expansion program. The selection will be based on the attractiveness of the plans, and on the real capabilities of the financing agent to finance the Susitna Project or any other alternative.

Final Payout and Financial Statements

A complete financial balance will be established for each selected financial plan. A final analysis will be made of each financing plan including borrowing requirements, revenue requirements, and a description of the payment statements.

Analyses will be made of the sensitivity of these results to changes in costs and financing terms.

Institutional Analyses

The financial effect of the project on the local utilities in the Railbelt area and their customers will be studied by means of alternative financial analyses for the individual utilities with the Susitna project and with the most favorable alternative expansion program.

Feasibility Report

A feasibility report will be prepared to document the technical, and financial feasibility of the project; its safety; and its environmental and social acceptability. The feasibility report will consist of a main report and several Appendices.

The main report presents the conclusions, and recommendations for subsequent action and will describe the project and establish its physical, economic, and financial soundness.

Appendices will be prepared for the major disciplines:

a. Hydrology, River Hydraulics, and Sedimentation

b. Geology, Soil Mechanics, and Foundations

c. Preliminary Design and Cost Estimates

d. Power Operation Studies

e. Economics and Finance

f. Environmental Considerations

The Appendices will include sufficient information to allow experts in the various disciplines to substantiate the soundness and accuracy of the conclusions and recommendations presented in the main report. There will be sufficient basic data included to establish project dimensions. The appendices will include descriptions of the methods of investigations and analyses used.

PHASE III - FERC LICENSE APPLICATION

The preparation of an application for the Federal Energy Regulatory Commission will constitute Phase III of the engineering and environmental studies. The basic studies required for the preparation of the license application will be done in Phase II, and those studies will be planned from the beginning to meet the requirements of the license application. The preparation of the license application is planned to overlap the final work on the feasibility report by about three months, and it will begin at such time as APA decides, on the basis of the feasibility study reaching completion, to authorize the preparation of the application.

The requirements for preparation of the technical exhibits have been considered in the preparation of the Plan of Study. Informal discussion with the FERC staff and other appropriate agencies will be initiated at the beginning of Phase I, and continuing contact with these officials will be maintained so the study team will be aware of and deal with those items of concern to the FERC and other agencies regarding the license application.

Harza will be responsible for preparation of the technical and environmental portions of the license application, subject to APA review, and for the assembly of the complete application. APA will be responsible for certain other exhibits, as described below, with assistance from Harza if requested.

The exhibits now required for an FERC license application are listed below, with a brief indication of their content and the organization responsible. The environmental exhibits R, S, V, and W are listed in their present form, although we understand that the FERC plans to combine them into a unified environmental exhibit.

FEDERAL ENERGY REGULATORY COMMISSION

EXHIBITS FOR LICENSE APPLICATION

Exhibit	Content	Primary Responsibility
A	Charter and Articles of Incorporation	(APA)
B	Minutes and Resolutions	(APA)
C	State Hydroelectric, Water Power, and Other Applicable Laws	(APA)
D	Evidence of Applicant's Compliance with State Laws	(APA)
E	Ownership of Water Rights	(APA)
F	Lands Owned or Planned to Be Used	(APA)
G	Financial Ability of Applicant	(APA)
H	Hydrology	(Harza)
I	Power	(Harza)
J	General Project Area Map	(Harza)
K	Detailed Project Area Map	(Harza)
L	Project Layouts and Description	(Harza)
M	Equipment	(Harza)
N	Cost Estimate	(Harza)
O	Schedule	(Harza)
R	Recreation	(Harza)
S	Fish and Wildlife	(Harza)
T	Statement Why Project Should Be	

Exhibit	Content	Primary Responsibility
	Developed by APA	(APA & Harza)
U	Statement Showing the Manner in Which Power and Energy Is To Be Developed and Used	(Harza)
V	Natural, Historic, and Scenic Values	(Harza)
W	Environmental Quality	(Harza)

PART C

ENVIRONMENTAL STUDIES

Brief summaries of the environmental work tasks have been presented in Volume I. The following sections discuss each of these tasks, explains the purpose and objectives of the tasks, and provides information relative to anticipated timing.

As indicated in Volume I, the tasks are divided into six areas of expertise:

Human Ecology (S)

Aquatic Ecology (A)

Terrestrial Ecology (T)

Historic and Archeologic Resources (H)

Recreation Resources (R)

Land Management and Aesthetics (V)

Human Ecology

The objectives of the Human Ecology studies are two-fold. The first is to assist in the development of future electrical load projections for the Railbelt Region of Alaska on the basis of past consumer demand for electrical power by consumer group, current energy consumption patterns, and expectations of future energy consumptions patterns. These data, combined with population projections for each consumer group and data derived from the utilities in the market area, will be utilized to project high, most likely, and low load demand forecasts for the area. The second objective is to develop a time-series analysis of significant sociocultural factors specifically of the Matanuska-Susitna Borough, from earliest historic records to the present. This information will permit a trend analysis of the probable "without condition" and thereby permit evaluation of the magnitude, intensity, and duration of human ecologic impacts of the proposed project.

Task S-1: Electrical Consumption Patterns

This task will consist of conducting a survey of significant social and economic sectors which are broadly representative of larger consumer groups in the Anchorage, Fairbanks, and Glennallen-Valdez power market areas to identify present and anticipated future electrical consumption patterns with and without system expansion.

Estimation of future load projections will entail two stages. First, past consumer demand for electrical power will be studied in the Anchorage, Fairbanks, and Glennallen-Valdez power market areas. In each area a survey of consumption patterns will identify significant social and economic sectors which are broadly representative of larger consumer groups in the area. In addition, surveys of subsamples utilizing a stratified-cluster sampling method and structured interview techniques will address current energy consumption patterns, current expectations of future energy consumption patterns without the project, and propensity to consume electrical energy in the future with the project. The result of these surveys will be a verification and update of current consumption patterns without the project, and expected changes in propensity to consume with the project.

Task S-2: Population Projections

This task will consist of developing independent population projections for the power market region on the basis of available secondary data and cohort-survival projection techniques.

The second stage of estimating future load demands will be standard population projections for the market region utilizing cohort-survival projection techniques. Secondary data available from the US Department of Commerce, Bureau of Census, and the Alaska Institute of Social and Economic Research, together with State of Alaska vital statistics (mortality rate, birth rate, fertility rate, infant death rate), will be sufficient. This will give a good idea of the expected population increase, which will permit projection of high, most likely and low load demands for all goups of certain broad consumption patterns.

In order to verify this evaluation of future load demands, the data on propensity to consume for the sample groups will be matched to the broad sectors of the population which they represent and any anomalies will be adjusted. In this way load projections can be verified for population sectors, based on our knowledge of the sector propensity to consume and the assumed growth of that sector. This two stage approach will provide not

only standardly derived load demand estimates, but also useful data regarding current and expected use patterns for the public information and participation process.

Task S-3: Socio-economic Characteristics

This task will consist of assessing social and cultural values, economic conditions, and life-style goals of the inhabitants of Talkeetna and other portions of the Matanuska-Susitna Borough that may be impacted by project construction.

Social and cultural values of the Matanuska-Sustina Borough population will be assessed through an additional survey utilizing unstructured and structured interview techniques and a stratified-cluster sampling method. A combination of self-administered questionnaires, received and returned by respondence through the mail, and interview-administered questionnaires will be used to control for bias. Sampling errors, question format errors, and interview sequence errors will be controlled by pretesting questionnaires, which will also permit the training of interviewers in sensitivity to local issues.

Information obtained will serve several uses. It will provide knowledge of the diversity of perceptions of the history of the region, its attractions, and its drawbacks, the nature of contemporary problems of the residents, and their personal and group aspirations for the future. Information from the attitudinal surveys will also be used to project the impacts of the proposed project upon Borough life styles. Finally, the data will provide substantive and reliable indicators of public views which in turn will make the design of the public participation program responsive and relevant to Borough values.

Data from the Alaska Institute of Social and Economic Research and the US Department of Commerce will be used to analyze historic economic activity in the Borough, and to project economic data to the year 2020. The following will be utilized: employment and unemployment rates, occupational structure of population by major economic sector, basic and non-basic employment, per capita income, median income, income distribution, and demographic data. These data will be combined with the cohort-survival demographic projections (Task S-2) to produce major industrial sector and non-industrial sector economic projections of employment, income, and unemployment into the future. The results will be utilized to evaluate economic impacts of the project.

Task S-4: Social Impacts

This task will consist of calculating the magnitude, intensity, and duration of project impacts on the human ecology of the area. Special attention will be paid to unavoidable impacts such as any displacement of people, changes in health, safety, and social welfare conditions, changes in economic activity, and changes in cultural values and life-styles. Similarly, any irreversible or irretrievable commitment of human resources stemming from the project will be detailed.

The objective is to measure the changes which can be predicted as a result of the proposed project. The analysis will have a dual focus: construction stage impacts and operation stage impacts. Data from the preceding tasks will be used with only minimal field verification.

Data on labor requirements for each year of the project's life will be gathered including occupational levels and income structure of the project work force and the characteristics and availability of Alaskan workers. The propensity to consume locally for workers of different skill levels will be projected. Capital expenditures are expected to impact outside the Borough, therefore most impacts on the Matanusha-Susitna Borough will stem from the worker consumption and savings patterns.

Data on project characteristics will be combined with data from Phase I Basin Studies to calculate the magnitude, intensity, and duration of impacts upon each of the following factors; labor market, income distribution, commodity and factor market, housing market, local commerce and industry, public services, public costs (tax base, income tax, business tax, etc.), and cultural and sub-cultural values.

Opening-up effects of road construction in the form of increased settlement and colonization, increased land values, and increased public costs will be examined. In addition, other resources development projects in or near the region will be considered together with the possibility that commercial and planned unit residential developers would be stimulated to make major investments in or near the project.

Data and analyses from Phase I Basin Studies and Phase II Feasibility Studies will be incorporated under the following headings into the FERC License Application:

1. Baseline Socioeconomic Conditions

2. Construction Phase Human Ecology Impacts

3. Operation Phase Human Ecology Impacts

4. Actions to Minimize Adverse Impacts on Life-Styles

5. Unavoidable Human Impacts

6. Irreversible and Irretrievable Commitments of Human Resources.

Aquatic Ecology

Due to the economic importance of many of the freshwater and estuarine species found in the general Susitna Project area, as well as the expressed concerns of the State of Alaska Department of Fish and Game and the U.S. Fish and Wildlife Service, aquatic ecological impacts have been identified as being of critical importance for the Susitna Project. The program presented below is designed to be fully responsive to these concerns. The detailed program, as presented, is scheduled and costed for the 27-month study period through completion and submission of the environmental portion of the FERC License Application, but is designed to be continued for the full five-year period advocated by the Muslca Department of Fish and Game once the identified project has been shown to be feasible. It is anticipated that the overall levels of effort for the continuing studies will be somewhat lower than the initial 27-month program, although in some cases (e.g. anadromous fish, Cook Inlet studies) the level of effort for individual tasks will be largely undiminished or even increased.

Freshwater Studies

The overall objectives of the Susitna River basin studies will be to characterize the existing freshwater ecological populations and to identify, characterize and quantify the critical habitats upon which these populations depend.

The specific tasks presented below are designed to:

- Identify and map habitat types in the area of the basin to be affected by the project;
- Characterize the use of these habitat types (ie, milling, spawning and incubation, rearing, schooling areas etc.),

- Index these habitat areas by level of use;

- As possible, select representative areas for each habitat type for a number of reaches of the river for more detailed study.

Based on this type of analysis, project-related changes in the physical/chemical environment will then be superimposed on the system, regardless of the actual project selected, and project impacts clearly identified.

Upper Cook Inlet

Our general understanding about ecological processes in North American estuaries has improved appreciably over the last decade principally as a result of work along the east coast salt marshes of the United States. Our overall knowledge of North Pacific estuarine systems, however, remains scanty and is based primarily on Canadian efforts within the Nanaimo and Fraser Systems. Fortunately, certain similarities exist between these river delta estuaries and the Susitna system, especially as in regards their importance to marine resources, in particularly the Pacific salmon species.

A fundamental problem in the Upper Cook Inlet is to evaluate the effect of predicted physical and chemical alternations on estuarine processes and the production of salmon and other commercial species. Juvenile salmon for example, may be linked to the estuarine carbon pathway through the plant-detritus-microbe consumer network. This would have significant ramifications if most of the carbon for upper-level organisms in the Upper Cook Inlet area is derived from river input and not via in-situ autotropic (food producing) heterotrophic production.

A good understanding of the life history characteristics of the major biological components is required in order to determine the links between commercially important species and estuarine processes. If such direct links can be demonstrated, the impacts of river regulation on estuarine autotrophs (which are strongly influenced by water levels, flooding frequency, sediment characteristics, salinity and nutrients) and estuarine heterotrophs (influenced principally by dissolved organic matter, temperature, and nuturients) are critical. However, if such processes are shown not to be integrally related to fishery production, then the importance of data gaps in this area is dramatically reduced and costly field research can be scaled down.

Our approach will be to identify key ecological interactions in the Upper Cook Inlet, identify areas of uncertainty, assess the importance of these uncertainties vis a vis project feasibility, develop precise studies to address alternate system impacts and make evaluations based on supporting evidence and areas of uncertainty.

Riverine Baseline Studies

Task A-1: Water Quality. Baseline water quality sampling programs will be developed in close coordination with the hydrology program and the instream flow studies. This coordination will be particularly important during initial phases of the study when monitoring stations are identified and sampling frequencies determined.

A minimum of seven major sampling stations will be established after preliminary analysis of the basin dynamics. For major sampling stations on the mainstream river and tributaries, initial sampling frequency will be twice per week with a wide range of parameters. Both frequency and number of parameters will be reduced over time for those cases where variability is found to be low.

Where possible, remote monitoring equipment will be used. Initial employment of such equipment will be limited to the use of systems known to be reliable. As the study progresses and a better understanding of field conditions (i.e., opportunities and problems) develops, efforts will be made to increase the use of remote monitoring equipment where such equipment is shown to provide reliable data and reduction in field costs.

In addition to long term water sampling at the identified monitoring stations, numerous intensive sampling programs will be carried out over shorter periods of time in conjunction with specific aspects of the fisheries, instream flow and aquatic modeling studies. These studies will be done using traditional field equipment.

Parameters to be sampled initially at the long term monitoring stations include: alkalinity, turbidity, conductivity, suspended solids, pH, hardness, dissolved oxygen, dissolved nitrogen-argon, calcium, sodium, magnesium, potassium, sulfate, chloride, fluoride, silica, ammonia, nitrate, nitrite, organic nitrogen, total nitrogen phosphate, total phosphorus, carbon dioxide, total organic carbon, biological and chemical oxygen demands, temperature, and other cations and anions as required.

Particular attention will be given to water temperature regimes and dissolved oxygen levels, as they are affected by ice formation and accumulation both now in the free-flowing river, and in the future following development of one or more reservoirs. Specific water quality models sensitive to short-term temporal variations, spatial variations, and differences in ice thickness will be required in order to produce results that are appropriate to the hydrological and meterological conditions of the Susitna basin.

Task A-2: Physical Parameters. In addition to water quality, physical parameters such as depth, current velocity, bedload movement, and sedimentation determine aquatic habitat quality. These parameters are in turn determined by water quantity and seasonal flow regimes. Substrate type and particle size are also dependent on flow regimes.

As work on invertebrates and resident and anadromous fish populations progresses, critical habitat areas and areas of high use or high productivity will be identified and their physical parameters measured. This work, along with related engineering hydrology studies, will be utilized as baseline data for designing and implementing the instream flow studies as described below.

Task A-3: Instream Flow Studies. Recent development of instream flow programs for evaluating changes in flow regimes and the effects of these changes on fish and wildlife uses by the Cooperative Instream Flow Service Group, Department of the Interior (USFWS) has provided a potentially valuable tool for evaluating impacts of hydroelectric projects such as the Susitna Project. Where such programs have been utilized successfully, significantly improved impact analysis and mitigation development has been possible. However, at present, application of this methodology to conditions such as those found in Alaska has been limited and the probable necessary refinements have not yet been identified.

For these reasons a limited utilization of this methodology is proposed, to begin in the second year of the 27-month study period. As previously discussed, more traditional habitat quality information will be collected during the first year and will be utilized to refine the basic design of the instream flow program.

In order to apply instream flow methods, probability of use curves for principal fish species will be required. Such curves predict level of use from physical and chemical habitat parameters. Development of these curves for the Susitna studies will be based on existing published life history information. It is anticipated that three or four study areas will be required to calibrate and test these curves under field conditions. Two or three of these sites will be on the mainstream river and one or two on important tributaries.

Task A-4: Aquatic Vegetation. Principal aquatic plant species will be identified and spatial-temporal distributions and densities determined in those areas where such vegetation forms a major component of the aquatic habitat for invertebrates and fish. Principal habitat parameters determining aquatic plant abundance and distribution, including existing flow conditions, substrate type, depth, and turbidity, will be characterized for such areas. Backwater slough salmonoid rearing areas will receive special attention in these vegetation studies.

Task A-5: Invertebrates. Qualitative and quantitative surveys of planktonic, nektonic, and benthic invertebrates will be carried out in the mainstream river and important tributaries and backwaters. Sampling methods will include Surber-type and round samplers, drift nets, substrate baskets, and plankton tows as appropriate. Species composition for different habitat types (e.g., riffle and backwater sloughs) will be determined, habitat requirements and seasonal productivity of significant invertebrate groups will be characterized, and areas of high productivity will be identified. Quantitative sampling efforts will be concentrated in those areas identified as important to rearing of juvenile anadromous fish so that invertebrate production levels can be correlated with rearing success of juvenile salmonids and with water quality and physical habitat parameters in those areas.

Invertebrate populations potentially important to resident fish species will also be characterized as outlined above, but at a lower level of effort.

Task A-6: Anadromous Fish. Upstream migrations of adults will be characterized as to approximate number of migrants, timing, and principal routes for each anadromous species downstream of Devil Canyon. Juvenile migrations will be studies to establish timing of migrations and to obtain, to the extent possible, estimates of numbers of downstream migrants. Critical habitat areas will be identified for each species, including existing and potential impediments to passage of migrants, adult milling areas, spawning and incubation areas, and juvenile rearing and schooling areas. Estimates of the numbers of fish

using these areas at various stages of their life cycles will made and used to calibrate the probability of use curves discussed under the Instream Flow Studies task. The physical and chemical parameters of these critical areas, described under the Aquatic Habitat task descriptions, will then be measured so that correlations with hydrological data can be made. These correlations will provide a means of predicting effects on anadromous fish stocks of with-project changes in the natural river flow and water quality regimes.

The geographical scope of this study must initially include the entire mainstream river and all principal tributaries and backwaters downstream of Devil Canyon. However, as the study progresses and critical habitat areas are identified, effort will be concentrated in those areas. Certain specific areas of each particular type of critical habitat can then be selected as representative of that type within a given reach of the river or tributary so that intensive sampling can be carried out to describe physical and chemical habitat parameters in detail.

Parent stocks in the river will be identified using meristic and other characteristics so that their contribution to the commercial and sport fisheries can be determined.

Field techniques which will be employed include traditional nets, traps, electrofishing, mark and recapture, and catch per unit effort methods. In addition, technologically based approaches will be employed including biotelemetry, aerial counts, and sonar counting installations.

The absolute abundance of migrating adults will be estimated using sonar. The adult fish will be enumerated as they pass upstream through a volume of water being hydroacoustically sampled. Species composition will be estimated in conjunction with radio tagging work. The sonar site will be located downstream of the first major tributary of the Susitna River.

Sonar is proposed in preference to other fish assessment methods for several reasons. The most important reason is that its use requires significantly fewer assumptions concerning sampling efficiency and selectivity for the range of species of interest than other methods, considerations that are very important if absolute rather than relative abundance estimates are desired. Other considerations are the feasibility of high temporal resolution of fish passage rate, realization of real time instantaneous and cumulative abundance estimates, operating costs competitive with other methods, and the fact that the high turbidity of the Susitna River during periods of adult migration prevents visual methods of fish counting, the method most

commonly used to estimate absolute abundance of migrating adult salmon in Alaska.

The distribution of adult anadromous fish in the watershed will be estimated by radio tagging. Fish will be captured and radio tagged at a site upstream of the sonar site. The passage of radio tagged fish into major tributaries and their distribution along the mainstream of the Susitna River will be estimated based on the numbers passing unmanned radio monitoring stations. Precise determination of the location of radio tagged fish at any time during the migration period or on the spawning grounds will be possible if necessary.

Radio tagging is proposed for this portion of the study because the detection of radio tagged fish can be automated, reducing costs and the probability of non-detection of tagged fish without a loss in quality of data. Since the movements and destination of radio tagged fish can be determined without recapturing the fish, radio tagged fish return more information than a larger number of fish tagged with passive tags. Other methods of obtaining this data would require tagging much larger numbers of fish and high labor costs. Statistically sufficient numbers of tagged fish would have to be recaptured in the trubutaries and mainstream of the Susitna River during the period of active migration as well as later on in the spawning grounds.

Task A-7: Resident Fish. Studies to determine abundance, seasonal distribution, movement, significant life history requirements, and critical habitat areas of resident fish will be carried out in the mainstream river, tributaries, and backwaters both up and downstream of Devil Canyon. Below Devil Canyon this work will be performed in conjunction with anadromous fish studies and will, of course, include areas which may be important to resident but not anadromous species. Studies above Devil Canyon will extend upstream as far as required to characterize resident populations which could be affected by development of any combination of potential hydroelectric sites. Initially this would require that upstream studies extend at least to the confluence of the MacLaren and Susitna Rivers. As selection of damsites proceeds, it is anticipated that the geographical scope of upstream studies will be substantially reduced.

Methods and goals for this work task will be similar to those outlined under the Anadromous fish task description, except that use of biotelemetry and sonar systems is not anticipated during the 27-month study period.

Estuarine Baseline Studies

Task A-8: Water Quality and Quantity. A study program will be developed to monitor physical and chemical parameters in Upper Cook Inlet and the influence of the Susitna River on estuarine dynamics and nutrient levels. The initial phase of the program will be devoted to selection of a limited number of monitoring stations, test parameters, sampling frequencies and methodologies. Special attention will be given to establishment of both vertical and horizontal profiles of critical parameters (including salinity, temperature, and nutrient levels) in order to characterize time-dependent stratification and circulation patterns. Concurrently, the influence of river flow, tidal variation, and wind speed and direction on these patterns will be investigated. This monitoring program will integrate remote sensing techniques for estimating and mapping selected parameters with field data measurements, where applicable.

Sea surface temperature maps of Alaska marine environments derived from satellite data can be acquired within hours of image production. Five years of data are available for the Gulf of Alaska region. These maps, available from the National Environmental Satellite Service of the National Oceanic and Atmospheric Administration, will be used to generate temperature profiles for Upper Cook Inlet.

Similarly, data collected from both environmental and meteorological satellites will be used to monitor sea ice conditions in Upper Cook Inlet. Product types consist of periodic ice movement, type, and concentration charts. Satellite sensing of sea ice is done in portions of the spectrum not affected by cloud cover.

Satellite and aircraft multispectral scanner (MSS) data will be used in estimating and mapping water quality parameters in Upper Cook Inlet, including turbidity, salinity, and chlorophyll A concentrations. Parameter estimates will be made using manual and computer-assisted techniques.

Turbidity in terms of suspended sediment distribution and circulation will be mapped directly from the MSS imagery. Tonal differences in the green and red wave length bands serve as indicators of varying concentrations of suspended sediment: light tones correspond to high loads while dark tones correspond to little or no load. Suspended sediment distributions in Cook Inlet are characteristic of the fresh water intrusions. Circulation patterns are clearly delineated, with the fresh water showing up as lighter tones and the clear ocean water as dark tones.

Quantitative measurements of turbidity, chlorophyll A concentrations and salinity are derived through the digital processing of MSS data. State-of-the-art techniques will be utilized in the Upper Cook Inlet Study, where necessary.

Once estuarine dynamics have been characterized in sufficient detail, data developed under the riverine water quality and hydrology tasks, as well as remote sensing data, will be used to determine the extent of the river's influence on the estuarine system.

Task A-9: Fish. Under this task a sampling program will be developed to delineate the importance of Upper Cook Inlet and the river estuarine zone to Susitna River basin fish stocks. Migratory stocks will be identified and correlations of migration timing with river flows, water temperatures, and other parameters studied. Adult milling areas will be identified. Temporal and spatial availability of food organisms will be determined and correlated with physical and chemical parameters in the estuarine zone. Estimates of carrying capacity for juvenile fish will be made on the basis of food organism availability.

Task A-10: Invertebrates. Populations of commercially important invertebrates (e.g. King, Dungeness and Tanner crabs, Razor clams, shrimps) will be assessed as to population size, location and seasonal characteristics principally through existing data and spot sampling of commercial harvests. Stomach analyses of selected fishes will be used to determine forage importance. Limited field sampling (grabs and tows) will be used to verify the above findings.

Task A-11: Commercial and Sport Fisheries. Both commerical and sport sources of significant fishing harvest in Upper Cook Inlet, and other areas as necessary, will be identified. Commercial yields and economic values for each species will be estimated on the basis of landing statistics for each commercial gear type. Sport fishing catches and effort will be estimated from creel type censuses and the value estimate will reflect recreational economic value.

To the extent that Susitna stocks can be distinguished from other stocks in the commercial and sport catches, their contribution to the catch will be determined. A program of study will be designed to investigate potential identification methods, including various marking techniques, scale, otolith, and other meristic analyses, and biochemical methods such as enzyme electrophoresis.

Assessment and Mitigation

Task A-12: Limiting Factors. Baseline data on the physical and chemical parameters and biological components of the various types of fish habitat will be integrated so that food webs, energy dynamics, and habitat/fish population relationships can be analyzed. This integration and analysis will lead to the identification of habitat factors which limit fish population sizes. Such factors may include low levels of certain nutrients which limit production of fish food organisms, scarcity of various types of critical physical habitat (suitable spawning and incubation gravels, for example), or hydrological parameters such as flow, bed load, and suspended sediments which limit survival of eggs and juvenile fish.

Critical habitat and other limiting factors will be characterized for each important fish species for those areas of the Susitna basin and estuarine zone which would be affected by any of the hydroelectric development alternatives being considered.

Task A-13: Impacts of Alternatives. Anticipated changes in, or losses of, fish habitat will be determined for alternative concepts for each project system component type, including damsites, pool levels, operational regimes, access road and transmission line routings, and construction schedules and procedures. Based on these anticipated habitat changes and on the integrated baseline data on habitat/fish population relationships described previously, project impacts on fish populations will be determined. Analysis of project related changes in limiting habitat factors will play a key role in establishing the magnitude of these impacts and their resultant economic effects.

Task A-14: Evaluation of Alternatives. Once the types and magnitudes of impacts associated with alternative project components have been delineated, various combinations of components in alternative project systems will be compared for purposes of reducing number and/or severity of impacts. During this comparison process the initial concepts for some components may be modified in order to reduce impacts, and component concepts with unacceptably severe impacts will be excluded from further consideration. Iteration of this process of component impact assessment, combination of components into project systems, identification of cumulative system impacts, and modification of components to reduce system impacts, will yield a small number of system concepts from which the final project development scheme can be selected.

Task A-15: Mitigation Measures. Selection of a final, smallest-impact, project development scheme based on the procedure described above will be followed by formulation of recommendations for reduction of those adverse impacts which are unavoidable. Such recommendations may deal with construction scheduling and methods, detailed design criteria for particular civil works (e.g., multilevel intake, intake screening), and fine-tuning of project operation (e.g., timing of flow releases during especially critical periods for anadromous fish).

Reports and License Application

Task A-16: Reports. Close cooperation will be maintained with the Alaska Department of Fish and Game and other appropriate state and federal fisheries and water quality agencies throughout the aquatic studies. Drafts of the reports summarizing results of the baseline aquatic studies, impact assessment, and recommended mitigation measures will be prepared and submitted to APA and these agencies for their comment. These agency-reviewed reports will then be incorporated in appropriate format into the license application for submittal to the FERC.

The critical relationships between wildlife and habitat are important considerations in the environmental feasibility analysis of the Susitna Project. Studies conducted to date by the Alaska Department of Fish & Game and the U.S. Fish and Wildlife Service have identified potential impacts on several wildlife species that either reside in the project area, use the area for migration or other seasonal purposes, or use habitat downstream which may be altered by changes in river flows. The studies we propose to undertake as part of this POS concentrate in the areas of habitat analysis, big game, and non-game species and fur bearers. The complex inter-relationships within and among these aspects will be analyzed to the extent that they will affect, or be affected by, project identification, construction, and/or operation.

The diversity of game and non-game species in the Susitna Basin and the need for expertise totally familiar with Alaskan conditions essentially dictates that the proposed long-term studies be performed by specialists from the Alaska Department of Fish and Game (ADF&G), the University of Alaska, or consultants with many years of applicable Alaskan experience. Harza's biologists have identified highly qualified groups and individuals meeting these criteria to conduct the proposed studies. In addition, since potential impacts on moose and caribou appear to be one of the key issues identified by the studies conducted to date, we propose to utilize the services of

an outside consultant, with extensive experience with Alaskan ungulate populations, proposed work programs for adequacy and to periodically review and comment on the results of the investigations and impact analyses so that they may be maintained at the highest possible level.

Terrestrial Ecology

Throughout the course of the study, Harza's terrestrial and wildlife biologists will closely monitor study progress to ensure that end results will be usable, communicate and interpret interim and final conclusions for planning and design engineers, and integrate individual program results into the comprehensive environmental report required for completion of the Feasibility Study and for submission as one portion of the FERC License Application. Harza's wildlife biologists will work closely, not only with study participants, but also with ADF&G and U.S. Fish and Wildlife personnel to assure that investigation programs and information derived therefrom are adequate to meet the needs of the project and are consistent with established local and regional long-term wildlife management objectives.

The following individual work tasks have been developed as an integrated program to supplement the available baseline information, undertake the detailed biological studies needed to fully assess project impacts on terrestrial resources, provide a basis for programs for minimizing or mitigating adverse impacts, and prepare a comprehensive report on the relationship between the project and existing and future terrestrial resources of the area.

Task T-1: Vegetation Mapping. The objectives of the vegetation mapping task is threefold: 1) Identify and describe vegetation and habitat types within and adjacent to proposed impoundment areas, along transmission corridors, and along the downstream floodplain, 2) Determine importance of habitat type, and individual components thereof, for moose and other key wildlife species, and 3) Determine effects and extent of project-induced habitat alterations.

Vegetation maps of most of the requisite areas have been prepared as parts of broader, multidisciplinary studies cooperatively being conducted by State (DNR) and federal (BLM, SCS, NASA) agencies and the Geophysical Institute of the University of Alaska for the Denali Planning Unit Remote Sensing Project and the Susitna River Basin Comprehensive Study. These maps were prepared from aerial photographs and LANDSAT imagery and those of the Denali Planning Unit were checked by stratified field sampling during August 1979. Analytical techniques, vegetation mapping units, area of coverage, and reporting formats

for these habitat mapping programs will be critically reviewed in order to develop a unified vegetation classification and mapping system responsive to the needs of the Susitna Project environmental studies. Data gaps and inconsistencies will be identified and resolved so as to provide habitat classifications and base maps that can be utilized for most of the other terrestrial studies.

Task T-2: Wetlands. This task consists of identifying type, distribution, and major species composition of wetlands in the study area. Section 404 of the Clean Water Act and Executive Orders 11988 and 11990 require special consideration of wetlands and floodplains in assessing the impacts of proposed activities which may alter or destroy wetlands. Results of this task will be utilized in the evaluation of alternative development schemes. Extensive impacts on wetlands could make a given alternative less environmentally desirable.

Most of the information needed for this task will be derived from the Vegetation Mapping Program. (Task T-1). During field checking in that task, particular attention will be paid to wetland areas. During the feasibility level investigations of the initial project, any wetlands in the areas to be affected will be studied in greater detail to identify the magnitude and significance of resultant impacts.

This task will be closely linked to the Vegetation Mapping Program and initial work will be done simultaneously. Impacts of the selected project will be considered during the 1981 summer season.

Task T-3: Riparian Habitat. This task consists of characterizing interrelationships between maintenance of willow/moose habitat in the downstream floodplain and seasonal flooding characteristics. Riparian willow vegetation provides critical winter moose habitat. Alterations in the flows released from the project may result in-changes in riparian vegetation and thus a reduction in moose habitat and moose populations. Understanding of the sensitivity of these relationships will be required for the evaluation of impacts and the formulation of mitigation and management practices. Differential flood tolerances of willow, spruce and other species important to the maintenance of good moose habitat will be determined from literature reviews and correlation of existing habitat conditions (vegetation successional stages) at different elevations with historic flood flow records. Frequency of recurrence, duration,

and magnitude of high flows required to maintain desired riparian vegetation characteristics will be determined in cooperation with project hydrologists. Effects of altered flow regimes on key plant species (as identified in wildlife studies) will be determined in cooperation with personnel working on studies related to vegetation and habitat analyses, habitat requirements by game and non-game species, and in-stream flow requirements he will determine Any areas where substantial vegetation changes might be expected will also be mapped.

This work will be performed during the 1981 summer season, after likely ranges in project outflows have been determined. Depending on the results of this task, additional work may be required in subsequent years. If so, it would be conducted as one aspect of the on-going big game management studies discussed elsewhere.

Task T-4: Non-game Animals. This task consists of determining distribution and abundance of non-game vertebrate species in the study area. Almost nothing is known of the birds and small mammals (non-game and furbearers) of the project area. This information will have to be obtained for the license application and discussion of project impacts. Extensive studies of species distribution and population levels in the area will provide data for comparisons with the fauna of better known comparable areas of Alaska and will provide indications of unexpected species or concentrations of species if such are present. The extensive study, up to approximately five miles back from the river, will also provide natural history and other data on species not found in the habitats of the intensive study sites.

The intensive study sites in upland and wetland habitats will provide data on bird and small mammal species composition and density in each of the most extensive habitats of the region, providing, among other things, an indication of habitat uniqueness and productivity. These intensive sites will provide data that can be extrapolated to similar habitats throughout the upper basin and will provide a basis for predicting faunal changes based on habitat changes caused by project alterations, including changes in water level.

A survey of the avifauna of the upper Susitna River basin will be conducted within an approximate five-mile band on either side of the river, from Gold Creek to the Denali Highway with more or less continuous observations from mid-April to mid-October and at least one mid-winter period of observation. All habitats of the region will be visited on a regular basis

throughout the migration and summer period and all birds seen or heard will be recorded, along with other pertinent field data. Particular attention will be paid to long-lived species, those that are particularly sensitive to human disturbance, those subject to hunting pressure, and any endangered species (raptors, cranes, swans, grouse and ptarmigan, etc.). Incidental sightings of mammalian species will also be recorded. Two aerial surveys will be made each year to search for evidence of large nesting raptors (osprey, bald and golden eagles, peregrine, and gyrfalcon). Aerial surveys of waterfowl will be conducted over wetland areas periodically throughout the migration and summer seasons. Comparable aerial surveys will be conducted over alternative transmission alignments once they have been identified.

Square 10-hectare census plots will be established on sites of uniform conditions within each of the major terrestrial habitats in the vicinity of the proposed dam sites. During the breeding season, 7-9 censuses will be conducted on each plot using a modification of the territory mapping method. One or two censuses will be conducted during the winter months. Vegetative characteristics of each plot will be determined using the point-centered quarter method with modifications to include sampling of ground cover and shrub vegetation.

Trapline transects will be established in the census plots to census the smallest mammals (shrews, voles, and mices). One late-spring early-summer, one fall, and one winter census will be conducted for each of three or four years on each of the habitat plots. More general methods (sightings and sign) will be utilized to quantify the presence of larger mammalian species in the area.

Task T-5: Big Game. This task consists of identifying big game abundance, habitat utilization, movements, and species composition. Impacts of the project on moose, caribou, bear, wolf, and wolverine are major concerns of ADF&G. Extensive programs utilizing aerial census surveys and radio-tracking of marked individuals will provide an understanding of the populations of these species using the project area and subject to project impacts. This information, combined with data on habitat conditions derived from Tasks T-1 and T-4, will provide a basis for predicting the magnitude of anticipated impacts and for developing appropriate mitigation programs.

Some of the moose that were marked with radio-collars in 1976 and 1977 are still emitting radio signals. Movements of these individuals, and others that will be similarly collared (including all big game species noted above) will be monitored in

much the same manner as was done in the previous ADF&G investigations.

Systematic aerial surveys will be conducted approximately monthly to record the location, activity, species, age, and sex of all individuals seen. Initially, flight lines at approximately one mile (moderate intensity) intervals will be flown to cover the Susitna River from Talketna to the glaciers and the lower portions of the major tributaries. The coverage pattern will include areas within ten miles of the river or less than 3500 feet in elevation, whichever produces the narrower band. These surveys will commence in February on March 1980 and will continue until October 1981. Seasonal distribution maps will be prepared showing areas of prime importance to big game. Results of these studies will be correlated with studies of "observability" in different habitats. From this information, estimates of use of different habitats by different species will be determined.

Results of these aerial censuses will also be utilized to finalize the radio-tracking aspects of these investigations. Rather than applying radio-collars to animals throughout the Upper Basin, efforts will be concentrated in those portions to be affected by the initial project. Although some individuals may be collared during March 1980 in the Devil Canyon to Vee Damsite reach of the river, the major thrust at collaring individuals will occur in August to October 1980. Analyses will be made of the data from the aerial censuses to determine the minimum numbers of each species that should be tracked in order to adequately determine the habits and habitat requirements of each species utilizing the immediate project area during some portion of the year. Collars will also be placed on animals in downstream areas that may be affected by alterations in project outflow, but this will be delayed for approximately one year while determinations are made as to the relative extent of flow and habitat alterations that may reasonably be expected following project completion.

Each radio-collared animal will be located regularly (at least monthly). For each relocation, the exact location, habitat type, activity, and association with other animals will be recorded. More intensive monitoring flights will be made during the periods of precalving and postcalving movements and winter shift to determine present migration routes and the timing of migration. Results of radiotracking flights will be compared with visual censusing flights to determine the percentage of each species normally seen by visual censusing.

Although these programs will be initiated shortly after authorization to begin work on the Susitna Project, it will be

necessary that they continue for an additional one to three years following submittal of the license application. Anticipated impacts will be identified prior to license submittal, but the subsequent time will be required to obtain sufficient information to form a reliable basis for management programs during and following project construction. One aspect of these management programs will likely include mitigation measures to minimize identified impacts and these measures will have to be identified and evaluated as part of the continuing big game studies.

History and Archeology

FERC regulations, as well as state and federal law, require that the applicant provide a report on the historical and archeological resources in the project area and the impact of the project on those resources. The report must be prepared in consultation with the State Historic Preservation Officer and the U.S. Heritage Conservation and Recreation Service.

A review of literature directly related to the history and prehistory of the study area, as found in the Alaska Heritage Resource Survey, and various published and unpublished reports, indicates that six prehistoric and thirteen historic sites have been recorded within the study area. The apparent paucity of sites in this area may be attributed to the fact that only limited archeological research has been carried out. In surrounding areas where archeological research has been more intensive, the number of sites documented is considerably higher.

Because of the minimal quantity of data available on the cultural resources within the study area, the reconnaissance and intensive surveys developed for this study are of paramount importance in identifying cultural resources and providing the appropriate recommendations as required by law. These tasks include, at a minimum: (1) Identification and documentation of cultural resources within project areas to be impacted, and (2) a description of any measures recommended for the purpose of locating, identifying, and salvaging historical or archeological resources that would be affected by the project, together with a statement of the applicant's position regarding the acceptability of the recommendations and proposed programs for their implementation.

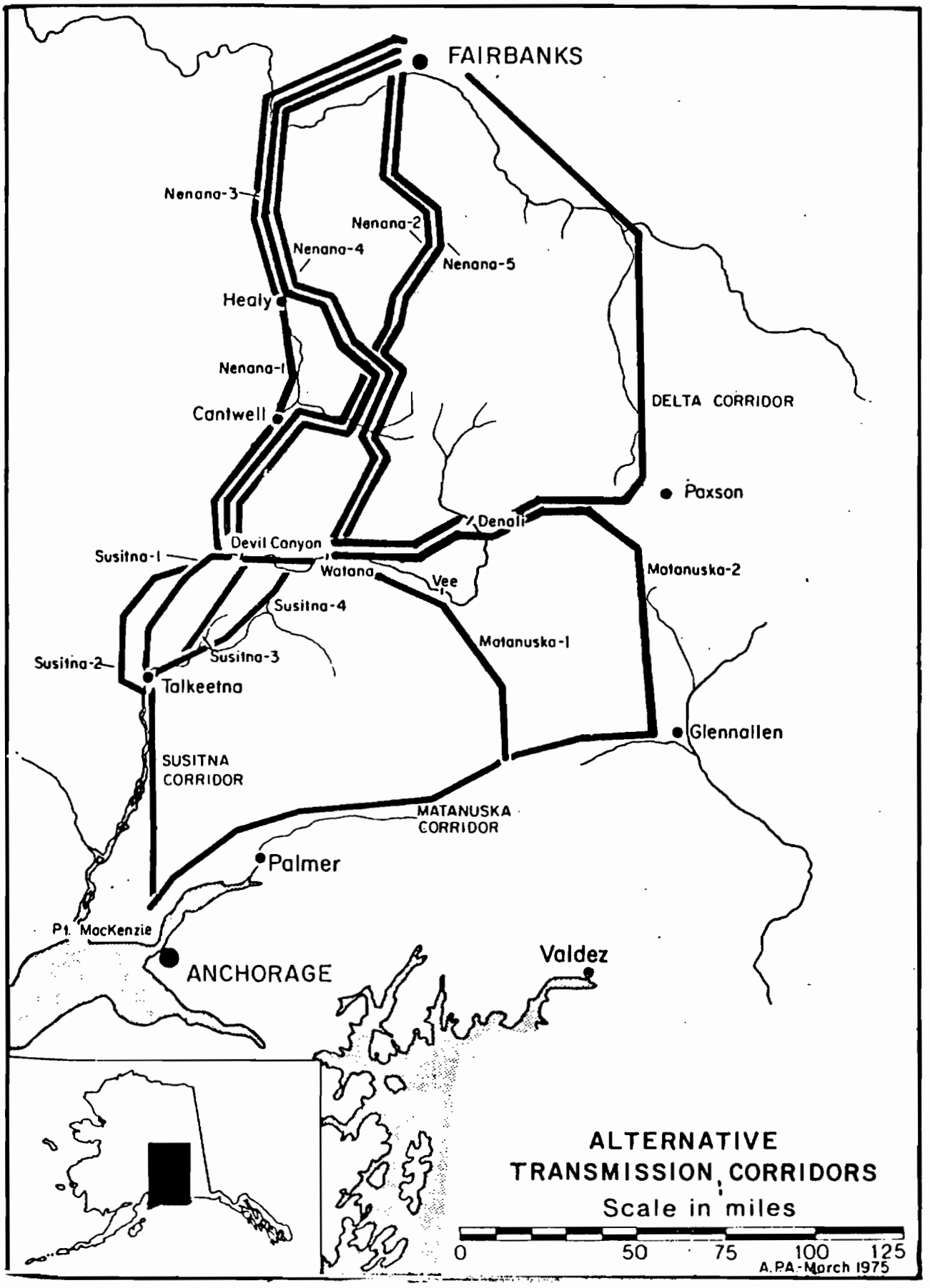
The proposed historic preservation efforts should be conceptually divided into (1) the effort necessary to obtain the license, (2) effort necessary to mitigate possible adverse effects during the course of the study essential to obtain the license, and (3) effort necessary to mitigate damage to all

historic and prehistoric sites that will be impacted by the construction phase.

Task H-1: Office Preparation

This task consists of conducting literature reviews, developing a specific research design and sampling strategy, and obtaining necessary permits. These are basic tasks needed for implementation of the history and archeology program. If not done in a timely manner, other project investigation tasks (e.g. geologic exploration) may be delayed. The study area for this initial task is defined to include three related but geographically distinct locations: a) Susitna River from Gold Creek upstream to Tyone Creek-five miles either side of the river; b) Susitna River downstream from Gold Creek to Cook Inlet to an elevation 100 ft above the floodplain or five miles either side (whichever is less); and c) alternative transmission corridors between Anchorage-Fairbanks and the development site as shown on Figure C-1.

Figure C-1


FAIRBANKS
Nenana-3
Nenana-2
Nenana-4
Nenana-5
Healy
Nenana-1
Cantwell
DELTA CORRIDOR
Paxson
Denali
Devil Canyon
Susitna-1
Watana
Vee
Matanuska-2
Susitna-4
Matanuska-1
Susitna-2
Susitna-3
Talkeetna
Glennallen
SUSITNA
CORRIDOR
MATANUSKA
CORRIDOR
Palmer
Pt. MacKenzie
ANCHORAGE
Valdez
ALTERNATIVE
TRANSMISSION CORRIDORS
Scale in miles
0
50
75
100
125
A.P.A.-March 1975

Prior to initiating field investigations during the summer of 1980, the archeologist consultant, possibly the University of Alaska Museum, will execute the following tasks:

1) Apply for, and secure a Federal Antiquities Permit and any state documents that may be necessary for the archeological portion of the project. (Office of Archeology and Historic Preservation, Interagency Services Division, National Park Services, U.S. Department of the Interior, Washington, D.C. 20240; State Archeologist's Office, State of Alaska, Department of Natural Resources, State Division of Parks, Anchorage Alaska).

2) Conduct an exhaustive literature review of available documents that pertain to the history, prehistory, ethnography, geology, flora, fauna, and late Pleistocene and Holocene geology of the areas covered by this project. Museum staff will utilize the resources of the University of Alaska Library and Archives, data files of the University Museum, and records at the State Office of History and Archeology. Consultation with other professionals who have worked in or have knowledge of the study areas will be utilized as necessary.

3) The results of the literature search will be used to synthesize the regional and local cultural chronology of the study area as well as to provide the basis for the research design.

4) Air photos of the study area will be examined and their interpretation will focus on the identification of probable areas containing cultural resources.

5) Known historic and archeological sites will be plotted on 1:63,360 scale maps. Each resource will be specifically identified. A preliminary aerial reconnaissance of the project area will be conducted.

6) Utilizing the information base produced by the above research, a research design will be developed to include a sound professional sampling strategy specifically designed for the unique needs of this project.

7) Following formulation of the research design and sampling designs, the Principal Investigator and Project Supervisor will recruit essential personnel for the field portion of this project.

It is estimated that these prefield-season tasks will take approximately five months. Upon completion of the prefield tasks, the necessary personnel and data base will be utilized for the reconnaissance level survey, and mitigation of adverse effects on cultural resources which may possibly occur as a result of the licensing study activities.

Task H-2: Reconnaissance Surveys.

This task consists of conducting a reconnaissance level archeological survey of portions of the area covered in Task H-1 based on priorities determined by project planning activities. Highest priorities for field archeological studies will be given to those areas to be disturbed by activities essential to meet licensing requirements (e.g., camps, test holes, access facilities, etc.). Within the areas selected for field reconnaissance, crews will implement surface and subsurface sampling procedures in order to locate, document, and inventory historic and prehistoric sites that may occur in the area to be affected by the project. Results from these surveys will be utilized in evaluation of alternative developments and in planning of the selected initial project so as to minimize impacts.

As it is not the intent of a reconnaissance level survey to cover 100% of the study area, preselected areas identified in Task H-1 will be selected for survey. Within these areas field crews will implement surface and subsurface testing procedures in order to locate, document, and inventory historic and prehistoric sites that may occur in the study area. This site specific data will be used to develop and direct subsequent work in areas identified as being specifically impacted by project activities (e.g. areas, construction, inundation).

Available aerial photographs, as well as LANDSAT photos, will be reviewed for all preselected areas in order to aid in locating potential site areas. Aerial reconnaissance will also be conducted at the preselected areas in order to enhance site location during this task.

If, on the basis of information from Tasks H-1 and H-2, extensive areas of high historic or archeologic significance are located, these areas may justify avoidance in the selection of the ultimate project development site. Otherwise data derived from this task will be included in the matrix evaluation of in-basin alternatives.

During this phase of the overall study, as well as during the second or feasibility phase, every effort will be made to work with other professionals involved in the project, to see that the archeological survey is conducted early in each area that may be disturbed as a result of the investigations required for project investigation and licensing. If any archeological sites are found during the course of the survey in areas slated for subsurface disturbance during predam construction, it will be necessary to undertake immediate mitigating measures. Where feasible (e.g. temporary camp locations) such activities will be relocated away from the sensitive areas.

Task H-3: Detailed Field Surveys

This task consists of conducting more intensive surveys in construction zones of the identified initial project so as to provide information necessary to delineate mitigation measures. Each identified archeological or historic site will be evaluated and recommendations made as to required mitigating measures. On the basis of this work, a final report will be prepared in accordance with state and federal regulations documenting the sites identified and a mitigation comment or recommendation for each.

This task consists of intensive testing of sites located during the reconnaissance survey (Task H-2) of the project area. Only sites located in areas specifically impacted by the selected initial project will be considered. A grid will be made of each site and a sampling scheme applied for testing. Each square selected for test excavation will be systematically excavated and all artifacts and features recorded, using standard archeological field methods. Site maps and soil profiles will also be prepared. Photographs will be taken to document artifacts and features in-situ as well as to document the site and its location. Horizontal and vertical site limits will be delineated and data will be recovered for analysis and evaluation. Based on the analysis of this material, National Register criteria will be applied to see if the site is eligible for inclusion in the National Register of Historic Places as specified in the federal regulations that apply to this project.

Intensive testing will also provide the means for evaluating the effects of the preconstruction and construction phases of the Susitna Hydropower Project on cultural resources. Each site will be evaluated and recommendations as to mitigating measures will be made and incorporated into the FERC License Application. Field crews, teams consisting of three archeologists, will focus efforts on the dam sites, impoundment areas, access roads,

staging areas, camps, borrow pits, etc., of the selected project(s).

Task H-4: Transmission Corridors

This task consists of conducting a reconnaissance level field archeological survey of alternative transmission corridors identified to service the selected project(s). This task will be comparable to Task H-2 in terms of level of intensity and techniques. Data from this task will be evaluated during the selection of probable transmission alignments. Following selection of final alignment, a more detailed survey similar to Task H-3 will be conducted.

Task H-5: Report

This task consists of preparing an overall report on the historical and archeological resources of the project area based on the research that has been conducted. This task entails compilation of the individual reports for the other phases of the archeological study as well as synthesizes all data recovered and makes appropriate recommendations for mitigation, if necessary. The task is specifically aimed at the final analysis of the project in terms of sites located and documented during the other phases. The final report will include the general location, description, and a mitigation recommendation for each site reported during previous tasks.

In order to protect archeological sites from disruption by amateur collectors and those seeking artifacts for sale or personal collections, the actual location of each site will be omitted from the report. In keeping with the prevailing practice for such surveys, sites will be designated by numbers and the reader informed that qualified individuals may obtain further information from those conducting the study, or from the Office of the State Archeologist.

The report will include mitigation recommendations, if necessary, for the sites located, and estimated budget for archeological excavation that must be done prior to the start of actual construction of the hydropower project as specified by federal and state regulations. The overall effectiveness of the research design, field procedures, and analysis will be discussed.

Recreation Resources

The objectives of the Recreation Resources Study are to inventory and evaluate the recreation resources within the Susitna Basin for the purpose of assessing the impacts that hydroelectric development might have on them, and to determine the need for, and the types of additional recreational facilities that could be associated with Susitna hydroelectric development. This work will be responsive to the FERC requirements for a report on recreation resources. The report will be developed in consultation with the Division of Parks of the Alaska Department of Natural Resources, the Matanuska-Susitna Borough Planning Department, the U.S. Heritage Conservation and Recreation Service and other local, state and federal agencies.

Most information will be obtained from federal and state agencies as well as from local communities. Through contact with these agencies it will be determined if any long-range studies or surveys need to be conducted. Most data concerns will concentrate on the following:

1) Recreation Resources and Facilities

2) Recreation Demand/Need

3) Visitor Use Data

4) Socioeconomic Data

5) Land Use Data

There will be close coordination with other studies being done, primarily fish & wildlife and socieoeconomic, to ensure incorporation of their results into the recreation assessment.

Task R-1: Existing Resources

This task consists of identifying and describing existing recreation resources and facilities in the Railbelt Area and evaluating recreation resource potential and demand within the Susitna Basin. Existing resources will be mapped in relation to population centers and travel routes. Much of this work will be done through review of previous studies and close coordination with state and local agencies. Study of the basin's opportunities and constraints for recreation activities will be done on the basis of such factors as physical site qualities, access, and population pressure. In this way the basin's opportunities and constraints for recreation activities can be

shown. Likewise, demand potential will be evaluated by defining the basin's market area, socieoeconomic characteristics, accessibility, and seasonal availability. Close coordination with the Alaska State Division of Parks will be required at this point. Impacts resulting from various alternative development schemes on the existing and potential recreation resources will be assessed. Certain features would enhance recreation potential while others would degrade that potential by destroying the resource. Still other features, while not degrading the recreation potential, change it from a low-impact use potential to a high-impact use potential. These conditions will be described and mapped for report and display purposes.

It will be important at this time to provide inputs to the public information and participation program in order to inform the public and gain information on preferences for recreation types. Public response will provide an indication of the magnitude of potential impacts of potential project alternatives and information on recreation demand and for various types of recreational opportunities that might be incorporated into a recreation plan for the initial project.

Task R-2: Impacts

This task consists of assessing recreational impacts resulting from the selected initial project and developing a recreation plan for public utilization of project lands and waters. The recreation impact assessment will be structured around the identified project facilities and operations and compared to the existing conditions. The projected beneficial and/or adverse impacts of the project will be expressed in terms of physical effects on recreation resources as well as on visitor use. The latter will be further defined in terms of recreation carrying capacities as well as realistic estimates of use levels.

Upon identification and evaluation of the impacts on recreation resources, measures will be developed to enhance beneficial and/or mitigate adverse impacts. This will be done primarily through the development of a recreation plan which will be developed according to projections of recreation demand and visitor use. Field work will be necessary at this time to insure that the design is sensitive to the site's potentials and constraints.

The final recreation plan will be developed in cooperation with APA, the State Division of Parks and the Matanuska-Susitna Borough to enhance beneficial and/or mitigate adverse impacts. Initial and ultimate visitor use for the recreation plan will be

estimated based on activity design standards, total capacity, turnover rates, and seasonality in order to provide a base for economic comparison. Identified costs will include development costs, operation travel costs and maintenance.

The inventories and analyses of recreation resources identified in the feasibility study will be summarized in maps, text, and charts consistent with the format established for theFERC License Application. The report will primarily respond to the necessity of providing public utilization of project waters and adjacent lands for recreational purposes. It will also include documentation of the nature and extent of consultation and cooperation with federal, state and local agencies.

Land Management and Aesthetics

The FERC requires that a report be prepared on the management of land within the proposed project boundary and the protection of the scenic values of the project area. The report will be prepared following consultation with local and state zoning and land management authorities and federal agencies with managerial authority. At the present time the land is under the jurisdiction of BLM. It is anticipated, however, that in the near future title may be transferred to the native village corporations of the Cook Inlet Region, Inc. Throughout the course of all planning activities, we will maintain close contract with both organizations to ensure that all needs and requirements are met.

Task V-1: Existing Resources.

This task consists of making inventory and evaluating the natural and scenic resources of potentially impacted areas of the Susitna River basin for the purpose of comparing alternative development programs. All resources which contribute to the wildland character of the area will be identified and mapped in cooperation with other ongoing resource inventory tasks. These resources include such categories as rare or endemic species, wildlife migratory routes, unique plant communities, outstanding lakes and waterfalls, and glaciers. Investigation of topographic maps, aerial photography and interviews with local agencies and citizens will facilitate this task. A follow-up ground survey will be conducted to verify the location of these resources. Reference to information derived from the History and Archeology

studies will further enhance the usefulness of the mapping of aesthetic resources.

The identification of scenic resources actually deals with three related factors: 1) Classification of the area into landscape types and variety classes; 2) Unique scarce and fragile visual resource sites; and 3) Viewer sensitivity. These resources will be identified through reference to published material and from extensive photographic records obtained during field reconnaissance. The foundation for most of the scenic evaluation at this step is based on the U.S. Forest Service Visual Resource Management System. The scenic resources will be mapped on an overlay for use in subsequent analyses.

Before evaluation and comparison of impacts of potential alternative developments, an overlay will be developed showing mitigation potential and future land use. Some landscape types lend themselves to mitigation measures more readily than others, therefore each landscape type identified should be rated as to the probability of success and appropriateness of such efforts. In addition a future change in land use can drastically change the character of a landscape setting and therefore is an important consideration in the siting of project facilities.

By combining these overlays into a single map, identification of potential high-impact zones from a cultural/aesthetic viewpoint can be achieved. This map can then be used to evaluate the alternative development schemes that are identified for the basin.

Task V-2: Impact

This task consists of assessing the potential impacts the selected project might have on aesthetic and visual resources and identifying measures to ensure that project works blend, to the extent possible, with the surrounding environment. Two computer programs utilized on comparable Harza projects will be utilized to provide a set of versatile, rapid, low-cost and objective techniques for evaluating the visual impacts of land use proposals before they are implemented.

The VIEWIT program delineates the terrain visible from single or multiple observer points by calculating lines-of-sight. Various subroutines provide distance weighting, elevation profiles, and slope and aspect classification. The weighting of viewable areas in terms of the number of times seen by mulitple observers of the visual magnitude imposed by distance will provide a measure of visual impact. The MOSAIC/PHOTOMONTAGE

system combines photographic and computer graphics techniques to provide perspective plots of landscape alterations which can be overlaid directly on a photograph. Proposed developments can therefore be quickly and accurately visualized, evaluated, and modified; the advantages this provides in considering development alternatives in a scenic region are significant. The landscape alterations currently available with the MOSAIC/PHOTOMONTAGE system include, spoil banks, fuel breaks, timber cuts, man-made water bodies, earthen dams, cuts and fills for transportation rights-of-ways, and various types of structures such as powerline towers. Boundary lines, such as for designated Wilderness Areas, may also be plotted. Both programs use digital topographic data as input. Such data will be obtained through aerial photogrammetric surveys of the project area. One or two iterations of these programs will permit the design of project facilities and transmission lines that have minimum impact on their natural setting.

Information derived from these investigations will be presented at public meetings to allow interested parties to see and understand the process, as well as allowing the study team to gain input from the public's own evaluation and suggestions. Such meetings will insure that information from the public is fully considered along with the technical information in the planning stage.

The inventories and analyses of aesthetic resources described in the feasibility study will be summarized in maps, text, charts, and photographs consistent with the format established for the FERC License Application to show how the project will be designed to avoid or minimize conflict with the cultural/aesthetic resources. Graphics will be prepared in a manner suitable for display at public and agency meetings.

Resource Inventory and Data Management

The scope of the studies for Susitna River Hydroelectric Project will encompass a variety of engineering, geotechnical and environmental disciplines. The various elements discussed in this Plan of Study include significant emphasis on the inventory of information on the resources to be developed or impacted by the project. The geographic scope of these information requirements will intensify as the project proceeds from the basin planning (siting) stage to licensing. We recognize the need to collect, store, analyze and display project data in a manner that is cost-efficient and compatible with the needs of the APA, as well as the requirements of regulatory agencies and the public. We therefore propose a program of integrated

resource inventory and subsequent data management as a specific component of the Plan of Study.

Project Data Needs

Table C-1 summarizes the variety of resource data which will be required during this project, and some of the variables which will be important to the data collection and management tasks. The table provides an indication of the scope, magnitude and complexity of the project's information requirements although it is not intended to be all inclusive at this stage. The data to be obtained will exhibit several variable attributes:

a. Level of detail (basin-wide to site-specific);

b. Location;

c. Time (e.g. daily and monthly streamflow, seasonal distribution of migratory big game, river channel migrations, etc.);

d. Interdependence with other resources and investigations. (e.g. wildlife populations and vegetation; geology exploration and archeologic reconnaissance).

The data will be required for the purposes of project siting, planning, design, impact assessment, public information dissemination, coordination with cooperating and regulatory agencies, and eventual project operation and resource management. In order to minimize costs and maximize the utility of the project data base, all of these needs will be considered in the design of the data collection and management program.

Data Collection

Project information requirements will be met through the use of existing maps, records, and literature references, supplemented as necessary with original data collection programs. State (DNR, ADF&G) and federal (BLM, SCS, NASA) agencies have established data collection programs within the Susitna basin, particularly with respect to geology and environmental resources. The project data management program will utilize the results and techniques of these ongoing efforts to the extent practical.

The personnel responsible for project data management will participate in the design of original data collection programs for the project in order to ensure that interrelated information requirements are fully met. As an example, studies of the visual impact of project structures (e.g. transmission lines) are based

on computer-generated line-of-sight analyses which use digital topographic data as input. Such data may be obtained at low cost through photogrammetric means if proper specifications are included in the aerial survey contract. Such coordination will be the responsibility of the data management personnel. Likewise, to the extent practical, field data collection programs will be integrated to minimize costs.

Data Analysis and Display

Since much of the information required for project development has a spatial dimension, it may be expressed and compared with other information in a map format. This capability will be especially useful during the basin planning stage, as well as for the assessment of potential environmental impacts. In addition, much of the project data base will be usable for mathematical models. Both attributes--spatial character and digital format--indicate the utility of computer-compatible storage and display.

As soon as the project is initiated, a detailed program will be formulated to develop appropriate formats for project data files and procedures for collection, storage and retrieval of project data. The Resource Inventory and Data Management Program will therefore function as a supporting service throughout project planning and licensing. Data lists, statistical summaries, graphic representations and maps will be the principal display devices provided. Such output will be prepared for project planning and analysis, and will also provide important visual aids for public and agency presentations.

Table C-1

Summary of Susitna Project Resources Inventory and Data Management Requirements

Required Data	Geographic Scope	Data Sources	Variables & Format
I. Engineering/Planning			
A. Topography	1) Basin-wide 2) Project dam site, reservoir area, and transmission line route	1) USGS Quadangles 2) Aerial Survey and ground control	Elevations (contours) on a horizontal grid.
B. Hydrology			
1. Surface Water	1) Basin-wide drainage patterns and meteorology 2) Site-specific hydrologic regimes	1) USGS & NOAA maps and records 2) Field instrumentation	Flow volume, duration, frequency; sediment volumes; various meteorological variables.
2. Ground Water	1) Project dam sites 2) Reservoir areas	USGS records	Depth, movement, recharge zones, quality
C. Energy Economics	Power Market Area	Public utilities	Power demand and supply variables
D. Geotechnical	1) Basin-wide 2) Dam site, reservoir area and transmission line route	1) Existing maps and data 2) Field exploration programs	Rock types and age, lineaments, faulting, seismicity
II. Environmental			
A. Terrestrial Ecology			
1. Vegetation	1) Basin-wide 2) Project site and transmission line routes	1) and 2) Ongoing state and federal mapping programs 3) Field programs	Vegetation types, composition, structure, condition, successional level and values
2. Wetlands	Same as above	Same as above	Same as above
3. Wildlife Habitats	Same as above	Same as above	Habitat food & cover values, wildlife species correlations
4. Wildlife Populations (Game & non-game species)	Same as above	Same as above, including radio-tagging and aerial survey of big game	Population distribution, migration, cycling
5. Rare and Endangered Species	Project site and transmission line route	Literature and field programs	Occurence, location, population, condition, sensitivity to development
B. Aquatic Ecology	1) Susitna River and project area tributaries 2) Upper Cook Inlet 3) Surface water bodies in reservoir area	1) Literature and field programs 2) Same as above 3) Same as above	Habitat quality, species, composition, habitat use movements, seasonal use, harvest
C. Historic & Archeological Resources	Project area, site-specific	State Historic Preservation Officer, field surveys	Site locations and value
D. Recreation & Aesthetics			
1. Recreation Activities & Resources	1) Basin-wide 2) Project area	1) State and federal agency files 2) Field programs	Facility locations, activity distribution, visitor use, travel patterns, expenditures
2. Scenic Resources	1) Basin-wide 2) Project area	1) Corps of Engineers studies, 2) Field programs	Landscape character types, viewing populations, viewshed limits, lines-of-sight

PART D

DETAILED BUDGET ESTIMATES

The budget estimates are summarized by discipline or major program on Table D-1. The bases for the estimates are discussed in Part A, Section 3, "Budget Summary" of Volume I.

The estimated budget for each work item in the Plan of Study, by quarter, is given in Table D-2 (17 sheets). The estimates include all activities through submittal of the FERC License Application.

Table D-1

Plan of Study Budget Summary
($1000)

Item No.	Discipline or Major Program	1980 1st Q	1980 2nd Q	1980 3rd Q	1980 4th Q	1981 1st Q	1981 2nd Q	1981 3rd Q	1981 4th Q	1982 1st Q	Discipline Total
1.	Project Management	68	67	68	55	54	54	54	60	77	557
2.	Logistics	376	860	1454	224	391	794	911	183	107	5300
3.	Public Information Support	74	75	75	100	61	61	61	100	50	657
4.	Photography, Surveying, and Mapping	30	131	154	20	-	60	25	-	-	420
5.	Environmental Studies										
	a. Data Coordination & Management	44	40	40	45	45	45	45	45	35	384
	b. Terrestrial Ecology	174	232	237	248	160	179	163	193	99	1685
	c. Aquatic Ecology	433	172	245	168	128	227	227	203	101	1904
	d. Recreation & Aesthetics	-	12	25	10	15	15	10	8	-	95
	e. History & Archeology	31	63	106	41	34	63	88	74	44	544
	f. Human Ecology	20	37	32	-	-	28	3	-	-	120
	g. Quality Control & Technical Editing	12	8	4	2	3	3	3	5	12	52
6.	Engineering Studies										
	a. Hydrologic & River Hydraulics	21	11	58	53	33	50	27	50	18	321
	b. Power Market	30	34	4	-	-	-	-	-	-	68
	c. Alternative Sources of Generation	69	117	-	-	20	20	39	-	-	265
	d. Hydroelectric Project	76	187	166	17	49	86	156	299	68	1104
	e. Power System Expansion and Operation	-	16	16	-	-	15	15	-	-	62
	f. Transmission & Systems	-	53	22	-	-	8	25	9	5	122
	g. Engineering Geology	64	36	107	17	17	124	239	48	14	666
	h. Drilling & Testing	-	-	-	-	-	393	576	10	-	979
	i. Soil Foundations and Construction Materials	48	90	63	25	32	65	45	16	16	400
	j. Seismic Geology & Seismology	160	157	180	20	60	142	136	129	-	984
	k. Economic and Financial Analyses	-	-	30	-	-	-	41	41	-	112
	l. Construction Costs & Programs	14	38	10	-	5	23	31	55	14	190
	Quarterly Subtotals	1744	2436	3096	1045	1107	2455	2920	1528	660	16,991

Table D-2

Discipline or Major Program: 1. PROJECT MANAGEMENT

Detailed Budget Estimate by Quarters ($1000)

Phase		Work Item or Activity	1980 1st Q	1980 2nd Q	1980 3rd Q	1980 4th Q	1981 1st Q	1981 2nd Q	1981 3rd Q	1981 4th Q	1982 1st Q		Activity Total
I	1.	Harza Proj. Management & Coordination	52	51	52								155
	2.	Management Support Services	16	16	16								48
												Subtotal Phase I	203
II	1.	Harza Proj. Management & Coord.				40	40	40	40	45			205
	2.	Managmement Support Services				15	14	14	14	15			72
												Subtotal Phase II	277
III	1.	Harza Proj. Management & Coord.									53		53
	2.	Managmement Support Services									24		24
												Subtotal Phase III	77
Quarterly Subtotal			68	67	68	55	54	54	54	60	77	Discipline Total	557

Table D-2 (con't)

Discipline or Major Program: 2. LOGISTICS

Detailed Budget Estimate by Quarters ($1000)

Phase		Work Item or Activity	1980 1st Q	1980 2nd Q	1980 3rd Q	1980 4th Q	1981 1st Q	1981 2nd Q	1981 3rd Q	1981 4th Q	1982 1st Q		Activity Total
I	1.	Housing and Food		366	517	110							993
	2.	Arctic Clothing	26										26
	3.	Radio Equipment	42										42
	4.	Helicopter Charter	21	188	262	53							524
	5.	Fixed Wing Charter	10	88	98	29							225
	6.	Aircraft Fuel	79										79
	7.	Diesel for Camp	58										58
	8.	Expand Exist Facility	118	181	530								829
	9.	Misc. Logistic Support	16	11	21	6							54
	10.	Dispatcher/Parametic/ Radio Oper./Logistic	6	26	26	26							84
												Subtotal Phase I	2,914
II	1.	Housing and Food					158	462	487	69			1176
	2.	Helicopter Charter					47	218	285	68			618
	3.	Fixed Wing Charter					9	83	108	23			223
	4.	Aircraft Fuel					100						100
	5.	Diesel for Camp					52						52
	6.	Misc. Logistic Support					11	9	8	7			35
	7.	Dispatcher/Parametic/ Radio Oper./Logistic					14	22	23	16			75
												Subtotal Phase II	2,279
III	1.	Housing and Food									37		37
	2.	Helicopter Charter									37		37
	3.	Fixed Wing Charter									16		16
	4.	Aircraft Fuel									5		5
	5.	Misc. Logistic Support									4		4
	6.	Dispatcher/Parametic/ Radio Oper./Logistic									8		8
Quarterly Subtotals			376	860	1,454	224	391	794	911	183	107	Subtotal Phase III	107
												Discipline Total	5,300

Table D-2 (Con't)

Discipline or Major
Program: 3. PUBLIC INFORMATION SUPPORT

Detailed Budget Estimate by Quarters
($1000)

Phase	Work Item or Activity	1980 1st Q	1980 2nd Q	1980 3rd Q	1980 4th Q	1981 1st Q	1981 2nd Q	1981 3rd Q	1981 4th Q	1982 1st Q		Activity Total
I	Assist APA in Public Meeting, Public Information, etc.	74	75	75							Subtotal Phase I	224
II	Assist APA in Public Meetings, Information, etc.				100	61	61	61	100		Subtotal Phase II	383
III	Assist APA in Public Meetings, Information, etc.									50	Subtotal Phase III	50
	Quarterly Subtotals	74	75	75	100	61	61	61	100	50	Discipline Total	657

Table D-2 (Con't)

Discipline or Major
Program: 4. PHOTOGRAPHY, SURVEYING & MAPPING

Detailed Budget Estimate by Quarters
($1000)

Phase	Work Item or Activity	1980 1st Q	1980 2nd Q	1980 3rd Q	1980 4th Q	1981 1st Q	1981 2nd Q	1981 3rd Q	1981 4th Q	1982 1st Q	Activity Total
I	1. Reconnaissance Mapping	30									30
	2. Dam Site Photography & Mapping		41	4							45
	3. River Valley Photography & Mapping		90	70							160
II	1. Stream Channel Cross Sections			80	20						Subtotal Phase I 235
	2. Additional Photography & Mapping						60	25			100
III	None										85
											Subtotal Phase II 185
	Quarterly Subtotal	30	131	154	20	0	60	25	0	0	Discipline Total 420

Table D-2 (con't)

Discipline or Major
Program: 6. HYDROLOGIC AND RIVER HYDRAULIC STUDIES

Detailed Budget Estimate by Quarters
($1000)

Phase	Work Item or Activity	1980 1st Q	1980 2nd Q	1980 3rd Q	1980 4th Q	1981 1st Q	1981 2nd Q	1981 3rd Q	1981 4th Q	1982 1st Q	Activity Total
I	1. Data Collection & Field Investigation	5	2								7
	2. Delineation of Baseline Conditions	6	5								11
	3. Water Supply, Flood, & Sedimentation Studies	10		17							27
	4. Assess Existing Data Collection System		4	7							11
	5. Master Plan Report			17							17
										Subtotal Phase I	73
II	1. Available Water Supply				16						16
	2. Flood Analysis			13	14	14	18				59
	3. Sedimentation				5	5	7				17
	4. Tailwater and Water Surface Profiles				10	3	3				16
	5. Water Quality			4	8	11	22	22	6		73
	6. Feasibility Report							5	44		49
										Subtotal Phase II	230
III	FERC License Application Exhibits									18	18
	Quarterly Subtotals	21	11	58	53	33	50	27	50	18	Discipline Total 321

Discipline or Major
Program: 5. ENVIRONMENTAL STUDIES (Cont'd)

Detailed Budget Estimate by Quarters
($1000)

Phase	Work Item or Activity	1980 1st Q	1980 2nd Q	1980 3rd Q	1980 4th Q	1981 1st Q	1981 2nd Q	1981 3rd Q	1981 4th Q	1982 1st Q		Activity Total
II	4. Recreation & Aesthetics				10	15	15	10	8			58
	5. History & Archeology by U. of Alaska				41	34	63	88	74			300
	6. Human Ecology											
	a. Load Projections						28	3				31
	b. Impacts											
	7. Quality Control & Technical Editing				2	3	3	3	5			16
											Subtotal Phase II	2,526
III	1. Environmental Data Coordination & Management									35		35
	2. Terrestrial Ecology											
	a. Non-game Species Studies by U. of Alaska									27		27
	b. Wildlife Biology									4		4
	c. Big Game Studies by Alaska Dept of Fish & Game									68		68
	3. Aquatic Ecology											
	a. Studies									23		23
	b. Instream Flow & Water Quality by U. of Alaska									11		11
	c. Fisheries Studies by Alaska Dept of Fish & Game									67		67
	4. History & Archeology by U. of Alaska									44		44
	5. Quality Control & Technical Editing									12		12
											Subtotal Phase III	291
Quarterly Subtotals		714	564	689	514	385	560	539	528	291	Discipline Total	4,784

Table D-2 (con't)

Discipline or Major
Program: 6. HYDROLOGIC AND RIVER HYDRAULIC STUDIES

Detailed Budget Estimate by Quarters
($1000)

Phase	Work Item or Activity	1980 1st Q	1980 2nd Q	1980 3rd Q	1980 4th Q	1981 1st Q	1981 2nd Q	1981 3rd Q	1981 4th Q	1982 1st Q	Activity Total
I	1. Data Collection & Field Investigation	5	2								7
	2. Delineation of Baseline Conditions	6	5								11
	3. Water Supply, Flood, & Sedimentation Studies	10		17							27
	4. Assess Existing Data Collection System		4	7							11
	5. Master Plan Report			17							17
										Subtotal Phase I	73
II	1. Available Water Supply				16						16
	2. Flood Analysis			13	14	14	18				59
	3. Sedimentation				5	5	7				17
	4. Tailwater and Water Surface Profiles				10	3	3				16
	5. Water Quality			4	8	11	22	22	6		73
	6. Feasibility Report							5	44		49
										Subtotal Phase II	230
III	FERC License Application Exhibits									18	18
										Subtotal Phase III	18
	Quarterly Subtotals	21	11	58	53	33	50	27	50	18	Discipline Total 321

Table D-2 (con't)

Discipline or Major
Program: 7. POWER MARKET STUDIES

Detailed Budget Estimate by Quarters
($1000)

Phase	Work Item or Activity	1980 1st Q	1980 2nd Q	1980 3rd Q	1980 4th Q	1981 1st Q	1981 2nd Q	1981 3rd Q	1981 4th Q	1982 1st Q		Activity Total
I	1. Power Market Studies	30	34	4								
											Subtotal Phase I	68
II	None											
III	None											
	Quarterly Subtotals	30	34	4							Discipline Total	68

Table D-2 (Con't)

Discipline or Major
Program: 8. ALTERNATIVE SOURCES OF GENERATION

Detailed Budget Estimate by Quarters
($1000)

Phase	Work Item or Activity	1980 1st Q	1980 2nd Q	1980 3rd Q	1980 4th Q	1981 1st Q	1981 2nd Q	1981 3rd Q	1981 4th Q	1982 1st Q		Activity Total
I	1. Identify Alternative Sources of Generation	5	6									11
	2. Identify Plant Sizes, Locations, fuels, Transmission Requirements	5	16									21
	3. Evaluate Thermal Plant Alternaives	34	50									84
	4. Evaluate Other Hydro Alternatives	15	20									35
	5. Evaluate Non-conventional Alternatives	10	4									14
	6. Prepare Report		21									21
											Subtotal Phase I	186
II	1. Evaluate Possible Load Management in Railbelt Area					20						20
	2. Analyze Fuel Costs for Alternative Thermal						20					20
	3. Prepare detailed cost of Thermal Alternative Selected in Phase I							39				39
											Subtotal Phase II	79
III	None											
	Quarterly Subtotals	69	117	0	0	20	20	39	0	0	Discipline Total	265

Table D-2 (con't)

Discipline or Major
Program: 9. HYDROELECTRIC PROJECT STUDIES

Detailed Budget Estimate by Quarters
($1000)

Phase		Work Item or Activity	1980 1st Q	1980 2nd Q	1980 3rd Q	1980 4th Q	1981 1st Q	1981 2nd Q	1981 3rd Q	1981 4th Q	1982 1st Q		Activity Total
I	1.	Reconnaissance Studies	27	70									97
	2.	Formulation & Evaluation of Alternative Basin Plans	34	101	34								169
	3.	Initial Selection & Cost Estimate of Mechanical & Electrical Equipment	9	10									19
	4.	Reservoir Operation Studies	6	6	10								22
	5.	Finalize Basin Plan			17	17							34
	6.	Prepare Basin Plan Report			105								105
												Subtotal Phase I	446
II	1.	Feasibility Studies & Lay-out & Cost Estimates of Concrete Dam and Appur-tenant Works					49	70	120	120			359
	2.	Determination of Mechanical & Electrical Equipment Costs						16	16				32
	3.	Feasibility Report							20	179			199
												Subtotal Phase II	590
III	1.	FERC License Application									68	Subtotal Phase III	68
Quarterly Subtotals			76	187	166	17	49	86	156	299	68	Discipline Total	1,104

Table D-2 (con't)

Discipline or Major
Program: 10. POWER SYSTEM EXPANSION AND OPERATION

Detailed Budget Estimate by Quarters
($1000)

Phase	Work Item or Activity	1980 1st Q	1980 2nd Q	1980 3rd Q	1980 4th Q	1981 1st Q	1981 2nd Q	1981 3rd Q	1981 4th Q	1982 1st Q		Activity Total
I	Preliminary Studies		16	16							Subtotal Phase I	32
II	Feasibility Studies						15	15			Subtotal Phase II	30
III	None											
Quarterly Subtotals		0	16	16	0	0	15	15	0	0	Discipline Total	62

Table D-2 (Con't)

Discipline or Major
Program: 11. TRANSMISSION & SYSTEMS STUDIES

Detailed Budget Estimate by Quarters
($1000)

Phase	Work Item or Activity	1980 1st Q	1980 2nd Q	1980 3rd Q	1980 4th Q	1981 1st Q	1981 2nd Q	1981 3rd Q	1981 4th Q	1982 1st Q	Activity Total
I	1. Review Data on Load Forecasts		7								7
	2. Formulate Alternative Transmission Networks		6								6
	3. Formulate Alternative Transmission Plans		10								10
	4. Estimate Transmission Losses		2								2
	5. Determine Alternative Substation Requirements		9								9
	6. Field Reconnaissance and Identification of Transmission Problems		13	10							23
	7. Preliminary Cost Est. for Transmission & Substations for each Alter.		6	7							13
	8. Prepare Report & Drawings			5							5
											Subtotal Phase I 75
II	1. Formulate Alternative Transmission Routes						5				5
	2. Compare Evaluate, & select Alternative						3	8			11
	3. Size Transmission & Substations							11			11
	4. Cost Estimates							6	5		11
	5. Feasibility Report & Drawings								4		4
											Subtotal Phase II 42
III	Input to FERC License Application									5	Subtotal Phase III 5
	Quarterly Subtotals	0	53	22	0	0	8	25	9	5	Discipline Total 122

Table D-2 (Con't)

Discipline or Major
Program: 12. ENGINEERING GEOLOGY

Detailed Budget Estimate by Quarters
($1000)

Phase		Work Item or Activity	1980 1st Q	1980 2nd Q	1980 3rd Q	1980 4th Q	1981 1st Q	1981 2nd Q	1981 3rd Q	1981 4th Q	1982 1st Q	Activity Total
I	1.	Review Data and Literature Search	23									23
	2.	Study Satellite Imagery & Aerial Photos	4									4
	3.	Map Studies	4									4
	4.	Initial Evaluation of Regional Geology	22									22
	5.	Prepare Surface Geology Work Progress	2									2
	6.	Surface Mapping of Potential Dam Sites		22								22
	7.	Reconnaissance of Potential Access Roads & Transmission Routes	2		9							11
	8.	Reconnaissance of Economic Minerals & Cement Plant Potential		7								7
	9.	Identification of Geologic Hazards			11							11
	10.	Define Geologic Site Conditions for Alternate Plans	7	7	7							21
	11.	Basin Plan Report & Drawings			80	17						97
											Subtotal Phase I	224
II	1.	Preparatory Work for Subsurface Exploration					17					17
	2.	Subsurface Exploration						263	367			630
	3.	Geophysical Testing						86	155			241
	4.	Field Support						74	109			183
	5.	Monitor Field Program						40	44			84
	6.	Review & Evaluate Field Data						7	18			25
	7.	Evaluate Rock Core & Aggregate Tests							2			2
	8.	Review Geophysical Data							2			2
	9.	Seismic Coordination & Review							16			16
	10.	Engineering Geology Studies						3	18	3		24
	11.	Feasibility Report & Drawings							30	45		75
											Subtotal Phase II	1,299
III		FERC License Application Exhibits									14	Subtotal Phase III 14
		Quarterly Subtotals	64	36	107	17	17	473	761	48	14	Discipline Total 1,537

Table D-2 (Con't)

Discipline or Major
Program: 13. SOIL FOUNDATIONS AND CONSTRUCTION MATERIALS

Detailed Budget Estimate by Quarters
($1000)

Phase	Work Item or Activity	1980 1st Q	1980 2nd Q	1980 3rd Q	1980 4th Q	1981 1st Q	1981 2nd Q	1981 3rd Q	1981 4th Q	1982 1st Q		Activity Total
I	1. Review Existing Data & Summarize	32										32
	2. Map Studies	16										16
	3. Field Reconnaissance		46									46
	4. Conceptual Design of Alternative Sites		26	25								51
	5. Evaluation of Alternatives		18	18								36
	6. Prepare Phase II Invest. Program			5								10
	7. Review & Coordination			15								15
											Subtotal Phase I	206
II	1. Geotechnical Field Investigation						25	25				50
	2. Laboratory Testing of Conc. Aggregate, etc.						28	36	10			76
	3. Test Pits & Trenches						16	16				32
	4. Feasibility Level Layout & Design				4	8	8	4				24
	5. Feasibility Stage Design Studies				16	24	32	16				88
	6. Feasibility Report & Drawings								16			16
											Subtotal Phase II	286
III	FERC License Application Exhibits									16	Subtotal Phase III	16
	Quarterly Subtotals	48	90	63	25	32	109	99	26	16	Discipline Total	508

Table D-2 (Con't)

Discipline or Major
Program: 14. SEISMIC GEOLOGY AND SEISMOLOGY

Detailed Budget Estimate by Quarters
($1000)

Phase		Work Item or Activity	1980 1st Q	1980 2nd Q	1980 3rd Q	1980 4th Q	1981 1st Q	1981 2nd Q	1981 3rd Q	1981 4th Q	1982 1st Q		Activity Total
I	1.	Review of Available Data	57										57
	2.	Short-term Program & Seismologic Analysis	77	77	78								232
	3.	Reservoir Induced Seismicity		4									4
	4.	Interpretation of Remote Sensing Images	26	26									52
	5.	Seismic Geology Reconnaissance		50	50								100
	6.	Evaluation & Reporting			52								52
												Subtotal Phase I	497
II	1.	Short-term Program & Seismologic Analysis				20							20
	2.	Long term Program					60						60
	3.	Reservoir Induced Seismicity						22					22
	4.	Seismic Geology Reconnaissance						20					20
	5.	Seismic Geology Field Studies						50	86				136
	6.	Evaluation & Reporting						50	50	129			229
												Subtotal Phase II	487
III		None											
	Quarterly Subtotals		160	157	180	20	60	142	136	129	0	Discipline Total	984

Table D-2 (Con't)

Discipline or Major
Program: 15. ECONOMIC AND FINANCIAL AND ANALYSES

Detailed Budget Estimate by Quarters
($1000)

Phase	Work Item or Activity	1980 1st Q	1980 2nd Q	1980 3rd Q	1980 4th Q	1981 1st Q	1981 2nd Q	1981 3rd Q	1981 4th Q	1982 1st Q		Activity Total
I	1. Preliminary Economic Analysis			19								19
	2. Preliminary Financial Considerations			11								11
											Subtotal Phase I	30
II	1. Detailed Economic Analysis							27	27			54
	2. Development of Financing Plans & Payoff Schedule							14	14			28
											Subtotal Phase II	82
III	None											
	Quarterly Subtotals	0	0	30	0	0	0	41	41	0	Discipline Total	112

Table D-2 (Con't)

Discipline or Major
Program: 16. CONSTRUCTION COST AND PROGRAMS

Detailed Budget Estimate by Quarters
($1000)

Phase	Work Item or Activity	1980 1st Q	1980 2nd Q	1980 3rd Q	1980 4th Q	1981 1st Q	1981 2nd Q	1981 3rd Q	1981 4th Q	1982 1st Q		Activity Total
I	1. Preliminary Unit Price Estimates	14	20									34
	2. Preliminary Constructability Analysis		9									9
	3. Construction Schedules of Alternative Plans		9									9
	4. Report, Sections, & Drawings		0	10								10
											Subtotal Phase I	62
II	1. Feasibility Level Cost Estimates					5	23	23	5			56
	2. Constructability Analysis								22			22
	3. Construction Schedules							8	14			22
	4. Feasibility Report Sections								14			14
											Subtotal Phase II	114
III	FERC License Application Exhibit									14	Subtotal Phase III	14
	Quarterly Subtotals	14	38	10	0	5	23	31	55	14	Discipline Total	190